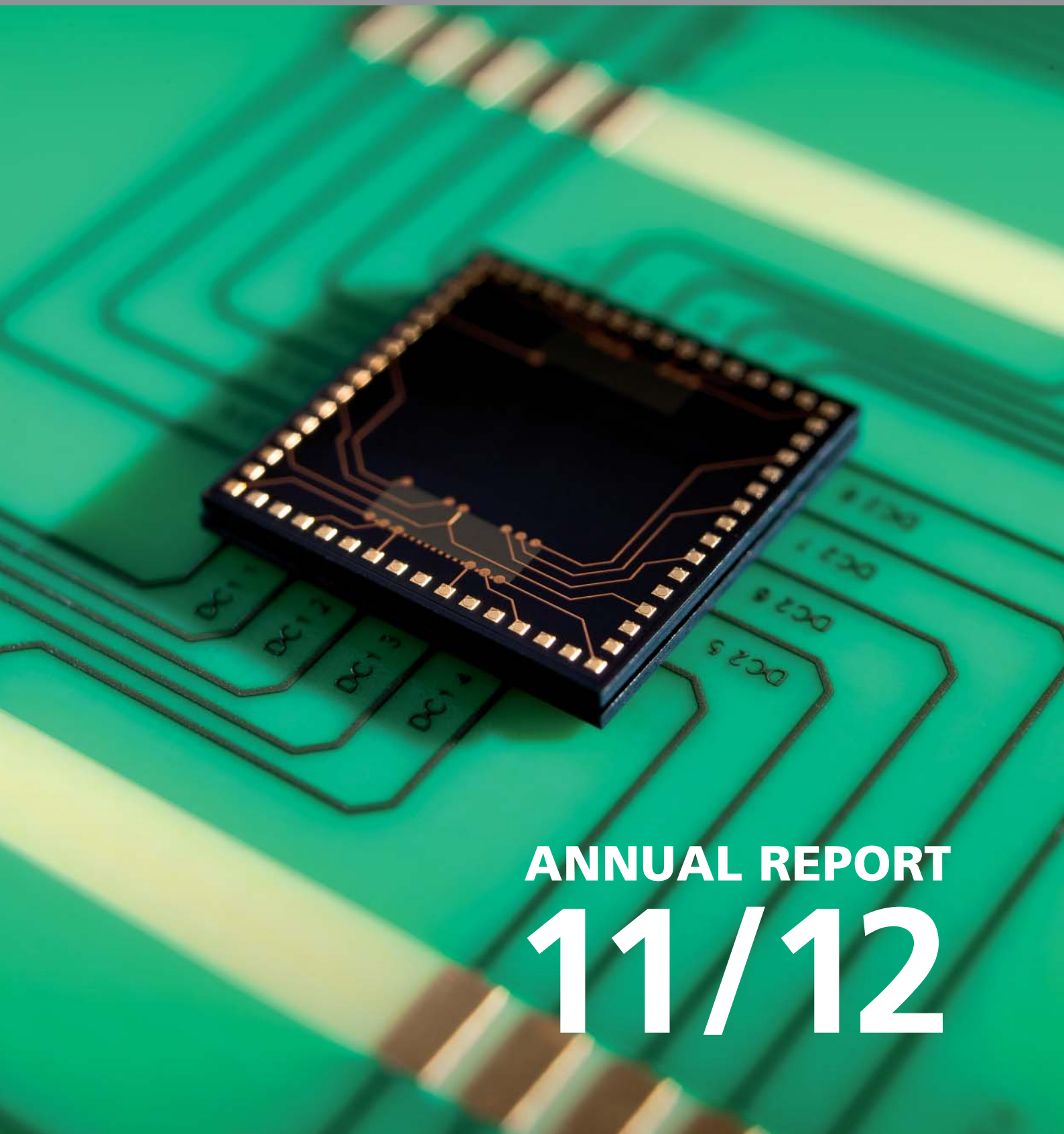
Fraunhofer
IZM

FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM



ANNUAL REPORT
11/12

CONTENT

A STRONG TEAM: INDUSTRY AND FRAUNHOFER IZM

German industry enjoyed a good year in 2011. The success of 2010 was followed by solid economic growth, which has boosted confidence in ongoing favorable prospects. Fraunhofer IZM once again proved itself a reliable partner in research and development during this time by advancing innovative product ideas from the pre-development phase to series manufacture competently, rapidly, and according to the needs of the application in question. Our international partners also benefited from this.

Our strong performance in research and development was reflected by our excellent assessment in the research rating exercise conducted by the German Council of Science and Humanities, which scrutinized 47 electrotechnology research institutes. Research performance, effectiveness, efficiency, advancement of young researchers and knowledge transfer – Fraunhofer IZM received top marks in all areas, ranging from very good to excellent. We are proud of these results. Only those who lead research and development today can demonstrate excellent results in transferring know-how into industry tomorrow.

This excellent outcome was made possible by the expertise of our staff, who develop convincing, customer-oriented solutions in highly effective, interdisciplinary teams. Using the processing lines for wafer processing (up to 300 mm), system integration (e. g. 3D with TSVs) and PCB manufacturing (e. g. large area embedding), we have been able to advance and implement new standards that reflect real manufacturing conditions.

We also have designated experts for power electronics, photonics, automotive technology, safety and security technology and medical engineering. Apart from being the first port-of-call for new ideas in these promising application areas, they also assemble project teams that will best meet the needs of the development ideas in question and coordinate the group's activities.

One example of the many successful collaborations with customers from industry is the microcamera, which was one of the winners of the Germany-wide innovation competition »365 Landmarks in the Land of Ideas«. The tiny camera, with dimensions of less than a millimeter, is inspiring completely new project ideas in addition to its established application in endoscopes.

Whatever your goals in the development and application of microelectronic systems and microsystem technology – we help you with the design, the technology, qualifying the manufacturing process, reliability and environmental impact assessment of your products, either as individual services or throughout the entire process, from the first concept study to series manufacturing.

Feel free to get in touch with me or one of our 200 scientific staff members in Berlin, Dresden or Oberpfaffenhofen. Together we can realize efficient and cost-effective system integration technologies for competitive products.

I would like to take this opportunity to thank our partners and customers from industry and research, the federal and Länder ministries and the project coordinating bodies for their trust and the excellent collaboration.

And not to forget all the Fraunhofer IZM employees for their excellent work, tireless commitment and ongoing creative input in this dynamic research area – my sincere thanks go to you too!

Yours,

Prof. Dr. Klaus-Dieter Lang, Director Fraunhofer IZM

FRAUNHOFER IZM

FRAUNHOFER – A STRONG NETWORK

The Fraunhofer-Gesellschaft
Fraunhofer IZM is one of 60 Fraunhofer Institutes conducting applied research predominantly in the realm of science and engineering, because research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

The majority of the more than 20,000 staff are qualified scientists and engineers, who work with an annual research budget of €1.8 billion. Of this sum, €1.5 billion is generated through contract research.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies, and helping to train the urgently needed future generation of scientists and engineers.

Fraunhofer Group Microelectronics
Fraunhofer has pooled the competences of institutes working in related subject areas in the seven Fraunhofer Groups Information and Communication Technology, Life Sciences, Light & Surfaces, Microelectronics, Production, Defence and Security, and Materials and Components. Fraunhofer IZM is a member of the Fraunhofer Group Microelectronics and is your partner for packaging and smart system integration.

The Fraunhofer Group Microelectronics VμE has been coordinating the activities of Fraunhofer Institutes working in the fields of microelectronics and microintegration since 1996. Its membership consists of thirteen institutes as full members and three as associated members, with a total workforce of around 2,700 and a combined budget of roughly €307 million. The purpose of the Fraunhofer VμE is to scout for new trends in microelectronics technologies and applications and to integrate them in the strategic planning of the member institutes.

The group pools the core competences of its member institutes in the following cross-sectional fields of competence:
- Technology – from CMOS to Smart System Integration
- Communication Technologies
- Safety & Security

as well as in the application-orientated business areas:
- Ambient Assisted Living & Health
- Energy Efficiency
- Mobility
- Smart Living

www.mikroelektronik.fraunhofer.de

YOUR PARTNER FRAUNHOFER IZM

Fraunhofer IZM specializes in applied research that meets the needs of industry. Its four technology clusters cover all aspects of developing and integrating reliable electronics. The technologies and product solutions developed at Fraunhofer IZM are easily transferred to industrial processes. Moreover, the institute's equipment and infrastructure, to which all our customers have equal access, reflects real industry conditions. We also introduce technologies on-site if required.

Our customers come from as many different branches as there are application areas for electronics, including the large semiconductor firms and material, machine and equipment suppliers. But Fraunhofer IZM is equally focused on developing electronics and microsystems for the automotive industry, medical engineering, industrial electronics and even the lighting and textile industries.

The institute is active around the world and its research advances electronic packaging internationally. The institute's staff sit on national and international committees that develop the frameworks necessary for innovative integration technologies.

Responsibility for individual application areas and key research topics is spread across different departments, which ensures that the full breadth of applicable technologies is always available. This organizational structure is also a response to the fact that technology development is increasingly shaped by the application. Promising up-and-coming topics are designated as key research topics, and are monitored and developed in detail by Fraunhofer IZM's researchers, paving the way for future collaborative projects with industry.

Fraunhofer IZM works closely with the Technische Universität Berlin and scientific institutes around the world on these basic research questions. The institute has enjoyed a highly productive cooperation with the TU Berlin since its establishment, which is reflected by the current practice of jointly appointing the institute's director to a TU professorship.

Fraunhofer IZM has a staff of over 300 and had a turnover of €24.2 million in 2011, of which over 90 % was earned through contract research. The institute has four branches in Germany. Apart from its headquarters near Berlin Mitte, it is also represented in Dresden and Munich, both strategically important centers for electronics development and manufacturing. A fourth research group is based at the Berlin technology park Adlershof, ensuring close ties to optical technology companies and research institutes.

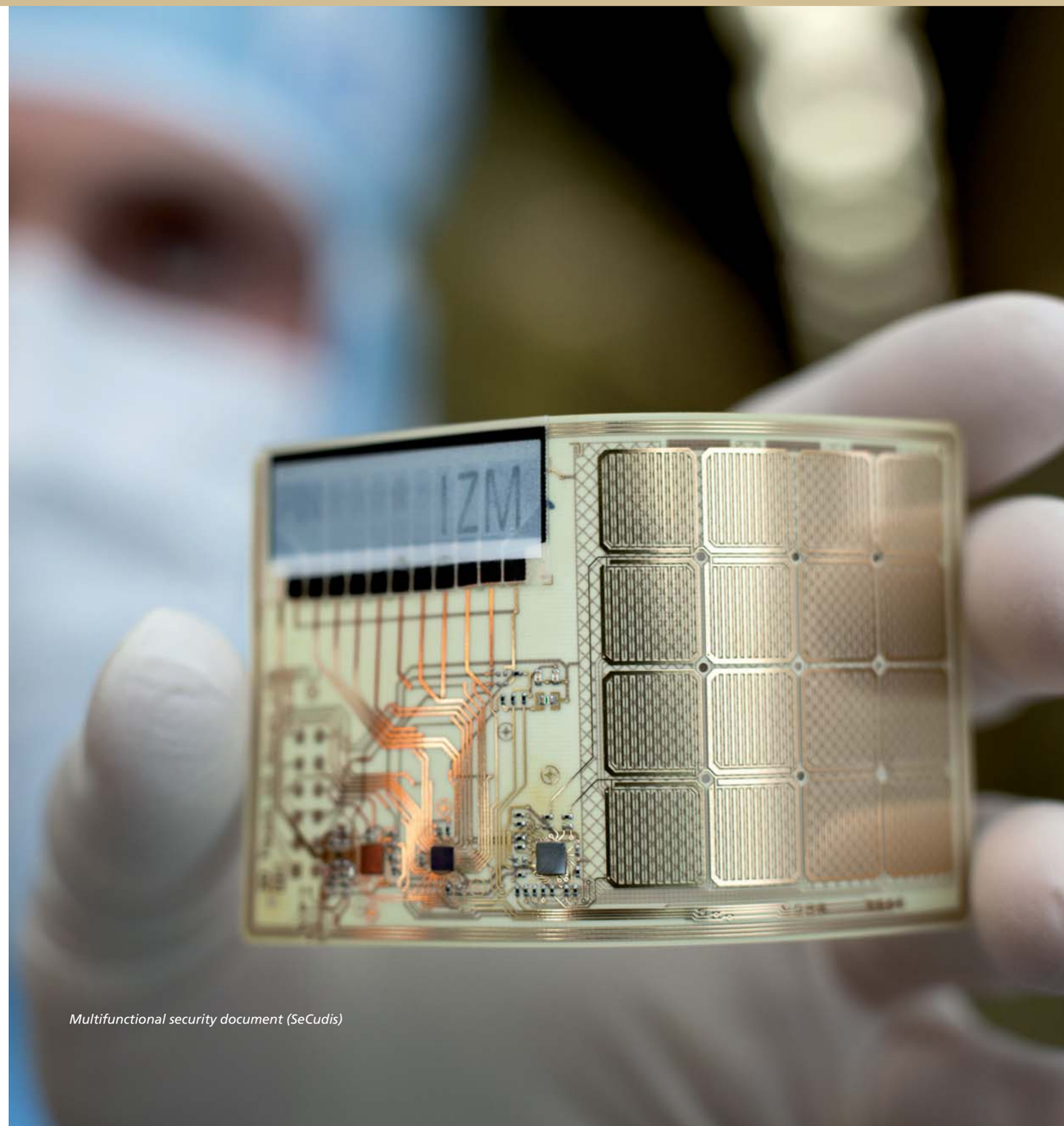
We consider our contract research customers to be partners in research and development: We develop innovative packaging technologies and product-specific solutions for integrating electronics and microsystem technology into your products, exclusively for you and according to your requirements. With direct access to a highly qualified, interdisciplinary research team and cutting-edge laboratory equipment, you can be sure of the right results and stand to save time and thus reduce costs.

Individual contracts are perhaps the most typical type of cooperation. Our customer might want to release a product innovation, improve a workflow, or qualify and certify a process. Together with Fraunhofer IZM, the possible solutions and methods of cooperation are identified, along with the expected expense and effort. What form the cooperation takes can be decided jointly with the institute. Often a successful cooperation starts with a preliminary, generally free, consultation.

Only once the extent of the cooperation has been decided and the corresponding agreements finalized does Fraunhofer charge for its R&D. The customer holds ownership of the material project results developed as part of his contract. Moreover, he is granted the necessary rights to the inventions, property rights and know-how created by Fraunhofer IZM during the cooperation.

Some problems necessitate pre-competitive research. In these cases, it makes sense to strive for a solution together with several partners and public funding support. External partners and other companies can also be recruited.

Regardless of whether our customers already know their way around electronic packaging or are just getting their toes wet – Fraunhofer IZM helps its customers come to grips with their reseach and development questions and accompanies them on the path from idea to product. In all these cases, Fraunhofer IZM's Marketing division is the right first port-of-call. We refer you to the appropriate department, identify the best people to talk to or facilitate technical discussions and workshops with our experts. You particularly stand to benefit from our extensive services in packaging technology and the many technologies that Fraunhofer IZM develops further on an ongoing basis.

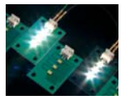


Multifunctional security document (SeCudis)

FRAUNHOFER IZM APPLICATIONS

// INVISIBLE, INDISPENSABLE – FRAUNHOFER IZM'S TECHNOLOGIES AT WORK

Invisible, indispensible, Fraunhofer IZM's packaging technologies have come to shape everyday life. The range of applications unthinkable without the institute's research and development is vast and the following pages provide just a brief overview of our diverse research projects and product solutions. A common thread unites the application areas that rely on our technology – a demand for more reliable, more cost-efficient, miniaturized electronics and microsystem technologies. Moreover, today's technology development has to set the needs of the application as its highest priority. Applied research is Fraunhofer IZM's specialty and the experts listed on the following pages are committed to providing the best solution for any and all applications.



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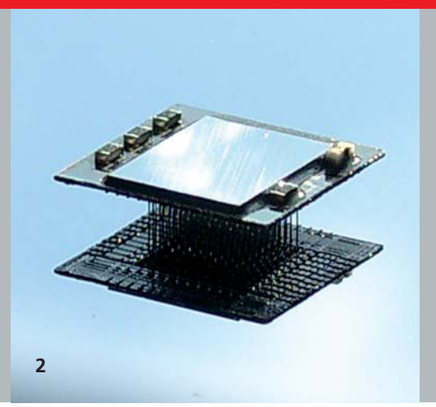

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AUTOMOTIVE / TRANSPORTATION

Automotive / Transportation: On the go safely, reliably and comfortably

Modern traffic systems have to be environmentally friendly and cost-efficient. High-performance, reliable and, in some cases, highly miniaturized systems are key tools for developers creating innovative forms of transport and traffic systems for road, rail, water and in the air.

Since Fraunhofer IZM's establishment, every department has included these application areas as core competences. The institute helps OEMs, tier 1s and in particular their suppliers include electronics in vehicles quickly and efficiently. We develop future-proof, reliable solutions, if necessary also as prototypes, to improve the safety and comfort of conventional, hybrid and electric engines and systems. Our portfolio even includes rail technology, customized for its unique parameters, not least of which are the much smaller lot sizes.

Aeronautic applications have to run extremely reliably and predictably, with the additional challenge of the limited build space and weight. For shipping technology we have to develop innovations that also withstand moisture and often also salt.

Fraunhofer IZM's researchers and staff are the right points of contact for all stages of development, from the initial idea, to the start of manufacturing, through to ensuring availability after commercial release.

Key technologies for electromobility – 5 example projects

Fraunhofer IZM is participating in five projects of the German Federal Ministry for Education and Research (BMBF) program »Key Technologies for Electromobility (STROM)«.

Specifically, we are:

- addressing the reliability and durability of new electronic components for electromobility at all stages of the development process (project RESCAR).
- researching technologies for manufacturing and optimizing high-temperature (up to and above 200 °C) PCBs for power electronics and electric control units (project HELP).
- optimizing soldering technologies for such high-temperature boards (project HotPowCon).
- developing customized technology for manufacturing reliable, embedded high-current PCBs for power electronics and motor control units (project Hi-Level).
- improving wire bonding reliability for power electronic systems by optimizing materials and processes (project RoBE).

Services

Our spectrum of services is interdepartmental and covers the following areas besides power electronics:

- Sensor and actuator technology
- Reliability management and assurance
- Robust design

1 *Sensor module fort the detection of ambient light*

MEDICAL ENGINEERING

Medical Engineering - Higher performance and smaller, finer geometries

Today's hearing aids are so small that they can be completely hidden in the ear canal. Pacemakers work better and last longer. Simulators help patients get urinary incontinence under control. Many of the innovations that have improved the lives of patients are the result of advances in microintegration technology. Diagnostics is another area that benefits greatly from such progress. Modern X-ray sensors in dentist practices, microcameras used in endoscopy, high-performance CT sensors or so-called pill cameras, which can simply be swallowed, would not have been possible without miniaturization.

Fraunhofer IZM has been front and center in this development process for 15 years. Our know-how in microtechnology and innovative integration processes helps manufacturers realize innovative new medical engineering products. With demand for the institute's services shifting from pure technology development to support throughout the development chain (from concept to prototype), the institute has established the new research area Medical Engineering.

