Fraunhofer

Technology List 2016

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2. Fraunhofer Institute for Applied and Integrated Security AISEC

Website Link: http://www.aisec.fraunhofer.de/en.html

2.1 Institute Overview

English: Fraunhofer AISEC supports firms from all industries and service sectors in securing their systems, infrastructures, products and offerings. On behalf of our clients, we develop qualitatively high-value security technologies which increase the reliability, trustworthiness and tamper-resistance of IT-based systems and products. The approximately 80 members of the Fraunhofer AISEC scientific and technical staff balance economic needs, user-friendliness, and security requirements to develop optimally tailored concepts and solutions. Our security test labs are equipped with state-of-the-art equipment, and our highly-qualified security experts evaluate and analyze the security of products and hardware components as well as software products and applications for our customers. In our laboratories, we test functionality, interoperability and compliance and give our clients targetted, effective advice. Our clients are producers, distributors and users in the areas of (among others) chip-card systems, telecommunications, automotive production and distribution, logistics and aerospace, mechanical engineering and automation technologies, healthcare, and the software industry, as well as the public sector like eGovernment. Strategic partnerships with global industrial companies as well as with international universities (in particular, the Technical University of Munich – a federally-designated »University of Excellence«) guarantee the scientific excellence of our work as well as its market-driven implementation.

Korean: 프라운호퍼 응용 및 통합보안 연구소(AISEC)는 산업 및 서비스 부문 전체를 대상으로 시스템, 인프라, 제품 및 서비스의 보안을 지원하고 있습니다. 고가치 보안기술을 통해 IT 기반 시스템과 제품의 안정성을 향상시키고 탬퍼링을 방지합니다. 80 여명의 연구기술진은 경제적 니즈, 사용자 편의성, 보안 요구사항에 최적화된 맞춤형 컨셉 및 솔루션을 개발하고 있습니다. 연구소 내 실험실은 최첨단 장비를 보유하고 있으며, 풍부한 경험을 갖춘 보안 전문가들이 제품, 하드웨어 부품, 소프트웨어 제품, 응용제품 등의 보안성을 평가·분석하고 있습니다. 또한 기능성, 상호운용성 및 컴플라이언스를 시험하고 고객들에게 효과적인 맞춤형 자문을 제공합니다. 주요 고객은 칩카드 시스템, 통신, 자동차, 물류, 항공우주, 기계공학, 자동화 기술, 헬스케어, 소프트웨어 등 각종 산업부문과 전자정부 등 공공부문의 제조사·유통사·사용자입니다. 세계 유수

기업 및 대학(연방정부 선정 우수대학인 뮌헨대학 포함)과의 전략적 파트너십을 통해 기술적 우수성뿐 아니라 시장 지향적 응용을 추구하고 있습니다.

2.2 Embedded Security

The fast reduction of structure sizes in semiconductor technology allows the fabrication of increasingly powerful, energy-saving, and low-price microprocessors. Small micro-controllers can nowadays be found in more and more devices of daily life, like cars or mobile phones. These so-called embedded systems perform various sophisticated and sometimes safety-critical tasks. Failures of these systems have an immediate impact on our real live. These systems impose high requirements on safety and reliability.

Especially the increasing connectivity among embedded systems (Internet of things) demands security functions to ensure a reliable and safe operation of embedded systems. Because of the stringent resource constraints of embedded systems (computational power, energy), these security functions have to be combined with the actual functionality of the embedded system. Integrated security functions are therefore a necessity for a safe and reliable operation of embedded systems.

Expertise

For our costumers, Fraunhofer AISEC develops hardened embedded systems, in which software security functions are complemented with matching hardware security functions. We offer an integrated hardware and software engineering process, as well as the necessary migration of functionality into hardware. Fraunhofer AISEC provides concepts, and develops and evaluates solutions for embedded systems according to different criteria, like energy consumption, computational power, and communication cost. These customized solutions range from the correct integration of hardware security elements to the development of tailored security solutions in hardware and software, according to the dedicated needs of our costumers.

2.3 Security Evaluation

IT systems are nowadays part of our daily live and part of many common devices. They perform various sophisticated, and sometimes safety-critical tasks. Security has a direct impact on safety. Lack of security can cause loss of reputation, loss of revenue, and even liability claims.

Many security holes are caused by design or implementation faults. Often developers are not aware of the whole bandwidth of possible attacks on their system. An analysis and evaluation of the system's security aspects is often never done. In addition, security rivals with other goals as costs, duration of the development process, and functionality.

A security evaluation is a crucial part of a high-quality system development. With a security evaluation during the development process, threats can be detected and corrected early. But also after the end of a project, a security evaluation can be useful to know existing threats and potential vulnerabilities of your system, e.g., to avoid them in future systems.

Expertise

Fraunhofer AISEC offers comprehensive and independent tests for the security evaluation of distributed and embedded systems, hardware and software products, or web-based and cloud services. For this purpose, Fraunhofer AISEC can resort to its modern test labs to conduct security tests, compliance tests, and interoperability tests.

Hardware lab

Our hardware testing laboratory, equipped with the newest devices, allows us to perform a huge variety of attacks on embedded systems, reveal vulnerabilities, and develop solutions for their mitigation together with our costumers. The bandwidth of our test possibilities ranges from simple attacks on embedded systems, like attacks over open interfaces (JTAG), to passive side-channel attacks and semi-invasive fault-attacks. Our advanced hardware test lab with adequate tool chains ensures that the security of embedded components can be tested with the most recent classes of attacks.

GSM test lab

Fraunhofer AISEC operates an own GSM test network with a workbench that allows to perform attacks over the mobile network on mobile end devices. The GSM test lab offers the possibility to test various mobile end devices regarding vulnerabilities of the GSM stack. In addition, the lab provides the potential to simulate future payment applications over GSM/UMTS in a realistic way.

Smart metering lab

In Fraunhofer AISEC's testing environment, we analyze commercial smart meter components and evaluate them regarding their security properties, as for the protection profile for smart meter of the German BSI. We help our customers to increase the quality of their products and advise users on the selection of suitable smart meter components. In addition, we develop dedicated security solutions for our costumers, which are tailored to their needs, or we support our costumers in improving their products towards more security.

Mobile payment lab

Mobile payment with NFC has a high market potential, since a setup of a complex payment infrastructure is not needed, and transactions can be conducted with passive components without an own power supply. Mobile payment with NFC inherently leads to security challenges. Security properties are here not limited to mobile end devices, but also the communication with readers has to be trustworthy and secure. In our NFC test lab, we analyze and evaluate the security of specific NFC implementations in order to obtain an evidence about the security of NFC-based payment transaction systems.

Automotive lab

Fraunhofer AISEC operates an own test lab, where the security properties of software and hardware components of automotive systems, like ECUs, head units, and interfaces for maintenance and diagnosis, can be validated. This environment is made available for OEMs, suppliers, manufacturers, or system integrators, in order to perform security tests.

Cloud Lab

In the CloudLab of the Fraunhofer AISEC, we run functionality, reliability and interoperability as well as risk assessment and benchmarking tests. In these tests and in close cooperation with our customers, we analyze all components of a cloud ecosystem. In addition, we accompany all relevant development phases, starting with the design of separate service, the prototypes over to the security analysis of market-ready systems. Fraunhofer AISEC tests products and solutions around cloud computing, identity management and the underlying components of service-oriented architectures. Open source solutions, such as Ubuntu and Eucalyptus, comprise the technical foundation of the private cloud operated by us. This enables us to conduct comparative analysis of the security functionality using flexible and efficient, pre-configured virtual machines (VMs) and the services based on them. Beyond this, our offering consists of CloudLabs interoperability tests, which always pose a great challenge when it comes to the operation of identity management systems.

2.4 Hardware Security

Embedded systems in many applications consist of multiple different chips and are physically accessible to owners, users, and also possible adversaries. Therefore, they are at risk from attackers with advanced skills in electronics, communication engineering, implementation engineering or hardware attacks. Such attackers can also obtain access to internal interfaces, such as debugging interfaces, or interfaces of integrated memory chip directly. For these reasons, it is essential to target a high level of hardware security from the very beginning while designing such systems. A comprehensive and tailored design approach and the application of specific cryptographic algorithms is required to establish a high hardware security level according to the respectively relevant threats and circumstances. In most cases, the integration of dedicated security chips with specific features and properties into the embedded system is necessary to protect against such modern hardware attacks.

However, comprehensive security designs with standardised cryptographic algorithms for embedded systems are no longer enough. Adversaries have advanced skills in the side-channel analysis of cryptographic implementations and in fault attacks on such. For example, a key can be cracked by measuring the current consumption. It is therefore essential to use advanced protective measures.

A promising approach in the field of hardware security is the use of Physical Unclonable Functions (PUFs). One possible application of this technology is the derivation of cryptographic keys from the unique physical properties of individual chips of the same type. The resulting keys are ‘stored’ in the physical properties and are therefore extremely difficult to read out.

Expertise

Fraunhofer AISEC analyses the hardware security of products and systems. In an ultra-modern hardware security lab, attacks on security are analysed using both white-box and black-box scenarios. The range of analyses extends from simple physical attacks, such as reading out memory, to highly complex sideband analyses or fault attacks. Security experts analyse potentially available proprietary encryption algorithms and their applications, and provide support in the selection and secure use of suitable cryptographic algorithms. Fraunhofer AISEC also provides support in the implementation of protected cryptographic algorithms and security against side-channel and fault attacks. In side-channel analysis, the main focus of the laboratory is on high-resolution measurements of the magnetic field of security chips. In fault attacks on security chips, the main focus is set on laser fault injection using a station developed in-house to carry out attacks using two separated laser beams.

In many cases it is appropriate to use dedicated security chips. However, there are a many products from different manufacturers. Based on the specific circumstances of each case in terms of security functionality and cost, Fraunhofer AISEC supports companies in choosing suitable chips and in developing and implementing tailored security architectures at a reasonable cost.

2.5 Product Protection

Big economic damages which reach always new record values originate from the dishonest imitation of products, components and design. The negative effects of technology theft and product piracy are a serious menace. The manufacturers lose shares of the market and suffer image damages. Consumers use (unconsciously) inferior products whose security, functional ability and reliability stands in question. Even national economies are weakened, in the end, by investment decline, job dismantling and tax failures.

Embedded systems are a component of many modern capital goods and consumer goods. If no preventive protection technology is used, attacks on hardware and software in embedded systems are possible. The attack-scope ranges from specific modifications up to entire reverse engineering and product piracy. By suitable measures in the electronics and software it is possible to thwart such attacks.

Expertise

Fraunhofer AISEC develops technological preventive measures on the basis of the newest scientific knowledge to counteract product piracy and to protect enterprise values. The application-oriented security experts of AISEC have many years of project experience and proven professional competence.

Within the scope of the research offensive Innovations Against Product Piracy funded by the German Federal Ministry of Education and Research, employees of the Fraunhofer AISEC (at that time still under the name Fraunhofer SIT) have developed innovative solutions for the protection of embedded systems and have supported the involved industrial partners to apply preventive measures in three different products. This work was done during the joint research project Gestaltung von Piraterierobusten Produkten und Prozessen (Creation of piracy-robust products and processes).

Fraunhofer AISEC is a member of the consortium Product- and Know-how Protection (http://pks.vdma.org/en_GB/) within the VDMA (Verband Deutscher Maschinen- und Anlagenbau - German Engineering Federation).

2.6 Service & Application Security

Service-oriented architectures and elastic deployment models of IT-resources serve as key-enablers of modern service infrastructures in corporations, public institutions as well as the internet. The security of the cloud-platforms, infrastructures and dedicated cloud service offerings (Software-as-a-Service) available is a crucial success factor for the providers of such cloud and service offerings.

Expertise

In the year 2009, the Fraunhofer AISEC (using its former term Fraunhofer SIT) published the first comprehensive, German-language study of security in the field of cloud computing. Key results comprised of a systematic taxonomy for the analysis of security as well as guidance for the users of cloud computing services. A detailed, subsequent analysis of the market leaders in cloud computing on behalf of the Federal Office for Information Security (BSI), which ended in spring 2011, revealed deep insights into the state-of-the-art of developments and technology of the most widespread, commercial service offerings in cloud computing. In addition to this, we conduct interoperability and practical comparative analysis of these offerings with open-source solutions in our laboratory.

Fraunhofer AISEC supports customers with the conception, the design, the realization and evaluation of security and reliability related aspects, as well as the robustness of SOA and Cloud solutions. Consultation of users of cloud computing service offerings, such as small and midmarket businesses, is carried out by Fraunhofer AISEC in the areas of business process outsourcing and applications in cloud computing environments. We conduct security research and analysis and, where appropriate, develop tailored applications that enable the secure and comfortable usage of cloud computing service offerings. This includes the use of innovative technologies, which enable Security-as-a-Service, e.g. identity management in the sense of Identity-as-a-Service.

2.7 Automotive Security

Today's vehicular systems comprise complex and distributed structures and encompass in some cases more than 70 Electronic Control Units (ECUs). In the near future the number of electronic components will further increase and more and more vehicular functions will be implemented in hard- and software. However, for this reason the threat potential for those systems increases significantly. In order to make use of the IT penetration for OEMs, suppliers, repair shops, service providers etc., the security of the deployed technologies is an indispensable requirement.

Expertise

Fraunhofer AISEC supports OEMs, suppliers, device manufacturers and system integrators in development, implementation and integration of secure vehicular functions, applications and value-added services, and thus assists enabling innovative products by the approach »Safety by Security«.

Fraunhofer AISEC has competencies in a widely spread spectrum securing both internal and external vehicular communication by using automotive suitable security mechanisms and protocols, which are qualified for the long product life cycles in the automotive industry. We advise and provide solutions for secure function enabling, secure linking up with backend services, and also for protection of Internet attacks or other potential attacks (e.g., chip tuning). In the field of in-vehicle systems, Fraunhofer AISEC develops security mechanisms which in particular increase the safety of vehicular components. Additionally, we develop and implement concepts which enable the secure integration of those vehicular components in existing or new automotive systems.

2.8 Secure Software Engineering

Expertise

Many industries are undergoing radical change. More and more products and services are being created with software or they contain critical software-based components. Competition and innovation are forcing companies to continuously accelerate the software life cycle. The organizational and engineering dividing lines between the pre-operational and operational phases are becoming blurred.

Software development frequently includes wide range of separate value chains involving software manufacturers, outsourcing providers, system integrators, and in-house company resources. The result is that commercial and individual software components are combined with software services and then aggregated into complex, software-based solutions.

These developments impact not only providers such as in the media industry, which is characterized by increasingly digitalized production and marketing processes and the need to supply direct interfaces all the way to the end user through software-based solutions. With growing numbers of products that contain critical software components and which are integrated into various systems by means of software-based interfaces, other industries are also affected by these trends, whether it's medical equipment manufacturers or durable goods producers.

The use of software and software-based solutions can put various aspects of an enterprise at significant risk, including proper operation of the business, the intended use of its products, intellectual property, the company's reputation, and adherence to regulatory requirements. Vulnerabilities can arise through third-party or in-house developed software components, how they are combined and configured, and also as a result of unanticipated operational conditions.

Fraunhofer AISEC develops methods, tools, and approaches for the development and analysis of secure software components and software-based solutions. We take a holistic view of the software solution life cycle, focusing on constructive measures to ensure that security is incorporated into the design and given adequate consideration during the integration and configuration phases.

2.9 Industrial Security

Industry 4.0 is expected to transform the industrial landscape and intelligent production processes towards the creation of customized products, increased flexibility and efficiency of manufacturing, and advanced automation. It incorporates digitalization and the Internet of Things. The new features require establishing information networks that connect machinery, facilities, and devices. Therefore, Industry 4.0 also leads to an increased risk of cyber-attacks from external threats.

Industrial espionage and sabotage are becoming a significant threat, and, due to increased network connectivity, the risks will continue to grow. Attacks on industrial plants can lead to a loss of reputation and direct financial damage, for those who provide the infrastructure and for those who operate plant and machinery. In extreme cases, in sensitive areas, lack of security and protection from attackers can lead to exposure of safety of those plants.

In the light of these threats, there is a need for security solutions that take future developments into account. This requires integrating necessary security measures into facilities and machinery at an early stage of the product design and development (Security by Design). Nevertheless, there is still the need for solutions that enhance security at existing sites that are in operation now. This includes the provision of security for specific components, communication channels, embedded systems, and control mechanisms.

Expertise

- Security analysis of core components such as PLCs, addressing their security levels
- Secure remote access, maintenance, and updates
- Providing security for manufacturing equipment and plant networks
- Secure machine-to-machine communication
- Providing security for field bus communication
- Protection for service processes (e.g., managing function activations and maintenance modes being accessible only by authorized technicians)
- Support in the development of manipulation-resistant components
- Securing data by bridging the gap between virtual and real-world production environments

3. Fraunhofer Center for Maritime Logistics and Services CML

Website Link: http://www.cml.fraunhofer.de/en.html

3.1 Institute Overview

English: The Fraunhofer Center for Maritime Logistics and Services CML develops and optimizes processes and systems along the maritime supply chain. We support private and public-sector clients with the initiation and realization of innovations through practical research projects in the fields of shipping, ports and logistics.

In accordance with the project and customer requirements, we put together interdisciplinary teams of engineers, economists, mathematicians, information scientists and marine engineers to create customer-specific solutions for ship and fleet management, marine transport and navigation, ports and transportation markets. We take both the results of our varied research activities and the latest scientific insights into account. Fraunhofer CML is part of the Fraunhofer Institute for Material Flow and Logistics IML in Dortmund.

Korean: 프라운호퍼 해운물류서비스센터(CML)는 해운 공급망 내 공정과 시스템을 개발 및 최적화하고 있습니다. 해운, 항만, 물류 분야의 실용적인 연구 과제를 통해 민간 및 공공부문의 혁신 실현을 지원하고 있습니다. 과제 및 고객 요구사항에 따라 기술, 경제, 수학, 정보과학, 해운 등 분야별 전문가들로 팀을 구성하여 선대관리, 해상운송 및 항해, 항만 및 운송 시장에 대한 맞춤형 솔루션을 제공합니다. 이때 다양한 연구활동 결과와 함께 최신 기술 인사이트도 반영하고 있습니다. 프라운호퍼 CML 은 도르트문트(Dortmund)에 소재한 프라운호퍼 물자흐름 및 물류 연구소(IML)의 산하기관입니다.

3.2 Ship and Information Management

Modern maritime information management on board and on land offers significant efficiency and economic profitability. The focus lies on personnel and procurement processes, that often represent large parts of the operational costs. The CML develops and pilots individual solutions for its customers to optimize business processes for the operation and control of shipping fleets.

Core Competences:

- Development of environments to support personnel requirement planning and crew scheduling decisions
- Mathematical optimization for planning decisions
- Strategic procurement planning for the supply of fleets
- Support with the conceptual design and optimization of after-sales services in the maritime supplier industry
- Development of new information and communication technologies

3.3 Sea Traffic and Nautical Solutions

The growth of maritime transport and ship sizes brings challenges for safety and efficiency in shipping, faced by innovations in information technology and nautical solutions.

The CML brings these two aspects together in the field Sea Traffic and Nautical Solutions. Thus waterways, vessel traffic and ship handling technologies are analyzed, evaluated and optimized, thereby improving the safety and efficiency of vessel traffic

Core Competences:

- Use of ship handling simulators as test environments for innovative nautical technologies and processes

- Development and assessment of technologies for autonomous systems and nautical assistance systems
- Nautical safety analyses for planning approval purposes and port layout assessment
- Nautical risk analysis and maneuver optimization
- AIS-supported analyses of maritime transport and routing

3.4 Transport Market Assessment

Ongoing globalization, the availability of innovative technologies and rapidly changing market requirements are altering maritime supply chains. Making infrastructures and transport chains more flexible is one answer to these developments. CML supports its customers with market development trend studies and assists with strategic, futureoriented investment decisions.

Core Competences:

- Data processing and statistical analyses of traffic volumes and transportation demand
- Simulation-based determination of traffic projections for strategic infrastructure development
- Cost-benefit analyses, infrastructure and technology assessments
- Use of planning tables for visually supported port and terminal planning
- Software applications for process modeling and logistics simulation

4. Fraunhofer Research Institution for Microsystems and Solid State Technologies EMFT

Website Link: http://www.emft.fraunhofer.de/en.html

4.1 Institute Overview

English: Fraunhofer EMFT stands for applied research into sensors and actuators for people and the environment.

The following competences form the basis of the research work at Fraunhofer EMFT: Functional Molecules, Silicon Technologies, Devices and 3D Integration, Foil Technologies, Micropumps and Design, Test & System Integration. Each of these competences in its own right allows new kinds of sensors and actuators to be created. But the real strength of Fraunhofer EMFT lies in the interaction between these areas: after all, innovations often emerge where technologies reach their limits and begin to cross-fertilize.

Korean: 프라운호퍼 마이크로시스템 및 고체상태 기술 연구소(EMFT)는 인간·환경 감지 센서 및 액츄에이터에 대한 응용연구기관으로, 기능성 분자, 실리콘 기술, 기기 및 3D 집적, 포일(foil) 기술, 마이크로펌프 설계, 시험 및 시스템 집적 분야의 핵심 연구역량을 보유하고 있습니다. 일반적으로 기술이 한계에 도달하여 타 기술과 융합될 경우 혁신이 발생하게 됩니다. 연구소는 분야별 연구역량과 이를 아우르는 융합 연구능력을 기반으로 새로운 형태의 센서 및 액츄에이터를 개발하고 있습니다.

4.2 Functional Molecules

The competence to develop molecules and particles with new properties and extended functionalities and then integrate them into various substances forms the basis for development of sensor materials. These novel sensor materials are both sensitive and selective, offering enormous potential for the detection of chemical and biological parameters. Research into precise and reliable detection methods is much needed in these areas. What is more, measurement systems based on sensor materials offer the advantage of not necessarily requiring electric power. This means they are well suited to application areas with no infrastructure or difficult access to power grid, e.g. portable handheld devices in medical technology and environmental analytics.

Indicator dyes can be used to make a whole range of sensor materials, such as sensor particles which can be used as nanosensors for cell analytics. The indicator dyes can also be applied to surfaces by means of coating or printing techniques. In this way, the scientists can develop sensor foils, sensor textiles and even liquid sensor materials such as paints. In combination with Fraunhofer EMFT expertise in the area of semiconductor technology, indicator molecules of this kind can be used to create new sensor systems.

4.3 Silicon Technologies, Devices and 3D Integration

In the area Silicon Technologies, Devices and 3D Integration, the main focus is on making sensor systems smaller, more efficient and multifunctional, thus enabling new areas of application. Fraunhofer EMFT has an industrially compatible CMOS line for 200 mm wafer production. The 0.65 µm CMOS process is used to make test circuits to assess new semiconductor processes, materials and system integration technologies. Twin-well CMOS technology also allows for modular integration of special components if required.

Other focus areas are silicon epitaxy for high-impedance intrinsic layers and silicon-germanium epitaxy (SiGe epitaxy) for dedicated strained layers or sacrificial layers. The technological expertise for producing thin wafers is an important basis for system integration. The Munich site is excellently equipped for the complex processes required for thinning, so the devices produced at wafer level can be as thin as needed. 3D integration is a key technology in creating miniaturized, multifunctional and high-capacity microelectronic components. Here, Fraunhofer EMFT staff have many years of experience with through silicon interconnects (Through Silicon Vias; TSV).

In the area of MEMS technology (Micro Electro Mechanical Systems), Fraunhofer EMFT has an extensive range of process modules for structuring and processing which enables individualized solutions to be realized even for small wafer quantities as well as the creation of complex MEMS components. As a supplement to MEMS technology, Fraunhofer EMFT researchers are also active in the field of Multifunctional On-Top Technologies (MOTT), looking at modular integration of new functionalities and components in existing standard silicon technologies. Here they are able to draw on extensive expertise from existing research results from work on CMOS circuits and 3D integration.

4.4 Micropumps

Piezoelectrically driven micropumps are the core components of micro dosing systems. Technological requirements like exact dosing, back pressure capability, miniaturized and flat design, low energy consumption, particle resistance, bubble tolerance and free flow protection require a number of technological solutions. The Fraunhofer EMFT research team has a long-term experience as well as practical knowledge in this field, especially concerning the design of micropumps.

The competence area micropumps includes the following fields of technology:

Design of micropumps

- design methodology, including the influence of practical interferences
- comprehensive libraries of analytic models, FEM models and system simulation

Established technology platforms for low-risk implementation

- Silicon development platform

- Metal Development platform
- Assembly platform for piezo ceramics including parallel tests

Integration of micropumps into systems

- Library of control electronics
- Wide range of flow sensors and dosing monitoring
- Handling of particles and bubbles

4.5 Foil Technologies

Foil technologies include various processes for layering and structuring of flexible substrates for manufacturing electronic foil systems.

One focus area in this competence field is heterointegration, which enables the combination of various technology worlds, in order to provide efficient solutions for the production of foil systems. Here, heterointegration of silicon and foil technology has a key technological role to play: while silicon technology allows extremely miniaturized components to be realized, foil processing offers greater scope for design, enabling flexible, flat and biocompatible electronics. With its laboratory facilities and technological experience in the area of polytronics and foil processing – especially roll-to-roll manufacturing technology – Fraunhofer EMFT has at its disposal a unique technology platform for the development of flexible electronics.

4.6 Design, Test & System Integration

By means of demonstrators, prototypes and systems, Fraunhofer EMFT scientists are able to illustrate potential application scenarios for the technologies and components developed at the institution. For customers, this development expertise is an essential part of the Fraunhofer EMFT service portfolio: especially SMEs often require complete solutions rather than individual components. In particular, extensive expertise in system development provides an essential basis for translating innovative technologies and solutions (such as energy harvesting and ultra-low power consumption) quickly and successfully into applications to create future-oriented products.

The development expertise of our experienced interdisciplinary team covers IC design, hardware and software, electronics, mechanics, optics and also fluidics with micropumps and microvalves. Extensive experience in test and analysis of electric systems provides for reliability and robustness of the systems developed at Fraunhofer EMFT.

Our services in the area of system development range from drafting initial concepts through to feasibility demonstrators, prototypes and complete systems, depending on needs.

5. Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI

Website Link: http://www.emi.fraunhofer.de/en.html

5.1 Institute Overview

English: The Ernst-Mach-Institut studies high-speed processes in experiment and simulation. We consider them from a physical and engineering perspective and develop solutions for industrial applications.

Our center of interest is on security, resilience, reliability, efficiency and sustainability of structures, components and systems under dynamic and extraordinary loads. We analyze phenomena of crash, impact and shock-waves in materials, microstructures as well as in complex systems.

Our applications range from components and design of structures to whole vehicles and defense technology systems, from buildings and infrastructures, urban systems and networks to satellite systems.

Korean: 프라운호퍼 에른스트마하 연구소(EMI)는 시험 및 시뮬레이션의 고속공정을 연구하며 물리학·공학적인 관점에서 이들 공정을 분석하고 산업 응용 솔루션을 개발하고 있습니다.

주요 연구분야는 동적·이상 하중 조건하의 구조, 부품, 시스템의 보안, 복원력, 안정성, 효율성, 지속가능성으로, 재료, 미세구조, 복잡계의 충돌, 영향, 충격파 현상을 분석합니다.

부품, 구조 설계, 전체 차량, 방위기술시스템, 건물, 인프라, 도시 시스템, 네트워크, 위성시스템 등 다양한 응용기술을 연구하고 있습니다.

5.2 Laboratory acceleration facility

Laboratory acceleration facility for attaining impact velocities ranging from 10 meters per second to 10,000 meters per seconds.

Recording, description Recording and modeling of the physical processes observed during impact, shock-wave and laser effects.

5.3 Visualization techniques

Visualization techniques for transient processes: high-speed photography and high-speed videography, schlieren photography; flash X-ray photography, X-ray tomography and X-ray cinematography.

5.4 High-Speed Measurement Technique

Implementation and development for hig dynamic and transient processes as well as harsh environments; distance, speed, acceleration, impact load and pressure; EMC analyses.

5.5 Diagnostics development

Diagnostics developments such as optical and laser-based techniques intended for temperature and velocitiy of (combustion) gases and high dynamic surfaces (VISAR and PDV).

6. Fraunhofer Institute for Electronic Nano Systems ENAS

Website Link: http://www.enas.fraunhofer.de/en.html

6.1 Institute Overview

English: The growing complexity and miniaturization of innovative products lead to the fact that systems integration will be getting more and more important for the scientific and technical development. Thereby, not only multi functionality but also the implementation of different devices (multi device) consisting of different materials (multi materials) plays an important role. The integration of nano materials as well as printed functionalities causes new challenges and requires new approaches in terms of design, testability and reliability.

The Fraunhofer Institute for Electronic Nano Systems ENAS supports companies to cope this task. Together with the Center for Microtechnologies ZfM of the Technische Universität Chemnitz, the Fraunhofer ENAS offers research and development as well as services in the following main fields:

- Smart Systems Integration
- Micro and Nano Systems
- Reliability
- Printed Functionalities
- Back-End of Line for microelectronics and nanoelectronics
- 3D integration

Korean: 제품의 복잡화·소형화가 이루어지면서 연구개발 분야에서 시스템 집적의 중요성이 더욱 부각되고 있습니다. 이로 인해 다기능성뿐 아니라 각기 다른 재료로 이루어진 다중 기기의 구현도 중요한 역할을 하고 있습니다. 나노소재 및 기능성 인쇄의 적용은 새로운 과제를 제시하며 설계, 시험가능성, 신뢰성 면에서 새로운 접근법을 요구하고 있습니다.

프라운호퍼 나노전자시스템연구소(ENAS)는 켐니츠공과대학(Technische Universität Chemnitz) 마이크로기술센터(ZfM)와 협력하여 다음 분야의 연구개발을 수행하고 있습니다.

- 스마트 시스템 집적
- 마이크로 및 나노시스템
- 신뢰성
- 기능성 인쇄
- 마이크로전자 및 나노전자 백엔드
- 3D 집적

6.2 Micropumps & Integrated Liquid Handling

The transportation of small liquid volumes in miniaturized systems for biological or chemical analyses require pumps which are integratable, inexpensive, and easy to manufacture. Various microfluidic actuators, such as pumps and valves, are being developed at Fraunhofer ENAS and adopted and optimized for different applications.

The actuator's working principle is based on an electrochemical process. Thus, the micropumps and microvalves require little space and allow for high achievable back pressure. They are characterized by simple fabrication processes and the possibility of parallelization (array mode) at almost no additional cost.

Micropumps based on this principle reach typical flow rates between 0.1 and 1µl/s and can work at back pressures of more than 1 bar. Typical dimensions are in the range of (3x3) mm² at a height of 200 µm.

6.3 Temperature Control

The temperature in a microfluidic system needs to be varied for many reasons, such as: hybridization, PCR, isothermal PCR, or lysis of cells. ENAS works on various (low-cost) approaches for localized, integrated heating and temperature control inside microfluidic cartridges. The picture above shows a temperature zone at 65°C for hybridization inside the area of a fluorescence-based biosensor.

6.4 Control Electronics & Communication

For Lab-on-a-Chip Systems, but also other applications, ENAS develops both the necessary control electronics and the software to run these systems. While the miniaturization of the control electronics is steadily on-going, its functionality is increasing. Currently, implemented communication protocols, for example, include Bluetooth, ZigBee, USB, SPI, I²C. It can drive up to 15 pumps and 4 heating elements, can be driven either by other microcontrollers or directly by a specific pump-control software, and has an implemented charging circuitry for portable systems working with rechargeable batteries.

6.5 Power Supply

A first prototype has been developed with an integrated, rechargable battery (providing power for pumps, sensors, electronics and bluetooth communication. Thus, the cartridge can be used autonomeously due to the integrated batteries.

At a later stage, also printed batteries can be used an directly integrated on the cartridge.

6.6 Biosensor Integration

The cartdiges are able to hold different kinds of biosensors. Sensors integrated include a polymer-based optical TIRF sensor, a silicon-based electrochemical sensor and an amperometric/voltametric/conductivity sensor screen-printed on polymer foil.

6.7 Fluidic Actuators for AFC

Fluidic Actuators for active flow control (AFC) became widely used in many fields of science and technology and continues to be the subject of intense experimental and numerical studies in a number of research centres.

Actuators that require energy to operate and in turn add energy to the flow are known as Active Flow Control Devices. The classification of these actuators can be done by their function. Examples for such devices are oscillating electro-mechanical and piezoelectric flaps, steady blowing and pulsed blowing, powered resonance tubes, fluidic oscillating jets and plasma actuators. Fluidic actuated flow control for different applications shows high potential and appears attractive due to the small size of the actuator elements.

Fraunhofer ENAS develops various fluidic actuators for active flow control. To achieve high performances, requirements from partners are considered on the one hand and new concepts are developed on the other hand to make the actuators more compact, efficient and capable of being integrated. The development addresses two different streams: Synthetic Jet Actuators (SJA), which do not require any pressurized air and Pulsed Jet Actuators (PJA), which create a pulsed air flow out of pressurized air.

6.8 Mechanical Actuators for AFC

As for mechanical actuators for the active flow control there are embedded mainly piezo-based transducers to realize new concepts of actuators. Those include:

- Smart Leading Edge with integrated Actuators
- Smart Flaps
- Smart Vortex Generators (Smart VGs)

Example: Smart VGs

Fraunhofer ENAS develops concepts for so-called Smart VGs, which means mechanical Vortex generators that could for example be placed on wings. Besides they can be adapted to different stream situations. The activities of this process focus on integration, innovative concepts of drive and the combination of actuators with new and composit-based materials.

Vortex generators (VGs) are well known to delay stall. They are used on swept wings at transsonic speed, on ineffective control surfaces and on short-takeoff and landing aircrafts. But they also have their drawbacks, for example increased drag. To overcome this drawback, an increase of feasibility could be reached by making them adaptable and retractable.

6.9 System Control, Electronics and Software

System Control

Fraunhofer ENAS deals with the evaluation of suitable control hardware and with the definition of control interfaces. This includes the system design where the implementation of control algorithms for the flow control system and the control of each individual actuator is necessary.

Electronics and Software

Beside the development of mechanical and fluidic actuators for Active Flow Control the field of activity of the Fraunhofer ENAS also includes the development of electronics to control and regulate these actuators. In various projects concepts are developed to for example to adjust the electronics to the requirements of aviation, to design appropriate networks, to control different actuators in an optimal way within a limited expense of information and to create closed loops for new applications such as AFC Closes Loop Control.

6.10 System Integration

It is necessary to carry out a permanent or at least regular monitoring for the various fluidic actuator concepts. This can be done to control the actuators, to adapt to changes of the conditions or to check the actuators regarding their functionality. For this purpose it may be necessary to embed various sensors in structures or to embed the actors themselves. Fraunhofer ENAS analyzes concepts which include the integration of

- Pressure Sensors
- Flow sensors
- Strain Sensors

in order to increase or rather optimize the scope of work of the structure, the component or the actuator. An additional step is the integration of the electronics and the necessary interfaces of communication into systems to indicate the thought of "Smart Systems Integration" also for Active Flow Control.

Fluidic actuators are integrated into panels for a stackable mounting and the panel surface is adaptable to any shape. Actuator-panels are necessary for the mounting of the single actuators or actuator arrays. They are also expandable to a multiple number of nozzles and the surface is also adaptable to any configuration because of their flat design.

6.11 Fluidic Design

Gas fluidic systems can be applied in various fields of application (aviation, cooling of components, etc.). To adapt the design of sensors, actuators and fluidic components to the different applications already in the early stage of development, models are necessary which support this process. Therefore, the Fraunhofer ENAS is using:

- Analytic Models
- Lumped Element Models
- Numerical Simulations.

For instance the Synthetic Jet Actuators have been optimized by means of the so called Combined Simulation (connection of LE modeling and numerical simulation). Appropriate to the several concepts of the actuator-impact, e.g. piezo or electro mechanical, studies for the geometry optimization for SJA's have been realized. The performance is addicted different parameters like the membrane and nozzle diameter, the dimensions of the cavity, the resonant frequency and the reachable deflection of the membrane. The aim of the model development is a tool for the precise calculation of a design, which accomplishes requirements of different applications.

6.12 Integrated Optical Sensors

Spectroscopy has developed to an important and useful analysis method over the past years. The existence of compact, portable devices in the ultraviolet, visible or near infra-red spectral range offers a lot of applications and new possibilities.

Thereby an increased density of integration can be achieved by using solid-based light sources or monolithically integrated detectors. Another aspect of miniaturizing spectral sensors is the enormous cost advantage resulting from a reduced number of components.

We offer the following services:

- Transfer of user-defined performance parameters to design requirements,
- Characterization of relevant optical, electro-optical and electrical properties of single components and assemblies
- Concept, design and optimization of optical sensors using sequential and non-sequential ray-tracing method (Zemax ®) and finite-difference method (FDTD) to refine the significance in the scattering, reflecting or non-linear photonic components,
- Mechanical design and implementation,
- Electronics development (analog, digital),
- Software development,
- Testing and qualification.

6.13 Integration of Autarkic Sensors

Current industrial trends in mechanical engineering and plant manufacturing address engines condition monitoring mainly to minimizing system failures. Appropriate machine elements therefore are seals since they can be found in nearly every machine. At this point, informations such as impermeability, temperature of the sealing lip or wastage of the seal, are important reliability parameters.

Measuring these parameters preventive

- ensures a trouble-free working of the machine,
- and avoids cost-intensive down time or failures.

The implementation of sensors, electronics for signal conditioning, wireless signal transmission (necessary due to rotating parts) and self-sustaining power supply allows an autonomous and efficient operation of those for various applications. Two different approaches of such seals (Simmering® with optical sealing function detection on air side, Radiamatic HTSII with sputtered platinum layer for wastage and temperature control) were developed in a jointly cooperation with Freudenberg Sealing Technologies GmbH & Co. KG, Weinheim and Fraunhofer IZM, Berlin.

6.14 MOEMS Fabry-Pérot Interferometer as tunable IR filter

Tunable infrared filters can be used in many application fields, such as the infrared spectral analysis of gas concentration, the analysis of biogas, the determination of ethanol in breathing gas, hyper spectral imaging or the detection of carbon dioxide in beverages.

The Fraunhofer ENAS jointly developed with the Center for Microtechnologies and InfraTec GmbH Fabry-Pérot interferometers (FPI), which are well suited for these applications. The FPIs are based on stacked quarter-wavelength reflectors deposited on thick silicon carriers. In between the reflectors an optical resonator, the Fabry-Pérot interferometer is formed. A special developed spring support of the movable carriers allows the preparation of very flat and parallel mirrors. As a result a potentially high wavelength resolution and high transmission rate are observed.

The advantages of the developed tunable filters are its high precision, good parallelism of the reflectors, good mechanical stability, as well as the typical micro system features small size and light weight.

6.15 Meta materials for optical applications

The application of sub-wavelength structured thin film materials in MOEMS opens the way towards devices with enhanced performance and may replace special materials, those are not compatible to most MEMS technology sequences. It has been shown by a research group of ENAS that replacement of the reflection layer stacks by sub-wavelength structures, which form the cavity of Fabry-Pèrot-Interferometers (FPI) have the potential to yield in infrared pass band filters with high transmittance. Periodically arranged metal ring resonators are investigated regarding reflectivity and sensitivity with respect to polarization angle by Finite Difference Time Domain Method (FDTD) analysis. E beam lithography is used for the fabrication of arrays of ring resonators made from aluminum on silicon nitride thin film substrate. The wavelength depending reflection coefficient for random polarization and for linear polarization in different directions is measured by Fourier Transform Infrared Spectrometer and compare well to the results from theoretical analysis. Current numerical analysis and practical experiments show that with appropriate design ring resonator arrays achieve broadband reflectivity >95% without directional dependence on polarization. On FPI-Etalons consisting of two ring resonator arrays forming a cavity numerical FDTD analysis and measurements successfully demonstrated the correctness of the physical approach, paving the way for further investigations.

6.16 Humidity Sensors

On the basis of composite materials, novel capacitive humidity sensors are developed and manufactured in collaboration with the Fraunhofer Institute for Applied Polymer Research (IAP) and the companies Chemnitzer Werkstoffmechanik GmbH (CWM) and Gesellschaft für Mikroelektronikanwendung Chemnitz mbH (GEMAC). Sensors have been realized with different layouts on printed circuit boards and glass substrates. The nominal capacity is in the range of 200 to 500 pF, depending on the layout.

The humidity-sensitive dielectric of the sensor consists of ceramic particles embedded in a polymer matrix. Because of special preparation techniques, the particles are in good contact to the environment, despite the matrix.

The composite humidity sensors reveal a very high sensitivity of up to 4.5 pF / % r. h. and response times of less than 20 seconds.

With the humidity-sensitive composites, almost any sensor design is creatable - flexible substrates and curved and uneven surfaces are not an obstacle. With different coating technologies, e.g. screen printing, we are able to produce scalable large-area sensor arrays to determine humidity distributions quickly and reliably.

6.17 Magnetic Force / Position Sensors

Key feature of the in cooperation with the Fraunhofer Institute for Applied Polymer Research (IAP) developed measuring systems are magnetically sensitive particles, which were incorporated into polymer matrices. Sensors with different composite layers and designs have been produced. Advantage over selective sensors such as Hall sensors, is an easily scalable universal sensor design. Systems for spatially resolved measurements in the range of a few millimeters to several tens of centimeters can be implemented on any surface.

6.18 Quantum Dot Based Systems

n the framework of the nano system integration network of excellence “Nanett” (www.nanett.org) at Fraunhofer ENAS we deal intensively with the use of semiconductor nanocrystals (e.g. CdSe / ZnS particles) for material-integrated sensors. Here quantum dots are used for detection, storage and optical visualization of mechanical (over-) loads, for example at reinforced lightweight components.

Key feature of our concept for material-integrated sensor technology is a double layer consisting of a piezoelectric layer and a semiconductor nanocrystal polymer composite film. The mechanical structure, which has to be monitored, will be covered with this double layer. Application of a mechanical load to the structure leads to an accumulation of charges within the electrodes of the piezoelectric layer. The charges are then transferred to the composite film by charge transport layers and injected into the nanocrystals, causing non-radiative exciton recombination. This results in photoluminescence quenching, which can be detected as local optical contrast. The ‘dark state’ is as long as the additional delocalized charge is stored within the particle. Hence the load state, e. g. an impact, can be stored in the functional layer and can be read later, for example during a safety inspection of the mechanical structure.

6.19 RF-MEMS

Electrostatic actuated Ohmic switches in series SPST configuration for DC up to 4 GHz signal frequency (<0.5 dB insertion los, 35 dB isolation) and in shunt switch SPST configuration for a frequency range from RF up to 75 GHz (<1.2 dB insertion los, 20 dB isolation) were developed. A novel high aspect ratio MEMS fabrication sequence in combination with wafer level packaging is applied for fabrication of the samples and allows for a relatively large actuation electrode area, and for high actuation force resulting in fast on-response time of 10 µs and off-response time of 6 µs at less than 5 Volt actuation voltage.

Large actuation electrode area and a particular design feature for electrode over travel and dynamic contact separation lead to high contact force in the closed state and to high force for contact separation to overcome sticking. The switch contacts are consisting of noble metal, and are made in one of the latest process steps which prevents contamination of the contact surfaces by fabrication sequence residuals. A life time of 10e9 switch cycles has been achieved. The switch devices are hermetically sealed by wafer level packaging. A defined vacuum pressure leads to optimized response time and no contact ringing. It was shown by a long term life time test that the electrostatic drive system is free of charging.

6.20 Electronics Design for Smart Systems

Electronics Design

Electronics play a crucial role for the operation of sensors and actuators. Only the concerted interplay makes the individual elements contribute to an overall optimal functioning system. For this reason, a careful development in the areas of hardware and software is essential.

Therefore, the main points of the electronics development lie in the areas

- analog and digital circuits and mixed signal,
- PCB layout,
- software programming.

6.21 MEMS Active Probe for Wafer and Chip Level Characterization of MEMS

The fabrication of MEMS with batch processing calls for a challenging characterization of the MEMS, especially in the case of a 100-percent testing. For the functional test of many of micromechanical structures it is necessary to measure the mechanical motion. A capacitance-change to voltage conversion is a cheap and commonly used method. To achieve an optimal signal to noise ratio, it is desired to have the conversion as close as possible to the MEMS.

The presented “MEMS Active Probe” has been developed and built for exactly this case of application. It allows the measurement of the motion of micromechanical elements. The “MEMS Active Probe” covers the frequency range up to 200 kHz (3 dB) with a sensitivity of 90 mV/nA. The output impedance is matched to 50 Ohm to be directly used with a spectrum analyzer. The bracket can be used with common positioners. The probe is used for dynamic measurement of very low currents (pA to nA)

6.22 Reliability of micro and nano components and microsystems (MEMS/NEMS)

The group "Reliability of micro and nano systems" has a longstanding experience in studies on reliability in micro system technology by both simulation (FEM) and thermo-mechanical experiments. The combination of numerical simulation with experimental methods has become one focus of the Micro Materials Centers research activities

First, joint projects with partners of the industry and scientific facilities with regard to reliability of advanced products and technologies are the main focus. Besides of electronic components and micro systems with respect to packaging issues, a wide variety of problems concerning most difficult stress problems from macro to micro and nano is analyzed.

Second, direct co-operation with industrial enterprises enables support with respect to thermal and/or mechanical design of components, to failure analysis and to improve the reliability properties of the analyzed products.

Numerical simulation base on simulation tools like ANSYS or ABAQUS and are accompanied by suitable experimental analytical tools, e.g. SAM, SEM, LSM, Thermoire, FIB, or X-ray tomography, which are the main topics of the group "Characterization of Micro and Nano Systems".

Broad experience exists in simulations considering size or microstructural dependent nonlinear thermo-mechanical properties which are essential in microscopic dimensions. Additionally, the analyses on irregularities like flaws, cracks, and delaminations have been in the focus for many years.

Theoretical modelling is combined with experimental deformation measurements by means of micro DAC and related methods and metallographic analyses. This results into a well-established failure analysis, the prediction of lifetime and optimization of micro systems from a mechanical reliability standpoint.

6.23 Micro and nanosecurity

Advanced sensorics have already been playing an important role in modern safety technologies, advancing miniaturization and system integration mean further progress. However, the interdependence of Security-Safety-Reliability (i.e. the close links between targeted security, safety of the technology and reliability of the overall system) should be paid a lot more attention: Guarding against the terrorist exploitation of existing gaps in security systems must be given the same priority as hidden partial system failure. In this area, the group acts in concert with enterprises and end-users.

In a second topic, methods of advanced digital image correlation (DIC) are adapted to and refined for security applications. In principle, they enable the mostly ed“ detection of deviations that means „suspicious“ changes, like falsifications, looming risky situations, or system malfunctions, at critical structures and areas.

6.24 Reliability of clean technologies

Clean Technologies mark an emerging philosophy in engineering development.

Its vision is to combine green technologies with high technologies. This way, Clean Technologies constitute the (electrical) engineering response to the global challenges.

The fields of CleanTech Applications comprise the transportation (naval and automotive electronics, avionics), communication, and information technologies, health care and wellness, energy generation and distribution as well as safety and security solutions.

The mission of the group Reliability of Clean Technologies is to deliver precise assessments of the fabrication and reliability risks to the development process of those innovative solutions in electronics, micro and nano systems technologies, which are committed to increase the resource efficiency, the global benefit, and the safety of the engineering solutions yet showing highest functional performance and profitability in fabrication.

The group Reliability of Clean Technologies utilizes numerical simulation methodologies to assess structural, thermal, thermo-mechanical and fluidic effects (including fluid-structural interactions). The finite element method (FEM) is applied based on commercial codes (ABAQUS, ANSYS, Workbench) in combination with state-of-the-art DoE and optimization techniques. The studies and investigations are carried out in close interaction to process development, material characterization, and reliability testing within Micro Materials Center, neighboring Fraunhofer groups, at TU Chemnitz and other universities, as well as at our industrial partners (SME … large scale industry).

This approach provides for very precise, i.e., quantitatively case-matching, geometric, material, and load models. They are needed for accurate parameter identifications, sensitivity and robustness analyses, response surface assessments, as well as for the optimization of design, material, and process with respect of the effects listed before.

The group's target is to perform risk assessments regarding functionality, manufacturability, and reliability of new technologies and products as basis for design guidelines. Fully parametric models have already been developed or under development for automated quantitative lifetime estimation of systems and their components under thermo-mechanical and mechanical loads. By means of this virtual prototyping approach, the experimental effort can directly be reduced by 50% and more without losing any information since the prediction accuracy of the simulation tools is in the range of experimental scatter.

The group is involved in Research Project activities of the European Joint Technology Initiatives (JTI) Clean Sky and ENIAC, contributes to joint projects funded by Deutsche Forschungsgemeinschaft (DFG) and the German Government as well as is in direct co-operation with a number of industrial partners.

6.25 Inkjet Technology (FUJIFILM-Dimatix DMP 3000)

The piezoelectric inkjet printing system from Fujifilm Dimatix acts as the interface between laboratory testing and industrial production. The basic features of the system which it shares with the DMP 2831 are enhanced so that inks can be optimized on industrial scale and complex print patterns can be generated.

6.26 Hybrid printing systems microFLEX

The web-fed press microFLEX built by 3D-Micromac AG is a modular system for the integration of several printing techniques as well as post press processes for the application of different materials on flexible substrates. The modular design allows the combination of conventional and digital printing techniques such as gravure and inkjet into one printing system. This hybrid-system not only incorporates the advantages of different printing techniques but with the integration of laser systems also the possibility of a direct post processing of the printed layers.

6.27 Hybrid printing systemsLaborMANgravure

The roll-to-roll laboratory printing system by manroland is equipped with a gravure unit, a web cleaning unit, a corona, two drying units (each 10 m drying length) and a optical quality control unit. Additionally a inkjet head XAAR 1001 is integrated. Different processing tests can be performed up to 2,5 m/s with a variety of flexible substrates and inks.

6.28 Gravure printing test station IGT G 1-5

The gravure printing test station IGT G 1-5 is suitable for tests of printability of substrates and inks. The easy handling of the device enables the determination of different processing parameters within a very short time and without great effort. With up to 1.0 m/s and a printing force of maximum 1000 N substrate with up to 4 mm thickness can be printed. The maximum printing width is to be 50 mm and the maximum printing length is to be 140 mm.

6.29 Airgap Technologies

Low-k and even low-k (ULK) dielectric materials have been successfully developed with respect to their electrical properties. Numerous CVD or spin-on materials are available fulfilling the required permittivities. The integration of these materials in interconnect technology caused various challenges associated to process compatibility (sidewall damage, interface to barrier materials, pore sealing), thermal properties, mechanical (CMP, packaging) and chemical stability. Therefore the ITRS roadmap targets for interlevel metal insulator k-values (bulk/effective) have been softened annually. Airgap technologies, using air (k=1), as interlevel dielectrics, seem to be potential candidates for lowering the interlevel effective k-value and a simultaneous avoidance of integration issues, known especially from porous low-k materials. The different strategies for airgap formation, known from literature, can be allocated in two general techniques – void formation via non-conformal PECVD deposition and usage of sacrificial layers between metal lines.

In collaboration with TU Chemnitz two similar airgap technologies were developed. Both approaches, called “mask” and “spacer” approach are sacrificial layer methods and use sacrificial PECVD SiOx which is removed lateron by buffered HF wet etching. Controlled by additional patterned hard masks, they offer the opportunity of well defined etch attack, ensuring adequate mechanical and thermal properties. This is an appropriate basis for an application to multilevel metallization (especially successful CMP treatment) and sufficient reliability.

Structures of both approaches were characterized in terms of electrical, thermal and mechanical behaviour.

6.30 Carbon Nanotubes (CNT)

Carbon Nanotubes for Interconnect and Sensor Applications

Since the discovery of Carbon Nanotubes (CNT) in the year 1991 big efforts were made to profit of their outstanding structural, electronic and mechanical properties in various applications. For electronic applications the capability of carrying extreme current densities, the insensitivity to electro-migration, and the excellent thermal conductance protrude. This makes CNTs an ideal candidate as an via-material in future interconnect systems of IC-devices which is our major interest. Beyond that we are working on the implementation of CNTs as basic elements in NEMS and as sensors with high sensitivity and selectivity. The aim of our work is to achieve selective growth of high quality and dense CNT films at temperatures lower than 450°C. Furthermore good electrical contacts at the CNT-metal interface and the alignment of MWNTs as well as SWNTs are essential for our purposes. For the integration of CNTs we follow two approaches:

(1) Chemical vapour deposition (CVD) is applied for direct growth of CNTs on substrates. For this we use a special high temperature horizontal CVD reactor (Fig. 1) for processing samples up to 4” in diameter. Optionally we can apply an electric field during the process to align CNT-growth. For growth of CNTs we use single metallic catalysts (e.g. Ni) as well as bimetallic catalysts and ethylene or acethylene diluted in N2/H2 as reaction gases. The predominant aim is to grow vertical and densely packed CNT-arrays at low temperatures with acceptable structural integrity.

(2) Dieelectrophoresis (DEP) technique is used as the second approach to selectively deposit and align CNTs. The protruding challenge of this technique is the deposition of high quality single walled CNTs and multi walled CNTs at low temperatures which is key factor for integration of CNTs in temperature sensitive systems. Our aim is the horizontal deposition of CNTs from a mild dispersion with a high alignment degree and with only few residuals after deposition.

Selected results

In the CVD process we are investigating the influence of process parameters like substrate, catalyst, temperature, and gas composition. We are able to grow multi walled carbon nanotubes (MWCNTs) in dense films at temperatures ranging from 450°C to 700°C. REM and TEM observations revealed MWCNTs with controllable diameters in the range from 10 to 20 nm. Raman measurements were applied to study the effect of process conditions on the quality of the CNTs and revealed that MWCNTs with a relatively small defect density can be obtained. Furthermore with the preparation of an single damascene architectures with a Cu metallization and a TiN barrier, selective growth of CNTs was achieved (Fig. 2).

In the DEP-experiments we are trying to get debundled CNTs placed between electrodes. For this we have tried CNT-dispersions with different CNT-material and different dispersing agents. In this way we have achieved dense alignment of SWNTs on electrode structures (Fig. 3).

6.31 Atomic Layer Deposition (ALD) and Targeted Application Areas

Atomic Layer Deposition (ALD) has been an active area of research and development at Fraunhofer ENAS together with the Center for Microtechnologies at TU Chemnitz since 2006. Starting with processes for copper oxide and copper, further materials are continuously implemented for a variety of application areas.

Available Equipments

- 100 mm single-wafer tool with two BRONKHORST liquid delivery systems and two home-built bubblers
- MicroSystems 200 mm multi-chamber tool with two ALD chambers currently under ramp-up. Each ALD chamber is each equipped with:
- Two KEMSTREAM direct liquid injection systems
- Two BRONKHORST liquid delivery systems
- Variety of special gases
- Possibility of thermal and remote plasma ALD

The MicroSystems 200 mm cluster system further includes in-situ XPS and Raman spectroscopy for direct analysis of the samples without vacuum break. Furthermore, a CVD chamber for carbon nanotubes (CNTs) and a chamber for ion-beam sputtering/etching to deposit standared metal films are available on the tool. All chambers, including the analytics, are fully 200 mm capable

ALD Materials and Application Areas

1. Metals

Copper

- Seed layers for metallization of nanoelectronic interconnect systems and trough-silicon vias (TSVs) in 3D integration
- Functionalization of CNTs and CNT integration in metallization systems

Nickel

- Liner for interconnect systems
- Seed layers for TSV metallization
- Functional films in magnetic/spintronic film systems
- Functionalization and metallization of CNTs

2. Metal Oxides

Copper Oxide

- Intermediate stage for ALD of copper
- Functionalization of CNTs, e.g. for sensors

Nickel Oxide

- Intermediate stage for ALD of nickel
- Functional films in magnetic/spintronic film systems
- Functionalization of CNTs, e.g. for sensors

Aluminum Oxide

- Passivation layer, e.g. for MEMS, electronic devices, solar cells
- Dielectric with high permittivity, e.g. for storage/memory applications
- CNT functionalization

3. Metal Nitrides / Carbonitrides

Titanium(carbo)nitride and Tantalum(carbo)nitride

- Diffusion barriers against copper diffusion in nanoelectronic interconnect systems and TSVs for 3D integration
- Electrode material in conjunction with high-k oxides
- Hard coatings / abrasion protection for MEMS

At least one of these two nitride / carbonitride materials will be implemented at the MicroSystems 200 mm cluster system.

6.32 Interconnects for Micro and Nanoelectronics

Materials Research, Process Development and Integration for Micro and Nanoelectronics

In a nutshell

Increasing performance of electronic components, continuous downscaling towards nanometer features along with entirely new device concepts are calling for advanced materials and elaborate manufacturing processes.

The Department Back-End of Line is collaborating with the Center for Microtechnologies at Chemnitz University of Technology. Together we deliver solutions for materials and processes, as well as their integration for micro- and nanoelectronics. Among others the work concentrates on technologies such as Atomic Layer Deposition (ALD), Airgap approaches for Cu damascene metallization, and CVD of Carbon Nanotubes (CNT) for applications in interconnect systems of ICs.

Airgaps

- Airgaps as ultra low-k dielectric
- Use of sacrificial layers to generate airgaps
- Well balanced electrical, thermal and mechanical behaviour
- Individual process and technology optimization

Copper damascene metallization with low-k dielectrics

- ALD of Cu seed layers for electrochemical Cu deposition
- Ultra-thin diffusion barriers
- Cu MOCVD for IC metallization and 3D integration
- Integration of ultra low-k materials
- Cleaning methods in using of low-k and ultra-low-k materials in the technology of 45 nm and below
- Optimization of etch processes via in situ diagnostics, e.g. to minimize sidewall damages in using of porous ultra-low-k dielectrics
- Chemical mechanical polishing (CMP)
- Process and equipment simulation of PVD, CVD and CMP processes

Carbon nanotube based interconnects

- CNTs as via and contact material in ICs
- Preparation of multi-wall nanotubes on mono- and bimetallic catalysts
- Characterization with SEM, TEM, Raman spectroscopy and XPS

6.33 3D Integration

3D Integration is of major interest for several applications in fields of microelectronics and MEMS technology. Hereby chips are stacked vertically to minimize electrical path lengths and thus enhance the electrical and thermal performance as well as to minimize the chip size. On the other hand, 3D Integration provides the opportunity to integrate electronic devices of different functions and technologies, e.g. MEMS electronic devices of corresponding activation and evaluation electronics. The fabrication technology comprises processes such as wafer thinning, Through-Silicon-Via (TSV) drilling/etching, TSV filling and wafer bonding.

Research and Development Topics

We have been working in the field of 3D Integration for several years with focus on the development of TSV etching processes and TSV metallization. For the full process chain Fraunhofer ENAS is collaborating closely with Fraunhofer IZM Berlin, IZM-ASSID Dresden and EMFT Munich.

TSV Etching

The geometry of TSV's has large impact on the subsequent filling with conductive materials. We are developing etch processes for optimized via profiles such as tapered openings.

- Aspect ratios up to 9
- Smallest TSVs: 3x10 µm² with depths up to 70 µm
- Tapered via opening with 86° top to sidewall angle

TSV Metallization

The metallization scheme is the following:

- MOCVD TiN
- Deposition of adhesion layer (TiN based)
- In situ MOCVD Cu (CupraSelect ™)

TSV's with diameters smaller than 3 µm can be completely filled with Copper CVD. For larger TSV diameters Cu-MOCVD is used to deposit seed layers for Cu-Electroplating. The results of all deposition processes are strongly influenced by the geometry and depth of the TSV's and structure density. The processes should be optimized for each TSV layout for best compromise in deposition rate and step coverage.

Equipment

- AMAT PRECISION 5000 CVD-Tool for barrier and Cu-CVD
- Applied Materials P5000 DCVD (PECVD SiO2, SiN, SiC:H, SiCN:H, PE-TEOS, TEOS/Ozone)
- STS DRIE etching tool
- AMAT Mirra for barrier and Cu CMP
- IPEC472 for Si- and SiO2-CMP

6.34 Simulation of Devices, Processes and Equipment

The department Back-End of Line has many years of experience in simulation and modeling of processes and equipment for the semiconductor industry.

As the development of new technologies requires new or optimized processes and equipment, advanced models and simulation tools are specifically designed for PVD, CVD, ALD as well as CMP. They support the development of improved deposition and polishing techniques by optimization of process conditions, tool configuration, and feature topography.

The simulation of PVD processes has been extensively applied to study the formation of ultra-thin metal layers as diffusion barriers for adjoining copper interconnects, as contact layers, or as seed layers for subsequent deposition steps. PVD simulations are able to cover all important aspects of the deposition such as rate, conformity, composition, or energy deposition even for the demanding conditions within small vias or trenches. CVD simulation applies hydrodynamic methods at the reactor scale and ballistic methods at the feature scale. In addition to optimum deposition rates, the uniformity of film thickness and doping across large wafers and batch sizes, as well as conformal film deposition in deep trenches and vias are predicted and optimized.

An emerging field is the device simulation which becomes more and more important for understanding device behavior and optimizing device performance. Using adequate models, the increase of transistor performance induced by stressor films prior to metallization can be predicted. Device simulations are also applied to model the electrical as well as the heat transport within nanoscale interconnects. Besides microelectronics applications, device simulations are also applied to study the influence of novel solar cell concepts on cell efficiency.

Simulation and modeling of the electrical reliability is another key issue on the way to a comprehensive description of the interconnect system. Biased temperature stress (BTS) data from inter-metal dielectrics can be analyzed and compared with various available models in order to investigate the electrical failure mechanisms.

For future nanoelectronic and NEMS devices, modeling of materials properties at the nanoscale is becoming more and more important. Therefore, a new research area is the ab-initio simulation and modeling of transport properties of nanostructures, such as nanoscale Cu interconnects and carbon nanotubes. Furthermore, quantum chemical modeling and simulation supports the development of metal ALD processes.

Simulated conductivity and current density within a nanoscaled interconnect structure with a given grain size distribution of copper.

6.35 Materials and Metallization for NEMS

Materials and methods for interconnect systems in nano-electromechanical systems (NEMS) is an emerging topic at the ENAS department Back-End of Line. Because carbon nanotubes (CNT), due to their unique properties, appear of particular interest for NEMS based sensors and actuators, current work concentrates on contact formation between metal electrodes and CNTs. In this respect, methods such as dielectrophoresis for the controlled lateral deposition of carbon nanotubes as well as atomic layer deposition (ALD) for three-dimensional functionalization and metallization of CNTs are studied.

6.36 Wafer-to-Wafer Bonding

The term wafer bonding describes all techniques for the permanent or temporary joining of two or more wafers with and without intermediate layer. In department System Packaging, besides traditional permanent waferbonding methods such as silicon direct bonding, anodic bonding, glass frit bonding and adhesive bonding, also metallic bonding techniques like eutectic bonding are available.

These techniques are applied to the packaging of sensor and actuator components, fabrication of RF substrate materials as well as wafer level integration of electrical, micro mechanical or optical components. The techniques are optimized continuously regarding their process parameter (e.g. temperature), yield and bonding strength. Further approaches for technological developments are given by an increasing diversity of materials in micro systems technology. Especially plastics, metals and ceramics are in the research focus to include aspects such as temperature, chemical resistance or low cost fabrication in the product development.

For instance thermocompression bonding, solid-liquid interdiffusion bonding (SLID) or bonding by reactive nanoscale multi-layer systems are investigated as metallic joining technologies. For other bonding techniques the pretreatment by special processes like plasma activation or chemical-mechanical polishing are of interest. Besides wet chemical wafer pretreatment, chemical reactive plasma discharge is able to increase the bonding strength of direct bonded material composites (plasma activated bonding).

6.37 Chip-to-Wafer and Chip-to-Chip Bonding

Functional blocks are usually integrated two-dimensionally in a package or mounted on circuit boards. With the help of the third dimension, those functional blocks can be stacked vertically, whereby each block sets up a separate level. Each level is contacted by vertical interconnections. By using 3D-Integration, the shape factor (the dimension in X- and Y-direction) of the system is reduced. The dimension in Z-direction typically remains negligibly small. Stacking can be done by wafer-to-wafer, chip-to-wafer or chip-to-chip level.

Currently applied packaging concepts on chip-to-chip or chip-to-wafer level are integrated in commercial products like smartphones, cameras or notebooks. Increasing requirements by manufacturers of electronic systems demand for ideal combinations of functionality, performance, reliability and price. Also the geometrical dimensions of the systems play an important role.

6.38 3D Integration - Mechanical and electrical connections

For system integration different approaches like System-on-Chip (SoC), System-in-Package (SiP) or System-on-Package (SoP) have been developed. Novel SiP approaches also utilize the third dimension which results in complex system architectures. In this respect, the 3D integration with through-silicon vias (TSV) or through-glass vias (TGV) is one of the most promising approaches. However, 3D integration of MEMS with TSV/TGV is challenging because of the large variety of MEMS and their different fabrication technologies, materials and customer-specific packaging methods. Matters are complicated further by the different requirements regarding the interaction with the sensor environment (e.g. openings for the pressure in pressure sensors or hermetic sealing in case of acceleration sensors). Thus, advanced techniques of 3D integration cannot be simply transferred to MEMS. Solutions for MEMS integration are rather developed specifically for different conditions. The process of 3D MEMS integration basically consists of four steps:

- Formation of vias and isolation
- Via metallization
- Wafer thinning and planarization
- Wafer and/or chip bonding

These process steps can be arranged in different sequences to realize various process flows.

6.39 Carriers, interposers and flexible substrates

For smart systems integration and More-than-Moore technologies the implementation of several components is necessary for reaching a higher functionality and smaller system dimensions. Therefore special substrates, e. g. flexible ones or even interposer made from Silicon, Glass, and Ceramics could be used for mounting and connecting sensors, actuators, and electronics as chips or chip-sized-packages.

Within 3D integration for smart systems Silicon and Glass interposer are of increasing importance. One main reason is the possibility to adapt different design and technology rules from microelectronics and MEMS processes. With interposers a redistribution of interconnects could be realized and at least a chip sized package (CSP) with different components is enabled.

6.40 Wafer thinning and thin wafer handling

In the last decade the reduction of the device thickness plays an important role. This thickness minimization required the thin wafer handling. With thicknesses less than 50 µm the wafer becomes flexible and facilitate new applications e.g. the fabrication of through substrate vias (Through-Silicon Vias, TSV). The mechanical stabilization such ultra thin wafers require new temporary waferbonding and debonding technologies. The system packaging department focused on an adhesive temporary waferbonding technology to remove the device from the carrier wafer in a room temperature peel off debonding process after wafer thinning.

The complete process flow consists of an adhesive waferbonding process of carrier to device wafer (temporary waferbonding). The special carrier stabilized the device wafer during the wafer thinning. Afterwards the device will be rough (200...300 µm/min) and fine (1...10 µm/min) back grinded with high velocity. The rough and fine grinding generate defects in the material, reduce the mechanical stability and leads to wafer bending. After grinding the surface roughness is less than 20 nm. The damaged layer required a wet chemical or plasma dry etching process to reduce the defects and increase the mechanical stability. The modified surface roughness after etching is less than 10 nm and can minimized up to 1 nm with chemical mechanical polishing. Finally the carrier wafer will be removed with special thin wafer handling methods to avoid the cracking of the thin wafer (debonding).

6.41 Design of Electrical and Multi-Physical Systems

The spectrum of tasks during the development of complex micro and nanoelectronic systems encompasses all relevant areas of system design, starting from the chip, through packages and modules right up to the PCB. A major focus of this work lies on the characterization of complex electronic systems by modeling, simulation and measurement of parasitic electromagnetic effects. For this purpose the department ASE employs several commercial simulation tools, such as CST Studio Suite and Agilent ADS, as well as highly sophisticated measurement instruments that allow for the analysis of a large diversity of parasitic effects. The combination of these disciplines allows to characterize and analyze new technologies like e.g. wireless power and data transfer, 3D molded interconnect devices (3D-MID) and sensor systems even before manufacturing prototypes.

Since with increasing levels of complexity of systems to be simulated the time costs and therefore the overall costs increase, an efficient and precise modeling that enables significant reductions in calculation time is needed. Thus, techniques are analyzed in order to find the transmission behavior of very diverse structures that best approximate the time and frequency domain behavior. For nonlinear systems this is achieved by using neuronal networks. By employing specific methods to identify parameters and systems, the input and output behavior of complex systems can thereby be approximately described. For the class of nonlinear systems new concepts, methods and algorithms are being researched and developed as well as automated design concepts (i.e. hardware / software co-design) that are linked with commercial software products are being created.

A further key research area, the department ASE is focused on, is the analysis and advancement of accurate and very time and computer resource efficient event-driven simulation models for mixed-signal systems. An example for such a system is the phaselocked loop (PLL). It is required in applications ranging from modulation and demodulation, clock and data recovery up to the synchronization and frequency synthesis. For an optimal and robust design of PLLs an efficient model for the highly nonlinear behavior of such circuits is essential. Hence, non-ideal effects like e.g. dead zone, voltage controlled oscillator characteristic and noise are being incorporated into an event-driven model to optimize the design for a large range of different boundary conditions as well as to increase overall quality of the application.

6.42 Wireless Sensor Systems

Modern industrial systems such as conveyor and production systems, wind turbines or aircrafts, are exposed to high loads and an associated wearout. To avoid failures due to unforeseen defects, a continuous sensory monitoring of such components is crucial. In this context, the engaged sensor systems must generate a digital and failure-free output signal that automatically adapts to the input variables of event space and allows an independent signal optimization by the fusion of different input signals (e.g. temperature, power, speed, acceleration, etc.). The parallel detection of several system parameters and the combination of various sensor signals allow the detection and compensation of defective sensors or faulty information in situ. At the same time, the sensor data should be measured directly on the manufactured work piece or critical moving parts (drives, blades of wind turbines). This limits the use of classically wired sensor systems largely. To overcome the limitations, small sensors that permanently monitor their surroundings and transmit observed data wirelessly form the core of such systems. These sensors usually require a processor, some memory and a wireless sending and receiving unit for the assessment and the transmission.

In order to allow a sensor to run autarkic it needs an integrated energy supply. Most easily a battery can be applied. However, for employing sensors without a time limitation and without the need of maintenance, an energy-harvesting concept that uses external energy from sources as sunlight, warmth, vibrations, movement or even a wireless energy supply has to be implemented. Especially in the field of energy supply of such systems the ASE has many years of experience in the development and deployment of intelligent RFID systems and the inductive energy transfer under harsh industrial conditions collected in a large number of funded and industrial projects. This knowledge base on highly efficient modeling and analysis methods for the characterization of high frequency electromagnetic systems, takes hard EMC conditions among others into account. Our department is researching the realization and integration of complete sensor systems that incorporate existing methodologies and technologies from the fields of sensor technology, wireless data and energy transmission, as well as energy harvesting. The highest demands are made regarding complete systems in respect to energy efficiency, flexibility and overall size. They are also required to be multifunctional and cost-effective. In order to be able to efficiently dimension, optimize and read a new sensor, it is necessary to adapt or re-design the assessing electronics, the energy supply and the transmission of data for every individual application situation. Therefore it is the goal of the research and development conducted by the department ASE to provide innovative, customer-orientated solutions for the optimization of existing methods and techniques.

6.43 Wireless Energy Supply

When considering the area of wireless communications, many different interfaces has been established, supporting the global strategy of Internet of Things. Recent issues of electronic devices show a growing need of wireless energy supply for portable devices and intelligent systems with embedded sensors and actuators. The energy supply system of current mobile equipment used in medicines (like implants), industrial production environments or consumer electronics (like smartphones) based on a cabled energy supply or chemical energy storage (like batteries) has to be maintained and regularly replaced or recharged. Thus, the most important advantage of a wireless energy transmission system is related to the spatial positioning freedom it offers, avoiding complicated chunky cabling and galvanic contacts. A further advantage of a contactless energy system is given by the possibility of encapsulating hermetically the systems, isolating them from unwanted external impacts (like dust, humidity, heat, etc.).

In order to supply a device wirelessly with energy, several feasible methods exit and rely on different physical concepts. In the case of a near-field transmission, the inductive and the capacitive couplings are recommended. For higher ranges, the energy transmission can take place using electromagnetic propagating waves. By considering the classical inductive coupling technology, coils and ferromagnetic materials are used in order to guide the magnetic field from the transmitter to the receiver. Such designs operating in low frequencies typically lead to bulky and heavy structures which restrict their integration within surfaces or limited volumes. A space-saving integration is achieved by using higher frequencies which allow the use of conventional printed circuit boards for the antenna design. At the same time, these higher frequencies offer the possibility of optimized efficiency combined with higher transmitted energy to be transmitted. Typical point-to-point RFID-based energy transmission systems (RFID or other systems) operate with frequencies ranging from 70 kHz up to 30 MHz. With such techniques, the transmittable energy is in the magnitude of 100 mW up to 100 W with an efficiency comparable to the charging and discharging cycle of accumulator systems.

The increase of both efficiency and positioning freedom of wireless energy transmitting systems taking into account the legislative electric smog limits is a top technological issue for the market penetration of wireless transmitting systems. Only an emission-reduced architecture can allow applications in close proximity to human beings or in EMC critical environments. To achieve this, the department ASE has developed an array of juxtaposed and interlaced coils which are controlled separately. By detecting the presence or absence of an authorized receiver, only the transmitting coil in front of a corresponding receiver is activated, increasing the transmission efficiency by minimizing the radiated unwanted fields. Based on this very innovative approach, the department ASE has built up a solid know-how in the area of wireless energy transmission which is offered as technological upgrade service in application domains like medical devices, industrial automatization and consumer electronics.

6.44 Electromagnetic Near-Field Measurement Techniques

The More-Moore and More-than-Moore assembly trend of smart low-power electronic systems make the components become continuously smaller integrating heterogeneous functionalities with smaller switching times and therefore reduced energy consumption. In parallel, the signal-to-noise ratio decreases, making every new generation of a circuit more sensitive. For the developers of electronic circuits this results in increasing electromagnetic compatibility issues. Not only the electronic device itself needs to be protected but progressively each individual component on the printed circuit board must be considered. These boundary conditions require a focus on the parasitic influences during the system design to guarantee a flawless design. By using appropriate EDA tools and simulators, it is possible to analyze a multitude of such parameters in the design phase. However this does not allow for sufficient security, since the ratio between the biggest dimension (PCB) and the smallest structure (bond wire) can differ by several orders of magnitude and leads to extremely complex 3D models. Indeed, the radiating characteristics are directly determined by the switching behavior of the circuit and its geometric structure. Moreover, the internal signal level and the internal signal form of integrated circuits are not known and therefore assumptions have to be made.

Near-field measurement technique provides a mitigation to this problem. They allow the precise detection of weak electric and magnetic fields within a resolution of a hundredth of a millimeter and can be employed for the characterization and discrimination of potential electromagnetic interference (EMI) sources in active systems. This measurement technology has the ability not only to locate EMI sources locally but also spectrally. Thanks to this dual property, it is possible to quickly and directly identify and correct conception faults at early design stages. However, near-field measurement systems need to be adjusted to the specific requirements of EMC compliance measurements. For these adjustments, the department research focuses on the influence of the near-field probe on the field to be analyzed itself and has developed methodologies to compensate this influence.

Such compensation is necessary, since a real probe is not only sensitive to the desired field component (i.e. the normal component of the E-field) but also on other field components such as the tangential E- and H-fields. A central research point of the department ASE related to this issue is the continuous improvement of the mechanical and electronic components of the near-field scanning system.

Beside the application field of EMC, the high and wide-band sensitivity of the developed near-field measurement technology allows the electromagnetic analysis of security-relevant systems such as smart cards, which is a new and promising application area of this advanced measurement system. By using near-field measurement methods it is possible to uncover weaknesses in such systems and elaborate countermeasure strategies.

7. Fraunhofer Institute for Embedded Systems and Communication Technologies ESK

Website Link: http://www.esk.fraunhofer.de/en.html

7.1 Institute Overview

English: Fraunhofer ESK undertakes applied research geared toward new information and communication technology (ICT) processes and methods. The activities focus on designing these increasingly distributed, heterogeneous and networked ICT systems to be more reliable, flexible and resource efficient, thus ensuring that they contribute to improved products and production environments in the automobile and traffic, energy, automation, building and security engineering and telecommunication industries.

Fraunhofer ESK bundles the engineering expertise of five core competencies across the Automotive, Industrial Communication and Telecommunication business units: Wired Transmission Technologies, Wireless Networks, Reliable Ethernet/IP Communication, Adaptive Systems, and Dependable Software.

Korean: 프라운호퍼 임베디드 시스템 및 통신기술 연구소(ESK)는 새로운 정보통신기술(ICT)에 대한 응용연구를 수행하고 있습니다. 점점 분산화되는 이기종 ICT 네트워크 시스템을 보다 안정적이고 유연하고 자원 효율적으로 설계하여 자동차, 교통, 에너지, 자동화, 건물, 보안, 통신 등 각종 부문의 제품 및 생산환경 개선에 기여하고 있습니다. 연구소는 자동차, 산업용 통신, 통신 사업부로 구성되어 있으며, 유선통신기술, 무선네트워크, 고신뢰성 이더넷/IP 통신, 적응형 시스템, 고신뢰성 소프트웨어 등 5 대 핵심기술역량을 보유하고 있습니다.

7.2 Wired Transmission Technologies

Since its inception, Fraunhofer ESK has been actively involved in the optimization of broadband transmission systems running over copper wire circuits. The institute is currently the only commercial provider in Germany with a fully-equipped DSL and access test and measurement lab for analyzing broadband transmissions over twisted-pair copper lines. In addition to DSL, researchers evaluate in-house transmission technologies, particularly data transmission via powerline communication (PLC).

