Fraunhofer
IZM

FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM

ANNUAL REPORT 10/11

CONTENT

Prof. Klaus-Dieter Lang,
director of Fraunhofer IZM

PREFACE

Last year's economic upturn has seen Fraunhofer IZM take on new research and development projects. With external funding of over 90 percent, the institute was able to reach the highest worth since the institute was established in 1993.

This not only indicates that we are heading in the right direction, but also that integrating electronics and microsystem technology in products is a growing priority for industry. Fraunhofer IZM will continue down this road with even more determination in the future, and its strategic technology development will focus even more sharply on the special needs of individual applications. Thanks go to our cooperation partners at this point, whose high-quality, timely support helped us significantly in achieving our success.

Focus on applications

As strategic measure to further strengthen our emphasis on applied research and development, we have appointed topic specialists to provide fast and competent advice to customers and fast track joint projects. The following areas are covered:

- Automotive and traffic technology
- Medical technology
- Security technology
- Optical technology
- Power electronics

This measure also ensures that special requirements and trends in the application areas are integrated directly into the technology developments. We are currently preparing to appoint topic specialists for further areas.

Electronic packaging in automotive and traffic technology has the highest requirements in terms of harsh environments, high reliability and lifecycles of several decades. At the same time, complex value-added chains necessitate comprehensive understanding of technologies and manufacturing processes, to determine optimal solutions during the design phase. Key parameters include system integration suited to the build space, operation at high temperatures and the integration of power electronics and multifunction sensors.

New concepts for the assembly of power electronics are gaining significance not just in the automotive industry. Other application areas also require new concepts in packaging technology to provide reliable and efficient functionality even with limited build space and weight. Optimized thermal management and electromagnetic shielding must also be ensured.

In optical technology, LEDs are a good solution for efficient lighting and also offer new possibilities for integration in products. High loss densities require new concepts and technologies for heat distribution and dissipation. Technical solutions must also be found for optical signal transmission, specifically methods of integrating and interconnecting optical and electrical components in a module cost-efficiently.

Electronics plays a crucial role in life-science applications for sport and medicine, helping to facilitate healthy lifestyles invisibly and imperceptibly. Further miniaturization is necessary for applications that are implanted in or worn on the human body. Such applications also have special safety, material stability and lifetime requirements.

Autarkic sensor systems that record and transmit critical parameters such as the presence and levels of harmful gases can improve the safety of our living environments. Energy-saving sensors and radio transmission technology must be developed for miniaturized sensor nodes with self-sufficient power supplies.

Key technology areas

Fraunhofer IZM's future technical challenges include multifunctionality, miniaturization and adapting electronics to the application environment. These features shape the strategic technology development at the institute, particularly on wafer, module and board levels. This allows us to establish a foundation for continuing to contribute to the technology and process development of innovative products. Fraunhofer IZM's key technology lines in this area feature comprehensive industry compatibility and ensured manufacturing quality.

Wafer level packaging at Fraunhofer IZM was significantly bolstered in 2010 by the establishment of Fraunhofer IZM - ASSID All Silicon System Integration Dresden. With support from the German Federal Ministry of Education and Research, the free state of Saxony and the EU, a new, internationally cutting-edge 3D integration technology center was founded. The center is developing systems with 300 mm silicon technologies in extremely small build spaces for a wide variety of functionalities.

Fraunhofer IZM Berlin is able to develop system-in-package technologies on module and board levels that are reliable and process-optimized. Tiny systems, such as a camera system with lenses for endoscopes, are assembled reliably and cost-efficiently. Wafer level molding enables encapsulation directly on wafer level and the assembly of multi-layer heterosystems. Entire systems can be manufactured flexibly from very different components and distinct substrate and packaging technologies. The embedding of components and chips in the circuit board also opens up new possibilities, such as space-saving integration of electrical and non-electrical functions. Here, too, the implementation of the developments is carried out using continuous, industry-compatible processing lines.

Integrated design, the environment and reliability

Fraunhofer IZM also provides customers and partners with outstanding support during the entire product development process, from manufacturing prototypes fit for industry use to securing the manufacturing quality. Determining reliability and evaluating environmental friendliness are obviously key components of the design process. Interactions between technology, design, the environment and lifetime are assessed collectively and optimized in terms of the application, efficiency and lifecycle. To develop robust systems for harsh environments, a comprehensive understanding of the material properties, possible failure mechanisms and parameters is necessary. From nano-characterization of the material characteristics through to assessment and optimization on system level, Fraunhofer IZM develops methods that ensure cost-efficient, application-oriented and sustainable product development.