Now manufacturers and research partners have a one-stop contact for all of Fraunhofer IZM's services in this area, which allows them to select a technology that is precisely tailored to their individual requirements. Of course, Fraunhofer IZM also performs customized reliability analyses, evaluates biocompatibility and assesses risk according to ISO standards, which are all based on an understanding of the relevant processes, materials and application-specific failures. Often simulation models that draw on this background data are also used.

Cajal4EU - point-of-care diagnostics

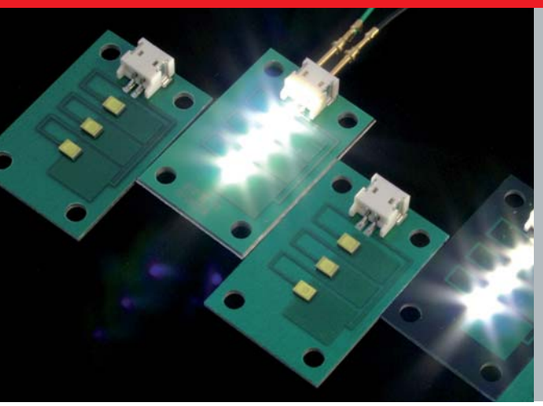
Fraunhofer IZM participates in government projects and bi- and trilateral cooperations with medical engineering companies and researchers throughout Europe and overseas. For example, in the European project Cajal4EU (www.cajal4eu.com) we are developing a fully integrated diagnosis platform that uses nanoelectronic components and covers all aspects of the diagnostic process, from taking the specimen through to analyzing the results.

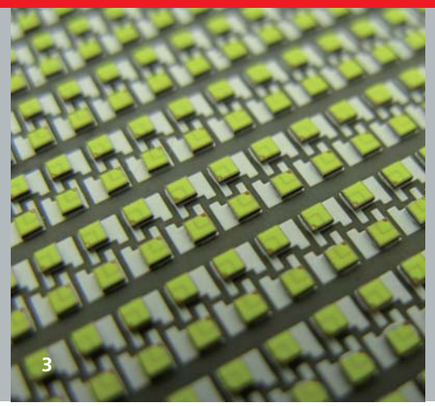
In the BMBF-funded pilot project KoAI-A we have developed an algorithm with the TU Munich to reconstruct a pit viper's infrared organ. This approach, which was derived from biological and cognitive science, can also be applied to technical systems. The Saapho (www.saapho.eu) project is integrating sensor microtechnology into the everyday environment of seniors and other people requiring assistance so that their vital statistics and other monitored parameters can be fed into an open-standard communication platform and used to improve quality of life. Here Fraunhofer IZM is contributing to the development of an intelligent medicine dispenser, a universally applicable activity monitor and a blood pressure measuring system that transmits data via the NFC protocol.

Services

- Packaging technology and reliability analysis for miniaturized medical devices and implants
- Lab-on-substrate technologies for patient-friendly laboratory diagnostics
- Improving the functionality of neuronal interfaces and intelligent prostheses

2 *Wireless neural interface*





LIGHTING / LED

Lighting / LED: More light!

The optoelectronics industry is increasingly turning to solid state lighting, particularly LEDs. Above all power LEDs are set to become widespread in general and street lighting. And although retrofit products have shown the largest turnover to date, outdated standards are limiting efficiency gains.

Instead, the future lies in new lighting systems that factor in heat dissipation from the very beginning. Fraunhofer IZM has much to contribute to this technology shift, because the packaging rather than the socket now limits heat dissipation.

Moreover, apart from ensuring the required thermal dissipation, the packaging design also has to balance the differing CTEs of the materials used. Further research areas include the power supply's overall efficiency, the light extraction and the very different operating conditions, ranging from interior lighting, to medical products, through to industrial applications in corrosive atmospheres.

Fraunhofer IZM is meeting all these challenges. We qualify existing products, develop alternative joining technologies and conduct innovative research into design, simulation, component evaluation, process development, product characterization and reliability analysis.

We also perform failure analyses and identify failure causes for products in the field.

CooLED – extremely high-performance LED assemblies

Fraunhofer IZM is working hand-in-hand with two industry leaders on the German Federal Ministry of Education and Research (BMBF) project CooLED. CeramTec GmbH supplies innovative aluminum nitride liquid cooling manufactured by extrusion. Fraunhofer IZM's Oberpfaffenhofen branch is designing the thermal and fluidic parameters and is mounting the cooling body with new LEDs using cutting-edge bonding technologies. Excelitas Technologies (previously PerkinElmer Elcos GmbH) then equips the fully functional LED modules with electrical and fluidic interfaces and optical socketing.

Light sources of 600 to 1200 W have been developed in the project that feature a thermal flux of just over one W/mm², has to be evenly distributed across the surface. Fraunhofer IZM put together the data on the materials, supplied the design, developed packaging processes, helped establish the necessary soldering and sintering processes and performed a thermal characterization of the modules.

Services

Design, assembly concepts and characterization for:

- Chip and substrate evaluations
- 3D integration in silicon
- 1st and 2nd level interconnects (including underfill)
- Wire bonding
- Transparent filling and converter applications
- Primary and secondary optics
- Cooling

3 *1200 W LED module with Ag-sintered white chips*

SAFETY & SECURITY

Safety & Security: As much as necessary, as little as possible!

Modern safety and security technology is far more than just fire and burglar alarms or surveillance technology. Our solutions range from sensors integrated into protective clothing and textiles for monitoring vital statistics, to technology that ensures equipment reliability (component reliability, autonomous sensors, technical textiles), through to technology concepts for the unambiguous identification of objects (forgery protection) and persons (ID cards, access authorization). Moreover, we also research the quality assurance of critical components (probability of failure, early detection of material defects or fatigue).

Intelligent safety and security technology, judiciously applied, protects people and equipment in equal measure and ensures our day-to-day is safe.

We specialize in the following areas:

- Electronic integration on/in flexible substrates such as plastics and textiles
- Ultrathin systems based on innovative embedding technologies for active and passive components
- System concepts for autarkic sensors
- Wireless system and networked sensor node design

In cooperation with our industry partners we develop tailor-made concepts, conduct technology-oriented analyses and identify the most promising solution approaches. Our work makes competitive, innovative products and systems possible and opens up new opportunities for our industry partners.

The alarm textile that foils burglars

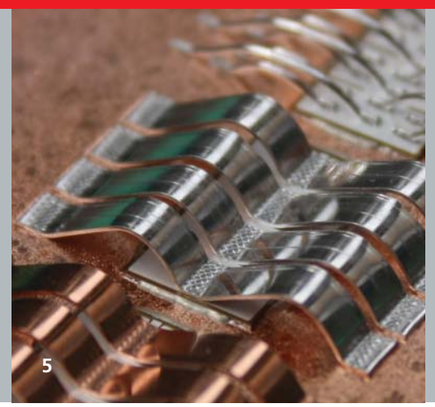
Designed as burglar alarm system for large surfaces such as rooftops and truck platforms, the fabric features conductive traces and integrated electronics. Not only damage to the conductive wiring is detected, but also the precise location of the failure. Together with ETTLIN AG, we were able to develop just such a fabric as part of the project »Alarm Textile«, funded by the German federal ministry of economics and technology (BMWi)'s central innovation program for SMEs (ZIM).

The alarm textile has many other exciting possibilities, such as integration in concrete walls and drywall panels, to secure bank safes or to fit flooring with pressure sensors that can be configured to distinguish between pets and humans by their weight. Of course, the electrical currents running through the fabric are far too low to pose a danger to humans or animals.

Services

- Packaging technology for human and goods identification products (smart cards, RFID)
- Integration of electronic components into textiles and composites
- Embedding of passive and active components for ultrathin systems and high-security applications (invisible electronics)
- Design of systems for quality assurance
- Antenna and circuit design for safety and security applications
- Packaging for mm-wave, terahertz and infrared sensors

4 *Extremely thin transponder for security documents*



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POWER ELECTRONICS

Power Electronics: The key to reducing energy and resource consumption

Power electronics is the technology for developing intelligent and flexible power supplies and controls for the many different applications that use electricity. Switching power supplies, electric drives in road and rail vehicles, and large industrial drives have to function as efficiently as possible to conserve our natural resources. Using power electronics, energy from renewable sources can be processed into a form suitable for the existing electrical grid.

Fraunhofer IZM develops these innovative and reliable power electronic systems. We research the possibilities opened up by the new semiconductor materials silicon carbide (SiC) and gallium nitride. The materials require higher temperatures of up to 250 °C, which has to be factored into the packaging design.

Thanks to their properties, SiC semiconductors are almost perfect switches. High switching speeds combined with parasitic capacitances and inductances within the package and at the component connections create unwanted oscillation that can hamper chip function. However, EMC-optimized package design can help reduce losses and keep interference to a minimum. A good connection to the installation environment is also important.

We have the skills and know-how required at every stage of the development chain, from system design, to packaging, thermal management, electromagnetic compatibility, through to reliability and damage analysis.

SoLar – rapid and efficient design of power electronic systems

The development of commercially viable, power electronic systems involves meeting many different and sometimes contradictory requirements. Developers have to ensure the technology is highly efficient, robust, reliable and low cost, and that it has high lifetime, high power density and good electromagnetic compatibility (EMC). They also have to assess all these properties against each other.

The collaborative project SoLar is developing a simulation and design technique of the rapid and efficient design of power electronic systems. The new method will allow developers to factor in the main parameters of new, highly efficient power electronic systems at an early stage of development using validated simulation models and optimization strategies. This will prevent unnecessary (and expensive) revisions later in the development process.

To analyze the new models, Fraunhofer IZM is developing, assembling and testing a 15 kw solar converter mounted with SiC chips.

Services

- Miniaturization and system integration
- Thermal Management
- Electromagnetic compatibility
- Reliability
- Innovative packaging technologies

5 *Cu- and Al-ribbon bonding for power semicnductors*

INDUSTRIAL ELECTRONICS

Industrial Electronics: Innovative and multifaceted

Three main topics currently dominate automation technology: energy efficiency, wireless automation technology and application-specific sensor packaging. Fraunhofer IZM is developing application-optimized solutions for each of them.

Energy efficiency

Automation technology is a key means of streamlining design and manufacturing processes. Fraunhofer IZM helps businesses identify potential energy savings and supplies the know-how required for the assembly of intelligent power electronics. Intelligent, because the power and control components are integrated into the same housing. Our technologies also ensure that the power component itself has lower dissipation.

Wireless automation technology

In wireless automation technology, Fraunhofer IZM's primary areas are power supply, networking, robust communication and application-specific assembly of sensor nodes.

Application-specific sensor packaging

Sensors for automation technology can almost be said to perform miracles. They have to collect data extremely accurately, often while exposed to the harshest environmental conditions. Packaging takes on a crucial role here. It has to protect the sensors from environmental influences without impeding their functionality. Fraunhofer IZM specializes in stress-free and highly robust sensor packaging that makes new processing windows possible. We also research and develop optical sensor packaging, such as miniaturized camera systems, spectrometers and fiber optic sensors.

Monitoring shaft seals in gear motors

Monitoring shaft seals is difficult. To evaluate the seal's condition, mechanics have to disassemble the gear motor, which is a very time-intensive task. Freudenberg Dichtungs- und Schwingungstechnik GmbH & Co. KG and the Fraunhofer Gesellschaft teamed up to tackle this problem and have developed a sensor with a self-sufficient power supply integrated into the shaft seal, which monitors sealing and temperature. By making continuous monitoring possible, the intelligent seal prevents sudden damage and failures.

An IR reflection light barrier measures the sealing function. Temperature and rpm are also measured. An integrated wireless interface sends the sensor signal to a receiver in the gear housing during operation. From there it is fed into industry-standard bus systems. An integrated generator provides the system with a self-sufficient power supply. Moreover, gear motors can be retrofit with the intelligent shaft seal without any additional adjustment measures.

Services

- Development and assembly of electronics for harsh operating environments
- Industrial sensor packaging
- New concepts for integrating sensors into machines and equipment
- RFID solutions for industry and logistics
- Robust, energy-efficient power electronics
- Reliability and lifetime testing

6 *RF board mounted on radial seal of a gear shaft*

COOPERATION WITH UNIVERSITIES

To effectively realize its research targets Fraunhofer IZM has formed strategic networks with universities in Germany and abroad. The following pages provide an overview of our most important cooperation project.

Cooperation with Technische Universität Berlin
Close collaboration between Fraunhofer institutes and universities throughout Germany and internationally has always been a cornerstone of the Fraunhofer Gesellschaft's ongoing success. Universities bring their innovativeness and their expertise and know-how in basic research to the table, while Fraunhofer contributes excellence in applied research, outstanding technical infrastructure, continuity in human resources and long-standing experience in international projects.

Fraunhofer IZM's close relationship with the TU Berlin's Forschungsschwerpunkt Technologien der Mikroperipherik is proof-positive of this collaborative model and dates back to the institute's very founding in 1993. Under the stewardship of Professor Herbert Reichl, the institute was one of the world's first research institutes for packaging technology.

Since February 1st 2011, the traditional double appointment of Fraunhofer IZM Director and Head of the Forschungsschwerpunkt Technologien der Mikroperipherik has been held by Professor Klaus-Dieter Lang. Both institutions research and develop smart system integration with a joint goal, namely to integrate components that may have been manufactured using very different technologies on or in a single carrier substrate at high integration densities to increase flexibility and yield while reducing costs.

In pursuit of these joint goals, the Forschungsschwerpunkt, in cooperation with Fraunhofer IZM, is focusing on basic research into assembly and interconnection technology for sensors, microelectronics and microsystem technology. Key areas of research include:

- Materials and processes for integration technologies on wafer, chip and substrate level
- Nano interconnect technologies
- Polytronic microsystems
- Reliability from nano structures up to the system
- Sustainable technologies
- System design and modeling

Fraunhofer IZM also supports teaching at Technische Universität Berlin by offering students additional seminars and the opportunity to participate in national and international research projects.

H-C3: Human Centric Communication
The Human Centric Communication Center, H-C3 for short, opened its doors in February 2009. Goal of this TU Berlin initiative, in which more than 50 TU Berlin departments and 11 other research institutes are participating, is to facilitate the general public's intuitive access to and handling of growing amounts of information by developing suitable hardware and software technologies.

Three PhD candidates from Fraunhofer IZM and the Forschungsschwerpunkt are working on five different research areas dealing with technological, economic and sociological aspects of human communication. Specifically, the researchers are developing design and integration technologies for the assembly of the required hardware, as well as energy management technologies for autarkic sensor networks.

Towards zero waste in industrial networks
The European project »Towards Zero Waste in Industrial Networks« is concerned with regional collaboration of companies from traditionally separate sectors which exchange by-products, energy, water and materials in such way, that the waste from one industry becomes raw material for another. The sectors construction, automotive, photovoltaics and laptop production are being examined for symbiotic relations. In the framework of this project TU Berlin's Forschungsschwerpunkt Technologien der Mikroperipherik develops design for recycling-measures for laptops and photovoltaic systems.

»Design for Recycling (DfR)« is a part of ecodesign and aims at minimizing the environmental impact of products at the end of their (first) life, bringing the product back into a second life and thus enhance product longevity. In a dialogue with designers, producers, recycling companies and science almost a hundred such DfR-measures have been developed and collected, and their technological feasibility, environmental and economic impact have been evaluated. Selected measures are being implemented in a DfR-laptop and a DfR-photovoltaic system.

INTERNATIONAL RESEARCH COOPERATIONS

Heterogeneous Technology Alliance (HTA)
Together with other Fraunhofer institutes and leading European microelectronics research bodies (France's CEA-Leti, Switzerland's CSEM and Finland's VTT), Fraunhofer IZM is participating in the Heterogeneous Technology Alliance (HTA). The research partners are working on joint research topics and responding to European tenders to extend their edge over international competitors. The alliance is combining its know-how under the title »4-Labs« for joint research projects that provide customers one-stop solutions for innovative products.

Cooperation with the University of Utah
Fraunhofer IZM has been closely cooperating with the University of Utah since 2005. The initiative comprises two projects in which neural prostheses are being developed, with Fraunhofer IZM responsible for the integration of wireless communication technology in the new technology. Two IZM researchers were seconded to Salt Lake City from 2006–2008 to provide their expertise on-site.

Since 2008 Fraunhofer IZM has also been funding a research position at the University of Utah for the analysis of biocompatible packaging technologies and supports a bilateral student exchange. Along with these transatlantic research projects Fraunhofer IZM is also involved in the realization of commercial components for neuro signal processing and has started a patent exploitation initiative together with the Technology Commercializtion Office (TCO).

European Center for Power Electronics (ECPE)
Leading companies from the realm of founded the European Center for Power Electronics (ECPE) in 2003 in order to promote research, education and technology transfer in this field. The aim was to demonstrate the relevance of power electronics to the public, to increase acceptance of political decision-makers and to encourage students to look for a career in this area.

Fraunhofer IZM is a member of the ECPE's competence center and provides support in its areas of expertise, i. e. design, simulation, assembly and packaging, electromagnetic compatibility and reliability for power electronics. The institute is also regularly involved in the organisation of ECPE tutorials and workshops.

International research project on patient-centred laboratory diagnostics
The aging population and steadily increasing costs of medical care pose great challenges to the health care systems of industrial nations. To improve health care over the long-term and reduce costs, new methods for the early detection of diseases and individual, effective therapies are required. With this overarching goal in mind, 32 partners from eight European countries are developing an innovative, cost-efficient analysis platform for in vitro diagnosis. The collaboration forms part of the ENIAC project »Chip Architectures by Joint Associated Labs for European Diagnostics« (CAJAL4EU).

Specific aims include:
- Developing and optimizing innovative biosensors based on semiconductor chips.
- Developing microfluidic lab-on-a-chip systems for specimen collection and handling.
- Integrating the sensors into the lab-on-a-chip environment.