The institute also analyses the effects of high bit rate transmissions on live systems. One example is emission behavior, a characteristic that plays an important role when deploying broadband in specific environments such as buildings and power grids.

Broadband transmission using twisted pair lines and DSL technology

Fraunhofer ESK relies on dynamic spectrum management (DSM) techniques for optimizing wired transmission technologies. One example is utilizing VDSL vectoring to mitigate far-end crosstalk (SELF-FEXT) in VDSL systems. Vectoring can be combined with circuit bonding or with phantom mode, which yields additional transmission capacity that can result in data rates as high as 300 Mbit/s. This group is also evaluating the use of low power mode together with algorithms that improve the stability of individual DSL systems. Using measurements as a basis, the institute developed twisted pair and coaxial cable models and set up a simulation environment with the goal of making broadband transmission more energy efficient. Apart from using simulation platforms for examining wired transmission systems, new technologies such as the G-hn standard are integrated into the lab's test environment and then evaluated under real conditions.

Powerline communication

To address the demand for broadband Internet access in buildings, optimized high bit rate links are gaining popularity. Given its structure and penetration characteristics, powerline communication (PLC) offers a promising alternative. Researchers are evaluating both broadband PLC and narrowband high bit rate PLC. Assessing the viability of broadband PLC requires research into new transmission methods that allow the use of frequency ranges above 30 MHz for data transmission. The goal is to achieve data rates exceeding 100 Gbit/s, which would make powerline communication suitable for multimedia and IPTV applications in multifamily dwellings. Research in the narrowband area is focused on bandwidth efficiency, meaning transmission rates of up to 1 Mbit/s using minimal frequency resources. This transmission technology must be extremely robust in order to support services such as smart metering or demand side management.

7.3 Wireless Networks

The utility of wireless networks has long since moved beyond the telephone and computer and into a wide range of new applications. Concrete examples are networked vehicle environments (Car-to-X Communication) and networked industrial applications such as machine-to-machine (M2M). In many cases, standard technologies cannot be directly deployed. For example, unreliable connectivity is one factor that keeps potential users from utilizing wireless technologies. On the other side of the coin, wireless networks feature characteristics such as flexibility and device mobility that make applications like Car-to-X and industrial sensor networks possible in the first place. This aspect, plus the potential cost savings that result from the reduced installation effort, make wireless systems an attractive alternative.

Wireless data transmission is subject to special physical constraints. In contrast to wired transmission technologies, wireless networks possess specific characteristics such as transmission loss, sensitivity to external emissions and multipath propagation that can cause interference. The environment, whether outdoor or indoor, determines the characteristics of the channel. When designing transmitter and receiver systems and the implementation of the protocol stacks, engineers have to take these characteristics into account.

Cognitive radio in local networks

The growth in wireless traffic necessitates more efficient utilization of the frequency spectrum. At the same time, transmissions must be made more robust by preventing collisions and interference from occurring. Fraunhofer ESK relies on cognitive radio technology to carry out research in this area. Spectrum sensing and channel prediction methods were also evaluated and implemented. Researchers utilize software defined radio (SDR) technology as the underlying platform. This research has yielded several important developments including a wireless test and measurement station for analyzing and monitoring the wireless spectrum, as well as a software component library for cognitive radio.

Wireless sensor actuator networks

In the area of sensor networks, Fraunhofer ESK focuses on reliability, energy-efficiency and realtime-capability. Using its own modular sensor network stack, the institute developed a protocol stack designed especially for applications that require a high level of energy efficiency. An additional highlight of this work is an energy-optimized MAC protocol that works in the 868 MHz and 2.4 GHz ranges. Furthermore, research into robust and scalable routing protocols, as well as sensor network middleware solutions, will be carried out.

Car-to-X Communication

The 5.9 GHz band is reserved for safety relevant applications in Car-to-X Communication, which is carried out in 10 MHz wide channels. Even during heavy traffic periods, the fast and reliable transmission and forwarding of safety-critical information from other networked vehicles is essential. For this reason, Fraunhofer ESK evaluates reliable and realtime-capable communication methods suitable for cooperative traffic safety applications. This includes analyzing heterogeneous wireless transmission technologies, reliable routing protocols, multihop and multichannel communication and mechanisms for controlling distributed congestion. To accelerate the development and testing of these methods, Fraunhofer ESK implemented its own Car-to-X Framework that contains the protocol stack, in addition to the basic services.

7.4 Reliable Ethernet and IP Communication

Although Ethernet and IP technologies are independent of one another, they are often mentioned in the same breath. They benefit from one another and enjoy a near-monopoly in local networks. Because these technologies were originally designed for pure transport, QoS mechanisms for applications such as telephony and multimedia transmission have evolved gradually.

To date, the industry still lacks integrated mechanisms for addressing realtime requirements. Apart from QoS in embedded environments, resource issues such as energy consumption and CPU and memory usage are of major importance. So far, Ethernet and IP technologies and their various implementations have failed to sufficiently solve these issues.

In response to this situation, one-off or special solutions have become well established. Examples include FlexRay and MOST for the automotive industry and EtherCat/ProfiNet for industrial automation applications. These special solutions are usually complex and costly, possess little evolution potential and stand in stark contrast to the desire for cost-effective Ethernet and IP solutions with high bandwidth.

Automotive Ethernet and IP networks

Infotainment and driver assistance systems require a high degree of network connectivity and significant amounts of bandwidth. This was the impetus for evaluating a time synchronization method for transporting media streams via Ethernet based on the IEEE P1588 and P1722 standards. Apart from the implementation of realtime Ethernet, there is ample demand for research into communication and network planning and in the reliable administration of resources.

In particular, practical experience has shown that the testing of time synchronization mechanisms is increasingly difficult. Precise network planning, together with specific tests to determine adherence to the defined behavior patterns, ensures reliable Ethernet communication.

To ensure an adequate degree of reliability and quality regardless of the state of the system, the adaptive resource management approach is implemented at runtime. Research into the management of functional safety and energy management under modified network circumstances has also been lacking. Fraunhofer addresses this demand by carrying out research in the area of adaptive resource management and by developing solutions for autonomous parameterization and system descriptions.

Building communication via Ethernet and IP

Compared to automotive systems, the field of building communication has longer innovation cycles. The development of market-ready technologies in conjunction with industry partners is therefore spread over a longer timeframe. Ten years ago, Fraunhofer ESK developed an approach for representing new and existing building-specific services on a common networking platform. For multifamily dwellings, such platforms have to be set up on a distributed basis, thus creating the need for a realtime, broadband backbone network. At the IP level, the focus is on representing the specific application within the IP protocol environment, be it intercom services or door communication. This requires enhancing protocols such as SIP with several specifications. Together with an industry partner, Fraunhofer ESK designed a complete, IP-based integrated building communication system that has already moved into the product implementation phase.

7.5 Adaptive Systems

Adaptivity improves the resource efficiency and flexibility of software-driven embedded systems. The term adaptivity refers to the extent in which a system is capable of adapting itself to changes in its internal and external environment, resources and requirements. The corresponding control mechanisms must ensure reliability, an essential factor for many embedded systems. Another issue involves the growth of distributed systems, meaning multiple processors that are networked together to provide common services. The key challenge in such distributed environments is making sure the adaptive systems exhibit a high level of coordination, efficiency and consistency, all of which must be guaranteed during the design and analysis phases.

Taking adaptivity into account at the design level requires new concepts for designing distributed services and functions in networked systems. With existing approaches, the features and aspects of the system - also referred to as variability - are specified in the design and cannot be adapted at runtime. Against this backdrop, one of Fraunhofer ESK's research goals is to develop an end-to-end methodology and modeling technique for adaptive systems that features inherent variability and adaptivity and the associated control mechanisms.

At the core of these activities is the design, implementation and evaluation of distributed embedded system concepts.

Adaptive software systems

For this area of research, which centers on networked system adaptivity, Fraunhofer researchers developed several concepts that enable the efficient and reliable reconfiguration of distributed software. The concepts were evaluated with simulation platforms and then demonstrated on automotive electronic control units (ECU). The research activities encompass the development of system and architecture concepts for adaptive systems, as well as the reconfiguration process itself. There are several important aspects to enabling adaptivity through the reconfiguration of software components, one of which entails designing a control structure capable of streamlined and accurate decision making. That means executing reconfigurations only in the right situation and within the time constraints of embedded systems, which are often subject to strict availability and realtime requirements. Reconfiguration also requires ascertaining a valid new configuration and then completing the process by switching to the new configuration without impacting the system.

Adaptive system development

Fraunhofer ESK developed a feature-based methodology and architecture concept that enables the transition to adaptive systems. The goal is modeling of the individual system features and systematic development of a product based on design decisions made during the development process. By modeling the dependencies between the features and the system resources - also referred to as non-functional characteristics - developers have the opportunity to systematically handle potential variabilities at the design and runtime levels.

7.6 Dependable Software

Software is the basis for a wide range of functions in today's networked systems, such as in automobiles or industrial systems. The networking and interaction of these functions is becoming increasingly complex, creating a demand for new approaches to software development and validation. To ensure the reliability of software-intensive embedded systems, developers can use different methods and approaces. One example is the use of model-based methods to create an abstraction, which helps developers deal effectively with these complex network and interaction environments. A key example is executable specification models, which aid in identifying and localizing weaknesses and gaps in the specification during the early phases of development. Such models have already been successfully implemented by Fraunhofer ESK for validating the behavior of vehicle infotainment software functions.

Exploration of the Design Space and Analysis

The development of networked systems requires taking into account not only functional, but non-functional characteristics such as timing behavior and reliability. Through modeling extensions such as MARTE , engineers can specify the non-functional characteristics in UML software components. As part of the CHESS project for instance, researchers examined the automatic generation of an analysis model to validate timing behavior in a simulated environment using Fraunhofer ESK's own ERNEST framework.

In order to develop resource-efficient and thus cost-effective systems, especially in embedded environments, early exploration of the design space is essential. A key factor here is integrating various application-specific methods. Apart from the pure software architecture, the characteristics of the target platform must also be taken into account in the development model.

The Fraunhofer ESK researchers rely on iterative methods that provide repeated feedback from the simulation processes and other analyses. This requires using new solutions for tracing and debugging these complex networked systems. A key element here is feeding the analysis results directly back into the specifications or design models or using this information to improve them.

Improving Reliability through Validation

The use of specific model-based methods can also be advantageous during the integration and validation phase. For validating networked systems, the focus of the researchers is on the communication behavior. By incorporating tracing information into the debugging and analysis, engineers can detect flaws in the early stages of design and improve the reliability of networked embedded systems. This phase encompasses test specification models, specific executable test models and models for the coverage, generation and evaluation of test cases. Fraunhofer ESK carries out research into passive validation models for the automated or semi-automated generation of specification models. These models run parallel to the system or components under test and are designed to identify deviations from or flaws in the specified behavior, using a method that is currently being patented. For critical applications such as those found in the rail industry, formal development methods can be integrated into otherwise semi-formal methods.

Development Tools and Tool Platforms

Fraunhofer ESK is enabling the use of these improved domain-specific test methods in real development environments by integrating them into tool platforms. This is frequently accomplished by creating model transformations, which allow engineers to generate and test different communication interface implementations. Development tools must frequently support the special requirements of networked embedded systems such as when they are required for performance evaluations, testing or debugging

8. Fraunhofer Institute for Organic Electronics Electron Beam and Plasma Technology FEP

Website Link: http://www.fep.fraunhofer.de/en.html

8.1 Institute Overview

English: We focus on developing technologies and processes for surface modification.

Our core technologies are sputtering technology, plasma-activated high-rate deposition, high-rate PECVD, and electron beam technology, which we use to develop surface technology solutions for various industrial tasks.

The deposition of individual layers and multilayer systems and the processing of surfaces are of huge practical importance for many industries. Regardless of whether for machine building, the utilization of solar energy, the packaging industry, biomedical engineering, optics, sensor technology, or electronics: We develop suitable processes and technologies and the associated technological key components.

Feasibility studies, to evaluate surface coating and processing, and pilot production, to facilitate the introduction of new customer products to the marketplace, are also included in our range of services.

The scaling up of technologies to industrial quantities and integration into suitable plant technology and into existing production processes are key services of the Fraunhofer FEP. The cost efficiency of a technology for industrial production is always taken into account.

Korean: 프라운호퍼 유기전자, 전자빔 및 플라즈마 기술 연구소(FEP)는 표면개질 기술 및 공정 개발에 주력하고 있습니다. 주력기술인 스퍼터링(sputtering) 기술, 플라즈마 활성 고속증착, 고속 PECVD, 전자빔 기술을 기반으로 산업 분야별 표면기술 솔루션을 개발하고 있습니다. 단층 및 다층 구조의 적층과 표면처리는 기계 제작, 태양에너지 활용, 포장, 의공학, 광학, 센서기술, 전자 등 각종 산업에 활용되는 실용적인 기술입니다. 연구소는 분야별로 최적화된 공정, 기술, 및 핵심 부품을 개발하고 있습니다. 또한, 표면코팅 및 가공, 파일럿 생산에 대한 타당성 분석을 통해 신제품 출시를 지원하고, 비용 효율성을 고려하여 기술의 양산 적용과 기존 생산공정에의 도입을 지원하고 있습니다.

8.2 Electron beam technology

Generation, shaping and control of the electron beam, its effect on the material and the realization of the necessary process technology, are the key aspects of our work in this core competency. Electron beams are very flexible tools. They can be used for a variety of processes for treating materials. The best known applications are welding, curing, PVD coating using electron beam evaporation as well as sterilization of surfaces and modification of plastics.

In our business unit „electron beam applications“, we open up new fields of application for this technology. Customized development and testing of process engineering solutions right through to their implementation in production allows optimal tailoring of processes to the needs of our customers.

This work includes providing samples of customer-specific work pieces and test samples and carrying out pilot applications of electron beam technologies. As well as process monitoring and quality assurance. The development and realization of plant technology for specific innovative applications also takes into account economic aspects of industrial-scale processes.

8.3 Sputtering technology

We utilize and develop sputtering technologies in order to efficiently deposit layers and multilayer systems in vacuo to large areas.

Sputter processes are particularly suitable for the precise deposition of thin electrical and optical layers on an industrial scale. They allow layers of very accurate thickness, low roughness, and good layer adhesion to be achieved.

The Fraunhofer FEP is specialized in pulse magnetron sputtering (PMS) and the control of reactive sputter processes. A pulsed electrical energy feed in the magnetron gas discharge allows undesired arcing processes to be reduced.

Reactive process management allows considerable expansion of the range of materials that can be deposited. For example, oxides, nitrides, and oxynitrides can be deposited in addition to metals. Using dual magnetron sputtering (DMS) systems, namely the bipolar technology variant, materials with high electrical insulation properties can also be deposited.

The focus of our work in this core area is technology development, adaptation to new applications, and the development of complex integrated process technology and known-how packages.

8.4 Plasma-activated high-rate deposition

Effective vacuum coating requires high coating rates over large areas. However, the way towards higher coating rates, especially for high-rate deposition, is not straightforward, since the fast growing layers feature columnar layer structures.

Even for bond formation during a reactive evaporation process, the energies of the vapor particles are often insufficient for stoichiometric deposition of oxide, nitride or carbide layers. A suitable way of increasing the energy of the particles is plasma activation during the evaporation.

High-power sources for dense plasmas, which allow a high coating rate and the coating of large areas, are required for this purpoose. At Fraunhofer FEP, processes giving high-rate deposition with differently steered arc discharges (SAD and HAD processes) have been developed.

8.5 High-rate PECVD

Plasma-enhanced chemical vapor deposition (PECVD) using microwave or high frequency (HF) plasma is an established process for depositing silicon-based polymer layers for various applications. Vapor-phase monomers enter a reaction chamber and are ionized, excited, or decomposed by a plasma. The fragments then deposit on the substrate surface. Compared to chemically crosslinked polymers, the layers have higher density, greater hardness, and provide a higher barrier effect. The method is especially suitable for coating large surfaces of thermally sensitive materials. For example, permeation barrier layers and optical layers / layer systems can be deposited on plastic films. The layer properties can be relatively easily varied by modifying the plasma excitation and by changing the composition of the process gas.

The Fraunhofer FEP has developed a number of variants of the plasma-enhanced process. The magnetron variant (magPECVD) has the advantage that it gives good layer homogeneity and allows high coating rates on large areas. Also, the process can be readily combined with other coating processes such as magnetron sputtering because it operates at the same process pressure.

arcPECVD gives very dense plasmas, and this allows very high coating rates to be achieved. The process pressure can be varied over a broad range, meaning the process is also compatible with other vacuum coating technologies.

A feature of high frequency PECVD is the even greater range of process pressure. A very wide range of monomers can be used for this technique.

8.6 Technologies for organic electronics

The strength of Fraunhofer FEP is the availability of numerous processes and equipment as well as clean rooms that enable process development and innovation through combination of methods and processes. Fraunhofer FEP can access various coating technologies, as vacuum evaporation of organic and inorganic material, atomic layer deposition (ALD), print and lamination methods as well as laser ablation. A lot of these processes can be carried out or combined without vacuum interruption or under inert conditions.

8.7 IC and system design

Our long-term experience in design of analog, mixed-signal, digital IC provides a basis for the realization of customized solutions. The typical applications follow the slogan more-than-moore, in the integration of additional functions. Therefore the standard CMOS processes is disrupted namely the post-treatment is implemented (deposition of organic emitting or photo diodes). Fraunhofer FEP is fabless and works with various CMOS-foundries. For the post-treatment Fraunhofer FEP can use 200 mm cleanroom.

9. Fraunhofer Institute for High Frequency Physics and Radar Techniques FHR

Website Link: http://www.fhr.fraunhofer.de/en.html

9.1 Institute Overview

English: We develop concepts, methods and systems for electromagnetic sensor technology, particularly radars, implementing modern methods of signal processing and innovative technologies, ranging from microwaves to the lower end of the terahertz band.

In Germany, we have played a pioneering role in the development of new technologies for numerous applications: e.g. space reconnaissance with radar, multi-function radar systems with phased array antennas, adaptive interference suppression, millimeter wave techniques, ultra-high resolution radar imaging, moving target recognition with space-time filtering, target classification and passive radar.

The most valued competencies of Fraunhofer FHR – numerical calculation of electromagnetic fields, high-frequency technology and sensor signal processing – enable the institute to design, develop and implement complex high-frequency systems, executing each step in-house. Fraunhofer FHR unites leading edge technology with sophisticated methods of signal processing to devise new types of system. This is accomplished by the interdisciplinary collaboration of physicists, engineers and mathematicians. The activities in the business units Defense, Space, Traffic, Environment, Security and Production constitute concrete examples of innovative applications that are being implemented in many areas of society.

Korean: 프라운호퍼 고주파 물리 및 레이더 기술 연구소(FHR)는 레이더 위주의 전자기 센서를 연구하며, 전자레인지에서 테라헤르츠 대역의 하한에 이르기까지 다양한 첨단 신호처리 방식 및 혁신기술을 개발하고 있습니다. 독일은 레이더 우주감시, 위상배열 안테나 기반의 다기능 레이더 시스템, 적응 간섭 억제, 밀리미터파 기술, 초고해상도 영상 레이더, 공간-시간 필터링이 적용된 이동 표적 인식, 표적 식별, 수동형 레이더 등 각종 부문의 신기술 개발에 앞장서 왔습니다. FHR 연구소는 전자기장의 수치계산, 고주파 기술, 센서신호처리 분야에 특화된 연구역량을 바탕으로 복잡한 고주파 시스템을 자체적으로 설계, 개발, 운영하고 있습니다. 또한, 최첨단 기술, 정교한 신호처리 방식과 더불어 물리, 공학, 수학 등 학제간 협력을 기반으로 새로운 유형의 시스템을 설계하고 있습니다. 방위, 우주, 교통, 환경, 보안, 생산 등의 사업부로 구성되어 있으며, 사회 여러 분야에 적용중인 혁신적인 응용기술을 개발하고 있습니다.

9.2 Electromagnetic fields

The core competency »Electromagnetic Fields« embraces several fields of scientific activity, all of which are important to ensure the proper functioning of modern radar and communication systems. These include cross-disciplinary research tasks such as the numeric modeling of electromagnetic fields, wave propagation in various media, the development of antennas and the corresponding components as well as HF measurement technology which are currently performed by approx. 25 employees in various departments. The scientific challenge lies in the implementation of differential (Maxwell's) equations for electromagnetic fields in numerical calculation methods which then form the basis for the subsequent development of efficient software using high performance computing (HPC). Depending on the complexity of the object and its size compared to the wavelength, various approaches, e.g. geometric optics, physical optics and ray-tracing, are used and combined with each other (hybrid methods). Fraunhofer FHR has been working on the development of special hybrid methods for the numerical calculation of electromagnetic fields for a number of years already. The newly developed software, such as FARAD, Cyl-Patch® and FEBI®, which are now registered trademarks, is used to design and analyze antennas and antenna arrays. Compared to other software that is commercially available for the HF area, it offers greater flexibility and is a unique selling point of the institute. Due to their precision and efficiency, the simulation tools also achieve very good results in international benchmarks (e.g. JINA Workshop EM2).

9.3 High frequency systems

The core competency »High Frequency Systems« embraces several facets and subdisciplines which all essentially focus on the implementation of hardware for high frequency systems. This competency covers a broad spectrum of themes. When integrating passive microwave components, for example, it blends fluently with the core competency »Electromagnetic Fields«. On the other hand, it also has a direct relation to the core competency »Signal Processing« when engaging in the hardware-oriented implementation of algorithms in an embedded system. Furthermore, this core competency addresses all abstraction levels of high frequency circuit design, from single transistors to the implementation of complex systems, e.g. the multi-functional SAR/MIT system PAMIR. This, on the one hand, reflects the great scientific challenge of designing, constructing and operating high frequency systems with ultra wideband multi-channel phased array antennas in connection with GPS/DGPS/INS avionics and, on the other hand, the worldwide recognition this work has achieved, which is substantiated by the invitations received to give talks and lectures (e.g. at the European Radar Conference) and prizes that have been won (e.g. Raytheon Radar Prize).

In a technical sense, the core competency is a very broad field, as high frequency systems which (particularly in very high frequencies) were realized with waveguide components, are now also being realized to a growing extent in planar technologies and can now be integrated at chip level. Due to its strong technological orientation, this core competency is characterized by a high level of innovation. FHR is committed to using and shaping this technological progress. One example of this is the expansion of the core competency to include the design and implementation of our own chips.

Due to the enormous technological progress in the last years, radar systems have, on the one hand, become less and less expensive with the result that they can be used for a broader range of applications. On the other hand, the systems are becoming increasingly complex thus facilitating the realization of cost-effective multi-static systems. The resulting »market pull« represents an enormous opportunity for FHR, as new markets for radar techniques are opening in a large number of niches. This also involves a great deal of risk as it would be disastrous if we were to lose sight of the competition in technological terms.

This core competency, which accounts for 50 to 100 employees at FHR, has a strong and diverse footing throughout the institute. With numerous demonstrators, the institute has successfully demonstrated its technical leadership time and time again. In its days as a department-oriented institute, FHR focused on the development of highly efficient systems which, in part, is not conducive to cost-effective implementation. Since commencement of the start-up funding, the institute has, however, worked continuously of the further development of cost-effective planar technologies and recently rounded its technical spectrum through its involvement in chip design.

9.4 Signal processing and imaging

The core competency »Signal Processing and Imaging« focuses on the development and derivation of suitable and optimal signal processing methods for stationary, airborne and space-based radar systems. These highly complex algorithms are modified to suit a wide variety of radar types and applications. The algorithms for multi-channel radar systems play an important role are these are/will be used to a growing extent in current and future systems. Radar systems can be divided into several classes, whereby the imaging radar systems at Fraunhofer FHR are of great significance. The institute plays a pioneering role in the areas of highest resolution SAR, interferometric SAR, bi- and multistatic SAR, MIMO-SAR (Multiple-Input Multiple-Output) and the imaging of moving objects (ISAR, inverse SAR). With regard to research in the field of surveillance radar, Fraunhofer FHR is also a global leader in the areas of moving target indication (MTI) and interference suppression. Fraunhofer FHR is also involved in the field of passive radar and ranks among the world leaders in the detection of small aircraft (UL, ultra-light) using PCL technology (Passive Coherent Location). Moreover, is a global initiator and trendsetter in several areas, e.g. in the field of compressive sensing (CS) for radar as well as in the field of space time adaptive processing (STAP).

The work conducted by FHR in the field of multi-channel airborne radar and SAR systems is characterized by extremely high scientific standards. In this area, FHR successfully combined the competence in adaptive array signal processing which was acquired over many years with its competence in the area of imaging radar. The space time signal models and the derived algorithms not only require high mathematical standards but also a connection to the practical engineering environment. The work conducted by FHR in this area was published in books and recognized and honored on numerous occasions at an international level.

9.5 Cognitive Radar and Classification

Modern radar systems represent intelligent sensors with a variety of software-defined degrees of freedom. Cognitive radar control enables optimal adaption of the waveform and other parameters to the environment. Machine-learning techniques and other methods from the field of computer-science and artificial intelligence allow for the automation of cognitive abilities and expert-knowledge, that was previously confined to subject-matter-experts.

The concept of cognitive radar pursued at Fraunhofer FHR hence follows the “Three-Layer-Model” of human cognitive performance.

The lowest level of skill-based performance describes the layer of continuous signal processing. It relies on adaptive signal processing methods and provides an estimate of the environment and the transmission channel. This can then be utilized for optimally matching the transmission wave to the environment and executed radar task. Technological improvements, such as AWGs, DSPs and FPGAs allow for experimental verification of the concepts at FHR.

The level of rule-based behavior utilizes the underlying skill-based-layer of signal processing. The perception-action feedback loop that is typical for cognitive radar is implemented in a reactive, rule-based fashion. The competency in the field of classification for scene recognition has historically emerged from the task of determining the class (or even identifying the type) of aircrafts, vehicles and ships, solely based on their radar-signatures. The classification methods developed are based on a comparison of the measured signature with a set of potentially relevant objects in a reference data base (“Non-Cooperative Identification”). As opposed to traditional approaches in image-processing, the unique features of radar-signatures are exploited. An adaption to detection problems in other applications fields, such as automotive-radar or material sciences can easily be achieved.

The knowledge-based processing layer represents the highest level of abstraction under consideration of external data or interfaces. Such a task- or goal-based radar system exhibits a semantic understanding of the radar-scene with respect to the current radar task and is capable of planning a long-term sequence of radar-modes in the anticipated mission context. Furthermore, system-engineering and operational concepts need to be considered, when experimentally realizing such a fully integrated, cognitive radar system.

9.6 Space radar

Many of the requirements that arise in the course of increasing globalization can only be met through the utilization of space technology, with the result that this area has experienced an ongoing boom over the last years. The rapidly increasing and practically unregulated utilization of space does, however, create problems and challenges which can only be resolved in the presence of up-to-date knowledge relating to the current situation in space (space situational awareness) and through the development and utilization of advanced space-based systems and technologies. Due to its special properties, radar plays a leading role in Earth observation using space-based sensors as well as in the measurement and analysis of objects in space. The core competency »Space Radar« therefore focuses on the research, development and testing of methods, technologies and systems that can be used in the physical conditions that prevail in space. One special feature is the space observation radar TIRA, which was continuously developed and expanded since it was first constructed in the 1960s and is now one of the leading international research instruments. The core competency combines the basic theoretical and analytical capabilities such as

- theory and algorithms of high-resolution mono / bistatic interferometric, 1D, 2D and 3D ISAR imaging, subsequent image-based reconnaissance and the technical analysis of space-based systems,
- theories, algorithms and techniques for the detection, interception, discrimination and orbital tracking of radar-critical targets in space along with extensive knowledge of satellite and astrodynamics, satellite orbit calculation and propagation

with technical and technological capabilities such as

- design, integration, operation and further development of highly efficient radar devices and large antenna technology as well as drive, control and air-conditioning technology,

- planning, organization, execution and evaluation of complex, quasi-operational measurement campaigns with the TIRA system as well as the coordination and synchronization of bi- and multi-static national and international campaigns.

Additional expertise and special knowledge from the areas of space physics and space technology such as

- leading (DE, EU) expertise in the area of space reconnaissance and satellite re-entry / collision forecasting,
- extensive expertise in all important aspects of space situational awareness, such as surveillance, reconnaissance, threat analysis, space debris situation and space weather

round off the core competency.

10. Fraunhofer Institute for Applied Information Technology FIT

Website Link: http://www.fit.fraunhofer.de/en.html

10.1 Institute Overview

English: Our research, development and consulting services for our partners in the private and public sectors are aggregated in five business areas:

- Management of Coperation and Innovation develops technologies and offers research-based consulting to support digitization in companies. In addition to communication and cooperation systems, we focus on professional training and on innovative solutions for interaction and visualization using Mixed and Augmented Reality.
- Life Science Informatics, focusing on microsystems technology and integrated imaging systems for High Content analysis in diagnostics and drug research.
- Internet of Things / Energy Efficiency, focusing on cyber-physical systems for smart monitoring, optimizing and management of systems and devices to reduce energy consumption, as well as solutions for Smart factories, Smart Cities and Industry 4.0.
- Usability and User Experience Design, with special emphasis on context-optimized man–machine interaction, optimal usability of applications and devices, professional usability training, Web compliance and accessibility.

- Sustainable finance management on the microeconomic as well as the macroeconomic level, focusing on micro-analytic simulation in impact assessment as well as on (risk) analysis and efficiency improvement of complex business processes, using decision support tools, among others.

Korean: 프라운호퍼 응용정보기술연구소(FIT)는 기업 및 공공기관을 대상으로 다음 5 개 분야에 대한 연구개발 및 컨설팅을 수행하고 있습니다.

- 협력 및 혁신을 통한 기술개발과 연구기반의 컨설팅을 제공하여 기업의 디지털화를 지원합니다. 커뮤니케이션 및 협력 체계 외에도 전문교육과 혼합·증강현실을 활용한 인터랙션 및 시각화 관련 혁신적인 솔루션 개발에 주력하고 있습니다.
- 마이크로시스템 기술, 진단 및 신약연구 시 하이컨텐트 분석용 통합영상시스템 등 생명과학정보학
- 스마트 모니터링용 사이버물리시스템, 에너지 소비 절감을 위한 시스템·기기 최적화 및 관리, 스마트 팩토리, 스마트 시티, 산업 4.0 관련 솔루션 등 IoT 및 에너지 효율
- 맥락에 최적화된 인간-기계 상호작용, 응용기술 및 기기의 사용성 최적화, 전문가 사용성 교육, 웹 접근성 준수 등 사용성 및 사용자 경험 디자인
- 영향평가의 미시분석적 시뮬레이션, 의사결정 지원도구를 통한 복잡한 비즈니스 프로세스 위험분석 및 효율성 개선 등 미시경제적 및 거시경제적 수준에서의 지속가능한 재무관리

10.2 User-Centered Computing

The User-Centered Computing department develops IT systems and technologies that focus on their users throughout their complete life cycle. We aim for systems that provide effective personalized support for the task at hand and fit perfectly into the work environment. Our expertise from more than 20 years of R&D on Human–Computer-Interaction and adaptation to context enables us to build intelligent environments and IT systems that satisfy the requirements of usability, Web compliance and accessibility in their individual context.

Our wide repertoire of design methods lets us combine appropriate test-oriented methods from User-Centered Engineering with ethnographic and participatory approaches, so we can involve the users from the start in the planning, design and evolution of their systems. The range of our activities includes usability engineering of products and systems, support for the design of standard-compliant Web and desktop applications as well as the use of sensor technologies and embedded systems in industrial environments.

10.3 Cooperation Systems

Building on its long CSCW experience and social computing concepts the Cooperation Systems department develops and evaluates novel groupware, community and knowledge management systems for distributed organizations and teams. We also provide personalized and collaborative learning environments and investigate methods to infer the goals, tasks and preferences of their users, based on precise observations of teachers and learners.

The department enriches work environments with novel forms of interaction that use mixed reality technology. Multi-touch panels, gesture control and Augmented Reality are among the technologies in our idea of the workplace of the future. We investigate pervasive games, exciting new computer-based games that use the players' real vicinity as their playing field. Our scientific and technological expertise in these fields enables us to build custom-tailored systems for the needs of real organizations.

10.4 Life Science Informatics

The Life Science Informatics department develops new approaches to produce highly specific information on diseases and individual patients.

After the sequencing of the human genome had been successfully completed, automatic instruments and computerized data analysis moved into the focus of biotechnology and medicine. On all levels, from molecular interaction to cellular function, tissue or organ structure, and the course of a disease in an individual patient, new instruments can produce information about the processes involved in a disease and can help to improve diagnosis and therapy.

This potential motivates our R&D in the field of information-intensive instruments using optical and electronic detection methods. We develop novel components, like fluidic microsystems to study cells and molecules, smart scanning microscopes and software for image analysis and object detection. We test and validate complete applications in cooperation with their users. We use our components to build application-specific systems that provide seamless integration in state-of-the-art network infrastructures and mobile access.

Computer scientists, engineers and natural scientists in two close collaborating groups work in our projects.

10.5 Project Group Business & Information Systems Engineering

We develop holistic solutions at the interface of Financial Management, Information Management and Business and Information Systems Engineering, which are focused on the following principles: innovation, interdisciplinarity and sustainability, value based management and the integration of risk and return management.

10.6 Risk Management And Decision Support

The Risk Management And Decision Support department addresses methods and measures for risk preparation and mitigation, response in crisis situations, and recovery from emergencies. Our prime focus is the development of integrated risk management systems, specifically the support of decision-making by different tools and formal methods. The scope of decisions includes the planning and coordination of resources for fire brigades, the design of novel pieces of equipment for relief services, or the assessment of alternatives in drafting financial legislation.

We also customize our text and data mining tool SWAPit, which detects similarities and relationships among large volumes of documents.

11. Fraunhofer Institute for Open Communication Systems FOKUS

Website Link: https://www.fokus.fraunhofer.de/en

11.1 Institute Overview

English: In the near future everything can or will be connected to the internet: buildings, automobiles, trains, factories in fact even animals and plants. This continuous and extensive networking will fundamentally change the communication and interaction in all areas of life and work, be it in the healthcare system, the control of traffic, movement of goods or in production. Fraunhofer FOKUS as a neutral research organization develops solutions for the digital networking, with the requirement to make the networked world safe, reliable, scalable and trustworthy.

Fraunhofer FOKUS offers it's solutions in seven business units: Three of the seven units address the horizontal issues of digital networking: networks, system quality and visualization. Four of the seven business units are vertically positioned and focus on the design of digital networking in the respective branches: media, general public, mobility and security.

Thereby FOKUS acts as a supplier and technology independent agent between industry, science and the public administration, that can combine long standing scientific expertise and experience from various branches to optimal solutions for its customers. The researchers concentrate not only on the technical infrastructure but furthermore develop practical concepts, prototypes and applications in a pre-competitive environment. At the center of the research activities lies the development of cross-domain and cross–organizational solutions that are both interoperable and user-centric.

Korean: 가까운 미래에는 건물, 자동차, 기차, 공장, 심지어는 동식물까지 인터넷과 연결될 것입니다. 이처럼 광범위한 네트워크는 의료시스템, 교통관제, 상품이동, 생산 등 일상과 업무 환경 전반에 걸친 의사소통과 상호작용에 근본적인 변화를 가져올 것입니다. 프라운호퍼 개방형 통신시스템 연구소(FOKUS)는 디지털 네트워킹 솔루션을 개발하는 독립적인 연구기관으로 보다 안전하고 신뢰할 수 있으며 확장 가능한 네트워크 세상 구축을 지향하고 있습니다. FOKUS 연구소는 네트워크, 시스템 품질, 시각화 등 디지털 네트워킹의 수평적 이슈를 다루는 3 개 사업부와 미디어, 대중, 이동성, 보안 등 디지털 네트워킹의 수직적 이슈 및 설계를 담당하는 4 개 사업부 등 총 7 개 사업부로 구성되어 있습니다. 연구소는 민관학을 연결하는 기술 독립적인 기관으로, 오랜 기간 다양한 경험과 노하우를 바탕으로 고객들에게 최적의 솔루션을 제공하고 있습니다. 특히 기술 인프라 연구뿐 아니라 선경쟁적인 환경에서 실용적인 개념, 프로토타입, 응용기술도 개발하고 있습니다. 주요 연구분야는 상호운용적이며 사용자 중심적인 교차 도메인 및 교차 조직 솔루션 개발입니다.

11.2 Highly-Automated Driving

Advanced driver assistance systems nowadays move on from single-purpose functions to integrated automated driving as showcased in functions such as “Distronic plus” (automated driving in stop-and-go situations) or even fully automated highway driving. In parallel, cooperative functions are getting closer to market introduction, proving technical maturity and effects on traffic safety and efficiency in Field-operational Trials such as simTD or DRIVE C2X.

The cooperative driving group of Fraunhofer FOKUS aims to adapt cooperation into novel driver assistance systems, by combining experience from fields of research and development. Communication offers novel insights to driver assistance, that no other sensor can provide: a look “inside” other vehicles. As such it is possible to share knowledge, intentions and maps between vehicles. These local dynamic maps enable vehicles to “see around the corner” or even beyond sensor range with multi-hop communication. Intelligent integration of cellular communication allows to share aggregated knowledge even further.

High-automated vehicles and autonomous vehicles can go one step further: by communicating these vehicles can negotiate and conduct cooperative driving maneuvers. Constraints such as low-penetration rates, reliability, security and trust in wireless communication are key factors for feasibility of these functions. The investigation and prototyping of such novel applications is in the focus of the cooperative driver assistance systems group. High-precision digital maps are a key requirement for all current high-automated and autonomous vehicles. These maps are created initially as 3D high resolution scan and provide landmarks for localization and attributes for driving behavior – but roads and road properties change over time! By combining the distributed knowledge of the highly automated vehicles driving on these roads, a cooperative adaptive map service can be created – combining precision and timeliness of information. Fraunhofer FOKUS is working with industry leaders on creation of these state-of-the-art adaptive map services.

11.3 Learning Map

Hi-precision digital maps are a key pillar for smart mobility systems. They enable advanced in-vehicle assistant systems including semi- or full-autonomous vehicles. Moreover, they provide the basis for a highly integrated mobility solutions among all stakeholders.

Fraunhofer FOKUS is researching on the generation, management and maintenance of such maps. On the one hand hi-precision maps address individual vehicles to enable automatic vehicle control. In this context, Fraunhofer is mainly interested in information fusion among multiple vehicles using low cost sensors, exploiting the capabilities for V2X communication technology and a powerful backbone.

On the other hand, FOKUS develops solutions to integrate dynamic information in real-time such as public transport information, 3weather information, road blockings and congestion information. The concept to integrate and exchange the information is basis to the LDM++, an extension to the Local Dynamic Map.

11.4 Collaborative mobility

Engineering mobility has been a topic for many years. In 1886, Carl Benz showed the Benz Patent Motorwagen - widely regarded as the first automobile. When looking at the

Motorwagen and a modern Daimler Benz car, the more than 100 years of development is more than obvious. Brilliant engineers like Henry Ford, Ferdinand Porsche, Preston Tucker have caused great success of the automobile until today. But especially the developments of recent years open completely new perspectives on automotive engineering. The main reason for that is that communication technology has entered vehicles.

While most developments focus on bringing more services and better information to the driver, collaborative mobility focuses on a new perspective: It underlines, that the system under development goes beyond the singular car. With V2X communication technology automotive engineers become traffic designers and could target the greatest challenges of mobility directly, such as pollution in the city, congestion, parking problems. There was no possibility to address such challenges before in such a direct and efficient manner.

Where traffic participants - particularly vehicle drivers - act in an aligned way to address such problems, we call it collaborative mobility.

FOKUS develops applications that exploit such possibilities.

11.5 Smart pollution management for smart cities

It is a common fact, that inner city areas suffer from vehicular pollution: NOx, CO, Benzene, respirable dust, noise and others. There are a lot of activities in research and industry to lower the emission of each individual vehicle.

That is worthwhile but it misses one central aspect: Normally it is not the pollution caused by an individual vehicle that harms people’s health but it is the aggregate effect of all polluting nodes. That is the starting point of the joint work of Fraunhofer FOKUS, the Hamilton Institute at the National University of Ireland Maynooth (funded by the Science Foundation Ireland) and Technische Universität Berlin.

We developed a system - including a prototypical implementation – that manages the aggregate pollution making use of the great potential of hybrid vehicles. With help of information technology, networked vehicles and stochastic control algorithms, we showed that we could manage and limit the overall pollution – in fact the air quality directly - in urban areas.

Simulations as well as an adapted proof-of-concept full hybrid vehicle show that the approach works today – with today’s technologies.

Detailed information could be found in "Cooperative regulation and trading of emissions using plug-in hybrid vehicles", Submitted to IEEE Transactions on Intelligent Transportation Systems, 2012.

11.6 European Open Data Portal

The European Open Data platform will bring together Open Data from 39 European countries and improves the discoverability and the ability to re-use this data. With the Open Data Portal, the European Commission intends to unlock the economic potential of public data that is estimated of possible gains exceeding 40 billion Euros per year. Its further objective is to improve the governance of countries and empower citizens to address societal challenges.

Fraunhofer FOKUS will be one of the key technical partners in this ambitious Open Data project, responsible for developing the data repository and harvesting datasets from existing open data sources. The data repository bundles all different data entries based on their metadata while the harvesting-tools allow to collect data sets from various sources across all the EU countries. Capgemini Consulting will lead this three-year engagement. Further partners apart from Fraunhofer FOKUS are Sogeti, Intrasoft International, the Open Data Institute, con terra, the University of Southampton and time.lex.

11.7 Cloud for Europe

Cloud for Europe supports public sector cloud use as collaboration between public authorities and industry. The project identifies obstacles, finds innovative solutions and builds trust in European cloud computing.

Cloud for Europe uses pre-commercial procurement as an instrument for public sector innovation. The pre-commercial procurement identifies innovative solutions for cloud services that best fit public sector needs, but also provides better information to public procurers about the potential of cloud services.

Cloud for Europe will give a clear view on the public sector requirements and usage scenarios for cloud computing. Supported by stakeholders from the public sector, industry and standardisation bodies, the main objectives of Cloud for Europe are:

- Identifying obstacles for cloud use in the public sector
- Defining services that overcome these obstacles
- Procuring research from industry to find innovative solutions for cloud services

The Cloud for Europe initiative, in support of the European Cloud Partnership, will allow the public sector to implement well-defined cloud computing strategies. Supported by stakeholders from both public and private sector, Cloud for Europe aims to remove the obstacles for cloud adoption. Cloud for Europe brings together industry and the public sector to provide conditions for a digital single market for cloud computing in Europe.

The project started in June 2013 and runs until November 2016. It is co-funded by the European Commission under the Framework Programme for Research and Innovation (FP7).

11.8 tag.check.score

To open up the image archives of the Berlin Ethnological Museum to the public, the museum and Fraunhofer FOKUS developed the Tag.Check.Score. crowdsourcing app in the context of the Code for Europe initiative. The app is based on the idea of digital volunteer work. With the app, users can add metadata to the museum’s photos, correct existing tags and earn points doing so. The goal of Tag.Check.Score. is to develop an open-source solution that other museums, libraries and archives can also use to tackle similar challenges.

11.9 Policy Compass

The main goal of Policy Compass is to develop a research prototype of an easy-to-use, highly visual and intuitive tool for social networks and eParticipation platforms, enabling citizens and public officials to easily create, apply, share, embed, annotate and discuss causal models, charts and graphs of historical data from trusted open data sources. The aim is to develop methods and tools that facilitate more factual, evidence-based, transparent and accountable policy evaluation and analysis. The project aims also to facilitate more objective, evidence-based and transparent policy deliberations.

The research question the Policy Compass project will address is whether and how open public data, social media, eParticipation platforms, fuzzy cognitive maps and argumentation technology can be integrated and applied to provide better tools on the World Wide Web for constructing, sharing, visualising and debating progress metrics and causal models of policies.

The aim is to provide easy-to-use tools for both the lay public, on social networks, as well as professional policy makers, to improve the quality and transparency of the policy analysis and monitoring phases of the policy life-cycle. Policy Compass will make use of

Europe's increasing amount of public sector open and structured data resources. Policy Compass will make better use of Europe's open public data resources and empower policy-makers and citizens (especially the younger generation) to better assess government policies in the policy analysis and monitoring phases of the policy cycle.

11.10 IPv6

Fraunhofer FOKUS as an expert in "one-stop government" and BearingPoint were commissioned by the German Federal Office of Administration (BVA) to carry out the research project "IPv6 profiles" for public administrations under the supervision of the BVA.

The project objectives include: The definition of profiles for device classes, the assessment of migration strategies for IPv6 and the documentation thereof. This project presents a significant contribution to the future-proof migration of the German network infrastructures to IPv6. It has been carried out in close collaboration with the German Federal Ministry of the Interior. The experience gained in the course of this project will be incorporated into IPv6-related projects started by the EU commission and will be further supplemented.

Taking current developments into account, a technical criteria catalogue as well as IPv6 profiles for the public administration will be developed. The results are recommendations for the introduction and provisioning of IPv6-compliant components. Complex migration scenarios are re-enacted in the network and eGovernment laboratories of Fraunhofer FOKUS in order to define, test and document migration steps from an IPv4-only infrastructure to an IPv4/IPv6 dual stack infrastructure. Therewith, practical knowledge about the migration, the necessary steps and the expected complexity will be documented. In parallel, a realistic assessment of the IPv6 functionality within the IT infrastructure and for the used software components can be achieved.

11.11 EnhAnced Government LEarning

Public administrations need to cope with various challenges: new regulations, an aging workforce and the need for adopting their ICT. Technology-enhanced learning represents thus a sensible option notably for rural local governments that need to keep up with such changing environments, but do have limited access to training courses.

EAGLE aims at creating an open learning platform and services to equip employees in rural local government administrations with a holistic training solution that supports learning of critical transversal skills such as ICT literacy, information literacy and professional management of change situations in entire organizations at all levels. Recognition of public servants as users and authors and for sharing their expertise with colleagues will be the incentive to keep the system lively and up to date.

EAGLE's Technical Mission is the provision of:

- Workplace based learning connecting everyday work documents and systems with learning opportunities
- Tailored system/ instances for public administration
- Linking work documents/ processes/ people to Open Educational Resources
- Linking skill profiles to content to allow personalized learning
- Collaboration facilities and support to allow collaborative learning and authoring

11.12 STREETLIFE

Reducing carbon emissions through sustainable urban mobility solutions based on Information and Communication Technologies (ICT) - this is the major objective of the STREETLIFE project.

To reach this ambitious goal, STREETLIFE develops multimodal mobility information systems for urban areas. Personalised information on their smartphone will motivate citizens to select sustainable transport means for their travel. Traffic management centres and city administrations will benefit from sophisticated STREETLIFE solutions for monitoring and control of urban traffic. The combination of these measures will reduce traffic and related emissions in cities.

11 partners from 3 European countries, representing ICT and transport research, industry and cities, will work together closely in the 3 year project. The European Commission supports STREETLIFE with € 4,3M from the 7th EU Framework Programme.

User Scenarios

Citizens will be equipped with mobile apps that provide multimodal personalised routing. Realtime data will be integrated and all kinds of available transportation modes will be considered. The appeal of the solutions will be essential in engaging people towards carbon-reducing mobility. Therefore, engaging user interfaces based on 3D virtual environments and Augmented Reality techniques as well as gamification approaches will be applied.

Traffic managers will be able to analyse the traffic situation in realtime on the basis of a comprehensive database. In addition, they will have available simulation techniques for the evaluation of different management strategies. Appropriate measures that will be taken as result of these analyses will improve the actual traffic control.

City administrations will also benefit from the STREETLIFE solutions, which can support their planning processes, e.g. by improving their urban mobility plans and by predicting the impact of their mobility strategies.

Pilot Sites

The effectiveness of the STREETLIFE solutions will be proven through an in-depth evaluation on three city pilots, in Berlin (Germany), Tampere (Finland), and Rovereto (Italy). The selected cities are quite different in size and number of citizens as well as the specific characteristics of their transport system. The impact assessment on traffic situation, end-user behaviour, reduction of carbon emissions and further environmental parameters from these diverse contexts will provide widely transferable results.

Local experts will support the STREETLIFE project by giving feedback in technical workshops at the pilot sites. Their feedback will be used to adapt the system components to the real needs of the cities and to implement two incremental releases of the STREETLIFE prototype system at the sites. A final test and evaluation phase will conclude the development activities.

Exploitation of Results

The project partners will elaborate joint technology exploitation activities which not only define the principal roles but also identify the best position for each partner in the value chain. Concrete business scenarios will be assessed with respect to a possible commercial follow-up.

At the end of the project, an international symposium and local dissemination workshops will be organized to present the achievements to a wider public.

11.13 Open Cloud for Europe, JApan and beyond – OCEAN

As highlighted by European Commission in its Digital Agenda, interoperability is a key challenge for developing a sustainable cloud ecosystem in Europe.

The fundamental goal of OCEAN is to foster the emergence of a sustainable open source cloud ecosystem and boost market innovation in Europe, by generating greater efficiency and economies of scale among collaborative research projects on open source cloud computing. OCEAN is addressing European FP7 projects funded under the Objective ICT-2011.1.2 as well as other European, European national and Japanese open cloud collaborative projects.

OCEAN is to play a pivotal role among collaborative cloud research projects, especially those that are naturally following an open source approach, to help reveal commonalities, being either potential overlapping and/or opportunities for collaboration and synergies. The OCEAN project is launched in order to provide the following results:

- Identify current collaborative projects developing open cloud components among European FP7 research projects, other European national research projects, Japanese research projects and register them together with other open cloud projects in an online Open Cloud Innovation Directory.
- Provide a relative positioning or functional mapping of these projects, in relation with key standards and reference models provided by leading standard defining organizations such as NIST, ETSI, DMTF, OGF, etc in what we call a Open Cloud Interoperability Framework and Roadmap.
- Pre-test and review software artefacts from some open cloud projects and provide online services enabling open cloud projects to build and test their software.
- Foster cooperation and integration between projects through the organization of two annual events called “Plugfests" that will provide project teams the appropriate environment to work on the integration and interoperability of their software.
- Foster collaboration between European and Japanese entities on open cloud computing, cloud interoperability and standardisation by involving them in the organised Plugfests and in discussions on the Open Cloud Interoperability Framework and Roadmap.

Europe as a whole needs projects such as OCEAN to ensure that the European Commission realizes its overarching vision. Only by closing gaps, eliminating overlaps, and avoiding missed opportunities amongst current projects will Europe be able to truly do its best at creating a unique, sustainable open cloud ecosystem

11.14 CloudWatch

To drive the wider uptake of cloud computing, Europe needs to pursue a continued dialogue between all stakeholders (business users, governments, researchers, providers and consumer associations) evaluating ways to increase commitment to transparency, openness and compliance. CloudWatch disseminates best practices on interoperable clouds contributing to an internal market of services to boost opportunities for businesses and citizens.

The goals of CloudWatch:

- Accelerate the adoption of cloud computing across European private and public organisations.
- Offer independent, practical tips on why, when and how to move to the cloud, showcasing success stories that demonstrate real world benefits of cloud computing.
- Foster interoperable services and solutions to broaden choice for consumers.
- Provide tips on legal and contractual issues.
- Feature insights on real issues like security, trust and data protection.
- Promote common standards profiles with practical guidance on relevant standards and Certification Schemes for cloud services.

CloudWatch offers sound recommendations based on real-life cases. It focuses on providing a portfolio of European and international use cases leading to the development of common standards profiles and testing around the federation of cloud services. CloudWatch also supports efforts around certification and compliance testing

11.15 Linked Open Apps Ecosystem to open up Innovation in Smart Cities

In today's scene of restrictions and shrinking budgets, the need to identify new ways of collaboration in the provision of services of public interest becomes essential to maintain its quality in European cities. On the other hand, the growing societal demands to open the public information and public goods for its re-use opens new opportunities to explore other ways of offering public services that have been traditionally solely delivered by public administrations.

The iCity project aims at making a step forward in the co-creation of services of public interest by third parties (developers, small and medium enterprises, ... etc.) that are pushing for their space as service providers in the urban spaces of Smart Cities. The project intends to develop and deploy an approach to allow these interested parties to create, deploy, operate and exploit services based on the use of available public information, digital assets and Opened Information Systems in cities. This represents a shift in the governance of cities and the concept upon which traditional public service delivery has been based.

The iCity project vision makes a step further on the concept of Open Data offering a novel approach of Opened Information Systems where the municipal ICT networks already deployed in urban spaces will be made available and accessible to the general public with the objective of maximizing the number of deployed services of public interest.

The services to be finally deployed will be developed by interested third parties who will be given access to public information and Opened Information Systems through a shared technological platform integrated in the four participant cities (Barcelona, Bologna, Genova and London): the iCity platform.

Special care is given in this project to reach developers, entrepreneurs and small and medium enterprises; the ecosystem that we believe is at the forefront of open innovation in cities. This will be done with the help of local promoters specialised in user engagement, like living labs.

In this sense, several local contests in every participant city will be organised to attract their attention and foster their use of the iCity solution for the development of services of public interest. Also, a Special Interest Group has been activated for those parties interested in closely following the development of the project and participating in its activities.

The main expected outputs of the project are:

- The iCity Platform that will give access to open information and Opened Information Systems in the participant cities.
- An ecosystem of services of public interest (mobile apps, web services…) created by interested third parties using the assets made available through the iCity Platform.
- A new methodology for user engagement in the creation of services of public interest.
- For more information kindly refer to the iCity project factsheet and presentation.

Technological Solution

The iCity platform, which will be offered as a Platform-as-a-Service (PaaS), will enable services deployment using appropriate municipal infrastructures in each city by providing a software development kit (SDK).

The features and capabilities of the iCity platform are:

- An advanced service delivery platform built on open standards.
- A rich set of common application infrastructure and business services to accelerate service creation and delivery.
- Integration with operations support systems/business support systems (OSS/BSS) to enable (at scale) service orchestration, activation, service monitoring, maintenance, and billing.
- Quick integration with a wide variety of devices through a device abstraction framework.
- Quick integration with city applications using an application abstraction framework.
- A Portal for the end consumer and city operating personnel.

iCity Platform

iCity is a secure, stable and standardised platform that makes it possible not only to access city data but also to a city ICT infrastructures in a controlled manner in order to create new services. It is the first of its kind, which renders it a pioneer in its field and makes it attractive for developers as well as system providers.

Thanks to its open nature, developers can find any available European platform that connects directly with the ICT Infrastructures of the cities involved. All in a very open, comprehensive and friendly way.

On the other side, cities and service providers are able to control any petition or access of any user in progress at any time, in an organized and structured way. Developed with the most secure software of the market, iCity Platform is oriented to accept any technology.

It gives a unique opportunity to interact with cities across Europe, such as Genova, Bologna, London or Barcelona, in just one click

11.16 5G R&D

5G represents the evolution of the telco ecosystem, towards a new network with ultra-high capacity, low delay, improved flexibility and for an extremely high number of diversified devices and applications. Fraunhofer FOKUS has prepared a set of research and testing environments for the core network related enhancements and improvements necessary to meet the expectations of 5G:

The 5G Playground is a live R&D testbed were researchers and engineers are able to bring their own prototypes and build together the 5G environment. It enables the evaluation, validation, interoperability and demonstration in a comprehensive environment, for new ideas, prototypes and solutions.

The playground platform is composed of the following practical toolkits:

- Open5GCore, a pre-standard software toolkit for the 5G Networks
- OpenSDNCore, a practical implementation of Network Functions Virtualization (NFV) and Software Defined Networks (SDN) paradigms, aiming at virtual functions deployments on top of carrier-grade, cloud based infrastructures.
- Open5GMTC, an R&D prototype, providing advanced features for device and connectivity management of a very large number of wireless devices (human controlled or machines).

11.17 From Specialized Hardware Components to Software Programs in Datacenters

Understanding the potential brought by the decoupling between hardware and software development cycles, Fraunhofer FOKUS is committed to develop a novel core network architecture addressing both the specific challenges in delay and management complexity of data center technologies, as well as the requirements of next generation radio technologies. This novel network virtualization functionality is integrated in FOKUS' OpenSDNCore toolkit which enables research in the following direction:

- Flexible re-allocation of computation and storage resources
- Load balancing mechanisms
- Software based re-design of core network architecture
- Flexible and automated EPC deployments
- Control Plane/User Plane separation

- Integration of cloud technologies i.e. OpenStack
- Virtualized core network management technologies

Based on the large experience developing hands-on toolkits of operator core networks, such as the worldwide renowned Open IMS Core and OpenEPC, Fraunhofer FOKUS aims at developing a novel core network architecture, pragmatically answering to all the specified NFV challenges from concept, securing IPR, to specification and to practical prototyping.

11.18 Impacts of SDN/OpenFlow on Telecommunication Networks

The Business Unit NGNI of Fraunhofer FOKUS and the chair AV of TU Berlin are developing the new OpenSDNCore toolkit to investigate the potential, opportunities and challenges on applying SDN principles on telecommunication networks.

Having a large historical background on research and development on telecommunication networks, we are now investigating the impact of SDN in telecommunication networks. In particular we are addressing the following non-exclusive research areas in SDN/telco:

- Continuing the 3GPP EPC control and data plane split further on in the packet core gateways. Separating forwarding functionalities from the gateways in the user plane part of the gateway and the control and management functions in the control part of the gateway.
- Enablement of network-aware services and core network enhancements for service-awareness for networks. Using the flexibility of SDN to enhance the 3GPP PCC functionalities.
- Flexible Traffic Management including Adaptive Flow Placement and Elastic Network Design. Flexible access- and core network topology management for supporting Self-Organizing-Network (SON) concepts and enabling smart resource control.
- Enabling efficient backhauling considering forwarding consistency, fast routing information convergence, reliable data forwarding according to transport and core network requirements
- Enabling data traffic forwarding parallelization, data traffic steering, backhaul level offloading for massive broadband communication between end-users and data centers and between data centers

11.19 Research in cloud federation and the applicability of clouds

Since mature cloud computing solutions are already existing and commercially available, our research efforts target specific open issues in the area of cloud federation and the applicability of clouds to the Telco domain.

While intra-cloud service offerings can be handled today, the migration of services between clouds is still an open issue today. This is due to the lack of widely accepted standards and agreed inter-cloud interfaces. Our research is centered on cloud federation and seamless integration of services between different cloud providers. This enables a number of scenarios for different sectors (e.g. Energy – “Follow the sun", IT – “Shortest link to my virtual computer", etc.)

In the Telco domain, cloud scenarios for fixed and mobile services offer a range of new business models and revenue streams. Due to reduced requirements for upfront investment, out- and In-sourcing of services offers new possibilities to SMEs and startups to get their business from the ground. The flexibility and elasticity of the cloud in combination with cloud-based Telco SDPs allow operators to quickly adapt to new situations and react to market demands rapidly. Smaller companies and individuals benefit from a low risk of acquiring (on demand) high end computing infrastructure and are relived at the same time from time and resource consuming tasks like maintenance, security updates, etc.

Also for smart cities and in the context of the currently ongoing Future Internet discussions, cloud scenarios are highly interesting for supporting future applications, e-government services and regional service markets. Many regional data and service providers like governmental authorities, insurance companies, power suppliers, etc. would benefit from integrated processes to share data and enable the composition of new services (e.g. the “house-moving application").

11.20 Sharing resources

Since 2006, the Fraunhofer FOKUS institute and the TU-Berlin chair AV actively contribute to the field of resource federation. “Resource federation is a concept for sharing resources beyond the boundaries of administrative (usually organizational) domains. Federations aim to implement a common service drawing upon the resources committed by participating organizations. This mechanism can follow a recursive model and can be applied with any meaningful granularity to fit specific federation contexts.” [Sebastian Wahle: "A Generic Framework for Heterogeneous Resource Federation", Doctoral thesis, TU-Berlin, 2011]

Jointly FOKUS and AV maintain a generic resource framework that has been developed in the course of multiple projects (Panlab, PII, TEFIS, G-Lab, OpenLab, Fed4Fire) and is used today to federate heterogeneous resources across multiple sites in Europe. Users from both industry and academia benefit from the prototypes and tools provided around this framework to gain access to distributed resources that can be used to perform testing and experimentation. Resource providers benefit from joining a federation due to increased average resource utilization, an additional "sales channel" for expensive experimental infrastructure, and the possibility to gain access to cutting edge Future Internet research and experimentation.

11.21 Fixed and Mobile NGN Evolution Towards the Future Internet

The progressing roll out of fixed and mobile Internet access has paved the way for seamless all-IP applications, thus creating a demand for the Future Internet (FI). This is why we address FI issues as part of our research activities.

In the last decade Next Generation Network (NGN) and Next Generation Mobile Network research (more information available at the FOKUS FUSECO Playground) has been a major focus of R&D activities in telecommunications globally. Most notably, interworking with and migration from fixed and mobile legacy telecommunication networks as a step towards the NGN/Next Generation Mobile Network model has been a major challenge. Many ongoing research activities concentrate on NGN security, emergency support, management and the integration of NGNs into advanced Service Oriented Architecture (SOA) based Service Delivery Platforms (SDPs) for the provision of revenue generating multimedia applications. However, NGNs and SDPs are currently being deployed all around the world and related NGN and SDP testbeds are helping to make these new technologies and their potentialities more understandable. From an R&D point of view, the next big challenge is coming into view; the NGN evolution towards the Future Internet.

While the telecommunications world has looked at NGN research and on the impact of Internet technologies and rich applications, the Internet community has started to investigate how the Internet is evolving to meet the new user demands created by innovative Internet applications. While many FI researchers have looked for a disruptive approach, also known as a clean slate design approach, in which the classic layered network protocol stack is replaced by a dynamic programmable cross layer protocol stack, nowadays an increasing number of researchers are also investigating an evolutionary approach from the NGN. This is motivated by a desire to maximize the reuse of the ongoing NGN investments and to enable a smooth transition from the existing converged network ecosystem into an open services market environment.

Here at FOKUS we are in the unique situation of having experts performing FI research in both of these directions. The former FOKUS competence center Network Research (NET) has a long tradition in FI research, and has been particularly recognized as a pioneer in the field of Autonomic Communications (AC). On the other hand, researchers from the competence center Next Generation Network Infrastructures (NGNI) have become internationally recognized as NGN testbed experts, particularly in the field of service-oriented SDP technologies over mobile and fixed NGNs for rich communications and multimedia applications. Since 2011 the NET group has been merged into the competence center NGNI to maximise the synergies of these expertise domains leading to our newest testbed referred to as NGN2FI Evolution lab in which we develop and validate NGN2FI interworking and migration scenarios.

In addition, FOKUS is active in many international research projects under the banner of the European Commission's Future Internet Research and Experimentation (FIRE) research framework and is investigating FI monitoring, security and management, as well as innovative multi-service and end system architectures. Here in NGNs and the FI the notion of dynamic service overlays is an important concept, starting from structured and centralized overlay architectures, like the IP Multimedia Subsystem (IMS), to more distributed ones like Peer-to-Peer (P2P), Over-The-Top (OTT) architectures, and Next Generation Service Overlay Networks (NGSON). With the global availability of fixed and mobile broadband Internet access, new and innovative Internet applications are emerging that render communication itself a commodity and classic telecommunication business models are ceasing to work as a result.

In the context of this research field, we currently investigate large scale Cloud Computing in NGNs.

11.22 Machine-to-Machine Communication

Machine-to-Machine (M2M) is a paradigm in which end-to-end communication is executed without human intervention connecting non-IT objects to an IT infrastructure.

M2M communication allows organizing, tracing, and managing communicating objects while minimizing related communication costs. The concept behind M2M is not a new one. Supervisory, Control and Data Acquisition (SCADA) systems are used in manufacturing industries since the 1970s. However, it is predicted that in the next decade the M2M market will witness accelerated growth. The forecasts regarding revenue or number of M2M connections may vary, but it is expected that there will be more objects connected to the Internet than human beings forming a global Internet of Things (IoT).

The rapidly increasing number of connected devices is based on the advancement of the semiconductor industry that continues to reduce chipset cost and power consumption. Also, network convergence and advanced wireless networks enable providing broadband data services at a significantly lower cost per transferred bit. The telecommunication industry will need to face the challenges associated with the inevitability paradigm shift from Human-2-Human communication towards M2M.

The Fraunhofer FOKUS OpenMTC platform is based on latest M2M standards and provides a realistic implementation of a cross-domain horizontal M2M platform enabling fast prototyping and know-how gain through practical experimentation. Through its openness, OpenMTC provides a hands-on shortcut in understanding M2M technology, latest standards, consideration of novel concepts, and their development.

11.23 The framework for a secure development process

The System Quality Center (SQC) has been working for many years on the development of standards for the telecommunications industry, model-driven software development and model-based testing. SQC is also a member of the standardization committees of the European Telecommunications Standards Institute (ETSI) and the Object Management Group (OMG). In these committees, SQC has advanced the development of the TTCN-3 test definition language and UML Testing Profile (UTP) in particular, and it has successfully used both technologies in numerous industrial projects. SQC also contributes to the International Organization for Standardization (ISO), the International Telecommunication Union (ITU-T) and the Open Mobile Alliance (OMA). Additionally, the standardization work of SQC influences the standards for automotive software and control devices that are defined in the Automotive Open System Architecture (AUTOSAR) development partnership. A detailed list of all standards to which SQC has contributed can be found in the downloads section.

11.24 Test modeling of communication systems with TTCN-3

Testing and Test Control Notation Version 3, or TTCN-3 for short, is a specification and programming language for testing communication-based systems. Specifically, this notation is used for testing mobile radio and Internet protocols, services, modules, CORBA-based platforms and programming interfaces. Telecommunication companies use TTCN-3 to test the functionality of end devices and network components, for example. Unlike many other (test) modeling languages, TTCN-3 makes it possible not only to specify tests but also to carry them out. With TTCN-3, tests can be generated with graphical or text editors, translated into conventional programming languages like Java, C++ or C# using compilers, and then adapted to any interface and executed using TTCN-3-based test systems. The programming language was created by ETSI, who continues to maintain and develop it. For 15 years, SQC has been involved in several ETSI expert groups known as Specialist Task Forces (STFs). SQC is currently focusing on the further development of the TTCN-3 standard and its use in testing LTE end devices and Internet network components.

TTCN-3 was presented to the public for the first time in September 2000. Since version 2.2.1., the language has been stable enough for use in tool development and industrial applications. The change request (CR) process has made it possible to transparently track changes since 2005.

11.25 Seamless transitions between system and test development: The UML Testing Profile (UTP)

The Unified Modeling Language (UML) is a graphical modeling notation that has been standardized by the Object Management Group (OMG) and is used for the object-oriented analysis and design of IT systems. UML has become an established “lingua franca" in both research and industry. The acceptance of UML as a modeling notation quickly influenced the research field of model-based testing (MBT). The modeling notation does not define any native test concepts. Such concepts are needed, however, to use UML for the systematic, structured validation and verification of IT systems. To remedy this shortcoming, the UML Testing Profile (UTP) – which SQC had proposed and devised together with other partners – was developed parallel to the draft of the UML 2 specification. UTP supports model-based test processes by specifying dedicated test concepts for analyzing and outlining test cases. UTP seamlessly integrates with UML and prevents any conceptual, semantic or notation-based gaps between system and test development. A new version, UTP 2, has been in development at OMG since

December 2014. Once again, experts from the System Quality Center are a driving force behind the UTP Working Group. UTP 2 directly addresses industry demands for a modern, graphical, easy-to-use test modeling language.

11.26 Information Security Indicators

Information Security Indicators (ISI) have been standardized by the ETSI Industrial Specification Group (ISG). These indicators provide the basis to switch from a qualitative to a quantitative culture in IT Security Scope of measurements: External and internal threats (attempt and success), user´s deviant behaviours, nonconformities and/ or vulnerabilities (software, configuration, behavioural, general security framework).

The Quick Reference Card for ISI summarizes security indicator components to support users to run e.g. security operation centers and/or to compare security measurements. In addition SQC contributes to the ETSI Industrial Specification Group about Information Security Indicators (see below) that focus on benchmarking the operational security in organizations. It has been provided for the ETSI ISG and members of R2GS clubs in France, UK and Germany.

11.27 Model-based Testing for a more efficient Development Process

Software-intensive systems are omnipresent: Whether in finance and healthcare, in aerospace or traffic, software plays an ever greater role. In order to remain competitive in the market, manufacturers are more and more under pressure to deliver high-quality software systems quickly and reasonably priced. The most effective way to ensure the quality of a software product is testing.

Model-based Testing leads to a more efficient Development Process

Traditional testing still faces the same challenges it has for many years. In short, testing bears a high optimization potential to reduce the time to market:

- Lack of automation
- Inflexible process structures
- Unstructured test case derivation
- Implicit tester's knowledge
- Inadequate documentation
- Insufficient communication among stakeholders

Leading experts in the field of quality assurance are convinced that the most promising approach to mitigate those challenges is Model-Based Testing (MBT). MBT uses formal models to improve automation, documentation and transparency of the entire software development process. This results in a more efficient development process – in time and costs – the main target of the Fokus!MBT tool chain.

Test Modeling Based on the UML Testing Profile

Fokus!MBT is an integrated test modeling environment that guides the user along the methodology of Fokus!MBT and thereby simplifies the creation of the underlying test model. The modeling notation used by Fokus!MBT is the UML Testing Profile (UTP) specified by the Object Management Group. It is a test-specific extension of the Unified Modeling Language (UML), which is prevalently used in the industry. This enables testers to rely on the same language concepts as system architect and requirement engineers, which overcomes problems in communication and support the mutual comprehension.

Test Service Infrastructure

The core of Fokus!MBT is based on a service-oriented concept for test-specific services:

- Interface description for test cases and/or test data generators, test script generators, test result feedback from different test execution platforms, report engines etc.
- Adjustment respectively creation of adequate user interfaces and context-specific actions
- Individual customization of Fokus!MBT

Customized Creation of Test Models

Fokus!MBT is based on the flexible Eclipse RCP platform, the Eclipse Modeling Framework (EMF), and Eclipse Papyrus. As a UTP-based modeling environment it is equipped with all UML diagrams but it also includes additional test-specific diagrams. Besides these diagrams, Fokus!MBT goes for a proprietary editor framework to visualize and edit the test model. On top of these features, Fokus!MBT integrates automated modeling rules which ensure the compliance of guidelines - particularly modeling and naming conventions - after and during working with the test model. These constructive quality assurance mechanisms distinguish Fokus!MBT from other UML tools, accelerate the creation of the model and minimize cost-intensive review sessions.

Extended Traceability of the Requirements in the Test Model

The consequent and continuous traceability among requirements and test artifacts is indispensable, but not sufficient. Fokus!MBT takes a major step forward by integrating the test execution results into the test model's inherent traceability network. This establishes a consistent traceability network between requirement, test case, test script and test execution results, making conclusions about the coverage of the particular requirement or the test progress itself immediately calculable. Furthermore the visualization of the test execution results allows a detailed analysis of the test execution flow to preprocess and ultimately evaluate the test results. Thus the test model includes all relevant information to assess the quality of the system under test in order to support the management in its decision making with respect to the release of the system.

11.28 Fuzz Testing – an effective technique for detecting unidentified security breaches

In this increasingly inter-networked world, security testing has become an essential component of the development process. Fuzz Testing has proven to be an effective technique for detecting unidentified security breaches (0-day vulnerabilities). Using this test method, the interfaces of the system that is undergoing testing are faced with non-standard and unexpected inputs in a variety of ways in order to test their robustness.

Random Fuzzing is the easiest way to find security breaches. However, due to the complexity of the input parameter space, it does not offer a sufficient level of efficiency to test the system comprehensively. Smart Fuzzing uses models of your interfaces, protocols or services to generate test cases, thus reducing the large number of test cases to only the most relevant and allowing complex errors to be discovered more easily. Smart Fuzzing is therefore considerably more efficient when compared with simple Fuzzing techniques.

We develop Smart Fuzzing heuristics both for Data Fuzzing (based on Fuzzino) as well as for Behavioural Fuzzing, which are tailored specially to your interfaces, protocols and services. For this, we use system models. However, even if these are not available, we can use functional test cases or system traces and therefore reduce the initial barriers. By using additional information from a risk analysis, the test process becomes considerably more efficient.

Our process is based on an analysis of the system that is to be fuzzed as well as, ideally, on a risk analysis. On the basis of these results, suitable Fuzzing heuristics will be chosen and new ones will be developed. The next step is choosing and, if necessary, annotating suitable test scenarios from which the robustness or security test cases will then be automatically generated. Using the example of an industry partner's banknote processsing system, we have created a risk analysis together with system experts and examined its protocol for possible weaknesses with the help of functional test cases. Based on these functional test cases and with the help of the risk analysis, suitable test cases were chosen and specific security tests generated from these. Both Data and Behavioural Fuzzing were used for this purpose. Thanks to an optimised runtime environment, a high coverage of risks could therefore be achieved in a more reasonable time. The results of this can be found on the DIAMONDS project website.

"Fuzzino", our basic solution for Fuzzing, has already been used by various tool suppliers, including Dornier Consulting and TestingTechnologies. With do.ATOMS, Dornier Consulting offers a test tool for model-based functional tests. With the help of Fuzzino, both security tests and functional tests can be carried out with Fuzzing using the same tool. TestingTechnologies' TTworkbench has also already been prepared for Fuzzing and the newest version offers a TTCN-3 language extension, with the help of which functional test suites can easily be reused for Fuzzing, supported by Fuzzino.

11.29 Tool for the generation and management of metrics

Metrino is a tool to support the validation and quality assurance of models and can be used as an independently or in combination with ModelBus® service. It is able to manage and generate the metrics for domain specific models and allows you to automatically derive metrics from a meta model based on an extensible set of rules or to define custom metrics for it. The metrics can be applied to any model, which conforms to the metamodel they have been generated for. Metrino analyzes and verifies the attributes of the artifacts including complexity, size and description. Furthermore the tool offers different capabilities to present and visualize the metric’s computational results, e.g. in tabular way and kiviat diagram. These results can be analyzed over time, since the tool stores results of multiple evaluations. The overall goal of Metrino is to improve each individual artifact as well as the complete system information and to assure the quality of the final software-based system.

11.30 Model-in-the-Loop for Embedded System Testing

At the early stage of new system functionalities development a model serves as a primary means for including the novelties, yet there is no code, no hardware, and thus no real reference signals for testing. In MiLEST FOKUS proposes a new method for the stimulation and evaluation of embedded hybrid systems behavior which breaks down requirements into characteristics of specific signal features. A novel understanding of a signal is defined that enables us to describe it in an abstract way based on its properties – e.g., decrease, constant, maximum.

11.31 Open Source Framework for tool integration

Today's system development processes are complex and distributed. Many different software tools are involved and typically many persons playing different roles take part in an active or passive position. The key problems faced are the lack of consistency of artifacts produced during the development process, the lack of automation, and the lack of interoperability between tools.

- ModelBus® is a tool integration framework which is used to couple software tools used for software and system engineering.
- ModelBus® bridges the gap between proprietary data formats and programming interfaces.
- ModelBus® automates the execution of tedious and error prone development tasks such as consistency checking across the whole development lifecycle.
- ModelBus® uses SOA and ESB principles and tools are connected to the Bus by provision of ModelBus adapters.
- ModelBus® is an Open Source initiative.

11.32 A Test Environment for Cooperative Driver-Assistance Systems

Avoiding rush hour traffic jams, safely and comfortably – cooperative driver-assistance systems are supposed to make this scenario a reality soon. Such systems can warn their drivers about unforeseeable situations like the end of a traffic jam behind a turn and then suggest alternative routes. The efficient communication technologies allow vehicles to communicate with other vehicles, as well as with the surrounding traffic control infrastructure. In this kind of communication process, each vehicle conveys anonymous data regarding its speed, its position or the traffic situation in its near environment. This data is then processed by intelligent driver assistance systems and – if required – provided to the driver. The foundation for these driver-assistance systems is a dependable and secure transmission of data between vehicles. With its V2X-testbed, Fraunhofer FOKUS, member of the Car2Car Communication Consortium, offers a test environment that is dedicated to this kind of communication and allows for testing the communication characteristics of cooperative V2X systems.

The FOKUS V2X testbed: Guaranteeing Higher Quality and Dependability

Vehicle-to-X-communication not only offers higher safety in traffic but also increases comfort for drivers. However, only if the cooperative driver assistance systems fulfill quality standards and are interoperable, all traffic participants can make benefit from the technology. The Fraunhofer FOKUS V2X testbed enables systematic and automated testing of networked, cooperative driver assistance systems. It creates a flexible and expandable basis for conformance, interoperability and regression testing. The testbed furthermore allows the testing of V2X-systems with regard to their functional features, real-time behavior, stability, robustness, security and interoperability. In addition, the tests can be executed in a virtual environment without using dedicated communication hardware (virtual testbed). That way, testing can already be carried out in the early stages of software development and thus can be used to detect applications errors in the early development phases when hardware is only sparsely available.

Standard-based Testing – Adaptable to Individual Needs

The FOKUS V2X testbed is flexible and configurable. It can realize and test different system configurations of individual vehicle systems (IVS), individual roadside stations (IRS), and traffic control centers. In this context, the customized user interfaces allow users to see both the technical communication details and the high level view on positions and velocities of the vehicles during the test scenario. The standardized test description language TTCN-3 guarantees an easy programming and automation of the testing procedure. Overall, Fraunhofer FOKUS' testbed guarantees the ideal test environment for the automatized testing of dispersed V2X-applications and V2X-systems. The technology thereby is an important contribution to the safe networking of future vehicles.

The V2X testbed was developed with the research projects simTD, DRIVE C2X and PRE-DRIVE C2X. It was used in cooperation projects with partners from the automotive industry.

11.33 Projector Auto-Alignment for Arbitrary Shaped Screens

A multi-projector system is often necessary when projecting content on curved screens, such as panoramic or dome projections. The challenge lies in calibrating the projectors with reasonable expenditures of time and effort in such a way that a homogeneous image is created.

VISCOM has developed an automatic camera-based projector calibration procedure that stands out with its great flexibility and speed. Test patterns are projected onto the screen and automatically captured by digital cameras.

Using imaging processing algorithms, the image parts sent by each projector are then distorted and adapted to the screen in such a way that a high-resolution, seamless image emerges. The projectors' partial images are accurately adapted to one another in the areas of overlap. Automatic projector re-calibration can easily and quickly be run whenever the position or the parameters of one or more projectors change. The projection screens can be of any shape: domes, spheres, cylinders, and curved screens are just some examples.

The system thus covers all necessary functions for an automatic multi-projector calibration: geometry correction (warping), automatic softedge blending, brightness correction and projector auto-alignment. VISCOM holds several patents on camera-based projector autocalibration.

Fraunhofer FOKUS is licensing the software (warping, blending, and projector autocalibration) and integrates it in existing and new systems, such as media servers, warping boxes and projectors.

In the last ten years, more than 130 multi-projector installations with more than 600 projectors in 13 different countries worldwide have been created using the Fraunhofer FOKUS software for projector autoalignment, warping and edgeblending. Most of the installations are planetarium domes, amusement parks, flight simulators and 3D dome cinemas.

In 2013, VISCOM disclosed the details of their automatic projector calibration technology in the book “Fullspace-Projektion. Mit dem 360°Lab zum Holodeck" that was published by the Springer Publishing

11.34 Automatic calibration for camera clusters

Camera clusters are systems composed of multiple cameras recording simultaneously, used for capturing very high resolution and surround-type content. The main problem with the camera clusters is compositing - stitching and blending the multiple video streams into a single perfect image, without visible seams. This explains the lack of real content for domes and other surround screens; most content is now computer-generated.

VISCOM's patent-pending technology offers automatic calibration for arbitrary camera clusters, able to cope with lens geometric distortion, position and orientations and produces the needed warping and blending data.

These can be used for both live streaming and for post-production. Most competing systems do not offer live capabilities, in contrast to VISCOM's system that can thus be used for augmented reality and tele-presence (for example for experiencing at home the complete immersion in the concert hall using VR glasses and live streams).

11.35 Media server for the control of multi-projector systems

Without specialized equipment, large-format or wide-angle projections can only be realized by distributing the image across several projectors. The media server that Fraunhofer FIRST has developed in close cooperation with Carl Zeiss facilitates auto-calibrating projections onto randomly shaped surfaces and consists of the show player, screen configurator, and show manager.

The player displays the media (e.g. films, videos, sounds, and texts) and provides partial images to each projector. No specialized hardware is needed because image processing takes place on ordinary PCs.

The screen configurator is the planning tool. With it, the projection geometry is defined in advance and an appropriate projector setting considering the respective projector types and determining projector number, position, and orientation is determined. It is responsible for auto-calibration and calculates the distortion rules needed by the player to compose a seamless overall image regarding geometry, brightness, and color from the projectors' partial images.

Different media types are combined to shows and replayed in real-time with a resolution of 8K x 8K. Similar to a video editing program, various media types such as film and still images can be combined and external devices can be integrated. Gamepads or joysticks can be connected to the system to provide an immersive gaming experience. Additionally, device-free control of multi-media content is possible through gesture commands. Live input can easily be integrated through the combination of different media in real-time (Realtime Compositing).

The technology is suitable for active and passive stereo projection.

The software can be licensed in two ways: the software can either control multi-projector systems directly as a stand-alone model. Alternatively, individual segments of the system can be integrated into existing visualization systems. Fraunhofer FIRST is available to license holders as a competent partner in the further development of the system. Carl Zeiss is using the system as the basis for its PowerDome system (digital planetarium).

11.36 Warping and blending for any application

In cooperation with the producer of graphic processors NVIDIA, the Business Unit VISCOM has developed a process for desktop warping. Laying at the graphic card driver level, it enables any application to benefit from warping and blending.The process is already successfully in use in multimedia-control rooms.

11.37 Real-time processing of medical image data

Modern endoscopes and microscopes as well as CTs and MRIs provide high-resolution image and video data. VISCOM is developing algorithms specifically tailored to its customer’s needs for real-time processing of such data on GPUs (Graphic Processing Units). As a result of their high degree of parallelization, GPUs are especially well-suited for execution of computationally intensive processes such as real-time image processing. Great data volumes can be analyzed swiftly and efficiently because of parallel processing of large numbers of processes.

Real-time processing of high-resolution images is for instance necessary for a realistic view of minimally invasive operative areas. VISCOM ’s software generates 360-degree panoramic views from the endoscope’s partial images that can be enriched with patient data, such as MRIs. The researchers are also assisting manufacturers of medical technology by integrating contactless user interfaces like head, view, voice, or gesture commands.

High intensity focused ultrasound (HIFU) minimally invasive surgery techniques need performant organ/tumor tracking in order to be usable in the body (outside of the head area) to compensate for the respiratory induced motion. VISCOM's motion tracking and sensor fusion algorithms offer very precise tracking, with continuous mm-level accuracy.

11.38 Simulators for equipment development

Efficient simulators can significantly reduce development times in medical technology and facilitate greater acceptance of the devices in advance. VISCOM's researchers design models of future medical devices, particularly for minimally invasive surgery, and integrate models of the human body into the simulator to test the behavior of the medical equipment. This makes it possible to test and improve the optical and mechanical properties at an early stage using a model which leads to significant error reduction. The simulation results are computed on GPUs (Graphic Processing Units), allowing for high frame rates, which in turn make real-time simulations possible.

12. Fraunhofer Heinrich Hertz Institute HHI

Website Link: http://www.hhi.fraunhofer.de

12.1 Institute Overview

English: At the heart of Fraunhofer Heinrich Hertz Institute's research work are developments of modern communication networks and multimedia systems. We develop concepts for innovative information technologies and create new applications for new products in partnership with the industry.

The core competencies of the Fraunhofer HHI are in the areas of photonic networks and systems, fiber optic sensor systems and video coding and transmission.

One focus is optical wireless communication. It enables high-speed short-range links, especially in environments where particular demands are made in terms of electromagnetic compatibility and security.

The Fraunhofer HHI focuses on 10 to 100 Gbit transmission in the field of high-performance telecom components. In the area of mobile broadband systems, the Fraunhofer HHI concentrates its development activities on signal processing, wireless link and system optimization.

The Fraunhofer HHI's developments of fiber optic measuring systems enable new and innovative laser und sensor concepts. They play an important role in the optimisation of energy efficiency and are a key factor for new and future-oriented markets.

Main research topics are additionally in the area of video- and audio-coding and transmission. The Fraunhofer HHI makes a significant contribution in the fields of greater efficiency in compression methods, autostereoscopic 3D displays and in the integration of real and virtual worlds for immersive multimedia applications.

Korean: 프라운호퍼 하인리히헤르츠 연구소(HHI)는 첨단 정보통신 네트워크 및 멀티미디어 시스템 개발에 주력하고 있습니다. 혁신적인 정보기술 개념을 구축하고 기업들과 협력하여 새로운 제품을 위한 응용기술을 개발하고 있습니다. HHI 연구소는 광학 네트워크 및 시스템, 광섬유 센서 시스템, 비디오 코딩 및 전송 분야에 핵심역량을 보유하고 있습니다. 특히 광무선통신은 전자파 적합성 및 안보 관련 요구사항에 최적화된 초고속 단거리 링크를 지원합니다. 연구소는 10~100 기가바이트 전송이 가능한 고성능 통신 부품, 모바일 브로드밴드 시스템 신호 처리, 무선 링크 및 시스템 최적화 관련 연구개발도 수행하고 있습니다. 광섬유 측정 시스템 연구를 통해 개발된 새롭고 혁신적인 레이저 및 센서 기술은 에너지 효율성 최적화에 크게 기여하고 미래형 시장에서 중요한 요소로 대두되고 있습니다. 비디오·오디오 코딩 및 전송의 경우, 고효율 압축, 무안경 입체 디스플레이, 몰입형 멀티미디어 응용을 위한 물리적 세계와 가상현실 결합 분야의 기술 발전에 크게 기여했습니다.

12.2 Optical wireless communication

Optical wireless communication can be considered as complementary to radio for wireless access, and is attractive for high-speed short range links in settings where radio is not desired. Possible uses include optical WLANs or point-and-shoot links in various environments.

Visible light communications (VLC) profit from various favourable factors, including

- Omnipresence of LEDs in displays, signalling and illumination
- LEDs, as semiconductor components offer a significant potential for high-speed modulation
- Data transfer piggybacked on illumination (or signalling) to create broadcasting hot-spots
- Add-ons without additional infrastructural components

As VLC relies on lighting, it is highly suited to settings where lights are always on, such as large offices, production facilities, medical areas or public transport systems, including airplane cabins. Yet VLC can equally be used in various applications beyond communication - such as light design for big halls or indoor GPS-data extension.

12.3 FTTx Network Planning

The central goal of FTTX-Plan is to support the strategic decision process of public utility companies and regional suppliers by performing an objective analysis that considers the varying, but always case-dependent boundary conditions.

The approach reduces planning uncertainties, supports a more realistic forecast of costs and also detects potential technological dead-ends early in the design process. Especially operators of future FTTx networks for city environments and small regions will benefit from these flexible analysis and optimization methods for strategic network planning.

To advance a positive business case, the techno-economic dependencies between total cost of ownership and the possibble system technologies need to be well understood. A thorough understanding of photonic technology trends and sophisticated optimization techniques canned in computer-based methods provides a key benefit for network planners of future FTTx networks.

12.4 On-Chip Measurements

In order to test research stage devices we offer electrical and optical characterization of photo diodes and edge emitting as well as surface emitting laser diodes. We carry out chip-level high frequency RF-contacting and stable fiber coupling for tests in system environments.

12.5 Optical Multi-Format Transmitter

The Optical Multi-Format Transmitter is a high bandwidth optical frontend. In combination with the electrical arbitrary waveform generator it enables the flexible generation of optical data signals with various modulation formats, such as OOK, QPSK, 8-PSK and 16 QAM up to 34 Gbaud. Software-based predistortion guarantees optimum signal quality.

12.6 Photonic Components

The Photonic Component Department (PC) does research for 100+ Gbit transmission and detection optochips and optoelectronic circuits and related analog ICs. These are a key enabler for cost efficient optical component and modules, and thus a key success factor for our customers. We offer production and development services in all our activities to the German and international industry. As an example, if you already have a concrete optochip design in mind, we offer additional consulting and would do design and fabrication iterations. Or if you start with a target spec, we would typically begin with a feasibility study and generate a design of our own. In all cases, we are able and willing to do initial production volumes in ISO certified, qualified production. We also offer our e-beam services, and design-to-spec diffractive optical elements.

The 1.2-1.9 µm wavelength range is very interesting for sensing applications. Here, telecom technology based lasers and detectors are in our portfolio serving applications from industrial combustion sensing to satellite-to-satellite optical communication. We also research silicon wafer based sensor applications.

Terahertz waves carry with them a multitude of potential applications, ranging from detection of ill teeth over final product control in drug manufacturing, up to detection of hazardous substances. HHI uses telecom technology to bring terahertz sensing from the lab table to a handheld technology.

12.7 Fiber Optical Sensor Systems

Fiber optic and photonic measuring systems drive development of innovative concepts of measurement and regulation while also opening up whole new areas of applied use. They play a role in the optimization of energy efficiency and serve as a key innovation factor for new and future-oriented markets.

In the Fiber Optical Sensor Systems department at the Fraunhofer Heinrich Hertz Institute the focus of our application-oriented research is squarely on a new generation of photonic sensors. These are distinguished by extreme miniaturization, high networking and communication capability and extremely low power consumption or even complete energy self-sufficiency.

The challenges this involves are manifold - new materials need to be researched and new processing methods for integrated optical components with ultrashort laser pules need to be developed along with new concepts for the production of chip based photonic sensors and sensor systems.

The Fiber Optical Sensor Systems department is located on the EnergyCampus in Goslar close to the Energie-Forschungszentrum Niedersachsen (EFZN) and the Clausthal University of Technology.

12.8 Femtosecond laser processing of miniaturized optical systems and sensors in glass substrates

Ultrashort laser pulses (< 100 fs) are very well suited for tailored processing of optical transparent materials on a micrometer scale. Due to the very short time of interaction no thermal processes arise and a structural change of materials is restricted to the laser focus volume. By adjusting carefully the laser parameters in glasses an increased refractive index change can be induced by femtosecond pulses. Based on this we developed a technique for direct writing of optical waveguide structures in nearly all glass materials. In figure 1 waveguides with different diameters for single or multi mode applications are shown. A further advantage of our technique is the ability of an easy adaption of the diameter of the waveguides, tailored for the mode field and wavelength of the guided light for a broad wavelength range from the visible to NIR. Additionally Bragg grating structures can be introduced inside the waveguides. This Bragg grating waveguides (BGW) can be used as high reflection mirrors or spectral filter elements for wavelengths from visible to NIR in optical circuits (figure 2). All optical structures are not visible by eyes. 3D-Optical elements like splitter or coupler waveguide elements, spectral filters or mirrors can be introduced in nearly all glass materials, enabling miniaturized applications in measurement engineering (figure 3).

We have successfully introduced BGW in ultra thin glasses from Schott (figure 4). This opens new applications for sensing of local deformation of surfaces (displays) or can be used as optical microphones. Ultra thin glasses often are used as packaging materials for MEMS. With our technique now this can be combined for integration of optical elements enabling new architectures in design of photonics and MEMS.

Glass chips with BGW structures are also suited very well for sensitive chemical analytics or for monitoring industrial chemical production processes. For this the waveguides with the Bragg grating structures are guided close to the surface of the glass substrate. Due to evanescent interactions with the chemical medium, surrounding the glass chip, a shift of the reflection wavelength is introduced. The sensitivity for specific chemical targets can be increased by deposition of associated receptors.

In summary, our technique is best suited for rapid prototyping of miniaturized optics for wavelength from visible to near infrared in glass substrates. In comparison to lithographic techniques for fabrication of waveguides no time consuming development for masking and etching is necessary, but rather new technological developments are made accessible.

12.9 Femtosecond laser processing of micro- or nano surfaces: controlling tailored physical or chemical properties of materials

Photonic processes, particularly laser based material processing methods allow for a variety of possibilities to provide materials with novel characteristics. Especially laser beam sources, emitting ultra short laser pulses with durations in the femtosecond regime (10-15 s), enable the realization of such novel material properties. On this time scale the light – materials interaction is too short for an efficient heat transfer into the material. Subsequently the processed material does not melt and micro- or nanostructures build up within the area of the Laser focus. Depending on the Laser pulse parameters (pulse energy, pulse duration, number of pulses, shape of pulse, wavelength of laser) and the surrounding process gas atmosphere a variety of structures can be adjusted precisely. Moreover tailored laser pulse can be formed on a time scale individually by adaptive dispersive optical elements. A feedback loop is implemented for monitoring the emerging structure of surface during laser process. This enables a set up of a closed process loop with a self learning algorithm which is used to optimize the shape of femtosecond laser pulses (figure 1). By this materials with specific tailored properties can be designed within one processing step:

Hydrophobia: Hydrophobic surfaces can be functionalized by nano- and microstructures, so that they exhibit dirt-repellent (figure 2).

Heat sink: The characteristic surface appearance of micro structured metal surfaces is a spiked-structure at micrometer level (figure 3). Aluminum plates with micro structured surfaces have a significant enhanced heat radiation and can be used for cooling tasks (figure 4). In comparison to conventional heat sinks the weight and volume of micro structured Aluminum plates are strongly reduced which makes them attractive for cooling elements of LEDs or for space technologies for satellites.

Optics: The reflectivity of the laser structured surfaces can be adjusted precisely with the choice of tailored laser pulses. This can be used to fabricate reflection standards for optics or diffuse scattering screens for lightning applications with LEDs (figure 5).

Photovoltaic: Femtosecond laser structuring of Silicon in Sulfur Hexafluoride atmosphere enables the expansion of light absorption into the mid infrared which makes such materials attractive for solar industry or as elements for NIR detectors.

Rechargeable Batteries: Nano structured surfaces of electrodes are promising candidates for enhanced production of hydrogen or for rechargeable energy storage in novel rechargeable zinc-air batteries (see Project Zisak).

12.10 MediaExplorer

Search in large video collections is usually done by using keywords such as “beach“, “flower“ or “landscape“. The manual assignment of such keywords to videos for video search, is however very laborious and inaccurate. The Fraunhofer Heinrich Hertz Institute HHI has developed technologies to automatically analyze video content and assign keywords to videos.

Technical Background

The approach for automatically assigning keywords to videos is divided into three steps

- Extraction of metadata
- Training
- Classification

In a first step, features (e.g. edges, color and geometric shapes) suitable to describe video content are automatically extracted from video frames. For each category (e.g. “beach“) to be learned by the system, a training set of video frames is required, which contains positive and negative samples of the category.

In the second step, the system is trained with the features extracted from the training set, in order to be able to distinguish the learned category from other categories. The system is then able to determine if previously “unseen“ video frames belong to the learned category or not, by analyzing their features.

12.11 Interactive Soccer Experience

Soccer is one of the most popular sports in the world, attracting billions of fans. The Fraunhofer Heinrich Hertz Institute offers a wide spectrum of automatic analysis technologies for soccer broadcast. These technologies enable faster and more precise retrieval of soccer content as well as a more interactive experience when watching soccer matches.

12.12 HEVC - Software and Hardware Solutions

High Efficiency Video Coding (HEVC - officially to be approved as ITU-T H.265 | ISO/IEC 23008-2) is the next-generation video-compression standard of ITU-T and

ISO/IEC. It was developed by the Joint Collaborative Team on Video Coding (JCT-VC) with significant contributions from Fraunhofer HHI's Image Processing department. Compared to its predecessor H.264/AVC, HEVC achieves about 50% bit-rate reduction at the same subjective video quality.

Fraunhofer HHI's Image Processing department develops HEVC software and hardware solutions, demonstrating the benefits of the newest video-coding technology H.265 / MPEG-HEVC.

12.13 HEVC 4K Bitstream Test Suite

To achieve high coding efficiency, the HEVC standard allows much more flexibility in encoding decisions and bitstream variations compared to previous video coding standards. For HEVC decoder products, it is important to ensure as early as possible that they are compatible with all possible conforming bitstreams that current and future encoders might produce. The aim is to avoid update or replacement costs if incompatibilities are found later.

The HHI HEVC bitstream test suite is a set of specially crafted coded video sequences that can be used to test conformance of HEVC decoders. Each of these bitstreams has specific characteristics that test the functionality of all individual components of an HEVC decoder and their interactions. A reference decoder is shipped with the test suite that can be used to verify the decoding results.

The HEVC bitstream test suite is targeted at 2160p60 Main and Main 10 Profiles (both at Level 5.1 Main Tier).

12.14 Authoring for MPEG-DASH

Dynamic Adaptive Streaming over HTTP (MPEG-DASH) is the recent open, standardized solution for high-quality video delivery over IP to connected TV sets, set-top boxes and mobile terminals. The Fraunhofer HHI offers an Authoring software for MPEG-DASH which is suitable for HD, 3D and future media codecs.

12.15 H.264 Bitstream Test Suite

H.264/MPEG-4 AVC is a new high efficiency video coding standard that has been chosen as a base technology for a variety of applications like mobile multimedia (3GPP, DMB, DVB-H,), SD and HD TV broadcast (DVB-S2) or home cinema (HD-DVD, Blu-ray Disc)

For survival in the fast growing market of H.264/AVC decoder products it is crucial to develop stable and correct implementations of this complex technology. Such high quality products require intense testing regarding all features of the video coding standard.

Fraunhofer HHI offers different sets of test bitstreams which can be used for testing H.264/AVC decoder chips or Set Top Boxes. For covering all different aspects of decoder testing, these streams are provided in the following categories:

- low level syntax test bitstreams
- high level syntax test bitstreams
- typical broadcast bitstreams
- stress test bitstreams
- pathological test bitstreams for testing error resilience / error concealment

12.16 HEVC 4K Real-time Hardware Decoder

Fraunhofer HHI has developed a completely hardware based H.265 / MPEG-HEVC decoder IP core. Without an additional processor core, the decoder achieves real-time performance for 4K ultra high definition (UHD) video requiring only moderate clock frequencies. For evaluation purposes the design is available as an implementation for the Altera Stratix V GX Advanced Systems Development Kit (4K /UHD) and the Altera Stratix V DSP Kit (up to 1080p60).

12.17 Real-time Stereo-to-Multiview Conversion

Glasses-free 3D will be the future of 3D home entertainment. To display stereoscopic 3D content on multiview displays a 3D format conversion is required. Developed at Fraunhofer HHI, the real-time stereo-to-multiview conversion engine allows playback of any stereoscopic 3D video content on most existing autostereoscopic displays. Costly offline conversion is no longer needed and personal 3D viewing preferences can be adjusted on-the-fly.

Depth estimation – the heart of stereo-to-multiview conversion – is now available as a pure hardwired IP core suited for FPGA and ASIC implementation. For evaluation purposes a reference FPGA implementation can be provided.

12.18 Enhanced Low Latency Video Codec

The Fraunhofer Heinrich Hertz Institute HHI offers a range of H.264 /AVC compliant codecs (IPs) for use in industrial applications. Specially tailored to real-time applications, the IPs allow coding of up to 1080p resolution on current FPGA technologies. The codecs are fully hardwired implementations with low power consumption and minimal resource usage.

12.19 Ultra Low Latency Video Codec

Fraunhofer HHI offers an ultra-low latency video encoder compliant with the H.264 baseline profile. The encoder is implemented as a hardwired solution, which can be mapped on FPGAs or ASICs without the need of external memory. It is especially tailored to real-time applications and allows up to 1080p encoding with today's FPGA or ASIC technologies.

12.20 OmniCam-360

The scalable, mirror-based multi-camera system OmniCam was developed at the Fraunhofer HHI. It allows the recording of live video in 360° panoramic format. The newest OmniCam-model, the OmniCam-360, consists of ten 36° mirror segments. Each mirror segment is equipped with one HD camera. The cameras of the OmniCam-360 are arranged vertically and in a circle and are therefore reciprocal to the cylindrically arranged mirror segments. Also, the cameras are placed around a virtual center. This arrangement allows parallax-free image stitching of scenes in the range between 1 meter and infinite. The covered field of view is about 60°.

With a resolution of up to 10,000 x 2,000 pixels, OmniCam-360 generated videos are optimal for immersive applications. Since 2014, material generated by the OmniCam, can be processed in real-time. Supported by the Real Time Stitching Engine developed at the Fraunhofer HHI, the panoramic content can be displayed on tablets and VR-glasses in real-time.

By enlarging the system, the OmniCam-360 can also generate 3D-video content. The crucial difference between the 3D OmniCam and its 2D version is the number of cameras. While the 2D version is equipped with a single camera per mirror segment, the 3D version is equipped with two cameras per segment. The 3D-rig of the OmniCam-360 features a total of ten 36° mirror segments with two cameras each. This amounts to a total of 20 micro HD cameras for 360° 3D panoramic recordings. To achieve the 3D effect the lenses of each camera pair are arranged in distances between 40 and 70mm. Lens pair distances are adjustable within this range. Further, to achieve optimal 3D imaging, each lens pair should be distanced close to the average eye distance of 65 mm.

As in 2D imaging, the vertical image section is also 60° in 3D panoramic imaging. The 3D OmniCam system allows parallax-free recording for distances larger than 2 meters.

12.21 Real Time Stitching Engine

The Real Time Stitching Engine (RTSE) is a software-based solution for the real-time processing of ultra-HD panoramic recordings. The software supports all necessary steps to process a certain number of omnidirectional camera images into an ultra-HD panorama. Processing includes color matching, warping, stitching and blending. The software runs on a single multi-core PC with the factory installed graphics card. It is possible to process several HD input streams simultaneously.

The Real Time Stitching Engine supports various output formats:

- A low-resolution panorama, which may be embedded in a regular HD image; these images may be used to create onsite panorama previews as well as for the purposes of reviewing raw recordings and the processing of proxies during post-production editing
- HD images, which may be panned and zoomed within the HD panorama; this technique may for example be used in live productions to control critical recording features such as image transitions, to transmit HD component images from the panoramic content to regular transmission environments or to enable the navigation by users in the various interactive applications
- Various panoramic HD outputs may be deconstructed into overlapping, simultaneously codable HD tiles and used for the live transmission of the entire ultra-HD content
- The latest developement makes it possible to transmit the UHD panoramic content to so-called Virtual Reality (VR) glasses so that the spectator is able to enjoy a truly immersive experience

12.22 Tomorrow‘s immersive Media Experience Laboratory

Behind the acronym TiME Lab (Tomorrow‘s immersive Media Experience Laboratory) hides an entire chain of systems and applications, which we unlock while working on projects. In the showroom setup in Berlin, experts integrated innovations in the areas of 180 ° video projection, steric audio rendition and the real-time broadcasting of panoramic recordings. In 2009, the Heinrich Hertz Institute (HHI) opened the TiME Lab to demonstrate new media technologies. It is a one-of-a-kind media laboratory, which measures about 60 square meters and features a 3.35 meter high and 12 m long curved projection screen, 14 HD projectors and a ring of 120 speakers at ear level, 15 ceiling speakers and 4 subwoofers. With a design of this scale this TiME Lab showroom sets new standards in media technology.

The acoustic in this showroom by far outperforms the acoustic of cinema halls. Precise acoustic renditions are achieved by using elaborate acoustic dampening among other techniques. The speakers are integrated in acoustic damping materials. Four independently controlled subwoofers reproduce acoustic 3-D effects and create a directional acoustic experience in the low frequency range. Until now, listeners heard low-frequency sound only from the front. The IOSONO Company provided the speaker system for the TiME Lab showroom.

Another special feature of the TiME Lab is the acoustically transparent, curved projection screen. The ring of 120 speakers is completed behind this screen. The building of a cylindrical screen has been realized for the first time in the showroom.

Since 2012, our mobile version of the TiME Lab allows us to demonstrate many applications such as live broadcasts of ultra HD recordings. The mobile TiME Lab can also be used for panoramic projections as part of exhibitions and trade fairs. The mobile TiME Lab resembles a so called room-in-room treatment, in which up to 60 viewers can be accommodated. The mobile TiME Lab has already been used on several occasions.

12.23 Hybrid 3D

The powerful Stereo 3D Production Workflow

A system based on Trifocal Depth Capture is providing a way towards reliable depth maps with only minimal additional effort on set compared to 2D. During postproduction dense depth maps are estimated allowing rendering additional virtual views with an individual virtual camera baseline optimally adjusted for the planned screening scenario.

12.24 Multi Camera Content Creation

In the European FP7 research project MUSCADE the Fraunhofer Heinrich Hertz Institute HHI develops calibration and assistance tools for multi-camera setups that enable high-quality 3D production for next-generation 3DTV with no need for special glasses.

12.25 Virtual Eye Contact Engine

Fraunhofer Heinrich-Hertz-Institute presented the Virtual Eye Contact Engine for the first time to the public at 3D Stereo Media 2010. This prototype demonstrator allows the user to perceive direct eye contact with a remote party although the user is captured by cameras mounted on top of the display. The eye contact problem is one of the key drawbacks of current video conferencing systems and is caused by the fact that the cameras cannot be mounted at a position where the user is looking at, i.e. the centre of the display. By applying a real-time 3D analysis on multiple camera views and a succeeding virtual view rendering, it is possible to create a novel view of a camera virtually placed at the centre of the display. The perception of eye contact awareness strongly depends on the quality of the depth estimation and on the rendering of a novel view in high quality and high resolution. This is convincingly offered by the presented system.

12.26 STAN – Stereoscopic Analyzer

Perfect Stereo 3D Production in Real-time

The Stereoscopic Analyzer STAN is a system for production of perfect stereo 3D. STAN combines real-time image analysis with intelligent automated tools. An intuitive graphical user interface assists camera operators and production staff in shooting technically correct stereo for all 3D genres including live events.

12.27 Real-time Stereo-to-Multiview Conversion

Watching 3D without glasses will be the future of 3D home entertainment. However, current stereoscopic 3D content is not suited to drive autostereoscopic displays and a 3D format conversion is required.

The real-time stereo-to-multiview conversion engine allows playback of 3D Blu-ray content or any other stereoscopic 3D video content on most existing autostereoscopic displays. Costly offline conversion is not needed anymore. Personal 3D viewing preferences can be adjusted by the user on the fly.

12.28 AFX Plug-in Suite for Stereo-to-Multiview Conversion

3D content generation for autostereoscopic displays from live-action stereoscopic 3D

Glasses-free 3D using autostereoscopic displays in digital signage is going to become a competitive alternative to conventional 2D presentations. Several companies already provide fully integrated 3D solutions for digital signage. Content creation, however, is still a major problem. While computer-generated content can easily be converted to multiview representations required for autostereoscopic displays, content creation or conversion of live-action content still remains a challenge. Fraunhofer HHI now provides an easy-to-use AFX plug-in solution for high-quality 3D content conversion from live-action stereo footage.

12.29 Multi-Projection

The Fraunhofer Heinrich Hertz Institute has developed an immersive projection technique (panorama projection) for digital cinemas, which should convey a realistic (immersive) impression. With this technique you are able to project electronical movie pictures in a high size and resolution never seen before.

The typical large screen projection with overlapping of multiple single projections has been dramatically improved through absolutely field adjusted synchronization of any given number of sections as well as a transition- and stripe free overblending of the horizontal and vertical arranged projectors.

A modular concept and the MPEG-2 standardized compression algorithm, help to realize user specific formats and at the same time to reduce amount and expenses. Those features listed above were all implemented in the CineBox.

This principle (patent pending) will be sold through the supervision of a license

12.30 Virtual Mirror

Our Virtual Mirror enhances the visualization of customized consumer articles like:

- shoes
- clothes
- jewelry
- etc.

Instead of viewing yourself in a real mirror to verify the appearance of apparels, highly sophisticated 3D image processing techniques are used to visualize the look of new products without the need to actually put them on. A camera captures the real world and outputs the mirrored image onto a large display which replaces the real mirror. The 3D movements of the person are tracked in real-time and computer graphics models of the consumer articles are augmented into the video such that the person seams to wear the virtual objects.

Features

Augmented reality visualization without glasses or other technical aids

Combination of real and virtual parts in one world

Visualization and customization of virtual products in real environments

Possible applications of the system are the visualization of customized shoes, clothes, jewelry, glasses or hairstyles

Innovations

High-end augmented reality technique

Highly sophisticated image processing techniques allow real-time experience

Simple hardware architecture for more reliability

13. Fraunhofer Institute for Applied State Physics IAF

Website Link: http://www.iaf.fraunhofer.de/en.html

13.1 Institute Overview

English: High frequency circuits for communication technology, robust gallium nitride voltage converters for efficient use of regenerative energies, infrared and UV detectors, semiconductor lasers for the detection of hazardous substances, micro-sensors for gas and fluid analysis, or innovative diamond technologies – this is only a small selection of developments with which the Fraunhofer IAF advances research and the development of innovative semiconductor technologies.

Based on III-V semiconductors we develop electronic and optoelectronic devices for a wide range of applications. As one of the leading research facilities worldwide in the area of III-V semiconductors we cover the entire value chain: our core competences range from materials research, design, technology and circuits to modules and systems.

Korean: 프라운호퍼 응용고체물리학연구소(IAF)는 고주파 회로 통신기술, 회생에너지의 효율적인 사용을 위한 질화갈륨 변압기, 적외선·자외선 검출기, 유해물질 검출용 반도체 레이저, 가스 및 유체분석용 마이크로 센서, 다이아몬드 기술 등 혁신적인 반도체 기술의 연구개발에 앞장서 왔습니다. 연구소는 III-V 반도체를 기반으로 각종 분야에 사용되는 전자 및 광전자기기를 개발하고 있습니다. III-V 반도체 분야의 세계적인 선도 연구기관으로 산업 가치사슬 전반을 다루며, 특히 소재연구, 설계, 기술, 회로, 모듈, 시스템 연구에 주력하고 있습니다.

13.2 High Frequency Electronics

Increasing amounts of data need to be transmitted within a very short time – be it in applications for communication, sensors or astronautics. Tomorrow's solutions place high demands on electronic devices: they need to be fast and energy-efficient but also small in size.

We develop a wide range of high performance integrated circuits for frequencies up to and over 600 GHz based on III-V compound semiconductors in the business unit »High Frequency Electronics«. Moreover, we create monolithic integrated microwave and millimeter-wave circuits by means of metamorphous HEMT technology on GaAs substrate. Together with our project partners from research and industry we manufacture complete systems for sensors and communication technology.

Our electronic devices increasingly advance into the terahertz regime. Within the next few years, we will further increase the functionality of the circuits – up to complete systems on a single chip.

13.3 Power Electronics

Increasingly efficient systems to produce, distribute and use electrical energy are necessary to cover the increasing worldwide energy needs. Further development of new semiconductor materials, such as gallium nitride, is necessary to meet these challenges.

The business unit »Power Electronics« develops high performance transistors and monolithic integrated circuits on the basis of the compound semiconductor gallium nitride (GaN). The semiconductor material can realize more powerful and more efficient electronics than silicon. We use modern high electron mobility transistor technology to realize power electronics for operating frequencies between 1 MHz and 100 GHz.

GaN devices can save energy in a wide array of application. They can give new drive to the market of electric and hybrid vehicles in the form of efficient voltage converters and increase the efficiency of photovoltaic systems or household appliances. Gallium nitride based high frequency power electronics will also be used in mobile communication and plasma generators.

13.4 Photodetectors

Imaging systems for wavelength regions not visible to the human eye have a tremendous impact on security and safety systems. They are also key enablers for industrial process control, environmental imaging as well as medical diagnostics.

Our business unit »Photodetectors« focuses on the development of detectors with high spatial resolution and the ability to detect infrared radiation in different wavelength ranges simultaneously – our high resolution dual-color infrared cameras are unique worldwide. A large part of our research addresses bi-spectral thermal imaging systems for infrared detectors within the two transparent atmospheric windows in the midwavelength infrared (λ = 3 – 5 µm) and the long-wavelength infrared (λ = 8 – 12 µm). In addition, work in our business unit includes technology development for UV and IR detectors and small scale serial production.

Short-wave infrared detectors (λ = 1.4 – 3 µm) with very high sensitivity are developed for the replacement of night vision goggles and for active imaging systems such as gated viewing cameras. We are also working on advanced detector concepts based on compound semiconductor heterostructures to increase the performance of bi-spectral imaging systems.

13.5 Semiconductor Lasers

Photonics has been recognized as a key enabling technology with widespread use in a multitude of innovative applications. Most of today's photonic applications are powered by semiconductor lasers or light-emitting diodes (LEDs) as compact and robust light sources, which directly convert electrical energy into light. A particularly prominent example is the use of high brightness LEDs for lighting (»solid state lighting«).

The main tasks of the business unit »Semiconductor Lasers« are the development of infrared semiconductor lasers and laser systems covering the 2 – 11 µm spectral range as well as the realization of LED modules for the visible and UV spectral range. This research will help extend the wavelength range where efficient semiconductor-based light emitters will replace conventional light sources. Furthermore, the light sources will be equipped with additional functionalities such as wavelength tunability or the generation of ultra short optical pulses.

Our goal is to help make semiconductor-based emitters the prominent light source, not just for solid state lighting but also in a wide range of other applications including medical diagnostics, optical hearing implants, process analysis and control, as well as safety and security.

13.6 Semiconductor Sensors

Using tiny sensors to detect hazardous materials and pathogens or monitoring industrial processes – micro- and nano-sensors find applications in many areas of daily life. The miniaturization of electronic devices, their interconnections and ever faster processing of signals are constantly pushed forward.

Using modern materials which possess extraordinary physical properties, like diamond, metal oxides and III-V compound semiconductors, we develop a variety of different sensors in the business unit »Semiconductor Sensors«. The spectrum of our research ranges from UV to IR lenses, gas detectors, electro- and biochemical sensors, high-energy radiation and particle detectors, heat spreaders, single photon sources to micro- and nanoelectromechanical systems (MEMS/NEMS).

Our micro- and nano-sensors can be used in a wide variety of applications, e.g. in the identification of diseases and toxins as well as in all types of reliability testing and safety assessment. These sensors need to work reliably even under extreme conditions.

14. Fraunhofer Institute for Intelligent Analysis and Information Systems IAIS

Website Link: https://www.iais.fraunhofer.de/en.html

14.1 Institute Overview

English: Increasing digitization and networking throughout society leads to the twin challenges of ever increasing amounts of data being generated at increasingly greater speeds. As an alternative to analyzing individual data silos the application of a holistic semantic analysis can help optimize processes, support decisions and develop new business models.

Successful solutions not only link data and technical devices but also departments and corporate processes – Big Data is not simply a technological topic but, above all, it is a strategic one. Big Data is at the heart of intelligent systems: The Fraunhofer IAIS supports companies and organizations throughout the entire process – from the development of new IT strategies through to the implementation of Big Data procedures in company systems and eventually to the development of specific technical solutions.

Our expertise in data science, pattern recognition and system modeling and analysis has made the Fraunhofer IAIS one of Europe's leading applied Big Data research institutions in Europe. Our 200 strong team is capable of combining in-depth industry knowledge with scientific expertise across a full range of technical disciplines, most notably information technology but also mathematics, natural sciences, business management, geo sciences and social sciences.

Korean: 오늘날 디지털화 및 네트워크화로 인해 방대한 양의 데이터가 점차 빠른 속도로 생성되고 있습니다. 데이터 사일로의 개별 분석이 아닌 전반적인 의미 분석은 절차 최적화, 의사결정 도출, 신규 비즈니스 모델 개발 등을 가능하게 합니다. 성공적인 솔루션은 데이터를 IT 기기뿐 아니라 부서 및 기업 내부 절차와도 연결시킵니다. 빅데이터는 단순히 기술적인 문제가 아닌 전략적인 문제로, 지능형 시스템의 핵심입니다. 프라운호퍼 지능형 분석 및 정보시스템 연구소(IAIS)는 신규 IT 전략 개발, 기업 시스템에 빅데이터 활용, 기술 솔루션 개발 등 다양한 분야에 걸쳐 기업 및 기관을 지원하고 있습니다. 연구소는 데이터 과학, 패턴인식, 시스템 모델링 및 분석 분야의 전문성을 기반으로 유럽 내 선도적인 빅데이터 응용연구기관으로 자리잡았습니다. 200 여명의 임직원을 두고 있으며, 폭넓은 업계 지식과 연구역량을 기반으로 정보기술, 수학, 자연과학, 경영관리, 지구과학, 사회과학 등 각종 분야의 연구를 수행하고 있습니다.

14.2 Big Data Architecture and Analytics

Big Data technologies are indispensable for data that is too big, too fast, and too complex to be processed by classical techniques. We investigate and set up high-performance infrastructures for complex data analytics tasks on very large datasets or under realtime conditions.

Going beyond the pure infrastructure, we also investigate new data mining algorithms - such as stream mining or sub-linear algorithms - which scale under these extreme new conditions.

14.3 Machine Learning

Machine learning for smart systems

Machine learning algorithms fuel future smart systems, make them more adaptable to new situations and more intuitive to use. Whether in factories or smartphones, business processes or the web, machine learning needs to be deeply engrained into complex systems, work with heterogeneous and quickly changing data situations, and deliver results that can be processed seamlessly.

Examples

- Detecting patterns, with applications in fraud detection or decision support

- Detecting complex events in times series, with applications in sensor data and factories of the future
- Mining in big data architectures including stream mining

Mining complex data

In modeling real-world applications, often various dependencies need to be taken into account: friends linking to friends in social networks, the flows of goods in logistic networks along streets, tracks or flight lanes, or biological processes in the human body. These are just a few examples of data that can be represented adequately only in the form of graphs. Because of their complexity compared to tabular data, mining graphs and other highly structured objects is significantly more challenging than other forms of data mining. We investigate efficient methods to adequately extract knowledge out of graphs and network data.

14.4 Interactive and Visual Analytics

Humans and machines have to join strengths to make sense of complex data and address the challenges of data-driven decision making. Sometimes, a picture can say more than 1000 words. Usually, systems are only smart when they are able to understand the user. Always, understanding the machine is better than trusting a black box. We research and develop systems that bridge the gap between the user – layman or expert – and the machine.

14.5 Text Analytics

People talking in social media and the web, reports and emails written in companies, legal documents and patent information, knowledge stored in libraries and scientific publications – text is the pre-dominant form of communication on today's society. Understanding texts can give insights in what people think, tap into knowledge that is waiting to be exploited, and help humans and machines to communicate efficiently. Significant advances have been made in the recent past towards understanding texts and discovering semantics.

Techniques and methods

We investigate and develop algorithms for semantically mining various form of unstructured text data, including topic detection to efficiently summarize large corpora of texts, named entity and relation extraction to obtain semantic information, and sentiment analysis to describe subjective emotional coloring by the author. Novel deep learning algorithms make text analytics scalable to very large collections of data. This, coupled with linguistic know-how and long-standing practical experience, allows us to gain new insights into all kinds of texts.

Our research focuses on text mining for challenging, innovative applications. This includes:

Mining social media to uncover trends, follow discussions, chart emotions and interests, thus extracting information from the web

Extracting high-level information from technical documents, business documents like contracts, patents, scientific literature, and other textual sources

Learning from structured and unstructured data, combining textual information with information from other data sources such as data bases or linked open data

Mining medical texts, e.g. from electronic health records

14.6 Natural Language Question Answering

Question Answering systems are becoming the inspiring model for the future of search engines. While, recently, datasets underlying QA systems have been promoted from unstructured datasets to structured datasets with semantically highly enriched metadata, question answering systems are still facing serious challenges and are therefore not meeting users' expectations. In our investigations we focus in particular on systems based on knowledge graphs and linked data.

14.7 Multimedia Pattern Recognition

Pattern Recognition in Multimedia Data

»Multimedia Pattern Recognition« involves the research and development of pattern recognition processes, tools and software solutions for voice, image, audio and video data as well as documents. The surge in digital data has increased demand for automatic analysis and recognition methods. This type of evaluation will frequently need to be undertaken in real time such as for the automatic recognition of traffic signs or the generation of subtitles during live broadcasts. Evaluating such enormous amounts of data manually would also be prohibitively expensive.

Methodology: Data-driven Procedures and Learning Procedures

Two main issues need to be taken into account when researching and developing pattern recognition technologies: First of all it is usual for statistical classifiers to be used for recognition purposes before being trained using extensively annotated data pools. These types of data-driven methods lead to the robust recognition technologies which make the use of learning procedures possible. Secondly, pattern recognition technology is selected and developed to ensure it is suitable for real-life scenarios. Specific application scenarios present particular challenges to research and development teams working in this area.

Stable Recognition Technology for Long Runtimes

Statistical classifiers such as deep neural networks, support vector machines and hidden Markov models are applied to the transformed input data as part of the actual recognition process. As the recognition technology is being used in a productive environment it is important that it is particularly stable in terms of its runtime behavior and maintainability.

14.8 Deep Learning (Cognitive Computing)

Penetrating Data with Artificial Neural Networks

We are currently experiencing an artificial intelligence revolution thanks to Deep Learning. Deep Learning is a new information processing method based on artificial neural networks which has led to ground-breaking achievements in image recognition, speech processing and robotics.

Central to its success is the fact that Deep Learning is most effective when particularly large amounts of data – Big Data – are available to train the neural networks. Thanks to its many years' experience working on neurocomputing and Big Data Analytics solutions the Fraunhofer IAIS in Germany is among the pioneering developers of Deep Learning methods for industry.

We have successfully implemented Deep Learning processes in projects as diverse as Intelligent Automotive, Multimedia or Customer Churn Prediction.

14.9 Cognitive Robotics

Intelligent Robots learn by interacting with other technical systems and humans

Cognitive robots can cope with complex environments and unexpected situations. They are equipped with rich sensors that they interpret to perceive their environment. Cognitive robots act goal-oriented by making plans, can actively explore their environment, and identify opportunities for actions. In this way, they achieve robustness in dynamic environments. Cognitive robots don't work in isolation, but in close interaction with other technical systems and humans. They are able to improve their behavior through learning.

Key challenges

Key challenges when developing cognitive robots are the systematic treatment of uncertainty, the semantic modeling of the robot environment, the identification of suitable learning methods, and the design of intuitive user interfaces. To master these challenges, we employ techniques from Probabilistic Robotics, Artificial Intelligence, and Machine Learning.

Through numerous projects, IAIS has experience in particular in the area of field robotics.

14.10 Artificial Intelligence

Artificial intelligence (AI), one of the most important aspects of our future digital age, is currently experiencing a major boom in science, the economy and the media and has already become an everyday technology. Thanks to SIRI we can now speak to our smartphones, the first self-driving cars have started to appear on the roads of California and logistics providers are already testing autonomous flying drones. However, if machines are to be used safely in factories, hospitals and households they must – just like us humans – be able to act, react and learn by observation and experience and not simply operate in accordance with pre-programmed data.

Hybrid research methods:

Combining knowledge-driven and data-driven approaches to close the »semantic gap«

»Multimedia Pattern Recognition« and »Data Science« are the Fraunhofer IAIS's core areas of research and most important areas of expertise in relation to artificial intelligence and its applications in robotics, image and speech processing and process optimization. Central to the research being done at the Fraunhofer IAIS are hybrid artificial intelligence solutions: This is where we combine the knowledge based research methods of professors Dr. Sören Auer and Dr. Jens Lehmann with the data-driven methods by professors Dr. Stefan Wrobel and Dr. Christian Bauckhage.

The knowledge-based approach is founded on people's predetermined empirical knowledge and the conclusions drawn from it – and has recently been encapsulated in the phrase »Semantic Web«. The data-based approach on the other hand uses »Machine Learning« methods to analyze statistical correlations. The aim of combining both approaches is to close the »semantic gap«. This is where intuitive empirical knowledge and statistical knowledge meet and need to be put into context if they are to replicate the human ability to understand meaning from a given context.

14.11 Semantic Technologies & Linked Data

Lightweight Linked Data Integration

The ubiquitous proliferation of computers and data networks as well as the resulting digitization of data, content and processes leads to profound changes in all business and societal domains. Established value chains and business models are challenged and entirely new ones, based on the technologies of a digital world, are triggered by the altered market mechanisms. These new market mechanisms are based on taking advantage of minimal marginal costs, on reversing the investment pyramid towards marketing and customer acquisition, on serving Long Tail markets, as well as consumer pull and technology push. From a technological standpoint, the digital revolution is particularly driven by the new network technologies (5G, RFID, NFC, IoT), data-centric analysis and integration (Big Data, Smart Data, Deep Learning), new computing paradigms (Cloud or Fog Computing, Everything-as-a-Service, virtualization), or new methods of human-machine interaction (Mobile/Ubiquitous Computing, Augmented Reality, Crowdsourcing)

In terms of digitization, it is of central importance to systematically process, integrate and organise data. Data must be structured, represented and linked in such a way, that existing data silos will be broken down, data value chains will be established and innovative applications can be implemented efficiently. The Linked Data Principles, RDF as the lingua franca of data integration and the related W3C Standards form the basis for the transformation of the traditional enterprise architectures into networked, knowledge-based information networks, which lay the foundation for new digital business models and intelligent applications.

15. Fraunhofer Institute for Industrial Engineering IAO

Website Link: https://www.iao.fraunhofer.de/lang-en/

15.1 Institute Overview

English: Fraunhofer IAO helps companies and institutions introduce new business models and efficient processes to make their businesses more successful. With our in-depth knowledge of organizational structures and technologies, we have the skills you need to put applied research into practice. We participate in international networks, investigating and shaping the frontline themes that are most relevant to the future of Germany as a business location. Our goal is to systematically optimize the ways in which people, organizations and technology interact.

Fraunhofer IAO has its finger on the pulse when it comes to today's mega trends in technology and society. We investigate and shape a wide range of future-oriented, frontline themes including

- digitalization of production, service, office tasks and knowledge work
- how urbanization is turning cities into high-potential markets of the future
- demographic change, and the consequences for employment and work
- future mobility, with a particular focus on smart technologies and sustainability.

Our clients range from major corporations and SMEs to public sector bodies and institutions. We offer you a distinctive knowledge advantage and show you ways of quickly adapting this knowledge to your specific needs and using it to make your business more profitable. Whatever the project, people are at the heart of everything we do – and we never lose sight of the social repercussions.

Our interdisciplinary teams bring together colleagues from a range of specialist fields, including business management and economics, computer science, engineering, natural sciences, and social science. They take a wide-ranging, holistic approach to analyzing key issues in order to pinpoint the most practical and feasible solutions.

We work closely together with our partner institute – the Institute of Human Factors and Technology Management (IAT) at the University of Stuttgart – as well as the Technical University of Berlin and a number of other institutes of higher education. Combined, Fraunhofer IAO and the IAT employ about 600 people and have a total of 15,000 m2 of office space, demonstration centers, and development and test laboratories.

Korean:

15.2 Corporate Development and Work Design

Covering a wide range of research projects, the teams of scientists from Corporate Development and Work Design devise new analysis and design methods, alongside future scenarios, roadmaps and solution approaches. Commercial pilot projects ensure the practicable viability of results. Our customers include public sector sponsors such as the

European Union, the German federal ministry of education and research (BMBF) or the state of Baden-Württemberg, as well as commercial associations focusing on innovation.

15.3 Service and Human Resources Management

Research and consulting projects in the field of service and personnel management call for a clear focus on objectives and implementation. Our teams develop customer-oriented solutions using interdisciplinary working practices, and a consulting approach that involves continual input from the client’s management team and staff. Independent analyses and recommendations, as well as observing and complying with standards throughout all project phases, underpin this work.

Our projects are mainly carried out directly on behalf of industrial and service companies, sponsors such as the European Union, the German federal ministry of education and research (BMBF) or the state of Baden-Württemberg.

15.4 Engineering Systems

In our research projects, we develop new methods and technologies for virtual engineering and Human Factors Engineering. These projects are carried out on behalf of funding authorities which include the European Union, the Federal Ministry of Education and Research (BMBF), or the State of Baden-Württemberg. This provides a springboard for our work on implementation projects contracted directly by industrial clients.

15.5 Information and Communication Technology

The business unit Information and Communication Technology conducts numerous collaborative research projects together with national and international partners. The overarching goal of these research activities is the design and evaluation of useful and usable IT architectures and applications to answer societal and business needs.

The topics addressed in those projects include scenario-based and user-centric design methods, collaborative information management concepts, IT integration paradigms, business concepts for IT services and viable security solutions.

15.6 Technology and Innovation Management

We engage in a wide variety of research projects to develop and test new methods and innovative procedures for technology and innovation management. Many of our projects are commissioned by funding partners such as the European Union, the German federal ministry of education and research (BMBF) and the Land of Baden-Württemberg. We use the results of these research activities to enhance the work we perform on behalf of our customers.

15.7 Mobility and Urban Systems Engineering

Our research is about looking for creative and dynamic approaches to designing mobility and urban systems. And it is this focus on systems that reaches across all the different subject areas we work in.

16. Fraunhofer Institute for Applied Polymer Research IAP

Website Link: http://www.iap.fraunhofer.de/en/fraunhofer-iap.html l

16.1 Institute Overview

English: The Fraunhofer IAP specializes in researching and developing polymer applications. It supports companies and partners in the customized development and optimization of innovative and sustainable materials, processing aids and processes. In addition to characterizing polymers, the institute also produces and processes polymers in an environmental-friendly and cost-effective way on a laboratory and pilot plant scale.

Biopolymers

The sustainable use of renewable materials is the main objective of the biopolymer research at the Fraunhofer IAP. Natural polymers, such as cellulose, starch or lignin, as well as biobased plastics, such as polylactide, can be processed into fibers, nonwovens, films, molded paddings and fiber-reinforced composites. In addition to developing products made from natural polymers, we focus on synthesizing new biobased plastics. Since 2013, we have had stabilization and carbonization technologies for carbon fiber development at our disposal. In addition, biopolymers can be chemically, enzymatically or physically modified in order to optimize existing applications or to open up new application possibilities. The spectrum ranges from starch derivatives for the paper industry to nanocelluloses, adhesives, thermoplastic starch, cellulose derivatives and lignin fractions and derivatives that are used in thermoplastics and thermosets. New activities include biotech research into the technological use of proteins, in particular for cosmetic, pharmaceutical and detergent applications.

Functional Polymer Systems

Polymers with special physical and chemical properties are increasingly being used as functional materials in high-tech applications. Our spectrum ranges from materials and technologies for organic electronic elements, to sensors, actuators, optical components and chro-mogenic polymers. Quantum dots open up new opportunities to develop the technology of OLEDs and organic photovoltaics, as well as diagnostics that employ photonic methods. Function-alized surfaces are another focus of this research division.

Synthesis and Polymer Technology

The Synthesis and Polymer Technology research division specializes in the synthesis of novel polymer structures and the development and optimization of polymerization processes. Focus is on fossil-based and renewable-based heterochain polymers. Our research spectrum also includes the microencapsulation of active substances and additives, as well as particle ap-plications. Other areas of R&D include function integrated polymer films and shape-memory polymers.

Life Science and Bioprocesses

In the Life Science und Bioprocesses research division, biotechnology, nanotechnology and interface chemistry are combined with traditional polymer research to develop new functional biosystems, colloidal structures and bio-hybrid materials. Focus is also on the manufacture and production of biobased building blocks using fermentation processes and bio-catalytic conversions. Research and development also concentrate on “intelligent” polymer systems, biomaterials, hydrogels, implants and new materials and products for the pharmaceutical, medical and cosmetic industries.

Pilot Plant Center for Polymer Synthesis and Processing PAZ

At the Fraunhofer PAZ in Schkopau, the Fraunhofer Institutes for Applied Polymer Research IAP and for Microstructures of Materials and Systems IMWS combine their expertises in polymer and process development and in plastic processing. Flexible, state-of-the-art pilot plants enable the latest research findings to be transferred to scales needed for production and for sample quantities up to ton scale. New products and innovative technologies can be developed along the entire value chain – from monomers, polymer synthesis and polymer processing, to testing made-to-measure components.

Polymer Materials and Composites PYCO

The Polymer Materials and Composites PYCO research division develops and conducts research into materials made from cross-linked plastics and composites made from multiple interconnected materials. These are primarily fiber-plastic composites. The fibers, particularly carbon, glass or natural fibers – are used in technical textiles such as woven, knitted, crocheted, non-woven and felt fabrics. These are embedded in a resin matrix in special geometric shapes that are used in later applications. This results in excellent material properties that have a comparatively low weight.

Korean: 프라운호퍼 응용고분자연구소(IAP)는 고분자 기술 전문 연구기관입니다. 기업 및 기관을 대상으로 지속가능한 혁신 소재, 가공조제, 공정의 맞춤형 개발 및 최적화를 지원하고 있습니다. 또한 고분자 특성분석을 실시하고, 실험실 및 파일럿 수준에서 친환경적이고 비용효율적인 방식으로 생산용 고분자를 생산 및 가공하고 있습니다.

생체고분자

IAP 연구소의 생체고분자 연구부는 재생 소재의 지속가능한 사용을 지향하고 있습니다. 셀룰로오스, 녹말, 리그닌 등 천연고분자와 폴리랙타이드 등 바이오 기반 플라스틱은 섬유, 부직포, 필름, 몰드 충전재, 섬유강화 복합재료로 가공 가능합니다. 연구소는 천연고분자 제품 개발뿐 아니라 새로운 바이오 기반 플라스틱 합성에도 주력하고 있습니다. 또한 2013 년부터 탄소섬유 개발용 안정화·탄화 기술을 활용해 왔습니다. 생체고분자는 화학적·효소적·물리적 변형을 거쳐 기존 응용제품을 최적화시키거나 신규 응용제품을 개발하는데 사용됩니다. 제지 산업의 전분 유도체, 열가소성 수지 및 열경화성 수지에 사용되는 나노셀룰로오스, 접착제, 열가소성 전분, 셀룰로오스 유도체, 리그닌 분획물 및 유도체 등이 이에 해당합니다. 최근에는 화장품, 의약, 세제 등 단백질의 산업용 활용에 대한 생명공학 연구도 진행하고 있습니다.

기능성고분자 시스템

특수한 물리적·화학적 특성을 지니고 있는 고분자는 유기 전자소자, 센서, 액츄에이터, 광학부품, 변색고분자 등 첨단 응용제품의 기능성 소재로 활용되고 있습니다. 퀀텀닷의 경우, OLED 및 유기 태양전지, 광자진단 관련 기술개발을 촉진하고 있습니다. 연구부는 기능성 표면에 대한 연구도 진행하고 있습니다.

합성 및 고분자 기술

합성 및 고분자 기술 연구부는 신규 고분자 구조의 합성과 중합 공정의 개발 및 최적화를 전문으로 하고 있습니다. 주요 연구개발분야는 화석연료 및 재생에너지 기반 이종사슬 고분자, 활성물질 및 첨가제의 미세캡슐화, 입자 응용, 기능성 고분자 필름, 형상기억 고분자 등입니다.

생명과학 및 생물공정

생명과학 및 생물공장 연구부는 기존 고분자 연구에 생명공학, 나노기술, 계면화학을 접목시켜 새로운 기능성 바이오시스템, 콜로이드 구조, 바이오 복합소재를 개발하고 있습니다. 주요

연구개발분야는 발효공정을 통한 바이오 유래 중간물질 생산, 생촉매 전환, 지능형 고분자 시스템, 생물소재, 수화젤 및 임플란트, 의약, 의료, 화장품 산업용 신규 소재 및 제품 개발 등입니다.

고분자 합성 및 가공 파일럿 설비 센터(PAZ)

프라운호퍼 응용고분자연구소(IAP)와 소재 및 시스템 미세구조 연구소(IMWS)는 슈코파우(Schkopau)에 소재한 고분자 합성 및 가공 파일럿 설비 센터(PAZ)를 공동으로 운영하며, 고분자 및 공정 개발, 플라스틱 가공 분야의 전문성을 결합하여 제공하고 있습니다. 첨단 파일럿 설비를 사용하여 최신 연구결과를 수 톤 규모의 샘플 생산에 적용하며, 단량체, 고분자 합성, 고분자 가공, 맞춤형 부품 시험 등 가치사슬 전반에 걸쳐 신규 제품 및 혁신 기술을 개발하고 있습니다.

고분자 소재 및 복합재료(PYCO)

고분자 소재 및 복합재료 연구부(PYCO) 는 가교형(cross-linked) 수지 기반 소재 및 다수의 상호연결된 소재 기반의 복합재료에 대해 연구하고 있습니다. 이들 대부분은 섬유 플라스틱 복합재입니다. 탄소, 유리, 천연섬유의 경우, 레진 기질에 기하학적 형상으로 첨가되어 직물, 편성물, 편물, 부직포, 펠트직 등 산업용 섬유에 사용되고 있으며 저중량 특성을 가지게 됩니다.

16.2 Lignocellulose

The development of products from natural raw materials such as wood, cotton, annual plants, or crab shells is the focus of the research activities of the department of Lignocellulose. By chemical, physical or enzymatic modification of polysaccharides - in particular of cellulose and starch, but also hemicellulose, inulin, hyaluronic acid, chitin and chitosan - products can be produced in a wide range of applications. By systematic studies on the molecular and supramolecular structure, the novel polysaccharide derivatives are characterized and their structure-property relationships is determined.

Applications as diverse as structures

The natural polymers mentioned differ in their chemical and physical properties extraordinarily, resulting in a variety of applications. Thus, derivatives of polysaccharides are used in mass products such as building materials, detergents or paper as well as in form of highly refined specialty products. Special derivatives are also used e.g. in medicine, biotechnology and pharmaceutics as substrates for enzymes and drugs

Tailor-made functionality

To set a custom functionality, we derivatize the polysaccharides with hydrophilic, hydrophobic, ionic and nonionic reagents. The syntheses are carried out under homogeneous and heterogeneous process conditions. Using esterification, etherification, oxidation, and graft polymerization on the polymer chains, the properties of the corresponding derivative is determined by the degree of substitution within the monomer unit and along the molecular chain.

16.3 Starch Modification / Molecular Properties

Starch is one of the most important renewable resources. Worldwide, more than 60 million tons are produced annually. Thereof, about 9.4 million tons are manufactured in Europe, and additionally, further amounts are imported. About 60 percent of starch and starch products are used in food and beverage sector. In the non-food sector, the paper industry is the main consumer. In addition, starch products are used in cosmetics and pharmaceuticals, fermentation, bioplastics, adhesives, building materials, sizing or cleaning agents.

In the department »Starch modification / Molecular properties« starch and starch products for industrial applications are modified and optimized. Our projects result from the industry's needs. On request, we adapt the renewable resource specifically to processing processes and applications. The special properties of starch − water solubility, water binding and viscosity properties − is just as important as its inhibiting swelling power and the limited water vapor permeability of films. Furthermore, the replacement of synthetic organic polymers on the basis of modified starch offers numerous advantages: the production processes are environmentally friendly and reduce harmful environmental influences.

16.4 Fiber Technology

Fibers, films and nonwovens for industrial and textile applications, as well as respective processes for their production are key issues of industry-related work of the Fiber Technology department. Extensive and variable equipment for solution and melt spinning in the laboratory and pilot plant scale are available, here. The use of biopolymers such as cellulose, lignin, proteins, or polylactide and the development of environmentally friendly, efficient spinning technologies play an important role. With the extensive analytical capabilities for structure characterization at the Fraunhofer IAP, structure-property-relationships can be elucidated in order to draw conclusions for the corresponding spinning technology, resulting in optimal material properties.

16.5 Material Development and Structure Characterization

Biobased alternatives to traditional polymer systems based on petroleum chemistry, become more and more important in a variety of application fields. The limited availability of fossil resources, the dependence on oil and raw material-related netto emissions of CO2 from burning (or rotting) of plastics are reasons to look for new ways to manufacture polymers from renewable resources. However, with respect to imported petroleum-based materials, marketable technical solutions for biobased products must also offer advantages concerning properties or price. The application-oriented research activities of the department "Material development and structural characterization" follow this aim:

Material development

Applied material development in the field of thermoplastics and thermosets is the department's research focus. Key aspects are the modification, additivation and reinforcement of both petrochemical-based and biobased polymers. The aim is to improve the material's physical, mechanical, thermomechanical and processing related properties.

Structure characterization

An essential component of our work is to explore structure-property relationships of advanced materials. We use the extensive experience of our staff in the areas of light and electron microscopy, X-ray diffraction and NMR spectroscopy as well as good scientific equipment for structural characterization. The different methods complement each other very well and are therefore often used in an effective combination.

16.6 Processing Pilot Plant for Biopolymers Schwarzheide

With the establishment of the Processing Pilot Plant for Biopolymers at BASF's site Schwarzheide we develop contributions for processing of marketable and new biobased plastics. We benefit from the locational advantage of the chemical park in order to transfer the results of our research and development work faster to the market. The main goal is to help small and medium-sized plastics processors extend their product range to include biobased materials.

16.7 Functional Materials and Devices

Imagine a very lightweight, energy-saving, foldable or rollable display that offers a perfect picture from any angle − no matter how bright the room is. This is not a future vision, it is close to reality − achieved by the flexible organic light-emitting diodes, OLEDs. TVs with OLED technology represent the next generation of displays that will soon be available everywhere. The screen is only one example in which the OLED technology will be applied. OLEDs can also be used as symbol displays, segmented displays and as light sources. We develop the technology for "Large Area Organic Electronics" (OLAE).

Nanomaterials already conquered almost every area of our lives. In cosmetics, paints and cleaning products, we find them today in every household. The materials we develop show completely new properties and can improve the light performance of a display, they can "collect" the light from the infrared spectral region but are also used in medical diagnostics. Quantum dots are revolutionizing the display technology and improve the efficiency of solar cells. For this we develop customized materials.

Also, sensors are indispensable in today's world. But mostly ceramic materials are used. They can be found in cars, at home and wherever you want to measure temperature, pressure or humidity. We deal with sensors that are built up from polymeric materials and can be excellently adapted to the quantities to be measured. In the opposite case, certain polymeric materials can also perform mechanical movements if voltage is applied to them. These materials are the heart of so-called actuators. We develop customer-specific sensors and actuators.

Surfaces and interfaces play an important role in many parts of the systems mentioned above but also in other areas. The activation (oxidation) of the surface makes it possible to print on polyethylene films (shopping bags), polypropylene stick (smart cards) and painted polymer surfaces. The chemical composition of a few nanometers thick surface layer is responsible for these properties. We set the properties of surfaces in accordance with the requirements of an application.

16.8 Chromogenic Polymers

Chromogenic materials change color and transparency reacting to temperature, voltage, pressure or light. They can also be specifically controlled by external stimuli.

Our focus is on thermochromic polymers. We develop hydrogels, thermoplastics (foils), thermosets and additives which change their color and/or transparency at a change of temperature. The application potential of these materials lies among others in solar technique, engineering, automotives and information technique.

16.9 Thermotropic polymers

Thermotropic polymers autonomously switch from a clear to a scattering state when the temperature rises. No external power is required for this process. They are therefore suitable for applications in the sun, glare and overheating protection as well as in light control.

These new materials reduce the energy consumption of buildings. In winter, the solar heat reduces heating energy requirements. In summer, a large portion of the solar radiation is reflected, thus reducing the cost of cooling and ventilation.

Focus of our material development is the transformation of thermotropic effects in polymer matrices - self-supporting thermoplastic films and wall sheets, as well as resins and hydrogels for laminated glass.

16.10 Piezochromic polymers

The focus of R & D work are piezochromic polymers, the pressure variations <1 bar show in the form of a visible color change.

16.11 Photochromic polymers

Photochromic effects are based on the reversible light-induced conversion amongst two particle groups, which change the absorbtion spectrum and consequently their physical properties. The focus of R & D activities are photochromic polymers for sun protection glazing.

16.12 Microencapsulation/ Particle Applications

The production of polymer-based microcapsules and matrix particles by reactive and nonreactive encapsulation is the research focus of the department Microencapsulation/Particle Applications. This technology can be applied in many different areas − from plastics technology to life science.

Besides microscale particles, we also offer particle systems in the submicron and nanometer range, which are prepared by emulsion or dispersion polymerization. Not only size and distribution of the particles can be customized for various applications, but also their morphology, functionality, and reactivity.

Our synthesis competencies available in the field of amino resin chemistry are used for both particles applications and in the material sector.

We have many years of experience in the characterization of polymers, microcapsules and particle systems, and modern analytical methods are available in these fields.

16.13 Polymer Synthesis

A key competency of the department is to develop innovative methods and technologies for the production of polymers. We also want to establish the conditions for the implementation of these processes under production conditions. Besides polycondensation and radical polymerization processes in bulk solution, we especially focus on process development for polymerization in heterogeneous systems in classical and inverse systems. We use reaction- and process analytical methods to optimize the processes for polymer formation and modification and to transfer processes from lab to miniplant scale.

The synthesis of biobased hetero-chain polymers with the aim of developing materials with improved performance characteristics, are another focus of our research and development services. Currently we are concentrating our activities on the material use of lactic acid for the synthesis of aliphatic polyesters. Corresponding works focus on expanding the range of properties of polylactide (PLA) via synthetic routes that are compatible with the technical production processes of PLA. Aiming on an expansion of the project goup's application potential we have been expanding and intensifying the R&D activities in the field of bio-based polyester including a number of other glucose-based blocks (various dicarboxylic acids, diols, multifunctional devices). These approaches are complemented by studies on procuction of nanocomposites from petrochemical and biobased hetero-chain polymers via in situ polycondensation processes.

Further key topics are both product- and process-oriented in order to obtain new or enhanced polymer-based tools for solid-liquid separation processes, which are applied for example in wastewater treatment or in paper production.

16.14 Shape-Memory Polymers

Shape-memory polymers are functional materials, which offer significant potential for the opening up of new applications. In our team we carry out application-oriented synthesis and process developments. Another core competence is design and development of stimuli-responsive, multifunctional polymer materials.

16.15 Functional Protein Systems/Biotechnology

The department deals with the production and implementation of biobased functional building blocks by chemical, physical and biotechnological methods. Main focus lies on the integration of biological functionalities in polymeric materials, fermentation processes and bio-catalytic implementations for the production and modification of biopolymers from renewable raw materials.

16.16 Functional Polymers for Medical Technology

The department Functional Polymers for Medical Technology develops biomaterials for diverse applications. Nanotechnology, surface chemistry and polymer science are combined to develop new high-tech materials for the medical engineering ready for use, such as implants and drug systems. Research and development take place in an interdisciplinary team.

16.17 Polymer Synthesis

The department Synthesis and Product Development at the Fraunhofer Pilot Plant Centre PAZ is active in the areas of free radical polymerization, anionic polymerization and coordinative polymerization, as well as polycondensation.

Depending on the project focus, activities can start with recipe- and product development in lab-scale, however main focus is on technology and process development, in particular on the scale-up from laboratory to pilot scale.

For project realization, well-equipped laboratory facilities (analytics and polymer synthesis), as well as a sophisticated multi-product multi-functional pilot plant, are available. In the pilot plant, a large number of technically relevant processes can be realized in pilot-scale and sample quantities up to the tons-scale can be generated.

With respect to materials, so far projects focused on rubber and elastomers, on polycondensates such like polyesters and polyamides, but also many other material systems were successfully studied.

16.18 Polymer Processing

The department of Polymer Processing − a field of competence of the Fraunhofer IMWS − has both an extensive know-how in the field of polymer processing, as well as in the characterization of structure property relationships for thermoplastics, thermosets, elastomers and composite materials. We focus on the material, process and component development for long fiber reinforced thermoplastics (LFT), highly filled plastics and blends.

For the processing of these materials, we have extrusion and injection molding equipment. Moreover, the direct compounding possible in one injection molding compounder (IMC). Here extrusion and injection molding carried out in a single-step process in the same machine.

One focus of our activities is placed on the systematic evaluation of the impact of material systems and technological conditions on the component's characteristics. The experimental and numerical results provide information about the performance characteristics and the reliability of the plastic components.

16.19 Polymeric Materials and Composites PYCO

Chemists, physicists, engineers and technicians of Fraunhofer sites in Teltow and Wildau are developing highly crosslinked polymers (thermosets) for all applications with particular reference to aviation, IT-technology and instrumentation.

Today, our work is particularly focused on lightweight composites and on micro- as well as optoelectronics: new (nano-)materials, prepregs, core materials, laminates, all kinds of fiber reinforced materials, sandwich structures, bistable displays, integrated optical devices and barrier layers.

The application of our thermosets is in the field of adhesives, coatings, varnishes, binders, inmolds and gelcoats, castings, foams, prepregs, Resin Transfer Moulding (RTM) and pultrusion. The following properties can be designed into these resin systems: high flame retardancy, high fracture toughness, minimum volume shrinkage upon curing, fast and latent curing at a time, disbonding ability (e.g. with adhesives), barrier properties against water vapor and oxygen, adjusted thermal coefficient of expansion, adjusted refraction index, rework and recycling ability. As those properties are often in contrast to each other, we focus particularly on the combination and optimum balance of material properties like high Tg (glass transition temperature) along with high fracture toughness in a single system, just to mention an example.

We are developing polymer systems along the whole supply chain, beginning with the monomers up to the finished part which is unique with any material research center in Germany. We synthesize monomers and prepolymers including or not one or more of the following: coreactants, flame retardants, tougheners, fillers or modifiers. Subsequently, we take efforts to ensure the processability of the systems and manufacture first prototype parts, mainly in close cooperation with our customers. We characterize the finished parts and work on quality assurance criteria. As a result, we are providing thermosetting polymer systems in any developmental stage as agreed between us and our clients. Those stages can be the reactive resin system itself, fiber reinforced materials, sandwich structures or any other demonstrator part that has been agreed upon.

17. Fraunhofer Institute for Biomedical Engineering IBMT

Website Link: http://www.ibmt.fraunhofer.de/en.html

17.1 Institute Overview

English: Operating in the international growth markets for life sciences and medicine/(bio)medical engineering, since its foundation in 1987/1992 the Fraunhofer Institute for Biomedical Engineering (IBMT) has worked primarily as a technology developer and device manufacturer for customers from all over the world. The Fraunhofer IBMT's strategy is focused on the areas of biomedical/medical engineering (especially non-invasive and minimally invasive as well as miniaturized technologies), biotechnology, implants, cryotechnology, biobanks and stem cell research. Trend-setting automated laboratory technologies, the development of mobile special laboratories (S3, GMP, GCLP, etc.) and information technologies for healthcare solutions round off the portfolio of the Fraunhofer IBMT. Decades of expertise in biotechnological and medical research and development fields also allows us to solve a variety of purely technical tasks. This includes ultrasound-based level metering, special transducers for acoustic applications, but also microelectrodes and miniaturized manipulation systems as well as automated in vitro culture devices.

Core competencies of the Fraunhofer IBMT are:

- biomedical/medical engineering
- molecular and cellular biotechnology/medical biotechnology
- bioprocessing and bioanalytics
- nano(bio)technology and molecular diagnostics/therapy
- cryo(bio)technology from cryoprocedures to cryomicroscopy
- stem cell research and cell differentiation
- tissue engineering and development of new in vitro culture systems
- design and construction of small, medium-sized and large biobanks
- implants

- theranostics
- neuroprosthetics and technical implant components
- (mobile) laboratory technologies, new concepts for wireless energy supply
- medical and technical ultrasound applications
- autonomous deep-sea systems and acoustic imaging
- sensor manufacturing/microsystems technology
- telemetric data and energy transmission
- multi-local sensors connected by communications technology
- health information systems/medical networks

Korean: 프라운호퍼 의공학연구소(IBMT)는 1987 년 설립 이래 전 세계 고객을 대상으로 생명과학 및 의공학·의료공학 분야의 기술 개발 및 기기 제조를 전문으로 해왔습니다. 주요 연구분야는 의공학·의료공학(비침습 및 최소침습, 소형화 기술 위주), 생명공학, 임플란트, 크라이오기술, 바이오뱅크, 줄기세포 등이며, 세부적으로는 혁신적인 실험실 자동화 기술연구, 이동식 실험실(S3, GMP, GCLP 등) 개발, 의료솔루션 정보기술 개발 등을 수행하고 있습니다. 생명공학 및 의료 연구개발 분야에서 수십 년 동안 축적한 경험과 노하우는 초음파 계측기, 음향기술 전용 변환기, 미세전극 및 조작시스템, 자동 체외배양 기기 등 다양한 기술과제 해결에 원동력이 되고 있습니다. IMBT 연구소는 다음 분야에서 핵심역량을 갖추고 있습니다.

- 의공학/의료공학
- 분자·세포생명공학/의약생명공학
- 생물공정 및 생물분석
- 나노(생명)기술 및 분자진단/치료
- 저온공정, 저온현미경 등 크라이오(생명)기술
- 줄기세포 및 세포분화 연구
- 조직공학 및 체외배양 시스템 신규 개발
- 소·중·대형 바이오뱅크 설계 및 구축
- 임플란트
- 치료진단
- 신경보철 및 임플란트 부품

- (이동식)실험실 기술, 무선 에너지 공급 관련 신기술
- 의료용·산업용 초음파 기술
- 심해 자동 시스템 및 음향 영상화
- 센서 제조, 마이크로시스템 기술
- 텔레매틱 데이터 및 에너지 전송
- 통신기술로 연결된 다중 로컬 센서
- 의료정보시스템/의료 네트워크

17.2 Pluripotency & Regeneration

Pluripotency is the ability of a cell to proliferate indefinitely combined with the ability to differentiate towards any cells that constitute an adult body. Since the discovery of induced pluripotency in 2006, induced pluripotent stem cells (iPSCs) have become a powerful tool for biomedical research and hold great promise for regenerative therapy forms. The working group Pluripotency & Regeneration investigates the cellular mechanisms that maintain and modulate pluripotency, using human iPSCs and the freshwater planarian Schmidtea mediterranea as model systems. Another aim of the working group is to automate the currently labour-intensive protocols for the generation, maintenance, cryopreservation and quality control (QC) of hiPSCs.

17.3 Biomedical Optics

The working group Biomedical Optics was founded 1990 to foster research and development on the areas of solid state sensors and microsystems engineering and to manufacture products for the market. The activities of the department comprise technical microsystems interfacing biosystems as well as sensor systems whose application requires a combination of low cost sensors. The department applies sophisticated technologies and processes for the assembly and interconnection of hybrid, integrated sensor systems.

17.4 Automation Processes

The working group Automation Processes deals with the transfer of hitherto manually executed operations, cell culture systems and cell-based assays to a standardized automation process. It operates a fully automated cryobank for cryopreservation and low temperature storage of biological material, microorganisms and clinical samples up to security level S2. This cryobank serves as a mirror bank for the “European Bank for induced pluripotent Stem Cells (EBiSC)", a project funded by the European Community for provision of standardized and induced pluripotent stem cells of high quality (iPSCs) for disease relevant stem cell research. The cryobank is subject to a certified quality assurance program controlling the storage and the expansion of stem cells according to the guidelines of DIN EN ISO 9001.

Manual cell culture processes and cell-based assays are being automated, optimized and validated. The automated production of HIV-1 pseudotype viruses is being realized, for example, in a fully automated system for cultivation of eukaryotic cells and the aliquotation of the viruses according to the guidelines for "Good Clinical Laboratory Practice" (GCLP). Other examples for the development of automated cell culture processes include the beat-coupled cell cultivation in bioreactors or the reprogramming and differentiation of iPCs.

Alongside automated cell cultivation, the transfer of cell-based assays to the automation is another focus of the working group. Examples for the successful transfer of these cell-dependent tests include neutralization assays, immunological testing procedures (e. g. ELISpot), embryonic stem cell tests and cytotoxic assays.