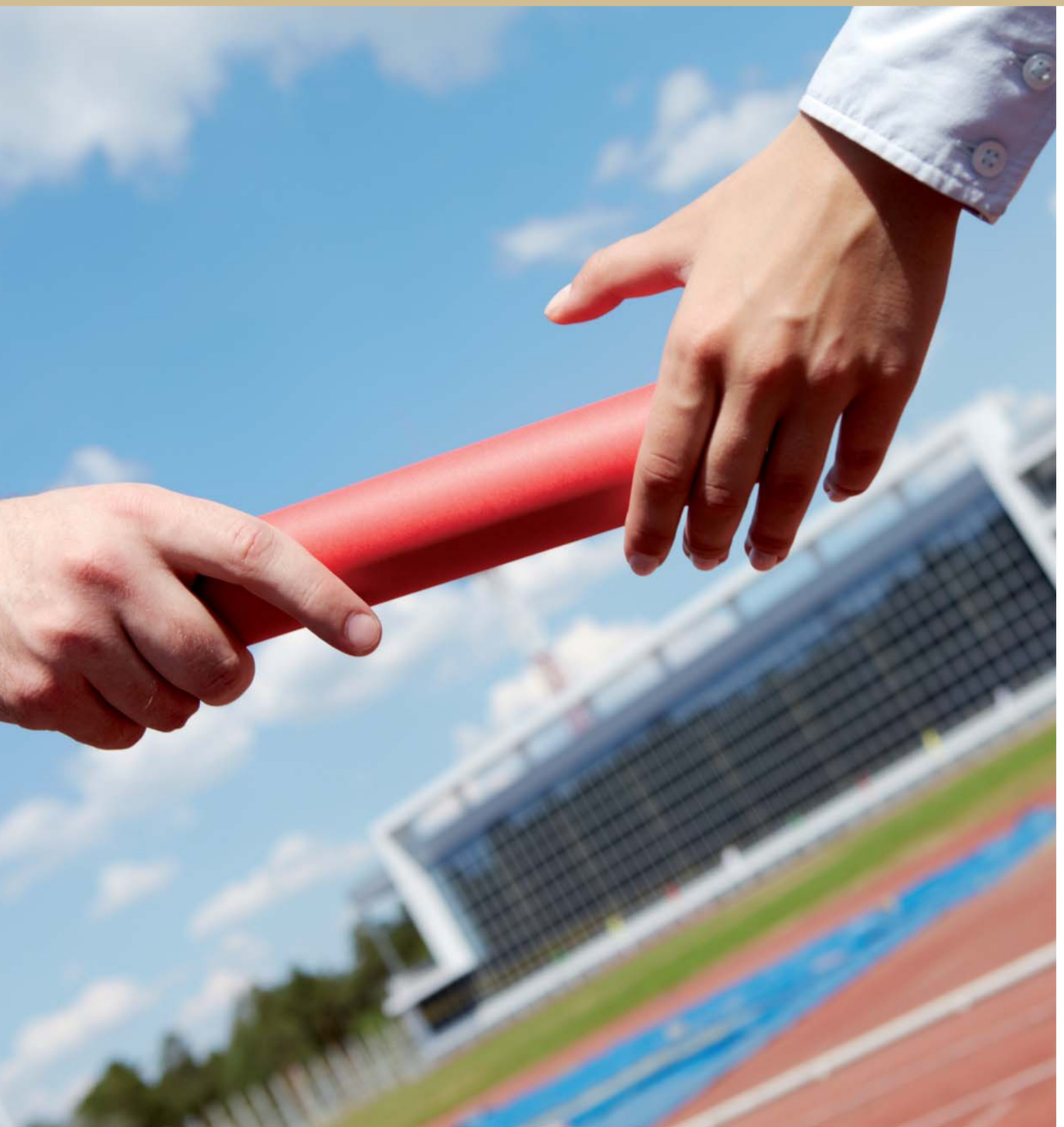
Fraunhofer IZM is coordinating the project in Germany and developing microsystem technologies for integrating the process control and diagnosis components into a point-of-care platform.

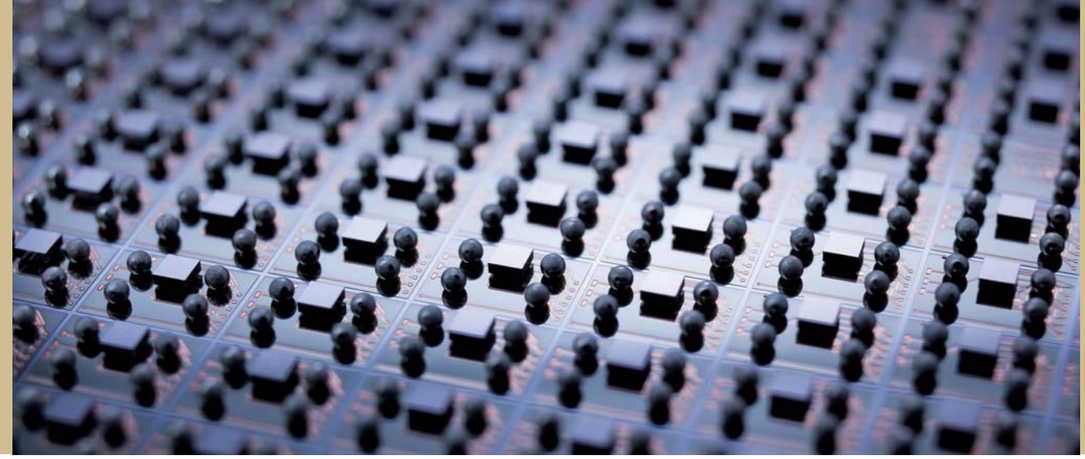
Cooperation with the National Institute for Materials Science (NIMS) in Japan
In 2010 Fraunhofer IZM signed a memorandum of understanding (MOU) on cooperation and joint research regarding »Nanotechnology and Environmental Engineering« with the National Institute for Materials Science (NIMS) in Japan. Under this agreement, Fraunhofer IZM's Environmental Engineering Department and the Hybrid Materials Center of NIMS will exchange researchers and information, as well as promote the joint research on environmentally relevant information on the life cycle of nano materials in products, the risks of nano materials in electronics, as well as a basic exchange on new nano materials in Asia and Europe.

The kick-off workshop for the cooperation was postponed due to the natural disaster at Fukushima and finally took place in Tsukuba in November 2011. In 2012 the first exchange of students from both institutions will take place, later on further workshops and an exchange of scientists are planned.

Some of Fraunhofer IZM's other university partners
Technical University of Delft, The Netherlands
Technical University of Eindhoven, The Netherlands
Technical University of Tampere, Finland
Bologna University, Italy
Cárdiz University, Spain
Tokyo University, Japan
Twente University, The Netherlands
Uppsala University, Sweden
University College London, Great Britain
Albert-Ludwigs-Universität Freiburg
Christian-Albrechts-Universität, Kiel
Friedrich-Alexander-Universität Erlangen-Nürnberg
Humboldt Universität zu Berlin
Technische Universität Chemnitz
Technische Universität Darmstadt
Technische Universität Dresden
Universität der Künste Berlin
Universität Potsdam
Universität Rostock

FRAUNHOFER IZM COOPERATION





YOUR BRIDGE TO FRAUNHOFER IZM TECHNOLOGIES

Regardless of whether you are already using electronic packaging technologies or are planning to invest in it; Fraunhofer IZM Marketing and the Application Center Smart System Integration offer the support and collaboration you require to reach your development aims.

Fraunhofer IZM Marketing – employing advanced technology is the key to investing in the future

You already know what kind of technology you want to employ and would like to make sure you will be harnessing the latest trends? You are familiar with the technology but need assistance in development, failure analysis or with optimizing your products? We can provide consultancy from the Fraunhofer IZM research department by organizing workshops and technical discussions.

Collaboration with us not only ensures you access to our many services in system-in-package and system integration, but also sees you benefiting from the development of our cutting-edge technological products.

APZ Smart System Integration – Remain one step ahead by employing cutting-edge technology

You want to upgrade your products but have not yet invested in microsystem technology or only use it to a limited extent? Despite this, you would like to make use of our know-how and technology in system-in-package and system integration? The APZ Smart System Integration links industry with Fraunhofer IZM's wider activities, including active support by the German Ministry of Education and Science.

If your company plans to integrate microsystem technology into your product line for the first time in the near future, you can reap enormous rewards from recent developments in IZM technology.

In addition to providing support at any development stage, we offer:

- Customized technological consultancy, e.g. on selecting feasible technologies
- Feasibility studies
- Complete technology transfer
- Provision of manufacturing capacities

You will be accommodated with the entire range of services required, from developing your idea, through to successfully marketing the product. Our technology workshops and laboratory facilities are in high demand, too.

FRAUNHOFER IZM MARKETING

You face problems in developing your product and need advice but lack contact with research facilities? You would like to expand your know-how with the help of a special technology workshop or directly benefit from our technological expertise?

Our marketing team will be your first port-of-call, facilitating your access to key players in the relevant research departments. Specifically, our services include:

Company-specific workshops

Whether you are on the look-out for upcoming trends and technologies that could be relevant for your company or plan to put your own latest technology to the test, we can organize a customized workshop that offers access to our services and facilities.

We provide access to our specialists who can discuss the entire bandwidth of technological advancement in electronic packaging. When you need a partner to assist you in taking your product line to the next level, you can rely on us.

Special technology workshops

Extending or optimizing your product line is a high priority and you find you need assistance with choosing the right technology? We arrange technical discussions with our staff members and specialists. Our experts will discuss with you the pros and cons of your options, taking into consideration the current state of your company's technological infrastructure.

Consultancy for specific technological problems

You have questions regarding ongoing technological developments and current trends? We can assist in identifying the right contact in the Fraunhofer IZM team of experts. Simply contact us.

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APPLICATION CENTER SMART SYSTEM INTEGRATION

One of the application center's highest priorities is offering a broad range of developmental know-how on microsystem technology products, thereby accelerating a product's path to application.

Not only do we foster relationships with companies established in the field of microsystem technology, but we also encourage newcomers who have not yet invested in this type of technology. In fact, the application center was launched as an initiative of the German Ministry of Education and Research with a specific charter to provide consultancy and technological support for companies at every stage of development.

How do we support your product development?
You have an idea for a certain product and would like to develop it? But you are unsure about the feasibility, quality, development costs and time it requires?

We offer consultancy and development support modules, from which you can choose according to your specific requirements at any stage of development. The product development support modules are described as follows:

- First, we compile a basic study on the general feasibility of your idea and list some initial ideas for implementation. Depending on your wishes, we provide patent searches, extensive market research and trade leads, as well as some groundwork regarding expenditure. We provide you with a customized requirements specification as outcome
- Second, all feasible solutions will be processed by conducting evaluations, calculations, tests and simulations to collect the data required for further development and delimit the possible from the impossible. The information is compiled in a functional specifications sheet
- As a third step, we can produce a demonstration model as a proof of concept
- If requested, we can develop a prototype (hardware, software and technology) and take the next step toward a market solution in close collaboration with your company
- As an additional service, we can assist you in locating the manufacturing capacities for the final product

Helping you develop your product is our main aim, so please contact us for more information. The following example will give you a rough overview of our work.

USB stick for the easy installation of wireless modules in intelligent buildings
Intelligent networking in buildings is relying more and more on battery-free wireless components, which are easy to install and do not even require servicing. The only remaining drawback is that wireless signal transmission within buildings is often poor or faulty. Consequently simple, rapid analysis of the wireless signal and its strength is indispensible for ensuring smooth communication between the wireless components.

Our application center joined forces with EnOcean GmbH to develop a wireless gateway packaged in a USB stick as a convenient tool for testing a building's entire wireless network. Because it can transmit data bidirectionally, the USB stick simplifies remote configuration and parameterization dramatically. The new tool comprises a RF transceiver, UART interface, a 20-pin programming cable (optional), LEDs and an integrated RF antenna with adaptable components. The PCB monopole antenna is configured for both the 868 MHz (Europe) and 315 MHz (USA) bandwidths. As add-on, the wireless module can also be programmed directly, which should appeal to OEM developers.

Ambient assisted living technologies for the elderly and their families
Technological living aids should be applied as much as necessary and as little as possible. This rule-of-thumb also is the key to providing individualized measures to help the elderly maintain their independence. However, solutions that can be adapted to meet the requirements of the individual are few and far between. Our application center teamed up with ESYS GmbH and PME Familienservice, who specialize in support services for families, to develop an electronic, modular system comprising sensors, and data processing, remote transmission and actuator components. The components can be retrofit, are easy to operate and can be assembled and configured as required. The new system was designed to help the elderly feel safer and keep their next-of-kin up-to-date on their well-being.

To illustrate the potential of the technology, we assembled an autarkic power, location and brightness sensor system. At designated intervals, the sensors record the status of devices and the environmental conditions in the elderly person's home and relay the data to family members if necessary. The sensors use EnOcean's energy-optimized protocol and a PAD located in the elderly person's home. As the central hub, the PAD also incorporates the system's user interface. Thanks to the power sensor, which was developed in-house and can simply be clipped to power supply cables as required, any and all electrical devices are easily monitored. Typical examples of applications include monitoring whether the stove is on or the elderly person's activities by which devices they turn on and off.

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1 *Loss of orientation – a typical symptom of dementia*

FRAUNHOFER IZM SERVICES

Fraunhofer IZM not only carries out development and research for you, but provides access to its machines and equipment.

Our laboratories include:

- Training center for interconnection technologies (ZVE)
- Flip chip line
- Die and wire bonding center
- Micromechatronics center
- Process development and qualification for the electronics encapsulation
- Qualification and test center for electronic components (QPZ)
- Electronics condition monitoring laboratory
- Laboratory for thermomechanical reliability

We cover a broad spectrum of technologies, from material characterization, to support in manufacturing questions, through to assistance with quality and reliability problems throughout the value chain – and thus deal with all possible problems that can arise in the manufacture of electronics.

Our outstanding laboratories for reliability testing and optimization include:

Training Center for Interconnection Technology (ZVE)
The ZVE is ESA approved and IPC certified (IPC A 610) and operates as a training and service center for assembly and connection technology. The training program includes courses and seminars on lead and lead-free manual, reflow or wave soldering, SMT component repair and lead-free connection technology. Other ZVE services include process qualification and consultation on quality-assurance for electronic component manufacture.

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Qualification and Test Center (QPZ) for Electronic Components
The Qualification and Test Center focuses on application-specific qualification of new solder alloys and packaging solutions for electronic components on a wide variety of substrates. All tests are carried out according to DIN EM, IEC, IPC and MIL standards. Component inspections and failure analyses after testing include the investigation of structural alteration, intermetallic phase growth, crack propagation using metallography, SEM/EDX analysis or focused ion beam (FIB) preparation.

Troubleshoot component failure with online assistance from Fraunhofer IZM
QPZ is now offering online, optical failure analysis based on the IPC-A-610 standard. The new service provides companies that experience component failure during manufacturing or shortly after deployment in the field with fast, sound advice on the component problem and its possible cause.

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Electronics Condition Monitoring Laboratory (ECM)
ECM specializes in function tests on electronic systems under environmental stress beyond purely thermomechanical strain. Combined testing processes are employed, such as vibration combined with humidity and/or temperature. The component's condition is determined precisely during testing using degradation-dependant parameters and by recording the stresses. The resulting data are compared with failure models and used for the design and testing of monitoring structures and to assemble condition indicators.

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PCB Prototyping Process Line
The new prototyping and process line can handle substrates with a maximum size of 610 mm x 456 mm and features:

- High-precision component placement
- Vacuum lamination press for multilayer fabrication and component embedding
- UV laser drilling and structuring
- Mechanical drilling and milling
- Photolithographic patterning using laser direct imaging and dry-film photo resist
- Horizontal spray development of ultra-fine line structures
- Horizontal spray etching and photoresist stripping
- Automatic and manually operated galvanic equipment

The technology can be easily transferred to conventional industrial manufacturing environments.

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Wafer Level Packaging Line
Our wafer level packaging line in Berlin boasts a 800 m^2 clean room (classes 10 to 1000), with wafer processing of different materials (Silicon, III-V semiconductors, ceramic, glass) and sizes (4'', 6'' and 8''). For some applications prototyping equipment is also available on 300 mm.

- Thin-film deposition (sputter and evaporation)
- Photolithography (including photo varnishes, polymers and spray coating)
- Galvanic bumping, circuit tracks and through-via filling (Cu, Ni, Au, AuSn, SnAg, PbSn)
- Wet-chemical processes (etching, cleaning)
- Wafer bonding (support wafer, thin-wafer handling)
- Silicon plasma etching (through vias, cavities)

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Mold Encapsulation Lab
The mold encapsulation lab offers various encapsulation processes, related material and package analysis and reliability characterization tools as a one-stop-shop.

- Compression molding on module- and wafer level
- Compatibility to PCB-based and thin film RDL application
- 3D-redistribution by through mold vias (TMV)
- Transfer molding of leadframe-based SiPs and of SiPs organic substrates (MAP molding)
- Rapid tooling for feasibility studies with real live prototypes
- Sensor packages with exposed sensor areas by film molding
- Transfer molding of large volume packages

Transfer to industrial production is guaranteed due to use of production equipment.

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All Silicon System Integration Dresden - ASSID
The Fraunhofer IZM-ASSID Center in Dresden is equipped with a 300 mm wafer process line for the development and processing of integration technologies with analogue-digital or digital-digital circuits on CMOS-basis. Fraunhofer IZM-ASSID provides the following services:

- Cu-TSV interposer technology
- High-density Cu-TSVs for active and passive device integration
- Wafer thinning and handling of thinned wafers
- Wafer level bumping
- Wafer level assembly
- Wafer level solder ball attach (100 – 500 µm)
- Customer-specific prototyping

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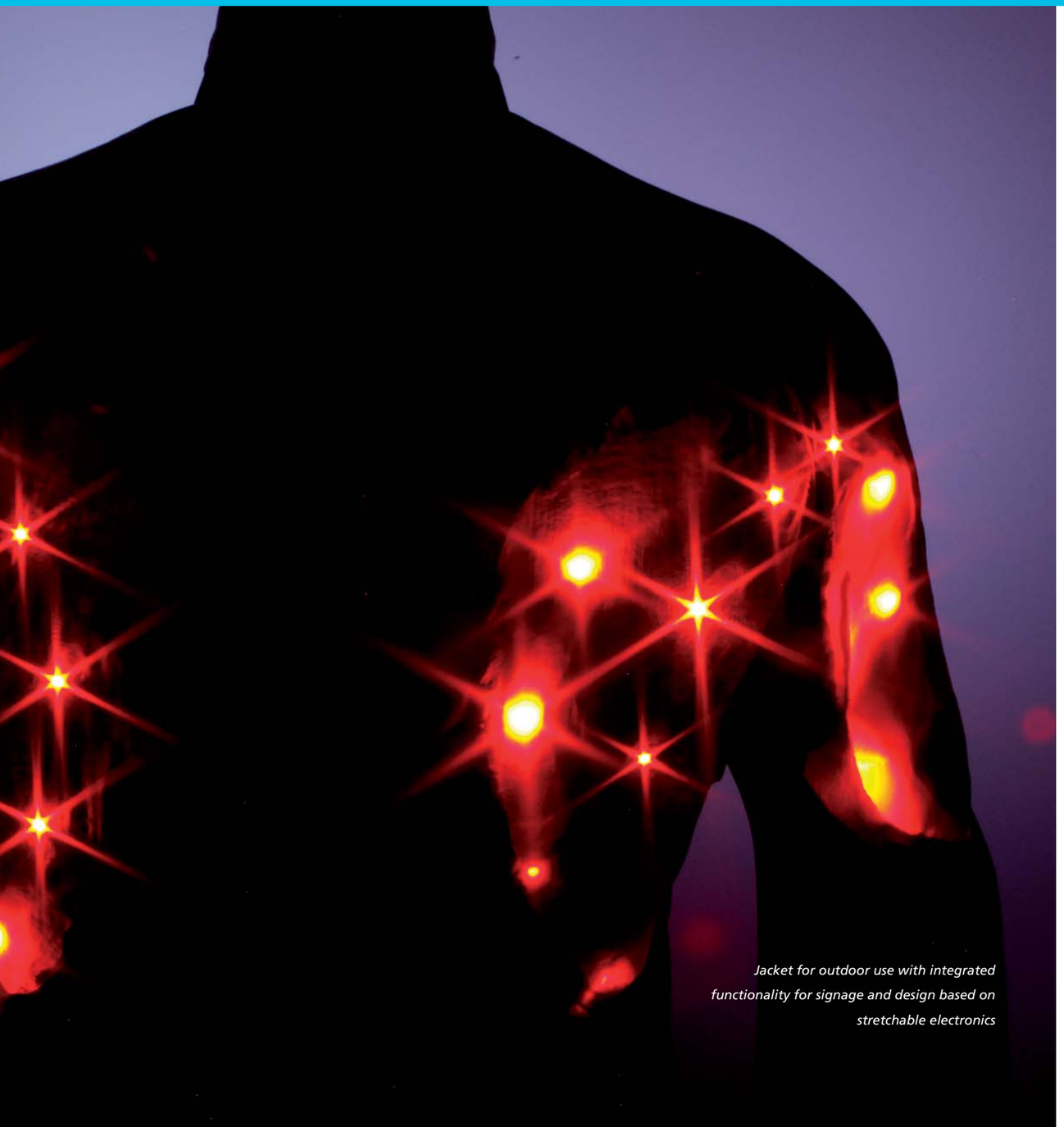
FRAUNHOFER IZM
CORE COMPETENCIES

RESEARCH CLUSTER INTEGRATION ON SUBSTRATE LEVEL



Jacket for outdoor use with integrated functionality for signage and design based on stretchable electronics

HIGHLIGHT 2011

Stretchable and textile electronics

Over recent years our department has been contributing to two large-scale, Europe-wide projects to develop an innovative manufacturing technology for stretchable electronic systems. The new technology, which includes the assembly/interconnection of components on the board, has now achieved technological maturity and has been implemented by a number of different manufacturers. A key advantage of systems fabricated using the new process is that conventional, commercially available components can be used. The copper wiring within the stretchable matrix material has a meander-shaped layout, which ensures that the material remains stretchable/expandable.