17.5 Biomonitoring & Cryobanks

Biomonitoring, the monitoring of chemicals in humans and the environment, serves as the basis for a wide range of political decisions and regulation measures in the field of human and environmental health. In the areas of human biomonitoring and environmental monitoring, the working group Biomonitoring & Cryobanks of the Fraunhofer IBMT is developing groundbreaking platforms for the standardization of processes of the pre-analytical and analytical phase right up to cryostorage of samples. This includes the development of standardized methods for the collection and preparation of the samples for the analysis of pollutants such as heavy metals, plasticizers and nanoparticles, for cryopreservation and for the transport of human and environmental samples under cryogenic conditions. Furthermore, the working group is collaborating in the inter-working group development of mobile laboratory units for use in biomonitoring. The team has many years of experience in the standardized sampling of diverse environmental samples and human samples under BLS2 conditions.

17.6 Cellular Bioprocessing

The working group Cellular Bioprocessing develops future-oriented platforms for the collection, preparation, conservation and distribution of bioreagents and clinical samples for worldwide networks. This includes optimized processes for the production and preparation of samples and their cryopreservation. In this context, the Fraunhofer IBMT built up a global HIV cryobank of safety level S3 within the framework of the global initiative for the development of a HIV vaccine ("Collaboration for AIDS Vaccine Discovery – CAVD") which is funded by the Bill & Melinda Gates Foundation and the State Government of Saarland. The laboratory areas and the connected cryobank for bioreagents are subject to a certified quality assurance program which monitors the work according to the guidelines of "Good Clinical Laboratory Practice" (GCLP).

In addition to this, manual work sequences and cell-based assays are being automated and validated up to certification under suitable quality management systems. The production, for example, of HIV-1 pseudoviruses or infectious HIV-1 clones takes place in a fully automated system for the cultivation of eukaryotic cells, or cell-based tests such as neutralization and immune assays are being automated.

The working group Cellular Bioprocessing thus offers a platform for the further development and clinical testing of vaccines and new therapies. This biobank also serves as a cryorepository for a German-African joint project funded by the German Research Foundation (DFG) for the investigation of the pathogen Staphylococcus aureus. The scientists in Germany and Africa want to find out how widespread and resistant the pathogens are on the African continent, and what can be done to stem this deadly hazard.

17.7 Preclinical Nanotechnology & Nanotoxicology

The working group Preclinical Nanotechnology & Nanotoxicology deals with the preclinical testing of nanoparticular formulations for medical application and the toxic risk analysis of synthetic nanomaterials.

The synthesis and preclinical testing of nanoparticular formulations for specific “Drug Targeting” is a focus of the group´s work. “Drug-loaded” nanoparticles are able to transport the agent (e. g. cytostatics) directly to the target cell without causing heavy, undesired side effects in the surrounding tissue. It is possible to examine the specific accumulation of the nanoparticles and of the incorporating agent (e. g. tumours) as well as the nanoparticular-mediated surmounting of biological barriers (e. g., blood-brain-barrier, gastro-intestinal-barrier) in different cell culture models. Different nanoparticular formulations are currently being tested in the course of several projects. Corresponding cell culture systems like the cultivation of primary brain capillary endothelial cells in the

Transwell® system and co-cultures are established within the working group. The aim is to find new nanoparticular formulations which mediate a target-oriented therapy by selective cellular enrichment of the pharmaceutical substances bound to particle systems and which allow a transport of pharmaceutical substances via e. g. the blood-brain-barrier.

In addition to this, the surmounting of the intestinal barrier is of major importance for the application of oral pharmaceutical substance systems. Corresponding cell culture models, e. g. the Ussing chamber are available for transport studies of newly developed pharmaceutical substance formulations. The working group´s studies could show that such a targeting using functionalized nanoparticular formulations is possible. A range of other cell culture systems for the simulation of further biological barriers, e. g. the skin-lung-barrier, are on hand for testing of similar formulations for other projects or can be established if necessary.

The investigation of nanotoxicological effects and the risk analysis of nanomaterials is a second field of attention for the working group. The focus of the examined nanomaterials is set on synthetic nanomaterials which are commercially interesting. Due to the increasing use of nanotechnology-based consumer products, an increased input of nanomaterials into the environment can be assumed. Alongside the question of ecological and human-toxicological impacts of synthetic nanomaterials, there is increasing focus on the question of improved alternative testing methods for risk analysis, also within REACH. Research is aimed at the development of new cell culture model systems which can be adapted and extended according to the interrogation. E. g. Transwell® system-based methods are available to examine the effect of a unique or chronic exposure to aerosols-containing nanomaterials at the air-liquid interface. Useful analysis methods for toxicological risk analysis are also being established and optimized within the working group

17.8 Ultrasound Systems/Clinical Applications

The working group Ultrasound Systems/Clinical Applications specializes in providing flexible customized development of multichannel systems and ultrasound imaging techniques for use in medical, biomedical and technical applications. This rangs from low frequency applications (sonar and treatment systems), to clinical diagnostics high-frequency and ultra-high-frequency imaging systems and procedures for imaging on small animals and for acoustic microscopy.

The systemic basis for research and development is the Digital Phased Array System (DiPhAS). This system is an in-house development of a scalable multichannel digital phased array ultrasound platform, which is medically approved and customisable for different requirements. Besides standard imaging techniques it supports modern ultrafast ultrasound imaging and can be used for beamforming research, applications including elastography, vector velocity imaging and functional ultrasound.

In addition to the methods of creation and processing of ultrasound images and signals, as well as their reconstruction and visualisation for use in diagnostic and interventional imaging (navigation, control treatment), opto-acoustic procedures/systems and high as well as ultra-high resolution systems allow access to novel solutions and more accurate diagnostic procedures and translational imaging.

Another focus of the working group lies in the development of accompanying project management for the approval of medical devices under the Medical Device Directive 93/42.

17.9 Biomedical Ultrasound Research

The working group Biomedical Ultrasound Research researches and develops possibilities for the use of ultrasound technology in the area of medical diagnosis and therapy as well as in biological research and technology.

In the medical field this includes the non-invasive retrieval of information for diagnosis as well as the targeted destruction of tissue and the release of drugs for therapy. In biology ultrasound can be used for the non-destructive characterization of biological materials and living organisms as well as for the targeted manipulation and as an enabling technology for biotechnical processes.

Within this large spectrum of possible applications of ultrasound technology, the working group Biomedical Ultrasound Research offers all levels and types of research and development such as: feasibility studies, concept creation, prototype design and certified product development.

17.10 High-Frequency Piezosystems

Future applications of high-frequency ultrasound will be found in ophthalmology, dermatology, the diagnostics of vascular walls, the examination of small animals and the non-destructive testing of semiconductors. The increase in frequency leads to lower wavelengths and therefore permits improvement of the spatial resolution and the imaging of small structures down to the micrometer range.

The working group High-Frequency Piezosystems develops non-focusing and focusing ultrasound transducers and linear ultrasound arrays for the frequency range between 30 MHz and 1 GHz. This includes research in material science and new technologies in order to fabricate active and passive ultrasound elements. In the area of active sound-generating elements, microsystem technologies are applied to deposit thin piezoelectric layers and structure them as transducers or arrays. In addition to traditional piezoelectric materials, CMUTs (capacitive micro-machined ultrasound transducers) are also being tested for high-frequency applications. Passive elements, such as coupling materials, acoustic matching layers and damping materials are developed by means of nanotechnology. This could be used, for example, to produce nano-doped acoustic matching layers with adjustable acoustic impedances.

17.11 Technical Ultrasound Systems

The working group Technical Ultrasound Systems integrates both the electrical and mechanical component know-how for an ultrasound system for medical and non medical applications. With an appropriate combination of hardware and software it is possible to measure physical quantities such as distance, level, speed, flow, volume and obstacles with high precision.

17.12 Transducer Development

The sensor of an ultrasound system is very important for the overall system performance. In most cases it is necessary that working frequency, beam pattern and sensitivity are adjusted for the needs of an application.

Before a new idea or product can be placed on the market, it is necessary to develop the appropriate sensors or modify an existing sensor.

The working group Transducer Development assists you on the complete path of product development, from the idea to the production with the following services:

- Sensor development
- Sensor modification
- Consulting services
- Feasibility studies

- System integration
- Ultrasonic measurement technology
- Sensor production technology

17.13 Manufacturing Technology

The sensor of an ultrasound system is very important for the overall system performance. In most cases it is necessary that working frequency, beam pattern and sensitivity are adjusted for the needs of an application

Before a new idea or product can be placed on the market, a development of appropriate sensors or the modification of an existing sensor is necessary.

The working group Manufacturing Technology (ISO 9001 & 13485) assists you on the entire path of product development, from the idea to the production with the following services:

- Sensor development
- Sensor modification
- Consulting services
- Feasibility studies
- System integration
- Ultrasonic measurement technology
- Sensor production technology

17.14 Simulation

With its various working groups and resources, the Fraunhofer IBMT deals with a large spectrum of sensor systems, both on a microscopic and a macroscopic scale. These are based on physical effects ranging from magnetic resonance, optics, to ultrasonic wave propagation.

The working group Simulation works as an internal and external service provider. Using numerical and analytical tools we can speed up application development and improve sensor performance.

17.15 Microsensors & Microfluidics

The working group Microsensors & Microfluidics concentrates on the miniaturization of sensor and fluidic systems based on silicon, glass or polymers, and offers the corresponding technologies.

One of our activities involves the development of highly miniaturized active medical implants, some of which can be placed in the oral cavity, such as the salivary stimulator Saliwell with closed loop control as well as the drug delivery system IntelliDrug.

In the field of microfluidics we focus on realizing microfluidic systems to handle biological cells, e. g. cell transportation or cell separation.

The working group also concentrates on the integration of biochips in Lab-on-Chip. We are well grounded in a long-standing know-how as well as numerous technologies for biochip-compatible assembly and interconnection technologies and the realization of microfluidic systems. Above all, the cross-institutional cooperation within the Fraunhofer Society allows the customized development of complete analytical systems.

17.16 Biotelemetry

The working group Biotelemetry deals with the development of modules and systems for the wireless transmission of biological and physiological signals for bio-monitoring and remote control of active medical implants. This includes the wireless transmission of energy for the operation of medical implants.

17.17 Active Implants

According to BBC Research, the worldwide market for microelectronic medical implants and accessories will grow to 24,8 billion US Dollars by the year 2016. Active implants are technically challenging medical devices that impose particularly high demands in terms of application-oriented research & development, design, production, testing and regulatory approval. Innovations always need to consider biocompatibility and biostability issues, patient security, reliability over the complete service life as well as compatibility with other medical and non-medical devices. Miniaturization, efficient and space-saving powering, wireless power and data transfer between external and implanted modules as well as innovations in encapsulation and housing are key issues for the future of active implants.
The Fraunhofer IBMT offers concept, design, development and prototyping services for active implants in a wide range of applications. We have more than 15 years of experi-

ence in the business of active implants and bordering areas. We gained our knowledge in publicly-funded and industry-funded projects covering all aspects of the innovation chain from concept and feasibility studies to product design and development as well as prototyping. We have experience in various application fields of active implants, such as:

- dental implants for monitoring, electrostimulation and oral drug delivery purposes
- implants for remote-controlled hydrocephalus treatment
- implants for wireless monitoring of intracranial pressure
- implants for electrostimulation purposes
- orthopaedic active implants

  The Fraunhofer IBMT pools the experience and know-how of different units to offer a wide range of services dedicated to active implants:
- wireless powering and data transfer (RF, RFID, infrared and ultrasound)
- microelectrodes, microsensors and microactuators
- encapsulation and housing (flexible and rigid)
- electronics design & development
- miniaturization by intelligent electronic design
- firmware/software development and signal processing
- biocompatibility and biostability testing
- system aspects and integration
- regulatory issues

17.18 Neuromonitoring

Neuromonitoring utilizes electrical activity of neuronal and myogenic structures for diagnosis and the control of initiated therapeutic measures. The methods include electroencephalography (EEG), electromyography (EMG) and evoked potentials (EP).

The focus of the working group Neuromonitoring is on the equipment technology and methodology required for acquisition, conditioning and transmission of bioelectric potentials. This also includes vital parameters that can be influenced by neuronal structures (e. g. temperature, blood pressure, respiration, eye movements, skin conductance etc.). Research is being carried out in the fields of sensor technology, signal processing, data transmission and signal analysis. Another approach is the integration of suitable stimulators for closed-loop systems. This enables the development of networks made up of different self-sustaining distributed actuators and sensors.

17.19 Neuroprosthetics

The aim of neuroprosthetics is to compensate neural dysfunctions with a sensory or motor background, and to restore functionality. To this end, myogenic and neuronal structures in the peripheral, spinal and central nervous system are electrically stimulated. Cardiac pacemakers, cochlear implants as well as implants for deep brain stimulations, e. g. for paraplegics and stroke patients, have already found their way into clinical practice.

The core competence of the working group Neuroprosthetics is the development and fabrication of implantable microelectrodes, which can be applied to open up new fields in neuroprosthetics. For instance, interfaces for stimulating the retina or the vestibular system, as well as bidirectional interfaces for selectively accessing the afferent and efferent fibres of the peripheral nervous system have been developed.

The application of microtechnology enables the fabrication of ultra-light, flexible microimplants made of biocompatible materials for multi-channel contacting of nerves and control of neuroprostheses.

17.20 Silicone Technology

The technical competence of the working group Silicone Technology lies in the optimization and functionalization of PDMS structures. This makes actuators and sensors for medical engineering possible with completely new properties and applications. Examples of this include all-polymer electrodes which, due to their optimized mechanical properties, are particularly suitable for use in the musculature. With the aid of bio functionalization it is possible to achieve an interaction between materials and their biological environment without any sacrifices in terms of the basic physical properties. For various methods of the release of active ingredients, the parameters substance concentration, release time and duration of release are optimized for individual applications.

17.21 Health Information Systems

Against the background of demographic change, the working group Health Information Systems develops personal health systems and intelligent assistants for the elderly and chronically ill persons. Its homecare and telemedicine platform TOPCARE was used in many telemedicine pilots in Europe and America. Our R&D efforts are focussed on solutions for personalized and preventive medicine such as predictive health assessment systems. In addition to this, the working group realizes the vision of intelligent, ad hoc networking, plug and play-enabled medical devices and sensors, for which it provides the middleware framework Semantic Medical Device Space for semantic interoperability and for self-learning.

The working group develops the electronic infrastructure and respective tools for the networked clinical research. Examples are its GRID-enabled, ontology-based management system for multicenter clinical trials ObTIMa, which facilitates the integration of study data, or eurocryoDB, an innovative sample logistics system for biobanks.

In the working group, we have developed an SOA-based middleware infrastructure using Semantic Web and Semantic Web Service (SWS) technologies, known as Semantic Medical Devices Space (SMDS), which is being used to develop the next generation of Ambient Intelligent (AmI) medical devices/sensors, having the capabilities to semantically discover the desired medical devices/sensors based on their physical and/or functional characteristics, and use their service(s) for exchanging the measurement results and producing a higher level of interpretation of these results. SMDS is enriched with our own developed Semantic Medical Devices Discovery Protocol (SMDDP) and an integrated micro OWL Description Logic (DL) Reasoning System (µOR), which provides semantic discovery, knowledge querying, knowledge consistency checking and inference capabilities on each AmI medical device/sensor.

18. Fraunhofer Institute for Building Physics IBP

Website Link: http://www.ibp.fraunhofer.de/en.html

18.1 Institute Overview

English: The primary focus of the Fraunhofer IBP’s work is on research, development, testing, demonstration and consulting in the various specialist areas of building physics. These include areas such as noise control and sound insulation measures in buildings, the optimization of acoustics in indoor spaces, and solutions for improving energy efficiency and optimizing lighting technology. They also include issues related to climate control and the indoor environment, hygiene and health protection, building material emissions, weatherproofing and protection against heat and moisture, preservation of building structures and the conservation of historical monuments. The institute employs life cycle engineering methods to analyze the potential environmental, social and technical impacts of products, services and processes. This enables us to evaluate and make lasting improvements towards sustainability and to foster innovation processes. Our portfolio of building science services also includes building chemistry, building biology and hygiene, as well as cutting-edge work in the field of concrete technology. Our

Kassel branch applies and builds on conventional methods of efficient energy use and provides key expertise in the development of building system components.

Korean: 프라운호퍼 건축물리학연구소(IBP)는 건물 소음 제어 및 방음 기술, 실내 공간 내 음향 최적화, 에너지 효율 제고 솔루션, 조명 기술 최적화 등 건축물리학의 다양한 분야에서 연구개발, 시험 및 컨설팅을 수행하고 있습니다. 또한 실내 온도 조절 및 실내 환경, 안전보건, 건축자재 방출, 내후·방열·방수, 구조물 보전, 역사유적 보존 관련 연구도 수행하고 있습니다. 수명주기공학을 바탕으로 제품, 서비스, 절차의 환경적·사회적·기술적 잠재영향을 분석함으로써 지속가능성을 평가 및 개선하고 혁신적인 절차를 고안합니다. 연구소는 건축화학, 건축생물학 및 위생, 콘크리트 기술 분야에서 건축과학 서비스를 제공하고 있습니다. 특히 카셀(Kassel) 연구소의 경우, 기존의 효율적인 에너지 이용방식을 적용 및 발전시키고 있으며, 건축 시스템 부품 개발 분야에서 전문성을 보유하고 있습니다.

18.2 Acoustics

Noise is a typical product of technological progress that in many cases can only be reduced or eliminated by developing innovative acoustic technologies.

A broad focus that covers multiple topics is the starting point for interdisciplinary research and development and simultaneously its strategic goal. Our researchers develop calculation and simulation techniques and analysis and forecasting methods with a broad scope of application that often extends well beyond the realm of pure acoustics to encompass mechanical and plant engineering, aerodynamics and acoustic diagnostic technology.

We also focus on developing new kinds of acoustic building components such as alternative sound absorbers, passive, reactive and active silencers, and sound insulation materials designed for buildings and for reducing the noise of machines, plants and vehicles. In collaboration with more than 15 industrial licensing and cooperation partners, the department offers a constantly expanding international platform for innovative acoustics which aims to optimize the acoustic system quality of complex products and structures.

Our research work is based on modern analysis systems such as scanning laser vibrometry, microphone array systems and binaural dummy head technology in combination with over 20 acoustic test stands. This equipment also forms the backbone of the test centers in the departments of building acoustics and environmental noise control which have been granted flexible accreditation under the DAP German Accreditation System for Testing.

Our services include airborne and impact sound insulation for all kinds of building components, sound absorption of material systems, and the measurement of noise emitted by building systems and services. We also have a versatile four-wheel chassis dynamometer which can be used to run a wide range of vehicle acoustics tests and a wind tunnel for aero-acoustic and aerodynamic measurements.

Fraunhofer IBP organizes regular acoustics forums in collaboration with the trade press to help transform research results into practical applications.

18.3 Building Chemistry, Building Biology, Hygiene

The working groups chemistry, biology, senory, testing, concrete technology and functional construction materials are involved in the research of chemical, sensory, concrete-engineering-related, biological and hygienic problems occurring in relation to the interiors and exteriors of buildings as well as the insides of vehicles and aircraft. They provide consulting services for customers and develop new materials and analytical methods.

The focus is put on technical materials, components and construction products for indoor use, for buildings also materials and composites for external envelopes. For example, the scientists are involved in the research of emissions and eluates from materials, semi-finished products, end products and manufacturing methods, in evaluating odors by human olfactometry and subsequently identify the sources by chemical analysis. In addition, the department researches resistance against biological growth and infestation and is involved in microbiological examinations, for example, of mold and algae, which are of concern in the area of materials science and in the environmental media water, soil and air.

Moreover, existing materials, systems and system components are optimized, and new materials with more targeted functionality are developed. For example, functional surfaces, multifunctional materials and components, such as catalytic, self-cleaning or biostatic surfaces, bionic components, filter materials, sensors and sound-absorbing structural components.

Our employees analyze the mass transfer and absorption processes in materials and composite materials, such as filter media, catalytic converters and active construction components. They then measure and model the processes, incorporating material-specific, chemical and physical properties and realistic boundary conditions. They use this knowledge in the development of new analytical methods and are able to derive rapid tests which combine environmental simulations as well as chemical and microbiological problems to provide essential knowledge for the areas of "Construction materials, construction components, buildings", "Vehicles and Propulsion Systems" and "Aircraft, aircraft components".

An additional emphasis of our work is the further development of concrete materials. For example, the addition of admixtures can increase stability, or research can be undertaken in order to find entirely new functionalities for the widely-used material.

18.4 Energy Efficiency and Indoor Climate

The department Energy Efficiency and Indoor Climate (EER) does research and development in the field of energy efficient buildings and construction for home living and the workplace at the IBP branches in Stuttgart, Holzkirchen, Kassel and Nürnberg. Its focus is on energy-related issues of buildings and districts, the development of efficient energy-supply concepts, on measures to minimize energy demand and on renewable energy. Research activities include identifying criteria for user-friendly indoor environments and developing appropriate solutions for indoor climate – not only in buildings, but also in vehicles and airplanes. On the one hand, the department addresses the relation between climate impact and perceived levels of thermal comfort. On the other hand, research concentrates on how to provide optimum indoor climate conditions with less resource use.

EER scientists develop, supervise and evaluate nearly-zero energy buildings, zero-emission and energy-surplus buildings (for new buildings and for retrofitting existing buildings). Besides, the researchers focus on developing concepts for energy efficient cities and communities (up to CO2 neutrality). In addition, the department creates energy-efficient concepts with a range of applications, from small communities to entire cities. At the district level, innovative energy concepts are designed (in the range of plus-energy buildings and beyond), which comprise the implementation of energy efficiency measures in combination with the integration of renewable energy for generating heat, cold, and electricity. With the aim of optimizing energy utilization, principles of exergy are also applied in this context, for instance when assessing the use of energy.

In addition, the department's researchers deal with issues in urban climatology, e.g. avoiding so-called 'heat islands' and ensuring adequate daylight and fresh air supply as well as street lighting.

Further important areas include the evaluation and demonstration of innovative developments, concepts and technologies. Here, EER covers a wide range of services, from performing laboratory and field tests up to accompanying in-situ demonstration projects and pilot applications. These include own IBP developments as well as assessing developments of our partners and clients.

The department's scientists create innovative solutions for lighting and building services systems for indoor and outdoor spaces, advise clients on specific questions and conduct assessments. Here, a particular focus is on methods for designing and controlling technical building systems including lighting and shading systems. The comprehensive range of analyses provided by the department includes laboratory measurements to be performed in various unique measuring and testing facilities (such as VERU, MEGA, flight lab, IATC, DressMAN, test school house, goniophotometer), test group studies on thermal and visual comfort, and building simulations. Building constructions, building components, building materials and system components for heating, ventilation, air conditioning, lighting and energy systems can be examined at the EER Holzkirchen branch, where tests at a 1:1 scale are possible under real-life climate conditions, based on realistic usage scenarios.

Further, EER scientists create assessment tools and calculation tools for energy-efficient building design, indoor air-conditioning and lighting in buildings and vehicle cabins. Computer-assisted planning tools and information systems are created for end users; calculation kernels are developed and maintained for software companies.

The prediction models used by EER are based on experimental data and have been developed at the Fraunhofer IBP. Among other features, these models support flow simulations and thermal comfort analyses. Besides con-ducting energy-related analyses, building simulation also allows for statements to be made with regard to the damage-free performance of the space-enclosing building systems. The focus is also on air flow patterns in interior spaces and large halls and on the temperature behaviour of buildings in summer.

The department coordinates national and international demonstration and standardization projects as well as guidance committees. EER staff members support and develop concepts for national and international studies and transfer projects of the International Energy Agency (IEA), the European Union, the German government, the federal states, municipalities and industry companies. The portfolio is rounded off by providing education seminars and assessing research, funding, and transfer programmes of public and private project management organisations.

Clients of the EER department include international manufacturing companies, planners or developers from the public, the commercial or the private sector. Our constant aim is jointly transforming recent findings into marketable innovations, products and services.

18.5 Life Cycle Engineering

Transparency as an integrated aspect

Life Cycle Engineering analyses products, processes, and services from an ecological, economic, social, and technological viewpoint. This analysis extends over the entire life journey – from the extraction of raw materials, through production and use, up to end of life. This is all based on the analysis of life cycle-related process chains, and material and energy flows. With a broad coverage of all three pillars of sustainability, complex issues can be solved that require consideration of ecological, economic, social, and technical aspects. Depending on the objective, the analysis of individual aspects is also possible and appropriate. In addition to individual decisions, the optimization of a system or of specific innovations can also be the aim and the subject of Life Cycle Engineering. The particular benefits of Life Cycle Engineering are derived from the consistent analysis of a system from several perspectives; this paves the way for new findings and prevents one-sided decision making. Life Cycle Engineering thus helps reduce risks and identify opportunities.

18.6 Hygrothermics

The Hygrothermics department is specialized in analyzing the dynamic heat and moisture behavior of building materials and components and whole building complexes. This includes analyzing the energy and moisture behavior of ventilation and air-conditioning systems and their interaction with the building envelope and other hygrothermal storage capacities. Such analyses form the basis for optimized systems technology that is adapted to the planned function of a building.

Material tests are conducted alongside the laboratory analysis of complete building and system components which are modified as required. All-important practical tests include those conducted outdoors under defined boundary conditions, climate simulations in suitable differential climate chambers, and new testing methods specially developed at Fraunhofer IBP.

A large part of the department's work is also devoted to the development and application of numerical simulation models. Many years of experience with both experimental and computational research methods, enable researchers to comprehensively evaluate energy-related building and systems behavior as well as the climate-related moisture protection of building structures. This experience also leads to their targeted improvement and optimization of building products and the development of innovative building equipment, materials and construction systems.

Architects and construction firms are faced with new challenges resulting from the need to save energy while meeting the growing demands for more comfort, which are both accompanied by the desire to ensure sustainable development in the building sector. These challenges cannot be met without an in-depth understanding of hygrothermal interactions.

The department's core areas of expertise, supported by its constant expansion of testing facilities and new hygrothermal simulation tools, form the basis for innovative product development. The humidity-controlled vapor retarder now being marketed in many countries is exemplary of the department's achievements in development, while considerable potential has also been identified for the researchers' novel cooling fountain. In contrast to conventional decorative fountains, it uses a chilled film of water. In addition to conditioning the air inside the room, this also cools people and objects in the room through the exchange of long-wave radiation. The water film's low temperature not only leads to effective cooling, but also dehumidifies the air in the room at the same time, creating a pleasant indoor climate even on hot and humid days. It may appear counter-intuitive that air can be dried with water but this happens every time when condensation takes place on cold surfaces. If the temperature of a water film drops below the dew-point of the ambient air vapor condenses on it

19. Fraunhofer Institute for Chemical Technology ICT

Website Link: http://www.ict.fraunhofer.de/en.html

19.1 Institute Overview

English: We carry out research and development work in the fields of energetic materials, energetic systems, applied electrochemistry, environmental engineering and polymer engineering. Our expertise ranges from the conception and design of processes, material development, characterization and processing, through to design, set-up and operation of pilot plants.

We work mainly on plastics-related projects such as material development and selection, product development, component design and processing technology, with particular emphasis on the further development of direct processes. Recycling management and sustainable development define company strategies for future generations. The Fraunhofer ICT is one of the most high-profile research institutes working in the environmental technology sector. The institute has played a key role in shaping the field of environmental simulation, which involves the investigation of environmental impacts on materials and technical products.

Korean: 프라운호퍼 화학기술연구소(ICT)는 에너지 물질, 에너지 시스템, 응용 전기화학, 환경공학, 고분자공학 분야의 연구개발을 수행하고 있습니다. 공정구상 및 설계, 소재개발, 특성분석 및 가공, 파일럿 설비의 설계, 설치 및 운영 분야에서 연구역량을 갖추고 있습니다. 연구소는 직접과정 개발을 중심으로 소재개발 및 선정, 제품개발, 부품 설계 및 가공기술 등 플라스틱 관련 과제를 수행하고 있습니다. 또한, 재활용 관리 및 지속가능한 개발 연구를 통해 차세대 기업 전략 수립을 지원하고 있습니다. ICT 연구소는 환경기술 부문에서 두각을 나타내는 연구기관으로, 재료 및 기술제품의 환경영향을 평가하는 환경 시뮬레이션 분야의 발전에 크게 기여했습니다.

19.2 Batteries

The research group working on batteries has over 35 years of experience with electrochemical energy storage devices for civil and defense applications. Work focuses on lithium ion systems on a cell and modular level, and double-layer capacitors.

19.3 Fuel cells

Fuel cells are characterized by high efficiency, low noise, low emission of pollutants and high energy storage density. The Department AE has extensive expertise in electrochemical processes in fuel cells, as well as the equipment needed to carry out every conventional test on fuel cells and their components. Additional research topics include energy systems for military applications and hybrid battery / fuel cell systems.

19.4 Redox-flow batteries

Redox-flow batteries are more efficient than conventional batteries and have a significantly longer service life. The storage concept allows the power output to be up-scaled independently of the capacity. The battery can therefore be tailored to any application.

19.5 Sensors and Analytical Systems

We offer customer-specific development of sensors, analytical methods and pattern recognition based on electrochemical methods. We also develop methods and systems to measure low concentrations of substances in the air, soil and water.

19.6 Chemical processing technology

In the research area of chemical processing technology, techniques for the synthesis and processing of energetic materials and fine chemicals are developed up to pilot scale. Current examples include microreaction technology, supercritical fluid crystallization processes and fluidized bed technologies.

19.7 Safety and Security research

Research topics in the area of safety and security research include the detection of explosives and the development of new flame retardancy concepts and high-temperature insulation. At the Fraunhofer ICT manufacturers can also test the suitability of their devices for explosives detection.

19.8 Defense research on explosives

The group for defense research supports the decision-making and consulting competency of the German Federal Ministry of Defense. Work is focused on formulations for explosives, rocket propellants, gas generators, gun propellants and pyrotechnical compounds.

19.9 Smart Materials

In the research area of smart materials, the functionalities of microstructures are researched and applied. Examples include microcapsules, molecularly-imprinted polymers, ceramizing layers, ionic liquids, carbon nanotubes, micro- and nanocomposite materials and co-crystals.

19.10 Combustion and pyrotechnics

Combustion processes are relevant to many areas of daily life, including transport, energy, fire protection and military technology. Pyrotechnic systems are used in vehicle safety, as signal ammunition for rescue systems and in defense systems.

The group for combustion and pyrotechnics is concerned with the physical mechanisms and chemical reactions that occur in combustion processes, and their optimization.

19.11 Interior ballistics and detonics

Experimental investigations into energetic materials and systems, for both defense and civil applications, are a central task of this research group. Energetic materials are characterized and evaluated in terms of their performance, sensitivity and safety behavior. Research focuses on the evaluation of explosives, and on technical safety in the production, transportation, storage and application of the material in the system, from laboratory to real scale.

19.12 Gas generators and non-lethal weapons

Pyrotechnic gas generators are reactive solid mixtures that release large quantities of gas when they react. Beside their application in airbag systems, their potential for separating electrical connections, generating motion and expelling powders and liquids has attracted attention. Pyrotechnic gas generators are light and low-maintenance, have a small installation size and an adjustable gas flow rate, and also have no pre-loaded pressure gas system.

19.13 High-performance fiber composites

The research group for high-performance composites is concerned with material and processing tasks relating to resin transfer molding (RTM). The aim is the further development and industrialization of the process for the large-scale manufacturing of components made from high-performance composites based on thermosetting and thermoplastic (T-RTM) matrix resins.

19.14 Nanotechnology

The main research topic of the nanotechnology group is the production of polymer compounds using nanoscale additives to adjust the electrical, mechanical or thermal properties of thermoplastic polymers. Beside a research focus on the properties of the compounds, work is also carried out on processing techniques for the manufacture of the compounds, and on the development of analytical methods to measure the nanostructure of the materials.

19.15 Thermoplastic processing

The research group for thermoplastics processing is mainly concerned with process development for the large-scale processing of thermoplastics. Beside standard injection molding and extrusion processes, resource and energy-efficient one-stage direct processes are developed, for example to process long-fiber-reinforced thermoplastics (LFT) in combination with local continuous-fiber reinforcement.

19.16 Microwave and plasma technology

The Fraunhofer ICT's competences in the area of microwave and plasma technology extend far beyond simple processing technologies. They include the development of production units and measurement technology, accompanied by numerical simulation of the electromagnetic field and the resulting heating or plasma formation. Particular attention is paid to the reproducible and controlled application of microwaves. Plasmas generated with microwaves can be used for the cleaning, modification or coating of surfaces (PECVD).

19.17 Thermoset processing

The research group for thermoset processing is concerned with material and process development for the large-scale manufacture of long-fiber-reinforced composite components with thermosetting matrix materials, for structural and surface-specific applications.

19.18 Foam technologies

Foamed materials have numerous advantages compared to their compact counterparts. In the area of foamed polymers the Fraunhofer ICT covers the entire development chain, including material development, the production of extrusion-foamed particles and semi-finished products, and component production.

19.19 Compounding and extrusion

During compounding, the material properties are adapted to the requirements of further processing and in particular the final product. Research topics in the field of compounding and extrusion include:

- Process development - to allow completely new mixing processes with twin-screw extruders
- Material development - to generate improved material properties on the basis of new material

In many cases these two elements are equally important in our work:

19.20 Technical services - plastic testing

We offer a comprehensive range of services, supplying polymer producers, design engineers, component manufacturers and their purchasers with important information that enables material evaluation or quality comparisons of finished parts at every level.

The material testing laboratory of the Fraunhofer ICT offers a neutral group of experts which is independent of manufacturers and has the necessary market proximity and corresponding laboratory and technical equipment to test your products or materials and perform failure analysis.

19.21 Polymers and additives

The research group for polymers and additives develops technical polymers with new or improved properties. One field is the recovery of new building blocks from sustainable raw materials. Another is the application of flame retardants in plastics (synthesis, formulation, flame retardancy tests).

19.22 Reaction and separation techniques

The research group for reaction and separation techniques covers thermal, mechanical and chemical processing techniques. Emphasis is placed both on the separation of individual components and on the manufacture of new products, for example via chemical reactions.

19.23 Environmental simulation and product qualification

The research group for environmental simulation and production qualification uses specially-developed testing units to simulate environmental influences on products and materials. The effects of these influences are measured and evaluated. Tailored tests are also developed.

19.24 Recycling and resource efficiency management

Resource efficiency and sustainability form a basis for the material, process and concept development in the research group for recycling and waste management. Competences range from the characterization of material streams through to the high-value application of these streams in production processes.

19.25 Analytics

The analytics group in the Environmental Engineering Department works on the analysis of natural materials, polymer products and mineral components in recycled materials. Investigations using GC-MS, LC-MS, GPC, EA and ICP-OES are carried out for example on lignins, sugars, fats and platform chemicals for synthesis.

20. Fraunhofer Institute for Digital Media Technology IDMT

Website Link: http://www.idmt.fraunhofer.de/en.html

20.1 Institute Overview

English: The Fraunhofer Institute for Digital Media Technology IDMT is doing applied research in the field of audiovisual media. The Institute is known as a competent partner of industry when it comes to developing groundbreaking technologies for the digital media domain. Together with its contracting partners Fraunhofer IDMT develops cutting-edge solutions consistently designed to meet user requirements and expectations.

Korean: 프라운호퍼 디지털미디어기술연구소(IDMT)는 시청각 미디어 분야의 응용연구를 수행하고 있습니다. 기업의 디지털 미디어 혁신기술 개발을 지원하고 있으며, 다양한 연구기관과 협력하여 사용자 요구사항 및 기대에 부응하는 최첨단 솔루션을 지속적으로 개발하고 있습니다.

20.2 Hearing Perception and Sound Quality

What are the characteristics of a good sound? Why are some noises annoying, while others indicate that a product is functioning reliably? Can a vacuum cleaner sound powerful even though it is quiet? Psychoacoustics sets out to provide answers to these questions. For this purpose, research is conducted into the physical factors that influence the subjective perceived sound quality. In order to describe and predict the quality of sounds, the Fraunhofer research scientists work in close cooperation with the scientists conducting fundamental research at the Carl von Ossietzsky University of Oldenburg to develop computer models that simulate the hearing perception of normal and impaired hearing. The scientists develop application-specific evaluation measurements for sound parameters such as loudness, speech intelligibility, roughness or annoyance.

20.3 Enhancement of Speech Intelligibility

Technical transmission of speech is often subject to superposed interference noise and reverberation, e.g. in the case of railway station announcements or when using mobile phones. The Project Group for Hearing, Speech and Audio Technology offers real-time signal processing methods that analyse and represent speech intelligibility under conditions with unknown and variable interference noise. For this purpose, the current acoustic situation is detected using a microphone. An adaptive signal processing algorithm developed at the Fraunhofer IDMT is then able to automatically adapt the speech signal to the background noise. By taking into account the latest hearing research findings, this makes it possible to achieve a high level of hearing comfort even for signals with limited bandwidth and for people with impaired hearing.

20.4 Hearing Assistance for Telephone and Consumer Electronics

Everyone has their own auditory perception, own sound preference and own sensation of loudness. From the age of fifty onwards, normal hearing ability also deteriorates in many people. The Project Group for Hearing, Speech and Audio Technology develops signal processing methods to adapt the audio output of telephones and consumer electronics devices to individual hearing needs. By integrating methods from hearing aid technology, it is possible to selectively optimise the dynamic range of high- or low-frequency sounds for the individual user. Studies have shown that people suffering from hearing loss also benefit from the technology, which allows them to more easily understand telephone conversations even under conditions with background noise, for example. Together with end users, the scientists develop user interfaces for adaptation of the audio output.

20.5 Audio System Technology and Signal Processing

Applications in the fields of audio system technology and signal processing are one of the main areas of expertise of the Project Group for Hearing, Speech and Audio Technology. The researchers develop technologies for signal recording and enhancement that can be combined and integrated on a modular basis. Depending on the acoustic requirements, vibration sensors or arrays with a large number of different microphone types are used. Using single- or multi-channel signal processing, the signal can then be optimised for the respective application. Thanks to their in-depth know-how of methods for implementing signal processing in embedded systems and of synchronous transmission technology, the scientists are able to optimally integrate new audio technologies in existing applications and designs.

20.6 Speech Recognition

Robust even under difficult acoustic conditions

Intelligent speech input systems are increasingly being used as a user interface in human-technology interaction. The Project Group for Hearing, Speech and Audio Technology is working on speech detection systems that function robustly even under conditions with background noise and with a large distance between the microphone and speaker. The scientists use current scientific findings from psychoacoustic and psychophysical fundamental research to develop algorithms with a minimum false recognition rate. The phonologically-based speech recognisers can even be adapted to the reduced articulation of stroke patients.

Signal processing in embedded systems

When recogniser systems are implemented on microprocessors, all processing tasks are performed in the device and an internet connection is not needed. This also permits realisation of applications with high data protection

20.7 Acoustic Monitoring

Computer-based methods for acoustic event recognition are developed at the Fraunhofer IDMT – from recognition of individual acoustic events through to analysis of complex scenarios. One application area is inpatient or home care: potentially dangerous situations such as breaking glass, frequent coughing or calls for help are acoustically recognised. As part of corresponding research projects, scientists investigate the potential solutions and methods that will allow use of acoustic data in networked buildings and cities for applications in the fields of security, traffic management and energy efficiency. Abnormal operating noises can also be detected acoustically, e.g. in vehicles, in status monitoring of machines or for acoustic end-of-line checks in industrial production.

20.8 Evaluation and User Studies

At the Oldenburg location, the Fraunhofer Project Group has access to different laboratories and special rooms for evaluation studies as part of the cooperation with the Haus des Hörens and the University of Oldenburg. The communication acoustics simulator allows simulation of the acoustic characteristics of practically any room, such as class-rooms, offices or even railway station concourses. A central database with over 2,400 test persons is available for performing customer studies. This allows test persons to be selected according to specific criteria such as age, sensory impairments or technology acceptance and technical competence. In addition to qualitative and quantitative user survey methods, the scientists use new neuroergonomic methods to measure the mental effort involved in use of products and technologies.

21. Fraunhofer Institute for Experimental Software Engineering IESE

Website Link: http://www.iese.fraunhofer.de/en.html

21.1 Institute Overview

English: Fraunhofer IESE is a competent and reliable partner for businesses from all sectors of industry regarding the issue of “Software Engineering”. We offer dependable methods and tools for the software development of embedded systems and information systems. In addition, the development of interconnected systems all the way to entire “Smart Ecosystems” as well as process know-how for the successful adaptation and roll-out of such methods and tools in practice is another focus of Fraunhofer IESE. Furthermore, we support organizations with our interdisciplinary and cross-domain know-how when it comes to identifying new innovation ideas as well as the corresponding roadmaps.

Korean: 프라운호퍼 실험소프트웨어공학연구소(IESE)는 소프트웨어 엔지니어링 분야의 신뢰할만한 연구기관으로 자리잡았습니다. 연구소는 임베디드 시스템과 정보 시스템 구축을 위한 소프트웨어 개발 기술 및 툴을 제공하고 있으며, “스마트 이코시스템(Smart Ecosystems)” 구현을 위한 연계계통 개발과 관련 기술 및 툴의 성공적인 현장 적용도 연구하고 있습니다. 또한, 학제간 융합연구를 통해 혁신적인 아이디어 개발 및 관련 로드맵 수립을 지원합니다.

21.2 Smart Rural Areas

Making life in rural areas worth living in the future is our joint responsibility in government, research, business, and society. Science and research should make every effort to support the pursuit of new and innovative paths. The Fraunhofer Institute for Experimental Software Engineering IESE in Kaiserslautern therefore considers itself a pioneer and companion for future-oriented ideas, which are being developed in numerous collaborations with business enterprises.

21.3 Smart Ecosystems

Smart Ecosystems form a bridge between the Information Systems domain and the Embedded Systems domain. Smart Ecosystems connect Emergent Systems and CPS into a single ecosystem, in which the Internet of Services, Things, and Data merge with each other, thus resulting in cross-organizational innovative solutions.

21.4 Industry 4.0

According to the German Industrie 4.0 Working Group, it revolves around "networks of manufacturing resources (manufacturing machinery, robots, conveyor and warehousing systems and production facilities) that are autonomous, capable of controlling themselves in response to different situations, self-configuring, knowledge-based, sensor-equipped and spatially dispersed and that also incorporate the relevant planning and management systems" (Recommendations for implementing the strategic initiative INDUSTRIE 4.0).

21.5 Big Data

The discussion about Big Data is about much more than the clever and profitable analysis of Internet data. In the age of the fourth Industrial Revolution and the emergence of cyber-physical systems and ultimately highly integrated Smart Ecosystems, the issue is to generate actually tangible added value for companies and individuals from the potential availability of a seemingly endless stream of data.

21.6 Business Goes Mobile

Mobile business applications provide many opportunities to companies employing mobile workers and serving mobile customers. The workflows of mobile workers can be improved regarding work efficiency and work comfort. Existing as well as new innovative services can be offered to mobile customers leading to increased sales and customer satisfaction. Thereby, mobile business applications go beyond mobile applications to perform personal information management (i.e. email, calendar, etc. in mobile devices) or using the internet via mobile browsers.

22. Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM

Website Link: http://www.ifam.fraunhofer.de/en.html

22.1 Institute Overview

English: Founded in 1968 and integrated into the Fraunhofer-Gesellschaft in 1974, the Fraunhofer IFAM is one of the most important research institutions in Europe for adhesive bonding technology, surfaces, shaping and functional materials. At our institute's five locations – Bremen, Dresden, Oldenburg, Stade and Wolfsburg – we put our central principles into practice: scientific excellence, a focus on the application of technology, measurable utility for customers and ensuring the highest quality.

Our 580 employees, working in 24 departments, combine their broad technological and scientific knowledge and expertise into seven core competencies: Powder Technology; Sintered, Composite, and Cellular Metallic Materials; Adhesive Bonding Technology; Surface Technology; Casting Technology; Electrical Components and Systems; and Fiber Reinforced Plastics. These core competencies - both individually and in combination with each other – are not only the basis of our strong position in the research market but also of future-forward developments that will be useful for society.

Most of the products, processes, and technologies we develop are for sectors where sustainability is particularly important, namely for the aviation industry, automotive sector, energy and environment, medical technology and life sciences. The solutions developed at Fraunhofer IFAM are, however, also used in various other branches of industry including machinery and plant construction, electronics and electrical engineering, shipbuilding, rail vehicle manufacture, the packaging industry, and the construction sector.

Korean: 프라운호퍼 제조기술 및 첨단소재 연구소(IFAM)는 1968 년 설립 후, 1974 년 프라운호퍼협회에 흡수·통합되었으며 접착기술, 표면, 성형 및 기능성 소재 분야에서 유럽 내 선도 연구기관으로 각광받고 있습니다. 브레멘(Bremen), 드레스덴(Dresden), 올덴부르크(Oldenburg), 슈타데(Stade), 볼프스부르크(Wolfsburg) 등 5 개 지역에 위치하고 있으며, 과학적 탁월성 원칙에 기반하여 기술 응용, 측정 가능한 효용, 양질의 연구를 지향하고 있습니다. 24 개 부서 580 여명의 임직원은 분말기술, 소결·복합·다공질·금속재료, 접착기술, 표면기술, 주조기술, 전자 부품 및 시스템, 섬유강화플라스틱 등 7 개 분야에 과학기술 지식과 전문성을 토대로 핵심역량을 확보하고 있습니다. 이러한 개인 및 조직역량은 연구소가 해당

분야에서 선도적인 위치를 확립하는데 크게 기여했으며, 사회에 공헌하는 미래지향적 기술개발의 원동력이 되고 있습니다. 연구소는 특히 지속가능성이 중시되는 항공, 자동차, 에너지 및 환경, 의료, 생명과학 부문을 대상으로 제품, 공정, 기술을 개발하고 있습니다. 그 외에도 기계 및 설비건설, 전기공학, 조선, 철도차량 제조, 포장, 건축 등 다양한 산업을 지원하고 있습니다.

22.2 Powder Technology

Powder technology has long been successfully used by industry. Component manufacture using powder technology is unique in allowing the simultaneous customization of material properties and geometry. Powder technology is a core competence of Fraunhofer IFAM. Our expertise here extends from the powder to the product on all matters concerning the materials, shaping, tolerances, process safety, and special requirements.

The basis for powder technology solutions are the starting materials. Required property profiles can be achieved by the mixing of powders. For example, properties such as hardness, toughness, Youngs modulus, wear properties, and thermal expansion can be adapted to requirements. New soft magnetic materials and hard magnetic materials are gaining increasing importance.

A key aspect is knowledge of various shaping and production processes. Shaping and sintering are key processes for component manufacture.

Metal injection molding (MIM) is an example of an established and important shaping process. The experts at Fraunhofer IFAM possess an in-depth understanding of the whole process chain, from the starting powder to feedstock systems and injection molding through to the sintered product. Our range of services includes component development, the production of pilot series, knowledge transfer, and training of production personnel. Also covered are shaping processes for special products such as micro MIM, two component MIM, and extrusion.

Fraunhofer IFAM also has comprehensive expertise in additive manufacturing, where products are made from metal powders without molds being required and are manufactured in virtually any desired shape from 3D CAD data. This method is now not only being used for rapid product development but increasingly also for the production of high-quality, individualized products for end-users.

Functional printing is used to add functions to components. Various powder-based printing technologies therefore also form part of our expertise in powder technology. The methods are being transferred to an industrial scale using a specially designed production line.

Supporting technologies are also important. These include the simulation of shaping processes, as for topology optimization, as well as analytical technologies for powder characterization and rheology.

22.3 Metallic Sintered, Composite, and Cellular Materials

The development of materials with customized proper ties and combinations of properties and efficient manufacturing technologies are key activities of Fraunhofer IFAM. The utilization and tailored development of sintering and shaping processes create numerous opportunities for the manufacture and optimization of innovative metallic materials with unusual property profiles, in particular by combining properties in novel composite materials or by creating highly porous or cellular structures.

In the area of metallic and intermetallic sintered and composite materials for functional and structural applications, Fraunhofer IFAM possesses in-depth understanding of structure-property relationships and how to optimize these for specific applications. The complete powder-metallurgical technology chain from powder preparation and characterization through to various shaping and thermal treatment methods is covered. This is now being further expanded by methods such as rapid solidification of metallic melts (melt spinning and extraction) and special sintering processes (e. g. spark plasma sintering) as well as innovative oven analysis.

Fraunhofer IFAM has comprehensive knowledge of alloys and processes for manufacturing light metal components, in particular made of aluminum, for weight reduction in car manufacture. Regarding metallic composites, the focus is on materials development for thermal management of electronics, friction materials and sliding materials for high tribological loads, and special materials for mechanical and corrosive stresses at high temperature (> 800°C). The manufacture and testing of functional materials for energy storage and conversion is of growing importance. Key areas here are new and, in particular, nano-structured materials for hydrogen generation and storage, for heat storage, for efficient thermoelectric generators, and for supercapacitors.

Cellular metallic materials are another key development area. Prudent selection of materials and a wide range of customizable cell and pore structures allow a wide spectrum of application-specific properties and material savings to be realized. For example, highly porous metallic materials such as fiber-metallurgical materials, hollow sphere structures, open-cell metallic foams, 3D screen-printed structures, 3D wire structures, and porous metal papers can be used for applications such as noise absorption, heat insulation, energy absorption, mechanical damping, and material and energy transport as well as for achieving catalytic effects.

22.4 Adhesive Bonding Technology

Adhesive bonding refers to a manufacturing method, belonging to the group of joint processes, that involves the joining of substrates using an adhesive to form a material-fit joint. Over recent decades, adhesive bonding has become ever more widely used by a host of industries. The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM realized the potential of adhesive bonding technology at an early stage and developed this as a core competence. Fraunhofer IFAM is internationally recognized in this field and is the largest independent research organization in Europe working in this area.

The core competence adhesive bonding technology at Fraunhofer IFAM involves development and characterization of materials, development and usage of various application techniques, design and validation of structures, as well as in-depth quality assurance.

The institute has a wealth of experience regarding the modification of polymer systems as well as the development of adhesives and sealants. Challenges such as adhesion promotion and protection against aging form part of the portfolio as do the development and use of biomimetic adhesives. For characterizing adhesives and bonded joints a wide spectrum of chemical, physical, and mechanical test methods is utilized. The aging behavior and service life of bonded joints are often key aspects.

The integration of adhesive bonding technology into industrial production requires an application method adapted to the specific utilization. To achieve high-quality bonded joints it is often necessary to pre-treat the substrate surfaces. The substrates are cleaned and activated or modified to enable the adhesives to adhere to the substrates with good long-term stability. Process automation, including tolerance-specific production methods, is important in many industries. Also important are the design of bonded joints and the dimensioning of bonded structures. This is based on experimental parameters for materials, joints, and components determined in an accredited test laboratory, taking into account the specific boundary conditions of the application.

The institute provides consultancy on all matters relating to adhesive bonding technology. Optical methods, in-line analyses, and a wide variety of destructive and non-destructive test methods are used for quality assurance purposes. An established and comprehensive portfolio of training courses in adhesive bonding technology is also offered. The certificates of the courses which are given worldwide are accredited and recognized in all of Europe. These courses are a further key aspect of the quality assurance concept for adhesive bonding technology.

Fraunhofer IFAM also acts as a Certification Body of the Federal Railway Authority for auditing and approving companies that carry out or subcontract adhesive bonding work, sell bonded products, or offer services regarding the designing and dimensioning of bonded components for rail vehicle construction.

22.5 Surface Technology

New materials often drive innovation and end up in key technologies of everyday life. The industrial range of uses of many materials can be considerably expanded by customized modification of their surfaces. The Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM has long-standing and in-depth expertise in surface technology, acquired in projects with partners from a range of industries and involving many innovative products and processes.

In general, materials are designed to meet predefined property requirements, such as strength, elasticity, and heat resistance, or to meet the requirements of a production process. If components have to suit certain additional needs, this is often only possible using special surface technologies. Intelligent surface technologies such as pre-treatments and coatings are able to improve the properties of materials and components or provide them with additional functions.

The expertise of Fraunhofer IFAM covers the whole process chain of surface technology from materials‘ development to the characterization and evaluation of surfaces, their functionalization and modification, and on to various application methods. The development of processes – such as dry and wet chemical pre-treatment, coating processes, printing processes, as well as thin/thick film technologies – and also quality assurance are key areas of the work. The characterization and evaluation of surfaces using chemical, electrochemical, and structural analysis is an important aspect of the institute's work, as is the application of various simulation methods.

The experts at Fraunhofer IFAM have comprehensive knowledge of customized surface modification and functionalization. This includes the cleaning as well as the activation of surfaces and suitable pre-treatment prior to coating or bonding. The functional attributes of surfaces are very varied and depend on the respective application. Surfaces can be customized with low-drag, anti-icing, dirt-repellent, anti-fouling, antibacterial, and bio-compatible properties. Specific tribological or optical requirements as well as sensor functions can also be provided. In addition, a very wide spectrum of application methods can be used, ranging from the laboratory scale to pilot plants as far as upscaling for (large) series production.

Quality assurance is an important aspect of surface technology. In-line quality assurance concepts and test methods, which allow constant process monitoring, are developed at Fraunhofer IFAM. The institute possesses accredited test facilities, which are also utilized for failure analysis. Finally, special training courses are given and there is a regular transfer of surface technologies to industrial practice.

22.6 Casting Technology

Casting technology has many established applications in a range of industries. Fraunhofer IFAM supports industrial customers in the area of casting technology, from the initial idea to the final product. A variety of casting processes and materials are used for different applications.

Fraunhofer IFAM has built up in-depth know-how and has an extensive range of facilities for die casting, investment casting, and lost foam casting, the three most important casting methods.

Die casting is the most productive of the three methods and today still has enormous potential for enhancing value creation. Key current research areas include lost (salt) cores, cast structural components, and hybrid joining of FRPs with casting materials, in particular CFRP and aluminum.

Investment casting is useful for complex and delicate structures with fine surfaces. Here, a wax model of desired geometry is prepared, embedded in molding material, and then heated. The resulting hollow space is then filled with melt in the investment casting plant.

Lost foam technology is used for casting large and small parts of high complexity directly as near net shaped parts. The method allows uniquely complex components to be manufactured with any design of channels and undercuts – without demolding grooves or burrs. Fraunhofer IFAM is a leader in lost foam technology and works closely with industry via the Verbund des Lost Foam Council e. V..

The casting materials used include aluminum, magnesium, zinc, copper, steel, and customer-specific special alloys. In addition, special materials such as metal-matrix composites are developed and improved, opening up new applications for casting and cast components.

The function-integrated cast components being developed at Fraunhofer IFAM are a growing area of work. The integration of electronic components involves function-integration during the casting process. CAST$^{\text{TRONICS®}}$ technology allows advanced electronic, sensor, and actuator functionalization of cast components, for example RFID component identification and sensors for load detection. Numerical simulation of casting processes and extensive analytical facilities are also available at Fraunhofer IFAM.

Furthermore, there is the unique opportunity for customers to also benefit from the expertise of other related research groups at Fraunhofer IFAM, for example in the area of corrosion protection, surface coatings, and adhesive bonding.

22.7 Electrical Components and Systems

The core competence “Electrical components and systems” is a relatively new area for Fraunhofer IFAM. Our expertise in this area has significantly expanded over recent years and we collaborate closely with other areas of expertise at the institute.

Fraunhofer IFAM adopts a system research approach in this area, whereby individual technologies and components are always considered and developed in relation to the whole system, for example an electric car. At a component level, the scientists are developing novel metal-air batteries for, in particular, the synthesis and processing of new active materials. In addition, thermochemical energy storage systems are being developed based on innovative hydrogenatable metal alloys. Electrical drive technology is focusing on the development, control, assembly, and testing of electrical machines, in particular for drive applications. Adhesive bonding technology, surface technology, and coatings extend the expertise for matters such as the joining, contacting, insulation, and protection of electrically conducing materials.

As many electrical components are being developed for cars, an understanding of systems for electric cars and electromobility is vital. Our know-how in this area includes the design, efficient control, assembly, and testing of vehicles, concept vehicles, and their components, especially electric and hybrid drive systems. In order to improve operating reliability, individual components such as the electric drive train are being qualified by “hardware in the loop” simulation of operating performance on a test stand. Here, experience is utilized from the fleet of electric vehicles being operated in the Bremen/Oldenburg model electromobility region. We pass on our know-how by giving training courses in electromobility. These courses specifically target customers in Germany and China.

An example of the multidisciplinary approach at Fraunhofer IFAM is the cast coil. This innovative product, which was originally developed at Fraunhofer IFAM, involves expertise in casting technology and electric drive technology plus the development of special insulating coatings.

The incorporation of the former Bremer Energie Institut into Fraunhofer IFAM as the new Energy Systems Analysis department represents a logical expansion of the Electrical Components and Systems core competence. The matter of charging infrastructure for electromobility shows, by way of example, that not only technical challenges but also economic and regulatory boundary conditions must be taken into account.

22.8 Fiber Reinforced Plastics

Fiber reinforced plastics (FRPs) refer to materials that consist of a matrix with embedded fibers. Thermosets are used as matrix materials at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM. The advantages of FRPs are their high stiffness in the direction of the fibers combined with the ability of the matrix to be shaped. These advantages, along with their low specific weight, mean FRPs are ideal for lightweight components such as those used for aircraft and car manufacture.

In all areas of transport – cars, rail vehicles, ships, and aircraft – new materials and lightweight design are resulting in lower fuel consumption, reduced CO2 emissions, and hence resource friendly and environmentally friendly mobility. In the area of renewable energy, and in particular wind energy, FRPs are opening up energy-efficient construction methods and are improving the profitability of wind turbines. Lightweight design at Fraunhofer IFAM is particulary concerned with fiber reinforced plastics containing glass, carbon, and natural fibers. The expertise ranges from resin development, design, component manufacture, and surface modification to automated assembly as well as joining technologies.

The first task is the selection or development of suitable resin systems to meet the specific requirements of the manufacturing process such as low curing shrinkage and rapid curing. Challenges such as electrical conductivity, lightening protection, and impact resistance are also addressed. Only by customization of the interfacial properties between the fibers and matrix resin can an optimal material system be used. This is achieved using a range of surface techniques, including plasma treatment of fiber surfaces. Surface modification is also vital for the manufacture and further processing of the components. Techniques worthy of mention at this juncture are cleaning, activation, coating, and the application of functional layers.

The growing industrial use of FRPs necessitates increased automation of assembly and joining technologies – this is a further field of expertise of Fraunhofer IFAM. With the help of optical measurement techniques, shape and positional adjustments can be made to both small and large components to enable precision machining using robots.

Quality assurance is an absolute must in all phases – namely during the manufacture, assembly, and repair of FRP components. This is aided by Fraunhofer IFAM‘s comprehensive range of training courses. The training courses are a means of technology transfer, whereby technological findings and methods are passed on to industry.

23. Fraunhofer Institute for Factory Operation and Automation IFF

Website Link: http://www.iff.fraunhofer.de/en.html

23.1 Institute Overview

English: Now more than ever, investing in progress and innovation is essential. Anyone who fails to unleash all of their potentials with the latest technologies will have problems competing internationally.

This is where the Fraunhofer IFF’s research and development comes in. Our engineers know exactly what companies need. Years of experience in industry projects and work in distinct corporate environments have shaped our know-how. We researchers at the Fraunhofer IFF in Magdeburg are here to support you with our creativity and inquiring minds: We develop customized solutions for our clients and will help you make your products and projects reality.

We develop, engineer and implement innovative and client-driven solutions in the fields of

- logistics,
- automation,
- process and plant engineering and

- digital engineering.

Korean: 혁신을 위한 투자가 그 어느 때보다 중요한 시기입니다. 첨단 기술을 활용하여 잠재력을 충분히 발휘하지 못하는 기업은 글로벌 경쟁에서 뒤쳐지게 됩니다. 프라운호퍼 공장 가동 및 자동화 연구소(IFF)는 풍부한 산업연구 경험과 전문성을 바탕으로 기업의 니즈를 정확히 파악한 연구개발 컨설팅을 제공하고 있습니다. 마그데부르크(Magdeburg)에 소재한 연구소는 창의성과 탐구성을 바탕으로 맞춤형 솔루션을 제공하여 제품의 상용화를 지원하고 있습니다. 특히, 물류, 자동화, 공정 및 플랜트 엔지니어링, 디지털 엔지니어링 분야에서 혁신적인 맞춤형 솔루션을 개발·설계·운영하고 있습니다.

23.2 Smart Work Systems

The Fraunhofer IFF drives innovation in the design of future production systems and work systems. The goal is to maintain or enhance companies' performance and product quality over time while boosting manufacturing systems' flexibility. To do this, the Fraunhofer IFF develops new technologies for safe human-robot collaboration, thus combining humans' cognitive flexibility and alertness with automated systems high productivity. It designs integrated solutions that use digital assistance systems and state-of-the art testing and inspection technologies for quality assurance in manufacturing. And it is establishing methods of virtual learning to train staff flexibly and effectively.

23.3 Resource Efficient Production and Logistics

The Fraunhofer IFF designs efficient production and logistics systems that boost the sustainability of manufacturing and cut risks in the supply chain. Among other things, this means planning and operating factories to be more energy efficient, reducing transportation, and implementing smart energy cascades in manufacturing. Our researchers design new equipment and systems for closed energy and material cycles that sustainably use and recycle valuable resources and waste. As a systems provider, the Fraunhofer IFF leverages potentials for efficiency both in individual companies and in manufacturing and logistics networks among companies.

23.4 Convergent Supply Infrastructures

Germany has begun switching to renewable energy sources for a future viable energy supply. This entails developing new storage technologies and as well as energy supply networks. The Fraunhofer IFF pools its expertise in production, logistics, energy, and information and communications technologies to develop new, complex supply and disposal infrastructure's in and among companies as well as their surroundings. Our researchers develop smart energy management systems and design integrated production and logistics networks that make it possible to utilize volatile energies reliably.

23.5 Digital Engineering and Industry 4.0

Industrial development and manufacturing would hardly be able to remain competitive without digital technologies. Digital engineering makes it possible to use a product's digital design data in every stage of its design and manufacture. This makes products better and more reliable, expedites operations, conserves resources, and cuts costs sustainably. Digital engineering is strategically important to Germany, a center of development and manufacturing. This makes it essential to develop solutions that provide new forms and types of organizational, semantic and technical interoperability for interdisciplinary collaboration. Such research and development is for specific applications and thus constitutes a decisive competitive and knowledge edge for the particular company.

24. Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

Website Link: http://www.igb.fraunhofer.de/en.html

24.1 Institute Overview

English: The Fraunhofer IGB develops and optimizes processes and products for the business areas of medicine, pharmacy, chemistry, the environment and energy. We combine the highest scientific quality with professional know-how in our fields of competence – Interfacial Engineering and Materials Science, Molecular Biotechnology, Physical Process Technology, Environmental Biotechnology and Bioprocess Engineering, as well as Cell and Tissue Engineering – always with a view to economic efficiency and sustainability. Our strengths lie in offering complete solutions from laboratory to pilot plant scale. Customers benefit from the constructive cooperation of the various disciplines at our institute, which is opening up novel approaches in fields such as medical engineering, nanotechnology, industrial biotechnology and environmental technology.

Korean: 프라운호퍼 계면공학 및 생명공학 연구소(IGB)는 의료, 의약, 화학, 환경 및 에너지 분야에서 공정·제품의 개발 및 최적화를 지원하고 있습니다. 연구소는 계면공학, 재료공학, 분자생명공학, 물리공정기술, 환경생명공학, 생물공정공학, 세포조직공학 등 분야별 연구역량과 노하우를 경제적 효율성과 지속가능성에 접목시키고 있습니다. 특히, 실험실에서 파일럿 수준까지

전 과정에 대한 솔루션을 제공하고 있습니다. 연구소 내 학제간의 건설적인 협력을 통해 의료공학, 나노기술, 산업생명기술, 환경기술 등 각종 분야에서 혁신적인 해결책을 모색하고 있습니다.

24.2 Coatings and functionalizations

Some important properties of materials depend only on the chemistry and topography of its surface. These include, inter alia, wettability, adhesiveness, biocompatibility, adhesion properties or tribological properties. Other important material characteristics such as mechanical properties or processability are determined by the material used. By appropriate surface modifications, it is possible to obtain materials with a new property profile and thus to enable new applications.

We equip surfaces of plastics, ceramics or metals with new properties by applying thin layers or generating defined functions on its surfaces. For this, we use gas phase processes (CVD, PVD, PECVD), wet chemical processes and combined processes.

24.3 Biomaterials

Synthetic, bio-based or natural biomaterials are defined as materials in contact with biological systems such as cells or tissues. The minimum requirement for a biomaterial is that it must be biocompatible. Modern biomaterials, however, are even biofunctional or bioactive. For example, they transmit active signals to their biological environment by providing molecular recognition sites that serve as anchor points for coupling molecules or cells, or release biologically active molecules at the appropriate time. Also, biomaterials can imitate the mechanical and topographic properties of a natural cell environment and thus promote the growth behavior and the differentiation of cells. In this way it is possible to produce complete artificial tissues. In addition, stability and biodegradability as well as specific biological effects such as anti-thrombogenicity are crucial points in biomaterial development.

24.4 Membranes

Technical membranes are the tool of choice for the separation of complex mixtures. At Fraunhofer IGB we develop innovative membranes for applications such as high temperature applications (H2- and O2 gas production or cleaning, reformation, membrane reactors), filtration of aggressive media and membranes for medical devices (biocompatible or biodegradable).

24.5 Plasma processes

Plasma processing is nowadays one of the most important tools in thin film and surface treatment technologies, and thus plays a key role in manufacturing of many innovative products. For this reason, applications of plasma in surface technology belong to main research interests of the Fraunhofer IGB. The used plasmas are low temperature, low-to-medium pressure ones, enabling a gentle and controlled surface processing.

This way we are able to etch surfaces, e.g. to clean them, or to graft new chemical functionalities onto the surface. It is also possible to polymerize a thin film onto the surface, providing such functions as as scratch-resistance, dirt-repellency, or corrosion protection. By controlling the gas composition, power and other process parameters, a broad spectrum of chemical, physical and biological surface modifications is attainable.

24.6 Particle-based systems

Nanoparticles with a diameter in the range of 50 up to 300 nanometers are synthesized at the Fraunhofer IGB of organic as well as inorganic materials. Our research focuses on the design of special nanoparticles as carriers for biotechnology and medicine and the use of carbon nanotubes for actuator applications.

24.7 Functional Genomics

The development and application of innovative methods concerning next-generation sequencing, as well as synthetic biology, are the main focus of the Functional Genomics research group headed by Dr. Kai Sohn. These methods provide the basis for the identification of biomarkers for personalized diagnostics of various clinical indications and the molecular analysis of infection processes, but also for the characterization of microorganisms in industrial biotechnology. Furthermore, methods for the qualitative and quantitative characterization of complex microbial metagenomes and metatranscriptomes are developed and applied to diagnostics and environmental biotechnology.

To this end, a complete workflow was established in our group to provide an 'all-in-one' solution from sample preparation to bioinformatics. Our automated sample preparation, next generation sequencing and high performance computing workflows are available for cooperation and joint research projects, as well as research projects of industrial clients.

24.8 Infection Biology and Array Technologies

The Infection Biology and Array Technology working group led by Priv.-Doz. Dr. Susanne Bailer is concerned with the development and application of technologies for the diagnosis of infectious microorganisms and viruses. Furthermore, virus-based technologies are developed to make innovative therapies available.

24.9 Molecular Cell Technologies

The targets identified through our genome and proteome analyses are used to develop high throughput assays for the screening of compound libraries. Currently we screen combinatorial chemical libraries using assays that simultaneously measure both antifungal activity as well as the toxicity of the substances in relation to human cells.

In addition to drug screening assays, we have developed cell-based assays to detect pyrogens (e.g. remainders of bacteria) which cause febrile reactions up to septic shock in humans. These assays are ideally suited to test medical devices or pharmaceutical formulations for the absence of pyrogens and complement or replace previous pyrogen tests.

24.10 Industrial biotechnology

Oil is getting more and more expensive and fossil stocks are being gradually depleted. An alternative is the use of renewable resources and sustainable manufacturing processes. In this context, the white or industrial biotechnology is gaining importance – producing(basic) chemicals with biotechnical or combined processes.

At Fraunhofer IGB, in the field of industrial biotechnology both departments of Molecular Biotechnology (MBT) and of Environmental Biotechnology and Bioprocess Engineering (UBT) are working together. Focus of MBT activities is the biotransformation process either by microorganisms or enzymes.

For more than ten years we are experienced in the screening of novel enzymes for industrial applications as well as in the optimization and production of these biocatalysts. Using this know-how the Fraunhofer IGB Screening Center has successfully performed several projects with companies from the chemical and pharmaceutical industry. Hereby, classical as well as modern screening methods were applied.

24.11 Chemical Analytics

The Analytical Services group of the Fraunhofer IGB offers physico-chemical analytical services for internal use and for external clients from industry, municipal authorities and universities.

Modern technical equipment and motivated qualified staff guarantee a fast handling of the project as well as high quality. Our analytical methods are oriented to GLP, DIN/ISO and EN guidelines.

24.12 Heat and Sorption Systems

Efficient usage of energy in times of climate change and decreasing fossil resources is one of the big challenges we face today, and is thus a key field of activities at the group “heat and sorption systems”. One of our basic goals is to increase energy efficiency by applying and combining energy saving or process intensifying technologies. Concerning process technology, efficient application of energy can particularly be realized by technologies such as drying with superheated steam or the application of electromagnetic fields for volumetric heating.

Besides process intensification and the energy efficient design of industrial processes, the efficient usage of renewable energies and the possibility of energy storage are fundamental parts to ensure sustainable usage of energy. Vast amounts of waste heat are produced during many common industrial processes – the utilization of the waste heat provides an enormous potential in terms of cost and energy savings and process optimization. Key topics are the development, realization and optimization of innovative concepts for the thermal treatment of water and other substances, sorptive heat storage, solar desalination of seawater, concentration of industrial waste water and water harvesting from air humidity by a sorption process. For research, development and process applications on behalf of industrial clients, we operate with both stationary and mobile equipment. In addition, equipment for analytics and powerful software tools for simulation and design of prototypes are also available.

24.13 Physico-chemical Water Technologies

In numerous production processes water is used as a solvent or means of conveyance, as cooling water or washing water. Increasing costs for the purification and disposal of wastewater, regional or seasonal shortage of water, and a growing awareness of environmental issues within companies have increased water recycling. Water is used several times and impurities have to be removed selectively.

The use of oxidative and electrolytic processes for water treatment is one of the main fields of research of Fraunhofer IGB. We work on the improvement of existing processes such as adsorption, filtration, flocculation/precipitation, electrodialysis, homogenization and disinfection as well as on new approaches in process and unit operations. Water treatment and the circulation of process water can thus be carried out economically and sustainably.

24.14 Nutrient Management

Nutrients such as nitrogen, phosphorus, potassium, calcium and sulfur are essential for all living organisms, in particular for plants. Thus, these nutrients are the main components of fertilizers, and so they are indispensable for the world's food supply. Nowadays, these nutrients are only partially recycled in agro-ecosystems, since human intervention has created a linear, dispersive system.

The key response to this lack of sustainability within agriculture and waste management is to recreate a cycle of nutrients. For this reason, the Fraunhofer IGB has established a research field to develop and implement cost-efficient strategies and technologies for the integrated resource management of nutrients.

24.15 Aseptic Technologies

Contaminating microorganisms result in the spoilage of fresh goods and can even produce toxins and cause food poisoning. Thus foodstuffs have to be biologically stabilized as effectively as possible and filled or packed under hygienic conditions. Well-established processes for preserving foodstuffs such as heat sterilization or pasteurization frequently have the disadvantage that they destroy valuable heat-sensitive substances in the foodstuffs such as vitamins, thus reducing their nutritional value. Also, the addition of chemical preservatives can have negative effects on the quality of the product and potentially affect the consumer's health. Besides impairing the substances contained in foodstuffs, thermal processes can also inactivate active agents in pharmaceutical products. There is therefore a need for alternative for biological stabilization methods.

The development of new methods for the biological stabilization and/or sterilization of biogenic products such as foodstuffs, cosmetics and pharmaceutical drugs is the focus of the ˝Aseptic Systems˝ working group. We are investigating various physical methods, such as microwaves or pressure change technology, for their ability to reduce microbial load. Simultaneously, their effects on valuable food components are taken into consideration.

24.16 Prototype Development

In the product development in mechanical engineering enterprises and in the development of consumer goods the application of design methodology to ensure functionality and quality is commonplace. The continuous construction process uses specific methods to clarify customer requirements, solve technical problems systematically, creatively generate ideas, prevent errors and improve technical reliability. In contrast to the design of risk-carrying mass products where these techniques are commonplace, their application to process engineering tasks in the construction of plants and devices has been rudimentary, yet, even though there is a risk of high miss-investments is highdue to high costs.

The purpose of construction in process engineering is to translate physical, chemical or biological processes into components, devices and plants. Specifications derived from research often reveal complex problems with conflicting requirements in individual parts of a process which often lead to a conflict between objectives.

24.17 Water management and wastewater purification

Water is undeniably the most important single foodstuff. Water management – i.e. easy access to clean water, a guaranteed supply of water, the installation of hygienic sanitary systems and efficient, compact wastewater purification – is therefore one of the major global challenges facing this century.

To cope effectively with these major challenges, Fraunhofer IGB is working on an innovative semi-decentralized water and wastewater management. Geographical and climatic factors such as the (seasonal) shortage of water in arid and semi-arid areas are also taken into consideration.

In comparison to thermical and chemical processes, biological processes are more efficient and economic for the elimination of organic loads from wastewater and sewage. In combination with membrane technology especially efficient processes can be built up.

For over two decades, Fraunhofer IGB develops biotechnical and membrane processes for the purification of municipal and industrial wastewater. Additionally, we offer the economic optimization of sewage plants.

24.18 Bioenergy

Biotechnological processes can be established economically and ecologically advantageous for the substance recycling along with waste treatment. The center of interest hereby is the use of anaerobic or substance producing aerobic microorganisms. The best known substance recycling process of organic materials such as bio-waste or sewage sludge (as a kind of residual bio-mass) is the recovery of biogas as a renewable energy source.

By integrating further appropriate process steps, additional value substances such as fertilizer salts (from nitrogen and phosphate ingredients of sludge, sludge water and waste) can be recovered.

24.19 Microalgae biomass production

Algae are a natural renewable resource of unique products, little exploited until now, but which have an important role in solving dietary and health-related problems of future generations worldwide. Microalgae are undemanding and require only sunlight, carbon dioxide, phosphor and nitrogen to grow rapidly. They produce a broad variety of basic chemical substances such as vitamins, fatty acids and carotenoids with high added value potential for the pharmaceutical and food industries. The Fraunhofer IGB is concentrating activities on two markets in the food supplement sector: natural astaxanthin, a red pigment with antioxidative properties, and highly unsaturated fatty acids (omega-3 fatty acids), which play an important role in human cardiovascular and inflammatory diseases. For the production of algal biomass containing high-value substances we have developed at Fraunhofer IGB a specially designed low cost panel reactor built on the airlift-loop-principle.

24.20 Bioprocess Engineering

Fraunhofer IGB has a long tradition in the biotechnological processes nowadays collectively called white or industrial biotechnology. These methods are now used for the preparation of various industrial products, such as fine chemicals, bulk chemicals, enzymes, active compounds for cosmetics and pharmaceuticals, additives to food and animal feeds, and fuels. At Fraunhofer IGB, the Environmental Biotechnology and Bioprocess Engineering and the Molecular Biotechnology Departments work together to find R&D solutions in the field of industrial biotechnology.

Increased standards of product quality and a renaissance of natural materials for industrial applications require new and efficient production and processing methods. The Fraunhofer IGB develops solutions for optimized fermentation processes, for the isolation, separation and purification of (biotechnical) products and, in addition to this, offers the fermentative production in contract for its customers.

24.21 Interfacial biology and hygiene – Microorganisms on surfaces

Microorganisms like fungi and bacteria are omnipresent in nature and play an important role in all elemental-circuits. Therefore they are of vital importance to the continuity of ecosystems. They are even useful assistants to men: We employ them for brewing beer, baking bread, cleaning waste water or producing vitamins and antibiotics.

Though most of the time their adverse effects are detected so much faster: Contaminations in medical departments and industrial productionlines bring immense costs and cause heavy losses by rotting raw material or producing toxic by-products.

At the Fraunhofer IGB facility the relevance of biofilms was detected and their application promoted very early, e.g. to produce valuable products or to clean industrial and municipal wastewater. But as well their avoidance and abatement ist encouraged by innovative techniques. These requirements raised the demand for effective qualitative and quantitative evaluation methods to detect surfacebound microorganisms in medical engineering, construction and technical applications.

24.22 Non-Invasive Analysis of Cells and Tissues

The isolation and culture of cells from primary material (various tissues and species), differentiation and proliferation of pluripotent stem cells, construction of three-dimensional cell culture systems and the fields of tissue engineering and regenerative medicine are the expertise of the Fraunhofer IGB. We characterize cells with classical invasive methods such as histological and immuno-histological staining, but we have developed and adopted numerous non-invasive methods that allow for the continuous monitoring of cell culture and tissue on the molecular and morphological level. With over 20 years experience in cell culture, we are your partner for complex questions in regenerative medicine, tissue engineering and the development of cell-based assays for toxicology and biocompatibility.

24.23 Cardiovascular Tissue Engineering

Despite significant advances in cardiology and cardiac surgery, cardiovascular disease remains one of the leading causes of death in the world. In Europe alone, an estimated 10 million people are affected each year. The most common cause of heart failure is acute or chronic damage to the heart. The human heart possesses very little regenerative capacity. After a cardiac event, the loss of heart function cannot be naturally recovered, which permanently and drastically impairs the quality of life of patients. Therefore, restoration of normal heart function after the heart has been damaged or due to congenital defects is a driving goal for numerous researchers worldwide.

24.24 3D Tissue Models and Test Methods

New drugs and substances are required to be tested for quality, safety and efficacy before market authorization. Due to the lack of equivalent alternative methods, animal experiments are an important standard instrument in drug research. Due to species-specific differences; however, animal experiments are not always suitable for the authorization of new substances or the adaptation of new therapies to humans.

Therefore, the Fraunhofer IGB has been increasingly engaged in the development of alternative human test systems that mimic the complex characteristics of the body and permit the investigation of materials according to the ADMET criteria (absorption, distribution, metabolism, excretion and toxicity). These test systems are based on in vitro cultured human primary cells, cell lines, induced-pluripotent stem cells or adult stem cells. In order to ensure cell functionality in vitro, culture conditions are created that are similar to the natural microenvironment of the cell in the body. For specific applications, co-cultures with other cell types and custom-designed carrier substrates must be employed.

The Department of Cell and Tissue Engineering is specialized in constructing human three-dimensional (3D) tissues. The 3D nature of the scaffolds considerably affect parameters such as metabolic activity, viability, division, morphology and differentiation status and thus, ultimately, the function of the tissue as a test model.

24.25 GMP production

With the expertise of scientific project work and application-orientated research, we at Fraunhofer IGB focus on the role of a mediator between preclinical research and clinical application for the development of GMP-compliant manufacturing processes for tissue engineering and Investigational Medicinal Products (IMPs). Our qualifications are based on longstanding experience in primary cell culture technologies, tissue engineering, regenerative medicine and cell therapy; assisted by an excellent network of scientists, engineers and clinicians.

Building on these skills, we at the Fraunhofer IGB develop GMP-compliant processes for the manufacture of individual, autologous tissue replacement and medicinal products for regenerative medicine and its use in clinical studies, as well as the application for Advanced Therapy Medicinal Products (ATMPs) certification of cell-based therapeutics in our certified rooms. We are well equipped to support your product pipeline.

24.26 Chemical and biotechnological catalysis

Manufacturing of new products for the market often fail because respective economical production systems are missing. Process relevant reactions may be too slow, they lead to incomplete conversions or even involve undesired secondary and side products. In many cases operating expenses are too high for large scale product synthesis.

These problems can be solved via intensified application of chemical and biological catalysis. Fraunhofer IGB develops and improves suitable catalysts for specific application in production processes. Chemical catalysts as well as biocatalysts are tested individually and in combination to achieve the objective of high yields, defined product streams and low side reactions in the process.

24.27 Specialty and fine chemicals

Modern industries require various chemical feedings for their products and processes of manufacturing. To date, there is already a large number of such compounds available, which are generally summarized to so-called specialty and fine chemicals. They are applied e.g. to aromatics in foods, to active components in pharmaceuticals or to additives in polymers. There is still a need to develop further chemicals with special characteristics for well-defined applications.

At Fraunhofer IGB, complex synthesis ad modern analysis methods are combined for manufacturing of new specialty and fine chemicals. Amongst others, the application of natural synthesis methods and the utilization of regenerative resources are especially focused. Regarding ecological and economical aspects, custom-made chemicals are produced in laboratory scale designated to function in sustainable industry processes.

24.28 Chemical energy storage

The success of the turnaround in energy policy, in the course of which power generation from renewable energies in Germany is to be constantly expanded, depends on an extension of the power networks; however, new technologies are also required to store surplus energy. Thus energy storage systems insure a rapid balancing out of grid loads and make electrical energy available again at a later point in time. In addition to battery storage, chemical energy storage systems can also provide an effective solution.

24.29 Biomass, residual and waste materials

Due to the limited availability of fossil raw materials there is an increasing demand in alternative resources for the chemical industry. As alternatives may serve biomass, residual and waste materials, which accumulate in many established industrial processes mainly from environmental, agriculture and food sectors. To date, these substances are not suitable for further economical valorization and deposition with costs is necessary. Here, the goal is to integrate biomass, residual and waste material streams into established facilities by developing new processes for value creation.

Bio, Electro and Chemocatalysis BioCat, Straubing branch, developes solutions in lab scale for value creation from biomass, residual and waste materials in industry. The resources are used as substrate most effectively in new manufacturing processes, while replacing existing fossil raw material based products on the one hand and generating new attractive products on the other hand. Both are successful due to development and application of modern chemical and biological catalysts and through respective modification of process parameters. Thus, new commercialization is initiated to establish sustainable industrial cycles.

25. Fraunhofer Institute for Computer Graphics Research IGD

Website Link: http://www.igd.fraunhofer.de/en

25.1 Institute Overview

English: Fraunhofer IGD is the world's leading institute for applied research in Visual Computing. Visual Computing is image- and model-based information technology and includes computer graphics, computer vision, as well as virtual and augmented reality.

We develop prototypes and complete solutions based on customer-specific requirements. Our research and development projects are directly applicable to current problems in the economy.

Korean: 프라운호퍼 컴퓨터그래픽연구소(IGD)는 비주얼 컴퓨팅 분야의 세계적인 응용연구기관입니다. 비주얼 컴퓨팅은 영상 및 모델 기반의 정보 기술로, 컴퓨터 그래픽, 컴퓨터 비전, 가상현실 및 증강현실을 아우르고 있습니다.

연구소는 고객별 요구사항에 맞는 프로토타입과 실제 솔루션을 개발하고 있으며, 산업현장에 바로 적용 가능한 연구개발을 수행하고 있습니다.

25.2 Computer Graphics (CG)

Computer graphics, “image synthesis”, is an essential core discipline of “visual computing”. In this field, our researchers are developing procedures and technologies in order to visualize information virtually in the form of images.

25.3 Modeling (MOD)

Models are an integral part of visual computing. They offer an abstract view of selected aspects of reality. There are different visualization options. Our researchers are therefore developing different model types such as 2D, 3D or higher dimensions for practical applications.

25.4 Computer Vision (CV)

In order to represent real objects in the virtual world as well, our researchers are analyzing and interpreting real images, converting them into information. This requires special digitalization procedures and augmented-reality technologies which are developed in this research field.

25.5 (Interactive) Simulation (SIM)

Virtual worlds offer many opportunities. Physical objects or physical phenomena can be virtually reproduced and visualized quickly and without any risk. Our researchers are developing methods in order to accelerate and directly influence simulation processes.

25.6 Human Computer Interaction (HCI)

The interaction between human and machine is becoming increasingly similar to the natural behavior of man. However, technology is not to replace but support us. Therefore, our researchers are developing technologies for a more effective collaboration between human and machine.

26. Fraunhofer Institute for Integrated Circuits IIS

Website Link: http://www.iis.fraunhofer.de/en.html

26.1 Institute Overview

English: The Fraunhofer Institute for Integrated Circuits IIS is one of the world's leading application-oriented research institutions for microelectronic and IT system solutions and services. It ranks first among all Fraunhofer Institutes in size. With the creation of mp3 and the co-development of AAC, Fraunhofer IIS has reached worldwide recognition.

In close cooperation with partners and clients the Institute provides research and development services in the following areas: Audio & Multimedia, Imaging Systems, Energy Management,

IC Design and Design Automation, Communication Systems, Positioning, Medical Technology, Sensor Systems, Safety and Security Technology, Supply Chain Management and Non-destructive Testing.

Korean: 프라운호퍼 집적회로연구소(IIS)는 마이크로 전자 및 IT 시스템 솔루션과 서비스를 제공하는 세계적인 수준의 응용중심 연구기관입니다. 프라운호퍼 산하 연구소 중 최대 규모를 자랑하고 있으며, mp3 개발 및 AAC 코덱 공동개발로 국제적인 명성을 얻었습니다.

연구소는 협력기관 및 고객과의 제휴 하에 오디오 및 멀티미디어, 영상 시스템, 에너지 관리, IC 설계 및 설계 자동화, 통신 시스템, 위치추적, 의료기술, 센서 시스템, 안전·보안기술, 공급망 관리, 비파괴 검사 등 다양한 분야의 연구개발을 수행하고 있습니다.

26.2 DAB and DRM Technologies for the Entire Broadcast Chain

Regardless of whether you want to manufacture transmission equipment or design a receiver: Fraunhofer IIS has the technologies you need.

Fraunhofer technologies underpin not only the basic digital radio standard, from audio compression to data services and signal rendering, but also form an integral part of many products that enabled the successful introduction of digital radio.

Many of the radio encoders used by broadcasters and made by different manufacturers are based on Fraunhofer's ContentServer Technology. These highly compact solutions combine real-time audio encoding with the complete management of all standardized data services, and the production of the final digital broadcast signal.

On the receiving end, Fraunhofer technologies offer radio manufacturers a wide range of options. These extend from software defined radio solutions for DAB and DRM reception, to decoder components for audio and additional services such as Journaline® and EWF (Emergency Warning Functionality), through to complete PC-based radio solutions.

26.3 Wireless Communication

Wherever standardized wireless solutions prove too expensive, too complex or fail to have the desired characteristics – as regards data rate, range, networking or construction – often the only solution is to tailor the wireless system to customer requirements. For many wireless applications, the amount of space available plays a decisive role. Fraunhofer IIS has expertise in miniaturizing wireless technology for high-frequency circuit design and integrated circuit packaging. We have what it takes to realize a complete solution tailored to customer requirements.

26.4 Satellite Communication

Our research in the area of satellite communication is currently focused on satellite-supported and terrestrial systems for stationary and mobile applications. We also develop ground components, such as antennas and terminals, as well as communication payload for satellites.

Core competences:

- Broadband satellite communication
- SOTM (SatCom on the move) and nomadic systems
- Hybrid satellite systems: satellite plus CGC (complementary ground components)

Our portfolio comprises feasibility analyses, the development of components according to customer requirements, and the shaping of international standards. We operate outstanding measurement facilities for measuring components and validating prototypes.

Drawing on our experience of developing circuitry for space applications, we can implement RF and signal processing components according to your requirements.

On request, we will support you in our role as your development partner all the way from the initial concept and the testing of components and prototypes to achieving a complete system solution.

26.5 Voice Communication

We offer complete solutions for high quality communication applications, including audio codecs, echo cancellation and streaming technologies.

26.6 Audio & Multimedia

Fraunhofer IIS has been conducting research in the field of Audio & Multimedia for more than 25 years, with a special focus on audio coding and signal processing. The institute is widely known for its significant role in the development of the mp3 and MPEG AAC audio coding standards.

26.7 E-Car Communication Manager – ECM

As part of the Fraunhofer System Research for Electromobility project, Fraunhofer IIS is conducting research into communication technologies that integrate electric vehicles into their surrounding infrastructure. E-Car Communication Manager (ECM) was developed specifically for this purpose. The ARM9-based platform functions as a gateway and coordinates all important communication interfaces in different charging scenarios, such as »Allocation to charge spot«, »Vehicle identification«, and »Coordination of charging process with smart grid requirements«.

ECM combines the interfaces of a modern embedded system with the platform independence of Java technology. Integrated WLAN facilitates the universal connection of mobile devices inside the vehicle – for example, via HTML 5. This means that users can conveniently access and control charging processes even from outside the vehicle via tablet PC or smartphone.

Future expansion of the system to include additional communication possibilities promises even better integration of electric vehicles into existing infrastructure. Continuous internet access will be available via LTE. ECM is an experimental demonstration platform on which the interplay of all kinds of different communication technologies can be explored and tested. In addition, new applications can be implemented at little effort and expense.

Safety when charging and protection against operator errors are absolute necessities for all charging scenarios. In the case of communication for billing purposes or for influencing the timing of charging and discharging cycles, it is important that communication and data access are implemented accompanied by suitable security mechanisms. To ensure safety, ECM has an additional processor with suitable programming, whereas security aspects are implemented through Java and the OGEMA 2.0 framework or alternatively through an OSGi framework. Consequently, ECM has outstanding technologies at its disposal to enable problem-free software installations and updates, control interaction between software modules, and prevent unauthorized access to the system's data and software. Encrypted communication and unique authentication of web access are also possible, which safeguards personal rights management at the same time.

26.8 Security in the Field of Global Energy Management

Since commercial use of the internet and digitization took off in the 1990s, the networking of systems has become increasingly important. Implementing the transition to renewable forms of energy requires the intelligent management of decentralized energy production, storage, and consumption in the smart grid of the future. This is leading to a growing use of information and communication technologies (ICT).

This networking will create new application possibilities in the areas of system control (grid management), data recording (smart metering, monitoring), and commercial services (e.g. efficiency analysis, remote maintenance, remote diagnostics).

However, the use of ICT in the area of energy supply also entails major security risks. Cyber attacks are a real and present danger. The term covers scenarios such as the sabotage of infrastructure (e.g. Stuxnet) and networks and the manipulation of control systems and data. In the worst case, this can cause supply structures to break down.

The challenges consist not only in protecting personal and confidential data, but above all in protecting critical infrastructure such as energy supply grids, telecommunication networks, and company networks (Industry 4.0 in Germany, Industrial Internet Consortium in US). In addition to further developing existing security mechanisms, it is the job of research to develop new integrated security concepts. Tailored measures that meet the security and application requirements are required.

26.9 Smart Metering Gateways

The word »smart« crops up a lot in connection with future energy supply. It indicates a transition away from the old method whereby power is generated and transmitted to the consumer according to demand. The increasing use of renewable and often weather-dependent energy sources requires special components and control methods to ensure that the electricity grid remains stable. At the same time, private and commercial users should not have to suffer usage restrictions or other inconveniences, and there should be no major increase in energy prices as a result. The information and communication technology that has until now been used primarily at higher voltage levels in the transmission and medium-voltage grids will also become widespread in the low-voltage grid and among end consumers.

Since 2010, new buildings have been fitted with smart meters, which allow energy usage data to be shown on a special display in homes. This display encourages consumers to save energy, and the consumption data can be transmitted to the energy provider via a gateway. This makes monthly billing possible and rewards energy-saving behavior.

Under the German Energy Industry Act (Energiewirtschaftsgesetz) §21 c and e, smart metering systems will become binding from 2015, wherever technically feasible, for new buildings, old buildings that undergo extensive renovations, consumers whose demand exceeds 6,000 kWh, combined heat and power plants and other renewable energy generation plants as defined by the German Renewable Energy Act (Erneuerbare-Energien-Gesetz) which exceed 7 kW, and businesses with protection profile certification from the German Federal Office for Information Security (BSI).

According to the BSI protection profile, one of the primary goals for a smart metering gateway is the security of consumption data. Integrity, authenticity, and confidentiality must be ensured when transmitting meter data. Another primary goal is the security of power grids. This is achieved by means of firewalls for protection against cyber attacks and dedicated interfaces for WAN (wide area networks), HAN (home area networks), and LMN (local metering networks).

Through our work in committees and associations, we make a decisive contribution toward the implementation of standards, the specification of web services, and the drawing up of a standardization roadmap for smart cities.

26.10 Low Power Telemetrie

More and more energy management applications are being found for radio systems for wireless data transmission. These mostly narrow-band telemetry systems are used to transfer sensor data and control information. Fraunhofer IIS's wireless miniaturized low-power telemetry solutions are suitable for connecting as many as 1 Mio. sensors within a range of several kilometers. The compact transmitters are especially cost-effective and energy efficient.

26.11 IoT-Bus – The Secure Communication Bus

As part of the SEED project (Smart Ecological Energy Domains) we develop the technology IoT-Bus. This is a communication bus based on EIA / RS-485 of the IEEE 802.15.4 standard, which enables a secure and reliable transmission of measured values and commands and control and connectivity IoT. In many applications of the Internet of Things (IoT) a wired communication is a wireless preferable when it comes to reliability, robustness and security of communications.

26.12 Camera Technology

With technologies ranging from sensor control to professional, miniaturized 2D, 3D and multiview cameras featuring HD, HFR and HDR, we offer a wide range of systems and components for the movie and television industry, as well as for post-production and security technology applications.

26.13 Digital Cinema

Developments and technologies in the area of digital cinema are one focus of our R&D activities. This primarily involves participation in standards such as JPEG 2000 and MPEG, as well as the development and implementation of digital cinema standards in various products and applications. We also develop new post-production tools for creating, playing and encrypting digital cinema packages (DCP). Other developments include the creation and playback of the Interoperable Master Format (IMF), a new exchange format designed for professional post-production applications.

26.14 HDR - High Dynamic Range

One of the major challenges of camera technology is ensuring quality images under extremely variable lighting conditions. Researchers in the Computational Imaging group are involved in developing HDR processes for moving picture recordings with the aim of capturing improved image material for real recordings.

26.15 Light-field Technology

Light-field technology significantly expands post-production creativity. Intelligent processing algorithms can be applied to calculate diverse recording enhancements, whether it's shifting the point of focus, virtual camera panning, modifying visual depths, creating depth maps or generating matrix or vertigo effects. This provides the opportunity to modify the image material as required in post-production long after it has been recorded.

26.16 Image Coding

An important aspect of the research activities in this area is our participation in the development of image codecs such as JPEG 2000, which form the basis for digital cinema standards. The functions and the creative opportunities afforded by these codecs are exploited for the purposes of processing high-resolution image data, thus enabling the movie and television industry to deploy new streamlined workflows in production, post-production and distribution.

26.17 Image and Signal Processing

In the area of Image and Signal Processing, we focus on designing high-performance embedded platforms for 3D data analysis, sensor fusion and endoscopic applications. Our hardware solutions can be counted on to trigger impulses in innovation in various market segments such as industrial image processing and security and medical technologies.

26.18 Image Analysis

Our processes for object recognition, object analysis and calibration address the needs of a broad range of applications, including market research effectiveness through the SHORE™ software library, streamlined teleconference software enhancements and image optimization solutions designed for movie and television camera systems.

26.19 Image Processing and Medical Engineering

The medical engineering research field offers solutions in the areas of medical image processing, computer-assisted diagnostic support, vital signs sensors, biosignal processing and medical communication.

In addition to research and development, we also carry out associated investigations and studies to evaluate medical engineering systems and solutions in conjunction with cooperating hospitals such as Erlangen University Hospital.

To reduce the time to market for our customers and to turn research results straight into medical products, the Department of Image Processing and Medical Engineering and its quality management system (QMS) work in accordance to ISO 13485 and are certified accordingly

26.20 Non-destructive Testing research

The activities of the Non-destructive Testing research field are carried out at the Fraunhofer Development Center for X-ray Technology EZRT in Erlangen, which is a division of the Fraunhofer IIS. We work closely with the Fraunhofer IZFP to develop non-destructive testing processes that make it possible to examine objects for flaws and defects without impacting their functionality.

The Non-destructive Testing research field is organized into different departments that offer custom solutions ranging from optical 3D measurement systems and industrial x-ray cameras to turnkey x-ray systems for various levels of industrial production. We also perform structure and process analyses in this field of research.

26.21 Integrated Sensor Systems

Fraunhofer IIS possesses extensive sensor systems expertise in the areas of magnetic field, image, current, optical, signal and positioning sensors.

26.22 Sensor Systems in Automation

The institute’s design automation division EAS devises practical and viable solutions for a wide range of automation applications. The know-how of its experts is based on a wealth of knowledge in mathematics, feedback control systems and IT. This knowledge is complemented by specialized expertise in the design of complex mixed-signal systems, electronic design automation and modeling.

As a result we can apply the following specialized know-how and technologies:

Condition Monitoring

- Design and validation of smart condition monitoring techniques including signal processing, feature extraction and classification
- Automatic classification methods (self-learning strategies)
- Model-based methods of physical phenomenology and virtual sensing
- Mathematical methods for condition monitoring and predictive wear modeling
- Test and analysis station
- Robust Communications

Concepts for robust communication within an automation system

- Model-based coexistence studies and interference analysis of wireless networks in automation environments
- Application-specific protocols for wireless data transmission in harsh, interference-prone environments
- Prototype development
- Measurement services to assess the required transmission parameters for wireless communication in a given environment

26.23 Energy Harvesting

If batteries are not enough, sonsors can receive the neccessary energy from our surrounding, e.g. from light, temperature difference or vibrations. The Fraunhofer IIS offers a wide range of Energy Harvesting technologies for energy autarcic, maintenance-free and wireless systems.

26.24 Object and Status Classification

How can existing localization solutions be improved? Are there ways to improve vehicle traffic safety? Where is my machinery at the moment? To what extent can I document the work flow with respect to quality assurance? Over the course of examining these issues, Fraunhofer IIS developed algorithms that provide answers to these and other questions by classifying various statuses.

26.25 Supply Chain

Today, providing people with goods, information or services using effective, cost-efficient and yet sustainable methods calls for comprehensive solutions that take into account the entire supply chain. For this reason, within the Supply Chain field of research we do more than analyze a company's environment and its business and services processes. We also develop suitable smart object technologies such as RFID, wireless sensor networks and real-time positioning and navigation systems and transfer them into practice.

27. Fraunhofer Institute for Integrated Systems and Device Technology IISB

Website Link: http://www.iisb.fraunhofer.de/

27.1 Institute Overview

English: The Fraunhofer Institute for Integrated Systems and Device Technology IISB conducts applied research and development in the field of electronic systems for application in, e.g., electric mobility or energy technology. In this connection, the IISB extensively covers the complete value chain from basic materials to entire power electronic systems.

With its two business areas, semiconductors and power electronics, the institute provides innovation and solutions in materials development, semiconductor technology and manufacturing, devices and modules, vehicle power electronics, energy electronics, and energy supply systems. This is supplemented by broad activities in reliability, simulation, characterization, and metrology.

The institute is equipped with high-class laboratories, such as a test center for electric cars and an application center for DC grid technology. Together with the University, it operates 1500 m2 of cleanroom area for semiconductor technology on silicon and silicon carbide.

Korean: 프라운호퍼 집적시스템 및 기기기술 연구소(IISB)는 e-모빌리티, 에너지 기술 등에 사용되는 전자시스템의 응용연구개발을 수행하고 있으며, 기본소재에서 전력전자시스템에 이르는 가치사슬 전체를 다루고 있습니다. 반도체, 전력전자 등 2 개 사업부를 주축으로 소재개발, 반도체 기술 및 제조, 기기 및 모듈, 자동차 전력전자, 에너지 전자공학, 에너지 공급 시스템에 대한 혁신기술과 솔루션을 제공하고 있으며, 신뢰성, 시뮬레이션, 특성분석, 계측 등의 분야에서도 폭넓은 연구활동을 수행하고 있습니다. 전기자동차 테스트센터, DC 그리드기술 응용센터 등 세계적인 수준의 시험시설을 갖추고 있으며, 1 천 500 제곱미터 규모의 실리콘 및 실리콘 탄화규소 반도체 공정용 클린룸을 에를랑겐-뉘른베르크 대학(University of Erlangen-Nuremberg)과 공동운영하고 있습니다.

27.2 Application-specific device solutions and services

The „Devices“ Group is developing innovative device solutions with a strong focus on Power Electronics. This includes both novel device concepts on semiconducting materials like silicon and silicon carbide and on related materials providing a “technology-push” towards new and more powerful applications. Moreover, customer-specific devices based on conventional concepts are adopted to better satisfy the demands of individual solutions (“application-pull”). Here, the focus is also with the development of cost-efficient processes tailored towards implementation and realization of customized products.

27.3 Materials

We especially support material, device and equipment manufacturers and their suppliers in the areas of crystal growth, epitaxy, thin film deposition, and synthesis of nanometer-sized powders. Particular focus is put on process and equipment development for the material production and the correlation of the material properties with their production conditions. Out of the materials we process devices or small system demonstrators, we test the performance and reliability of the materials in their respective applications. We are equipped with tailored R&D-facilities for crystal growth, epitaxy, and thin film deposition, as well as with different software tools for solving heat and mass transport problems. Comprehensive characterization methods for the determination of the physical, chemical, electrical, and structural material properties are available, too.

The materials and markets which we address are

- semiconductors
- optical, laser, and scintillator crystals
- pyro-, and piezoelectric materials
- battery materials
- capacitor materials
- printable electronics

27.4 Technology & Manufacturing

Technology stands above all for research and development in the field of electronic devices on a micro- as well on a nano-dimensional scale. In addition, to focus more on facility services for customers, the service sector was re-organized in a separate organization unit which is called π-Fab. The purpose of π-Fab is the fabrication of custom-tailored prototype electron devices.

Furthermore, from nano-technology to printable macro-electronics, the Technology department is your contact for the realization and characterization of single process steps and devices up to prototypes. Based on comprehensive cleanroom facilities, silicon, as well as silicon-carbide processing, forms the backbone of the technology.

Examples for current activities are high-resolution nano-imprints on a large scale, fabrication of advanced integrated power devices, or low-temperature depositions of inorganic materials by printing techniques. The heterogeneous integration of various technologies is currently acquiring more and more importance.

27.5 Packaging & Reliability

The research field is packaging of power electronics. The drivers are performance, volume or weight per cost depending on the application. The goal is reached by investigations on different concepts of the electrical, mechanical and thermal design such as single and double sided die attach, single and double sided cooling, materials with minimized or matched coefficient of thermal expansion (CTE). By use of intelligent setups and application relevant choice of the electrical and thermal interconnections the bill of material can be minimized.

Work is done on joining technologies as well. There is a long experience in silver sintering as an alternative to the state of the art. Meanwhile a process is established to manufacture multichip power modules with high yield. Especially a selective sintering process brings high advantages to electronic packaging. The chip sizes meet the power electronics requirements. While the sintering improvements are ongoing the soldering technology is still covered from state to the art up to new high performance or high temperature materials.

27.6 Vehicle Electronics

Fraunhofer IISB takes a top position internationally in the field of power electronics for electromobility. This is expressed in a variety of development projects with all large automotive manufacturers and suppliers. Many of the results have gained international attention.

We permanently strive to open up new applications and functionalities. The grid integration of electric vehicles, e.g., will gain more and more importance in the future. For avionic applications the new possibilities of modern power electronics will pave the way towards the “more electric aircraft”. This means powering many more actuators electrically in order to improve the overall fuel economy, and to reduce the maintenance efforts associated with hydraulic systems.

27.7 Energy Electronics

A continuously growing share of electrical energy is processed by power electronics along the whole energy supply chain from generation over transportation and distribution up to the consumers. The ongoing transformation of the public energy supply to a self-sufficient system based on renewable energy sources will speed up this process significantly. Advanced power electronic systems are the key to increased energy efficiency along the whole supply chain, and to ensure highest availability and stability of the grid.

Since 2005 Fraunhofer IISB successfully concluded numerous research projects with the focus on power electronics for advanced electrical energy networks. This includes basic research work as well as industrial development projects with the objective of developing and qualifying components ready for series production. Main goal is to increase the efficiency, availability, and lifetime of the systems at reduced overall system costs.

27.8 Intelligent Use of Energy in Small and Medium-sized Industry – SEEDs

The basic idea of the SEEDs project is to reconstruct and optimize the local energy systems for small and medium-sized companies (industrial level) by utilizing and further developing existing approaches and techniques. The goal is to research, develop and implement sustainable energy production, energy storage, energy supply, and efficient energy use at a local industrial level. In this connection, the focus is on maximum efficiency, cost effectiveness as well as the security of supply and stability autarchy.

The areas covered in SEEDs are microgrids, energy storage, gas-to-power coupling, grid connection, load shift, sustainable creation, and the use of energy, as well as energy efficiency. The whole chain of energy technology is therefore investigated. Specific attention is paid to an efficient interlinking of power electronics and interfaces with different components of the local energy system, in order to set up a stable overall local energy system with respect to controlling. These interfaces are a core competence of Fraunhofer IISB. The Fraunhofer institutes IIS and ISC are also participating in the project. IIS covers communication-related topics, and ISC handles material aspects for electrical battery development.

The main institute building of the Fraunhofer IISB serves as a research and demonstration platform. The requirements for different energies (heat, cold, and electricity) as well as the range, infrastructure, and energy consumption of the IISB are comparable to those of small and medium-sized companies. IISB shows a high load fluctuation, high peak loads, and a substantial need for secondary energy due to a considerable amount of labs and equipment for semiconductor processing as well as manufacturing. A clean room is in continuous operation, and a large number of labs and offices are in use. Therefore, the IISB platform covers office as well as industrial and lab aspects, which means that nearly all facets of energy management and the energy sector of a local energy system are dominant. Production-related activities are continuously performed, but no direct production cycle will be disturbed for research and development. Therefore, this research and development platform seems to be ideal for applications such as research and demonstration activities.

28. Fraunhofer Institute for Ceramic Technologies and Systems IKTS

Website Link: http://www.ikts.fraunhofer.de/en.html

28.1 Institute Overview

English: As a research and technology service provider, the Fraunhofer IKTS develops modern ceramic high-performance materials, customized industrial manufacturing processes and creates prototype components and systems in complete production lines from laboratory scale to pilot plant scale. Furthermore, the institute has expertise in diagnostics and testing of materials and processes. Test procedures in the fields of acoustics, electromagnetics, optics, microscopy and laser technology contribute substantially to the quality assurance of products and plants.

Fraunhofer IKTS works in eight market-oriented business divisions in which it demonstrates and qualifies ceramic technologies and components as well as non-destructive test methods for new industries, product concepts and markets beyond the conventional areas of application. These disciplines include ceramic materials and processes, mechanical and automotive engineering, electronics and microsystems, energy, environmental and process engineering, bio- and medical engineering, optics as well as materials and process analysis.

Based on comprehensive materials expertise in advanced ceramic materials, the Institute's development work covers the entire value creation chain, all the way to prototype production. Fraunhofer IKTS is distinguished by its multiple areas of expertise: The triad of materials know-how, production technologies and systems integration is enhanced by the highest level of materials and process analytics. Chemists, physicists, materials scientists and engineers work together on an interdisciplinary basis at IKTS, with the support of highly skilled technicians.

The Institute is therefore available as a competent consulting partner and starting point for all ceramics-related issues: a real “one-stop shop” for all things ceramic.

Among our unique areas of expertise, we offer:

- End-to-end production lines: from starting materials to prototypes

For any class of ceramic materials, we have access to all the standard processes of raw materials preparation, forming, heat treatment and finish processing. Where it makes sense, the Institute can even conduct phase synthesis. In functional ceramics, we hold a particular core competency in paste and film technology. Multiple clean rooms and low-contamination production areas are kept at the ready, among other things, for multilayer ceramics and highly purified oxide ceramics lines of technology.

- Multi-scale development

Fraunhofer IKTS can convert developments from the lab into the technical standard. There is industrially suited equipment and machinery of the latest designs available for all relevant lines of technology, in order for partners and customers to realize the prototypes and pilot-production series needed for market launch, to develop production processes, and to implement quality processes. Thus, residual cost risks and time to market can be minimized.

- Synergies between materials and technologies

The combination of differing technology platforms, of functional and structural ceramics for example, allows for multifunctional components and systems that intelligently exploit ceramic properties. This enables the production of innovative products with markedly added value at low cost.

- Competent analysis and quality assessment

High-performance analysis and quality control are a decisive factor for market acceptance of products, especially in ceramic production processes. Since we understand materials as well as ceramic production processes at a fundamental level, while at the same time master the drafting and integration of complex physical testing systems, we can offer our customers unique solutions for materials issues in production and quality monitoring.

Korean: 프라운호퍼 세라믹 기술 및 시스템 연구소(IKTS)는 연구 및 기술서비스 전문기관으로 고성능 첨단 세라믹 소재와 맞춤형 제조공정을 개발하고, 실험실에서 파일럿 수준까지 생산라인 전반에 걸친 프로토타입 부품과 시스템을 제작하고 있습니다. 또한 소재 및 공정 진단·시험 관련 전문성을 갖추고 있습니다. 음향, 전자기학, 광학, 현미경 및 레이저 기술 관련 시험절차는 제품 및 공장의 품질보증에 크게 기여하고 있습니다. IKTS 연구소는 세라믹 소재 및 공정, 기계 및 자동차공학, 전자 및 마이크로시스템, 에너지, 환경 및 공정공학, 생명·의료공학, 광학, 소재 및 공정분석 등 8 개 사업부로 구성되어 있습니다. 해당시장에 특화된 사업부는 기존 응용분야 외 새로운 산업, 제품 컨셉 및 시장에 대한 세라믹 기술 및 부품과 비파괴 검사방법을 연구하고 있습니다. 연구소는 첨단 세라믹 소재에 대한 통합적인 전문지식을 바탕으로 프로토타입에서 생산까지 가치창출 사슬 전반에 걸쳐 연구개발을 수행하고 있습니다. 또한 최고 수준의 소재 및 공정 분석을 통해 소재 관련 노하우, 생산기술, 시스템 통합의 3 대 핵심역량을 보완하고 있습니다. 숙련된 화학, 물리, 재료공학 연구진은 전문 기술진과 함께 학제간 융합연구를 추진하고 있습니다. 연구소는 이처럼 탄탄한 연구 인프라를 기반으로 세라믹과 관련된 모든 분야에 대한 컨설팅을 제공하는 원스톱 기관으로 자리잡았으며, 전문 연구분야는 다음과 같습니다.

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소재와 기술 간의 시너지

기능성 세라믹, 구조 세라믹 등 다양한 기술 플랫폼의 결합은 세라믹의 장점을 최대한 살린 다기능 부품과 시스템의 개발뿐 아니라 저비용 고부가가치 제품 생산을 지원합니다.

분석 및 품질평가 능력

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28.2 Structural Ceramics

Fraunhofer IKTS masters powder technological production processes for all ceramic substance classes at highest level. Prototypes and pre-series, the development of industrial production processes and the implementation of quality processes can be realized for partners and customers.

28.3 Nanoporous Membranes

Nanoporous membranes are characterized by pores with diameters in the range of nanometers and sub nanometers which are able to separate liquid or gaseous mixtures. The separation of the fluids bases on the different size of the components (mole sieving), different adsorption (adsorption selectivity), wetting or steric hindrance. Ceramic nanoporous membranes are distinguished by high thermal, chemical and mechanical stability. Most interesting selective materials are amorphous metal oxides (sol-gel synthesis), zeolites and carbon.

28.4 High-Temperature Separation and Catalysis

The working groups of the department ”High-Temperature Separation and sis“ develop materials, components and processes for gas separation at high temperature and for heterogeneous catalysis. A main focus is the production of oxygen by membrane separation and storage materials. In contrast to mature technologies, saving of energy and an integration in industrial processes is aimed, e.g. for an intensified combustion, for the gasification without nitrogen, for carbon capture and storage and for a higher yield of chemical reactions by the use of membrane reactors. Another focal point is the development and characterization of mixed oxide catalysts favored without noble metals for heterogeneous catalysis. The development of stationary energy storage systems is in the course of construction.

The material development is based on complex mixed oxides characterized by special properties adjustable within large ranges. These materials synthesized and characterized as powders will be shaped by extrusion or dry compaction into components with optimized geometry. Special coating and joining techniques will be used for building up of ceramic components.

28.5 Biomass Technologies and Membrane Process Engineering

Processes and methods for energetic and substantial usage of biomass as well as development and implementation of efficient membrane based separation processes for liquid and gaseous media are the nucleus of the department »Biomass Technologies and Membrane Process Engineering«.

It focuses on design, technological development, testing, practical implementation and optimization of processes and devices for biomass conversion and waste- or process water treatment. Furthermore, the department deals with fluid-dynamic optimization of mixing processes as well as testing and piloting of membrane processes in liquid and gaseous or vaporous media.

With both the application center for membrane technology located in Schmalkalden and the application center for bioenergy in Pöhl the department provides exceptional infrastructures for practice oriented research in a technical scale in addition to the laboratories in Dresden and Hermsdorf.

28.6 Bio- and Nanotechnology

The “Bio- and Nanotechnology“ department at Fraunhofer IKTS offers materials, nondestructive testing techniques, and characterization methods combining materials science, immunobiology, and materials diagnostics. Scientists at the sites in Dresden, Hermsdorf, and Leipzig undertake applied research in bio- and nanotechnology to speed up development of marketable solutions for immunobiology, cell production, and medical technology. The department also develops acoustic and optical test systems for all materials classes in production monitoring and control. Extensively equipped laboratories and pilot-plant facilities ensure the efficiency and quality of the development process.

One of the department's core research activities is characterization of materials and components in terms of geometry, material defects (cracks, blowholes, pores, delamination, etc.), mechanical stresses, hardness, microstructure, and other features on a macroscopic to nanoscopic scale. Various methods – e.g., acoustic pattern recognition, atomic force acoustic microscopy, ultrasonic microscopy and laser ultrasonics, optical coherence tomography, and ellipsometry as well as other spectroscopic methods – are used. Special focus is on additive manufacturing. With integration of testing and process monitoring technologies developed at Fraunhofer IKTS, additive manufacturing processes can reach their full potential for bottom-up production of one-offs.

Another core activity is development of technologies and processes for characterization of (immuno)biological properties of implant materials and medical devices. With the help of non-destructive measurement and diagnostic methods, information on interactions between biological and artificial materials can be utilized to improve mechanical stability, service life, and biocompatibility. Materials development and measurement technology are combined to yield novel approaches that can generate considerable added value in all areas of life sciences.

28.7 System Integration and Technology Transfer

The “System Integration and Technology Transfer” department - an interface between application and customer - pools the expertise of Fraunhofer IKTS in the field of materials and technology development. Its aim is the development of complete energy systems. Currently, research activities are focused on fuel cell and battery storage systems, as well as generators and other energy storage systems.

This focus allows the department to work on isolated materials and technologies issues which might arise on the single steps of the value chain. It also allows for the development of specific systems based both on market and customer requirements and on available technological options. Based on a comprehensive validation and target-performance analysis of market maturity, both the feedback into material and components development and the quick solution of identified crucial aspects are guaranteed.

In order to develop large series production processes and quality assurance methods, a small series production of prototypes can first be carried out in the laboratories and pilot plants of Fraunhofer IKTS or in cooperation with our customers. Thus, Fraunhofer IKTS is qualified as a contractor for the complete process of technology development and the stepwise knowledge transfer into series production at the customer’s site.

28.8 Materials and Components

The “Materials and Components” department is involved in the development and preparation of functional ceramic materials and their application in functional elements.

Traditional fields are thick film technology, glass development, high-temperature fuel cells (SOFCs), and high-temperature chemical sensors. Extensive experience and outstanding technical equipment allow complex requirements and interactions in sophisticated applications such as fuel cells, lithium ion batteries and supercaps, sensors, microsystems, and packaging in complex materials systems to be controlled. At the Dresden institute branch, screen printing pastes, inks, and slurries are developed to be used in electrochemical components and microsystems.

Materials development in combination with different coating methods – especially for applications in electrochemistry and joining technology – form the basis for the development of new components (SOFC/SOEC, thermoelectric generators, sensors).

Close meshing with the "Modules and Systems" and "Industrialization Systems" departments ensures the practical relevance of the results. This allows us to give our customers attractive offers for materials, prototypes, and services along the entire process chain.

28.9 Sintering and Characterization

Extensive sintering and analysis know-how in this research field is concentrated at both the Hermsdorf and the Dresden location. With diverse characterization methods, thermodynamic and kinetic modelling, and extensive furnace equipment from the laboratory to the pilot scale as a basis, targeted development of materials, components, and processes is possible.

Existing methods range from particle and suspension characterization and ceramographic sample preparation using conventional and ion beam-based techniques to quantitative phase and microstructural analysis. In addition, a wide range of thermoanalytical and thermophysical characterization techniques and methods for tribological, mechanical, and electrical characterization are available. Mastery of these sophisticated analytical methods is coupled to detailed process know-how as well as materials and scientific knowledge, enabling well founded interpretation of results.

We also test electrical devices and equipment in accordance with national and international standards as well as customer-specific requirements and possess a wide range of possibilities for environmental simulation and calibration of measurement systems.

28.10 Smart Materials and Systems

The core competency of the "Smart Materials and Systems" research field lies in the control of the engineering and scientific processes for development and integration of dielectric functional ceramics into components, microsystems, and active structures. Complex, interdisciplinary problems are solved in optimization processes covering all aspects of the value chain from materials synthesis to functional verification in prototype systems. Functional optimization is accordingly performed on several levels through functional concentration in materials, utilization of property combinations of material composites, and adaptation of components to the system environment.

Special materials expertise exists in the field of complex perovskites, which, as high-performance piezoceramic or dielectric ceramics, are substrates with actuator, sensor, and electronic functions in monolithic components and composites with polymers, metals, glasses, and other ceramics. Thick film, multilayer, and piezocomposite technologies are available as closed technology chains. Combination with unique design and characterization tools enables innovative developments in piezotechnology, adaptronics, and mechatronics as well as microsystems technology and microenergy technology that also include in-house systems developments (e.g., piezotechnology).

For imaging of thin coatings, CVD, PVD, and sol-gel processes as well as reactive ion etching are used for structuring. With this technology portfolio, we can develop new materials solutions for semiconductor technology and wear protection.

28.11 Hybrid Microsystems

Development of functional ceramics and of miniaturized components and systems is the focus of the “Hybrid Microsystems” department. Applications lie in the areas of packaging for electronics and high-power electronics, sensors, and energy technology (micro-fuel cells and photovoltaics).

For the deposition of functional layers, both classic screen printing technology and additional mask-based (stencil and gravure printing) and digital printing processes (aerosol and inkjet printing) can be used, depending on the application requirements. In addition, a complete ceramic multilayer technology line (LTCCs, HTCCs) is available at Fraunhofer IKTS to produce 3D-structured components.

We also offer our customers a wide range of technologies for electrical contacting (soldering, gluing, bonding) and for mechanical and microstructural characterization of electrical connections.

28.12 Microelectronic Materials and Nanoanalysis

New materials drive innovations in micro- and nanoelectronics. Multiscale materials parameters and solid knowledge of compatibility of laminate materials are needed to integrate new materials into production processes and ensure the functionality, performance, and reliability of microelectronic components. Accurate thermomechanical properties must be available for materials at the wafer level and for packaging (including three-dimensional integration) as input parameters in finite element simulations. Local measurements, e.g., for mechanical stresses, are used for validation and calibration of physical models for estimating the performance and reliability of micro- and nanoelectronic components.

The "Microelectronic Materials and Nanoanalysis" department possesses a unique infrastructural range encompassing high-resolution electron, ion, and X-ray microscopy and offers industry and research partners competent consulting, contract analysis, and methodological development services. Mechanical stresses can be determined down to the nanometer scale. Multiscale analysis of the thermomechanical behavior of microchips and systems generates information on reliability-limiting mechanisms in microelectronic components, e.g., on chip-package interactions (CPIs).

In close cooperation with other Saxonian Fraunhofer institutes in the Dresden Fraunhofer Cluster for Nanoanalysis and Dresden-concept e.V., R&D projects involving all parts of the value and innovation chain from basic research to transfer to industry are completed. Core competencies lie in high-resolution non-destructive X-ray tomography for measurement of micro- and nanostructures as well as for non-destructive defect localization, micro- and nanomechanical testing in combination with electron, ion, and X-ray microscopy, and physical defect analysis for determination of damage and failure mechanisms in microelectronic components.

28.13 Nonoxide Ceramics

Nonoxide ceramics are characterized by a number of extraordinary properties. Among the carbides and nitrides of boron, aluminum, silicon, titanium, and zirconium, silicon nitride and silicon carbide ceramics are at the core of R&D efforts at Fraunhofer IKTS. Special attention is paid to the extremely high thermal, wear, and corrosion resistance as well as the specific electrical and thermal properties of nonoxide ceramics. Apart from classic monolithic ceramics, ceramic matrix composites (CMCs) and corrosion-resistant coatings as well as structural ceramics with tailored electrical functions (e.g., thermoelectric materials) are investigated. Applications can mainly be found in mechanical engineering, chemical and energy technology, and microelectronics.

Another core topic is ceramics with controlled porosities and cellular structures for filter, catalyst, and substrate applications in the automotive industry, environmental engineering, biotechnology, process engineering, and metallurgy.

The department develops and optimizes materials and components for specialized applications and investigates interactions with manufacturing processes in close cooperation with the Materials/Components department.

Current activities at Fraunhofer IKTS in the area of structural ceramics with tailored electrical functions include development of industrial manufacturing processes for zirconium carbide materials with high stability under vacuum as potential substitutes for tungsten and molybdenum materials in high-temperature applications. Other heating or temperature sensor tasks in combination with structural functions can be fulfilled with specially modified heating elements made of various ceramics.

In the field of carbide ceramics, Fraunhofer IKTS has, for example, developed a process for producing complex SiC components by pressureless casting. Materials made with this cost-effective process can replace conventional materials in pump impellers, nozzles, mills, recuperators, and burners. Thanks to the outstanding chemical, thermal, and tribological properties of SiSiC, increased machine service life and/or productivity can result.

Ceramic matrix composites (CMCs) can replace metals especially for use at high temperatures or for enabling processes to be carried out at much higher temperatures. Fraunhofer IKTS is currently expanding the coating facilities. Homogeneous and continuous coating of endless fibers and rovings as well as three-dimensional woven fabrics will be possible in the future. New possibilities in terms of coating technologies and variations will also be created.

In the field of porous ceramics, LPS-SiC was developed as a material for use in particulate filtration and qualified for mass production of diesel particulate filters, mainly for off-road applications. Industrial introduction of open-cell particulate filters and catalysts for high-efficiency wood-burning appliances, among other things, represents another milestone in our work.

28.14 Oxide Ceramics

The department “Oxide Ceramics” considers itself as contact point for all questions related to the development and application of dense, porous and composite ceramics on the basis of oxides. The advantages of high-performance oxide ceramics in various prototypical applications for medical technology, microelectronics, tool and mechanical engineering as well as lighting engineering are demonstrated in a unique way.

In addition to monolithic ceramics, material composites and coatings are increasingly in the focus of applied research. Closed technological chains from the synthesis of ceramic precursors or the use of commercial raw materials to cost-efficient production technologies to the application in the overall system. Accompanied by an efficient analysis and characterization as well as an intense technical networking with specialized application-oriented departments

29. Fraunhofer Institute for Laser Technology ILT

Website Link: http://www.ilt.fraunhofer.de/en.html

29.1 Institute Overview

English: With more than 415 employees and more than 19,500 m² net floor space the Fraunhofer Institute for Laser Technology ILT is worldwide one of the most important development and contract research institutes of its specific field. The activities cover a wide range of areas such as the development of new laser beam sources and components, precise laser based metrology, testing technology and industrial laser processes. This includes laser cutting, caving, drilling, welding and soldering as well as surface treatment, micro processing and rapid manufacturing.

Furthermore, the Fraunhofer ILT is engaged in laser plant technology, process control, modelling and simulation as well as in the entire system technology. We offer feasibility studies, process qualification and laser integration in customer specific manufacturing lines.

Korean: 프라운호퍼 레이저기술연구소(ILT)는 세계에서 손꼽히는 레이저 기술 위탁연구기관으로 약 1 만 9 천 500 제곱미터의 단지로 이루어져 있으며, 415 여명의 임직원을 두고 있습니다. 핵심 연구분야는 레이저 광원 및 부품 개발, 레이저기반 정밀계측, 시험기술, 레이저 공정입니다. 레이저 공정의 경우 레이저 절단, 조각, 천공, 용접, 납땜, 표면처리, 미세 가공, 쾌속 가공 등을 포함합니다. 또한, 전체 시스템 기술 외에도 레이저 설비 기술, 공정 제어, 모델링, 시뮬레이션 등을 연구하고 있으며, 타당성 조사, 공정 적격성 평가를 실시하고 레이저 공정의 생산라인 적용을 지원하고 있습니다.

29.2 Lasers and Optics

This technology field - Lasers and Optics - focuses on developing innovative laser beam sources and high quality optical components and systems. Fraunhofer's team of experienced laser engineers builds beam sources which have tailor-made spatial, temporal and spectral characteristics and ranging from µW to GW. These sources span a wide range of types: from diode lasers to solid-state lasers, from high power cw lasers to ultrashort pulse lasers and from single frequency systems to broadband tunable lasers.

In the field of solid-state lasers, oscillators as well as amplification systems with excellent power data hold the center of our attention. Whether our customers are laser manufacturers or users, they do not only receive tailor-made prototypes for their individual needs, but also expert consultation to optimize existing systems. In the realm of short pulsed lasers and broad band amplifiers in particular, numerous patents and record-setting values can be provided as references.

Furthermore, this technology field has a great deal of expertise in beam shaping and guiding, packaging of optical high power components and designing optical components. This field also specializes in dimensioning highly efficient free form optics. In general, the lasers and optics developed here can be applied in areas ranging from laser material processing and measurement engineering to illumination applications and medical technology, all the way to use in pure research.

29.3 . Laser Material Processing

Among the many manufacturing processes in the technology field Laser Materials Processing, cutting and joining in micro and macro technology as well as surface processes count among its most important. Whether it be laser cutting or laser welding, drilling or soldering, laser metal deposition or cleaning, structuring or polishing, generating or layering, the range of services spans process development and feasibility studies, simulation and modeling, as well as the integration of processes in production lines.

The strength of the technology field lies in its extensive know-how, which is tailored to customer requirements. In such a way hybrid and combination processes also result. Moreover, complete system solutions are offered in cooperation with a specialized network of partners. Special plants, plant modifications and additional components are the constituent part of numerous R&D projects. For example, special processing heads for laser materials processing are being developed and produced, based on a customer's specific needs. In addition, process optimization by changing the design of components as well as systems to monitor quality on-line count among the specializations of this technology field.

Customers receive laser-specific solutions that incorporate the working material, product design, construction, means of production and quality control. This technology field appeals to laser users from various branches: from machining and tool construction to photovoltaics and precision engineering all the way to aircraft and automobile construction.

29.4 Medical Technology and Biophotonics

Together with partners from the Life Sciences, the technology field Medical Technology and Biophotonics opens up new areas of applications for lasers in therapy and diagnostics as well as in microscopy and analytics. The process Selective Laser Melting, developed at the Fraunhofer ILT, allows implants to be generated, tailored to the individual patent on the basis of data from computer tomography. The material variety ranges from titanium through polyactide all the way to resorbable man-made bone based on calcium phosphate.

In close cooperation with clinical partners, this field develops medical lasers with adapted wavelengths, microsurgical systems and new laser therapy processes for surgery, wound treatment and tissue therapy. Thus, for example, the coagulation of tissue or precise removal of soft and hard tissue is being investigated.

Nanoanalytics as well as point-of-care diagnostics demand inexpensive single-use microfluidic components. These can now be manufactured with high precision up into the nanometer range using laser-based processes such as joining, structuring and functionalizing. Clinical diagnostics, bioanalytics and laser microscopy rely on the institute's profound know-how in measurement technology. In the area of biofunctionalization/biofabrication, processes for in-vitro testing systems or tissue engineering are being advanced. Thanks to its competence in nanostructuring and photochemical surface modification, the technology field is making a contribution to generating biofunctional surfaces.

29.5 Laser Measurement Technology

The focus of the technology field Laser Measurement Technology and EUV Technology lies in manufacturing measurement technology, materials analysis, identification and analysis technology in the areas of recycling and raw materials, measurement and test engineering for environment and security, as well as the use of EUV technology. In the area of manufacturing measurement technology, processes and systems are being developed for inline measurement of physical and chemical parameters in a process line. Quickly and precisely, distances, thicknesses, profiles or chemical composition of raw materials, semi-finished goods or products can be measured.

In the field of material analytics, the institute has acquired profound know-how in spectroscopic measurement processes. Applications are automatic quality control and positive material identification, monitoring of process parameters or online analysis of exhaust gases, dust and wastewater. The more precise the chemical characterization of recycling products, the higher their recycling value. Laser emission spectroscopy has proven itself as an especially reliable measurement tool. In addition to the development of processes, complete prototype plants and mobile systems for industrial use are produced.

In EUV technology, Fraunhofer's experts develop beam sources for lithography, microscopy, nanostructuring or x-ray microscopy. Optical systems for applications in EUV engineering are calculated, constructed and manufactured as well.

30. Fraunhofer Institute for Molecular Biology and Applied Ecology IME

Website Link: http://www.ime.fraunhofer.de/en.html

30.1 Institute Overview

English: The Fraunhofer IME is an applied life sciences research institute focusing on two main areas: Molecular Biology and Applied Ecology. We offer services along the entire value chain of product development and assessment to our clients. An interdisciplinary organization allows us to integrate our expertise in relevant scientific disciplines covering both areas, in cooperation with external institutions and partners if required, providing a basis for the successful completion of complex projects. Our laboratories, with state-of-the-art equipment including GMP facilities and complex facilities for environmental simulations, allow a wide spectrum of research and development services. Our work is closely linked with basic research within our university departments and we benefit from large international networks.

Therefore, Fraunhofer IME is a strong partner for contract research in the areas of pharma, medicine, chemistry, agriculture, as well as environmental and consumer protection. Our reseach and development portfolio is focussed on industry, small and medium enterprises and on the public sector. In 2015, the Fraunhofer IME cllaborated with around 100 national and international industrial clients and several international industrial associations for whom confidential projects were carried out.

Korean: 프라운호퍼 분자생물학 및 응용생태학 연구소(IME)는 분자생물학과 응용생태학 2 개 분야를 전문적으로 다루는 응용생명과학 연구기관입니다. 제품개발에서 평가에 이르기까지 가치사슬 전반에 걸친 서비스를 제공하고 있습니다. 융합연구를 통해 관련 학문분야의 전문성을 결합하고, 필요 시 외부 기관 및 기업과 협력하여 복잡한 연구과제의 성공적인 수행을 도모하고 있습니다. GMP, 환경 시뮬레이션 장비 등 최첨단 시설을 보유하고 있어 폭넓은 연구개발이 가능하고, 대학 내 관련학과와 기초연구 분야의 연구협력을 진행하고 있습니다. 특히, 방대한 국제적 네트워크는 연구소의 큰 강점입니다. 연구소는 의료, 의약, 화학, 농업, 환경 및 소비자 보호 분야의 위탁연구에서 두각을 나타내고 있으며, 주요 고객은 산업, 중소기업 및 공공기관입니다. 지난 2015 년에는 국내·외 100 여개 기업 및 다수의 국제적 산업단체와 협력하여 각종 비밀 연구를 진행했습니다.

30.2 Molecular Biology

The development and use of innovative solutions and product candidates for the diagnosis and treatment of human and animal diseases as well as the protection of crop plants and food sources: under the leadership of Prof. Dr. Rainer Fischer, the Molecular Biology Division focuses its R&D activities on specific areas according to this mission.

- Functional and Applied Genomics
- Immunotherapy
- Plant Biotechnology
- Industrial Biotechnology
- Integrated Production Platforms
- Bioresources
- Translational Medicine und Pharmacology
- ScreeningPort.

30.3 Applied Ecology

The research, development and service activities of the Applied Ecology Division in Schmallenberg are pooled in five business areas which address different customers: manufacturers of plant protection products, the chemical industry (including manufacturers of biocides and pharmaceutical products), food and feed manufacturing and processing industries, and governmental agencies.

- Environmental Risk Assessment of ChemicalsUmweltrisikobewertung von Chemikalien
- Retrospective Evaluation of Substance Concentrations and Media QualityRetrospective Evaluation of Substance Concentrations and Media Quality
- Environmental Risk Assessment of AgrochemicalsEnvironmental Risk Assessment of Agrochemicals
- Evaluation of Food Safety and Consumer Risk AssessmentEvaluation of Food Safety and Consumer Risk Assessment
- Sustainable Agricultural Production of Substances

31. Fraunhofer Institute for Microeletronics Circuts and Systems IMS

Website Link: http://www.ims.fraunhofer.de/en.html

31.1 Institute Overview

At the Fraunhofer IMS our field of attention has been, since its foundation in 1984, semiconductor technology and the development of microelectronic circuits and systems. Our technological core are semiconductor processes, CMOS and SOI technologies, microsystems technology, component and system developments and nano-(Bio)technologies. During our contract work we focus on strong, efficient and marketable developments. We offer comprehensive technologies and procedures which are applied in almost all industries. Application-specific adaptions to the requirements of our customers are the major focus of our work.

Korean: 프라운호퍼 마이크로 전자회로 및 시스템 연구소(IMS)는 1984 년 설립 이래 반도체 기술과 마이크로 전자회로 및 시스템 개발에 주력해왔습니다. 핵심 연구분야는 반도체 공정,

CMOS 및 SOI 기술, 마이크로시스템 기술, 부품 및 시스템 개발, 나노(바이오) 기술 등입니다. 효율적이며 시장성이 있는 솔루션 도출에 주안점을 두고 위탁연구를 수행하고 있으며, 거의 모든 산업부문에 적용 가능한 포괄적인 기술 및 절차를 제공하고 있습니다. 또한, 응용분야에 특화되고 고객의 요구사항에 최적화된 기술 적용에 주력하고 있습니다.

31.2 Semiconductor processes require stability and know-how

The development in microelectronics progresses anymore. It aims at increasing functionality. In addition to the high-volume products (storage, microprocessors), more and more custom-designed systems are provided, which however cover a huge market. Certainly, the cost reduction plays an important role.

The diminution of the structures is one way to reach cost reduction. Because of high invest and high entry costs it is only efficient in case of high volumes. European especially medium-sized semiconductor enterprises follow a different path: moderate scale under integration of components for the enlargement of the application base. This includes non-volatile storages, voltage-proof transistors, power devices, resistances and capacitors for analogue circuits.

CMOS processes are developed for power electronics, rough ambiances, high temperatures and for the integration of sensor elements (optical, mechanical, biological, physic-chemical).

Compact single chip Microsystems are developed for the use in medicine, industry, automotive and consumer applications.

Ideal conditions in the Fraunhofer IMS:

In-house CMOS line on 200mm wafer, professionally operated, acknowledged automobile quality, robust 0.35µm CMOS process. Fraunhofer IMS develops entire processes but also process modules, components, sensors directly in the CMOS e.g. in a process for CMOS imager or for integrated pressure sensors.

The integration of new materials or micro-mechanical structures are not possible by implication, because a CMOS line always has to be restricted to maintain the high level quality. Therefore, Fraunhofer IMS has additionally assembled an own line for post-processing, which is currently enlarged significantly. CMOS wafers act as “intelligent” substrate. They contain trigger and read-out circuits, signal processing, conversion and outwards interfaces up to the wireless power and data transmission. On these wafers, these “substrates” layers and structures are now deposited and by this new components are produced. The development’s aim is to produce compact, “intelligent” microsystems

31.3 . ASICs

From the concept up to the pilot fabrication is the maxim of the Fraunhofer Institute for Microelectronic Circuits and Systems. We provide our customers professional analogue or mixed signal ASIC design solutions from the concept up to verified silicon for “ready to use” ASIC products for the application in several areas. In doing so, we support our customers with our large system know-how.

In addition to implementations in various standard CMOS technologies we especially allocate design and technology solutions for high temperature, high voltage and sensor system applications. Special circuit parts or sensor system components are individually and custom-designed developed and integrated with standard components like sensor readout, signal processing, interface components or embedded micro controllers on an IC.

We offer design, ASIC processing, assembly and test from one source. Standardized and certified procedures connected with our high-capacity software and equipment ensure our efficient ASIC design and realization. They guarantee high-quality and solid products for innovative applications. Besides the monitoring of the whole development process we flexibly offer our competencies also for sub areas of these processes to allow for the individual requirements of our customers.

31.4 High Temperature Electronics

Microelectronics is a key technology used in more or less any application. With increasing complexity and demand for harsh environments especially for high temperature, standard electronic reaches its limits. Depending on the grade, integrated circuits are specified up to a maximum operation temperature up to 125°C or even less. Nevertheless sensors and actuators are used in industrial process with high environmental temperature, while commonly deposited electronics are used, which requires additional space and results in loss of performance.

Fraunhofer IMS thin film Silicon-on-Insulator (SOI) CMOS technology allows to overcome the above mentioned limits. Due to dramatically reduced leakage currents, analog, digital and mixed-signal circuits become feasible for use in a considerably extended temperature range up to typical 250°C and above. The process is equipped with a robust high temperature tungsten metallization instead of aluminum and therefore allows reliable operation at high temperature conditions. Besides the CMOS specific components the technology is equipped with non volatile memory based on EEPROM.

Based on this technology we realize integrated circuits for the extended temperature range up to typical 250°C and above.

Develop new application together with Fraunhofer IMS or optimize existing systems with respect to performance, type of construction, or cooling by using HT ASICs.

31.5 IR Imagers

The business unit IR Imagers offers the development (and pilot fabrication) of infrared sensors.

We analyze wave lengths from the near up to the long-wave infrared. The imagers, also referred to as Focal plane arrays, are one- or two-dimensional arrays of infrared sensitive pixels. They are based on radiation-sensitive structures in silicon technology. Integrated on one chip with CMOS read-out circuits, complete imager chips are developed.

Possible customers of this new IMS business unit come from the automotive industry, where driver assistance, night vision and pedestrian detection are important topics. In the industrial sector similar safety aspects e.g. personal security and also the measurement technology in the process monitoring matter. In the sensor system, the gas analysis is of increasing interest. Further applications are thermography in buildings or in medicine, but also for border and building security.

The aim of the versatile developments is to open up new markets by IR-Imagers. This includes easy application without cooling, tight casings and simple interfaces. Customized scalable imagers offer an application-adapted optimized solution.

31.6 CMOS Image Sensors

The solid-state imaging and photo detection based on CMOS technologies has reached a point where its quality and performance matches and even surpasses the outmost mature CCD technology. In addition, CMOS offers cointegration of sensor electronics enabling single chip camera modules. This progress has been intimately bound to CMOS process optimisation. Development of special photodetector devices or special treatments of the silicon surface boost the pixel performance and reduce the adverse effects.

Fraunhofer IMS possesses a long experience in CMOS photo detectors and imagers design, their processing and characterisation. We operate an in-house 8” (200mm) CMOS wafer line certified according to the automotive industry standards. Our customers profit from our standard 0.35µm CMOS process optimised for photo sensing applications. Furthermore, we offer CMOS post-processing, which involves colour filters and microlenses deposition, anti-reflection coatings, stitching, wafer thinning, MEMS, or flipped-wafer techniques. Our R&D activities cover the spectra ranging from X-ray over EUV, UV, and the visible range up to near infrared.

We offer custom designs that meet your requirements based on Fraunhofer IMS CMOS processes or foundry processes for the pilot fabrication, special post-processing services, joint process optimisation and our “know-how”. If you need a dedicated imager or photo sensor with special performance features and beyond state-of-the-art, do not hesitate to contact us. We will gladly accept the challenge!

31.7 Pressure Sensor Systems

In microelectronics the trend is toward smaller and smaller sensors. The same applies to pressure sensor technology. Our customized developments are particularly efficient, consume little power and, if required, are implantable in the human body due to their minimal size.

Therefore, new fields of application of pressure sensor technology, particularly in medical engineering, can be opened up.

Being fabricated as integrated capacitive pressure sensors in surface micromechanics, a connection to any kind of signal processing is possible. An example for this is the reading of our pressure and temperature transponders direct on-chip by a special A/D converter, which is integrated in the chip and alternates between pressure and temperature sensor during the data evaluation. The data acquisition is carried out by an external auxiliary attachment, which communicates with the chip either wireless or grid-bound. Many of our sensors are especially suited for medical applications such as the long-term monitoring of important physiological parameters like blood, intraocular or bladder pressure. Consequently, medical engineering gains in importance in regard to the future utilization of pressure sensors.

Miniaturized pressure transponders are also suitable for hydraulic applications in industrial engineering or for the measurement of tire pressures in automotive engineering. Due to the integration of the sensor system and signal processing in one ASIC, the

Fraunhofer IMS can comply with all realizable requirements and applications and can offer customized technologies for the future.

31.8 Biohybrid Systems

The identification of biological and chemical substances without extensive laboratory work marks a milestone for the progress in medical engineering. This can be realized by miniaturized systems which recognize substances by their electronic reaction via a sensor.

The essential of this method is that these systems do without marker and that they can be extended via electronics by several functions.

The Fraunhofer IMS offers the development of these highly sensitive detection systems, which state a cost-effective and fast option to optical analyses in the laboratory. These micro systems can also be integrated into larger measuring systems. This is particularly interesting for customers of medical engineering, who prospective can offer simple ways for examinations via non-invasive diagnosis and monitoring systems because bioelectronic sensors can detect medical and physical parameters leading to new opportunities in patient examination. These functions are also interesting for the food industry, which can profit by the simple and fast detection of biologic-chemical variations of their products.

Furthermore, the Fraunhofer IMS provides the development of intelligent bio sensor implants for monitoring patient data. Chips that are implantable in the human body send externally read data or stimulate nerves causing a reaction; this is a helpful method to improve the quality of life of permanent patients. Until now, we successfully developed micro implant systems i.a. for hypertonic types and the glaucoma therapy and the implementation of much more ideas is possible by bio sensors.

31.9 Wireless and Transponder Systems

Modern and trend-setting industrial production and handling processes, as discussed and realized in terms of “Industry 4.0”, can only be reliably operated, if detailed information about logistic and production processes is available and data about identities and measurement values of tools, components and machines is provided at any time. Based on this data manufacturing steps can be controlled and monitored, maintenance requirements can be detected, wearing can be minimized, durability and production yield can be optimized and quality recordings can be created automatically.

Transponder systems – especially sensor transponder systems – and sensor networks feature an excellent technological basis for the registration of identification and sensor data, in particular in case of objects which are mobile, rotation or in any way difficult to access. Hence this technology supplies an important contribution for the implementation of the “Internet of Things” (IoT). Wireless communication and power supply also open up new application areas, e.g. in medicine to get measurement data from implanted sensors for diagnostic and therapeutic purposes. Other interesting application areas are the building sector and logistics.

During many years and numerous research and development projects Fraunhofer IMS achieved a large know-how basis in the field of wireless short range communication, which is constantly updated. The IMS scope comprises active and passive (sensor) transponder solutions for all current frequency ranges, wireless sensor networks and embedded systems. In combination with our embedded software, system integration and internet competence Fraunhofer IMS provides all technologies that are relevant for the design and development of “cyber physical systems” (CPS).

31.10 Electronic Assistance Systems

Most of the people’s activities take place in rooms and buildings, e.g. nursing processes in nursing homes but also in private living spaces; building operation and facility management in commercial facilities under the boundary conditions of high efficiency, most simple handling and cost effectiveness. In the area of “mobiles”, e.g. cars, an electronic assistance is meanwhile implicitness. The Electronic Assistance System Solutions of the IMS now transfer these efficiencies into “properties”!

From novel assistance systems for more efficiency in the nursing and hospital area, in the area of energy facility management up to solutions for the next generation office – in the business unit Ambient Intelligence Systems the Fraunhofer IMS offers electronic AmI solutions for the gain of producers, operators and end users (AmI = Ambient Intelligence).

Since 1998 the Fraunhofer IMS has achieved a high know-how potential in this area by building up and managing the Fraunhofer inHaus center for intelligent room and building systems with its numerous possibilities and its reputation in the research and development market in Germany and Europe. Thereby, we understand innovation as the process “from the good idea to the good business”. The product range is precisely directed to the customers’ all-dominant thinking and actions. In doing so, many innovations could be successfully transferred into the commercialization e.g. service gateways of all kinds, simplest operation concepts, energy efficiency solutions (e.g. smart metering, remote heating pump systems) or even assistance solutions for the enormously increasing market of senior citizen living and nursing.

32. Fraunhofer Center for Internationl Management and Knowledge Economy IMW

Website Link: http://www.imw.fraunhofer.de/en.html

32.1 Institute Overview

English: Fraunhofer IML is said to be first address for all questions with respect to holistic logistics, the employees work on all fields of internal and external logistics. At the Institute, founded in 1981, there are at the moment 260 employees as well as 250 postgraduates and students, supported by colleagues in workshops, laboratories and service areas.

Made-to-measure arranged teams create cross-industry and customer-specific solutions in the area of materials handling, warehouse management, supply chain management, simulation supported business and system planning and also traffic systems, closed loop economy, resources logistics, building logistics and e-business. Not least, the Fraunhofer IML is acting as general coordinator for the multi-institute central theme »Internet of Things« within the entire Fraunhofer-Gesellschaft. If necessary, Fraunhofer IML can draw on 24,000 employees in 67 institutes of Fraunhofer-Gesellschaft.

With 120 partner companies as well as 11 educational and research institutions the EffizienzCluster LogistikRuhr is currently the biggest European research initiative in logistics.

Further locations beside Dortmund are Frankfurt/Main, Hamburg, Prien at lake Chiemsee, Lisbon and Beijing.

Korean:

32.2 Internationalization processes

Fraunhofer Center for International Management and Knowledge Economy specializes in internationalization processes, particularly in the fields of the knowledge society, value creation and sustainable development. The basic conditions for research, development and innovation are analyzed in an international context in order to improve, and thereby promote, the transfer of knowledge and technologies as well as the development of globalized value creation.

National and cross-border transfer strategies are also investigated in terms of their efficiency. On the basis of the latest findings, innovative transfer systems are developed with the goal of enhancing international access to knowledge. Fraunhofer Center for International Management and Knowledge Economy assists with the transfer of knowledge from science to the economy.

Small- and medium-sized enterprises (SMEs), with a specific focus on innovative production and service industries, are supported in their innovation management and internationalization efforts. Among other things, this is intended to put companies in a position to expand their value creation chains globally and market their products internationally.

In addition, SMEs as well as entire sectors are assisted in developing and implementing scientifically substantiated sustainability strategies.

Examples of activities:

- international country, industry and technology comparisons
- country- and region-specific status analyses
- analysis of the development of specific markets
- location and impact analyses
- market research and benchmarking
- projects, studies, strategies on innovation transfer and management, clusters and networks and company development and internationalization
- project management
- feasibility and foresight studies
- developing and implementing strategies in the field of research and development (R&D)
- monitoring research institutions, nationally and internationally

33. Fraunhofer Institute for Applied Optics and Precision Engineering IOF

Website Link: http://www.iof.fraunhofer.de/en.html

33.1 Institute Overview

English: The Fraunhofer IOF conducts application-oriented research in the field of optical systems engineering on behalf of its clients in industry and within publicly-funded collaborative projects.

The field of optical system engineering enables the step from specific optical, mechanical and electronic components to optical, opto-mechanical and opto-electronic modules and systems with complex functionalities. The objective is to control light, from its generation to its application. In this context, the sustainable energy-efficient use of light – "Green Photonics" – plays a special role for the Fraunhofer IOF, particularly with regard to the Fraunhofer innovation cluster.

Clients of Fraunhofer IOF come from the information and communications, lighting, transport, production, life sciences, food, medical technology, environmental and safety engineering markets.

The Fraunhofer IOF provides the entire process chain, starting from system design to manufacture of prototype optical, opto-mechanical and opto-electronic systems.

The competence portfolio encompasses:

- Design and Simulation,
- Micro and Nano-structuring,
- Optics and Photonics Materials,
- Coating and Surface Functionalization,
- Diamond-Based Ultra-Precision Processing,
- Materials Processing Using Ultrashort Laser Pulses,
- Micro-Assembly and System Integration,
- Laser Development and Non-Linear Optics,
- Measurement Methods and Characterization.

Korean: 프라운호퍼 응용광학 및 정밀공학 연구소(IOF)는 광학 시스템 분야의 응용중심 연구기관으로 기업의 위탁연구 및 정부지원 공동연구를 수행하고 있습니다. 광학시스템공학은 광학·기계·전자 부품에서 복잡한 기능을 갖춘 광학·광기계·광전자 모듈 및 시스템까지 다양한 응용제품을 지원하며, 빛의 생성과 응용 등 빛의 제어를 목표로 하고 있습니다. 프라운호퍼 IOF 연구소는 특히 프라운호퍼 혁신 클러스터와 관련하여 지속가능하고 에너지 효율적인 빛의 사용인

“친환경 광학(Green Photonics)”을 중점적으로 연구하고 있습니다. 연구소는 정보통신, 조명, 교통, 제조, 생명과학, 식품, 의료기술, 환경 및 안전공학 등 다양한 산업의 고객을 지원하고 있습니다. 또한 시스템 설계에서 광학·광기계·광전자 시스템의 프로토타입 제작까지 공정사슬 전반을 제공하며, 다음 분야에서 핵심역량을 갖추고 있습니다.

- 설계 및 시뮬레이션
- 미세 및 나노 구조화
- 광학 및 포토닉스 소재
- 코팅 및 표면 기능화
- 다이아몬드 기반 초정밀가공
- 극초단 레이저 펄스를 이용한 소재가공
- 미세조립 및 시스템 집적
- 레이저 개발 및 비선형 광학
- 측정기술 및 특성분석

33.2 Mechanical Design

Mechanical design and its combination with optical design are among the key competencies at Fraunhofer IOF.

This includes optimization in the mounting of optical components and the required joining processes (soldering, bonding, laser welding), the design of kinematic suspensions and the development of associated adjustment algorithms.

A further area of focus is the thermal design of optical systems, aimed at making these insensitive to temperature influences from the environment or to thermal lenses in high-performance applications.

Further focal areas include the design of optical elements with low mass and high stability for space applications and the design of adaptively optical elements on the basis of piezoelectric actuators.

Tools for this process are finite-element simulation and CAD systems.

33.3 System Design

The Fraunhofer IOF offers the full development of an optical system from a single source: from the idea to the prototype to system integration. Particular competence exists in the design and analysis of optical systems.

33.4 Photolithography

Lithographic processes enable the simultaneous production of a large number of elements with the highest lateral accuracy, a key requirement for micro-optical integrated on wafer scale.

The key technologies are:

- Binary photolithography in contact mask aligners, including use of positive/negative thick resists
- Photoresist reflow; here, binary photoresist structures are formed into precise, lenticular structures, a standard method for generating microlenses

Photolithographically structured polymer or metal layers serve as apertures, reflectors, color filters and as (masters for) binary gratings, diffraction plates, spacers etc.

Reflow structures serves as microlens master structures for diverse molding technologies or are transferred to the underlying glass or silicon substrate through reactive ion milling.

33.5 Grayscale Lithography

With outstanding flexibility, direct writing grayscale lithography enables

the generation of high precision microstructures for the implementation into optical systems.Thus, individual solutions for refractive and diffractive micro optical elements, even on non-standard or non-flat surfaces, can be realized in close collaboration with design and integration.

33.6 Functional Material Printing

The printing of functional materials is manufacturing technology e.g. for polymer electronics, organic LED, solar cells and wiring that is resource efficient and seen to be a visionary production technique. Being a locally generative method of creating structures and geometries it allows depositing functional materials exactly and only there where they are needed.

Fraunhofer IOF develops technologies for the ink jet printing of wirings made of silver and gold as well as that of actuation materials. These actuation materials are electro active polymers that change volume when applying an electric field and thus induce deformations and movements. When electro active polymers are printed in between electrode structures planar bending and deformating geometries can be created. This can be interesting for optical applications such as OLEDs and solar cells, since there the movement of micro optical structures can improve the illumination quality or the power conversion from light to electrical energy. Also in life science applications such as Lab-on-Chip for point-of-care diagnostics printed actuation structures are of interest, e.g. for chip integrated pumps and valves.

33.7 Stochastic Structures for Antireflection

Stochastic structures arise fully through self-organization or are initiated by thin layers following plasma and ion beam exposure on materials such as glass, plastic and silicon.

An effective material mixture of the substrate material and air is generated in the modified surface area. The effective diffraction index is correspondingly reduced.

Glare reduction, for example for optical lenses made of quartz and plastic in the visible spectral range or for solar applications (black silicon) is the focus of applications in such sub-wavelength structures.

33.8 Electron Beam Lithography

Micro- and nanostructured optics can be represented using lithography techniques, although the technical requirements on the lithography systems and process significantly deviate from those of microelectronics and in many respects exceed them.

The Fraunhofer IOF has many years of experience in the field of developing exacting micro- and nanostructures.

Key technologies are electron beam lithography for generating prototypes and transfer processes proceeding from the prototype (structure transfer with etching processes) and their replication (structure transfer with nano-molding).

The available technological facilities enable the efficient realization of such structures on surfaces of up to 300 mm expansion with the highest precision and resolution.

33.9 UV Molding

UV molding is a cost-effective method of producing micro-optics on wafer scale. Here, a liquid polymer resin is UV-cured between a substrate (e.g. glass or semiconductor wafer) and a transparent molding tool in a contact mask aligner.

The process has become established in fields in which the precision or stability of all-polymer optics is insufficient, e.g. in

- Collimation of laser or fiber arrays

- Diffractive elements
- Micro-optics directly on CMOS-Si wafers
- Wafer-level miniature cameras

or other complex/multi-layered micro-optical systems.

Using selective UV exposure, areas of the substrate surface can remain polymer-free for electrical contacts or assembly.

UV molding can also be used for the rapid generation of optical functional prototypes prior to mass production (e.g. with injection molding).

The use of correspondingly stable UV-curable polymer resins enables subsequent coating/scribe and breaking and other steps such as soldering or bonding.

33.10 Optics and Photonics Materials

Nanostructure technology enables the development of new materials for optics and photonics such as photonic crystals and metamaterials, opening up completely new applications in the fields of imaging, ultra-compact light sources, nanomicroscopy and optical nanomanipulation. The investigation of these materials is carried out at the Center for Innovation Competence "ultra optics®".

Applications lie in the fields of imaging, ultra-compact light sources, nano-microscopy and optical nano-manipulation.

33.11 Coating and Surface Functionalization

Functional coatings and surfaces are an essential element of optical systems. We offer extensive competencies in the design of optical layer systems, in the development of coating processes for diverse applications and in the characterization of surfaces and layers. Especially significant are ultra-reflective coating systems for optics in the EUV and X-ray range as well as the functionalization of plastic surfaces.