The new technique's processing sequence resembles that of conventional electronics fabrication. In the first step, a stretchable substrate, similar to a single- or double-sided PCB, is fabricated. However, instead of a rigid epoxy resin with glass reinforcement (FR4) or flexible polyimide (PI), the technology uses a soft thermoplastic polyurethane film as polymeric support matrix. As mentioned above, the copper interconnect pattern is meander-shaped, instead of straight as in conventional PCBs. A solder mask is then applied and a pre-etched polyurethane cover layer is laminated onto the substrate so that the interconnections can be completely embedded in the polyurethane. Subsequently, an electroless silver finish is deposited onto the copper pads to improve solderability. Automated component assembly, reflow soldering and underfilling follows, and finally the components are encapsulated in polyurethane housing, which provides mechanical protection. To ensure the substrate fabrication and processing and the component assembly are extremely robust, the stretchable substrate is fixed to a rigid carrier board throughout the fabrication process. Once completed, the packages are diced and released from the board.

By using the widely employed adhesive thermoplastic polyurethane as matrix material, the stretchable systems can be attached to many different surfaces. A particularly promising application is the integration of complex electronic systems into textiles. This is possible by simply laminating (a well-established technique in textile fabrication) the stretchable system onto the textile. Polyurethane has been demonstrated to be an ideal mechanical interconnection material between textiles and electronics manufactured using other technologies.

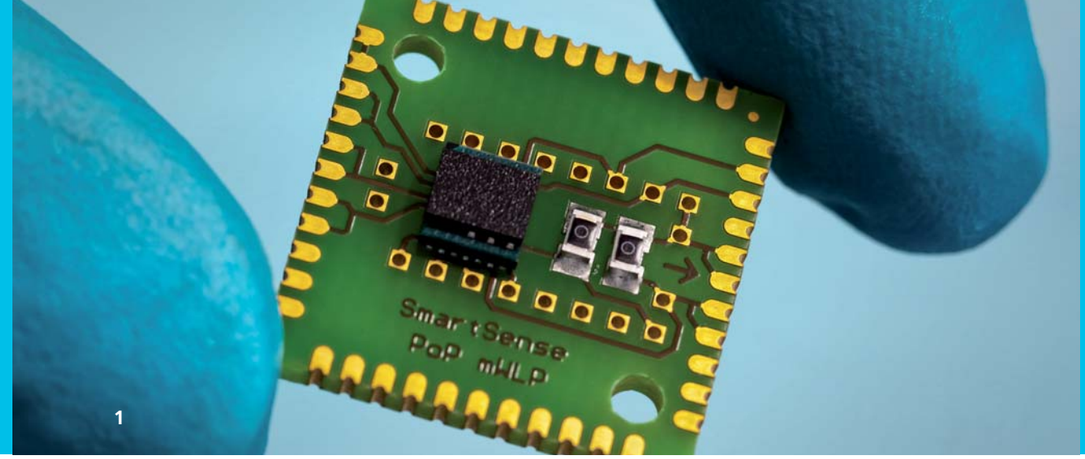
Promising applications are on the horizon in diverse fields, from medical engineering (diagnostics) to automotive technology (vehicle interiors), through to fashion. We are now focusing on further improving the technology's reliability, washability and bio-compatibility.

Dr. T. Löher
thomas.loeher@izm.fraunhofer.de

Due to increased demand for high-performance but cost-efficient solutions, extended functionalities are also integrated at package or module level using established technologies. This allows our developers to integrate several components into one package (system-in-package – SiP). Several packages can also be stacked three-dimensionally (package-on-package). Use of 3D-technologies at circuit-board level is also increasing. One new assembly method here is embedding bare dies in the substrate. In the future integrating optical functions will also be possible. Fraunhofer IZM is also working on new technologies in this area, such as thin-glass integration and new fiber-based coupling processes.

// CORE COMPETENCIES

INTEGRATION ON SUBSTRATE LEVEL



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SYSTEM INTEGRATION & INTERCONNECTION TECHNOLOGIES

The Department

The System Integration and Interconnection Technologies (SIIT) department with its 150 scientists and technical staff offers services ranging from consulting to process development and systematic technological solutions. The department develops processes and materials for interconnection technologies on board, module and package levels, as well as for integrating electrical, optical and power-electronic components and systems.

Our focus is on interconnection and encapsulation technology for electronic and photonic packaging, including:

- New solders, adhesives, types of wire and bumps
- Bumping techniques (electroless Ni/(Pd)/Au, stencil printing, mechanical stud or ball bumping)
- SMD, CSP, BGA and µ-optic assembly
- Flip-chip techniques (soldering, sintering, adhesive joining, thermocompression and thermosonic welding)
- Die attachment (soldering, sintering and adhesive joining)
- Wire and ribbon bonding (ball/wedge, wedge/wedge, heavy wire and ribbon)
- Flip-chip underfilling and COB glob topping
- Transfer and compression molding on lead frame, PCB and wafer
- Potting and conformal coating, hot-melt encapsulation
- Chip embedding
- Fiber coupling and optical interconnection to planar waveguides, fiber lenses and laser joining
- Manufacturing of optical wave guides
- Thin-glass and silicon photonic packaging
- Automation of microoptic mounting

Trends

The department meets the challenges of electronic and photonic packaging by combining system development with advanced interconnection technologies.

Our work on trends in future applications extends to:

- Design of multifunctional boards and interconnection technologies
- Heterogeneous packaging of system in packages (SIPs), such as MEMS, ICs, opto, RF and passive packages, and 3D-SIPs with embedded components and power ICs
- Evaluation of new surface materials for low-cost assembly technologies
- High and low temperature interconnection technologies
- Expansible electronic systems on PU basis
- Development of jetting processes for high high-viscosity materials, e. g. die attach and glob top
- Miniaturized electronics and fiber optics for modern medical diagnostic and therapeutic technologies
- Integration of ultra-thin chips in foldable flex modules, multilayer and security cards
- Alternative solder and sinter technologies for power module assembly
- Multifunctional (electrical, optical, fluidical) packages and substrates based on thin glass layers
- LED modules and white light conversion
- Multifunctional optical sensor systems
- Silicon photonics and microwave photonics system design

RESEARCH & DEVELOPMENT HIGHLIGHTS

3D mold embedded packages and smart power molding

Wafers reconfigured by vacuum compression molding are the backbone of 3D integration. We are currently using the technology to develop new 3D multi-sensor modules (such as for pressure, acceleration, magnetic field, gear rate sensors) for consumer electronics as part of the MST-SmartSense project.

Our research into transfer molding for large volume power electronic modules, i. e. SmartPower modules, augments Fraunhofer IZM's focus on electromobility. We have the demonstrated that the new technology meets applicable reliability standards by qualifying the molding compounds for use at high temperatures (>200°C) and for use in aggressive media.

Moisture diffusion in encapsulation materials

Our participation within the PolCap and DianaSens projects has yielded strong basic research results on moisture diffusion in polymers and polymer composites. In contrast to conventional approaches, our analysis focused on the package, which made directly transferring material data into the application possible. We developed new analytical tools and generated polymer-based encapsulation systems with optimized barrier properties that reliably protect microelectronic packages in harsh environments.

Wire bonding technology

The development and testing of new wire materials and surfaces, particularly for power electronics, has been a key focus. An innovative Al wire with selected alloy elements (currently known as AlX wire) features much higher resistance against softening at the high ambient temperatures that electronic devices are often exposed to during the assembly process. This should yield longer lifetime at alternating bending stress. Despite the fact that only a prototype of the wire has been investigated to date, the level of bondability and the bond quality achieved are very promising.

Another key area is Al-cladded Cu wire. Active power cycling experiments with Al-Cu wire on standard semiconductors are currently being prepared. The results will be used to assess whether the bonding wire improves lifetime.

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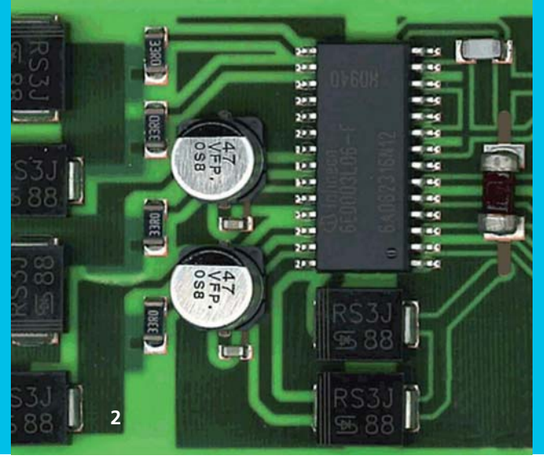
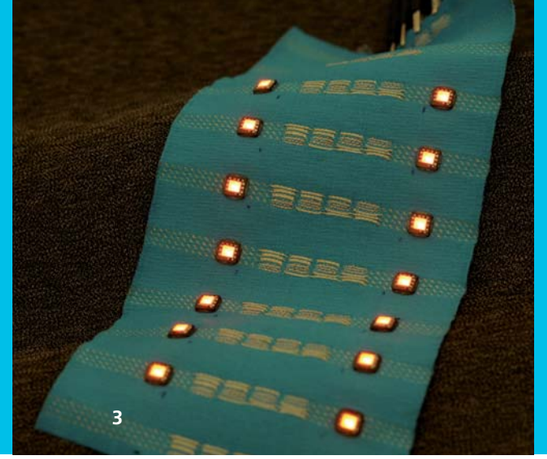
1 *Package on package stack with through mold via*





Advances in active power cycling equipment have proven very useful in our investigations. It is now possible to conduct active power cycling experiments under varying environmental conditions. Our customized cooling systems and test equipment allows for cyclic variation of temperature between -40 and 150 °C. These varying environmental conditions can be adjusted as required for the loads being tested. We plan to use this system for a series of investigations into the influence of overlapping and interacting failure mechanisms in power electronics.

Another breakthrough was our demonstration of the viability of wire bonded battery cells. By modifying the wire bonding equipment to optimize the battery surface and geometry, we demonstrated the feasibility of automated bonding of several hundred battery cells.

Embedded power semiconductor SiPs

Our recent research into embedding technology has been focused on developing innovative complex power systems, which are highly promising due to their compact size, robustness and high reliability. These systems can include a number of embedded dies in a single multilayer configuration along with additional surface-mounted components.

For example, we have been participating in the EU project »HERMES« (FP7-ICT-224611), which has developed an embedded control-integrated power system as a project demonstrator. The assembly can be used as a motor control for variable speed drives in industrial applications such as washing machines and air conditioners. Parts of the system operate at voltages of 600 V and electric currents of 5-50 A, whereas other parts operate at the moderate voltages and currents usual in state-of-the-art CMOS. The technology is manufactured by direct copper bonding (DCB), and features a ceramic carrier and thick copper metallization on both sides, power and logic components with driver IC, and passive components soldered on 2-layer PCB.

The project's goal was embedding the power devices in the PCB while mounting the application-specific logic devices and passives on top of the board. This approach ensured the logic components could be positioned very flexibly and allowed for careful design of the power dissipation from the power devices isolated from the heat sink. Apart from the obvious challenge of actually embedding the power devices, the design also had to factor in high thermal dissipation combined with electrical insulation.

The embedded IGBT die, with a thickness of 240 µm, is attached to a 70 µm thick copper foil using highly thermally conductive silver glue. Subsequently, the die is embedded into epoxy prepreg layers and is backside connected to the thermal pad at the heat sink using a thermal laminate layer that has the necessary thermal conductivity. The module comprises four layers and four embedded power chips.

This application demonstrates how flexibly embedding technology can be used to in application-specific modules such as single chip packages, embedded SiPs and even complex power SiPs. Another advantage is that the technology is suitable for manufacturing on large panels, such as those typical in PCB manufacturing.

Large panel, thin glass-based photonic PCB integration

We proved the viability of an advanced integration concept that bridges board and chip level using thin glass substrates for large panels. Here, we scaled already established wafer level technologies to the dimensions of large panel EOCBs. Drawing on our long-standing focus on optical integration in PCB manufacturing, we optically functionalized 210 mm × 297 mm thin glass layers by thermal ion exchange. The processing homogeneity of the ion exchange was validated using the refractive index profiles of multimode waveguide cross-sections. Preliminary manufacturing trials demonstrated the feasibility of large panel integration.

Lamination, drilling, cutting and milling were investigated and validated as viable techniques. TSVs are crucial to this technology and we successfully demonstrated copper plating of drilled through holes in hybrid stack-ups of glass and epoxy laminates. These results will accelerate the development of both EOCBs and integrated optical backplanes.

Multifunctional security document

As part of the SeCuDis project, our department helped develop a multifunctional smart card that illustrates the crucial role of electronic integration in security technology. The card is made of polycarbonate (PC), features Cu traces on both sides, and is mounted with thin flip chips and SMD components. After the assembly process, the device is laminated, during which the thermoplastic PC melts to form a homogeneous body. This makes the card tamper-proof, because the assembly then has no layers that can be separated, preventing manipulation of the electronic inlay. Numbers, such as a PIN, can be input thanks to an integrated sensor array.

Smart pixel integration

The Lumoled project, funded by the German ministry for education and research (BMBF), is developing large area textile lighting with high light density, intended for use as monitors. Here, the project is focusing on RGB pixels, whose driver ICs are embedded into the circuit board under the LED. Each pixel, sized only 5 x 5 mm^2 thanks to embedding technology, can be individually controlled by an I^2C bus. Even relatively high pixel density does not significantly reduce the fabric's flexibility.

Sensor microtechnologies for ambient assisted living

The ambient assisted living (AAL) project SAAPHO is working to embed a variety of sensors, including for monitoring vital statistics, improving the dispensing of medicine and promoting social interaction, into one unified infrastructure. To reduce the costs to reasonable levels and increase user acceptance, miniaturizing the sensor nodes is key to the project's success and is being addressed by our department.

1 *Al heavy wire-bonded battery cell module for automotive applications, developed as part of the ePerformance project*

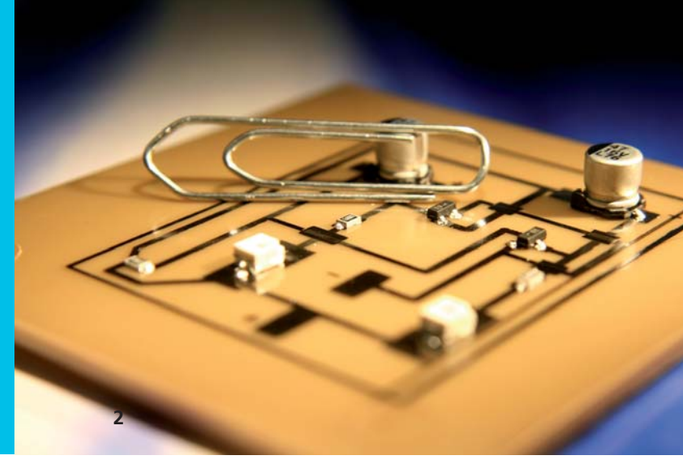
2 *The power SiP with assembled components and embedded dies has clear similarities to conventional PCBs*

3 *Smart pixels on a woven I^2C bus structure*

4 *210 mm × 297 mm double-sided, Al-patterned thin glass foil prepared for ion exchange in hot melt salt*

// CORE COMPETENCIES

INTEGRATION ON SUBSTRATE LEVEL



MICROMECHATRONICS AND PCB TECHNOLOGY

The Oberpfaffenhofen branch
The Fraunhofer IZM Oberpfaffenhofen branch is home to the Department of Micromechatronics and PCB Technology (MMZ) and the Training Center for Interconnection Technologies (ZVE).

MMZ specializes in the design, development and rapid prototyping of electronic systems on novel substrates. We also evaluate and test new concepts for adapting package designs to diverse applications. This includes comprehensive design flows for the assembly and packaging of chips, including the electrical and mechanical properties combined with simulation.

Another activity is the assessment of interconnection technologies for electronic components with higher reliability requirements due to harsh in-field environmental conditions. This includes customer-specific system qualifications, ranging from mechanical and electrical reliability tests and failure analysis of single electronic components.

ZVE provides training in standard and novel soldering techniques and solder-free interconnect technologies. The Oberpfaffenhofen site is an accredited ESA and IPC training center and AZWV skill center.

Trends
Integration of electronic systems into applications is leading to the merging of form and function.

Additionally, sectors like the aeronautics, medical engineering and automotive industries seek lightweight, integrated, affordable, but highly reliable alternatives to state-of-the-art technologies comprising several components, screwed, pasted, or pinned together (e. g. smart-power mechanics).

Our current goals are:

- New qualifications for multi-technology electronic systems
- Non-planar electronic and mechatronic system assembly
- New additive manufacturing and inkjet printing processes
- Improving rework and repair processes
- Applying solder-free interconnects like crimp and press-fit connectors
- New approaches for time- and cost-efficient in-situ monitoring of critical parameters in product qualification
- Novel reliability and quality criteria, e. g. for renewable power plants and electric vehicles
- Adapting training courses for expected demand (especially in medical engineering and solar technology)

RESEARCH & DEVELOPMENT HIGHLIGHTS

Reliability models for accelerated testing of press-fit interconnections
In this industry-sponsored project, we are developing models for testing press-fit interconnections using thermomechanical stress, with a special focus on the mechatronic environment of the interconnects. Here, the fiber-reinforced, thermoplastic carrier is the key component, as the load on the electrical interface between the press-fit interconnection and the PCB depends on the polymer's fiber orientation. This proves that reliability assessment cannot be reduced to testing individual electrical components, but instead has to evaluate the complex mechatronic assembly and environment as a whole. The reliability models being developed here are expected to reduce the time required for the qualification of solderless interconnects.

Electronic printing & inkjet printing
Our research into inkjet printing focuses on the structured metallization of engineering thermoplastics, especially polyamides. Firstly, these materials have acceptable thermal stability, with sintering of nano-scale silver conductive inks possible at 180 °C to 200 °C. Secondly, sufficient wetting has been demonstrated using different surface modifications. We recently showed that 2- and 3-dimensional specimens can be processed in series manufacture using injection molding, which highlights the exciting potential of inkjet printing.

Crimping
Many companies find dealing with the increasing number of interconnects in electronic systems a challenge. Crimping is a cost-efficient means of achieving reliable electrical interconnections and system cabling. Fraunhofer IZM's Oberpfaffenhofen branch has been researching crimping in a broad range of contexts over many years. Not only have we recently established a new laboratory for investigating and validating crimped cable connections, but we are currently also designing a series of training courses for industry, which will cover many different engineering applications. The course contents include correctly selecting single compounds, ensuring functionality and meeting the reliability requirements of the crimped connection, including final testing. The evolution of crimping as interconnect technology will be demonstrated with both new and established approaches, including the »slow motion test« and highly sophisticated destructive and non-destructive techniques for characterizing crimped connections.