33.12 Diamond-Based Ultra-Precision Processing

Diamonds are used to produce metal optics at Fraunhofer IOF. The scientists exploit the mechanical and thermal properties of diamond to produce metallic mirrors, gratings and plastic-based lens arrays. The creation of reflecting optics is already achieved in the first processing step. Complex surfaces such as aspheres and optical free-form surfaces can be generated simply and with ultra-precise accuracy. Numerous developments for single mirrors and mirror systems for telescopes and spectrometers for use in space, for terrestrial astronomy applications, for imaging optics in laser technology or mirror systems for lithography are realized.

At the present time, five modern ultra-precision turning, milling, planning and grinding machines for the production of precision optics made of metallic and polymer materials are available. This technological basis and the latest scientific investigations at Fraunhofer IOF enable the creation of off-axis aspheres with a size of 450 mm x 300 mm and on-axis mirrors of up to 650 mm diameters with diffraction-limited quality for applications in the UV, VIS and NIR spectral range.

33.13 Materials Processing Using Ultrashort Laser Pulses

Ultrashort pulse lasers with pulse duration in the range of a few picoseconds or femtoseconds show great use potential for the highly-precise structuring of a wide range of materials, in particular metals.

Due to the short energy deposition in one time range below the thermal relaxation time, surface removal – with suitable parameters – can be achieved with practically no mechanical or thermal damage ("cold" ablation). This generates minute structures which are only defined by the optical properties of the laser beam. The brief pulse duration with moderate pulse energies means a very high laser intensity. This enables the utilization of intense non-linear absorption processes. As a result, practically all materials, whether transparent or opaque, can be processed. In addition, specific three-dimensional structures are realizable in bulk.

The brief process times required by the production process can therefore be preferably realized with powerful ultrashort pulse laser sources. The fiber-based ultrashort pulse laser systems developed at Fraunhofer IOF offer high pulse repetition frequencies with high performance and outstanding beam quality. This results in an increase in processing speed and productivity.

33.14 Micro-Assembly and System Integration

The Fraunhofer IOF possesses extensive expertise in the development of technologies for the hybrid integration of diverse components with high precision for the construction of complex opto-mechanical and opto-electronic micro- and macrosystems. This encompasses assembly technologies (positioning, aligning), joining technologies (bonding, laser soldering, plasma bonding, laser splicing, alignment turning) and the integration of optical systems for space applications.

33.15 Laser Development and Non-Linear Optics

With expertise in fiber design, optics design, thermo-optics, assembly and joining technology for fiber lasers and in the development of efficient fiber couplers and beam guidance systems, excellent potential exists for the development of high-performance fiber lasers with diffraction-limited beam quality.

33.16 3D-Measurement

The Fraunhofer IOF designs and realizes optical 3D measuring systems for various applications on the basis of:

- modern imaging 3D measurement techniques (structured light projection, stereo image editing, photogrammetry),
- digital projection technology (LCoS, DMD, OLED), novel microoptical projection-technology (array-projection) and
- software concepts.

The possible areas of use for the optical 3D measuring systems are broad-based and range from:

- quality control in toolmaking and mold making,
- in the optical industry,
- in mechanical engineering,
- in the automotive industry all the way to
- medicine and forensic science.

The Fraunhofer IOF supplies applied system solutions using which the optical metrology can be seamlessly integrated within automated manufacturing and testing procedures.

33.17 Optics Characterization

Metrology is of vital importance for system development and analysis. The Fraunhofer IOF consequently characterizes new components and checks fully realized systems.

In addition, measurable variables, e.g. regarding scattering properties, luminance distribution or the modulation transfer function (MTF) flow directly into the design process. The Fraunhofer IOF provides the following measuring set-ups for these purposes:

- MTF, focal distance, image scale

- Luminance, near and far field
- Spectrometers
- Laser beam analysis
- Scattered light analysis of optical and non-optical surfaces
- Micro display characterization
- Free-form characterization and measurement of reflective objects
- Measurement of free forms with computer-generated holograms (CGH)
- Deflectometry

33.18 Surface and Thin Film Characterization

The Fraunhofer IOF has many years of experience in the field of surface and thin film characterization. This includes investigations of nano- and microstructures and their optical and functional properties. Application specific investigation programs are designed in order to efficiently support the development of surfaces, coatings, and materials. A comprehensive pool of measurement and analysis tools is available for this purpose.

33.19 Terahertz-Measurement Methods

Time of flight measurement of ultrashort THz pulses in combination with broadband spectroscopy enable numerous applications in the field of non-destructive testing, safety engineering and tomography:

Examination of layers in transmission/reflection: determination of thickness, homogeneity and delamination of layers and multiple-layer systems

Examination of closed plastic containers: control of contents, level measurement

Contactless counting of paper sheets

Homogeneity examination of polystyrene components (for example templates for metal casting)

2-dimensional spectroscopy measurements of closed letters and packages to test for drugs, weapons and explosives

THz Tomography: 3-dimensional reconstruction of components

33.20 Metrological Computer Tomography

Computer tomography enables the non-destructive detection and recording of the internal and external geometry of an object. Using virtual sections cut through the object, material testing, the identification of defects and the geometric recording of inner and outer structures is possible.

34. Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB

Website Link: http://www.iosb.fraunhofer.de/servlet/is/12481/

34.1 Institute Overview

English: Established on January 2010, the Fraunhofer Institute of Optronics, System Technologies and Image Exploitation IOSB grew to become Europe's largest research institute in the field of image acquisition, processing and analysis. IOSB's other areas of activity are control and automation technology, and information and knowledge management. The three core competencies of Optronics, System Technologies and Image Exploitation give the institute its distinctive profile.

The field of Optronics represents the interface between electromagnetic radiation and electronic signals. It deals with converting information about the appearance of the environment and the objects it contains into electrical signals and electrical signals into optical images. Image Exploitation covers conditioning and real-time processing of, and automatic and interactive information extraction from images and videos. System Technologies, which represent a cross-section of expertise and are essential for responding to difficult, comprehensive issues with integrated solutions, may, at first sight, appear to be our most abstract field of research. It covers everything that is required for analyzing, gaining an understanding of, modeling, developing, and controlling complex systems.

Korean: 프라운호퍼 옵트로닉스, 시스템기술 및 이미지응용 연구소(IOSB)는 2010 년 설립 이래 유럽 내 영상 수집, 처리, 분석 분야의 선도 연구기관으로 성장했습니다. 제어 및 자동화 기술, 정보 및 지식관리 분야도 연구하고 있으며, 옵트로닉스, 시스템기술, 영상응용 3 개 부문에서 핵심역량을 보유하고 있습니다.

옵트로닉스는 전자기파와 전자신호 간의 접점으로 환경 및 환경 내 객체에 대한 표면 정보를 전자신호를 거쳐 광학영상으로 전환시킵니다. 영상응용은 영상의 조절 및 실시간 처리, 자동적·상호적인 영상정보 추출을 다루고 있습니다. 집적 솔루션에 대한 난해하고 포괄적인

문제에 대응하는데 있어 필수적인 시스템기술의 경우, IOSB 연구소의 가장 추상적인 연구분야로 알려져 있습니다. 해당 기술은 복잡한 시스템의 분석, 이해, 모델링, 개발, 제어와 관련된 모든 요소를 망라하고 있습니다.

34.2 Information Management and Production Control (ILT)

The objective of the department Information Management and Production Control (ILT) is to develop components and complete solutions for the design, operation and maintenance of complex information, control and test systems. Security requirements are considered by design. Our focus lies on the application domains of environment, health, risk management, resource efficiency, production and security.

On the basis of agile methods in requirements analysis, system design and recognized architectural and communication standards, we implement open, innovative, and customized software solutions, encompassing and driving new paradigms of the »Internet of Things and Services« as well as »Industrie 4.0«. In order to accompany and support our customers on this way, we offer dedicated consultancy services, e.g. enterprise-specific Industrie 4.0 roadmaps, or the transformation of Manufacturing Execution Systems (MES) to the requirements and technologies of the smart factory.

We analyze the suitability of modeling and communication methods and IT security technologies for:

Complex manufacturing processes driven by Industrie 4.0 value chains (e.g. AutomationML and OPC UA)

Environmental sensors and models (SensorML)

Environmental observations (geospatial standards of the Open Geospatial Consortium OGC)

Our information management system »WebGenesis®« supports ontology-driven Web-based information systems, problem-specific information analysis and personalized user interaction. For the emerging Internet of Things (IoT) we draft and implement smart solutions for the efficient search in and processing of heterogeneous data sets (»big data«), the extraction of knowledge with data mining methods (incl. semantic annotation) and the fusion of heterogeneous sensor data to meaningful technical information for decision support (»Fusion4Decision«). We are responsible for the systematic and facilitated requirements and IT security analysis as well as for the specification and realization of service-oriented and event-driven architectures (SOA/EDA).

We develop thematic applications and connect them to integrated environmental information systems. Our software framework WaterFrame® renders data sources accessible and integrates geographical information system (GIS) components as well as innovative geostatistical methods. WaterFrame® provides support in generating thematic maps, diagrams and reports.

With the ProVis suite we realize production control system components and integrated solutions according to both the classical functional MES requirements, and the emerging IoT/Industrie 4.0 paradigms encompassing demanding IT security features such as intrusion detection services and secure communication. The functions offered by ProVis range from monitoring and managing production facilities up to engineering control rooms and the processes of manufacturing control. This allows us to deploy production control systems in automotive production sites and the steel industry, including Web-based analysis and reporting systems.

We run vulnerability tests for critical systems and develop test systems for selected de-facto standards such as Foundation Fieldbus, AutomationML, and HLA. Our technologies are integrated into the IT Security Lab for Industrial Production of IOSB. Our objective is to promote the adoption of standards in the market and to support interoperability in open systems. We therefore actively participate in the relevant standardization bodies in VDI/VDE, DKE, DIN, IEC, IIC, W3C and OGC.

34.3 Interactive Analysis and Diagnosis (IAD)

The department Interactive Analysis and Diagnosis (IAD) develops innovative interaction methods, smart environments and assistance systems with the aim of supporting people in various analysis tasks.

On one hand IAD is focused on the development of multimodal interaction within smart environments. The developed interaction techniques apply mostly to video-based interaction methods which cover capturing and tracking of persons, recognition of hand pose and pointing gestures, and analysis of activities within a certain environment using gaze-based interaction and speech.

On the other hand IAD develops assistance systems,whichsupport people in the process of decision-making. Application areas are diagnosis of technical systems, image interpretation, and intelligent surveillance systems. Our concepts take into account the strengths of both computer systems and humans. Computer systems are capable of rapidly saving, searching and calculating large quantities of data. Humans, on the other hand, are still superior to computers when it comes to recognizing and interpreting complex structures in images.

Accessing and processing large distributed data helps us to build more efficient interactive systems. Privacy and Security by Design allows us to incorporate legal requirements and data protection without sacrificing functionality, as often seen in conventional solutions. IAD employs a group of IT security professionals, who develop their privacy expertise in research projects and consult industry partners on how to combine data protection and functionality in their products.

34.4 Interoperability and Assistance Systems (IAS)

The Interoperability and Assistance Systems business unit offers solutions to the market which optimize human interaction with complex information-and technology-based systems. Through research and development projects, we make major contributions in the areas of computer-supported assistance systems, information management, cooperative work, and decision-making processes by applying innovative multi-modal and multimedia interactive technology.

Work stations for the analysis of aerial and satellite images, conceptualization and evaluation of systems solutions, conception of user interfaces for telecommunication equipment and assistant systems are focal points of our work.

To carry out these tasks, we apply rapid-prototyping tools, techniques for the model and check-list based dialog analysis, a usability lab, and a high-performance software development environment.

Our partners and customers include the Federal Ministry of Defense (BMVg/BWB) and the defence industry as well as the automobile industry.

34.5 Object Recognition (OBJ)

The department Object Recognition (Objekterkennung - OBJ) develops and evaluates algorithms for automatic object detection and object tracking in sensor networks.

The department´s activities range from the evaluation of video streams in the infrared and visual spectral band and the analysis of laser sensor data to the description of a three-dimensional, dynamic environment via multi-sensory data acquisition and automatic alerting in case of specifically defined occurrences. In addition, the possible real-time implementation of the algorithms is evaluated on the basis of heterogeneous hardware structures.

34.6 Optronics (OPT)

The department of Optronics researches methods and creates mathematical models for designing, evaluating and protecting active and passive electro-optical sensors in the business areas of Defense, Civil Security as well as Inspection and Visual Verification.

The work area active and passive sensors inspects and evaluates optronic sensors and sensor systems in terms of their performance and possible applications.

The area laser safety and optronic counter measures inspects, prepares and evaluates concepts for eye protection and the protection of electro-optical sensors (visual and IR) as well as the threat potential of laser sources for disturbing optronic systems.

In modeling and simulation,methods andalgorithms are developed for analytical modeling and imaging simulations to predict the performance of optronic systems in different situations.

Through close cooperation with the individual work areas, the department of Optronics disposes of the complete competence spectrum for the research, evaluation and simulation of innovative, electro-optical systems.

34.7 Scene Analysis (SZA)

The department Scene Analysis (SZA) develops automatic procedures for the processing of multi sensor image data in the network of reconnaissance. The motive force for the research activities is the demand for the prompt availability of data interpretation and geoinformation. Among other things, the department established models for the representation of urban terrain and carries out automatic 3d scene reconstructions. For the efficient processing of large data volumes powerful methods are developed for segmentation, classification, and change detection as well as for the fusion of data captured by different sensors.

The research services cover

SAR image analysis

- Simulation of SAR image signatures
- Ground motion determination by means of permanent scatter
- Building reconstruction from interferometric SAR images

Image interpretation

- Efficient screening procedures for the evaluation of large data volumes

- Structural change detection
- Evaluation of hyperspectral sensor data

3d analysis and network enabled capabilities

- 3d object reconstruction from image sequences and laser scanning data
- Automatic instantiation of building models from point clouds
- Automatic geo-referencing of image contents
- Image aided navigation

34.8 Signatorics (SIG)

Fields of operation of the department Signatorics (SIG) include the performance optimization of electro-optical systems (from the ultraviolet to the infrared spectral range) within the atmospheric environment as well as the improvement and development of signature management measures.

The expertise of the department lies within the range of warning sensor technology, signature management und environmental limitations.

The fields of work are in particular:

- Adaptive Optics
- Optics of the Atmosphere
- Signature Management
- Evaluation of Signatures
- Warning Sensor Technology

35. Fraunhofer Institute for Manufacturing Engineering and Automation IPA

Website Link: http://www.ipa.fraunhofer.de/en.html

35.1 Institute Overview

English: With nearly 1 000 employees, Fraunhofer IPA is one of the largest institutes in the Fraunhofer-Gesellschaft. It has an annual budget of over 60 million euros, with more than one third coming from industrial projects.

The 13 departments of Fraunhofer IPA are supplemented by six business units: Automotive, Machinery and Equipment Industry, Electronics and Microsystems, Power Industry, Medical Engineering and Biotechnology and Process Industry. This structure enables us to help our practice partners improve their market position as well as support their market entry into new application fields.

The focus of our strategic cornerstones is on sustainable projects with high industry participation. Mass sustainability aims at minimizing the consumption of resources while maximizing the standard of living. In flagship projects, such as the Ultra-efficiency Factory, Fast Storage BW, the Center for Lightweight Production Technology and the Center Smart Materials, we are putting this concept into practice together with our partners from industry, university research and politics. Mass personalization unites the advantages of economies of scale and scope. In ARENA2036, the research campus for functionally-integrated lightweight automotive construction and in Campus Personalized Production, we are working on ways to manufacture personalized products in batch sizes of one at the same price as mass-produced products.

Korean: 프라운호퍼 제조공학 및 자동화 연구소(IPA)는 1 천여명의 임직원을 두고 있으며 프라운호퍼협회 산하 연구소 중 대규모에 속합니다. 연간사업비는 총 6 천만 유로이며 이 중 삼분의 일 정도를 산업연구과제에서 충당하고 있습니다. 연구소는 자동차, 기계설비, 전자 및 마이크로시스템, 전력, 의료공학 및 생명공학, 가공의 6 개 사업부와 13 개 부서로 구성되어 있습니다. 이처럼 체계적인 조직구조는 고객이 해당 시장 내 입지를 공고히 하고 새로운 시장에 진입할 수 있도록 돕고 있습니다. 연구소는 특히 산업의 적극적인 참여가 요구되는 지속가능성 관련 사업에 주목하고 있습니다. 대규모 지속가능성(mass sustainability)은 자원 소비의 최소화 및 삶의 질 향상을 목표로 합니다. 이러한 개념은 초고효율 공장, 고속저장 BW, 경량화 생산기술센터, 스마트소재센터 등 연구소가 추진중인 주요 민관학 협력사업에 적용되고 있습니다. 대규모 개인화(mass personalization)는 규모의 경제와 범위의 경제의 장점을 결합시킵니다. 연구소는 미래형 차량제작 산학협력 과제인 ARENA2036 과 개별주문생산(Campus Personalized Production) 과제 등을 통해 일괄처리 규모의 맞춤형 제품을 대량생산 제품과 동일한 가격에 제조하는 방법을 연구하고 있습니다.

35.2 Coating systems and painting technology

Organic coating systems form the basis of the most economically important of all surface technologies. This is due to their flexibility and versatility. In January 2012 at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA, this led to the decision to merge the two departments “Coatings and Pigments” and “Painting Technology” into a single department. The aim behind this move was to develop end-to-end solutions for all issues related to the entire coating technology process chain. The department handles anything from small industrial contracts through to complex bilateral and consortium research projects. The topics and projects it deals with are highly varied, ranging from the development of new coatings and paint components, through coating application right up to the development, modelling and simulation of practicable production processes. We aim to improve application efficiency, shorten throughput times, achieve savings on energy and materials as well as develop new materials. We then help you implement and integrate our solutions, thus enabling you to significantly improve your process efficiency

35.3 Image and signal processing

The department “Machine Vision and Signal Processing” develops and implements innovative system solutions and applications for processing information that is related to technical processes. The focus of the department’s research and development work is on smart measurement and inspection systems, modern automation solutions and also assistive systems for the elderly. The department specializes in the intelligent, automated interpretation of image and sensor information to solve complex tasks. Applications range from 2D measuring and inspection systems (e.g. with image processing, thermography or ultrasound) through modern 3D measurement and inspection technology with computer tomography and optical 3D sensors (e.g. laser line sensors, 3D smart cameras, time-of-flight cameras etc.) right up to 3D object recognition and scene analysis in automation technology (bin-picking, line-picking) as well as automatic recognition of emergencies and falls in the case of assistive systems.

35.4 Biomechatronic Systems

Every year, 6.9 million people suffer serious health damage at their place of work (EU-OSHA, 2013). As a result, the prediction and prevention of physical disabilities as well as the preservation of health at work are ever-important issues. 50 percent of all chronic illnesses in our society are related to the musculoskeletal system. In the future, this figure is expected to rise significantly among people aged over fifty.

The department “Biomechatronic Systems” develops technical solutions to detect, control and generate human motion for medical and ergonomic applications. Our interdisciplinary team works closely with industry to conduct research at international level.

Together with our customers, we want to develop new solutions: for a mobile society undergoing a demographic change.

35.5 DigiTools for Manufacturing

“DigiTools for Manufacturing” bundles core competencies from different departments in consideration of requirements for Industrie-4.0. The system solutions developed here are supplied both to SMEs as well as large concerns in various sectors of the market by the five business units of the Fraunhofer Institute for Manufacturing Engineering and Automation IPA. In this way, Fraunhofer IPA is responding to increasing research and development demands related to the future issue of Industrie 4.0

35.6 Efficiency systems

By improving energy efficiency in production, companies are not only able to lower energy consumption and cut costs but also increase productivity, allowing them to gain a competitive edge. There is an enormous energy-saving potential in manufacturing enterprises to be tapped if the right energy efficiency measures are taken. Among these are innovative energy-efficient technologies, enabling energy to be used more effectively while adapting industrial production to fluctuating energy levels and optimally integrating production equipment into both the manufacturing and urban environment in terms of energy.

Our energy efficiency experts offer our customers a balanced range of advisory services, from identifying efficiency opportunities in production plants through implementing tailored concepts for corporate energy management systems right up to selecting appropriate financing models.

35.7 Factory planning and production management

If a company wants to stay ahead of the competition, its factories and production facilities have to operate at maximum technical, logistical and organizational performance levels. Continuous improvement as well as more drastic, fundamental changes and adaptions are decisive to a factory’s sustained success.

With our factory planning and production optimization services, we help manufacturing companies pursue their core factory goals. Our services range from planning factory premises, through strategically aligning production and optimizing operations, right up to product value engineering and designing the necessary manufacturing and assembly processes.

Our newly-developed methods not only ensure that your factory is designed using the latest information but also that it maintains its competitive edge for years to come.

35.8 Functional materials

Innovations are increasingly taking place at process level. Nano-modified high-performance materials make plastics more robust, metals lighter and energy storage systems more efficient.

In doing so, conventional materials are modified with nano-scale fillers, such as graphene, nanotubes and silver nano wires. These fillers are synthesized, functionalized, dispersed and applied according to individual customer requirements in our laboratories at the Fraunhofer Institute for Manufacturing Engineering and Automation IPA.

The department has a reactor park, dispersion testing facility as well as a range of pilot application systems. These are used for conventional printing processes and additive manufacturing technologies, such as fused deposition modeling (FDM).

The department is a pioneer in application-orientated material and process research. Today it is recognized as one of the largest research groups active in the field of functional materials. Thanks to its high level of integration, research issues are solved quickly and comprehensively, enabling results to be transferred efficiently to product and process innovations.

35.9 Electroplating

The successful implementation of electrochemical technologies (electroplating) not only calls for ever-precise material characteristics and geometric features but also reproducible application technologies based on robust and reliable processes. That is why we ensure consistent end-to-end monitoring of the entire R&D chain from process development right through to industrial systems engineering.

Our work always focuses on electroplating issues. As a unique service provider, we advise you on all aspects concerning the entire industrial manufacturing chain – from the development of new plating materials and related process chains, through failure analysis, right up to the implementation of industrial systems engineering. Combined with our conventional consulting services such as supplier evaluation, we assist our customers with new technologies from the idea right through to their implementation in manufacturing processes.

35.10 Laboratory automation and biomanufacturing engineering

Improved reproducibility, fewer external influences, higher throughputs without losing laboratory flexibility and sophisticated sterile certified environmental conditions: these are only some of the requirements to be met when developing automation solutions in the field of life sciences. The interdisciplinary team of 25 scientists working in the Department of Laboratory Automation and Biomanufacturing Engineering at Fraunhofer IPA addresses these challenges. We have the necessary expertise to implement innovative end-to-end solutions, from the concept through to the validated process. By combining our own key solutions with gold-standard components, we supply top-quality solutions that are reliable, flexible and suitable. Our ultimate objective is to ensure benefits for the end-user.

35.11 Lightweight construction technologies

Today, energy and resource efficiency are key issues in manufacturing engineering. The Department of Lightweight Construction Technologies at the Fraunhofer Institute of Manufacturing Engineering and Automation IPA develops innovative solutions to overcome these challenges.

The target of decreasing weight in automotive and aircraft construction is well known. However, in the future the quantities of materials used to manufacture consumer and investment goods also need to be reduced. This will not only cut production, transport and disposal costs but also help to alleviate the problem of resource shortages in the global market.

By implementing lightweight concepts and lightweight materials, such as carbon fiber reinforced plastic (CFRP), our customers need less energy to operate their machinery and lower their emissions at the same time. We also help them to implement lightweight concepts tailored to their requirements as well as use new materials to improve the performance of machines and equipment.

35.12 Sustainable production and quality

For Fraunhofer IPA, sustainable company management means giving economic, ecological and social aspects equal consideration both from a regional and global standpoint. Companies also have to be prepared to accept responsibility for current and future generations.

We make sure you get the quality you need for your products and processes at the level of manufacturing reliability you require.

How can you manufacture your products sustainably and cost-effectively? Within the scope of research and industrial projects, Fraunhofer IPA develops and optimizes energy-efficient production processes, products and technologies that are free of hazardous substances and gentle on resources – not just during each specific phase of life but also over the product lifecycle.

35.13 Ultraclean technology and micromanufacturing

We've been carrying out research on clean and ultra-clean working environments for over 30 years. Our expertise results not only to international standards but also in binding norms. We also have the world's cleanest cleanroom at our disposal. It's at least ten times cleaner than the quality demanded by the air cleanliness class of ISO 1. This means that a maximum of one particle no bigger than 0.1 micrometer in size may be present in one cubic meter of air. Ideal conditions for a reference cleanroom. Under these conditions and in an area totaling around 250 square meters (ISO 1), we carry out contamination control tests, even on really heavy components. In the cleanroom, we examine all the relevant manufacturing aspects for contamination-sensitive industries and products. In total, our cleanrooms have a surface area of over 500 square meters – approx. 250 square meters of which are ISO 1 and about 250 m^2 ISO 5 and better. We advise our customers on issues ranging from conception through realization up to the ramp-up of systems or even complete production facilities.

35.14 Robot and assistive systems

The department "Robot and Assistive Systems" is concerned with the development of robot systems and automation solutions for industry and also for the services sector. The department develops and implements key technologies in innovative industrial robots, service robots and intelligent machines.

With 40 years of experience in robotics and automation, multi-disciplinary teams, an unparalleled network, a wealth of expertise and superbly-equipped laboratories and workshops, we are able to offer a wide range of services in robot technology and application:

- System design
- Feasibility studies
- Simulation of robot systems and components
- Material flow simulation
- Prototype development
- Drafting of requirements and technical specifications

- Measurement of robots and systems
- Optimization of existing systems

35.15 Controls and drives

Highly-efficient controls and drives at the limits of technical feasibility can make all the difference when it comes to successfully acquiring a project, maximizing profits or manufacturing in high-wage countries. In order to achieve success in the long-term, continuous improvements need to be made to machines and equipment as well as technology fundamentally renewed.

Our daily work involves facing the numerous challenges of automation technology to meet these goals. With the control and drive services we provide, we assist you in pursuing your key manufacturing targets in the area of automation technology. To overcome your challenges, we offer the following services:

- Identification and implementation of potentials for optimizing machines and equipment
- Design and realization of automation systems right up to acceptance tests at the customer’s
- Optimization of control architectures
- Highly-efficient software and hardware control concepts (FPGA)
- Cycle time optimization of NC-programs and production processes
- Intelligent linking of machines and equipment
- Highly-efficient connection of drive technology and sensors to controllers
- Expertise in OPC UA from the terminal to the cloud
- Design and standardization of communication protocols right through to certification
- Development of cutting-edge, platform-independent, user interfaces
- Optimization of components and subassemblies using FEM
- Realtime simulation coupled with any control system
- Seminars and further training in the field of automation technology

36. Fraunhofer Institute for Physical Measurement Techniques IPM

Website Link: http://www.ipm.fraunhofer.de/en.html

36.1 Institute Overview

English: The Fraunhofer Institute for Physical Measurement Techniques IPM develops tailor-made measuring techniques, systems and materials for industry. Many years of experience with optical technologies and functional materials form the basis for high-tech solutions in the fields of production control, materials characterization and testing, object and shape detection, gas and process technology as well as functional materials and systems.

Korean: 프라운호퍼 물리측정기술연구소(IPM)은 맞춤형 산업용 측정 기술, 시스템 및 소재를 개발하고 있습니다. 다년간의 광학기술 및 기능성 소재 관련 경험을 바탕으로 생산제어, 소재 특성분석, 시험, 물체 및 형태 감지, 가스 및 가공기술, 기능성 소재 및 시스템 등 다양한 분야에서 첨단 솔루션을 선보이고 있습니다.

36.2 Production Control

In the Department of Production Control under the direction of Dr Daniel Carl, activities center on the development of optical systems and imaging procedures for the analysis and modification of 3D structures. The systems measure fast and accurately so that small defects or impurities can be detected even at high production speeds. This makes 100 percent inspection possible in production. A wide variety of methods are employed, which include digital holography, infrared reflection and fluorescence techniques combined with very fast hardware-related image and data processing. Systems are designed with a view to their practical applications, such as optimizing processes for industrial production or authenticating products

36.3 Materials Characterization and Testing

Fraunhofer IPM develops measuring systems that work with terahertz and microwaves for practical application in the characterization and testing of materials. Under the direction of Dr. Georg Freymann, the scientists use expertise from optical systems and measuring technology, spectroscopy and the development of crystal and semiconductor components for this purpose.

Terahertz or microwave measurement technology provides an alternative to ultrasound measurements if mechanical contact is not possible or desirable, but also to X-ray measurements if ionizing radiation raises problems. These measurement systems can be used to characterize materials through packaging and allow concealed drugs or explosives to be detected.

In materials testing, defect can be identified in ceramics, plastics or composites (glass fibers, etc.) on a non-destructive basis. There is particular interest in measuring the thickness of layers, e. g. in coating processes or also in the production of pharmaceutical tablets.

36.4 Object and Shape Detection

In the Department of Object and Shape Detection under the direction of Dr Alexander Reiterer, activities center on the development of laser scanners, fast image processing and camera systems. The systems measure the geometry and position of objects three-dimensionally at high speed and with high precision, particularly from moving platforms. Particular attention is attached to the robustness and long service life of the systems as well as to efficient data evaluation. Objects and shapes are detected over a broad size range: extending from tenth of a millimeter to dimensions of 10 meters. The measurement systems are in use around the world – in rail traffic and in the surveying of road surfaces. Supplementing them are special applications in the fields of safety as well as transport and logistics.

36.5 Gas and Process Technology

The department of Gas and Process Technology, headed by Prof Jürgen, develops concepts for new optical and sensor-based measuring systems and transfers them to customer-specific processes and requirements. Its core expertise includes spectroscopy, semi-conductor gas sensor technology and modular measurement probes. The range of materials that can be analyzed includes gases, liquids and solids – so that nothing remains concealed. Whether on the microscopic scale with Raman spectroscopy or in parts from space with UV spectroscopy, a spectroscopic analysis makes it possible to see what otherwise remains invisible.

36.6 Functional Materials and Systems

The »Functional Materials and Systems« business unit, headed by Dr Heinrich Höfler, manufactures and optimizes materials with special physical properties, developing them into systems. The materials include:

- nonlinear optical materials, e.g. for the development of novel lasers with adjustable wavelengths
- thermoelectric materials for the direct conversion of waste heat into electricity
- magnetocaloric and electrocaloric materials for efficient refrigerant-free heat pumps and cooling systems

37. Fraunhofer Institute for Photonetic Microsystems IPMS

Website Link: http://www.ipms.fraunhofer.de/en.html

37.1 Institute Overview

English: The Fraunhofer Institute for Photonic Microsystems IPMS in Dresden is your access to know-how, expertise and modern R&D infrastructure in the field of optical sensors and actuators, integrated circuits, microsystems (MEMS/MOEMS) and nano-electronics.

Our 15,000 square foot clean room at Maria-Reiche-Straße 2 in Dresden is at your service for all your technology development requirements, as well as for pilot production. Commissioned and online beginning in September 2007, our MEMS and CMOS facility is rated at Class 4 per ISO 14644-1, or Class 10 per U.S. Standard 209E.

The business unit CNT at Königsbrücker Straße 178 in Dresden deals with the certification of processes and materials on 300 mm wafers. More than 40 tools and an own clean room (class 1000) are available for the integration of customer processes and sub-nanometer characterization.

Korean: 드레스덴(Dresden)에 소재한 프라운호퍼 광양자 마이크로시스템연구소(IPMS)는 광센서 및 액츄에이터, 집적회로, 마이크로시스템(MEMS/MOEMS), 나노전자 분야에서 전문성과 노하우, 연구개발 인프라를 보유하고 있습니다. Maria-Reiche-Straße 2 내 1 만 5 천제곱미터 규모의 클린룸에서는 고객의 기술 요구사항에 따라 연구 및 파일럿 생산을 진행하고 있습니다. 2007 년 9 월 도입한 MEMS 및 CMOS 시설은 ISO 14644-1 규격 4 등급으로, 미국 규격 209E 10 등급으로 분류되어 있습니다. Königsbrücker Straße 178 에 위치한 CNT 사업부는 300mm

웨이퍼 공정 및 자재 인증을 전담하고 있습니다. 40 여개의 툴 및 클린룸(클래스 1000)을 활용하여 고객 공정에의 적용과 나노미터 이하의 특성분석을 지원하고 있습니다.

37.2 Spatial Light Modulators

The spatial light modulators developed at Fraunhofer IPMS consist of arrays of micromirrors on semiconductor chips, whereby the number of mirrors varies depending on the application, from a few hundred to several millions. In most cases this requires a highly integrated application-specific electronic circuit (ASIC) as basis for the component architecture in order to enable an individual analog deflection of each micromirror. In addition, Fraunhofer IPMS develops electronics and software for mirror array control.

The individual mirrors that vary in number and size per chip can be tilted or vertically deflected depending on the application, so that a surface pattern is created, for example to project defined structures. High-resolution tilting mirror arrays with up to 2.2 million individual mirrors are used by our customers as highly dynamic programmable masks for optical micro-lithography in the ultraviolet spectral range. The mirror dimensions are 10 µm or larger. By tilting the micromirrors, structural information is transferred to a high-resolution photo resist at high frame rates. Further fields of application are mask inspection and measurement technology for the semiconductor industry, microscopy and prospectively laser printing, marking and material processing.

Piston micromirror arrays can for example be used for wavefront control in adaptive optical systems. These systems can correct wavefront disturbances in broad spectral ranges and thereby improve image quality. The component capabilities attract special interest in the fields of ophthalmology, astronomy and microscopy, as well as in spatial and temporal laser beam and pulse shaping.

37.3 MEMS Scanners

To date, more than 50 different resonant scanners have been designed and manufactured. They are made to deflect light either one-dimensionally or two-dimensionally or for high-speed optical path length modulation. Scan frequencies from 0.1 kHz to 50 kHz have been successfully executed. Applications range from reading barcode and data code, through 3D metrology, and right up to laser projection and spectroscopy. An example is a MEMS scanner with integrated diffraction grating for spectroscopic applications which HiperScan GmbH, a Fraunhofer IPMS spin-off, has been distributing since 2007 a novel infrared wavelength micro spectrometer. Furthermore, the Fraunhofer

IPMS is engaged in custom-designed scanning mirrors, e.g. for Fourier Transform spectrometers, confocal microscopy, highly miniaturized displays, ultra-compact laser projection systems, endoscopic image acquisition as well as triangulation.

In addition to resonant scanners, quasi-static micro-scanners are also under development. These activities are geared toward applications such as laser beam positioning and switching.

37.4 Wireless Microsystems

Research and development activities in the area of Wireless Microsystems deliver wireless and sensor-based solutions as well as technologies for the Internet of Things (IoT) and Industrie 4.0.

These include:

- Optical wireless communication (Li-Fi)
- Passive, battery-free and active wireless sensor nodes
- Indoor real-time location and navigation
- Industrial DataSpace

37.5 Environmental Sensing

In the field "Environmental Sensing" customized solutions which register ambient conditions are developed. Both chemical and physical active principles are used for detection and designed as sensor elements. The individual sensory elements are in turn assembled to complex systems which are used in application markets such as analytics, medical technology and industrial metrology. Here, miniaturized MEMS components are used which allow the design of small and low-power sensors.

Fraunhofer IPMS stands ready to provide the expertise and equipment necessary for microassembly and microsystems integration of small series. This includes implementing 2D and 3D structures using various joining methods such as the application of adhesives and other fluids or soldering and thermocompression bonding.

37.6 Smart Micro-Optics

he research group »Smart Micro-Optics« (SMO) is working on the design and implementation of new and »smarter« components as alternatives to traditional silicon or silicon oxide based micro-optical components. Specifically the work of the group is dedicated to R & D of electro-active materials and their use in tunable micro-optical components.

The basic idea: Active elements made of intelligent, electro-active organic materials make dynamic manipulation of the components' characteristic parameters possible. The utilization of these new materials in combination with the silicon technology available at Fraunhofer IPMS is what makes the fabrication and ongoing development of innovative components for specific applications successful. Here the focus lies in the present research approaches for electro-active materials geared especially toward applications in integrated photonics and micro-optics.

The Smart Micro-Optics research group has competencies in R&D of electro-active organic materials, in simulation and modeling of optics and waveguide devices and in characterization of materials and optical devices. The fabrication of the innovative ‘smart’ organic materials based optical devices is carried out in the Fraunhofer IPMS cleanroom.

37.7 Micromachined Ultrasonic Transducers

Ultrasonography is a well-established technology. Common areas of application include material characterization and testing as well as medical diagnostics. Currently, ultrasonic transducers are manufactured based mainly on a piezoelectric material or piezo composite. These transducers possess properties adequate for applications across spaces of open air (distance measurement) or in the field of high-frequency material testing. However, they fall short particularly with high-resolution imaging, invasive testing and material testing of liquids.

Ultrasonic transducers manufactured with micromachining technology (MUT) can overcome these drawbacks. MUTs are basically MEMS structures which consist of two electrodes. One of the electrodes is fixed, the other is movable. An insulating layer and a vacuum-sealed gap separate the electrodes. The movable electrode in piezoelectric ultrasonic transducers (PMUT) are stimulated by a piezoelectrical film, e.g. AIN. In capacitive micromachined ultrasonic transducers (CMUT), stimulation occurs through electrostatic deflection of the movable electrode.

Fraunhofer IPMS offers research as well as development and pilot production of micromachined components for innovative areas of application.

37.8 MEMS Sensors

Fraunhofer IPMS develops and realizes customer-specific product solutions in sensor technology based on years of process expertise in bulk and surface micromachining.

Recently, we developed diverse physical and chemical sensors. Piezoresistive pressure sensors are adaptable to the pressure range needed by the application during the design phase. They can also be used in high-temperature environments. Photodiode arrays are applied in positioning systems, ion-sensitive field-effect transistors measure the pH levels in liquids. For these sensors we offer not only customer and application specific developments but also pilot fabrication in our clean room for microsystems.

In addition to our product oriented developments and pilot fabrication of sensors, we support clients and partners with leading-edge technologies for the individual processing of your MEMS sensors using our manufacturing know-how. For example, our Deep Silicon Etch (DSE) /Bosch process is used in the back-end of a client-specific fabrication of an IR thermopile

37.9 Mesoscopic Actuators and Systems

Hardly any fast-growing technical industry can exist without components for microsystems technology in terms of sensors and actuators. In order to meet the growing demands on the performance of micromechanical components and expand the technical base for new applications, further miniaturization is essential. The miniaturization as part of a technical evolution further means, that novel principles for micro- and nanomechanical systems are required. For this purpose, the Fraunhofer project group »Mesoscopic Actuators and Systems« (MESYS) is developing a new class of electrostatic bending actuators (NED) and tests these actuators in MEMS-based microsystems on various fields of applications.

37.10 End-of-Line Standard Substrates

Over the last few years, organic electronics have become a keyword for new types of applications based on organic semiconductors and other materials that can easily be processed. Typical for this new class of materials are low temperature processes and large area deposition and structuring with various coating and printing processes. The active semiconductor materials determine the performance of the entire system considerably. That is why a simple and reliable electronic characterization of these semiconductors is not only an essential prerequisite for material development in the labs of organic chemists but also for process developers and circuit designers.

For material analysis in the field of organic semiconductors, the Fraunhofer IPMS provides standardized single transistor structures in bottom gate architecture. These substrates for organic field effect transistors (OFETs) are produced in the clean room on silicon wafers with thermal silicon dioxide (SiO2) as full-area dielectrics and gold electrodes in lift-off technology. This is a significant advantage with respect to reliability and reproducibility that enables the application of these substrates for quality assurance in major chemical corporations.

The spectrum of possible customers is very large and ranges from universities, independent research institutions to industrial customers. The OFET substrates that are manufactured are used for research purposes in the field of materials testing or for quality control, respectively. They are essential for organic materials development. To date, the customer base of Fraunhofer IPMS in this sector has grown to 100 customers worldwide, including 15 key customers and two market-listed companies, both national and international.

The Fraunhofer IPMS offers different standard solutions and realizes customer-specific modifications by tailoring the samples with respect to chip size, design, and layer thickness of the thermal oxide. In order to simplify the measurement procedures of OFET substrates, the Fraunhofer IPMS has also developed a hand prober. This OFET mini-prober allows faster and easier measurements by reliable pad contacting.

38. Fraunhofer Institute for Production Technology IPT

Website Link: http://www.ipt.fraunhofer.de/en.html

38.1 Institute Overview

English: The Fraunhofer IPT develops systems solutions for production. We focus on the topics of process technology, production machines, mechatronics, production quality and metrology as well as technology management.

Our clients and cooperation partners represent all fields of industry: from aerospace technology to the automotive industry and its suppliers as well as tool and die making companies and the precision mechanics, optics and machine tool industries in particular.

Korean: 프라운호퍼 생산기술연구소(IPT)는 생산 시스템 솔루션 개발기관으로 주요 연구분야는 공정기술, 생산기계, 메카트로닉스, 생산품질, 계측, 기술관리입니다. 항공우주, 자동차, 금형제작, 정밀기계, 광학, 공작기계 등 각종 산업부문을 지원하고 유관기관과 협력하고 있습니다.

38.2 Fine machining & optics

The department of "Fine machining and optics" develops technologies for the production and processing of high-precision components including glass lenses, replication tools and components for the semi-conductor industry. The basis of the technology development is a strong basis for understanding. Using concrete tasks, we transform this base in the industrial practice with the use of the latest machines and software solutions. The technology portfolio includes the ultra-precise grinding and polishing, diamond machining and precision molding.

38.3 Precision technology and plastic replication

The work areas of the "precision technology and plastic replication" department covers all development tasks in special purpose machines and plant development - starting from individual machine concept planning and the design and optimization of critical components, through to control-related implementation of complex regulation systems. We take your individual machine requirements into account and implement your ideas precisely and resource-efficiently.

Another field of activity undertaken by department is the development of ultra-precision assembly solutions for optical systems such as laser or camera applications. We realize assembly systems orientated towards requirements for passive and active precision adjustment and with robust joining and logistics concepts.

38.4 Production quality

The competitiveness of manufacturing companies fundamentally depends on faultless as well as efficient production processes. Consistent digitalization and cross-linking of production data and maximal resource efficiency play an important role in the era of "Industry 4.0" in a sense of a cross-linked, highly adaptive production. Here it is very important to know and apply appropriate methods, software tools and technologies. Practical experience and well-founded methods form the basis of qualified and comprehensive consulting concerning the organization and quality assurance of your productions.

39. Fraunhofer Information Center for Planning and Building IRB

Website Link: https://www.irb.fraunhofer.de/?local=en

39.1 Institute Overview

English: Fraunhofer IRB is Germany's central institution for the national and international dissemination of construction knowledge. It provides access to design, planning, construction and economic know-how, from research and practice, in the fields of building design, civil and structural engineering, architecture, historic monument conservation, urban and spatial planning, housing, construction law and economics.

Fraunhofer IRB develops and markets information products and services that are geared to the specific needs of its target groups, i.e. designers, planners and other construction professionals. Activities focus on in-house databases, technical construction literature and tailored services.

Fraunhofer IRB sets out to provide each user group from the wide range of relevant disciplines with access to quality-tested information resources, in line with their requirements. This single-source access relieves users of the need to familiarize themselves with a multitude of individual offerings. The availability of information is guaranteed at all times, from any location and at fair conditions. To this end, IRB enters strategic collaborations with other providers and links up the key knowledge sources.

Through the cataloguing and provision of construction knowledge, Fraunhofer IRB helps to improve the quality of design, planning and construction services, boosts the expertise of building professionals and contractors, and promotes their information literacy. It assists in preventing duplicated or wasted effort in research and practice, plays a pivotal role in encouraging innovation among Germany's SMEs and supports the international transfer of construction knowledge. In doing so, Fraunhofer IRB promotes a sector of industry that is of outstanding economic, social and cultural importance for Germany and Europe.

Korean:

39.2 Data and information management

To ensure dissemination of planning and building related knowledge in the appropriate quality, our staff comprises civil engineers, architects and other experts from the planning and building domain with additional qualifications in information and knowledge management. Subject specialists identify relevant content (books, journal articles etc.) for inclusion in our literature and full-text databases.

All publications selected for database indexing are represented in our specialist library, accessible for the public. Our copy service is available for those who cannot visit the library: legal copies of journal articles can be dispatched on order.

39.3 Marketing | Public Relations | Distribution

The marketing team contributes to promotion,use and positive perception of the Fraunhofer IRB information products and services by the various target groups. Manifold communication channels and marketing actions are utilized for customer acquisition and support.

The distribution team constantly optimizes its existing and develops new channels of distribution, thus ensuring that customers have available a broad range of traditional as well as new product forms. All orders placed online are processed the same day.

39.4 Media Content Planning and Building

It is one of Fraunhofer IRB's tasks to analyse, identify and close gaps in the topical range of information supply for the planning and building sector by means of up-to-date books, journals and digital media.

Our book editors, all qualified architects and civil engineers, are responsible for content development, acquisition and support of authors. Our journal editors are especially in touch with the current information demands of target groups. Thus, a unique range of specialist information is offered, tailored to professional needs.

39.5 Media Production

Publications in the pipeline have to be set and formatted for their production medium. Our media experts provide all prepress work from layout and typesetting to technical finish of production data, including supervision and coordination of external service providers. An inhouse print shop offers quick and reliable production of smaller print runs.

According to requirements, publications are prepared in form of books and journal articles, as database content or e-books.

consulting concerning the organization and quality assurance of your productions.

40. Fraunhofer Institute for Silicate Research ISC

Website Link : http://www.isc.fraunhofer.de/inside-and-on-top-material-solutions-by-isc/?L=1

40.1 Institute Overview

English: The Fraunhofer Institute for Silicate Research ISC conducts materials research with a view to developing innovative non-metallic materials. The main focus of this work lies on developing materials that will enable tomorrow's new products to meet the most pressing challenges of our future in the realms of energy, environment, and human health.

These novel materials open up a whole new world of products for manufacturers and end users alike. One of the aspects to which Fraunhofer ISC gives central importance in its R&D activities is that of making more efficient use of energy and other resources. This approach involves continuous improvements to manufacturing processes and the development of new, multifunctional materials. We also make use of nanotechnology to create materials with enhanced properties and functions.

Korean: 프라운호퍼 규산염연구소(ISC)는 혁신적인 비금속 소재 개발을 목표로 소재연구를 수행하고 있습니다. 특히 신소재 개발을 통해 미래의 제품이 앞으로 다가올 에너지, 환경, 보건 과제에 대처할 수 있도록 지원하고 있습니다. 신소재 개발은 제조사와 최종사용자 모두에게 새로운 제품의 세상을 열어줍니다. ISC 연구소는 제조 공정의 지속적인 개선, 새로운 다기능 소재 개발 등 에너지 및 기타 자원의 효율적인 사용을 위주로 연구개발활동을 진행하고 있습니다. 또한 나노기술을 활용하여 소재의 속성 및 기능을 향상시키고 있습니다.

40.2 Bio-active systems

Fraunhofer Attract »3DNanoCell« is headed by Prof. Dr. rer. nat. Doris Heinrich and specialized in the development of cell-based 3D assays and 3D scaffolds for tissue engineering. Research is focussed on the analysis of interactions between novel (nano)structured scaffold materials and biological systems. High resolution live cell fluorescence microscopy is combined with state-of-the-art cell function stimulation techniques.DR - High Dynamic Range

Development of 3D-Scaffolds and Nano Carriers

R&D goal is to adapt innovative materials for bioactive surfaces and 3D scaffolds. To this effect, laser controlled production methods for 3D scaffolds are adapted for use in tissue engineering and regenerative medicine. Also, nanoparticles synthesized for target applications are modified to serve as drug carriers or optimized to direct and control cell functions.

The Vision of "Remote-Controlled Cells"

To modify scaffolds for cell-type specific use, »3DNanoCell« is investigating the cytoskeleton regulation to control and direct cell functions.

The understanding of living cells and their interaction with materials, surfaces and generally any physical or chemical impact from the cell environment will promote novel developments and solutions in medicine, e.g. accelerated tissue regeneration.

Regenerative Medicine and Tissue Engineering

In regenerative medicine, the capability for self-healing of the human body is controlled to optimize the accelerated integration of high-tech scaffold materials with cell tissue in the biological surrounding. In tissue engineering, 3D scaffolds foster the in vitro growth of tissue.

Both areas of modern medicine benefit from custom-designed 3D scaffolds in combination with nanoscale surface structuring and biochemical functionalization to achieve optimal colonization by living cells. 3D scaffolds help to ensure that cells are sufficiently cross-linked in space and supplied with nutrients in all scaffold areas.

40.3 Particle Technology

Small particles are essential building-blocks for many advanced materials that are relevant in almost all fields of today’s technologies. Small particles may be tailored to comprise multifunctional properties such as magnetism, electrical and thermal conductivity, luminescence, catalytic activity, flame retardancy etc. at one spot. When added to advanced materials, small particles may drastically enhance properties and ultimately, better and new products can be obtained.

The Particle Technology Group at the Fraunhofer ISC focuses on the customized synthesis and modification of small particles by wet-chemical approaches. Moreover, we offer upscaling of particle systems, processing and composite formulation.

(In-situ) analysis with high-end equipment and profound materials know-how complete our portfolio. Special focus of our research is on magnetic and silica particles, titanium, zirconium, zinc and perovskite oxides as well as on hollow and layered particles.

40.4 Theranostics

Future developments in medical diagnostics are linked with the increasing knowledge in molecular processes of dispositions of disease and disease development. Simultaneously, each improved diagnosis related to the individual results in a more individualized therapy.

The main emphasis of the competence field Theranostics is on products enabling highly efficient and personalized therapy accompanying in vitro and in vivo diagnosis or even combine diagnosis and therapy in situ. Smart materials diagnosing, supervising and treating physiologic processes and defects are therefore essential.

In line with current trends and requirements in the field of health, the focus is on companion and molecular diagnostics as well as multimodal imaging.

40.5 Dental glass ceramics

Glass ceramics have a proven reputation as materials for dental prostheses. Their crystalline components allow the translucency (partial light transmission) and mechanical properties (e.g. hardness and polishability) of the material to be adapted by varying the size of the crystals and the phase boundaries. Their resistance to chemical attack is also superior to that of plain glass – an aspect of prime importance to oral health.

Another property of these materials is of particular interest to CAD/CAM applications: At an intermediate stage in the crystallization process, they can be mechanically processed quickly and easily before being transformed into a highly stable glass ceramic in a final, short tempering stage.

The CAD/CAM process takes place directly in the dentist's surgery or dental laboratory on the basis of the individual patient's needs. Between 2009 and 2012, in a joint project with industrial partners, Fraunhofer ISC developed a novel glass ceramic material and a specially adapted system for fabricating dental blanks from it. The patented new glass ceramic features outstanding translucency, excellent chemical resistance, and remarkable strength.

A prototype system for fabricating dental blanks from this material has been designed, constructed and tested at Fraunhofer ISC. All development work on the material and the construction of the fabrication system took place in the institute's certified glass laboratories, which comply with the applicable directives for medical products and the required quality management standards. The material, which goes by the product names Suprinity® and Celtra®, was presented at the IDS International Dental Show in Cologne in March. Its market launch is planned for September 2013.

40.6 Dental hybrid materials

For applications in the field of dentistry, we develop bioactive functional materials for dental preservation (restoration, prophylaxis, regeneration) and dental prostheses, and for use in bone cement and in microsurgery. We accompany our partners and customers throughout all stages of these projects, from the conception and development phases up to the final marketable product.

These products include application-specific multifunctional precursors, together with monomer-free resin systems, nano-hybrid and other composites, glass ionomer cements, and customized self-etch and total-etch adhesives that provide an excellent basis for direct and indirect restoration (fillings, crowns, etc.), for which we also develop the relevant manufacturing processes.

Our work in this domain also includes chemical and physical characterization on a general level and for specific applications. Our competence teams have access to a wide variety of surface structuring techniques and synthesis methods for dental fillings, including their incorporation.

40.7 Ormocers

For over 25 years, a major focus of Fraunhofer ISC's research and development activities has been on ORMOCER®s, a material class of inorganic-organic hybrid polymers based on chemical nanotechnology. The know-how of the synthesis, functionalization and processing of ORMOCER®s has constantly advanced ever since, and they have been adapted for different kinds of applications. ORMOCER®s offer a vast variety of properties which are determined on a molecular level. The choice ofmonomeric or polymericprecursor compounds, as well as the variation of the processing parameters allow to create materials with multifunctional properties. So, there is no end to the application potential of these versatile hybrid polymer materials. Numerous products have been developed in cooperation with our project partners which are on the market today.

Typical areas of application:

- Bulk materials for mechanical, biomedical, dental, electrochemical or optical applications
- Protective coatings for polymers, glasses, ceramics, paper, metals, etc.
- Functional coatings: anti-reflective, hydrophobic/hydrophilic, anti-static, ultra barrier, decorative
- Patternable materials in (nano) biotechnology, (micro) electronics

- Adhesives, adhesion promoters
- membranes, (hollow) fibers, films
- nanoparticles, core-shell particles

41. Fraunhofer Institute for Solar Energy System ISE

Website Link: https://www.ise.fraunhofer.de/en?set_language=en

41.1 Institute Overview

English: Fraunhofer ISE conducts application-oriented research and development fo rkey technologies of the future. To this purpose, the institute addresses a wide range of subjects and pursues a holistic, systemic approach. This maximizes sysnergy between the five business areas:

Photovoltaics

- Silicon Photovoltaics
- III-V and Concentrator Photovoltaics
- Emerging Photovoltaic Technologies
- Photovoltaic Modules and Power Plants

Solar Thermal technology

- Material Research and Optics
- Thermal Collectors and Components
- Thermal Systems Engineering
- Thermal Storage for Power Plants and Industry
- Water Treatment

Building Energy Technology

- Building Envelope
- Heating and Cooling Technologies
- Energy Concepts and Building Performance Optimization
- Thermal Storage for Buildings
- Materials and Components for Heat Transformation

Hydrogen Technology

- Thermochemical Processes
- Hydrogen Production by Water Electrolysis
- Fuel Cell Systems

Energy System Technolgy

- Power Electronics
- Smart Grid Technologies
- System Integration - Electricity, Heat, Gas
- Battery Systems for Stationary and Mobile Applications
- Energy System Analysis

Korean: 프라운호퍼 태양에너지시스템연구소(ISE)는 미래형 기술에 대한 응용연구개발을 수행하고 있습니다. 다양한 분야를 아우르는 포괄적이며 체계적인 접근법을 통해 다음 5 개 사업분야 간 시너지를 최대화하고 있습니다

태양광

- 실리콘 태양광
- III-V 및 집광형 태양광
- 신규 태양광 기술
- 태양광 모듈 및 발전

태양열 기술

- 소재연구 및 광학
- 열 집열기 및 부품
- 태양열 시스템 공학
- 발전소용 및 산업용 축열
- 수처리

건물 에너지 기술

- 건물 외피
- 냉난방 기술
- 에너지 컨셉 및 빌딩 성능 최적화
- 건물용 축열

- 열 전이 관련 소재 및 부품

수소 기술

- 열화학 공정
- 수전해를 통한 수소생산
- 연료전지 시스템

에너지 시스템 기술

- 전력전자
- 스마트 그리드 기술
- 시스템 통합 - 전기, 난방, 가스
- 고정형·이동형 응용기술용 배터리 시스템
- 에너지 시스템 분석

41.2 Modeling of Aluminum Alloying Processes for Silicon Solar Cells

The silicon solar cells currently dominating the PV market feature a metal contact made of alloyed aluminum on the backside. To further reduce the recombination losses of such backside contacts and thus to increase the cell efficiency, a better understanding of the formation and effect of these contact structures is important. The model for description of the Al alloying process developed at Fraunhofer ISE now allows the prediction of the electric quality of such contacts taking into account different influencing factors during their production. When transferring the model into the cell production, the process parameters then can be respectively adjusted for Al alloys to achieve best-possible contact formation.

41.3 Neural Networks for the Use in Solar Thermal Systems

The control is an important system component of solar thermal systems. Programming of the control algorithms incurs significant component costs. Here, the use of the neural network methodology could result in significant cost advantages. At the same time, this also offers new possibilities for control optimization with respect to energy consumption optimization. The main objective of the “ANNsolar” project is the development and demonstration of the monetary and technical advantages of the neural network methodology. The option to generate self-learning algorithms enables the realization of complex control strategies for increased energy efficiency in a significantly simpler manner.

41.4 New Electrode Materials for Higher Efficiency for Organic Solar Cells

The objective of the “ArtESun” project is to increase the efficiency of organic solar cells with new semiconductor materials and electrode layers. Furthermore, prototype modules are produced using industry-relevant processes. This is done to demonstrate the unique design possibilities of organic solar cells based on printing processes. The focus is on three different applications that require specific prototype layouts. In the first application, the organic solar cell (OPV) is used as energy supply for an active RFID element. In the second application, the OPV is used as energy supply as well as antenna for an energy self-sufficient, networked sensor node. The third application is an OPV module for a large-area prototype facade.

41.5 Catalytic Hydrogen Vaporization Process

For many chemical processes, the prerequisite for stable and efficient operation is good mixture preparation. For oxidation processes, e.g. combustion in particular, the homogenous mixing of the reactants reduces emissions and limits soot accumulation. Our patented catalytic process converts liquid fuels into fuel vapor. The mixing advantages were demonstrated for diverse applications in numerous different projects (burner, particulate filter, reformer). We focus on coupling the evaporator with the engine, adjusting the fuel evaporator to match the in-engine performance. On our engine test bench, we can verify the anticipated reductions in NOx and soot emissions.

41.6 Simulation, Development and Setup of a High-efficiency DC/DC Converter Concept for Small Battery Units

Electric storage units, which can compensate differences between generation and consumption, are very important for the expansion of renewable energy usage. Storage solutions are also needed in off-grid electricity systems and to operate electric vehicles. As battery cells have a low cell voltage, the voltage must be adapted for the intended application. In battery packs, higher voltages are achieved by hard-wired series connection of the single cells. Here, the weakest cell limits the performance of all cells and one defective cell renders the whole battery pack unusable. A modular concept combined with intelligent power electronics can minimize these disadvantages. This leads to very reliable systems with low maintenance costs.

41.7 Development of a High-efficient PV Module Concept Based upon Multi Busbar Technology

Flat wire connectors are currently soldered on the busbars of the cell for wiring of crystalline solar cells. An alternative is wiring with thin round wires. This enables a more homogeneous power distribution on the cell, a lower silver consumption for front side metallization, and a higher module power due to improved light reflection. Beyond that, the many thin wires on the cell provide a homogeneous, aesthetically appealing appearance. Our measurements show that solar modules with this wiring technology show very good reliability under accelerated aging. They have potentially higher degrees of efficiency than standard modules.

41.8 Customized BIPV Shingles for Façades or Roofs

Customer-specifically produced PV modules for building integration (BIPV) are developed and tested in pilot applications of the "Construct-PV" EU project. The project focuses on BIPV applications in the opaque area of the building envelope. The development priorities are high yield, appealing aesthetics, and low costs. Here, not only the production costs of the modules, but also the planning, installation, and operation costs are considered. Particular attention is paid to the amortization of the additional investment costs [€/m2] that ar,e incurred due to the integration of the "solar power generation" function into the building envelope. In the project, several patents were filed for new developments. One of these developments is presented in this article.

41.9 Cooling of Molds Using Bionic Methods

Among others, Grunewald produces molds for the automotive industry. The objective of this feasibility study was the optimization of mold cooling, e.g., for the production of molded carpets. Current cooling concepts are based on stainless steel tubes that are cast in aluminum molds in a meander pattern. Due to insufficient cooling, hot spots often occur during the cooling process, which determine the cycle time, as the demolding process can only take place at a certain temperature. The objective of the project was more efficient cooling. This should be achieved with fitted FracTherm® structures of Fraunhofer ISE. The result is shorter cycle times and thus, energy savings.

41.10 CPV-Match

The standardization of measuring methods for the determination of the nominal power of modules is a current and important topic in the field of concentrator photovoltaics

(CPV). It will allow the comparison of the nominal power of CPV modules of different manufacturers. It is ensured at the same time that the application of the defined methods leads to reproducible results, regardless of the executing measuring laboratory. Decisive progress was achieved in a close collaboration between NREL (USA) and Fraunhofer ISE. An internationally acknowledged procedure for the determination of the nominal power of CPV modules was established. This procedure was frequently tested and verified at Fraunhofer ISE on CPV modules of different manufacturers and technologies.

41.11 Development of an Industrial Recycling Process for PV Modules

The Electrical and Electronic Equipment Act (ElektroG) was finally discussed in the German Federal Council (Bundesrat) on July 10, 2015. With that, the specifications of the European WEEE Directive (Waste Electrical and Electronic Equipment) were respectively implemented. Solar modules are classified as electronics scrap and must be recycled. By recycling the aluminum frames (10-15 % of the weight) and of the cover glass (70-75% of the weight) the legally prescribe quota is reached, however, this is not a satisfactory solution with respect to sustainability and resource saving. The separated remaining portion of silicon, silver contacts, tin, and heavy metal containing solder (lead) is usually burned together with the plastic foil.

41.12 Planning and Optimization of Energy Efficient Buildings Using Building Information Models (BIM)

In the collaborative EnEff-BIM project, information technology methods for planning, design, and operation of energy-efficient new and existing constructions are developed, tested, and made available to expert planners. Modelling, simulation, and operating optimization is based on open digital building information models (BIM). Based on a digital 3D planning model, a continuous data exchange should be achieved. The objective of the project is the development of an open interface for the automatic generation of Modelica sub-models based on BIM data. The Modelica interface to be developed also offers a basis for life cycle cost analyses, energy performance verification, and sustainability certification of buildings.

41.13 Database for Monitoring Data for Innovative Operating Strategies of Buildings

In the Energy-Optimized Construction (EnOB) research focus, innovative concepts, technologies, materials, and operation strategies are tested under real operating conditions in numerous demonstration objects. All demonstration buildings in the “EnOB” program are subject to detailed monitoring to investigate innovative concepts and technologies regarding their effectiveness and practicality. This measurement data represents a valuable pool of information, which is of interest to many stakeholders in the research and development, as well as to planners and executing parties. The measurement data of selected buildings is stored in a specially developed database at and by Fraunhofer ISE. Based on this data, cross-analyses are performed regarding the energetic performance of individual technologies and concepts.

41.14 Intelligent Usage of Electric Vehicles in the Overall Energy Concept of an Energy Plus House Group in Fellbach

The smart home of the future is networked, energy-efficient, and active in the power grid. The energy control unit estimates the electricity generated by its own PV system and the household consumption for the next few hours. It develops strategies e. g. to raise the share of internal electricity consumption, avoids generation and load peaks, and operates actively in the electricity market. To achieve this, certain loads or storage units are operated flexibly, coordinated by the central energy control unit. Electric vehicles, which do not always have to be fully charged immediately and heat pump systems are particularly well suited for this task. In the “Fellbach ZEROplus” project, this type of home energy-management system is being developed and practically tested by residents in energy-plus houses.

41.15 Sustainable Carbon Support Materials for Current and Future Catalytic Hydrogenation

To ensure a sustainable provision of fuels and chemical products, catalysis using hydrogen derived from renewable energies (e.g., solar and wind energy electrolysis) will be of decisive importance in the conversion of CO2 and biomass (e.g., from waste) into liquid energy carriers, platform chemicals, and materials. Against this background, the “Flex-C Cat” project concerns the optimization of the characteristics of biomass-derived carbon materials as solid support materials for catalytic hydrogenation. Using a scalable low-temperature HTC approach (HTC = hydrothermal carbonization) for the conversion of biomass, the synthesis of different porous carbons is possible. This provides scope for optimization of catalyst support properties for a specific catalytic application (e.g., hydrogenation of phenol to cyclohexanone in the aqueous phase).

41.16 Diffractive Back Structures for Highly Efficient Crystalline Silicon Solar Cells

Crystalline silicon solar cells absorb light in the near-infrared range between 900 and 1200 nm only very poorly. Diffractive structures on the backside of the solar cell can minimize the absorption losses respectively caused. We simulate and optimize these structures and integrate them into highly efficient silicon solar cells. An increase in quantum efficiency in the near-infrared range could now be shown experimentally for the first time using two different diffractive back side gratings – hexagonal spherical gratings and binary cross grating prepared using nanoimprint lithography. In particular, for solar cells with planar front side, a significant current gain of more than 1 mA/cm2 could be demonstrated. This leads to an overall efficiency of up to 22.1 % for solar cells with planar front side.

41.17 Determination of Reflection and Absorption of Solar Cells with Surfaces Textured on Both Sides

Texturing of silicon solar cells is a proven method for achieving high efficiencies. On the one hand, textures reduce front side reflection; on the other hand, they extend the light paths in the silicon. The “OPTOS” simulation formalism was developed at Fraunhofer ISE in order to determine ideal textures or ideal texture combinations on the front and rear side. “OPTOS” is a matrix-based method, which allows for the efficient calculation of reflectance and absorptance of solar cells with arbitrary surface textures on both sides. Textures from different optical regimes can be combined. It was demonstrated using “OPTOS” that the integration of a rear side diffraction grating enables an increase in photocurrent density of a 200-µm thick silicon solar cell with pyramidal front side by 0.6 mA/cm2.

41.18 Highly Efficient Concentrator Module With GaSb-Based Four-Junction Solar Cell

In high-concentrating photovoltaics (HCPV), the sunlight is focused with a factor of 300 to 1000 using optics onto a small solar cell with an area of a few square millimeters. As the cell area is very small, multi-junction solar cells can be used. These use the sunlight very efficiently across the entire spectrum. In the concentrator system, all components, such as solar cell, optics, electrical wiring, thermal design, and production technologies, must be adjusted carefully. In the “HeKmod4” project we use our long-term experiences in this range of topics to develop a concentrator module with a target efficiency of up to

39 %. The basis is a novel four-junction solar cell with Gallium antimonide (GaSb) lower cell. New characterization methods are developed for component and system assessment.

41.19 Highly Efficient and Integrated UPS Inverter with SiC Transistors

A highly compact inverter has been developed at Fraunhofer ISE for an uninterrupted power supply (UPS) with an efficiency of up to 98.7 %. Using silicon carbide (SiC) transistors, a design with a power of 10 kW and a volume of only 5 l was realized. The degree of efficiency is particularly important for the application in so-called online UPS systems, as they do not only compensate short-term voltage dips in the grid, but also supply the consumer permanently via the UPS. The research and development results can also be applied to other areas of power-electronics energy conversion, where weight and efficiency play a key role.

41.20 Liquid Energy Storage, Chemicals, and Fuels from CO2 and H2

The Power-to-Liquid (PtL) technology - the conversion of CO2 with sustainable H2 (e.g., generated through water electrolysis) to liquid compounds, such as methanol - offers numerous advantages: seasonal energy storage, a chemical buffer for provision of fluctuating renewable energies, reduction of CO2 emissions, generation of alternating fuels with improved combustion properties and valuable platform chemicals, importantly based on a sustainable and reliable energy/feedstock supply (e.g. from industry). Against this background, the pilot project of the “Sustainability Center Freiburg” investigates this process under the title “HyCO2” and concerns a joint research and development project between the Fraunhofer ISE, Fraunhofer IWM, and the Institute of Inorganic & Analytical Chemistry at the University of Freiburg.

41.21 Solar Hydrogen Generation using a HyCon System

Using electricity generated from renewable resources, hydrogen can be generated CO2-neutrally using electrolytic water splitting. In conventional solar hydrogen generation systems, PV modules are coupled using direct current matching to a central electrolysis unit. The disadvantages of this approach are the complex system setup and the high investment costs. Due to the high costs, this technology has not been established so far. The objective of this joint project is a simplification of the system using an integrated approach. Highly efficient III-V multi-junction solar cell are directly connected to an electrolysis cells in a concentrator module. This way, conversion efficiencies from sunlight into hydrogen > 20 % can be achieved.

41.22 Characterization and Modeling of a Catalyst Coated Membrane (CCM)

The membrane electrode assembly is the core of a fuel cell. It consists of a polymer electrolyte membrane coated with catalyst layers on both sides (CCM, i.e., catalyst coated membraned) and the gas diffusion layers (GDL) which can be additionally coated with a micro-porous layer (MPL). In this self-funded research project of Fraunhofer ISE, production technology and fuel cell technology competencies were merged and a reproducible CCM production method developed at the institute. The objective is to offer development and characterization services to component manufacturers, e.g. catalyst developers, and to support mechanical and system engineering in the development of production processes.

41.23 Spatially-Resolved Characterization of Automotive Fuel Cells

Automotive fuel cells have comparatively large cell areas and are operated at high current densities of up to 3 A/cm2. This results in large inhomogeneity over the active area, caused by the depletion of reaction gases and the increase in temperature and humidity due to the electrochemical reaction. In order to characterize these local effects, we utilize our worldwide unique multi-channel impedance test stand and segmented fuel cells. We further investigate these local effects by monitoring the behavior of single cells in an automotive fuel cell short stack by means of electrochemical impedance spectroscopy. These local effects are examined under various operation conditions in our climatic chamber.

41.24 Identification of Limiting Contaminations in Silicon with Photoluminescence Imaging

Already small contaminations in the silicon can significantly reduce the carrier lifetime and thus the solar cell performance. However, it is particularly difficult for material and solar cell manufacturers to identify the contamination responsible for a reduced material quality: The contamination concentration is usually too low for a detection in chemical analysis processes; Service life-based methods are currently limited to certain contaminations (such as iron, chromium, or boron oxygen defects). The newly developed method for measuring and analyzing temperature- and injection-dependent carrier lifetime enable the spatially resolved identification of contaminations reducing the solar cell performance.

41.25 Development of Nano-porous Silicon Layers in an Inline Process

Epitaxially grown and detached thin silicon layers for photovoltaics have cost savings potential of more than 50 % and are thus of high interest. In addition to silicon absorber deposition, the nucleation and removal layer consisting of porous silicon is the most important new process. Until now, this process based on electro-chemical etching in hydrofluoric acid / ethanol was only performed on single wafers. No systems are available today for a throughput of several thousand wafers per hour, which hinders the industrial introduction of epitaxial wafers dramatically. For this reason, the objective of the “iPorSi” project is to establish porosification processes for this Si detachment concept on a prototype inline system.

41.26 Quality Assurance (LowEx-QS)

The project addresses the analysis, evaluation, and optimization of hydraulic systems used in LowEx heating and cooling systems in buildings. The goal of the project is to establish characteristics and target values for the design and energetic evaluation of hydraulic systems for cooling and heating distribution systems in non-residential buildings, paying particular attention to LowEx system requirements. The analyses are used to develop suitable, simplified methods for the energetic evaluation within the scope of ENEV and DIN V 18599.

41.27 Meso-PIN

The extension of renewable energies is a central pillar of the energy transformation. For this, Photovoltaics can be of decisive importance. Thus, materials and concepts have to be developed that enable resource-saving in photovoltaics. Since a few years only, researchers have been producing solar cells from Perovskite crystals. The “MesoPin” research project coordinated by Fraunhofer ISE is planning to advance the concept of the Perovskite solar cell further. Besides other solar cell technologies, it could be another energy source for mobile and stationary applications. Different production processes are investigated by the research partners. In the first project year, solar degrees of efficiency of up to 16 % were achieved using laboratory cells.

41.28 Contamination Studies and Component Screening with the 30-Cell Tester

Fuel cells are operated with ambient air and are exposed to air pollutants, such as fine dust, nitrogen oxides, sulfur dioxides, carbon monoxides, etc. The project investigates the severity of response of PEM fuel cells to air pollutants. For this purpose, a fuel cell test stand for simultaneous operation of 30 single cells was developed. Two of these test stands are installed in the field at two locations with different levels of pollution and are operated for one year. Based on the comparison of the operating behavior of the single cells in the test stands, conclusion can be made regarding the contamination effects. The effects of air pollution under different operating conditions and with different fuel cell components should be investigated.

41.29 Sorption Materials and Coatings for Adsorption Processes

Adsorption processes on porous materials currently form the core element in numerous technical processes. These include gas storage and separation, heterogeneous catalysis and particularly thermally driven heat pumps and chillers. Our research is focused on the application of a new class of materials of metal organic frameworks (MOF) to these heat conversion processes for resource-efficient generation of heating and cooling energy. We have succeeded in synthesizing various water-stable MOF compounds and developing two complementary coating processes, using which MOFs can be applied to heat exchanger structures. Our work has already reached a pre-industrial level.

41.30 Solar Battery System Service Provider for the Power Grid

Batteries are increasingly installed at buildings with photovoltaic systems in order to match the volatile solar power generation with the respective load profiles. However, solar batteries with pure local operating specifications do not fully exploit their potential. Free battery capacities are often available that could be used for service provision to the power grid on a demand basis. In this regard, the provision of primary control power in combination with a local increase in the degree of self-sufficiency is of particular interest. The basic idea is to reserve a portion of the technically available storage capacity for different grid services, while the other portion is used for optimizing local energy flows.

41.31 Novel E-Mobility Grid Model (NEMO)

Just how existing power grids can be made fit for the future was the topic of the “NEMO” project in Germany, Denmark, and the Netherlands. Over a period of three years, the project partners from research and industry took well-proven techno-economic modeling and optimization tools and implemented them into the new “NEMO” tool suite. This forward-looking tool prepares the distribution grid for interaction scenarios between decentralized suppliers and consumers. After the test phases were completed successfully in all three countries, a workshop was held to present the capabilities and advantages of this new tool to distribution and transmission grid operators as well as associations, grid service providers and system operators.

41.32 Novel – Characterization of High-pressure Stacks

Using renewable electricity, "green" hydrogen is generated in a Proton Exchange Membrane (PEM) electrolyzer by means of water electrolysis. Hydrogen can be used as storable secondary energy carrier in many applications. The objective of the “NOVEL” project is the development of novel, efficient, and cost-optimized cell components for the electrolysis cell stack and for testing suitable test procedures for the investigation of durability and the derivation of accelerated aging tests. In the case of successful project completion, a prototype stack should produce hydrogen with an efficiency > 85 % (HHV) and a degradation rate < 15 µV/h. Specific stack costs < 2000 € / (Nm^3 h-1 H2) should be achieved.

41.33 Optimization and Operational Management of Complex Building Energy Supply Systems

In the collaborative “OBSERVE” project, the methods developed in the “ModBen” and “ModQS” for monitoring and optimization of the energetic operation of heating systems will be extended and applied to other facilities systems. “ModBen” and “ModQS” indicated paths for a paradigm shift in the design of facilities systems towards model-based methods. Complex facilities systems are often unique. They are custom planned, realized, and are operated differently. For this reason, the corresponding models differ from case to case. To enable the practical use of model-based methods, a high degree of systematization and high tool robustness are required to support building operators and facility managers efficiently and reliably in the operational management of buildings.

41.34 Optimization of Module Testing Procedures Based on Statistical Evaluation

Module manufacturers worldwide produce under enormous cost pressure. Module types with the same type designation are produced at different production locations and the BOM (Bill of Materials) and suppliers change frequently. This development presents new quality assurance challenges to investors and manufacturers. Cost- and time-efficient test methods that reduce the risk of faults and reduced power are required. The main objectives of this project are the improvement of the significance of module tests, the definition of quality criteria through description of the current state-of-the-art of technology, and the development of time- and cost-effective test procedures. For this purpose, test experiences are evaluated systematically and used for statistical analyses.

41.35 Optowind – Optically powered sensor networks for wind energy

In the “Optowind” project, an optically powered sensor system is developed for condition monitoring and assessment of the rotor blades of wind turbines. The copper wires used in conventional systems of this kind are very susceptible to lightning and the sensor design is also limited. For these reasons, an optically powered sensor system was developed that offers inherent galvanic isolation and thus, interference and lightning protection. Furthermore, the sensor unit can be installed in the tip of the rotor blade. The energy for optical power supply is routed in the form of monochromatic light from the base station in the hub via a fiber-optic light guide to the sensor unit. There, it is converted highly efficiently into electrical power (Fig. 1) using a photovoltaic converter developed at Fraunhofer ISE.

41.36 PV Diesel

Many villages, cities, islands and industrial operations worldwide in regions without grid connection are supplied with electricity from diesel generators. This established market for diesel generators must be replaced in relevant parts with sustainable energy supply systems, in particular with photovoltaics, and/or expanded in terms of the worldwide electrification programs. Within the scope of the joint “PV Diesel” research project, the interaction of photovoltaics and diesel generators should be researched and still open scientific, technical questions clarified. The key objective is to establish suitable system solutions and to cover the overall system diversity with suitable, standardized components, as well as significant cost reductions and improved reliability.

41.37 Development of an Inline-applicable Quality Assessment for Multi-Crystalline Silicon Wafers for Solar Cell Production

The quality assessment of multi-crystalline (mc-Si) and high-performance multi-crystalline (HPM) wafers in the incoming tests of industrial solar cell productions requires a reproducible description of the relevant material defects and classification schemes that can also assess materials of unknown manufacturers. For this purpose, an image processing software was developed at Fraunhofer ISE, which allows the detection of different crystallization-related defects in photoluminescence (PL) images and their quantitative classification. Here, the relevancy of the individual image properties is determined via their importance for the prediction of the voltage (Voc) of the finished solar cell (Al-BSF and PERC). The created classification scheme was successfully applied to 7500 wafers that cover almost the complete spectrum of commercially available materials.

41.38 Pilot Building-Integrated Installation of MWT-TPEdge Modules at Fraunhofer ISE

In the last years, Fraunhofer ISE developed and patented a series of innovative PV technologies at the cell and module level on a laboratory scale. The developments promise a significant increase of the degrees of efficiency and lowered production costs. The objective of the “RDemo” project was the demonstration of these technologies using an industry-oriented production process with substantial quantities and relevant formats for a building-integrated application. 70 edge-sealed modules of the TPedge technology were integrated in the facade of a new laboratory building of Fraunhofer ISE. The modules are based on HIP-MWT solar cells (high performance metal wrap through) and structured cell connectors for back contact cells. Comprehensive tests based on IEC 61215 confirm the reliability of the modules.

41.39 Evaluation of Low-Concentrating Photovoltaic Receivers and Systems

In low-concentrating photovoltaic (LCPV) systems the sunlight is focused 2 to 30 times with an optics onto adapted silicon solar cells. The individual solar cells are wired and enclosed in a receiver so that high electrical efficiency, good thermal conductivity and sufficient protection against environmental influences is given. Mirror or lens optics are used as concentrating optics. They are tracked towards the sun with one or two axis. In every system design the components must be carefully aligned to one another. We developed and investigated a prototype system that uses mirrors in a Fresnel layout as optical concentrator as well as in-house produced Si solar cells. We assess LPCV system concepts not only technically, but also economically.

41.40 Toolboxes for Systemic Retrofitting

The German government plans to achieve a nearly climate-neutral building stock by 2050. Key elements to reach this goal are to reduce the energy consumption of buildings significantly and to develop solutions for using renewable energy to meet heating loads. An interesting approach aims to combine thermal facade insulation with improved HVAC systems. However, no flexible and affordable concepts have been identified so far. Within the scope of different projects at Fraunhofer ISE, pre-fabricated facade systems are developed, which allow HVAC systems to be installed together with the thermal insulation. The goal is to supply media into the building through already existing window openings using respective new developed window elements.

41.41 Evolutionary Steps in the Cell Concept towards a Back-Contact Back-Junction Solar Cell

Plated metallization processes offer outstanding technical and economic perspectives for current as well as future solar cell concepts. At Fraunhofer ISE, this metallization concept was developed up to market maturity on p-type BSF and PERC solar cells. It has also been evaluated successfully on ten standard 60-cell solar modules with respect to finishing and long-term stability. We have derived processes for PERC, n-type, bifacial and back contact back junction solar cells from these processes. We were able to evolutionary advance the processes. With that, we were also able to pave the way for industrially completely new cell structures.

41.42 New Phase Change Materials Based on Sugar Alcohols for Latent Heat Storage

The objective of the project was the development of new phase change materials (PCM) based on sugar alcohols for thermal energy storage. The main application of the latent heat storage units in the project are long-term heat storage units for buildings. For example, excess heat of a solar thermal system in the summer can be stored for the winter. PCMs store heat in the solid-liquid phase change. Compared to other PCMs, sugar alcohols have a high melting enthalpy. The melting temperature is usually between 100 and 250 °C. To maintain the advantage of the high melting enthalpy and to reduce the melting temperature for the building, the partners developed sugar alcohol mixtures. A focus of the project was the characterization of pure sugar alcohols and the developed mixtures.

41.43 Efficient Heat Exchange for Solar Thermally Driven Refrigeration Generation

Heat rejection is of essential importance for refrigeration. However, the influence of the heat rejection unit on the performance is much more critical for thermally driven processes than for electrically driven processes. The reasons are that the amount of waste heat to be dissipated to the ambient is higher for thermally driven processes due to thermodynamic reasons, and that these processes react more sensibly to higher heat rejection temperatures. The objective of the collaborative “SolaRück” project is the development of optimized heat rejection processes. This shall promote a wider distribution of (solar) thermal cooling and a sustainable market development.

41.44 Comprehensive Integration of Energetically Active Facade Components into Building Processes

Future energy systems required large areas for the installation of thermal and photovoltaic energy converters. The objective of the “SolConPro” project is the development of the large potential of building envelope areas in a cost-effective, reliable, and efficient manner. The early integration of solar facades into the planning process is essential. Building Information Modeling (BIM) is the central method for this purpose. It is an important basis of the digitalized planning and building process. The results of the “SolConPro” project should facilitate planning and installation of all types of multi-functional components for the building envelope, not only for facades with active solar energy conversion.

41.45 Solar cell concepts for next-generation generators for space applications

In space, solar cells are the basis for the energy supply in satellites and space stations. While on earth costs per Watt is the economic assessment value, the assessment value Watt per gram is of great importance for space solar cells. The reason is that the typical costs of bringing a payload into orbit amount to 10,000-20,000 €/kg. Thus, maximizing the conversion efficiency of the solar cell is the central task for minimizing the weight of the sun awnings and thus of the satellite start weight. It must be observed that the cells are subjected to high-energetic electron and proton impacts in space, which can create crystal defects and thus reduce the efficiency value over time. Today’s cells maintain approx. 80 % to 90 % of their conversion efficiency until the end of the satellite service life. We develop solar cells that show fewer losses after high-energetic particle irradiation.

41.46 SOPHIA – Concentrator Module Round Robin

In order to compare the performance of PV modules of different manufacturers, standardized specifications exist, under which ambient conditions and using which methods, the nominal power should be determined. These specifications ensure comparability and repeatability of the measured output power of PV modules. Power and spectral distribution of direct solar irradiation (DNI), as well as ambient and solar cell temperatures are specified in concentrator photovoltaics (CPV). They are defined in IEC standard 62670-1. The methods for the determination of the nominal power under these conditions should be defined in standard IEC 62670-3. A CPV module round robin took place within the scope of the "SOPHIA" EU project to develop and establish these methods.

41.47 SOPHIA – UV Round Robin Test

Durability tests for materials contain UV stability tests, mainly for polymers. Type approval of PV modules according to the IEC 61215 and IEC 61646 standards contains so-called UV preconditioning with a dose of 15 kWh/m², which does not have any connection to actually occurring loads. Here, 3 - 10 % of the UV radiation must be in the wavelength range between 280 nm and 320 nm. As the materials to be tested react very sensitively to spectral differences, the spectral distribution of the radiation sources is of utmost importance. If the UV content is increased compared to the solar spectrum, the sample temperature should always be captured to avoid sample overheating and thus misinterpretation.

41.48 SpeedColl

SpeedColl investigates the durability of solar thermal collectors and their components. As part of this collaborative project, collectors are being exposed to the weather conditions found in a variety of climatic regions. The data gathered is used to develop accelerated aging tests and models. The aim is to detect possible weak points early and improve the reliability of solar thermal collectors in the long term.

41.49 Start-Stop Aging of PEM Fuel Cells

A testing procedure for the assessment and application-specific suitability of hydrogen-operated membrane fuel cell stacks in the power range from 0.1 to approx. 5 5 kWel was developed. This testing procedure should be aligned with the stack application as charging unit for secondary batteries. This is the system configuration typically used in so-called hybrid systems made of fuel cell and battery, in camping/recreational activities, robotics, small traction, as well as emergency power supplies/backup power. Start and stop are thus the operating sequences decisive for aging and suitability of the fuel cell system.

41.50 Temperature-stable PVD Layer Stack for Conventional Module Enclosure of Solar Cells

Many novel, high-efficiency solar cell contacts on silicon basis feature an aluminum back contact that is deposited using physical vapor deposition (PVD). The advantages compared to the established screen-printing technology are lower mechanical and thermal loading, less production steps, and reduced material consumption. As the PVD layer systems known so far can lose their soldering capability due to subsequent tempering (e.g., the activation of passivation layers, sintering of galvanic contacts, and reduction of contact resistances), solar cells with PVD aluminum back contact cannot be wired without difficulties in solar modules. A layer stack developed at Fraunhofer ISE solves this problem and allows wiring using the existing soldering technology also for solar cells that passed through a tempering process of up to 425 °C.

41.51 Higher Reliability of Transparent Glass Facades with Organic Solar Cells

The three-year “TOP” project addresses the central topic of energy supply in Germany and Europe: Approx. 20 million m² glass surfaces are installed in Europe every year for building facades. These surfaces are thus available for alternative energy generation, without requiring additional separate areas. So far, these surfaces have not been accessible or only been available to a restricted extent using conventional photovoltaic technologies. A solution seems to be possible with dimensionable solar foils that can be easily integrated on large surfaces and are available as transparent version. Fraunhofer ISE investigates the topics of reliability and understanding the degradation mechanisms within the project.

41.52 Very Low Angle Beam Spread in Polymethyl Methacrylate

Concentrator photovoltaics (CPV) follows an alternative approach to conventional flat modules. In the case of photovoltaic flat modules, large-area semiconductors collect the sunlight and convert it directly into electric energy. In contrast, concentrator photovoltaics uses very small solar cells and cover the large area with optics that focus the light. These large-area concentrator optics are mostly Fresnel lenses, often made of polymethyl methacrylate (PMMA). In photovoltaic power plants, these are subjected to weathering and intensive solar irradiation. We investigated material samples of lenses that were used up to 27 years in power plant operation at our measuring system for high-resolution analysis of very low angle beam spread (VLABS).

41.53 WESpe – Technical and Economic System Analysis for Power-to-gas Systems

The systemic relevancy and advantages of power-to-gas for an energy system in Germany mainly supplied from renewable energies are generally known to the public and in the research community. They have been proven by several studies of different stakeholders. The expert discussion focuses now on business models and specific technical implementations, based on which power-to-gas can be of major importance in the energy system today and in the next 20 years. In the "WESpe" project, scientists of the involved research institutes address the important aspects for power-to-gas, such as public acceptance, location assessment, evaluation of core components and storage units, as well as the technical and economic system analysis using simulation models.

41.54 Intelligent and Energy-Efficient Windows, Based on New Material Combinations

The EU-funded "Winsmart" project develops windows that improve the energy efficiency of buildings. Research focuses on the development of vacuum insulation glass (VIG). Here the gap between the two glass panes is evacuated, which can result in excellent thermal insulation also for very thin glazing. Another focus is the development of electrochromic and photochromic windows. Electrochromic windows can switch between transparent and dark by applying a voltage. One type of the electrochromic windows investigated here uses redox salts in electrolytes. Thus, it can achieve a strong contrast at high transmission in bleached state. The photochromic windows get dark when illuminated. They brighten again in the case of low light intensity.

42. Fraunhofer Institute for Systems and Innovation Research ISI

Website Link: http://www.isi.fraunhofer.de/isi-en/index.php

42.1 Institute Overview

English: The Fraunhofer Institute for Systems and Innovation Research ISI conducts applied research in six Competence Centers with a total of 22 Business Units and sees itself as an independent institute for society, politics and industry. Our expertise in the area of innovation research is based on the synergy of the technical, economic and social science knowledge of our staff members. In our work we apply not only a broad spectrum of advanced scientific theories, models, methods and social-science measurement instruments, but continually develop them further, utilizing the empirical findings from the research projects conducted.

On behalf of our customers we investigate the scientific, economic, ecological, social, organizational, legal and political framework conditions for generating innovations and their implications. We use scientifically based analysis, evaluation and forecasting methods. Our assessments of the potentials and limitations of technical, organizational or institutional innovations help decision-makers from industry, academia and politics in making strategic decisions and thus assist them in creating a favorable environment for innovations. Thus Fraunhofer ISI one of the leading innovation research institutes in Europe.

Korean:

42.2 Information and data security

The topic area information security has a long tradition at Fraunhofer ISI. As early as the 1990s the former department Information and Communication Systems worked on issues of IT security.

Currently research in the area of information security deals primarily with the security of critical infrastructures such as networked IT worlds. Furthermore, the impact of new technologies (in particular surveillance and security technologies) on privacy and data protection are investigated and privacy impact assessments are made.

42.3 Materials and raw materials

Materials and raw materials have been important research areas at Fraunhofer ISI for years. The motivation for the research is multifaceted and includes the recurring turbulences in global raw materials markets, the transition towards low-carbon energy together with the necessary technologies to achieve it, and an increasing change in values towards more sustainability while maintaining the competitiveness of the German/European economy.

42.4 Nanotechnology

Fraunhofer ISI already identified and characterized nanotechnology as an important future technology in the report “Technology at the beginning of the 21st century“, published in 1993. With the participation of all Competence Centers our institute today deals in numerous projects with issues regarding nanotechnological innovations – from early development to application.

Part of the portfolio are comparative analyses of nanotechnological innovation systems, elaboration of scenarios to forecast future nanotechnological developments, analyzing innovation drivers and barriers for the market diffusion of nanotechnological innovations, potential and impact assessments of technological developments, researching societal acceptance of emerging technologies, sustainability assessment as well as supporting the technology transfer.

43. Fraunhofer Institute for Silicon Technology ISIT

Website: http://www.isit.fraunhofer.de/en.html

43.1 Institute Overview

English: The Fraunhofer Institute for Silicon Technology ISIT develops and produces power electronics and microsystems according to customer's specifications. Important areas of application include energy technology, automotive and transport engineering, the consumer goods industry, medical technology, communications technology, and automation. Ultra-modern technological equipment based on 200 mm silicon wafer technology and expertise built up over decades put Fraunhofer ISIT and its customers at the forefront of the field worldwide.

Fraunhofer ISIT deals with all the important aspects of system integration, assembly and interconnection technology (packaging), and the reliability and quality of components, modules, and systems. The institute also provides manufacturing support for application-specific integrated circuits (ASICs) to operate sensors and actuators. Activities are rounded off by the development of electrical energy storage devices, with a focus on Li-polymer batteries.

Korean: 프라운호퍼 실리콘기술연구소(ISIT)는 고객 사양에 최적화된 전력전자 및 마이크로시스템을 개발·생산하고 있습니다. 주요 응용분야는 에너지 기술, 자동차 및 교통공학, 소비재, 의료 기술, 통신 기술, 자동화 등입니다. 최첨단 기술장비와 더불어 200mm 실리콘 웨이퍼 기술 및 전문성을 통해 해당 분야의 세계적인 연구기관으로 자리잡았습니다. ISIT 연구소는 시스템 집적·조립·상호접속 기술(패키징)과 부품·모듈·시스템의 신뢰성 및 품질을 연구하고 있습니다. 또한 센서 및 액츄에이터 작동용 주문형 반도체(ASICs) 제조를 지원하며, 리튬폴리머전지 등 전기에너지 저장장치도 개발하고 있습니다.

43.2 PSM-X2 Process Platform

The technology platform PSM-X2 features a low stress 10-30 µm thick poly silicon layer for the realisation of mechanical active and passive MEMS structures (Fig. 1). The use of high resolution lithography allows minimal structure dimension down to 0.5µm. An additional electrode layer beneath the active polysilicon layer is implemented. This gives the opportunity for out-of-plane signal detection or sensor stimulation. Additive functional layers enhance reliability and robustness of the MEMS devices (anti stiction, high-g shock).

For the wafer scale bonding of the sensor device and the protective encapsulation a dedicated multi pressure wafer level packaging process is applied using a gold silicon eutectic process at about 400°C. The metallic bond frame induces a hermetic encapsulation of the cavity and the pressure applied during the bond process will persist. Integrated getter films allow cavity pressure levels down to 10-6 bar and a pressure ratio within adjacent cavities of up to 1:400. The application range of PSM-X2 platform includes e.g. inertial sensors, micro mirrors or electro-optic deflection devices.

43.3 Dual-Layer EpiPolySilicon Process

Recently, Fraunhofer ISIT has developed an innovative process technology for the manufacturing of sophisticated MEMS scanners ($^2\varepsilon$ Process). Following the success of the well established surface micromachining technology PSM-X2 for inertial sensors, the $^2\varepsilon$ process is based on structuring two 30 microns thick epitactically grown polysilicon layers. This allows the realisation of staggered finger combdrives for mirror actuation and detection and the design of suspension

43.4 Metal Surface Micromachining

Metal surface micromachining is an alternative way to build up complete MEMS systems or a part of them. By using mainly electroplating and lithography in combination with PVD, PECVD and etching processes it is possible to fit the requirements for a variety of applications. The low CMOS/ASIC compatible temperature budget makes this process suitable for the monolithical integration of a complete MEMS system. Additional a high flexibility in design and thickness is given.

43.5 IC Technology

The IC Technology group develops and produces microelectronic components, power semiconductors and passive components.

In cooperation with Vishay Semiconductor Itzehoe GmbH the Fraunhofer ISIT operates a modern semiconductor production plant. Vishay produces power devices (powerMOS and IGBT) on 200mm-wafers. ISIT uses it for his development projects.

In the field of discrete power semiconductor the ISIT concentrates on the development of IGBTs, PowerMOS-transistors and diodes. The development of power devices is supported from the design phase to prototyping, including simulation and electrical characterisation.

Passive components developed and fabricated at ISIT are primarily chip capacitors, precision resistors and inductors on wafer level.

Based on a qualified production technology the ISIT disposes of a wide range of semiconductor processes for different challenges in development. Highlights are the processing of very thin wafers (<50µm) and the dopant activation by laser annealing. ISIT also offers specials procedures of metallization for advanced packaging.

43.6 Biochip Technology

The Biosensor Technology team designs and develops silicon based biochips to analyse liquid samples for various applications. The biochips were produced in ISIT's cleanroom facilities:

- Sensors with noble metal electrode arrays for sensitive electrical read-out
- Chips with micro pore membranes in etched cavities and integrated microelectrodes
- Integration of porous micro-separation columns in silicon chip based microsystems
- 3D-MEMS processes and packaging on wafer level
- Design and fabrication of microfluidic structures

43.7 Biosensor System Engineering

The Biosensor Technology team constructs and develops portable and user friendly systems for control and read-out of biosensors:

- Automated systems for bio-assay processing by micro-fluidic components and integrated electronics
- Cartridge development to enable electrical and fluidical connections to read-out units, pumps and valves
- Handheld systems designed for fast, flexible and mobile analysis for a variety of applications
- Integration of different sensors in combination with printed electronics into wearable systems

- Design, simulation and prototyping of electronics and mechanics as well as micro systems
- Software development for specific hardware (micro controller) and independent cross-platform applications

43.8 Electrical Array Biochips

Highly sensitive multi parameter detection tool for food analysis, process control or point-of-care diagnostics:

- Silicon based chips (8mm x 10mm) with 16 noble metal electrodes for sensitive electrical read-out
- Position specific dispensing in the nl-range of different biochemical capture molecules for immobilization on microelectrodes
- Automated bio-assay processing by micro-fluidic components and integrated electronics
- Detection of Antibodies, Toxins, Enzymes, Bacteria, Viruses, DNA/RNA

43.9 Continuous Enzyme Sensors

Amperometric sensors for continuous monitoring of glucose1) or lactate2):

- Silicon chip (6mm x 7mm) with etched cavities (0.65mm x 0.65mm) and fine pore membrane
- Adjustment of the linear range of the sensor by number (9, 25, 100) and size (10 or 5 microns in diameter) of pores
- Multiple cavities to determine multiple analytes in parallel or for differential measurements to compensate background interference
- Successful sensor validation by clinical trials for the continuous monitoring of glucose levels in diabetic patients
- Linear range of glucose measurement in interstitial fluid of diabetic patients: 0.05mM - 20mM (0.9mg/dl - 360mg/dl)
- Integration of the sensors in combination with printed electronics to wearable systems for sweat analysis (ELaN)

43.10 On-Chip Liquid Chromatography

The On-Chip Liquid Chromatography enables detection of small molecules in miniaturized systems:

- Integration of porous micro-separation columns in silicon chip based microsystems
- 3D-MEMS method for reproducible processing including hermetically packaging on wafer level
- The chips for micro liquid chromatography (LC, 20mm x 10mm) detect separated analytes by amperometry
- Cartridges enable electrical and fluidical connections (integration of miniaturized high pressure pumps possible)
- Fast, flexible and mobile LC analysis with handheld system for variety of liquid chromatography applications:
  - Food, Water, Environmental analysis
  - Process, Security control
  - DNA/RNA isolation or protein enrichment

43.11 Module Integration

The Fraunhofer ISIT offers a variety of concepts for module integration. On one hand, the classical techniques of assembly and interconnect are available, e.g. to build prototypes or to set up a pilot production. ISIT also gives advice to customers regarding the planning of multi chip modules or system-in-package solutions. On demand, ISIT provides test chips and -substrates from the existing portfolio or as an individually adapted solution.

Furthermore, the ISIT actively promotes new process technologies, be it as an exclusive development partner or by acquisition of public funding on a national or European level, e.g. to foster SME research or international cooperation

43.12 Waferlevel-Packaging

Wafer level packaging (WLP) is a highly parallel process for the hermetical housing of micro mechanical and micro optical components. Based on our longtime experience in this field we offer a WLP “off the shelf” concept, from design up to pilot production. A technology transfer to high volume Foundries is an additional option. This concept guarantees the advantages of cost reduction and risk minimization for the customer.

The verification of the inner pressure in a waferlevel package can be a stringent demand to estimate the expectable lifetime of a product. To date, there is no generally usable method for a cheap and sufficiently precise application to all kinds of MEMS. However, for resonant structures, ISIT has developed the "Neon ultra-fine leak test" based on measuring the Q-factor of an electromechanical oscillator (dampening effect of the enclosed gases), which allows to detect extremely small leak rates and to forecast the pressure increase over a product's lifetime. (Semi Guideline 4446 "Evaluating Hermeticity of MEMS Packages").

To maintain a vacuum in a very small package, outgassing and desorption of gas molecules from the inner surfaces has to be controlled. So-called "getter" films allow to absorb free molecules of the most frequently found gas species, like an in-situ pump that remains active through the whole lifetime of a product.

43.13 Chip Size Packaging

The massive increase of microstructured components in mobile electronic devices necessitates extremely miniaturised components with thicknesses below 1 mm. ISIT is specialised on the advanced hybrid integration of micro components like inertial sensors with their electronic driver circuits. This assembly concept can, depending on chip geometry and complexity, also be executed on wafer level (WL-CSP), which allows particularly thin assemblies.

The institute has developed a modular toolbox of key technologies that allow a rapid customer specific component development, like the following:

- symmetrical wafer thinning of MEMS components,
- special dicing techniques, e.g. to expose wirebond pads,
- electrical feedthrough in glass and silicon wafers (TSV: Through-Silicon Via),
- chip-stacking technique with adhesive transfer foils,
- spacer technology for chip mounting,
- 3D wire bonding and
- bumping and balling with solder preforms, paste or gold stud-bumps.

Transfer molding of the assemblies can be performed in collaboration with external partners to realise an industrial pilot production of qualified sample parts.

43.14 Testwafers and Substrates

Test chips are extremely helpful for process development, e.g. for material screening, but also for training purposes. Since many years, ISIT develops test chips and produces them in an industrial semiconductor fab. For many chip geometries, matching substrates are equally available for assembly and interconnect trials by flip chip and wire bonding. Depending on the planned development, the test chips can be customised by individual modifications. For example, wafer thickness as well as dicing pitch and dicing foil can be defined. Test chips can also be equipped with solder bumps or just a chemical Ni-Au under-bump metallisation. Through a daisy-chain structure available on all test chips, the evaluation of process yield and reliability of most assembly technologies is possible.

Test chips are usually provided as entire 200 mm wafers on foil. Customer specific samples with specific geometries, even on glass wafers, can be developed on demand. Glass dies with a Vernier structure are particularly suitable for an accurate post-bond inspection of a die bonder's alignment precision and for optimising underfill processes.

44. Fraunhofer Institute for Surface Engineering and Thin Films IST

Website Link: http://www.ist.fraunhofer.de/en.html

44.1 Institute Overview

English: As an innovative R&D partner the Fraunhofer Institute for Surface Engineering and Thin Films IST offers complete solutions in surface engineering which are developed in cooperation with customers from industry and research. The IST's "product" is the surface, optimized by modification, patterning, and/or coating for applications in the business units mechanical engineering, tools and automotive technology, aerospace, energy and electronics, optics, and also life science and ecology.

The principle technology units at the IST are

- atmospheric pressure processes with the main focus on electrochemical processes and atmospheric pressure plasmas processes,
- low pressure plasma processes with the main focus on magnetron sputtering and highly ionized plasmas and PECVD as well as

- chemical vapor deposition with the main focus on hot-wire CVD.
- The center of tribological coatings focusses on the friction reduction, wear and corrosion protection.
- The Application Center for Plasma and Photonics deals with mobile plasma sources and laser plasma hybrid processes.

The IST's expertise lies in the ability to control all of the above-mentioned processes and their combination with a great variety of thin films. Extensive experience with thin-film deposition and film applications is complemented by excellent capabilities in surface analysis using the very latest equipment and in simulating vacuum-based processes.

Korean: 프라운호퍼 표면공학 및 박막 연구소(IST)는 혁신적인 연구개발기관으로 기업 및 연구기관과 협력하여 표면공학 솔루션을 개발하고 있습니다. 표면개질, 패터닝(patterning), 코팅 등을 통해 최적화된 표면기술을 제공하며, 기계공학, 공구 및 자동차 기술, 항공우주, 에너지 및 전자, 광학, 생명과학 및 생태학 등 5 개 사업부로 구성되어 있습니다.

IST 연구소의 주요 기술분야는 다음과 같습니다.

- 전기화학 공정, 대기압 플라즈마 공정 등 대기압 공정
- 마그네트론 스퍼터링(magnetron sputtering), 고이온화 플라즈마, PECVD 등 저기압 플라즈마 공정
- 열선 화학기상 증착법(CVD) 등 CVD
- 마찰코팅센터의 주요 연구분야는 마찰저감, 마모 및 부식 방지입니다.
- 플라즈마 및 포토닉스 응용센터의 주요 연구분야는 이동식 플라즈마 발생장치 및 레이저 플라즈마 하이브리드 공정입니다.

IST 연구소는 상기 기술분야와 더불어 박막에 대한 각종 연구를 수행하고 있습니다. 박막증착 및 박막응용 분야의 풍부한 경험과 함께 첨단장비를 통한 탁월한 표면분석 능력, 진공기반 공정의 시뮬레이션 능력을 갖추고 있습니다.

44.2 Hollow cathode processes

Hollow cathode glow discharge is a special form of low-pressure glow discharge. Here the cathode assumes the shape of a hollow body, resulting in a much higher plasma density.

For many years, Fraunhofer IST has been examining the question of how this discharge type can be used in surface engineering. This has resulted in various plasma sources and corresponding processes with a broad range of potential applications. Among these, (hollow cathode) gas flow sputtering (GFS) is particularly noteworthy.

Gas flow sputtering (GFS) is a special PVD (physical vapour deposition) method among the sputtering processes. Unlike familiar magnetron sputtering however, the plasma is produced by a hollow cathode glow discharge and the transport of material is carried by an intense flow of argon gas. The (usually metallic) sputtering target takes the shape of a hollow cathode, generally in the form of two rectangular plates arranged in parallel or a short tube, with argon flowing through it. Ions from the hollow cathode discharge evaporate the target and the flow of argon transports the material to the substrate, primarily in atomic form. The typical working pressure is 0.2-0.8 mbar.

44.3 PACVD process

In the PACVD process, a plasma supports the precipitation of layers from the gas phase. Precursors (in the form of gases or vapours) containing the elements of the layer material are used. At Fraunhofer IST this method is used primarily for the precipitation of modified diamondlike carbon films (a-C:H:X, X stands for the additional elements that are introduced, for instance Si, O, F). Compounds such as TMS or HMDSO are used as precursors. Hard material films like TiN or TiCN can also be produced with PACVD processes.

44.4 Magnetron sputtering

Of all the coating technologies used on plate glass today, sputtering has achieved the greatest economic importance by far. More than 100 million m² of plate glass are coated worldwide using this technology today, with a continuing rising trend. Magnetron sputtering on inline coating systems has established itself as the standard technology for the production of low-E and sun control film systems. Such sputtering systems process substrates in the ribbon format of 3.21 x 6.00 m² with cycle times as low as 45 s. Operated in 3 shifts with one maintenance shift per week, such a system coats up to 12,800 substrates. This results in a maximum productivity of approximately 12 x 106 m²/a. Magnetron sputtering is based on the principle of cathode evaporation in low-pressure glow discharges. Ions are accelerated onto the cathode in the cathode drop so that a collision cascade is triggered in the cathode, leading to the release of target material. With the magnetic pressure increase method, the working pressure of the sputtering process can be reduced from approximately 5 Pa without a magnetic field to around 0.1... 1 Pa.

44.5 High-power impulse magnetron sputtering (HIPIMS)

High-power impulse magnetron sputtering (HIPIMS) and high power pulse magnetron sputtering (HPPMS) generate plasmas with a high proportion of ionised layer forming atoms. The resulting film systems feature entirely new and improved characteristics, for instance regarding density, hardness, roughness or the refraction index, which cannot be realised with any other technology available today.

To use HIPIMS technology in production, existing PVD systems can be expanded cost-effectively by installing a corresponding pulse unit. The technology is being used and further developed at the Fraunhofer Institute for Surface Engineering and Thin Films IST, and is currently being brought to production readiness.

44.6 Plasma diffusion treatment

The surfaces of many components and tools are subject to extreme strain. Diffusion treatment with carbon, nitrogen and boron can significantly reduce signs of wear through surface hardening. The treatment is often applied in gases, a salt bath or powder. Plasma diffusion as a treatment in plasma is however increasingly asserting itself.

44.7 Hot filament CVD process

The precipitation of polycrystalline diamond films using hot-filament chemical vapour deposition (CVD, HFCVD) is a core competence of the Fraunhofer Institute for Surface Engineering and Thin Films IST. Fully automated HFCVD systems developed at Fraunhofer IST are suitable for coating surfaces up to half a square metre. Processes and systems are also available for the diamond coating of three-dimensional base bodies and for interior diamond coating. Diamond layers with various modifications, for instance with a rough or smooth surface or also as electrically conductive films, are available for different applications.

44.8 Atmospheric pressure plasma processes

Cold physical plasmas with high-energy electrons and ions are produced directly from the surrounding atmosphere using strong electrical fields. This creates highly reactive radicals and more stable reactive oxygen and nitrogen species that attack the cell membranes and walls of bacteria and fungi in synergistic association with the free charge carriers.

By using suitable gases and reagents, atmospheric pressure plasmas can also be used for the chemical functionalisation of surfaces with reactive groups. The plasmas can also be produced in very low volumes if needed. Known as microplasmas, they can be used for the targeted local modification of surfaces, for example to configure the desired surface energy.

44.9 Laser-plasma hybrid technology

Laser and plasma – combining these technologies for surface optimisation and surface engineering makes it possible to process numerous materials precisely and homogeneously on larger surfaces with high productivity and at lower cost. The combination of the two technologies also supports the exact and efficient micro-structuring of optical components. This innovative laser-plasma hybrid technology opens up a broad range of new application possibilities for surface optimisation. Production and machining processes – depending on the desired application – become more efficient with higher quality and therefore more economical.

Serial or simultaneous laser-plasma hybrid processes are possible depending on the application and substrate. Here the materials that are used can exhibit conductive, semiconductive or also insulating properties.

44.10 Atomic layer deposition

Atomic layer deposition (ALD) is a modified chemical vapour deposition (CVD) process. Two successive, self-limiting surface reactions are characteristic for the process, so that extremely thin, defect-free and highly homogeneous films can be deposited. Plasma atomic layer deposition is a special version in which plasma is used for the activation of the second precursor. This allows less reactive precursors to be used, or alternatively the substrate temperature can be lowered, for example to coat sensitive substrates. Compared to other PVD and plasma-CVD deposition processes, the component being coated is not damaged by the plasma.

44.11 Electrochemical processes

Electroplating is the electrochemical precipitation of metallic coatings on objects. These objects are usually made of metal, but plastics are increasingly being coated as well. Galvanising takes place in a watery solution containing the ions of the metal being deposited (electrolyte). An electric voltage is applied between the work piece being coated (cathode) and a counter electrode (anode). This reduces the ions to the elementary metal on the work piece. Corrosion protection is the leading field of application (zinc and zinc alloys), followed by decorative coatings (chrome) and tribological functions (hard chrome, chemical nickel). Measured by the coated surface, electroplating is one of the leading surface engineering methods.

45. Fraunhofer Institute for Toxicology and Experimental Medicine ITEM

Website Link: http://www.item.fraunhofer.de/en.html

45.1 Institute Overview

English: Protecting man from health hazards in our industrialized world and contributing to the development of novel therapeutic approaches – these are the aims we pursue at the Fraunhofer Institute for Toxicology and Experimental Medicine ITEM.

A focus is on airway research. A wide range of airborne substances – pollutants but also pharmaceuticals – are taken up via the lungs. In collaboration with our clients from industry and the public sector we develop and test novel medications against respiratory diseases – in particular asthma, allergic rhinitis, and chronic obstructive pulmonary disease (COPD) –, study mechanisms of action, and determine the risks from potentially harmful substances.

Korean: 프라운호퍼 독성학 및 실험의학연구소(ITEM)는 산업화에 따른 건강 위해 요소로부터 인간을 보호하고 신규 치료법 개발에 기여하는 것을 목표로 삼고 있습니다. 인간의 신체는 폐를 통해 공기 중의 각종 오염물질과 약물을 흡입합니다. ITEM 연구소의 주요 연구분야는 기도질환으로, 기업 및 공공부문 고객과 협력하여 천식, 알레르기성 비염, 만성폐쇄성폐질환(COPD) 등 호흡기 질환에 대한 신약 개발·시험, 작용기전 연구, 잠재적 유해물질의 위험 분석 등을 수행하고 있습니다.

45.2 Drug Development

Before a drug candidate can reach final approval for commercialization, it has to go through a multistage development process that takes several years. Research at Fraunhofer ITEM is geared to this development sequence, and we accompany our clients through its different phases. Driven by enthusiasm for complex topics, a strong will to solve even difficult problems and to find new approaches, our scientists elaborate innovative concepts and methods to help advance the development of new therapeutics – and thereby help restore human health.

As researchers in translational medicine, working at the interface of basic research, clinical application, and drug regulatory requirements, we aim to translate scientific results into benefits for patients. The central questions in this context are: How can an idea be translated from the lab into an investigational medicinal product for use in clinical trials? How can the efficacy and side effects of this product be studied efficiently and conclusively in suitable models? And how can the proof of concept – the necessary evidence of the product's mode of action – be provided in humans?

45.3 Chemical Safety and Assessment

Environmental, occupational, and consumer protection are topics of rising concern. Our dedicated scientists are working on research topics to make our world safer. In recent years, a special focus has been on new materials such as nano-structured materials and improvement of chemical risk assessment technologies.

New materials such as nano-structured materials may develop very different characteristics and, therefore, general statements about the risks of nanotechnology or nanomaterials are difficult to make at this stage. Several studies deal with fundamental issues such as precise characterization of nanomaterials and the properties defining the inherent hazard potential. Here, we are working on studying the toxic effects of nanomaterials at different testing levels.

Our comprehensive activities in risk assessment also create ideas for new scientific approaches that may help improve chemical risk assessment methodology in the future. With research on mechanistic data, i.e. investigations of key events in so-called AOPs, and the use of in-silico approaches in risk assessment our scientists are working on new approaches which could help deal more effectively with emerging challenges for cosmetics products, foods, and chemical mixtures.

45.4 Translational Medical Engineering

Medical devices make a significant contribution towards improving patients' quality of life. Numerous universities and research laboratories are continuously developing new and innovative solutions to further improve patient care.

However, these basic research developments are not easily brought to the clinical testing stage, as test series of medical devices and medical products must have undergone standard-compliant manufacturing, the regulatory requirements of which are difficult for research institutions to meet. Service providers offering manufacturing of medical devices are, however, often unable to implement highly innovative products containing new materials and involving related processing steps.

This gap is closed by the Fraunhofer ITEM translation platform with trained scientists who are able to qualify these special – partially external – processes, supportively integrate them into medical device management and subsequently devise overall risk management strategies for the entire manufacturing chain.

The focus of the scientific support here is on so-called combination products involving the application of two or more components from medical engineering and other life science areas. This often means that a medical device is functionally integrated with a conventional medicinal product or with human products. As far as the Fraunhofer ITEM scientists are concerned, two thematic key areas form the starting point for this research, namely innovative inhalation systems and active implants.

45.5 Single-cell technologies

Genomic alterations (e.g. mutations, copy number changes) are currently searched for information enabling individual therapy selection. Currently, mostly tissue samples from primary tumors are used to retrieve this information. As tumor cells constantly change and clinicians aim to minimize repeated painful biopsies, various methods have been developed to detect and isolate tumor cells circulating in peripheral blood.

This approach aims to constantly monitor the development of the disease in each cancer patient, thereby enabling fast adaptation of individual therapies. It is hoped that this approach results in improved survival rates and quality of life.

45.6 Identification of target structures and therapy prediction

Currently, one in four deaths is caused by cancer, mainly as a result of systemic spread and metastatic disease. Despite new drugs, the currently available therapies are effective only in one in four cancer patients.This could be due to the finding that primary tumors and disseminated tumor cells differ considerably in both genotype and phenotype, so that the target cells of therapies cannot be inferred directly from the properties of the primary tumor.

To reduce the time required for development of novel systemic therapies, companion diagnostic tests are thus needed to enable prediction of whether disseminated tumor cells will respond to the treatment.

45.7 Mathematical modeling of disease processes

Acute health impairment, such as bone fracture, is mostly immediately understood and skillfully treated today. The situation is similar for many monogenic illnesses, such as sickle-cell anemia, in which a single gene, hemoglobin, is mutated. However, most cancers are multi-causal and sporadic in that they evolve somatic, i.e. non-inherited, genetic aberrations through numerous environmental factors, ranging from carcinogens and radiation to infections and diet. They can also result from erroneous cell division during physiological tissue renewal, e.g. in intestine and blood. Cancer cells are generated even in healthy individuals, but kept in check by the immune system or programmed cell death (apoptosis). In such complex, multi-level settings, modeling can help to better understand disease mechanisms and structure and combine local and global information, and finally integrate molecular diagnostic and clinical data for the most effective therapy with the least side effects for each individual patient.

45.8 Models of treatment and metastasis formation

The concept of personalized tumor therapy is based on the use of specific, custom-tailored medication to treat an individual's cancer. Besides comprehensive knowledge about the tumor's molecular properties, development of such treatment strategies benefits considerably from the use of cell models representing the actual target cells of the individualized therapy. Such cell models are needed to test novel therapeutics and to study the biology of specific tumor cell populations. Tumor cells that have already spread in the body – e.g. disseminated tumor cells (DTC), which are metastatic progenitor cells, and circulating tumor cells (CTC) in the patient's blood – are important target cells for specific therapy approaches in patients with metastatic disease.

Due to the very low abundance of DTC and CTC and the resulting difficulty to detect and enrich them, it is nearly impossible at present to expand these cells and thereby establish representative models for preclinical drug testing. The use of cell models based on these rare cells, however, will enable a deeper understanding of metastasis formation and improved testing of novel therapeutics.

46. Fraunhofer Institute for Industrial Mathematics ITWM

Website Link: http://www.itwm.fraunhofer.de/en/fraunhofer-itwm.html

46.1 Institute Overview

English:

Fraunhofer ITWM focuses on the development of mathematical applications for industry, technology and economy. Mathematical approaches to practical challenges are the specific competences of the institute and complement knowledge in engineering and economics in an optimal way. The main emphases are surface quality inspection, financial mathematics, visualization of large data sets, optimization of production processes, virtual material design and analysis of 3D models of microstructures.

Korean: 프라운호퍼 산업수학연구소(ITWM)는 산업, 기술, 경제 부문의 수학적 응용을 개발하고 있습니다. 연구소의 핵심역량은 현실적인 과제에 대한 수학적 접근법을 도출하고 이를 공학 및 경제학 관련 지식과 접목시키는 능력입니다. 주요 연구분야는 표면 품질검사, 금융수학, 대형 데이터 세트 시각화, 생산공정 최적화, 가상 자재설계, 미세구조 3D 모델 분석 등입니다.

46.2 Transport Processes

he main competence of the Department of Transport Processes is the mathematical modeling of complex industrial problems and the development of efficient algorithms for their numerical solution (simulation).

The problems belong to a technical scientific context (fluid dynamics, radiative transfer, acoustics, structure mechanics, etc.) and can be formulated mathematically as partial (integro-)differential equations which are mostly to be characterized as transport equations. Industrial customers typically require the optimization of products, the technical design of production processes, or simulation-based measurement methods. Here, the department offers, e.g., cooperation projects with those R&D departments of partner enterprises which are focused on scientific engineering, studies including design and optimization proposals, concept development, as well as software solutions.

46.3 Flow and Material Simulation

The department of FLOW AND MATERIAL SIMULATION deals with the modeling and simulation of fluid dynamical and structure elastic processes for the optimization of materials and components. One of our main competences is the efficient numerical solution of multiscale and multiphysical problems occurring in Material Simulation.

Our clients are producers of technical textiles and composite materials, metal and plastic processing companies, particularly foundries, as well as subsequent processing branches, such as filter producers and system suppliers in the field of automobile technology.

46.4 Image Processing

Based on innovative mathematical models and algorithms, the department Image Processing offers

- customized all-in-one solutions suitable for the needs of production and laboratory
- service and consulting

46.5 Optimization

The core competence of the department of Optimization is to develop individual solutions for planning and decision problems in logistics, engineering sciences and life sciences in close cooperation with customers. The methodology is based on the coupling of:

Simulation

Building models or data based virtual structures under consideration of restrictions and free parameters

Identification of measures for quality and costs in order to evaluate and optimize the structures under discussion

Optimization

Development and implementation of individual optimization methods to calculate best possible solutions

Of particular interest are multi-criteria problems with conflicting cost and quality indicators

Integration of simulation and optimization algorithms

Decision Support

Consulting in structuring decision support processes Development and implementation of interactive decision support tools, in particular for multi-criteria optimization problems

46.6 System Analysis, Prognosis and Control

Based on its core competences in system theory and data analytical methods the department deals with the modelling, analysis, prognosis and control of complex system and process behaviour both in the technical and the biological/medical environment.

System Analysis

Starting from process models constructed out of first principles, measurement data and/or expert knowledge mixed symbolical/numerical analysis techniques allow the derivation of fundamental system properties. Model reduction techniques play a central role both for a deeper system understanding, complex system simulations and controller designs.

Prognosis

Prognosis models that were identified considering possible disturbance sources and system uncertainties allow the reliable prediction of the system behaviour in case of unknown inputs. The combination of those prognosis models with interactive visual navigation tools leads to highly efficient multicriterial decision support tools.

Control

Concerning the design of monitoring systems and control algorithms the main focus lies on model based techniques, standard topics like PID-control however are covered as well. Special competences exist in the topic of robust observer and controller design to consider model uncertainties and nonlinear system behaviour e.g. dead time and hysteresis.

46.7 Financial Mathematics

The department of financial mathematics at Fraunhofer ITWM offers you competent consulting in different areas of financial mathematics. Our application-oriented research features modern solutions to problems, that arise during design, analysis and numerical realization of mathematical models in the financial sphere. Based on the newest achievements of financial mathematics and statistics we holistically develop, model and implement products for the financial industry. In Projects we are amongst others characterized by the fact that we flexibly realize our clients wishes.

46.8 Mathematical Methods in Dynamics and Durability

The department »Mathematical Methods in Dynamics and Durability« is concerned with modeling and simulation of usage variability, dynamic loading and energy efficiency of vehicles and machines.

We are developing statistical methods for durability, reliability and energy efficiency. Our software development project »virtual measurement campaign« combines statistical and simulation methods with geo-referenced data in a unique novel way.

Related to this our system simulation activities focus on »driver-vehicle-environment interaction«. We are developing models and software for tire simulation, ground interaction and invariant system excitation. Using our robot based driving simulator we are developing advanced driver and operator models.

Further we are simulating the mechanical behavior of highly deformable structures such as tires, rubber- and hydro mounts, cables and hoses. We develop methods which allow for modeling the non-linearity correctly at a calculation performance suited for system simulation or interactive assembly simulation applications.

46.9 Competence Center High Performance Computing

Development and use of numerical simulation processes are the heart of the research at the Fraunhofer ITWM and the basis for all technically complex developments in industry. In many industry sectors the demand to solve increasingly large problems is strongly growing, e.g. in seismic exploration and the life sciences. At the same time, engineers and scientists want to work interactively and more efficiently to solve their problems. Large data driven problems and interactivity are the drivers that led us to Petaflop's computers, GPU Computing and are stimulating the discussion about accelerator technology and Exaflop computing. High Performance Computing deals with the challenges associated with the algorithmic development, the implementation and the execution of compute intensive problems on HPC hardware. It is therefore positioned at the intersection between mathematics, computer science and the applied sciences. In recent years a paradigm shift has taken place at this intersection, which has by and large still not entered into practice

Over more than 10 years the increase in compute speed has simply been gained through higher clock speed. Since 2005 the clock speed stays the same and additional performance can only be gained by higher hardware parallelism. Since then we see a competition for the highest number of cores. This change in direction on the hardware side has considerable consequences for the development of performance-hungry software. An increase in performance is now only to be attained through parallelization and as the floating point performance goes to infinity the data transport is the limiting factor and determines the way we develop and implement new algorithms today.

The Competence Centre for High Performance Computing addressed this paradigm shift at an early stage and brought innovative new software tools for the development of parallel software to the market. The heart of these tools are the Global Address Space Programming Interface GPI, which replaces the previous MPI programming model, and an efficient library for the development of complex multi-threaded programs, the multi-core thread package MCTP. Expanding on this, new parallel programming platforms are currently being developed for large parallel computer systems. The Seismic Development and Processing Architecture SDPA implements a fault-tolerant system where domain-specific applications are developed inside a high-level graphical user interface , while the SDPA framework takes care of an efficient parallelization and throughput optimization. The SDPA speeds up the development for new applications from scratch and it is made to integrate legacy software modules at the same time. The system is intended for large parallel systems and will be used initially in the oil industry.

In the BMBF project IMEMO the patented parallelization framework GraPA is being adapted to the requirements of future hardware systems including GPUs. GraPA automates the parallelization using a graph-based approach. The creation of innovative tools for the development of parallel applications will a remain the main field of activity of the department in the coming years.

Since 2005 FhGFS, a new Parallel File System has been -under development at the ITWM. The development started from scratch, learning from the problems and hassles with -existing systems. In 2008 the first official release of FhGFS was available from the website www.fhgfs.com. A series of smaller installations in the oil and gas sector have confirmed the reliability of the system and first large installations have been implemented at various universities

Fraunhofer seismic imaging software enters into production in oil industry The software packages GRT for angle domain migration and PreStack-Pro for visualisation, processing and analysis of pre-stack seismic data have fulfilled the high demands of our industry partners and are now in productive use by companies worldwide

47. Fraunhofer Institute for Transportation and Infrastructure Systems IVI

Website Link: http://www.ivi.fraunhofer.de/en.html

47.1 Institute Overview

English: The Fraunhofer Institute for Transportation and Infrastructure Systems IVI is operating in a wide array of transport-related research and development topics, ranging from the fields of electro-mobility, traffic planning and traffic ecology, traffic information, vehicle propulsion and sensor technologies, while also incorporating traffic telematics, the information and communication sectors, as well as disposition and logistics.

Special attention for the Fraunhofer IVI has been raised by its electronic ticketing application, its mobile public transport navigation solution SMART-WAY, and its cross-border disaster protection system. Recently, it has especially been the 30,7 m long AutoTram® Extra Grand – the world's longest bus – equipped with hybrid propulsion technology and an electronic multi-axle steering system that has been the focus of attention.

Korean: 프라운호퍼 교통인프라시스템연구소(IVI)는 e-모빌리티, 교통계획, 교통생태계, 교통정보, 차량추진 및 센서기술, 교통 텔레매틱스, 정보통신, 처리 및 물류 등 다양한 교통개발 관련 연구를 수행하고 있습니다. 연구소는 전자티켓 관련 기술, 모바일 대중교통 네비게이션 스마트웨이(SMART-WAY), 국가간 재난보호 시스템을 개발하여 인지도를 넓혔습니다. 최근에는 하이브리드 추진기술과 전기모터식 다축조향시스템을 갖춘 길이 30.7m 세계 최장 버스인 오토트램 엑스트라 그랜드(AutoTram② Extra Grand)를 선보이며 주목을 받았습니다.

47.2 Transportation, Energy and Environment

Research in the fields of transportation and the environment is often subject to contrary demands, such as current mobility requirements and the associated use of resources. The efficient handling of energy is of great importance in this respect. The department »Transportation, Energy and Environment« operates in a versatile field of activity, which demands the scientific evaluation of this conflict by means of evidence-based methods as well as the enhancement of the research field with novel technical solutions.

The systematic chain of energy production, energy transmission, energy conversion and energy storage reflects the core competencies of the department's working groups: »Storage System and Converters« focuses on both mobile and stationary applications and designs energy efficiency concepts and innovative solutions. »Mechatronic Systems« abstracts systemic principles and develops targeted measures.

47.3 Intelligent Transport Systems

The department »Intelligent Transport Systems« has successfully operated at the market for more than a decade. Having emerged from the Working Group »Intermodal Information and Control Systems« of the Fraunhofer Research Institution for Process Control, the department

has significantly shaped the Fraunhofer IVI's research profile in transportation and traffic engineering.

The two Working Groups »Mobility and Travel Assistance« and »Ticketing and Fares« successfully realize projects in a large variety of research topics, acting in interdisciplinary teams with a broad range of skills. The staff includes computer scientists, information engineers, transportation engineers as well as automation technicians.

The department traditionally works in close partnership with the TU Dresden (University of Technology).

47.4 Strategy and Optimization

The department, which is divided into three working groups, offers a wide array of services in the research areas of security, business process analysis, logistics planning and infrastructure management. The interdisciplinary team includes computer scientists, geoscientists as well as mathematicians with both professional expertise and practical knowledge.

Application-oriented research and development projects are focused on decision support for an optimized planning and control of resources. The core competencies of the department comprise the development of novel optimization processes and algorithms as well as the conception and implementation of complex systems.

In the age of digitalization, it is not only the controllability of data that counts but the creation of data value as a business benefit. The Working Group »Business Processes« uses the AcubeS system (A^3 – Analytics as a Service) based on the Apache ecosystem in order to achieve highly dynamic data storage and analysis of structured and unstructured amounts of data.

47.5 Vehicle and Transport System Engineering

Technologies for novel commercial vehicle concepts are the main area of research in the Department »Vehicle and Transport System Engineering«. Core competencies include innovative vehicle solutions and key enabling technologies in the areas of road-bound and rail-bound public transport, including vehicle design, solutions for individual parts construction, innovative propulsion technologies, methods for energy-efficient vehicle operation regarding propulsion and auxiliaries as well as steering control and driver assistance systems. Many of the developed solutions have been applied in the AutoTram® Extra Grand.

We offer support to realize new mobility concepts and to develop integrated mobility technologies.

48. Fraunhofer Institute for Process Engineering and Packaging IVV

Website Link: http://www.ivv.fraunhofer.de/en.htmll

48.1 Institute Overview

English: The Fraunhofer IVV stands for high-quality food products and safe, effective, and convenient packaging systems. Efficient use of raw materials and minimal environmental impact are priorities in all our development work along the value chain. We also transfer our technologies and expertise to applications outside the food and packaging industries. Companies and research organizations appreciate the Fraunhofer IVV as a business partner. People are inspired by our research work and the resulting products.

Korean: 프라운호퍼 공정공학 및 포장연구소(IVV)는 고품질 식품과 안전하고 효과적이며 편리한 포장시스템을 개발하고 있습니다. 가치사슬 전반에 관한 연구를 수행하는 IVV 연구소는 식재료의 효율적인 활용과 환경영향의 최소화를 지향하며 식품포장 외 타 산업에도 기술을 이전하고 있습니다. 또한 각종 기업 및 연구기관으로 구성된 협력 네트워크뿐 아니라 우수한 연구인력과 제품개발 능력을 보유하고 있습니다.

48.2 Process Development for Plant Raw Materials

We develop mechanical and extraction processes on up to a small pilot plant scale for isolating plant raw materials efficiently and cost effectively. The resulting fractions, namely oil, protein, soluble dietary fiber, and secondary plant ingredients, are then modified enzymatically, chemically, and physically in order to customize, for example, the solubility, water binding capacity, or emulsifying capacity. The products are then stabilized and dried so that they can be used as ingredients for foods and cosmetics and for technical applications.

48.3 Food Process Development

Our state-of-the-art equipment and facilities allow us to develop a wide range of foods covering meat/sausage products, fruit/vegetables, baked goods, pasta, and confectionery. Our interdisciplinary team has in-depth expertise in, for example, the stabilization of textures, handling oxidation-sensitive materials, and sensory optimization of products. We are able to scale up our product developments to a small production scale for validation purposes. Our development work is aided by the use of innovative processing technologies such as electromagnetic fields and extrusion which allow gentle heating and the manufacture of new products, for example meat alternatives.

48.4 Retention of Food Quality

We evaluate the quality of foods and quality changes and the effect of physical, chemical, and microbiological parameters. This is also carried out for cosmetics and pharmaceutical products. This enables us to then optimize the quality and product shelf-life by customizing the manufacturing process, using active packaging, or applying sterilization methods. To carry out this work we sometimes have to develop special analytical methods. Our expertise also includes the testing, optimization, and development of sterilization plants for packaging materials, filling plants, and foods.

48.5 Sensory Analytics

Our interdisciplinary team has expertise in food chemistry and technology, sensory analysis, and physiology and addresses the various sensations encountered during food consumption and the physiological and psychological responses triggered by these sensory perceptions and by chemosensory-active substances. An additional focus of our research is the interaction of consumers with products such as (packaged) foods, cosmetics, consumer goods and packaging materials. Smell, taste, colour, texture, and the interplay between different sensory modalities are characterised both individually and from a multi-sensory perspective, with a particular focus on the development, optimisation and analysis of smell and taste attributes, as well as on the assessment of their perception and effects on human subjects.

48.6 Product Safety and Analytics

Our work involves evaluating the interactions between polymers and contact media. We systematically study the transfer (migration/permeation) of chemical substances into contact media such as packaged foods or other packaged products. A key area of expertise is determination of the diffusion and partition coefficients and subsequent modeling of the material transport processes. We also develop analytical methods for specific determination of substances in complex matrices (e.g. foods, packaging materials and their raw materials, biological samples, environmental samples, etc.). Our laboratories are equipped with state-of-the-art analytical instrumentation

48.7 Materials Development

Our expertise is the multilayer extrusion of flat and flexible polymer materials and the wet chemical or vacuum coating of these materials on a small pilot plant scale. The objective is the manufacture of (ultra) barrier films for technical applications and food packaging materials. This includes materials with integrated active functions. We test the mechanical and optical properties of the packaging materials. The surface structure and layer structure of these materials are evaluated using spectroscopic methods such as AFM (atomic force microscopy). We also characterize the polymer and polymer-coated packaging systems for their barriers to gases and water vapor. The permeation data are interpreted using advanced simulation programs. Various physical-chemical models are combined to form complex dynamic simulations, so enabling the extrapolation of laboratory measurements for specific applications.

48.8 Machine and Process Design

We develop machine processes for the food, pharmaceutical, and packaging industries. We possess expertise in industrial cleaning technologies and also production technology. Our pilot plant facilities have state-of-the-art equipment for thermoforming and joining flat polymers and polymer-containing materials, for studying web transport, and for mechanized product handling and industrial cleaning. Our expertise ranges from interdisciplinary process analysis to modeling and the development of systems and components. The focus is on efficient and innovative machine and process development and hygienic design.

48.9 Process Development for Polymer Recycling

We use mechanical and thermal processes to recover high-purity materials, mostly polymers, from complex mixtures of waste/residual materials. Waste/residual materials are first of all characterized by chemical analysis techniques. Recyclable materials are concentrated by mechanical means, selectively extracted in ATEX-approved pilot plants via percolation or in stirred vessels, and then fractionated, purified, and analytically evaluated. Typical recyclates and the starting residual/waste materials are: PET, PP, PE, and EPS from post-consumer packaging, PA from post-industrial waste mixtures/composites, and ABS, PC, HIPS, and PP from shredder residues.

49. Fraunhofer Institute for Wind Energy and Energy System Technology IWES

Website Link: http://www.iwes.fraunhofer.de/en.html

English: Fraunhofer IWES has two main thematic areas, wind energy (northwest) and energy system technology (Kassel).

Fraunhofer IWES Nordwest focuses entirely on wind energy. A steering committee for rotor blade testing has existed since test benches were first established. Direct feed-back at regular meetings ensures that test programmes and methods are tailored to the requirements of industry, but are at the same time absolutely neutral in their execution. In addition, staff of IWES Nordwest cooperate with manufacturers on IEC special com-mittees in developing requirements for future standards.

Within the framework of the "Innovation Cluster Power Electronics" questions concern-ing the reliability of power electronic components are systematically investigated to-gether with some 20 industrial partners. The aim is to achieve greater plant availability and to improve the economic efficiency of wind energy production.

IWES in Kassel mainly researches on energy system technology for the integration of renewable energy such as wind, solar and bio energy into supply structures. The cur-rent focus is on the transformation of the German energy system.

Korean: 프라운호퍼 풍력에너지 및 에너지시스템 기술 연구소(IWES)는 크게 풍력에너지(노스웨스트(Northwest)소재)와 에너지시스템 기술(카셀(Kassel) 소재) 두 부문으로 구성되어 있습니다. IWES 노스웨스트 연구소는 풍력에너지 연구를 전담하고 있습니다. 시험장치 구축 시점부터 회전날개 시험 운영위원회를 운영해왔으며, 정기 회의 시 의견수렴을 통해 시험계획과 방법이 기업의 요구사항을 충족하고 독립적으로 운영되도록 보장하고 있습니다. 연구진은 제조사들과 함께 IEC 특별위원회에서 규격 표준화 작업을 진행하고 있습니다. 연구소는 "전력전자 혁신 클러스터(Innovation Cluster Power Electronics)" 프레임워크 하에서 20 여개 업계 협력기관과 함께 설비 신뢰성 향상 및 풍력발전의 경제적 효율성 제고를 위해 전력전자 부품의 신뢰성을 체계적으로 평가하고 있습니다. IWES 카셀 연구소는 독일의 에너지 전환정책에 중점을 두고 풍력, 태양광, 생물 등 재생에너지의 공급 및 사용을 위한 에너지시스템 기술 연구를 전담하고 있습니다.

49.1 Wind Energy

Fraunhofer IWES Northwest ensures investments in technological developments in the field of wind energy through its validation services. Furthermore, it accelerates the mar-ket introduction of innovative products and enhances certification processes. Innovative measurement techniques support clients to improve their planning security.

It offers a unique testing infrastructure, state-of-the-art laboratories and measurement equipment that allow the systematic identification and reduction of development risks. These assets combined with the methodological competence of its employees makes it a preferred research and development partner for companies all around the globe.

49.2 Energy System Technology

Fraunhofer IWES in Kassel carries our specialist research in the areas of energy management and energy system technology, finding solutions for economic and technical problems relating to the energy transition.

Laboratories and development support as well as prognosis systems and studies are available to companies in the sectors of power supply, wind energy, photovoltaics, bioenergy, investment, grid operation, power electronics and energy informatics.

50. Faunhofer Institute for Mechanics of Materials IWM

Website Link: http://www.en.iwm.fraunhofer.de/

English: The intelligent use of materials is the key to future success and investments: our research work enables our customers to produce innovative and reliable products. We contribute to a society that strives for an efficient and sustainable use of energy and resources.

We make the mechanisms and processes in materials and material systems manageable by first assessing and describing them as models. This makes it possible to extract more of the potential performance and efficiency from technical systems.

We measure materials down to their atomic structures and influence the interactions. This enables us to modify material properties to meet requirements and achieve new functionalities.

We scrutinize material systems and manufacturing processes and transfer this knowledge into reliable products and technologies. Together with our partners from the fields of science and business, we develop innovations with a competitive edge.

Korean: 재료의 효율적인 사용은 성공을 보장합니다. 프라운호퍼 재료역학연구소(IWM)는 고객이 혁신적이고 믿을 수 있는 제품을 생산할 수 있도록 지원함으로써 에너지와 자원의 효율적이고 지속가능한 사용에 기여하고 있습니다. 연구소는 평가 및 관련 모델 구축을 통해 재료 역학, 공정, 재료시스템의 관리를 지원하고 기술시스템의 성능과 효율성을 제고합니다. 또한 원자 수준의 재료 구조분석 및 상호작용의 변화를 통해 요구사항에 맞게 재료 특성을 조정하고 새로운

기능을 개발하고 있습니다. 이와 더불어 재료시스템 및 제조공정을 분석하여 신뢰할 수 있는 제품과 기술의 개발을 지원하고, 각종 연구기관 및 기업과 협력하여 경쟁력 있는 혁신을 이루고 있습니다.

50.1 Material and component characterization

The key to accurately assessing and improving material reliability, component reliability and ultimately system reliability and service life is to understand the innermost structures of the material(s) in question. We have the skills and have ourselves developed many of the latest methods to investigate how materials and components react to to mechanical, thermo-mechanical, dynamical, corrosive, tribological, structural, chemo-mechanical and electro-mechanical loads and to identify failure mechanisms for reasons such as crack formation, wear, abrasion, fatigue or any other criteria important to the client. The experts at the Fraunhofer IWM will isolate and identify the necessary material parameters and assess them in correlation to their microstructure and to the structural processes at all levels of magnitude. Component reliability testing includes localized variations in material properties. We describe material structures and model material behavior from the macroscopic level, through the microstructural level right down to the atomic level. When assessing components, we account for failure characteristics and environmental influences.

50.2 Material modeling and simulation

Computer simulations and related simulation software are essential in order to avoid a lengthy (and costly) process of trial-and-error during advanced material and component development as well as in order to depict complex load scenarios. Such simulations are also crucial for predicting the operational behavior of materials and components. The in-house expertise at the Fraunhofer IWM provides the capability to model materials at different levels of scale (multiscale modeling) and to measure model-specific properties (Design of Experiments). We can also describe the deformation, damage, failure and functional behavior of materials. Our virtual testing laboratory enables us to predict the level of a component's safety, the various stress points at which a component may fail and service life. Process simulation enables us to improve manufacturing parameters and tools for optimum component properties. The virtual microscope makes it possible to assess and define the functions of new materials.

50.3 Tribology and surface design

Exposure to stress and loads during the manufacturing process or while in use often affect the component surfaces. Ultimately, such surfaces also frequently define the functionality of a technical system. The Fraunhofer IWM has well-founded know-how, methods and procedures (many created by our in-house experts and specialists) at its disposal with which to define the optimum component surfaces in terms of friction, appearance, wettability, conductivity, topography or adhesion. Modern analysis techniques are used to assess interfaces and surfaces and to determine failure mechanisms. The latest coating technologies or specific surface layer modifications can then be implemented. Computer simulation of layer growth, tribological contacts and adhesion phenomena enables us to optimize layer properties and coating processes.

51. Fraunhofer Institute Material and Beam Technology IWS

Website Link: http://www.iws.fraunhofer.de/en.html

English: The Fraunhofer IWS conducts applied research and development in the field of laser and surface technology. Our core activities cover a wide range of areas such as laser welding, cutting, coating, hardening and cleaning as well as surface and thin film technology, vapor deposition, process monitoring and nano particle technology.

Korean: 프라운호퍼 재료 및 광선기술연구소(IWS)는 레이저 및 표면기술 분야의 응용연구개발을 수행하고 있습니다. 핵심 연구분야는 레이저 용접, 절단, 코팅, 열처리 및 세정, 표면 및 박막기술, 기상증착, 공정 모니터링, 나노입자기술 등입니다.

51.1 Tailored Joining

Joining is a central production challenge and also a significant cost factor. In many cases current joining technology developments offer significant improvements and impulses. Therefore the Fraunhofer IWS in cooperation with the TU Dresden and other partners established the joining technology center “Tailored Joining”. The center is designed to provide an overview to users of joining technology, to show the different processes, their advantages and limitations. New developments will be presented and industrial solutions will be shown.

51.2 Battery Research

Research in the areas of electromobility as well as stationary energy systems is a central theme at IWS in Dresden. Important contributions can be provided to battery fabrication processes based on the numerous IWS manufacturing process technology development areas. To be in the position to offer solution to industry, the IWS is establishing a center for battery research.

The EU and the Free State of Saxony fund this project with 4 million Euros. IWS internal and Fraunhofer funds add 3 million. BMBF project funds contributed another 1 million Euros for equipment. This offers the best conditions to work on numerous public industry projects of which are listing here a selection

51.3 Energy Efficiency

The Fraunhofer IWS focuses its research on the advancement of resource-saving technologies and on the economical use of energy. Right from the beginning the IWS has implemented numerous technologies into industrial applications, which have benefited society and enterprises as a whole. One example is the development of a novel local heat- treatment technology, which is able to increase the energy-related efficiency of steam engines.

Another example is the IWS-developed laser welding technology applied for belly pod areas of different Airbus models enabling a significant decrease of the structure weight. In the case of the models A340 – 600 it became possible to save nearly 100 kilograms. With regard to primary structures our welding technology can even save up to 10 % weight.

The laser welding process has become nearly indispensable in mass production processes of car transmission parts. Considerable savings in terms of fuel and better energy efficiency have been achieved. Particular IWS friction-reducing coatings on motor components open up a novel way for fuel reduction. The IWS technology, in combination with the Diamor® deposition system is well on its way to a broad industrial application.

In 2009 the IWS-coordinated center “Dresdner Innovationszentrum Energieeffizienz DIZEEFF “was founded to advance the future topic “Energy efficiency” beyond its existing limits and to speed up innovations for the local economy.

The center joins scientists of the TU Dresden and of the Fraunhofer Institutes in numerous projects, which focus on highly efficient solar cells, fuel cells, high-temperature energy technology, lightweight construction and energysaving displays.

Current IWS developments focus on energy-harvesting processes through thermoelectric generators as well as on the reduction of magnetic losses in electric motors.

51.4 Additive Manufacturing

Additive manufacturing technology has led to a paradigm shift in manufacturing engineering. Thanks to the layer-bylayer generation material is only applied at the area where it is needed. The new manufacturing technology allows degrees of freedom for functional optimization and flexibility not seen before, beyond the limits of conventional manufacturing technology. There is a correspondingly high industrial interest in qualifying the additive manufacturing to a high industrial level.

The high potential of additive manufacturing is opposed to the large variety of unsolved issues. These issues can only be solved in a close collaboration between science and industry. Fraunhofer IWS initiated the project "Additive Manufacturing – Agent-3D" to advance the required collaboration. The consortium with its 60 partners establishes a strong network between industry and research organizations.

Within the framework DRESDEN-concept the scientists, together with partners of the TU Dresden, founded an internationally recognized competence center, in which material and manufacturing solutions for challenging products are interdisciplinarily developed. Presently the scientists focus on research fields such as aerospace, automotive industry, tool making, energy technology and medical engineering. In a rapidly developing high technology field the center offers an excellent networking platform for economy, scientific basic research and application-oriented research.

Our process portfolio includes

- laser buildup welding with wire and powder
- selective laser melting
- electron beam melting
- 3D printing technology

for metallic and intermetallic materials, polymers, functional materials and multi-material systems. With regard to procedures we offer developments for processes, for system and sensor technologies, and for on-line process diagnostics.

The research work of the center focuses on product chains comprising: component design, finishing and processing steps, repair and recycling. Testing and characterization of material and components produced with additive manufacturing technologies belong to the core competences as well.

51.5 Fiber Composite Technology

Lightweight structures, consisting of fiber composite materials and tailor-designed part geometries can excellently meet the demanding requirements to cost and energy-saving products. To reduce the costs for these structures, the scientists of the Fraunhofer IWS Dresden and experts from the Technische Universität Dresden focus their work to optimize this manufacturing process chain. Among others their foci include:

- controlled heat input through minimization of the interaction time with simultaneously high ablation rates using ultra-short pulsed lasers
- near-net-shape processing of consolidated and unconsolidated materials using the laser remote technology (remocut®FRP)
- generation of form-fitting joints applying generating and ablative procedures
- structural adhesive bonding of composite parts
- adhesive and laser fixing of fiber reinforced semifinished
- products
- inductively assisted adhesive bonding
- optimized material joining of hybrid components through tailored processing of contact areas by applying laser and plasma pretreating
- generation of reactive nanometer multilayers for high speed joining processes of thermoplastic fiber plastics composites
- laser assisted processes for the continuous carbonizing
- of stabilized precursor fibers for carbon fiber fabrication
- application of microwave radiation and microwave plasma
- for energy efficient carbon fiber fabrication
- fabrication of polymer fibers with diameters between
- 50 nm and 1 µm with integrated nanoparticles (e.g. carbon
- nanotubes)
- design and calculation of fiber composite components and metal fiber composite hybrid structures

52. Fraunhofer Institute for Nondestructive Testing IZFP

Website Link: http://www.izfp.fraunhofer.de/en.html

English: Fraunhofer IZFP offers its customers and research partners the entire range of nondestructive testing technologies, whether it involves basic or applied research.

Fraunhofer IZFP targets its activities toward nondestructive testing value chains within product lifetime cycles in key industries such as automobile manufacturing, aerospace, rail, energy, construction and agriculture by offering core NDT expertise and technologies designed for

- Electronics for NDT-Systems
- In-Service Inspection & Life-Cycle Monitoring
- Materials Characterization
- NDT of Components & Assemblies
- Production-Integrated NDT

Korean: 프라운호퍼 비파괴검사연구소(IZFP)는 기업 및 연구기관을 대상으로 기초 또는 응용연구 관련 각종 비파괴 검사(NDT) 기술을 제공하고 있습니다. 연구소는 다음 분야에 특화된 핵심역량 및 기술을 통해 자동차 제조, 항공우주, 철도, 에너지, 건설, 농업 등 주요 산업 내 제품수명주기의 비파괴검사 가치사슬을 중점적으로 다루고 있습니다.

- NDT 시스템용 전자
- 가동중 검사 및 수명주기 모니터링
- 소재 특성분석
- 부품 및 조립 NDT
- 생산통합 NDT

52.1 Electronics for NDT Systems

The Electronics for NDT Systems department develops innovative electronic modules for nondestructive testing solutions for and in collaboration with system integrators.

The activities focus on the development of new industrial-scale solutions for small-and-medium enterprises (SMEs) with the aim of giving them access to the market and the opportunity to independently maintain and support their products.

Internally, the department acts as a service provider for special electronics that are unavailable through the general NDT market. This includes transitioning laboratory prototypes to customized, industry-scale modules and carrying out the corresponding system implementation.

52.2 In-Service Inspection and Life-Cycle Management

The In-Service Inspection and Life-Cycle Management department develops nondestructive testing methods and processes designed to monitor and analyze the condition of structures over the course of their operational life. This work involves utilizing the entire spectrum of NDT processes, from ultrasound, electromagnetic and eddy current, to x-ray and thermograph.

52.3 Developing innovative testing methods for the determination of materials characteristics

The Materials Characterization department concentrates on laying the technical groundwork for carrying out material characterization, whether it involves researching physical test and measurement principles or developing industrial-scale inspection systems. To enhance and further develop nondestructive testing processes used in material characterization, the department focuses on merging various processes, improving spatial resolution and optimizing the inspection methods, with an emphasis on contactless measurements.

The testing methods are used in the development and production of new high-performance materials such as "smart materials" that feature sensor and actuator functionality, as well as multifunction, functionally graded, lightweight, fiber reinforced and other materials that have been in use for years. This involves not only metallic materials, but also construction materials. Miniaturized technology also allows the characterization of materials in microelectronics and micro systems.

52.4 NDT of Components and Assemblies

The NDT of Components and Assemblies department is engaged in the development and application of innovative nondestructive testing solutions with an emphasis on rapid, automated 3D inspections, data analysis and visualization (tomography-based), as well as in the fusion of data generated by different inspection methods and modes of operation (ultrasound/acoustic, thermograph, x-ray CT).

The department uses the available platform technology to rapidly transfer custom sensor and measurement and test technologies, especially software, into industrial test environments and applications with the aim of addressing complex issues. The flexible and certified transfer of innovative developments is carried out with an accredited lab that complies with DIN EN ISO/IEC 17025.

We offer fully tested and validated solutions that ensure the efficient production and reliable utilization of quality components.

53. Fraunhofer Institute for Cell Therapy and Immunology IZI

Website Link: http://www.izi.fraunhofer.de/en.html

English: The Fraunhofer Institute for Cell Therapy and Immunology IZI investigates and develops solutions to specific problems at the interfaces of medicine, life sciences and engineering.

One of the institute's main tasks is to conduct contract research for companies, hospitals, diagnostic laboratories and research institutes operating in the field of biotechnology, pharmaceuticals and medical engineering.

The Fraunhofer IZI develops, optimizes and validates methods, materials and products for the business units Cell and Gene Therapy, Drugs, Diagnostics and Biosystems Technology.

Its areas of competence lie in cell biology, immunology, drug biochemistry, biomarker, bioanalytics and bioproduction as well as process development and automation.

In these areas, research specifically focusses on the indications oncology, neuropathology, autoimmune and inflammatory diseases as well as infectious diseases and regenerative medicine.

The institute works in close cooperation with hospital institutions and performs quality tests besides carrying out the GMP-compliant manufacture of clinical test samples. Furthermore, it helps partners obtain manufacturing licenses and permits.

Korean: 프라운호퍼 세포치료 및 면역학 연구소(IZI)는 의학과 생명과학, 공학이 만나는 접점에서 특정 문제에 대한 솔루션을 개발합니다. 연구소는 생명공학, 의약 및 의료공학 분야의 기업, 병원, 진단 실험실, 연구기관을 대상으로 위탁연구를 수행하고 있습니다. 세포 및 유전자 치료, 의약품, 진단 및 바이오시스템 기술 등 3 개 사업부문으로 구성되어 있으며, 부문별로

최적화된 방법·소재·제품을 개발 및 검증하고 있습니다. 연구소는 세포 생물학, 면역학, 약품 생화학, 생물지표, 생물분석, 생물생산뿐 아니라 공정개발 및 자동화 부문에도 핵심역량을 갖추고 있습니다. 특히 징후, 종양학, 신경병리학, 자가면역 및 염증성 질환, 감염 질환, 재생의학 연구에 주력하고 있습니다. 또한 의료기관과 긴밀히 협력하여 품질검사를 수행하고, GMP 를 준수하여 임상검사 샘플을 제조하며 협력기관의 제조면허 및 허가 취득을 지원하고 있습니다.

53.1 GMP Cell and Gene Therapy

The Department of GMP Cell and Gene Therapy operates Fraunhofer IZI's three modern GMP facilities consisting of ten separate clean room suites (altogether 21 clean room grade B manufacturing rooms) which have been specially optimized for manufacturing of cell and gene therapy products, so called Advanced Therapy Medicinal Products – ATMP. The particular specialty of the more than 90 highly qualified staff members is the GMP-compliant manufacturing and quality control of investigational medicinal products.

GMP-compliant process and quality control development as well as the creation of Standard Operating Procedures (SOPs) are intensively discussed with the project partner before being implemented. The leading staff in charge has many years of experience in designing GMP-processes in the cell therapy area.

53.2 Therapy Validation

The department covers the following topics:

1) Planning and execution of preclinical efficacy and safety studies for new drug candidates (especially ATMPs) and medical devices (ISO 10993) under GLP or GLP-analogous conditions. This includes the development and validation of suitable in-vitro and in-vivo models.

2) Developing and optimising methods and processes for the diagnostic analysis of secretory and cellular protein biomarkers. This includes the development and production of specific monoclonal antibodies for detecting these biomarkers, as well as the development and validation of the corresponding diagnostic assays (e.g. ELISA, Luminex®, multicolour flow cytometry).

3) Identifying and validating new protein biomarkers for diagnosis and therapy of chronic inflammatory and tumour diseases, as well as for the sector of veterinary medicine / animal husbandry.

4) Developing human therapeutic monoclonal antibodies for the treatment of tumour and autoimmune diseases, as well as passive vaccines against bacterial toxins and pathogenic viruses, and their advancement to drug candidates.

5) Small-scale GMP production of therapeutic monoclonal antibodies for preclinical animal studies and clinical trials (Phase I and II).

53.3 Immunology

This area includes the development of methods for the stimulation or suppression of the immune system. One key topic is improving the smooth acceptance of transplants by inducing specific tolerance. Fraunhofer IZI develops techniques to monitor immunoreactivity and to monitor unwanted responses such as GVHD (graft versus host disease). It also develops vaccines on an innovative technology platform using plasmid DNA which are particularly safe, robust and inexpensive.

53.4 Cell Therapy

Our department develops and validates cell therapeutic methods in terms of safety, feasibility and efficiency. For this purpose, we maintain a plurality of model systems that enable the preclinical testing of novel concepts according to very strict quality criteria. In this manner, we ensure a high predictive value of our results for clinical implementation. A particular emphasis is on cell therapeutic methods for ischemic diseases like stroke and myocardial infarction, but also on methods for preventing degeneration and ageing of cells. Moreover, we investigate the "sleeping" potential of stem cells. We offer methods for the isolation and purification of cells from blood and tissues. We also develop special treatment methods employing T cell clones and natural killer cells for the treatment of tumors.

53.5 Diagnostics

In this field, Fraunhofer IZI is working on a new technology platform which enables RNA molecules to be identified and ascertained for their potential to effect the intracellular control of signal processes. This provides indications for the development of new drugs. Furthermore, Fraunhofer IZI develops pharmacogenomic and protein-chemistry techniques for the identification of individual-specific differences from which particular disease susceptibility, sensitivity to certain methods of therapy and even the course of disease can be predicted.

53.6 Automation

The department delivers solutions for complex laboratory automation tasks in biotechnology. Work here focuses on processes related to cell culture, expansion and monitoring and aims at increasing the efficiency, quantity and quality of cell products.

A further focal area is found in developing procedures and devices for a broad range of point-of-care applications. Among other things, an in vitro diagnostics (ivD) platform is available for this purpose, which can be adapted to different diagnostic tests depending on the task at hand. Furthermore, procedures and devices are also available for analyzing and using molecular interfaces and higher-order electronic effects.

Special importance is also assigned to developing procedures to gently dehydrate and fix dry reagents, which are used in all kinds of ways in diagnostics and analytics.