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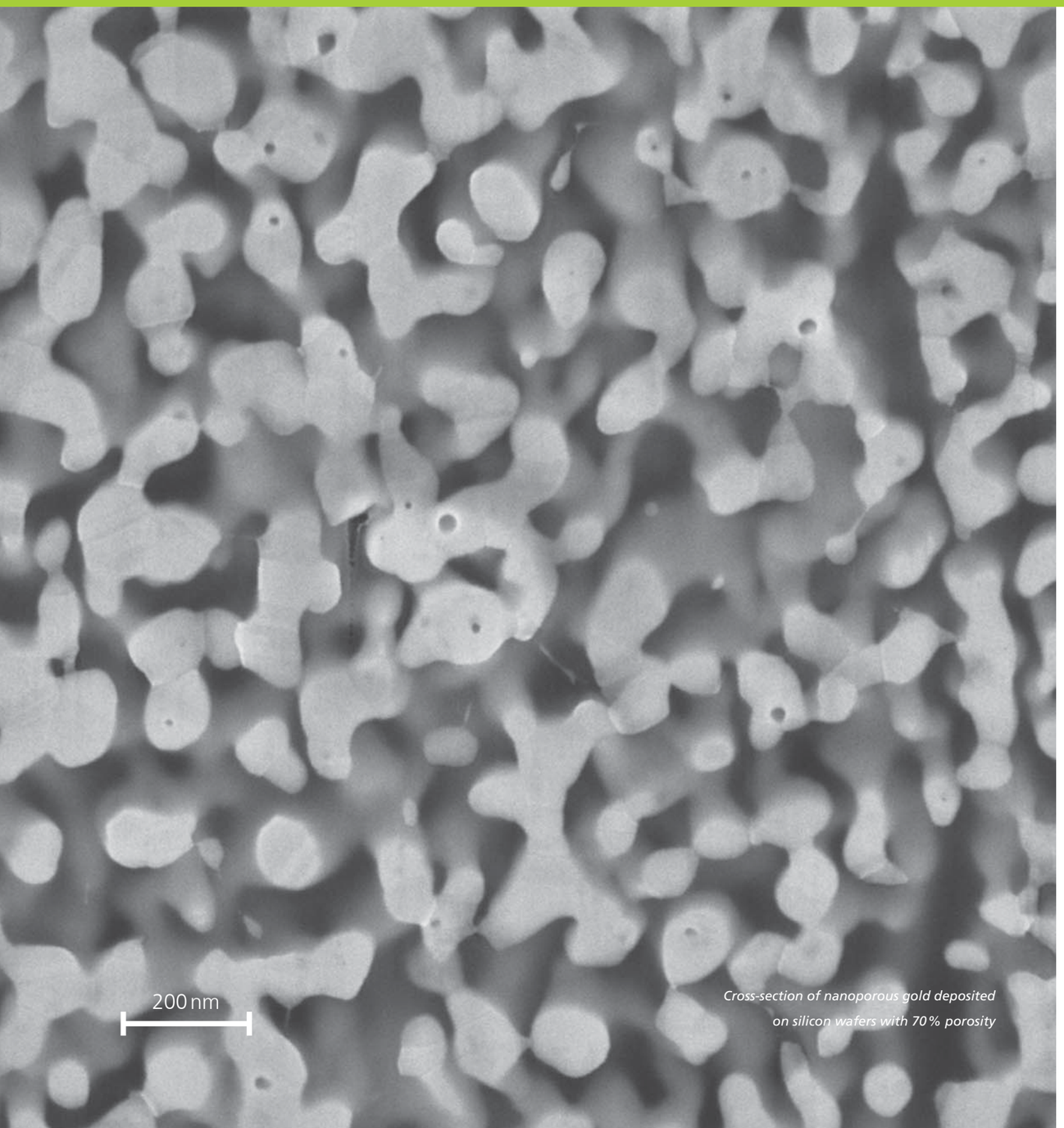
1 *Touch sensor, produced by direct digital manufacturing*

2 *Inkjet printed multilayer thermoplastic board*

RESEARCH CLUSTER INTEGRATION ON WAFER LEVEL



Cross-section of nanoporous gold deposited on silicon wafers with 70 % porosity

HIGHLIGHT 2011

Fabrication of nanoporous gold deposits

Porous Au structures on semiconductor wafers can be fabricated by electroplating of Ag/Au (70/30) layers with subsequent de-alloying of the deposits. The individual processing steps are largely compatible with the technology and equipment used for conventional Au and Au/Sn wafer level bumping. After a thin plating base is sputtered onto the wafers, a photoresist layer is applied and patterned. A gold socket is then electroplated into the resist openings followed by electrodeposition of the Ag/Au alloy. Finally, the silver content is selectively etched, exposing the sponge-like Au deposits.

Fraunhofer IZM has developed stable Ag/Au alloy electrolytes based on cyanide-complexed precious metals and thiosulfate/sulfite-based electroplating baths for this technique. Both these aqueous formulations are suitable for the replication of photoresist patterns, as they feature adequate resistance against light-induced precipitation combined with high-current efficiency and long-term stability.

The metal sponge structure is formed by surface diffusion and cluster formation during degrading of the Ag. Two different methods can be applied for de-alloying. Using chemical etching technique in a simple dip tank, the silver is dissolved using appropriate oxidizing agents. In electrochemical etching, the silver is oxidized by anodic potential applied to the plating base. A great advantage of the latter method is the ability to detect the end point of the silver dissolution by controlling the current/voltage profile.

These metal sponge structures can be adjusted to a nominal open pore size of between 20 and 200 nm and have a pore volume of around 70 %. The deposits are suitable for thermo-compression bonding, reducing the amount of force and temperature needed, and for joining with conductive adhesives. Due to the high compressibility of the porous structures, inhomogeneity and the topography of the chip or substrate can be evened out.

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The highest integration densities possible in heterogeneous assemblies are achieved using wafer level integration. All processing steps are carried out at wafer level after the actual front-end processes have been completed. The packages we develop have lateral widths almost identical to the chip dimensions. We also include active and passive components on the wafer in interlayers and even higher integration densities are achieved with 3D integration using through silicon vias (TSV) or using silicon interposers and TSV.

// CORE COMPETENCIES

INTEGRATION ON WAFER LEVEL

1

HDI & WAFER LEVEL PACKAGING – ALL SILICON SYSTEM INTEGRATION ASSID

The Department
Fraunhofer IZM's focus in wafer level system integration is developing and implementing technologies for packaging microsystems and microelectronic devices. Our technical platform is based on an industry-compatible technology line for thin film processing, established in the cleanrooms of both the Berlin (High Density Integration/Wafer Level Packaging, HDI and WLP: 800 m²) and und All Silicon System Integration Dresden (ASSID: 1000 m²) branches. The department cooperates with manufacturers and users of microelectronic systems, equipment manufacturers and the materials development industry around the world. HDI/WLP and ASSID provide research and development services to enterprises in fields ranging from process development to prototyping and low volume manufacturing for 3D integration, thin film multilayer substrates, wafer level redistribution for CSPs and wafer level bumping for flip chip assembly. The institute has the facilities and know-how for processing wafers from 200 mm to 300 mm. Newly developed technologies are adapted and qualified according to customer-specific requirements. The department offers regular training courses for customers and partners. Moreover, ASSID operates a state-of-the-art technology line for 3D wafer level system integration, which was specifically designed for processing 300 mm wafers and which meets the requirements of industry manufacturing conditions.

Key aspects of the processing modules include developing and manufacturing through silicon vias (Cu TSVs, via-middle, via-last processing), wafer thinning, temporary and permanent wafer bonding and creating 3D structures on wafer level and based on TSV interposers. The spectrum of services offered by Fraunhofer IZM ASSID covers customer-specific developments, to prototyping and low volume production, right through to process transfer.

Trends
3D system integration on wafer level is a crucial technology in microelectronic packaging, offering improved functionality, performance, form factor, reliability and reduced cost. The key to developing such 3D system-in-packages (WL SiPs) is addressing technology, design and reliability holistically.

3D integration
Through silicon vias (Cu TSVs) are core elements of 3D SiPs in active circuits and interposers with thin film multilayer wiring. TSV interposers are indispensible in the heterogeneous integration of different components, MPUs, GPUs, memory, sensors, transceivers and passive elements. In future systems, power supplies (micro-batteries), optical signal transmission systems and cooling systems will also be integrated.

Other foci include:

Wafer level CSP
Thin film redistribution (RDL) based on copper or gold with different polymer dielectrics, glass passivation, multi-device integration, ultra-small devices, package singulation.

Wafer Bumping
Micro-bumping for ultra-fine pitch (< 20 µm) FC assembly, bump metallization (Cu, Ni, Au, solder alloy, SnAg, AuSn, SnPb, Sn, In), Cu pillar interconnects, nanoporous Au-bumps, Cu-Cu interconnects.

Thin film multi-layer
Adapted polymers and photoresists, customer-specific layout adaption, multilayer wiring, polymer layers for HF applications, fine pitch redistribution, integrated passive devices (coils, capacitors, microgalvanic deposition of magnetic layers for coils).

RESEARCH & DEVELOPMENT HIGHLIGHTS

High-density, full wafer interconnection technology
Fraunhofer IZM has recently further advanced its well-established redistribution technology to include the manufacture of high-density chip-to-chip interconnections on 200 mm CMOS wafers, which function as clusters for neuronal networks. Based on polymer planarization and passivation and using galvanic copper, the fine, high-density wiring can bridge scribe lines up to 4 µm depth of adjoining ICs.

In preliminary studies, 56 ICs with a total of 159 744 connections were linked with a yield of over 99.9 %.

Hermetic encapsulation of MEMS on wafer level
Our department has developed hermetically dense housings for MEMS components, such as oscillating crystal or silicon resonators, using silicon interposers or ICs with through silicon vias and manufactured by wafer-to-wafer bonding. In this technique, MEMS components are first mounted at wafer level on silicon chips with electrical through contacts. The devices are then hermetically encapsulated with a cap wafer using AuSn solder. Up to 8000 capped devices can be manufactured on a single 200 mm wafer.

This development was one of several carried out as part of the project Go4Time (GlObal, Flexible, On-demand and Resourceful Timing IC & MEMS Encapsulated system), funded by the European Union.

3D Assembly (TSV interposers)
Fraunhofer IZM ASSID has successfully developed a technology for the fully automated singulation of interposer wafers and first- and second-level assembly (flip chip with underfilling) of interposers. Interposers were assembled for 3 devices (GPU, 2 DRAMS) via flip chip (25 µm SnAg) and mounted in an LGA package (Cu pillar).

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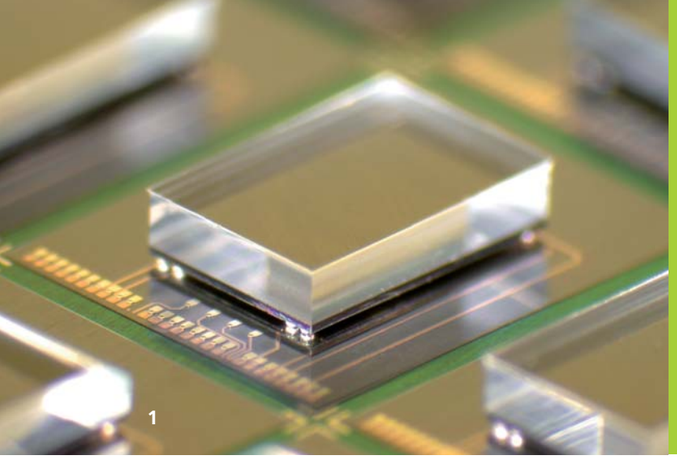
1 *Cross-section of silicon cap wafer bonded with interposer wafer and hermetically sealed MEMS device*



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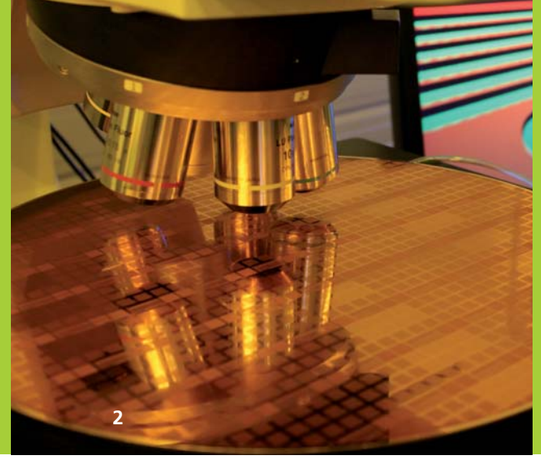

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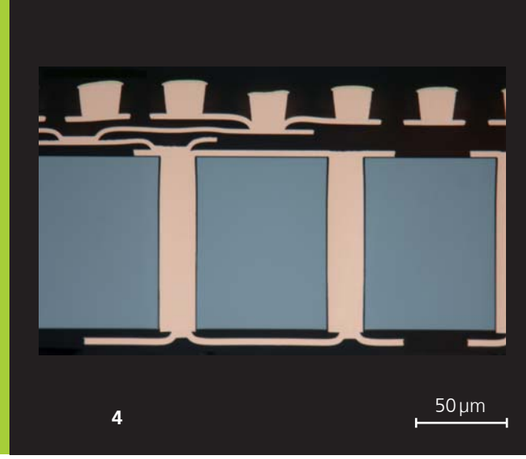


4

World's smallest camera delivers sharp images from inside the human body
Together with Awaiba GmbH, Fraunhofer IZM has developed microcameras sized less than 1 mm³. The camera can be used in endoscopes. A special manufacturing process ensures that the production costs remain low and that the camera can be manufactured for single-use. Consequently, elaborate sterilization processes are a thing of the past.

The cameras are manufactured by firstly bonding the sensor wafer to a glass wafer and then thinning it. Subsequently, the ICs are backside connected. It is this latter step that keeps the size of the cameras down and allows for high-volume production.

In a further step, a lens wafer is bonded onto the glass wafer. By these means, up to 28 000 microcameras can be produced in a single wafer level processing sequence.

300 mm silicon interposer with TSVs and polymer-RDL
We recently developed 300 mm Si interposers with TSVs, multilayer polymer redistribution and microbumps. TSV/RDL functionality was verified using daisy chaining and singulation and assembly of interposers on organic substrates was successfully demonstrated. To increase wiring density, GEN2 interposers were developed.

This technology with TSV (10 µm/110 µm) and fine pitch routing (3 µm line/space) heralds the new standard in silicon interposer technology.

Through silicon vias with Cu metallization (Cu TSVs)
Processing of through silicon vias with geometries of 20 µm/100 µm, 10 µm/120 µm und 5 µm/60 µm was developed on Fraunhofer IZM-ASSID's 300 mm technology platform. The development was part of projects funded by the German ministry of education and research (BMBF) and the European Union (JEMSIP_3D).

Its specifications include:
- TSV isolation: Thermal oxide or deposition via SA-CVD/PE-CVD
- Adhesion, barrier, contact layer: PVD deposition up to AR12
- TSV filling: Cu ECD with bottom-up filling up to AR12
- TSV-CMP: Removal of Cu overburden with stop in oxide layer

Wafer thinning and thin wafer handling
Fraunhofer IZM has established a number of different techniques for manufacturing and processing silicon wafers of just several micrometer thickness. These thinned wafers (50 µm – 150 µm) are very fragile and require a special handling technology. Our new techniques for temporary bonding of thin wafers on carrier wafers are extremely compatible with the wafer topography and subsequent processing steps. Efficient and reliable separation of the wafer from its carrier is crucial after processing and our department is cooperating closely with the EV group on this aspect.

3D microsolar module
We have developed new assembly and encapsulation technologies in which high-quality, monocrystalline silicon solar cells are segmented into tiny, single chips and adapted to three-dimensional, flexed shapes. Here, too, backside interconnection of the silicon solar cells enabled this advance. The modules are suitable for many different applications that feature flexed surfaces, such as helmets, backpacks, clothing, and automotive body parts.

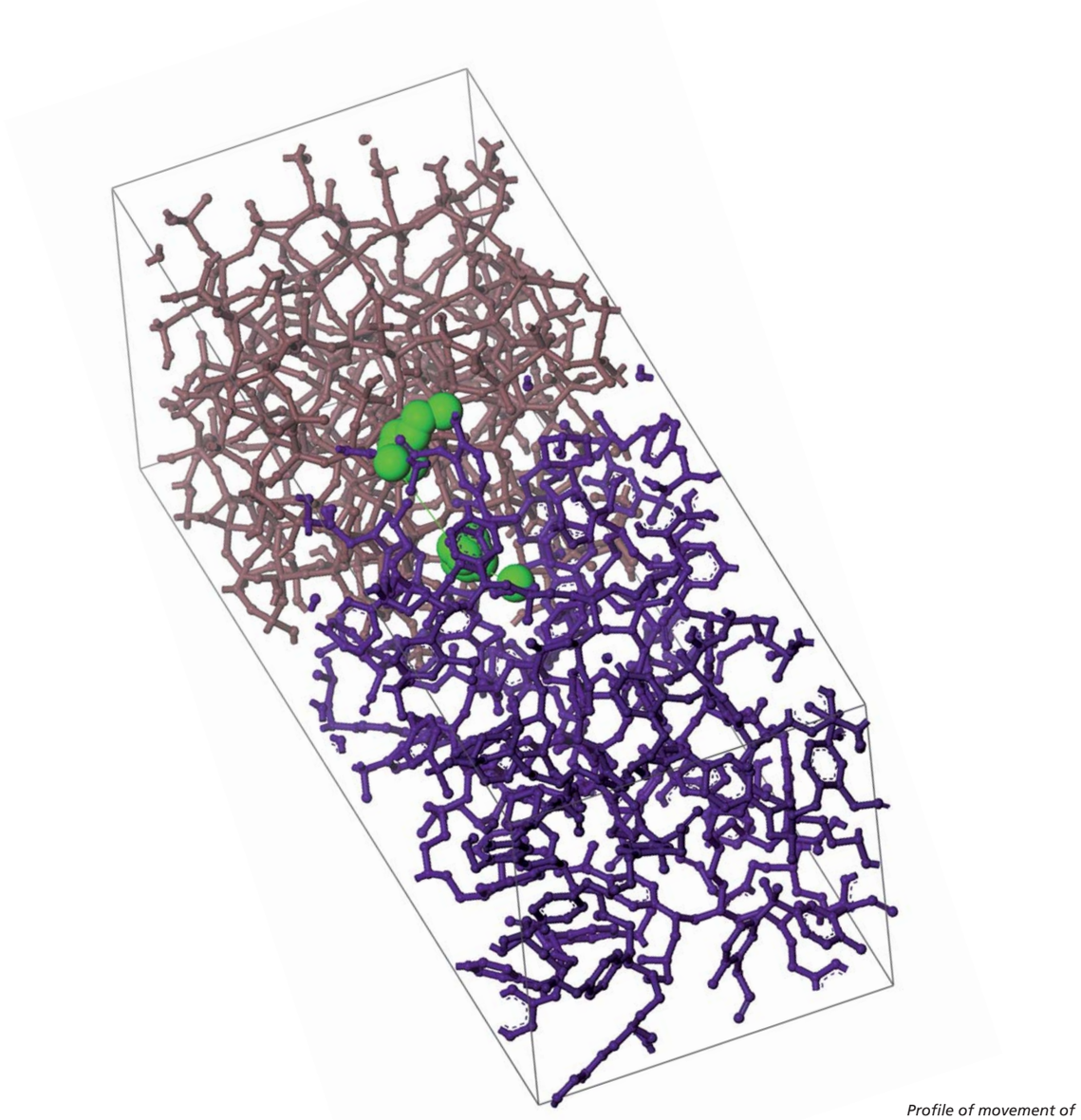
1 *3D demonstrator consisting in a thinned memory chip assembled on silicon TSV-interposer (Project: JemSiP 3D, ENIAC)*

2 *300 mm processing, automated optical inspection*

3 *Ski helmet with 3D solar module*

4 *300 mm TSV interposer with multilayer RDL*

RESEARCH CLUSTER
MATERIALS & RELIABILITY



Profile of movement of a single water molecule at the interface of epoxy/SiO_2

HIGHLIGHT 2011

Reliability and simulation from system to nano structure

Today microsystems integrate an increasing number of functions in application areas like industry, automobile, lighting and medical technology. New application conditions with high loads in temperature, moisture and vibration lead to increased requirements on system reliability. Short development times and cost efficient solutions require tools which enable an assessment of reliability already during the design and development phase. Simulation models enable early decisions in the design process and lead to the possibility of goal-oriented use of development time and cost. Appropriate methods for reliability assessment are being developed, tested and applied at Fraunhofer IZM.