53.7 Molecular and Cellular Bioanalytics

The department develops Lab-on-a-chip systems for the cultivation, processing and analysis of cell samples. The chips can carry out important tasks with a combination of controllable polymer surfaces, dielectrophoretic elements, and fluidic microchannels, as well as suitable sensors. Long-term cultivation and monitoring of defined cell clusters likewise can be reliably performed, as can the micron-precise positioning of solitary cells or the sorting of heterogeneous cell populations.

The department addresses biotechnology issues at the interfaces of biological structures and technical systems. In order to do this, among other things, stand-alone sensor elements or analysis and database tools are developed, which can be applied to various issues from the fields of environmental analysis, food monitoring, herd management, process control and diagnostics. Besides developing point-of-care applications, e.g. for drugs and serum screenings, specific assays are also developed in the department for validating biomarkers. To this end, the department has recourse to a large and varied number of spotting and dispensing technologies.

By integrating biobanks into so-called metabiobanks, the department also facilitates and supports the web-based case-by-case and sample-by-sample search for human biospecimens and associated data across institutional and national borders.

53.8 Cell-free and Cell-based Bioproduction

Conservation of resources and creating more efficient material flows are the current challenges facing the economy and technological development. Particularly in the field of health, a sufficient and cost-effective availability of high-quality synthetic products is an important basis for progress. For instance, highly complex proteinogenic active ingredients are the basis for vaccine and antibody development. But in food technology as well as in the agricultural, cosmetics and detergent industries, requirements are continuously increasing on enzymes, complex peptides and proteins or on synthetic biomolecules in general.

Currently, these substances are often manufactured with the help of living cells or organisms. However, these systems are subject to considerable limitations. A large material and energy input must be spent to maintain the metabolism of the microorganisms or cell cultures themselves, thus limiting the cost effectiveness of this approach. In addition, many metabolites and final products are toxic, or have a toxic effect on cells or organisms in higher concentrations necessary for economical production . Therefore many important substances cannot be manufactured at all or only in small quantities.

The development of cell-free production of high-quality biomolecules offers completely new possibilities. The exclusive use of subcelluar components of the organisms necessary for the synthesis makes it possible to efficiently produce biomolecules with complex and also completely new characteristics in suitable reaction environments. The technologies established at the Golm site allow an economically efficient use of these processes, thereby creating a new foundation for the economic production of active proteins.

The department's extremophile research is engaged with cold-adapted snow algae. We focus on their use for extracting high-quality substances such as antioxidants or fatty acids. Accompanying product-optimised photobioreactors are also being developed. The culture collection CCCryo is a unique bio-resource that can be used by interested academic and private enterprise groups.

54. Fraunhofer Institute for Reliability and Microintegration IZM

Website Link: http://www.izm.fraunhofer.de/en.html

54.1 Institute Overview

English: Fraunhofer IZM’s focus is on packaging technology and the integration of multifunctional electronics into systems. Our four technology clusters

- Integration on Wafer Level

- Integration on Substrate Level
- Materials & Reliability
- System Design

cover all aspects of developing and integrating reliable electronics. The technologies and product solutions we develop are easily transferred to industrial processes. Moreover, the institute's equipment and infrastructure, to which all our customers have equal access, have been specifically assembled to approximate real-life industry conditions as closely as possible. We even introduce technologies on-site if requested. Our customer portfolio is as varied as the countless application areas for electronics. Although Fraunhofer IZM works with leading semiconductor firms and material, machine and equipment suppliers, we are equally focused on providing the next generation of electronics and microsystems for the automotive, medical engineering, safety & security sectors and even the lighting and textile industries.

Korean: 프라운호퍼 신뢰성 및 마이크로집적 연구소(IZM)는 패키징 기술 및 다기능 전자장치의 시스템 집적을 연구하고 있습니다. 웨이퍼 수준의 집적, 기판 수준의 집적, 소재 및 신뢰성, 시스템 설계 등 4 대 기술 분야는 신뢰할 수 있는 전자장치의 개발 및 집적에 대한 모든 것을 다루고 있습니다. 연구소가 개발하는 기술 및 제품은 산업공정에 손쉽게 적용 가능합니다. 연구소 내 장비 및 인프라는 모든 고객이 사용 가능하며, 실제 산업현장과 최대한 유사하게 설계되었습니다. 필요 시, 연구소는 현장의 기술도입도 지원하고 있으며, 광범위한 응용분야만큼이나 다양한 고객을 보유하고 있습니다. IZM 연구소는 주요 반도체 회사를 비롯하여 자재, 기계 및 장비 공급업체와 협력하고 있으며, 자동차, 의료공학, 안전 및 보안, 조명, 의류 산업을 대상으로 차세대 전자 및 마이크로시스템을 제공하고 있습니다.

54.2 Sensor Development

Micro-mechanical sensors are gaining increasing importance in application areas e.g. automotive, entertainment, industry especially due to their small form factor, light weight and lower production costs. Fraunhofer IZM offers a complete development – from requirements, concept, manufacturing of sensor elements to packaging and test – of sensors for the measurement of physical parameters e.g. pressure, acceleration, force, gas concentration. For the realization of micro-mechanical sensors, different physical semiconductor effects can be used of to achieve a sufficiently high sensitivity and satisfying linearity.

54.3 3D Integration

3D system integration is one of the most important topics in current packaging and interconnection. Based on the vertical stacking of system components the concept offers specific advantages with regard to the heterogeneous integration of different components, such as sensors, processors, memories or antennas.

The use of the third dimension not only allows for more compact packaging, but also for shorter electrical interconnects, which in turn makes the entire system more powerful and efficient.

Current projects are focused on vertical integration of systems based on logic- and memory- or sensor chips as well as transceivers and antennas. Therefore through silicon vias (TSVs) are created into the devices at wafer scale to enable vertical routing of electrical signals from their top to their bottom side as well as subsequent vertical stacking.

The established TSV middle or TSV last processes comprise via formation by dry etching, via isolation, via metallization by copper filling, high density multi layer wiring, wafer thinning as well as handling and processing of ultra thin wafers.

The same technology is used to create silicon interposers with vertical through contacts as well as which act as component carriers or adapters between integrated circuits with highest IO densities and organic carriers.

54.4 Wafer Level Packaging

Wafer Level Packaging is a synonym for the whole technology spectrum enabling direct chip attachment on PWB or other substrates by Flip Chip Interconnection. In contrast to pure bumping processes additional thin film wiring layers are required featuring a higher level of integration by embedding active or passive devices onto the chip. The technology is feasible for any kind of CMOS wafers but also for III/V or even sensors.

The basic process is the so called redistribution process based on thin film technology. Thin film polymers like PI, BCB, PBO, Epoxy or other polymers or even thin glass layers are used for the electrical isolation between the layers and the mechanical and electrical decoupling to the base wafer. The metal routings are deposited by a combination of sputtering and electroplating using a photo resist process. Mostly Cu is used with a diffusion barrier and adhesion layer of TiW or pure Ti.

The final metallization can be adapted to the required bonding process for the next level of integration. Solder balls are deposited for standard FC-assembly. The size of the solder balls can be varied from ultra-fine pitch of 20 µm using electroplated bumps to the well established area array pitch of 500 µm using large preformed balls using ball drop. Thick Au (typically 5 – 20 µm) is used for a final metallization if an adhesive joint (ACA, NCA) is required on a board, glass or a flex. The final metallization can also be adapted to wire-bonding interconnection using Au or Al.

The emphasis of Fraunhofer IZM is in a custom-specific development or prototyping. The technology can be adapted to nearly all applications and requirements. Process transfer is an option for production.

54.5 High Density Assembly

Assembly and interconnect technology has to meet different requirements from microelectronics, MEMS, photonics, RF and power electronics and deals accordingly with Si, SiC, GaN, GaAs, InP, Ge and other semiconductor materials. Reflow soldering, transient liquid phase bonding (TLPB), thermocompression and thermosonic bonding are the favored interconnection methods for flip chip attach.

Assembly and interconnection technologies applied to 3D systems are strongly affected by IC technology nodes. Key parameters include die size, number of I/O, pad geometries, passivation layers, wafer-surface topologies, terminal pads and limitations to the thermal budgets that can be applied during assembly. Additional challenges in assembly and interconnect technologies for 3D systems include alignment accuracy, yield requirements and productivity that meet the demands of cost effective manufacturing.

Furthermore, WLSI has broad experience in fluxless assembly methods for photonics and MEMS as well as in hermetical sealing. Precision bonding with an alignment accuracy of 1 µm will be achieved for photonic applications using either thermode bonding with high positioning accuracy or with solder-assisted self-alignment methods – with or without mechanical stops.

54.6 Hermetic MEMS & Sensor Packaging

The combination of active or passive TSV silicon interposer wafers with cap wafers by wafer to wafer bonding technologies offers new possibilities for hermetic wafer level packaging of MEMS components. Based on its 200 mm / 300 mm compatible advanced wafer level packaging process lines, Fraunhofer IZM can support such new hermetic wafer level MEMS packaging concepts.

Process Scheme

The process scheme includes TSV formation into passive interposer or active CMOS wafers including wafer thinning and thin wafer processing on temporary carrier wafers for TSV back side reveal and RDL / contact formation at wafer back side. Following, the MEMS are assembled onto the back side of the thin TSV wafer which is done by sequential or collective die to wafer bonding. Additionally, cap wafers are manufactured with recesses and metal bond frames to fit exactly to the corresponding TSV wafers with the mounted MEMS. Finally, the cap wafers are bonded to the TSV wafers using a dedicated soldering regime. With that, all mounted components can be hermetically sealed in inert atmosphere or vacuum.

54.7 System Integration & Interconnection Technologies

The range of services provided by the department System Integration and Interconnection Technologies (SIIT), which has more than 100 employees, spans consultation, to process development, right through to technical system solutions. Developing processes and materials for interconnection technologies on board, module and package levels and the integration of electrical, optical and power-electronic components and systems are at the forefront of our research.

We assist companies with application-oriented pre-competitive research, as well as the development of prototypes and small volume production. Our services include application advice, technology transfer and further qualification of personnel through practical training.

54.8 Environmental & Reliability Engineering

New products and technologies have to comply with an increasing range of strict specifications, and at the same time have to be cost-efficient and environmentally friendly. The Department Environmental and Reliability Engineering supports technological developments until they reach market maturity with environmental and reliability analysis reaching from nano-characterisation level to evaluation and optimisation at the system level. Under the joint leadership of Dr. Nils F. Nissen and Dr. Olaf Wittler, a unique combination is achieved between the established cross-sectional specialist fields of reliability and sustainability.

In view of worldwide extending markets and limited resources, every new generation of products and technologies must generate more functionality and assured reliability while consuming fewer resources. Without adequate reliability, the commercial success of an application is anyway endangered, and at the same time the environmental impactof typically production-intensive microelectronics is increases furtherby premature failures or the need for replacements. Sustainable electronic technologies must therefore be reliable and have a low environmental impact.

54.9 RF & Smart Sensor Systems

The Department of RF & Smart Sensor Systems (R3S) researches methods and tools for the targeted, technology-oriented design of electronic systems. By simulating thermal and mechanical coupling and electrical, magnetic, electromagnetic phenomena at stages of the development process, we can compare the functionality and capacity of different technologies as early as during the concept design phase. Our services include functionality, volume, reliability and cost analyses, which can all be carried out at the earliest stages of the design process.

Using new methods and tools, we develop technology demonstrators and prototypes for electronic assemblies and embedded systems. The most important application areas are:

- Microelectronics and microsystem technology
- RF and high-speed system design
- Power electronic systems

54.10 Oberpfaffenhofen Trainings & Analytics

The Fraunhofer IZM Oberpfaffenhofen (near Munich) branch is home to both the Micro-Mechatronics Center (MMZ) and the Center for Interconnection Technologies (ZVE). All topics relating to simulation, micro-mechatronics, interconnection technology, crimping, encapsulation and components are researched. Certified training in soldering is also provided.

The integration of electronic systems and micro-mechatronics also leads to fundamental changes in the application, namely the merging of form and function. Industry sectors like aeronautics and space travel, medical engineering and automotive technology are looking for light, functionally integrated, cost-efficient and highly reliable alternatives to conventional multicomponent parts, which are usually screwed, glued or plugged together (mechatronics).

Our research and development focuses on the following:

- Cross-technology innovations for qualifying electronic systems.
- Assembly of non-planar electronic and mechatronic systems.
- Development of direct digital manufacturing (DDM), generative technologies, ink-jet printing processes and the corresponding analysis techniques.
- Improvement of rework and repair processes for component and microsystem interconnection.
- Application of non-solder joining techniques like crimping and press-fit connections.
- Development of methods for time- and cost-saving in-situ monitoring of parameters critical in product qualification.
- Analysis of modules and new components.
- Specialized soldering processes (induction, plasma, selective and laser soldering).
- Development of new qualification and reliability criteria, such as for condensing and electro-mobility.
- Training in soldering according to certified standards (IPC; ESA, DVS, AZWV).
- Further development of workshops (particularly in areas such as medical applications and solar technology) and continuing education courses in interconnection techniques

55. Fraunhofer Institute for Structural Durability and System Reliability LBF

Website Link: http://www.lbf.fraunhofer.de/

55.1 Institute Overview

English: At the Fraunhofer LBF, comprehensive material and energy-efficient solutions are developed in the areas of vibration technology, lightweight construction, reliability and polymer technology – tailored to the individual needs of each customer. Fraunhofer LBF reaches a number of different markets with its characteristic, wide-reaching competence and service portfolio, particularly in rail transport technology, ship building, aviation, mechanical and plant engineering, energy technology, building industry, medical technology and the chemical industry.

Korean: 프라운호퍼 구조적 내구성 및 시스템 신뢰성 연구소(LBF)는 진동기술, 경량건축, 고분자기술 분야에서 고객의 니즈에 최적화된 소재 및 에너지 효율적 솔루션을 포괄적으로 제공하고 있습니다.연구소는 철도교통기술, 조선, 항공, 기계 및 설비공학, 에너지, 건축, 의료, 화학 부문을 아우르는 광범위한 역량과 서비스 포트폴리오를 통해 다양한 산업을 지원하고 있습니다.

55.2 Large-Scale Research Systems

Additionally to the three material science oriented research departments, the division of polymers runs a forth department which maintains large-scale research systems needed for intra-departmental collaboration, promotes problem oriented solutions and also fosters specific developments in internal projects. Internal projects include NMR-Spectroscopy, scanning electron microscopy, transmission electron microscopy, pilot plants for compounding, injection molding, and high throughput screening or film extrusion.

55.3 Polymer Processing and Component Design

The properties of polymers are linked stronger to their particular processing conditions, compared to any other class of material. The fundamental research focus for the Department of Polymer Processing and Component Design lies within the examination of process chains ranging from the compounding of the material, to the processing of parts, up to the prediction of mechanical properties of these parts. This includes in particular the formation of process induced internal structures and internal stress as well as their consideration in the design of the component.

The many years of experience in the field of compounding includes expertise in technical thermoplastics and high performance polymers, compounds with an extremely high content of filler material, the control of reactive processes in extruders, and further developments in the compounding technologies, such as the optimization of the degassing performance of high performance double screw extruders. The development and consolidation of these technologies is assisted by fluidic simulation of compounding processes.

In the area of plastics processing the focus lies on injection molding and film production processes. Work priorities in material modeling are material behavior under high load velocities and multi-axial strains.

55.4 Polymer Synthesis

Polymers in different compositions and forms play an increasingly important role in our everyday lives. They stand for important development tendencies such as light-weight design, electronification, energy revolution, safety and many more, more than any other material. At the same time the requirements plastics have to meet become higher and more and more complex. There are a number of approaches to fulfill these requirements, for example additive reactive processing, formulation of new polymers, composite materials and many more. At the very beginning of all these possibilities lies an efficient chemical synthesis of new compounds.

Technological and material scientific specifications are translated into chemical substances and formulas with the expertise of our division and the close cooperation at Fraunhofer LBF. Additionally to the development of chemical synthesis of monomers, polymers, additives and reactive modifiers, a complete characterization of the substances is included with the option of technical optimization of the synthesis process and the up scaling, to provide the respective substances in sufficient quantities. Moreover the newly developed polymers and polymer formulations are tested in their material characteristics and processing properties. Hence we are able to picture the entire value chain from the beginning, with the development of the chemical synthesis to the finished part and predict further developments through analytical characterization.

55.5 Formulation Development and Durability

Many polymers achieve their full efficiency and applicability in longtime application areas only with effective additives. Through additives, polymers can be developed conform to their specification by purposefully configuring surface properties, morphology and polymer architecture. High performance stabilizers, this meaning anti-oxidants and light-stability agents, guarantee long-lasting properties even under challenging conditions. For the development of formulated polymer systems the department “Formulation Development and Durability” combines analytical and physical measurement methodology in the research groups “Additives”, “Interface Design”, “Material Analytics” and “Morphology and Dynamics”. Material safety and reliability (fatigue, aging, flammability, health hazards), failure characteristics and resource efficiency are essential areas of research. Furthermore the focus lies on the development of analytical methods for high performance polymers, fracture mechanics of multiphase resin-systems, also under influence of different media, the examination of the kinetics of reactive processes, the control of interfacial surface properties, especially of filled and reinforced systems, and the development of plastic additives from the synthesis unto long-term testing (stabilization, flame protection, plastics modification).

56. Fraunhofer Institute for Medical Image Computing MEVIS

Website Link: http://www.mevis.fraunhofer.de/en.html

English: Fraunhofer MEVIS develops interactive assistance systems for clinical routines. This development focuses on medical image data used in early detection, diagnosis, therapy planning, therapy support, or follow-up.

In close cooperation with clinical experts, the entire process is considered: from image generation and analysis to interpretation and therapeutic decision-making. From these medical images, diagnostic or treatment-relevant information can be extracted to supplement patient data and laboratory values and individualize them for each patient using biophysical numerical simulations.

This contributes to earlier, more accurate disease detection and therapy decisions that are tailored to each patient and evaluated in terms of risk. The success of each therapy becomes more understandable and measurable.

Korean: 프라운호퍼 의료영상 컴퓨팅 연구소(MEVIS)는 일상적 임상을 위한 인터랙티브 지원시스템을 개발하고 있습니다. 특히, 조기발견, 진단, 치료계획, 치료지원, 사후관리 등에 사용되는 의료영상 데이터 개발에 주안점을 두고 있습니다. 연구소는 임상 전문가들과의 협력하에 영상의 생성, 분석, 해석에서 치료 의사결정에 이르는 전 과정을 연구하고 있으며, 의료영상에서 진단 또는 치료 정보를 추출하여 환자 및 실험 자료를 보완하고, 생물물리학적 수치 시뮬레이션을 통해 환자별 분석을 수행하고 있습니다. 이러한 과정을 통해 보다 빠르고 정확하게 병변을 발견하여 환자별로 최적화된 치료 의사결정을 내리고, 그에 따른 위험을 분석할 수 있습니다. 또한, 치료의 성공요인에 대한 이해도를 증진시키고 그 성공률을 측정 가능하게 합니다.

56.1 Applicable Image Analysis Solutions

Image processing and analysis is core technology that permeates most of the work at Fraunhofer MEVIS. Image segmentation plays a particularly important role for measurements, visualization, and modeling. Our primary goal is to deliver robust, efficient, and directly applicable solutions for clinical problems. Always up to date in the state of the art, we identify the most suitable methods and tailor them to specific requirements. Successful participation in various technical challenges proves our scientific excellence. While open-source tools are becoming more widely available, our outstanding experience with diverse kinds of medical image data remains a hallmark.

- Advanced Computer Vision with Object-based Image Analysis
- Quantitative Oncological Follow-Up Assessment
- Multimodal Vessel Assessment
- Neurological Follow-Up Studies

56.2 Solutions

In many of our projects, large collections of data emerge. Those big data sets stem from population-based studies, interdisciplinary clinical research projects, or simply have accumulated over time. Using state-of-the-art machine learning techniques like Convolutional Neural Networks and other Deep Learning architectures, we explore the wealth of information contained in this clinical data. In close collaboration with the DIAG group in Nijmegen (NL), our aim is to automate data analysis processes in areas where computer intelligence can relieve doctors from repetitive tasks.

56.3 Applicable Image Registration

Image registration is a key technology in image-based medicine. The goal of registration is to harmonize medical imagery gathered from different modalities, capture times, or patients, so that this information may be evaluated together. Only reasonable image fusion allows clinicians to diagnose or monitor therapy reliably

Fraunhofer MEVIS provides applicable image registration solutions for every medical setting. The main focus is always on robust, reasonable, accurate, and efficient solutions. The integration of additional, anatomy-based information enables us to develop problem-tailored, individualized methods that yield the best outcomes.

56.4 Image Acquisition

Magnetic Resonance Imaging continues to have a high impact from basic research to routine clinical practice. The MR physics group at Fraunhofer MEVIS covers the complete scope of MRI applications from the simulation of underlying physical phenomena to the design of pulse sequences and their application in medicine and clinical research.

56.5 Modeling and Simulation

We develop models and simulations of biophysical and biomedical processes for clinical use and in close collaboration with the other sub-disciplines of medical image computing. In addition to these application-driven developments, we also perform basic research to enhance expertise and explore future application areas. We consider validation of the models indispensable for translating the models to the clinic and for gaining acceptance by industrial partners and doctors.

- Software Assistance for Interventional Radiology
- High-intensity Focused Ultrasound: Software Assistance for Tumor Therapy
- MEVISFlow: Non-invasive Interactive Exploration of In-Vivo Hemodynamics

56.6 Software Technologies

Rapid Prototyping using MeVisLab

Using the MeVisLab software platform created at the institute and today co-developed with our industry partner MeVis Medical Solutions AG, MEVIS developers can access a wide range of reusable algorithmic building blocks. MeVisLab was specifically developed to permit both highly flexible development and product-ready software implementation. Functional prototypes can be quickly developed and tested in clinical settings. Among other features, Fraunhofer MEVIS' internal development environment includes:

- Graphical programming of complex, hierarchical networks from high-performance C++ modules
  - 6000 modules developed by and available exclusively to Fraunhofer MEVIS
- Generic Insight Toolkit (ITK) and Visualization Toolkit (VTK) integration
- Flexible and dynamic 2D/3D visualization and interaction tools
- Application development using OO GUI design and Python scripting
- Server-based rendering
- DICOM support and PACS integration

57. Fraunhofer Institute for Algorithms and Scientific Computing SCAI

Website Link: http://www.scai.fraunhofer.de/en.html

English: The Fraunhofer Institute for Algorithms and Scientific Computing SCAI conducts research in the fields of computational science, optimization and bioinformatics, and is a prominent corporate partner in the industrial and science sectors.

SCAI designs and optimizes industrial applications, implements custom solutions for production and logistics, and offers calculations on high-performance computers. Our services are based on industrial engineering, combined with state-of-the-art methods from applied mathematics and information technology.

SCAI especially excels in coupled simulation of different physical disciplines, and develops software for visualization of calculation results. In bioinformatics, SCAI offers workflow-oriented and integrated IT infrastructures for information extraction. SCAI has accumulated specialized expertise in both structured storing and administration of data and research results, and in the organization of projects.

Korean: 프라운호퍼 알고리즘 및 과학 컴퓨팅 연구소(SCAI)는 계산과학, 최적화 및 생물정보학 연구를 수행하고 있으며, 기업 및 연구기관과 활발히 협력하고 있습니다. 연구소의 주요활동은 산업 응용기술 설계 및 최적화, 생산 및 물류 관련 맞춤형 솔루션 적용, 고성능 컴퓨터를 이용한 계산 등이며, 산업공학, 최신 응용수학 및 정보기술을 바탕으로 한 첨단 연구방식을 활용하고 있습니다. 특히, 학제간 융합형 시뮬레이션과 계산 결과의 시각화 소프트웨어 개발 분야에서 두각을 나타내고 있습니다. 생물정보학 분야의 경우, 업무흐름 위주의 통합형 IT 인프라를 제공하여 정보추출을 지원하고 있습니다. 또한, 데이터 및 연구결과의 구조화 저장 및 관리, 프로젝트 조직 분야에서 전문성을 보유하고 있습니다.

57.1 AutoPanelSizer

The software AutoPanelSizer identifies -optimized cutting layouts for the -production of rectangular parts from -rectangular stock material and minimizes the waste. It only generates layouts that can be produced with so-called guillotine cuts. These are cuts that dissect the sheet – or later the remainder of the sheet – by a cut at right-angles to the workpiece and thus separate it into two rectangles (see -examples part 1). Thereby, the software models a common technology for cutting rectangular parts, applied in particular for the machining of wood but also in the glass, metal, and plastics manufacturing industries.

In industrial manufacturing, typically interlinked saws are used. For example, a first saw cuts the sheet into stripes, while a second saw then cuts these stripes into parts with cuts that are perpendicular to the cutting direction of the first saw. Each saw in the combined system forms a so-called stage. Such a design of sawing facilities leads to additional restrictions for the cutting layout, because there are only as many stages possible as saws available. AutoPanelSizer takes into account -restrictions on the number of stages.

Furthermore, AutoPanelSizer can compute layouts with trim cuts after the last stage and head cuts in the first stage (see -examples part 2, 2 and 3, respectively). The software also incorporates miscellaneous constraints such as that are given by the machine or material properties. The -available rest pieces can be included in the optimization as can different sizes of stock material sheets. In addition, the -software can account for manufacturing costs for expensive processes, such as head cuts, or the storage of rest pieces after -cutting on the basis of adjustable parameters.

57.2 AutoNester-T

AutoNester-T is a software package for automatic marker making on fabrics. It is widely used in the garment and upholstery manufacturing industry. It is able to nest any set of pieces within a very short time in an optimal way, minimizing wasted material, while taking into account various types of constraints. The efficiency of the markers achieved by AutoNester-T is competitive to experienced human nesters.

The AutoNester-T software is organized as a Dynamic Link Library (DLL) to be used as a developer's tool kit. Developers of CAD-systems can integrate AutoNester-T into their software.

We also offer the creation of custom-made standalone applications for the end user which can be used to create markers from special data formats.

AutoNester-T is constantly improved and more and more kinds of constraints are incorporated. Currently, the following constraints are supported:

- stripe and plaid
- pre-placed pieces
- folded and mirrored pieces
- folded markers

- nap and flip restrictions
- bundle support
- rotation adjustable
- tilt support
- splitted pieces
- dynamic halfpiece sharing
- holes and defects in the fabric
- splice marks
- goal efficiency
- time limits
- unrestricted number of pieces

57.3 AutoNester-L

AutoNester-L is a software package for automatic marker making on leather hides. It is widely used in the leather and car manufacturing industry. It is able to nest any set of pieces within a very short time in an optimal way, minimizing wasted material, while taking into account various types of constraints. The efficiency of the markers achieved by AutoNester-L is competitive to experienced human nesters.

The AutoNester-L software is organized as a Dynamic Link Library (DLL) to be used as a developer's tool kit. Developers of CAD-systems can integrate AutoNester-L into their software.

We also offer the creation of custom-made standalone applications for the end user which can be used to create markers from special data formats.

AutoNester-L is constantly improved and more and more kinds of constraints are incorporated. Currently, the following constraints are supported:

- up to 16 different quality levels of the leather
- quality zones on the pieces and the surfaces
- holes in the surface
- free rotation of the pieces

For a full description of the software's capabilities please have a look into the documentation.

AutoNester-T is coded in a platform-independent way and runs under Windows 95/98/ME/NT/2000/XP/Vista and Windows 7. Other platforms are supported on request.

57.4 CutPlanner

CutPlanner is a software package for use in the textile manufacturing industry for automatic cut order planning. CutPlanner takes a customer's order for a clothing item and creates a cut plan for that item, including different sizes and different fabric types or colors, which minimizes production costs.

57.5 AutoCompactor

AutoCompactor is a new product of Fraunhofer SCAI and is intended to replenish the nesting functionality of AutoNester by an improved compaction algorithm. It takes markers which are generated by humans or automatic nesting software and tries to compact these markers by reducing their length. AutoCompactor is capable of considering nearly the full range of constraints which are supported by AutoNester. AutoCompactor also can be enabled to slightly modify the structure of the piece layout to further improve the result.

57.6 PackAssistant

The development of packaging solutions for the safe and efficient transportation of parts of cars, machinery or equipment from suppliers to the assembly line was previously an expensive fiddly job. Now the optimization software PackAssistant calculates the ideal filling of transport boxes with identical parts in a few minutes. The utilization of (storage or transport) containers based on the filling schemes computed by PackAssistant is far higher than solutions realized by even experienced packing designers. PackAssistant is in use worldwide especially in the automotive industry by numerous manufacturers and suppliers. Since the software can already be applied while the prototype is still under construction in the CAD-system, transport and storage can be planned early, fast and reliably.

PackAssistant enables the user to handle different types of packaging. These include packing with solid or flexible intermediate layers, with compartments or in stacks, and the simulation of loose goods. These include packing with solid or flexible intermediate layers, with compartments or in stacks, and the simulation of loose goods. In addition, parameters for customer-specific packing solutions are available:

- Possibility to select the minimum distance between parts, the container base and walls, and compartments. Compartments are particularly important to protect plastic objects from scratching.
- In order to facilitate the stability of the container, it is possible to define stable positions for the parts.
- Compute the minimum volume bounding box of a single part.
- Automatic choice of an appropriate container from a list.
- Loading in stacks: In addition to arranging objects in layers, PackAssistant can also load them in stacks. This is particularly suitable for thin-walled objects, whereby stacking can be vertical or slanted.
- Filling with loose goods: Small parts are often not put into a container in an orderly fashion but are simply allowed to fall from a curveyor belt into a container. PackAssistant can estimate how many parts fit into a container by simulating the
- physical behavior of each part, i.e. by simulating gravity, velocity and collision among parts.

The utilization of space calculated by PackAssistant usually excels that of experienced human planners. The software can be used at the same time while the Computer-Aided Design (CAD) of the parts to be packed is still going on, and thus enables early, rapid and reliable planning of transportation and storage of parts.

PackAssistant is a joint development of the company MVI Solve-IT GmbH and of Fraunhofer SCAI.

The graphical user interface, all interfaces and data management are provided by SOLVE-IT, a member of the MVI Group which specializes in overall software solutions for the automotive industry.

Based on result of the latest research Fraunhofer SCAI develops algorithms for solving three-dimensional packing problems in industry. PackAssistant benefits from the institute's long years of comprehensive algorithmic experience in the field of optimization and packing.

57.7 MpCCI CouplingEnvironment

The MpCCI CouplingEnvironment has been developed in order to provide an application independent interface for the direct coupling of different simulation codes. MpCCI CouplingEnvironment has been accepted as a ‘de facto’ neutral standard for simulation code coupling and provides a multi-physics framework. Within the MpCCI CouplingEnvironment the engineer can combine several ready to use models, define the application field and choose for the best-fit coupling method.

57.8 DesParO

Computer-aided simulations of technical processes and products commonly depend on many parameters, e.g. geometrical, material and process-controlling parameters. Engineers are interested in configurations of these parameters which optimize the production process as well as product features and quality.

DesParO is a software package for intuitive exploration and automatic analysis and optimization of such parametrized problems. DesParO can be coupled with simulation packages or can be used for measurement data. In particular, it focuses on keeping the number of simulations / experiments small which are needed for analysis or optimization. Moreover, simulations / experiments follow an experimental design (design-of-experiment, DoE) and therefore can be performed in parallel. Hence, DesParO is particularly useful for time- or ressource-intensive simulation runs or costly physical experiments.

In addition to DesParO licenses, training and studies, we offer consulting for interpolation, statistics and optimization and help in setting up strategies and finding suitable methods and tools.

57.9 Multiphysical Network Simulator MYNTS

MYNTS, our multiphysical network simulator, currently supports, for instance:

- MYNTS-Gas: simulation, analysis and optimization for gas transport networks, e.g. for TSOs or caverns
- MYNTS-Circuit: circuit simulation with tightly integrated device simulation
- MYNTS-EPower: simulation and analysis of electrical power networks, e.g. power flow analysis

More applications of MYNTS include cooling circuits, water, energy management and oil reservoirs (in particular, for comparative analysis of history-matched scenarios). If you are interested in these or other configurations, please contact us.

Special features include:

- user-programmable subnetworks with masters for instrumentation and control
- atomic elements and open modeling
- steady-state and transient calculations
- efficient numerical kernels (multi-core)
- several optimization tasks already pre-configured (continuous, single-criterion)
- coupling with DesParO for metamodelling (response surfaces), intense statistical analysis and (continuous) multi-objective optimization tasks

57.10 Algebraic Multigrid Methods for Systems

SAMG (Algebraic Multigrid Methods for Systems) is a library of subroutines for the highly efficient solution of large linear systems of equations with sparse matrices. Such systems of equations form the numerical kernel of most simulation software packages. Usually, the numerical solution of these linear systems of equations needs most of the computational time of the whole simulation.

Compared to classical methods (e.g., the ILU-preconditioned conjugate gradient method), SAMG has the advantage of being almost unconditionally numerically scalable. This means that the computational cost using SAMG depends only linearly on the number of unknowns. Depending on the application and problem size, the computational cost can be reduced by one to two orders of magnitude. SAMG can be incorporated into an existing software package as easily as any classical method.

57.11 ProMiner

The performance of ProMiner recognition of gene and protein names was tested in the international “Critical Assessment of Text Mining in Biology” (BioCreAtIvE I and BioCreAtIvE II). ProMiner was benchmarked against other industrial and academic named entity recognition tools. Updated and new generated dictionaries are continually evaluated in industrial applications.

57.12 chemoCR

chemoCRTM makes chemical information contained in depictions of chemical structures accessible as connection table for computer programs.

In order to solve the problem of recognizing and translating chemical structures in image documents, our chemoCRTM system combines pattern recognition techniques with a chemical rule based expert system. The method is based on the idea of identifying the most significant fragments of small molecules from depictions. The workflow consists of three phases: image vectorization, chemical entity extraction and molecule reconstruction.

57.13 Tremolo-X

An essential basis for designing novel materials is the understanding of their properties on the nanoscale. Molecular dynamics are an important tool for the analysis of a material on that scale.

To this end, we offer Tremolo-X, a massively parallel software package for numerical simulation in molecular dynamics. Here, much emphasis has been placed on the parallel implementation and its efficiency. In addition, a user-friendly graphical interface is being provided. Tremolo-X has been successfully applied within various projects in different fields of applications, e.g. nanotechnology, material science, biochemistry and biophysics.

57.14 SCAIView

SCAIView is a knowledge discovery software for the life sciences. It facilitates- the rapid identification of aggregate-d information from large text sources. For this reason it integrates the results of ProMiner with the associated text and allows semantic search.

58. Fraunhofer Institute for Secure Information Technology SIT

Website Link: https://www.sit.fraunhofer.de/en/

English: The Fraunhofer Institute for Secure Information Technology SIT is the leading expert for IT Security and develops solutions for immediate use, tailored to the customer's needs.

Over 160 highly qualified employees covering all areas of IT security make such customized services possible. The staff constitutes the competency foundation for cross-technological services at the highest level.

Fraunhofer SIT is active in projects for companies from all kinds of industries. Numerous successful projects carried out with international partners are the resounding proof for trustful and reliable cooperation.

Korean: 프라운호퍼 정보보안기술 연구소(SIT)는 IT 보안 분야의 선도 연구기관으로 고객의 니즈에 최적화된 즉시 활용 가능한 솔루션을 개발하고 있습니다. 160 여명의 임직원은 최고 수준의 융합 기술 연구역량을 기반으로 IT 보안 전반을 아우르는 맞춤형 서비스를 제공하고 있습니다. 연구소는 각종 산업 부문의 기업들을 지원하고 있으며, 국제적 제휴 등을 통해 협력사업을 활발하게 전개하고 있습니다.

58.1 BizzTrust for Android

In many enterprises smartphones are part of the corporate culture, but often these devices do not fulfill the necessary security requirements. With BizzTrust, Fraunhofer SIT develops a solution that protects sensitive enterprise services and data without restricting the system's functionality or the user access to personal data and applications.

Business users increasingly use employer-issued smartphones for personal as well as business applications (apps). However, in current devices little infrastructure is available to facilitate remote management and enforce enterprise security policy. Moreover, the use of smartphones for personal as well as business purposes increases the exposure to unknown software and unauthorized parties, putting the enterprise’s data and services at risk.

58.2 OmniCloud

In spite of the advantages offered by cloud services, many companies have great concerns about entrusting their business data to a cloud storage service.

Fraunhofer SIT provides with OmniCloud a solution that helps companies use cloud storage services safely. The basic idea of OmniCloud is to connect any number of applications and backup software with any cloud storage service. OmniCloud ensures the confidentiality of stored data - irrespective of the actual security mechanisms or recent security incidents at cloud providers. With OmniCloud companies are able to take advantage of cloud storage offers in a safe way and thus reduce costs in securing their digital data. Further, OmniCloud supports businesses efficiently when changing the cloud provider and thus prevents unwanted vendor lock-in.

58.3 Key2Share

Key2Share is a new solution for NFC-enabled Android smartphones that allows enterprise employees to access offices and other enterprise premises using digital access control tokens stored on their mobile phones. The Key2Share app utilizes Near Field Communication (NFC) technology, which enables the phone to emulate a contactless smartcard that can be used with standard contactless smartcard readers.

The Key2Share app allows an enterprise to distribute and manage the digital access control tokens of its employees in an efficient and controlled way. Tokens can be issued and revoked remotely, delegated to other employers or visiting guests, and support context-aware and time-limited access control policies. These policies may, e.g., deny access to office rooms during weekends and holidays, or specify whether tokens can be delegated to other users. Electronic door locks can provide access logs for auditing, or unlock all exits in case of emergency (such as fire or earthquake).

Storing and handling digital access control tokens on a mobile phone raises risks of being targeted by attacks. Particularly, in the context of enterprise usage scenarios attackers may be motivated to perform sophisticated attacks. These risks are addressed by the underlying platform security architecture, which protects digital access control tokens on the smartphone. It provides a secure storage and a secure execution environment, where digital tokens can be securely stored and processed in strict isolation from untrusted and possibly malicious code. Using digital access control tokens on NFC-enabled smartphones offers positive user experience to employees and provides security, convenient management and strict access control enforcement to enterprises.

58.4 Digital Watermarking Container

The container technology developed at Fraunhofer SIT is an efficient solution for individually marking large amounts of media data (transactional watermarking). This is used for example by online shops to mark downloaded data with information about the purchase or the buyer.

The watermarking embedding process is divided into two phases: First the total amount of information to be embedded, the secret key and other parameters are defined. Then the original data is converted into the container format. To create an individually marked file, only the information to be actually embedded is then necessary. Performance (on current off-the-shelf PCs) is roughly twenty times real-time for CD production and even 500 to 1000 times real-time for the creation of mp3 files.

58.5 Watermarking in Shops

Digital audio watermarking technology has been integrated successfully many times since 2004 in online shops selling mp3. The container technology used for this allows fast and individual watermarking without any perceivable quality degradation. The publisher Digerot Media for example offers thousands of audio books from dozens of publishers through its online portal that are protected by Fraunhofer digital watermarking technology. The music service akuma.de has more than 500.000 songs of thousands of music labels in its catalogue protected in such a way as well. While the customers of both companies can use the audio data without any technical restrictions such as may be posed by older mp3 players or devices installed in the car, the rights owners still have a control instrument allowing them to pursue copyright violations. This makes watermarking technology a good compromise in negotiations with rights holders.

58.6 Secure mobile VoIP

Fraunhofer Institute SIT addresses various aspects of Voice over IP security and the security of mobile systems. The prototype J2ME application »Secure mobile VoIP«, which can be used on current mobile phones, demonstrates the use of encryption technology to protect mobile VoIP conversations.

IP-telephony helps business and private users to reduce their costs. Many of the VoIP solutions available on the market can be manipulated or eavesdropped very easily, because they usually do not provide encryption. Especially when mobile equipment is used, for example latest generation mobile phones with VoIP over WLAN features or other specialized VoIP over WLAN phones, protecting the data exchanged is very important. These products are designed to be used at public, wireless hotspots, which do often not have any protection at the network level and thus make it very easy for attackers to wiretap conversations.

For this reason Fraunhofer Institute for Secure Information Technology developed »Secure mobile VoIP«, a prototypical solution based on the Java platform for mobile phones, which provides end-to-end security for mobile VoIP calls without demanding special hardware. The application can be used to protect sensitive conversations independent from the security of the transport network.

The prototype uses an AES algorithm to encrypt the speech channel and is based on J2ME, a programming platform supported by nearly all mobile phone manufacturers. First, when a connection between two phones is established, a cryptographic key is being negotiated with the method of Diffie-Hellman. This secret session key is used to secure the conversation. The AES encryption of »Secure mobile VoIP« works on nearly all mobile phones featuring J2ME, independent of the manufacturer or the network used (WLAN, UMTS or GPRS).

The encryption has no effect on the acoustic quality – there is no noise, clicking or other influences disturbing the audability. Customary mobile phones still exhibit delays, which prevent full real time conversation. In first attempts the application was therefore limited to push-to-talk conversations.

59. Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT

Website Link: http://www.umsicht.fraunhofer.de/en.html

English: Fraunhofer UMSICHT advances sustainable economizing, environmentally friendly technologies, and innovative activities in order to improve the quality of life for humans and to promote the innovation capacity of the national economy..

Korean: 프라우호퍼 환경안전에너지기술연구소(UMSICHT)는 인간의 삶의 질 향상과 국가경제의 혁신역량 강화를 위해 지속가능한 절약형·친환경 기술을 개발하고 혁신적인 연구활동을 수행하고 있습니다.

59.1 Energy Systems Engineering

We develop energy converters and work on new applications and their simulation, pilot testing, optimization and improvement of efficiency. As a service, we are offering concept design, customer-specific calculation, interpretation, planning and integration of such energy systems or the creation and assessment of technical concepts.

Waste Heat to Power

We are working on the implementation of new applications and systems for converting waste heat to power on the basis of the conventional and the ORC steam power process. In the focus are the application of small high-temperature ORC CHP processes with heat supplied from organic solid fuel furnaces, as well as the development of smaller low-temperature ORC processes for industrial waste heat and geothermal heat.

Compressed Air Energy Storage

We deal mainly with the development of innovative compressed air energy storage for storing electricity. The focus is on adiabatic low-temperature compressed air storage as well as innovative systems for storing heat and compressed air. Within the scope of system concept design and system optimization, we perform CFD calculations of expansion and compression machines.

59.2 Energy Systems

Energy Systems

Efficient energy systems are the goal of our work. In the interaction of energy supply, energy distribution, energy storage and use of energy, we develop and optimize energy-efficient and economical energy systems. One focus there is the integration of renewable energies into existing structures.

Energy Supply Systems

We develop energy systems for the energy supply of objects up to urban districts. We study system behavior and carry out energetic-economic assessments. In addition, we calculate the nationwide, regional and local energy balancing need and develop appropriate energy balancing concepts.

Energy System Optimization

The transformation of energy systems leads to a rapidly growing complexity and number of system variants. With the help of mathematical optimization models, we identify energy-efficient and economical energy systems. We optimize the sizing and the utilization planning of energy supply systems and energy storage systems in future markets.

59.3 Chemical Energy Storage

Endothermal chemical reactions require energy to build chemical bonds in a high-energy product while exothermal reactions release energy, forming a lower-energy product. In this way, we can develop energy storage systems that store electricity and heat to use them for a future energy supply or to provide basic chemicals for the chemical industry.

We develop electrochemical storage systems, catalytic processes and catalytic converters and develop process or system solutions for biogas processes.

Electrochemical Processes

The core of our research is the redox flow battery technology, which will allow large storage systems in the future. In addition to battery system and stack design we are also developing optimized materials (electrodes, bipolar plates and membranes). We furthermore are testing both redox flow and lithium battery systems.

Catalytic Processes

We develop heterogeneously catalyzed processes for storing energy in the form of chemical bonds. Closely related to basic research, novel catalysts are being developed and examined under close to industry conditions. This is the way that innovative procedures for a successful shift in energy and raw materials are to be created.

59.4 Thermal Storage and Systems

Electrical and thermal energy storage is a significant component in the energy system of the future. It makes it possible to store energy and thus create the temporal balancing between demand and production. Furthermore, in combination with heat pumps, chillers, CHPs etc. they contribute to load balancing. This makes it the key technology for the integration of renewable energies.

Materials

Thermochemical storage uses the reaction enthalpy of reversible chemical reactions for heat storage. It has the potential for high energy storage densities and low-loss long-term storage of heat. We identify suitable reaction systems, characterize new materials and design application concepts.

Components and Systems

We are developing thermal energy storage based on phase-change slurries for stationary and mobile applications in the range of up to 50 °C. Our further focal points are on system and component development for absorption chillers and steam jet ejector chillers as well as construction, operation and monitoring of chilling plants.

59.5 Biorefinery/Biofuels

To produce fuels and chemicals economically while at the same time reducing the emission of gasses harmful to the climate and taking into consideration the limited amount of fossil fuels: it is in this field of tension that we are moving. We develop biorefinery processes for the production of fuels and chemicals. In doing so, we use sustainable biomass such as renewable raw materials and biogenous residues holistically, also preferably a number of times, in a cascade-like manner. We develop, integrate and optimize production methods of biofuels and bio-based chemicals of the second generation, which are not in conflict with foodstuffs and have a small ecological footprint.

Source materials are residues and residue-based raw materials of different purity such as wood, straw, sugars, fats, oils, algae, alcohols, acids, and ketones.

We are pointing out strategies for the future to sustainably and competitively produce fuels, energy and chemicals, and are involved in efficiently integrating biotechnology and chemistry. Our service portfolio ranges from fundamental research all the way to initial process engineering designs and cost estimates. One of the fundamentals for this is a broad knowledge in the area of catalytic synthesis of fuels and chemical products from renewable resources.

Bio-based Chemicals

From sustainably (fermentative) produced, bio-based raw materials and residues (among others: oils, fats, alcohols, sugars, celluloses, algae) we are producing with new catalytic processes, chemicals and fuels that can replace, in the short to medium-term, products that were produced in a non-sustainable manner. We use automated laboratory equipment (mini-plants) to develop processes, which can be operated even at high temperatures and pressures, we carry out analyses and application testing of products and provide a basic design for processes that can be integrated in a centralized or decentralized fashion in the chemical industry.

Biofuels, Hydrocarbons

Vegetable oils, bio-based old fats and algae lipids represent both chemically and energetically valuable substance mixtures. We convert them, inter alia through surface-catalytic processes, into fuel components and chemical raw materials. Before the catalytic step we separate the interfering substances out and can this way still employ even low-grade residues profitably.

Thermochemical Conversion

Solid biomasses, mainly residues and waste products from agriculture and forestry are transformed into liquid and gaseous intermediate products which find their way into classic refinery processes as regenerative carbon sources or are used in decentralized CHPs using the thermal processes of pyrolysis and gasification.

Speciality Chemicals, Formulations

We refine chemicals and fuels by chemical modification, formulation etc. and expand their material base. The products are used primarily for applications in the customer-care sector (medicine, cosmetics, household, textiles). In our developments, we rely on a wide range of analytical methods (among others, structure analysis and thermoanalysis).

59.6 Process Intensification

In process intensification, we are pursuing the overriding objective to develop more efficient and sustainable processes. To achieve this, we increase the performance and functionality of materials and components, and connect and improve water engineering and adsorption processes.

Water Processes

Within the framework of the strategy - nano technology for water engineering - we are developing hybrid systems and reactive separation processes, such as functionalized filters to eliminate trace substances and recover rare metals. We recycle water from buildings and use the purified material flows for the building-integrated agriculture.

Adsorption Processes

Our topic is both the adsorption from the gas phase as well as from the liquid phase. In this manner, we are developing solutions for separating components from air (exhaust gas cleaning, air separation) and water (medicinal products, pesticides). For this purpose, we are utilizing adsorption; however we are also using it for storing gaseous fuels, such as methane.

Active Surfaces

In our electroplating and laser laboratory, we are developing materials and components with micro-structured surfaces, for example for friction optimization and improving material exchange processes. We are producing custom-fitted microsieves with functional surfaces and are dealing with the large-scale transfer of micro-topographies.

59.7 Information Technology

The knowledge available worldwide doubles every five years. Intelligent, target-group-specific information management aids in promptly separating valuable from unnecessary information and occupies a central role in today's production value adding chains.

Application Development

In connection with ergonomic user interfaces, the close interlinking of the operative processes with specific organizational and technical information closes existing information gaps. For this, customer-specific applications are developed and made available via service-oriented architectures in a location and client independent manner.

Modelling and Simulation

Efficient simulations offer insights that, using the traditional experimental methods, can be gained only in a very time-consuming and cost-intensive way. Selecting the appropriate model is a key to success, here. Our portfolio ranges from the creation of real models to abstract mathematical formulations.

59.8 Process Engineering

To use renewable raw materials, open up alternative energy sources, produce chemical products, foodstuffs, fuels and other energy materials in an efficient, clean and environmentally friendly manner – these are tasks for the process technology of the future that we are working on.

We are developing "green" ways of manufacturing and are helping to establish them on the market. In this, we are relying on renewable resources and biogenous residues that are not in competition with food.

Biotechnology for Environment and Energy

Within the topic area of electro-biotechnology we work on the integration of electric power into biotechnological production processes. In addition, we research biological degradation processes under aerobic and anaerobic conditions by employing standardized testing methods. As a testing laboratory approved by DIN CERTO we offer tests for the biodegradability of polymeric materials.

Bioprocess Engineering and Fluid Separation

We develop and design processes for the processing of materials from chemical or biotechnological syntheses. The downstream processing (mechanical and thermal separation processes), the manufacture of products made from renewable resources including biological conversion technologies are part of our tools of trade.

Biomass and Residue Utilization

The focus of our work is on the evaluation and optimization of the energetic utilization of biomass and residues through the creation and characterization of fuels (preparation, hydrothermal carbonization, torrefaction and incineration), the determination and minimization of (dust) emissions, as well as the recovery paths of ash are in the focus of our work.

Membrane and Food Technology

Our expertise is to develop system solutions for the membrane and food technology and to implement them in the laboratory systems, technical shop systems and demonstration plants. Functionalized process additives as anti-caking agents in wastewater treatment and the recovery of materials from process streams form the focus of our work.

59.9 Think Thank

New technological approaches or applications of existing technologies are identified, assessed and fundamentally developed with view toward application orientation. To achieve this, we employ opportunity management and technology screening. The current technical focal points are in the area of the utilization of gas hydrates and new process-engineering processes.

International Projects

Excellent results and sustainable successes of scientific research and development require, in a lot of cases, international networking. We adapt current technology approaches to the framework conditions of the partner countries and implement them in R&D and demonstration projects.

Urban Production

The metropolises of today and megacities of tomorrow require new technological approaches for the sustainable supply and the production in the city. Jointly with partners, we develop and demonstrate technologies, regarding, for example, urban farming, and accompany the interdisciplinary and transdisciplinary urban production as well as the resource and infrastructure questions associated therewith, e.g. through participatory processes.

Group Environmental and Process Technology (RUB*)

In cooperation with the Ruhr University Bochum, Germany, we develop the foundations for biomass conversion processes and engage in answering fundamental questions regarding the utilization of gas hydrates.

59.10 Bio-based Plastics

We develop bio-based application-oriented plastics. Our compounds and composites offer a specific, often also novel set of characteristics that corresponds to those of fossil-based polymeric materials or even exceeds them. In doing so, we cover the entire development chain, from the polymerization to the plastics processing including comprehensive material characterization. Our strengths are the assurance of the workability of our bio-based plastics on conventional processing equipment, cost-consciousness coupled with a view of market opportunities and availability of raw materials, as well as our many years of expertise.

Polymer Chemistry

We have felt at home for many years now in developing and synthesizing polymers and additive systems on the basis of renewable resources. In the area of natural fibers, we are offering expertise regarding their structure and chemical treatment, as well as in-depth knowledge of the market. The processing and characterization of natural fiber-reinforced plastics (NFP) rounds out our portfolio.

Material Development

We are working on the physical functionalization of biopolymers via blending, adding of additives and fiber reinforcement. Additional focal points in research and development are the reactive processing and the compatibilization in the melt. The main application areas are injection molding, extrusion and thermoplastic foaming.

Processing and Applications

New plastics require adjustments during processing, such as during injection molding, extrusion, or the production of blown film. We also provide on-site help to smoothly enter into the manufacture of products made of our bio-based plastics. End-user and consumer satisfaction - that is our goal.

Production Scale-Up and Testing

The development of new materials does not end in the laboratory, but in practical applications. It is for this reason that Fraunhofer UMSICHT is operating a compounding technical shop with twin screw extruders all the way to production scale at the Willich site. In addition, we have modern testing equipment for internal and external inspection orders available to us.

59.11 Material Systems and High Pressure Technology

The core of our department is the development, modification and functionalization of material systems. Plastics and natural materials like for example leather, woods and stones lie in the focus of our work. Our portfolio comprises coatings and particle technology as well as compounding, comminution and additive manufacturing of various materials.

Therefore we utilize next to conventional processes compressed carbon dioxide. We accompany you from laboratory up to pilot plant application always having the industrial implementation on our minds.

Construction

By modification or the introduction of functional additives, we tailor material systems for innovative applications in the construction area. Examples are: self-healing polymeric or sealing systems, micro-capsules, hollow micropheres, impregnated construction materials, metal-organic functional material systems and mineral substrates for greening.

Polymers

Customer-specific production of powder, additive manufacturing and blending of plastics to compounds, the subsequent injection molding, self-healing of plastics and the functionalization of polymeric surfaces are the most important development areas of the Group Polymers. In the field of powder production, cryogenic fragmentation and high pressure spraying are applied up to a pre-industrial scale.

Impregnation and Leather

The application of compressed carbon dioxide as a processing medium enables us to modify diverse matrices. We have developed a CO2-intensified tanning process with the cleantan®-process with which we produce leather in a wastewater-free and resource-efficient manner. By using carbon dioxide we can, for example, dye polymeric construction elements, endow them with antimicrobial activity, degrease or functionalize them individually.

Natural Materials

Natural vegetable and animal matrices of materials are the focus of our work. It is our aim to decompose natural and most of the time complex material systems in order to extract reusable materials or to endow them with selected additives. In that way, natural structures can specifically be functionalized. Within our product and process development we set great store on process controlling that can be scaled-up like for example for extraction, high pressure extraction or high pressure impregnation.

59.12 Sustainability and Resources Management

To ensure that earth will remain a planet that is worth living on, we have to reassess our way of life, our consumption patterns and our resource consumption. Our aim is to enable our customers to contribute to sustainable development through their actions and decisions.

We prepare customized sustainability strategies, help to close cycles and to assess the sustainability of products, processes, and services. Looking at product development, we integrate stakeholder interaction. This way sustainable innovations can be realized.

Sustainability Assessment

In collaboration with environmental scientists, engineers and sustainability management professionals we carry out ecological and economic evaluations of products, services, and organizational footprints. We provide decision making support in sustainable product development. For this purpose we use life cycle assessment (LCA) and social impact assessment tools, feasibility studies, and strategic analysis tools.

Spatial Analysis and Raw Material Systems

Our topics are potential studies, efficient use of waste and resources and sustainable urban concepts. We investigate the spatial layout of urban, industrial, and natural areas. We plan the intelligent use of raw materials, develop new approaches, assess concepts, engage stakeholders and present potentials, interactions and material flows spatially with the help of geographic information systems.

60. Fraunhofer Institute for Wood Research Wilhelm- Klauditz-Institut WKI

Website Link: http://www.wki.fraunhofer.de/en.html

English: Wood production is environmentally-friendly and sustainable, wood products have outstanding technical properties and exemplary life cycle assessments. The Fraunhofer Institute for Wood Research, Wilhelm-Klauditz-Institut, WKI in Braunschweig addresses current and future-oriented tasks concerning the use of wood and other renewable resources.

These include methods for the production of particle and fiber materials, surface treatments, measures for wood protection, environmental research and recycling. Outstanding achievements of the Institute were and are:

- the development of new materials from chips and fibers
- the testing and reduction of formaldehyde emissions from wood-based materials and furniture
- the analysis of emissions from construction materials and the reduction of VOC (Volatile Organic Compounds) and odorous substances
- the development of environmentally-friendly and durable coating systems for furniture and wood for outdoor use
- the testing and improvement of the properties of wood products through non-destructive methods such as thermography, ultrasound or magnetic resonance
- the recycling of production waste and old furniture in the manufacture of particleboards and fiberboards.

The research and development activities serve to achieve a better utilization of the raw material wood and an increase in the quality of wood products. The priority tasks for the WKI continue to include the preservation of old buildings and the renovation of half-timbered houses, as well as the development and testing of modern wooden structures.

As an accredited testing body, the WKI undertakes tasks concerning material testing and quality control. It assesses cases of damage and provides advice regarding damage restoration.

Korean: 목재생산은 환경친화적이고 지속가능하며, 목공품은 탁월한 기술적 특성과 우수한 수명주기평가 결과를 보이고 있습니다. 브라운슈바이크(Braunschweig)에 소재한 프라운호퍼 빌헬름클라우디츠 목재연구소(WKI)는 목재를 비롯한 재생가능 자원의 사용을 연구하고 있습니다. 핵심 연구분야는 입자 및 섬유소재 생산방식, 표면처리, 목재보존, 환경연구 및 재활용 등이며, 주요 연구실적은 다음과 같습니다.

- 목재칩 및 섬유 기반 신소재 개발
- 목재 소재 및 가구의 포름알데히드 방출 시험 및 방출 저감
- 건축자재의 방출 분석, 휘발성 유기 화합물(VOC) 및 악취물질 감소
- 가구 및 야외용 목재를 위한 친환경 고내구성 코팅 시스템 개발

- 서모그래피(thermography), 초음파, 자기공명 등 비파괴 검사방법을 이용한 목공품 특성 시험 및 성능 개선
- 생산 폐기물 및 폐가구 재활용을 통한 파티클보드(particleboards) 및 파이버보드(fiberboards) 제조

연구개발활동은 목재 원자재의 효율적인 활용 및 목공품 품질 개선을 목표로 하고 있으며, 고건축물 보존 및 반목조가옥(half-timbered houses) 개·보수, 현대식 목조건축물 개발 및 시험 등에 주안점을 두고 있습니다. 연구소는 공인 시험기관으로서 소재시험, 품질관리, 손상평가 업무를 실시하고 피해복구 관련 자문을 제공하고 있습니다.

60.1 Technology for Wood-Based Materials

Composite materials made from wood and other materials containing lignocellulose have a unique character: They are environmentally-friendly and extremely functional. We develop wood-based materials and natural fiber-reinforced composites as well as image-processing procedures for process and quality control. The spectrum of our material developments encompasses classic particle boards, medium-density fiberboards (MDF) and natural-fiber insulation boards through engineered wood products such as oriented strand boards (OSB), plywood, laminated veneer lumber (LVL) to wood-polymer materials (WPC), 3D molded parts and composite materials.

We would be pleased to assist you in the customized development of your materials.

60.2 Emissions from electronic cigarettes

Electronic cigarettes vaporize liquids to be inhaled and these liquids can contain nicotine. The e-cigarette is activated by pressing a button or by inhaling through it (see Fig. 1). In some cases, paper coverings are used to give the e-cigarette the look and feel of a real cigarette and even a burning tip can be simulated with LEDs. There has so far been little investigation into the health impact on e-cigarette smokers and no research at all has been done regarding their immediate environment. The question here is whether passive ‘vaping’ has an effect on others similar to passive smoking with cigarettes.

The aim of the investigations was to characterize the substances released into the air while an e-cigarette is being used. Tests were carried out involving a test subject in an 8 m^3 stainless steel emission test chamber. The volunteer was asked to use an e-cigarette with three different liquids and to smoke a tobacco cigarette. The volatile organic compounds (VOCs) emitted and the (ultra-) fine particles were analyzed. Particular attention was paid to developments in the formaldehyde concentration in the chamber. It must be noted that the study does not claim to provide any kind of toxicological assessment.

In general, the emissions from the electronic cigarettes were lower than those of the normal tobacco cigarette. The release of substances into the air took place practically only via the smoker's breath. Particularly in the case of the (ultra-) fine particles, it was possible to examine each individual draw on the cigarette. The smoke released similar to that from the burning end of a normal cigarette was negligible. There was no evidence of formaldehyde being released through the use of the e-cigarette. However, the use of the e-cigarette does have an influence on the indoor air quality in the room and therefore also the surroundings because the substances contained in the liquid are released. The fog fluid propylene glycol creates a visible vapour when the smoker exhales. The vaporized substances create an aerosol made up of (ultra-) fine particles in the e-cigarette which shrink again in the lung during the inhalation process. This slow evaporation of the condensed particles was not examined in the case of the tobacco cigarette, with which a high number of larger particles were found, due to their composition. In summary, e-cigarettes are a less significant source of indoor air pollution than typical tobacco cigarettes. They are, however, not completely free of emissions.

60.3 Gas chromatography and olfactometry

In our department, GC/O is used for material and indoor analytics in order to identify sources of odour nuisance and off-odours. The main focus here is placed upon the examination of differing consumer goods and materials through the application of GC/O-FID and the determination of the intensity of such products with the help of emission test chamber measurements. In this way, GC/O can additionally be applied for process and product optimisation.

Instrumental information and identification

The samples are placed in a desiccator (23°C) or directly in an emission test chamber and air samples are collected using Tenax TA adsorption tubes. The emitted substances can be gas-chromatographically analysed using the analysis device, formed by coupling the gas chromatography-olfactometry with a flame ionisation detector (GC/O-FID). At the end of the capillary column, the eluate is fragmented and, utilising the olfactory detection port (ODP), detected virtually parallel by the nose and the FID. The samples are inhaled repeatedly by several volunteers, in order to restrict the subjectivity.

The odour-active eluting components are marked and described with the help of voice-recognition software. The identification is carried out through external standardisation with the retention times and calculated indices of the individual substances as well as the classification of the odour impression. For this, an internal odour databank is implemented or the individual odour-active relations are measured directly as standards. Furthermore, the ODP chromatograms are compared with the recorded mass spectra from the samples

60.4 Odour emissions from building products for indoor use

roblems in interior spaces are increasingly caused by the perception of unusual or unknown material odours. The perception of odours is closely linked to emotions and can influence the well-being of the room user. Technology for the assessment of odours in interior spaces is therefore becoming increasingly important.

Nevertheless, there is still a lack of uniform procedures and criteria for odour assessment in interior air hygiene. One reason for this is that odours do not simply multiply; their interaction can be extremely varied and the individual components are therefore not always responsible for the odour impression. Another reason is that the odour-relevant substances are often only present in extremely small concentrations, making them impossible to detect with conventional analytical detection methods.

A wide variety of methods for the odour assessment of indoor areas and/or materials for indoor use exists and can be used as an alternative to chemical analysis. These methods are mainly used in the national labelling sector. However, due to the differences in the assessment procedures, a direct comparison of the results is not possible.

The DIN ISO 16000 - 28 (2010) describes the execution of the following odour assessment methods for building products:

- acceptance
- perceived intensity
- hedonic effect

For the “perceived intensity” method for the odour assessment of interior products, at least eight trained test persons must determine the intensity of a sample using an acetone comparison standard. For this, the test persons must arrange various reference concentrations in their order of intensity and thereby evaluate the strength of the odours. The hedonic effect is thereby also assessed.

The central point of the investigations was the substantiated implementation of the methods concerning the perceived intensity as per the standard ISO 16000-28. The results of the research project will form the technical basis for a suggestion regarding a uniform testing method for the examination and assessment of odour emissions.

60.5 Nanoparticle detector

In this research project, which is supported by the BMBF, we are working in co-operation with the TU Braunschweig, Institute of Semiconductor Technology, to develop robust cantilever resonance scales for the determination of artificial nanoparticles in the air surrounding work stations.

Resonance scales can be used to measure the smallest of quantities, including those of artificial nanoparticles. By using technology from the semiconductor industry, resonance scales can be produced in large quantities at a low price.

60.6 Preventative conservation for building work in museums

Museums preserve the historical identity of a population, a region or an epoch by collecting, conserving, researching and mediating artistic and cultural objects. In order to do this, the ambient conditions for the storage and presentation of the objects have to be perfectly matched to the characteristics of the objects themselves. Factors which might endanger a collection have to be identified in advance and avoided (or at least minimised over the longer term) by taking a comprehensive look at the environmental factors acting upon a collection and then prudently defining what the best environment would be.

Preventative conservation aims to define the actions which need to be taken in advance to avoid damage to objects of artistic or cultural value over longer periods. This ideally takes place by intelligently regulating the environmental conditions. Manipulating pieces of the collection by applying conservation substances or doing restoration work is to be avoided.

Environmental factors which are detrimental to collection pieces are primarily climatic parameters such as temperature, relative humidity, lighting and airborne pollution. These can cause damage ranging from an altered appearance (faded textile colours due to exposure to strong light, for example) through to the complete destruction of a material, as can be observed when lead objects are exposed to organic acids.

Although museums are generally aware of these challenges, a practical and efficient implementation of preventative conservation measures is often difficult and gives rise to further unanswered questions among those responsible. The aesthetics of the exhibition often seem incompatible with the conservation requirements and there is often little money for scientific analysis and personnel (especially in the case of smaller exhibitions). Museums are therefore often faced with the costs of retrospectively correcting poorly planned exhibitions to account for conservation requirements. Criteria for preventative conservation and specific environmental parameters which are derived from research work are also often not examined regarding their practical application.

A two-year research project funded by the German Federal Environmental Foundation (Deutsche Bundesstiftung Umwelt - DBU) accompanies two museums which are planning conversion and building work with the aim of clearly defining preventative conservation and practically implementing it while taking into account aesthetic and architectural requirements and budget restrictions.

60.7 Bio polymers for glass

Coatings for the decoration of glass are currently based mainly on petrochemical raw materials such as epoxy resins. We, together with Synthopol Chemistry Dr. rer. pol Koch GmbH & Co. KG and Ferro GmbH develop binders based on biosourced materials. Hence, formulations for decorative glass coatings are created to meet the high requirements of the glass industry in terms of resistance and adhesion requirements.

Three application fields are essential in the context of this project:

- On the basis of fatty acid and sugar derivatives waterborne, functional resin dispersions for spraying application are synthesized.
- Fatty acid derivatives and glycerol are the basis for reactive waxes that are converted with reactive resins to thermoplastic printing inks, so-called 100 %-systems.
- In addition, radiation curing resins (100 %) are synthesized for highly cross-linked, UV-curing printing inks.

New base formulations are developed for each of the three categories and are subjected to application-specific tests. This includes among others, application methods, such as screen printing and spraying, resistance, such as resistance to scratching, resistance to filling materials and determination of the durability against environmental influences and chemicals. In the case of success upscaling to a pilot plant scale will be made for both syntheses as well as for the formulations.

60.8 . Life expectancy of polymer coatings on wood

The life expectancy of polymer coatings on wood in outdoor applications depends to a significant extent on the climatic factors acting on them. The aim of this project is to be able to make more specific predictions of the long-term behaviour of polymer wood coatings under real-life conditions.

The life expectancy of polymer coatings on wood in outdoor applications depends to a significant extent on the climatic factors acting on them. By determining the chemophysical changes in the polymer matrix and their relations to mathematically-calcu-lated climatic indices, it should be possible to show the correlations between life expectancy and the effective climatic factors. The properties of wood coatings which determine their life expectancy depend to a considerable extent on climatic factors, which vary from region to region, and on the nature of the polymer binder. Generally speaking, polymer materials degrade through photo-oxidative processes such as chain scission, cross-linking and the creation of oxidative degradation products. After relatively long periods of weathering, these photochemical processes result in physical and mechanical changes in the coating system.

In order to be able to make more specific predictions of the long-term behaviour of polymer wood coatings under real-life conditions, ageing phenomena were measured and statistically analyzed for three wood coating systems typically found in con-ventional use. This was done within the context of an investigation determining dose-effect relations. Spruce panels coated in accordance with DIN EN 927 were exposed to weathering for twelve months at ten weathering sites in North America, Europe, Asia and Australia. The panels had been made at the Fraunhofer WKI and were evaluated both before and after exposure. The dose variables D were calculated using various climatic index formulae found in the literature for the corresponding weathering sites. In addition, two new climatic indices were derived on the basis of the correlation results calculated. The chemical degrada-tion processes of the solvent-based, red-brown pigmented alkyd system used, of the water-based white special acrylic resin system and of the water-based acrylic resin glaze (light oak) were analyzed by FTIR spectroscopy in ATR mode. In addition to the chemical degradation processes, the colour and gloss changes in the coating systems and their appearance after weathering were also defined as effect variable W. It was possible to reproducibly characterize the chemical degradation mechanism by the asym-metric (C-H) CH_2 valence vibration at 2920 cm^{-1} which is typical of alkyd systems, by the symmetric (C-H) CH2 valence vibration at 2850 cm-1 and by the C=O valence vibration at 1730 cm-1.

With reference to the climatic factors acting on the test panels, it was possible to find statistical correlations between the climatic indices, the chemical changes and the optical changes. To do so, the linear correlations between the climatic indices and the FTIR-ATR degradation rates measured were determined by applying Pearson's correlation coefficient. In addition, rank correlations based on Spearman's rho were also calculated in order to observe non-linear relationships and to reduce the influence of freak values amongst the measured values. Unlike Pearson's correlation coefficient, that of Spearman neither requires the assumption that the relation between the variables is linear nor is it necessary to measure the variables on an interval scale.

The results obtained have demonstrated that degradation processes in complex polymers and inorganic composite systems, which contain not only the binder matrix but also fillers, pigments and other additives, can be identified by ATR spectroscopy. The corresponding results of evaluation can then be related in a statistical context to the climatic factors acting on the composite systems. With this methodology, it is conceivable that it will be possible in the future to test the durability of alkyd-based wood paint systems with the aid of the present mathematical computational models at an easily-manageable number of weathering stations and then, by application of the climatic indices calculated, to transfer the results to different climatic regions. In addition, with the aid of the correlations identified, improved cycles in xenon-based and fluorescent weathering equipment should be secured and more dependable service life estimates obtained for wood coatings.

60.9 Robot-based coating of wooden elements

The Fraunhofer WKI now has a modern handling robot at its disposal. Within the framework of an AiF-funded project (ZIM – Co-operation module), our department, together with the surface technology company Reiter Oberflächentechnik, will further develop the robot-based coating of wooden elements. The aim is to utilise the airless technique to expand conventional spray technology so that one single robot can be used for both spray application and the considerably more material-efficient flow application.

The main focus of the development work is the production of a combined unit, consisting of a flow and spray nozzle head. The fundamental approach method for this task required the identification of a new process for flow application. The reason for this is that the robot guides the flow nozzle along the contour of the window frame which has been measured using a scanner; the previously-applied technique used a number of stationary nozzles to spray the frame section. The process is carried out in a similar way to the spray method but differs in that one spray nozzle in the system is replaced by a flow nozzle. This new, flexible flow and spray nozzle is technically adapted to provide a high-quality surface on the respective wooden elements using flow-compatible coating systems.

In order to enable a colour change at short notice, the amounts of material in the system must be kept to a minimum, so that a swift colour change with the smallest loss of material is ensured. Furthermore, the system must function in such a way that the superfluous coating materials, which tend to gather in thicker layers on the lower edge during flow-coating, can be evened out. A uniform layer application can be achieved through a targeted controlling of the flow process, which additionally results in increased savings as regards the coating materials.

The first step towards the development of the new robot-based flow application technology involved testing differing flow nozzles in a miniature flow application system at the Fraunhofer WKI. Simultaneously, coating systems and coating parameters for the primer and interim coats were tested regarding their significant coating characteristics and subsequently optimised. The results of the optical and microscopic assessment of the coated wood samples enabled identification of the individual flow nozzles which were suitable for installation in the flow head which was to be constructed by the research partner. The knowledge gained hereby enabled the research partner, Reiter Oberflächentechnik GmbH, to technically implement the robot flow head.

In co-operation with Reiter, the coating robot Fanuc Type M-16//B/20 in the surface technology laboratory at the Fraunhofer WKI was modified in order to enable quick and simple changing of the application heads (flow and spray). The flow nozzles selected by the WKI were mounted on the newly-developed Reiter flow head and subsequently utilised using a high-pressure pump. Preliminary tests showed 10 bar to be an ideal material pressure for robot-based flow application. In order to verify these preliminary tests, extensive test series were carried out in which various standardised wood samples were coated with transparent and pigmented primers, interim and top coats from various coatings manufacturers. The coating speeds and distances from the sample element were hereby taken into account. From the resulting characteristics profiles, it can be deducted that this newly-developed type of flow nozzle can be implemented to provide re-

producible and constant surface characteristics.
In a subsequent step, suitable flow coating systems for interim and top coats will be tested using the new flow head unit. A critical point here is the setting of an optimum flow and run angle, as both dimensions have a significant influence on the overall success of robot-based flow coating of wooden elements. Furthermore, it is necessary to ensure uniform flow coating of 3-D wood geometries through new programming steps. The new flow head unit was presented to potential users by the research partner and the Fraunhofer WKI at the Fensterbau/Frontale exhibition in 2010 in Nürnberg.

60.10 Coating and adhesive resins based on sugar derivates

Renewable raw materials are alternatives to limited petrochemical resources in many industrial areas. Their application range is extending. We develop synthesized polymer dispersions with high amount of renewable resources as binders for the preparation of water-based adhesives and coatings for wood and wood-based materials. The aim of this project is to incorporate the saccharide derivative in the acrylic dispersions, which exhibit equal and also novel properties compared to the commercial petrochemical products.

Saccharides with vegetable oils and fats are industrially important renewable resources. The monosaccharide glucose is primarily obtained from corn, potato and wheat starch. From glucose as starting substance the radical polymerizable sugar methacrylate can be synthesized in a two-steps reaction. The sugar methacrylate can be used in the synthesis of novel water-based acrylic dispersions by means of radical emulsions polymerization.

The properties of acrylic dispersions are influenced by the manufacturing process and the recipe. Very fine and relatively soft acrylic dispersions with a low solid content usually lower than 15% and a low viscosity are suitable for wood primers. The majority of acrylic dispersions for interior wood coatings are very fine sized with an average particle size from 50 to 100 nm. They are usually formulated with a high glass transition temperature from 30 to 60°C in order to achieve the desired hardness (see Fig. 2). However, the increasing environmental pollution as a result of solvent emission leads to the substitution of solvent-borne coatings by water-based products.

The thermal behaviour of acrylic dispersions plays a decisive role for the film formation. The glass transition temperature affects strongly the minimum film forming temperature. The sugar methacrylate as polymer exhibits a high glass transition temperature at

164°C. Accordingly to this the sugar methacrylate, as hard monomer, increases the glass transition temperature of the copolymer. The basic properties, such as polarity, hardness and flexibility of the coating, are fixed in the copolymer through the choice of standard monomers. The saccharide containing film formation takes place at room temperature without addition of a coalescing agent. Basically, it is also possible to make it a hydroxy functionalization 2K polyurethane acrylates and thus to cross the additional crosslinking to even higher-quality coating materials.

The beech plywood panels coated with a saccharide-containing acrylic dispersion are investigated according to DIN EN ISO 2409. The cross-cut test values of wet adhesion fulfil the normative requirements of wood external coatings. Furthermore the elasticity and the tensile strain of free lacquer films are investigated. Wood is a natural and flexible material. Therefore a suitable wood coating should be able to stand swelling, or other minor deformations of wood without cracking. The lacquer films are stored in the controlled environment and then artificially aged by storage in water. The selected saccharide-containing films provide an elasticity of more than 20%. The selected saccharide-containing films provide an elasticity of more than 20% (see Fig. 3).

The high glass transition temperature of the sugar methacrylate can open ways to develop formaldehyde-free adhesives for wood-based materials. This will require further investigations.

Present results show that the radical polymerizable methacrylate containing glucose forms a technically functioning alternative to synthetic raw materials for the synthesis of acrylic dispersions. It is preferably suitable as a hard monomer for furniture lacquers. The subject of future research is to find out to what extent it is possible to produce formaldehyde-free binders for the wood products industry.

60.11 Polyurethane dispersions from vegetable oils

Biomass is, in contrast to energy production methods using sun, wind or water, the only alternative to fossil raw materials as a source of carbon for the production of chemical and pharmaceutical products. A new method is the bio-technological manufacture of synthesis modules, preferably using renewable raw materials. The developed coating resins not only possess a high proportion of renewable components, they also demonstrate very good chemical and mechanical properties.

In 2005, 64,000 tonnes of non-fossil oils were used in paint and varnish production, accounting for approximately 5.6% of the total production of vegetable oils and animal fats.

Generally, the biogenic raw materials are chemically modified and subsequently polymerised. In addition to the chemistry of the biogenic oils and saccharides, the Fraunhofer WKI also offers a third strategic pillar in coating resin and adhesive synthesis through the use of bio-technologically-obtained raw materials.

Bio-technologically-produced 1,3-propandiol and 1,18-octadecanedicarboxylic acid are synthesised to produce polyester polyols. These are transformed into polyurethanes, from which PU dispersions and/or PU acrylate dispersions are subsequently produced.

The use of 1,3-propandiol results in an improvement of the strength-to-elasticity ratio compared to conventional synthesis components and enables the substitution of longer-chained diols such as 1,6-hexandiol, possibly resulting in a reduction of costs. The use of longer-chained dicarboxylic acids in the polyurethane dispersions results in highly-elastic paint films which, due to their low ester-bonding density, can be expected to demonstrate a high hydrolysis resistance. They can therefore be used as elastifying components for weather-resistant PU acrylate dispersions. The proportion of bio-technological-based components in the dispersion currently amounts to 34%. In the near future, the synthesis of further reactants within the field of bio-technology and the use of renewable raw materials for the synthesis will enable the manufacture of coating dispersions with a biogenic proportion of far more than 70%. From an economic perspective, these products are often ecologically comparable with petrochemically-manufacturedproducts