The aim is the realization of the reliability of complete systems, which depend on functionality of the subsystems, their constructional elements and materials. The assessment is based on understanding the underlying physical and chemical processes, which lead to failure. Therefore material behavior is being characterized under process and application conditions. The result is input to thermal, electrical and mechanical finite element models, which consider the interaction of different materials and loads. Together with modern significance and optimization analysis methods design recommendations are being deduced.

It is essential for the assessment to evaluate the calculated loads on materials, interconnects and components. Based on our longstanding experience on damage assessment and life time modeling a range of methods is available. Actual research projects address modeling of effects relevant for reliability on the micro and nano scale. Classical continuum mechanical approaches show no or only limited applicability in this range. Molecular Dynamics Modeling is an example of a new approach where material behavior is being simulated on atomic levels. For moisture transport at material boundaries the permeability can be calculated (BMBF funded project DianaSense). Thus reliability of polymer encapsulations under moisture load can be assessed, analyzed and improved. In parallel new approaches for evaluation of damage are being developed. A range of actual projects address solutions on modeling of crack initiation and growth at material interfaces and in materials.

It is the common goal of this work to achieve a fast transfer of results to the projects of our customers and project partners, because only a basic understanding of system reliability can enable the realization of innovations in complex applications.

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Reliability and environmental compatibility have become more important in the development of electronic components and systems in recent years. Fraunhofer IZM has been combining research into the reliability of electronic components and their environmental characteristics with the development of new technologies since it was first established. Fraunhofer IZM conducts reliability analyses on the materials right through to the system as a whole using material behavior and mechanical reliability models. Apart from simulation processes, we employ laser-optical, X-ray and material tests individually or in combination.

// CORE COMPETENCIES

MATERIALS & RELIABILITY

1

ENVIRONMENTAL & RELIABILITY ENGINEERING

The Department
New products and technologies have to meet more and more diverse and challenging requirements. At the same time, cost-efficiency and environmental protection are becoming more important. The Department of Environmental and Reliability Engineering helps prepare new technologies for commercial release with environmental and reliability assessments, ranging from nanocharacterization to evaluation and optimization on system level.

Jointly headed by Dr. Nils F. Nissen and Dr. Olaf Wittler, the department develops interdisciplinary approaches and conducts contract research into:

- System reliability from packaging to product level
- Design for reliability and lifetime simulation
- Material characterization und modeling
- Thermal design, thermal interface characterization
- Combined and accelerated load testing
- Aging and failure analyses, sample preparation and analysis
- Testability and online monitoring in accelerated aging
- Methods and hardware for condition monitoring
- Reliability management in development
- Microelectronic eco-reliability concepts, e. g. energy harvesting
- Carbon footprint, green IT, the use of renewable materials
- Eco-design, lifecycle modeling
- Environmental protection legislation (including RoHS, WEEE, EuP/ErP)

Trends
Current developments in the global market have created new challenges to ensuring environmental friendliness and reliability.

These can summarized by the following topics, which are the focus of much current basic and contract research:

- Methods for characterizing bonding techniques on micro- and nanometer level (through-silicon vias, intermetallic phases, thin layers, interfaces)
- Accelerated aging tests and models for high-temperature applications of up to 300 °C
- Application-specific lifetime tests for long-term usage (e. g. automotive, security cards, medical engineering)
- E-mobility: lifetime models for bonding techniques in power electronics for electric motors
- Strategies for reliability testing and condition monitoring of complex systems
- Long-term reliability of thermal interface materials (TIMs)
- Eco-reliability: Sustainability and durability assessment
- Resource efficiency with an increasing shift in focus from energy efficiency to other efficiency aspects
- Material availability (i. e. rare earths): analysis methods, optimization, substitution
- LED lighting (recycling, thermal characteristics, durability)
- Energy harvesting (energy efficiency, durability, environmental balance)

RESEARCH & DEVELOPMENT HIGHLIGHTS

Evaluating electromigration in soldering: from simulation to lifetime experiments
One factor limiting the reliability of increasingly miniaturized electronic systems is failure due to electromigration. This current- and temperature-induced mechanism leads to displacement of atoms in the conducting material and results in defects in the electrical traces and solder joints. A weak-spot analysis, adjusted to the requirements of the assembly technology in question, can be carried out by numerically simulating the varying parameters. The results can then be verified experimentally.

Eco-design for computers
Fraunhofer IZM helped the Irish company MicroPro develop an eco-PC called iameco, which is now the first of its kind to be granted the EU's EcoFlower status. The touch-screen all-in-one PC uses power-saving components, a durable and recycling-friendly design and wood as casing material.

Local material properties at high temperatures
Temperature-dependent mechanical material data are necessary to evaluate thermomechanical reliability using modeling. However, in high-temperature processes, the material properties of some alloys used in bonding only form during the bonding process itself. Consequently, the properties cannot be determined in conventional tensile tests. As part of the German federal ministry of education and research (BMBF) project HotPowCon, the mechanical material properties of miniaturized samples were determined by coupling a nanoindenter with a temperature module. The results showed that hardness and the elastic modulus decreases significantly in intermetallic phases that form at above 150 °C.

Thermal loading and failure mechanisms
The maximum current-carrying capacity of high-current connectors is limited by the thermal loads they undergo. However, the temperatures and accompanying failure mechanisms cannot be determined using simple measurement techniques. Fraunhofer IZM and partners in the project Water-Cooled High-Current Connectors have developed a load test system, which the institute uses to compare IR thermography measurements and models for currents of up to 5000 A. These analyses can then be used to estimate the presenting temperatures and correlate them to specific failures.

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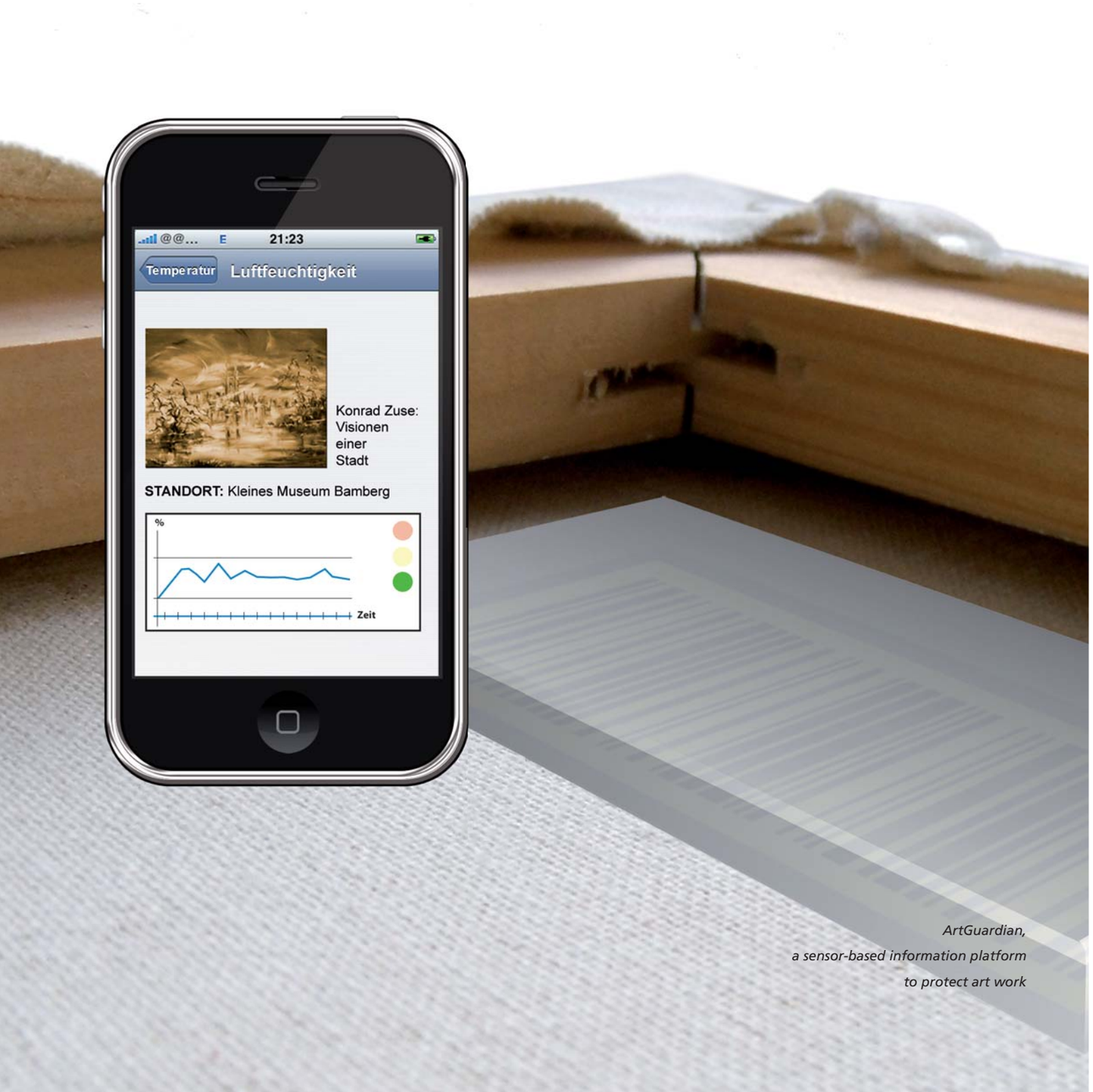
1 *Critical resources: Even more specific recycling processes are required*

RESEARCH CLUSTER
SYSTEM DESIGN



ArtGuardian,
a sensor-based information platform
to protect art work

HIGHLIGHT 2011

»ArtGuardian« – High tech protection for works of art

Travelling in an unfamiliar climate can be a strain, not only on human being, but also or even more so on valuable works of art. And while humans usually recover quite quickly, cold and humidity leave lasting traces on canvas: Colors fade or disintegrate, the paper corrugates. From now on, art lovers can relax: in the project ArtGuardian a new system to monitor the microclimatic conditions for artwork is being developed. ArtGuardian combines cutting-edge technologies in microelectronics, building physics and information technology to meet those requirements and to provide best conditions. The sensor-based information platform was developed by four Fraunhofer Institutes ISST, IZM, IAP and IBP, each contributing specific expertise.

The system comprises three essential components: a set of preventive conservation protocols, an autarkic sensor system and an IT platform.

The first component is an integrated set of preventive conservation protocols to assess the individual object's possible risks and the required conservation measures (preventive conservation). For each different kind of canvas the acceptable temperature and humidity range is established. The second component is a range of autarkic sensors developed at Fraunhofer IZM that measure the microclimatic conditions the artwork is exposed to, i. e. the humidity (invisible sensors). The sensors are fixed to the frame of the artwork, they measure the microclimate, i. e. temperature and humidity, as well as the light and any vibration.

The information thus gained is sent to the third system component – an IT platform with which the owner and other authorized persons can stay apprised of the artwork's location, condition and the stresses it encounters (Art Guardian Cloud). If the established temperature and humidity range is exceeded, the system raises an alarm.

In this way ArtGuardian does not only provide optimal protection, but also serves as a central information and communication platform. ArtGuardian is now in the pilot phase. At different locations, such as Hamburger Bahnhof in Berlin scientists have installed sensor systems for test purposes. The feedback from these tests will be incorporated into the system and by the end of 2012 ArtGuardian is expected to go into serial production.

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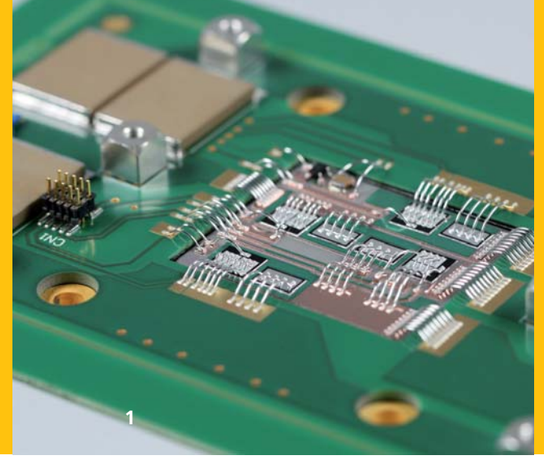
In highly integrated systems, design can no longer be carried out independently of technology and technology development cannot take place without considering electrical behavior. The term »codesign« is used to denote this synergetic approach to technology and design. Fraunhofer IZM's strength lies in the combination of excellent technology development and advanced modeling, simulation and analysis technologies (electrical, thermal and mechanical). Research and development in this area focuses on EMC and RF issues (parasitic effects). Subsequent connection to the incorporating system is also integrated into the design at this stage.

// CORE COMPETENCIES

SYSTEM DESIGN



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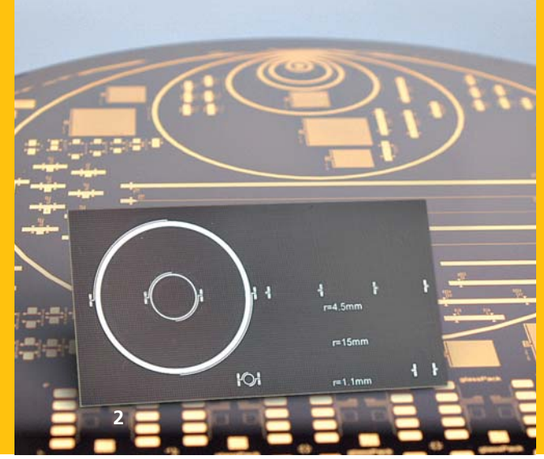

2

SYSTEM DESIGN & INTEGRATION

The Department

The department System Design & Integration pools Fraunhofer IZM's technology oriented system know-how and expertise. Our focus is on methods and tools for the design of systems in microelectronics and microsystems technology and power electronics. We help our customers design systems efficiently, from the feasibility study through to new system prototypes.

A key goal is identifying scientific fundamentals for the simulation of diverse phenomena, such as electrical, magnetic, electromagnetic, and thermal and mechanical coupling, at each stage of the design process. This ensures an integrated design process, in which coupling effects, technological parameter-based functions, volume, reliability and cost analysis are all included. We then transfer these findings into design tools that allow our project partners to make their own design processes faster and more reliable.

Our main research focus is on microelectronics and microsystem development, particularly wireless sensor systems, package design and package characterization, RF and high-speed system design, EMC and the packaging of power electronics systems.

Trends

The research conducted by the Department of System Design and Integration highlights the growing importance of system expertise for products based on highly sophisticated technology. The challenges of designing such products can only met by closely combining technology approaches with system design expertise.

Particularly autonomous microsystems will play a crucial role in cyberphysical systems over the next few years, which is why our current and upcoming research concentrates on technologies for optimizing the exploitation of residual energy in accumulators and energy harvesting.

Technology and system expertise are also beginning to converge in tool design, where new tools are being developed for a variety of applications, such as accelerating the design of 3D system integration using innovative technologies. Additionally, systems with extremely high signal frequencies pose special challenges that can only be overcome by including technical parameters, such as the properties of the packaging material, early on in the design process. Here, we expect the modeling-centered M3 approach to become very popular for such tasks.

The convergence of technology and system design expertise can also be witnessed in power electronics. For example, in coming years, packaging design will determine the crucial parameters for new, extremely high-reliability systems even more than is currently the case.

RESEARCH & DEVELOPMENT HIGHLIGHTS

Design tools

Our department develops innovative, efficient tools that maximize miniaturization and reliability in component positioning for compact assemblies. We also now provide technologies for embedding components in PCBs in the 3D design of SiPs. Using wireless sensor nodes with self-sufficient power supplies (autarkic) as example, we have developed modeling-based design methods for developing cost-efficient ultra-low-power systems.

Microelectronics and microsystem technology

In 2011 we were able to translate our research on autarkic wireless sensors into a demonstration system for monitoring conductor wires. We also designed and manufactured miniaturized wireless sensor nodes, methods and tools for autonomous, self-organizing manufacturing and for sensor networks that monitor engines and storage in industrial environments. For autarkic optical monitoring equipment, we added an analysis module for visible light to the FreshSCAN platform.

RF and high speed systems

Our department developed new methods for the efficient modeling and design of interconnects and integrated antennas. We systematically investigated the electromagnetic propagation modes in through-silicon vias (TSVs) and determined their dependence on the TSV geometry, silicon doping, frequency and the insulation layer. New configurations for wire bond antennae were also developed. Finally, IZM's M3 approach was used to develop an optimized interposer for 100 Gb/s IQM-based transmitters.

Power electronic systems

Our department helped German and international automotive manufacturers minimize electromagnetic interference in electric and hybrid vehicles. Other research foci included packaging silicon carbide (SiC) semiconductors and developing high-current PCBs and low-inductance power electronic modules. We also researched the miniaturization of power supplies using integrated inductances and transformers for LED power supplies and piezoelectric transformers for highly compact high-current power supplies. Finally, research was also conducted on high-temperature electronics, from integrated circuit concepts through to wide-range power supplies for security systems.

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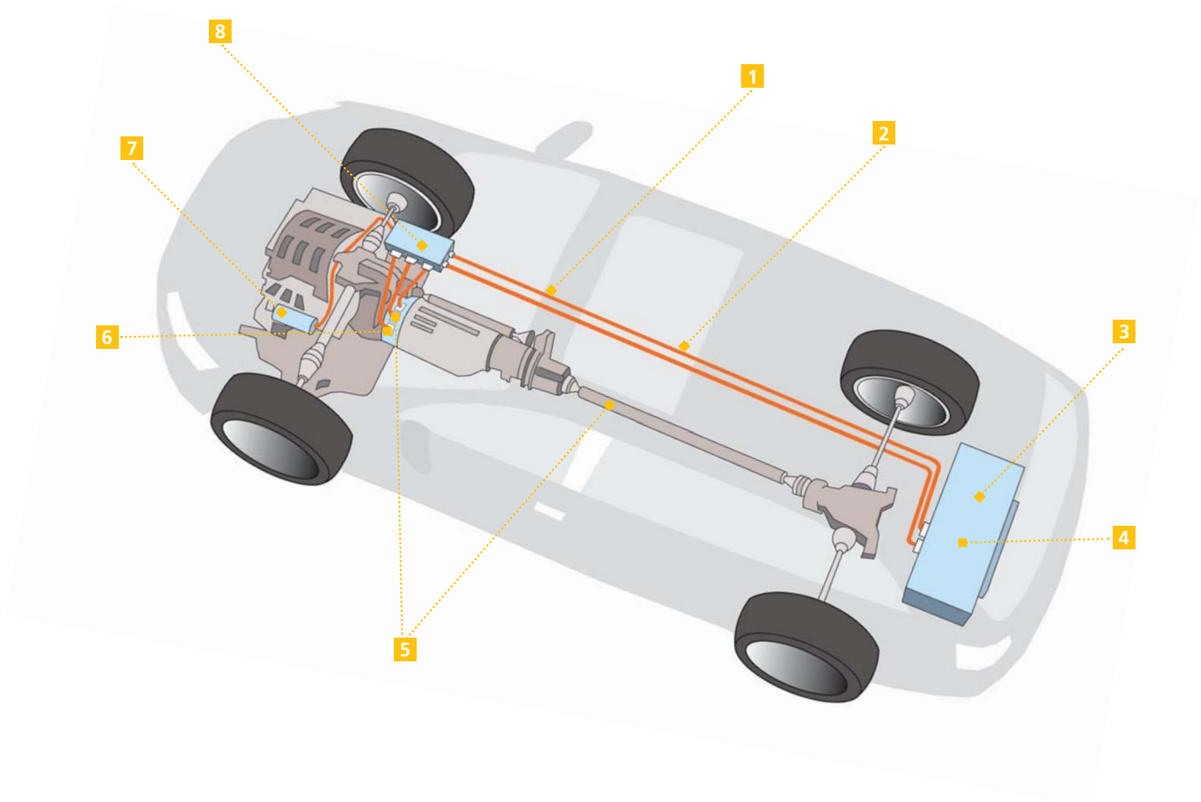
1 *Power control unit for electrical blade switch control*

2 *Ring resonator to determine dielectric constants*

FRAUNHOFER IZM
RESEARCH AWARD 2011



1) Limited shield and connector quality; 2) Shielded cables;
3) HV to LV coupling in components; 4) Battery;
5) Capacitive coupling to the motor and cardan shaft ; 6) Electric motor;
7) Air condition compressor; 8) Drive inverter.

Each year, the Fraunhofer IZM Research Award acknowledges outstanding scientific achievement by an institute scientist. In 2011, the award went to Dr. Eckart Hoene, Head of the research group Power Electronic Systems, for his work on the »Development and Industrial Implementation of Design Processes for the Electromagnetic Optimization of Power Electronics«. The award ceremony was held on December 21st, 2011 at the DZ Bank's Berlin headquarters.

Technical background

Frequency converters are used to convert electrical energy into mechanical energy for applications such as electric vehicles. The devices control the direction and rate of rotation in electric motors. Inverters chop the direct-current voltage into alternating voltage of any required frequency and, with some limitations, voltage level. The current and voltage changes take place at a speed of several hundred nanoseconds and can repeat up to 250 000 times per second. This creates interference that impedes signal transmission and has seen integrating the humble car radio into electric cars become something of a challenge. Various EMC measures are used to tackle the problem, including cable shielding, filters and very careful design of the cable layout.

Interference and unsolved issues in vehicle charger technology are hurdles in the development and commercial release of new generations of electrical and hybrid vehicles, leading a wide variety of customers from the automotive industry in Germany and abroad to turn to Fraunhofer IZM for help.

To advance the design techniques and simulation tools available for grasping and solving such problems, our department draws on practical solutions that have worked in the past. This ensures that our approaches always have a strong foundation in real-life conditions.

Beyond the automotive sector

Although suppressing interference in automotive devices currently has top priority, the renewable energy sector and industrial drives also need interference-free power electronic circuits and operating environments.

About the 2011 Research Award winner Dr. Eckart Hoene

Eckart Hoene is an internationally renowned expert on EMC in power electronics, whose expertise has been sought out by guest scientists from Japan, Korea and throughout Germany. He is in high demand as guest speaker at conferences and is frequently invited to share his knowledge and experience at seminars and workshops.

Dr. Eckart Hoene
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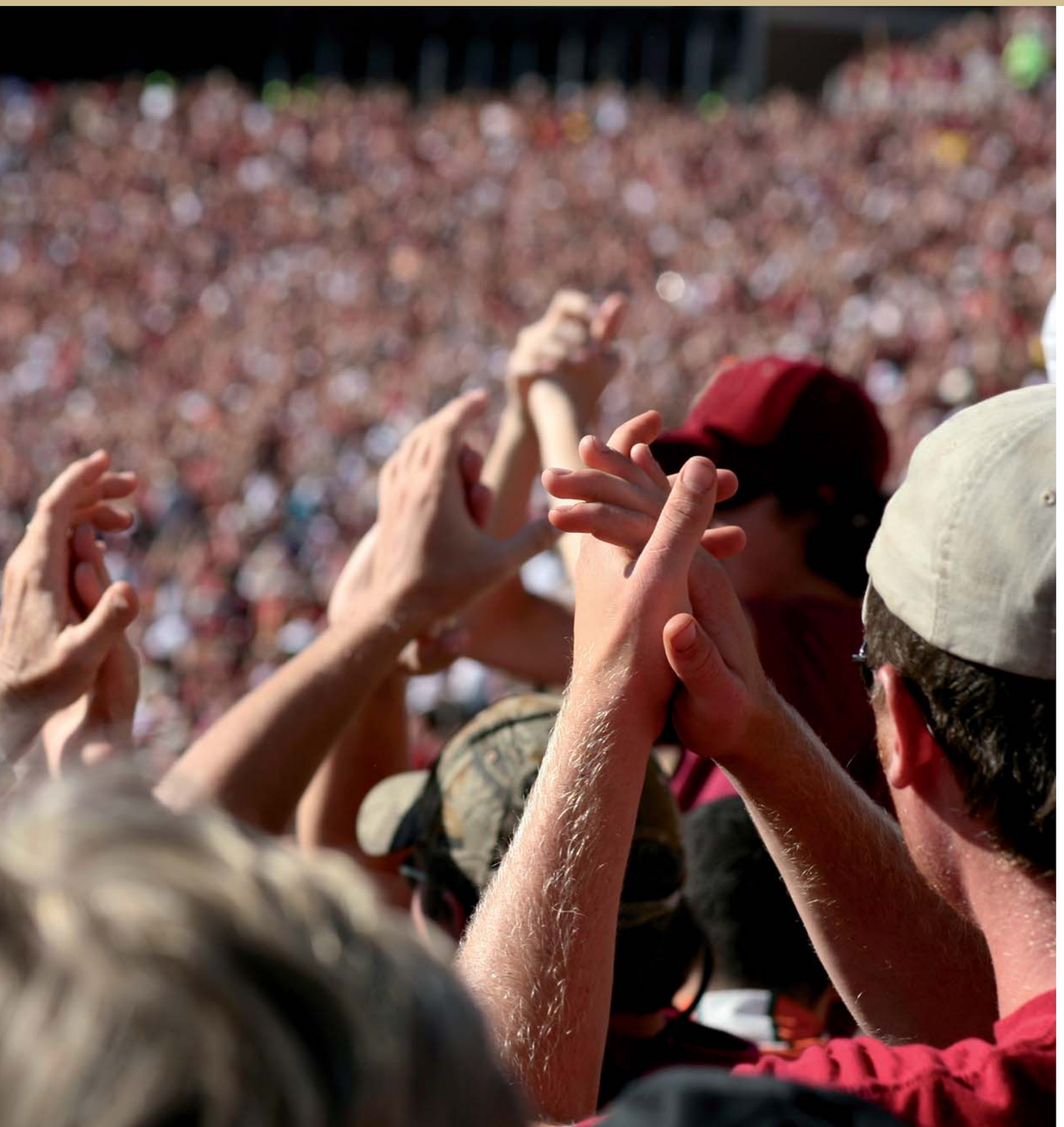
FRAUNHOFER IZM EVENTS



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EVENTS & WORKSHOPS

Fraunhofer IZM organizes the first international Maintenance, Repair and Overhaul (MRO) conference
The running costs of equipment and components have always been expensive and have recently even begun to escalate with spikes in the cost of raw materials. Cost-efficient solutions for maintenance, repair and overhaul (MRO) are now more sought-after than ever.

As part of the Fraunhofer innovation cluster MRO, Fraunhofer IPK and IZM jointly hosted the first-ever international conference addressing this issue on March 24th and 25th 2011. Hot topics at the conference, which was attended by over 200 scientists and professionals, included the latest developments in condition monitoring systems for electronic and mechatronic components, self-sufficient power supplies for such systems and new approaches for integrating them into harsh industrial or high-temperature environments.

Workshop: Customized packaging for electronics and sensor technology
On May 26th, 2011 approximately 40 participants caught up on the current trends in component integration at Fraunhofer IZM's workshop on »Customized packaging for electronics and sensor technology«.

After a theory-based introduction, the visitors put their new knowledge into practice in the institute's laboratories by testing component reliability, trying out different approaches in quality assurance and studying material- and stress-based failure mechanisms.

Getting the dirt on the cleanroom at Long Night of the Sciences
On May 28th 2011, Fraunhofer IZM and TU Berlin's TU Berlin's Forschungsschwerpunkt Technologien der Mikroperipherik participated in the Long Night of the Sciences. It was the sixth time that the two institutions presented their latest developments at the annual event that gives the lay public a first-hand look at the latest in scientific research. The TU's cleanroom drew the biggest crowd. Many of the just over 500 visitors seized the chance to glimpse behind the scenes of microchip manufacturing and take home their very own chip.

Fraunhofer IZM's focus in 2011 was medical engineering. The institute presented patient-oriented laboratory diagnostics, a lens-free chip microscope that was developed in-house and world's third-smallest camera, developed for single-use endoscopes. The latter exhibit called for a bit of teamwork, with one visitor operating the endoscopic camera to examine the tummy of a very out-of-sorts stuffed lion, while the other performed microinvasive surgery to remove an accidently »swallowed« piece of foam from said patient.

Saving a lion in distress proved popular, but not to worry - those queuing passed the time analyzing the color spectrum of gummibears using two of the institute's laser and LED scanners. The exercise showcased Fraunhofer IZM's fluorescence microscopy-based technology for determining the freshness of foodstuffs. By the end of the night, young and old had learnt a lot more about Fraunhofer IZM's work – and a very great number of gummibears had seemingly vanished into thin air! Well, we'll just write that off as yet another mystery of science awaiting investigation by inquiring young minds.

ZVE's 30th anniversary – grounds for celebration!
Over the 30 years since its founding, the Center for Interconnection Technologies (ZVE) has become the first port-of-call for any and all problems and issues related to the practical application of modern packaging technology. Its training courses are continually revised to cover all the latest developments. In addition to its now long-standing ESA and IPC certification, the program has recently been expanded thanks to certification by AZWV and for hand soldering by Deutscher Verband für Schweißen und verwandte Verfahren e. V. (German Association for Welding and Related Processes, DVS).

The anniversary was celebrated on October 18th with more than 40 invited guests from research and the technology sector. After a brief overview of the center's history by the ZVE Head Dr. Frank Ansorge, staff members presented ZVE's of core services and expertise in training, simulation and soldering. Last but not least Mr. Schmeller from Sumida Components & Modules GmbH gave a guest lecture showcasing his positive experience of a cooperation project with ZVE on »Ensuring the reliability of innovative package technologies for components and modules«.

Over 100 participants at Trends in System Integration
Customized solutions and the integration of non-digital components like sensors and power electronics are propelling advances in microelectronics. Over two days, more than 100 participants in the Trends in System Integration workshop found out which of these factors will lead to new products in microsystem technology in the next few years. Fraunhofer IZM scientists used practical examples from medical engineering, safety and security technology, industrial and power electronics, and LED and automotive technology to illustrate the maxim that underlies ongoing integration, namely "from the technology to the application".

Workshop: Miniaturized Electronics for Medical Products
Medical engineering products like pacemakers, hearing aids, microfluidic systems and retina implants are now simply unimaginable without microsystems. Held during COMPAMED 2011 in November, the workshop »Miniaturized Electronics for Medical Products« presented the innovative products just around the corner thanks to Fraunhofer IZM's technologies, including sensor-actuator components with wireless interfaces that literally disappear into the body, bandages with integrated sensors and t-shirts with electro-microfluidic functions. With participation by the companies Orthopädie Technik Winkler, maris TechCon and AIBIS Informationssysteme GmbH, the program extended beyond innovative research to include the commercial viability of products.

1 *First international MRO Conference in Berlin*

2 *Festive atmosphere at the Fraunhofer IZM Research Award Ceremony 2011*

1 *»365 Landmarks in the Land of Ideas« – Meeting of the Award Winners*

Workshop: Flexible Technologies
On November 16th and 17th, over 100 experts from around the world gathered in Berlin for the third international workshop on flexible and stretchable electronics. A one-day tutorial was held at Fraunhofer IZM as prelude to the workshop and included a comprehensive practical component in the institute's laboratories.

The subsequent two-day tutorial focused on practical examples for the integration of flexible technologies in different application areas. How will textile sensors change motor vehicles? How can intelligent textiles be used to monitor a patient's vital statistics? What is the lifetime of flexible interconnections and how can it be improved? These questions and more were covered in approximately 35 presentations by experts from science and industry, while the results of individual research projects were presented in about 20 posters.

Fraunhofer IZM: terrific scientific AND sporty!
Fraunhofer IZM again had several teams in Berlin Wasserbetriebe's 5x5 km relay race, held every June in the Tiergarten. Six teams, with a total of 30 runners from five departments joined in. Fraunhofer IZM's fastest team was 45th in a total of 4200 teams.

AMA training seminars on sensors
Fraunhofer IZM organized four seminars together with the TU Berlin and the AMA Association for Sensor Technology (AMA) in 2011. Two seminars focused on the technology-oriented design of autarkic wireless sensors, while further topics included energy harvesting and energy-minimized wireless communication. A newly added practical component, which gave the participants hands-on experience with autarkic sensor systems, was particularly well received. The other two seminars concentrated on plastic packaging, a new topic in the seminar series.

Over two days, Fraunhofer IZM experts presented, discussed and demonstrated the technologies used to encapsulate miniaturized sensors in plastic. The participants were given miniaturized USB weather stations as a handout and practical example.

European Center for Power Electronics (ECPE)
Fraunhofer IZM has been helping organize and teach ECPE seminars for several years. In 2011, the institute participated in a number of seminars, including a February event in Berlin focusing on »Parasitic Elements in Power Electronics« and a June seminar in Munich on »Electronics around the Power Switch«, at which the institute's scientists presented an advanced technique for measuring the temperature of power switches.

Apart from the EPE in Birmingham, the IZM also contributed to the »SiC & GaN User Forum« and last but not least the ever-popular »EMC in Power Electronics«, which was held for the fourth time in Düsseldorf.

Events with Fraunhofer IZM participation 2011 (Selection)	
International MRO Conference	March 2011, Berlin
Workshop: Customized packaging for electronics and sensor technology	May 2011, Berlin
Long Night of the Sciences	May 2011, Berlin
European Power Electronics EPE	August 2011, Birmingham (GB)
SiC & GaN User-Forum	September 2011, Birmingham (GB)
ZVE's 30th Anniversary	October 2011, Oberpfaffenhofen
Workshop: Trends in System Integration	October 2011, Berlin
Award »365 Landmarks in the Land of Ideas«	October 2011, Berlin
EMV in Power Electronics	October 2011, Düsseldorf
Workshop: Miniaturized Electronics for Medical Products	November 2011, Düsseldorf
Workshop: Flexible Technologies	November 2011, Berlin
Fraunhofer IZM Research Award	December 2011, Berlin
AMA Training Seminars on Sensors	2011, Berlin
European Center for Power Electronics	2011, Berlin

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FRAUNHOFER IZM AT TRADE SHOWS

Last year's conferences and trade shows kept Fraunhofer IZM very busy. The season kicked off in March with Dresden's Smart Systems Integration conference. As in previous years, a wide range of Fraunhofer IZM scientists contributed lectures. The institute also presented its latest electronic packaging results at the trade show that accompanied the conference.

Fraunhofer IZM then visited Nuremburg not once or twice, but three times last spring. The first event, in early May, was SMT, Europe's largest conference and trade show for system integration in microelectronics. Fraunhofer IZM put the spotlight on packaging for power electronics and exhibited all its recent developments in the field, including a prototype of a converter that controls a motor integrated into the hub of a helicopter rotor.

Another highlight was a prototype of a high-power LED module with integrated liquid cooling. The latter was also a great example of high density packaging – up to 160 LEDs were squeezed onto a carrier of just 250 x 1 mm^2. Harald Pötter, Head of Fraunhofer IZM Marketing, gave the event a thumbs-up: »This makes up for last year, which was a little slow. We've definitely seen many more visitors at our booth this time.«

Mid-May was again all about power electronics. One of Fraunhofer IZM's exhibits at Power Conversion Intelligent Motion (PCIM) was a current-compensated choke for 200 A, manufactured by automated processing. We also presented an active leakage current compensation device, whose features include preventing RCDs from tripping while an electric vehicle is being charged. The converter for a helicopter rotor's engine, already exhibited at SMT, again proved to be a draw card.

The third and final Nuremburg event was SENSOR+TEST in June. Here, the institute's showcase included FreshScan, a fluorescence microscopy-based device for monitoring the freshness of foodstuffs throughout the supply chain. The opportunity to try out the device, which was exhibited in fully operational mode, proved popular with many visitors.

In mid-November, the institute set off to Munich for PRODUCTRONICA 2011. Here, Fraunhofer IZM joined forces with other Fraunhofer institutes and presented its entire spectrum of microelectronics and microsystem technology services, with a particular focus on embedding technologies for power electronics. Another success, according to Harald Pötter: »We're pleased with the contacts we've made. Particularly our spectrum of services for power electronics (…) drew a lot of attention.«

For Medica 2011 in Düsseldorf, power electronics took backseat to make room for a topic central to almost all areas of medical engineering – highly integrated electronics. More flexibility, more reliability, more functionality – Fraunhofer IZM again took the lead in showing what electronics can do.

Ready, steady, go – live manufacturing at SMT organized by Fraunhofer IZM
The Application Center Smart System Integration organized the live production line Future Packaging at SMT in Nuremburg for the second time in 2011. The year's motto was »Highest precision at smallest lot sizes«. All eyes were drawn to LineRecorder, traceability software that helps manufacturers optimize their manufacturing environments.

The production line went live three times a day, accompanied by guided commentaries. We also provided set consultation sessions to give visitors a chance to ask questions and get advice in a one-on-one setting. Topics included underfilling/encapsulation, automated optical inspection (AOI), destructive testing, repair, wire bonders, vapor phase flip chip soldering, solder applications and traceability. Everyone involved in the production line came away happy in 2011. For example, Stefan Schulz from Brady: »We were more visible and were able to address more visitors because the machines and booths were organized differently this year«.

1 Production line »Future Packaging« Team at SMT 2011

2 Fraunhofer IZM at Productronica in Munich

WORKSHOPS 2012

Regular workshops at the Application Center Smart System Integration
We are holding several workshops again this year, focusing on transferring know-how from our experts to you.

You have a choice of three different kinds of workshops.

- Workshops on latest international technological trends focus on current technological developments with regard to designing future technology.
- Workshops on trends for medium-sized businesses present fully-developed technologies already in application.
- Hands-on-workshops combine market-relevant knowledge transfer with practical work in the laboratories or at machines.

Depending on demand we offer workshops in the different categories.

Please contact us if you are interested, we will tell you the dates for coming workshops and we will also be happy to organize individual events for your company.

For more information, go to
www.apz.izm.fraunhofer.de/bau/index.php?events

Contact:
Harald Pötter, harald.poetter@izm.fraunhofer.de

[1] 3D integration for medium-sized companies
Current developments and trends in 3D integration technologies are presented. Special attention is being paid to the needs of medium-sized companies.

What will you learn?
- 3D design
- Silicon 3D integration
- Stacking of chips and boards - 3D integration
- Reliability of 3D assemblies

Potential participants: international packaging experts from all industry sectors.

[2] LEDs – Application, reliability and technology
From design through assembly and interconnection to reliability analyses this workshop provides a comprehensive overview of power electronics.

What will you learn?
- Design and electromagnetic compatibility
- Assembly and interconnection technology
- Analytics
- Thermal management and reliability

Potential participants: developers and manufacturers from the realm of LEDs.

[3] Substrate technologies
This workshop is designed to discuss international research and development trends in the area of substrate technologies

What will you learn?
- SIP-design and Substrate-level integration
- Reliability and Embedding
- Interconnects, assembly and packaging

Potential participants: international packaging experts from all industry sectors.

[4] Autarkic sensor networks
This Fraunhofer workshop presents the state-of-the-art and current trends in wireless sensor networks.

What you will learn:
- Application examples and trends
- Energy supply for autarkic sensors
- Networks/communication
- Sensor packaging

Potential participants: technology-oriented small and medium-sized enterprises.

[5] Workshops on die and wire bonding
Quality and reliability aspects of wire bonds are discussed in this workshop and practical bond tests are carried out on test substrates.

What will you learn?
- Die-, US-wedge/wedge- and TS-ball/wedge-bonding
- Heavy wire- and ribbon bonding
- Visual inspection
- Pull- and shear test analyses

Potential participants: technicians, managers, developers and construction engineers.

Electronics Goes Green 2012
The fourth Electronics Goes Green Conference will be taking place in Berlin, Germany, from September 9 to 12, 2012. The event will build on the success of the last three »Electronics Goes Green« Conferences in 2000, 2004 and 2008, which were all attended by over 500 participants.

Organized by Fraunhofer IZM and Technical University Berlin, the event is a cutting-edge forum for discussion on electronics and the environment. Leading technology experts and eco-designers will meet for four days of lectures, workshops and networking on this ever more important topic.

Under the slogan, »Taking Green to the Next Level«, the program will feature exciting new approaches in green IT, life-cycle engineering, new technologies and all the latest issues in legislation and regulation, corporate social responsibility and managing critical resources and sustainability. The congress will include an exhibition of best practice products, where participants can get a hands-on look at all the latest in green technology and have a chance to meet with the developers and manufacturers of tomorrow's technology today.

For further information please go to
www.egg2012.de

PROMOTING YOUNG TALENTS

For more than 10 years Fraunhofer IZM has been trying to awaken young people's interest in technical development, as well as careers in technology and research. The professional training at the institute is based on the dual education model, combining apprenticeship with study at a vocational school. The institute also offers plenty of other opportunities for young people to familiarize themselves with the work at Fraunhofer IZM during workshops and internships.

Fraunhofer IZM extends its school partnership program
Recruitment problems, skilled worker shortages – many see education and training as stagnating. Fraunhofer IZM is making a positive contribution to countering this perceived downward spiral by expanding its partnership program with schools. The institute has already maintained a cooperation with the Diesterweg Gymnasium, a high school in the Berlin district of Wedding, for the past six years and now also plans to work with students from Berlins Heinrich-Hertz Gymnasium, which has strong focus on math and natural sciences.

The partnership program is intended to prepare students for the realities of the workplace and, above all, to encourage them to choose careers in technology and research. At the same time, Fraunhofer IZM will find out how to better tailor its vocational training program to the needs and requirements of the school system and thereby make careers in engineering more attractive to girls in particular. The time for such an initiative has never been better, with studies showing that only 10 percent of German high school students consider embarking on a career in engineering.

Work experience at Fraunhofer IZM a hit with high school students
Six eleventh and twelfth grade students from the Heinrich-Hertz-Gymnasium in Berlin-Friedrichshain completed a three-day work experience program at Fraunhofer IZM in January 2011. The high school recently joined Fraunhofer IZM's growing number of partner schools. Each pair of students took on an experiment from one of the following topics: Wire bonding technologies, Chemical laboratory/substrate technology and Long-term condition monitoring of electronic components. In the wire bonding laboratory, the students learnt how a silicon chip is electrically connected to the surrounding circuit board and, supervised by two microtechnologists, tested the reliability of a wire bond using a pull tester.

In the chemical laboratory, the students measured the layer thicknesses of electroplated circuit boards, and optically measured electroplated traces and pads. The students also managed to calibrate the X-ray fluorescence (XRF) machine using a bath analysis for circuit board manufacture.

The state of electronic components in machines under various environmental influences such as vibration and humidity is controlled and analyzed in Fraunhofer IZM's Electronic Condition Monitoring laboratory. Here the students performed vibration measurements on electronic components in shakers and, using acceleration testing, investigated how often a device can fall before the electronics fail. This was particularly interesting for the teenagers majoring in math, as the tests involve integral and differential calculus.

On the final day, all three groups presented short talks on the technical parameters of their measurement experiments and their results. The Fraunhofer IZM supervisors were extremely impressed at how deeply the students had gone into the material, how well they had understood details, and the extent to which they had digested the content in just three days.

Girls' Day: Encouraging up-and-coming young researchers
The eleventh annual Girls' Day enjoyed record participation, with more than 10,000 events throughout Germany. More than 125000, fifth-graders and over had free rein to explore technical, life-science, manual and IT professions – for example at Fraunhofer IZM. As in previous years, the institute offered 11- to 14-year-old girls interested in technology a glimpse of the institute's day-to-day research. Girls' Day aims to enthuse girls and young women for courses and/or careers in technical or technology-related fields.

The following topics were explored this year:
- Flashing a torch – how do LEDs work?
- Where do the chips in my mobile phone come from? – A tour of the cleanaroom
- A candle without flame – how to build an electronic circuit

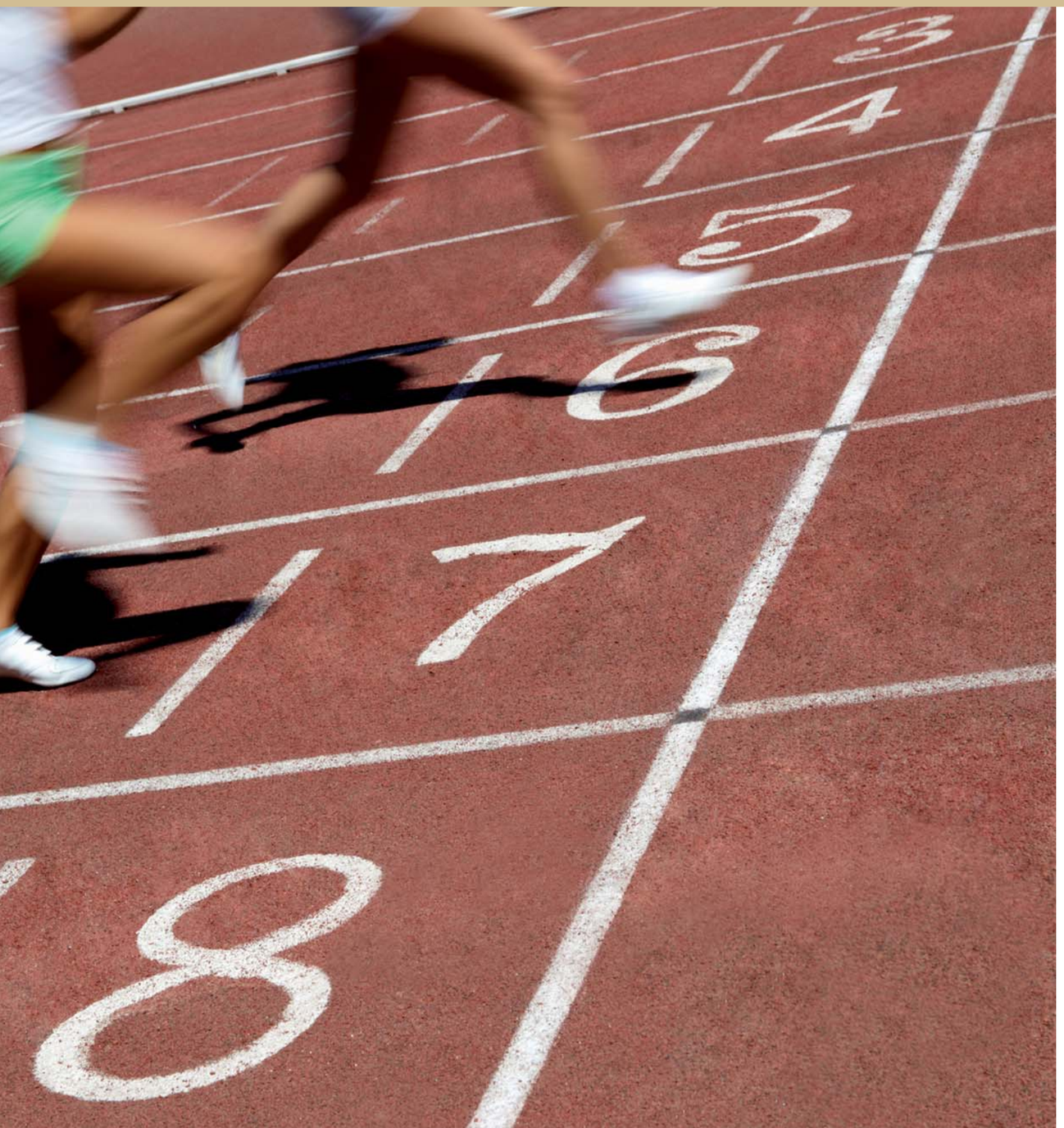
The last part of the workshop was a hands-on opportunity for the visitors to build their own little weather station.

Workshop: Micro-Mechatronics – The technology of tomorrow
The talent school is part of Fraunhofer's program to encourage up-and-coming researchers. At regular intervals, Fraunhofer scientists host a variety of workshops for young people interested in technology and discussing current scientific questions.

In November 2011, the Fraunhofer Micro-Mechatronics Center (MMZ) in Bavaria invited talented youngsters to learn more about the integration of sensors and actuators in robots, vehicles and machine elements. It was the fourth time the Center hosted the workshop. What is micro-mechatronics really? How does the holistic design of electronics and mechatronics work? MMZ Director Dr. Frank Ansorge answered these and many other questions using examples and case studies. In two practical workshops supervised by MMZ scientists, the teenagers picked up soldering irons to help assemble the MMZ IR BOT, a µ-processor controlled robot. Together the participants individually programmed their MMZ robot and learn about the interplay between sensors and actuators.

1 *Girls' Day 2011 at Fraunhofer IZM*

2 *Work experience 2011 at Fraunhofer IZM with high school students*



FRAUNHOFER IZM
FACTS & FIGURES

FRAUNHOFER IZM IN FACTS AND FIGURES

Financial situation
Fraunhofer IZM carried the success of 2010 into 2011, increasing its turnover by 5 % to 24.2 million euros. This was thanks in part to proceeds of €7.9 million from German and international industry and trade associations, which also increased by 5 %.

No small role was also played by the institute staff's ongoing commitment to rapidly transferring excellent results from publically funded research and development into the commercial sector.

Fraunhofer IZM financed 93% of its operating budget through external contracts in 2011, freeing up a total of €22.5 million for ongoing projects.

Equipment investment
Investment into the project group Fraunhofer IZM ASSID at the Dresden/Moritzburg branch, which had begun in 2009, were largely completed in 2011. Another round of equipment at a value of €8.1 million was acquired, installed and put into operation.

Additionally, the institute began establishing the »Crimping Technology« practical laboratory at the Oberpfaffenhofen branch as part of the Fraunhofer Academy. The new lab is being jointly funded to the tune of €0.4 million by the Fraunhofer Gesellschaft and the institute in order to extend the branch's range of application areas.

The planned courses will teach developers the critical parameters in selecting materials and the manufacturing requirements for quality-assured and reliable joining. The quality criteria for inspecting crimped joints will be covered, as will the calibration of various tools. Pull testing, voltage drop measurement and microsections will be used to determine the reliability of such joints.

Manufacturing staff will be trained in crimping using documented manufacturing instructions. Monitoring and evaluation of the joints is performed according to the inspection criteria of the IPC-A-620.

Furthermore, the institute is producing e-learning material for mobile devices in cooperation with the Fraunhofer Academy, which will then be available as part of the iAcademy brand.

The institute provided €1.9 million for ongoing maintenance and replacements. The funds were used to expand Fraunhofer IZM's infrastructure with a range of different individual machines and to increase the efficiency of existing equipment.

Human resources
Thanks to the positive balance sheet in 2011, Fraunhofer IZM was able to again create additional positions in 2011. The institute's staff increased from 180 to 197 at Fraunhofer IZM's branches in Berlin, Dresden/Moritzburg and Oberpfaffenhofen.

The institute also offers students the option of combining their studies with practical scientific research at Fraunhofer IZM's offices and laboratories. At the end of 2011, Fraunhofer IZM was supervising 152 interns, Masters students and student assistants. This represents an increase of almost 25 % over the previous year.

The institute continues to regard providing training and apprenticeships as one of its central tasks. In 2011, 9 apprentices were trained as microtechnology technicians and business administrators.

AWARDS

Fraunhofer IZM is Germany's top research institute on electrotechnology
The German Council of Science and Humanities (Wissenschaftsrat) has released a study comparing and appraising the research performance of all German universities and non-university research institutions working in the area of electrotechnology. Fraunhofer IZM was rated as »very good« or »excellent« in all five areas evaluated – research performance, effectiveness, efficiency, advancement of young researchers, and research transfer, which places it at the top of the 47 research institutes compared.

Fraunhofer IZM microcamera wins »365 Landmarks in the Land of Ideas« award
Fraunhofer IZM has won an award in the national innovation competition »365 Landmarks in the Land of Ideas«. The camera is used in healthcare technology, such as endoscopes. Smaller than the head of a pin and with a resolution of 62,500 pixels thanks to a unique »packaging technology«, Fraunhofer IZM's microcamera sets a new benchmark in healthcare technology. Earlier, similar cameras were equipped with fiber optics, which allowed a resolution of 10,000 pixels. At the award ceremony on October 26th, 2011, Ira Holl from the Deutsche Bank Berlin named Fraunhofer IZM's microcamera a »Selected Landmark 2011« and emphasized that »Fraunhofer IZM's new high-resolution microcamera revolutionizes endoscopy. Such convincing innovations ensure Germany has a pole position in healthcare technology.«

The tiny camera for high-resolution images is one of 365 award winners selected each year by the joint initiative »Germany – Land of Ideas« and the Deutsche Bank under the aegis of the German Federal President. »We are very proud to be have been named a 'Selected Landmark' in the Land of Ideas. Innovations like the microcamera show how extremely important microsystem technology is to the European research landscape.« commented Fraunhofer IZM's Prof. Klaus-Dieter Lang.

TU Berlin and the Association of German Engineers (VDI)
IZM employee Markus Wöhrmann was singled out for praise not just once, but twice for his Masters thesis, entitled »Managing Polymerization Stresses by Minimizing Mechanical Stress in BCB Thin Films during Processing«. The TU Berlin named him as one of the year's three top graduates of the degree Masters in Electrotechnology, while the Association of German Engineers Berlin-Brandenburg chapter also commended him for his outstanding results in Electrotechnology and IT.

IZM Research Award 2011 goes to Dr. Eckart Hoene
Each year, Fraunhofer IZM acknowledges outstanding scientific achievement by an institute scientist with the Fraunhofer IZM Research Award. In 2011, the award went to Dr. Eckart Hoene, head of the research group Power Electronic Systems.

Eckart Hoene, who has been working on power electronics for more than 14 years, was honored for his work on the »Development and Industrial Implementation of Design Processes for the Electromagnetic Optimization of Power Electronics«. Especially the manufacturers of electrical and hybrid vehicles benefit from Hoene's work. The prize was presented by Fraunhofer IZM director Klaus-Dieter Lang during a festive award ceremony on December 21st , 2011 at the DZ Bank's Berlin headquarters.

Fraunhofer IZM apprentice Pia Johne is honored for excellent exam results
Together with twelve apprentices from other Fraunhofer institutes, former Fraunhofer IZM apprentice Pia Johne (micro technologist, focus microsystem technology) was honored for her outstanding exam results by the Fraunhofer Board of Directors. The festivities took place at the Fraunhofer-Haus in Munich.

Pia Johne has taken taken up a course in biosystem technology at The University of Applied Sciences in Wildau and continues to work at Fraunhofer IZM as an intern. Fraunhofer is currently training just under 400 apprentices in 31 professions. Fraunhofer regards it a social responsibility to train in excess of their own demand.

Fraunhofer IZM's Torsten Nowak receives Gottlob-Schumann Award
For his outstanding diploma thesis Torsten Nowak of Fraunhofer IZM was honored with the Gottlob-Schumann Award in the category of natural and engineering sciences by the University of Applied Sciences Lausitz on December 6, 2011.

The award comes with prize money of €500 and was presented to Torsten Nowak in a festive ceremony at the university.

Young Engineer Award SMT 2011 for Daniel Hahn
The winner of the Young Engineer Award was announced on the last day of the 2011 SMT/Hybrid/Packaging trade show. Fraunhofer IZM Berlin's Daniel Hahn carried the day with his poster, entitled »The Reliability of Concave Flip Chip Solder Joints under Combined Temperature and Vibration Loading«. The winner was decided in a popular vote by visitors to the trade show and Daniel took home a prize of €500 as reward for his efforts.

1 *Fraunhofer IZM Research Award winner Dr. Eckart Hoene (center) together with Dr. Martin Schneider-Ramelow (left) and IZM's director Prof. Klaus-Dieter Lang*

2 *Festive tribute to Fraunhofer's best trainees in Munich*

DISSERTATIONS, BEST PAPERS, AWARDS

Dissertations

Morgenstern, H.
Effiziente Verifikation der Robustheit komplexer integrierter Schaltungen

Ohnimus, F.
Efficient Integration of Planar Antennas Considering Electromagnetic Interactions at Board Level

Linz, T.
Analysis of Failure Mechanisms of Machine Embroidered Electrical Contacts and Solutions for Improved Reliability

Best Papers

Ostmann, A.; Brühl, B. ; Manessis, D.; Seckel, M.; Lang, K.-D.
Modular Microelectronics by System-in-Packages with Embedded Components
Outstanding Paper Award, IMPACT 2011. October 2011, Taipei, Taiwan

Awards

Highest score in research ranking
Fraunhofer IZM

»365 Landmarks in the Land of Ideas« Award
Fraunhofer IZM

Fraunhofer IZM-Research Award 2011
Dr. Eckart Hoene

Top Fraunhofer Trainee
Pia Johne

Gottlob-Schumann-Award
Torsten Nowak

Young Engineer Award SMT 2011
Daniel Hahn

LECTURES, EDITORIALS

Lectures

Technical University Berlin

B. Bouhlal, Dr. T. Tekin
- Design, Simulation and Reliability of Microsystems

Dr. R. Hahn
- Miniaturized Energy Supply Systems

Prof. K.-D. Lang
- Technologies for Multi-functional Systems
- Hetero System Integration Technologies

Dr. I. Ndip
- Numerische Feldberechnung
- Electromagnetics for Design and Integration of Microsystems

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