We are sure of our ongoing ability to meet all requirements of our field of expertise. Our institute will continue to decisively shape microsystem technology and will remain a key partner in electronic packaging for industry and research.

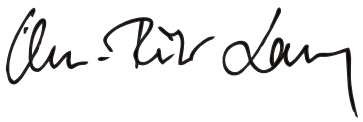
Our numerous cooperation projects with research institutes and companies, including in Europe, USA and Asia, through which we have taken electronic packaging to new levels, help us maintain this aim. For example, a key success was the third Electronics System Integration Technology Conference ESTC in Berlin in September 2010. Organized by IEEE CPMT, IMAPS Germany and Fraunhofer IZM, it was the largest ESTC conference to date with 500 participants from 34 countries.

In closing, I would like to thank our partners and customers from industry and research, in federal and Länder ministries and the project management organizations for their trust and fruitful cooperation.

Thanks also go to the institute's staff for their excellent work, indefatigable dedication and consistent creative flair in a dynamic research area. Very special gratitude must be extended to Professor Herbert Reichl, who entered well-deserved retirement in April 2010. Having led the institute since its establishment, he was central in shaping Fraunhofer IZM's role as an international leader in electronic packaging.

The following pages outline Fraunhofer IZM's characteristically outstanding research and development outcomes in 2010. I hope you find our recent results inspiring and look forward to working with you in the future.

Sincerely,



Klaus-Dieter Lang

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.

Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

Facts and figures

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 60 Fraunhofer Institutes. The majority of the more than 18,000 staff are qualified scientists and engineers, who work with an annual research budget of €1.65 billion. Of this sum, more than €1.40 billion is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now. Affiliated international research centers and representative offices provide contact with the regions of greatest importance to present and future scientific progress and economic development.

Application-oriented 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.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur. To foster a joint presence on the R&D market Fraunhofer has pooled the competences of institutes working in related subject areas in the Fraunhofer Groups Information and Communication Technology, Life Sciences, Light&Surfaces, Microelectronics, Production, Defence and Security, and Materials and Components.

Fraunhofer IZM is part of the Fraunhofer Group Microelectronics and closes the gap between wafer and application.

FRAUNHOFER GROUP FOR MICROELECTRONICS

The Fraunhofer Group for Microelectronics VmE has been coordinating the activities of Fraunhofer Institutes working in the fields of microelectronics and microintegration since 1996. Its membership consists of 13 institutes as full members and three as associated members, with a total workforce of around 2,700 and a combined budget of roughly €255 million. The purpose of the Fraunhofer VmE is to scout for new trends in microelectronics technologies and applications and to integrate them in the strategic planning of the member institutes. It also engages in joint marketing and public relations work.

Further activities of the group concentrate largely on establishing joint focal research groups and projects. In this way, the group is able to provide innovative small and medium-sized enterprises, in particular, with future-oriented research and application-oriented developments that will help them gain a decisive competitive edge. The group pools the core competences of its member institutes in the cross-sectional business areas semiconductor technology and communication technologies, as well as in the application-orientated business areas:

- Light
- Technology – from CMOS to smart system integration
- Security
- Energy efficient systems and eMobility
- Communication technologies
- Ambient assisted living
- Entertainment

Within the Fraunhofer Group for Microelectronics Fraunhofer IZM is your partner for packaging and smart system integration.

The central office of the Fraunhofer Group for Microelectronics coordinates all activities, working closely with the member institutes to forge durable contacts between science, industry and politics. Members are the Fraunhofer institutes IAF, IDMT (guest), FHR, IIS, IISB, IMS, HHI, FOKUS (guest), IPMS, ISIT, ENAS, IZFP (guest), IZM, EMFT and ESK and the Fraunhofer-Center CNTI.

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YOU CAN COUNT ON US: FRAUNHOFER IZM

System integration
Life without electronics is unimaginable. More and more products have sensors, which receive signals from the environment, electronically process these and then display the processed information graphically on navigation devices or send it on to other technical processes, such as thermostatic control units. Users hardly even notice the sophisticated electronics involved as technology is rapidly becoming indistinguishable from the product. However, to continue this trend, electronic designs have to be extremely miniaturized, robust and durable – all part of the work carried out by the Fraunhofer Institute for Reliability and Microintegration IZM under the heading »electronic packaging«.

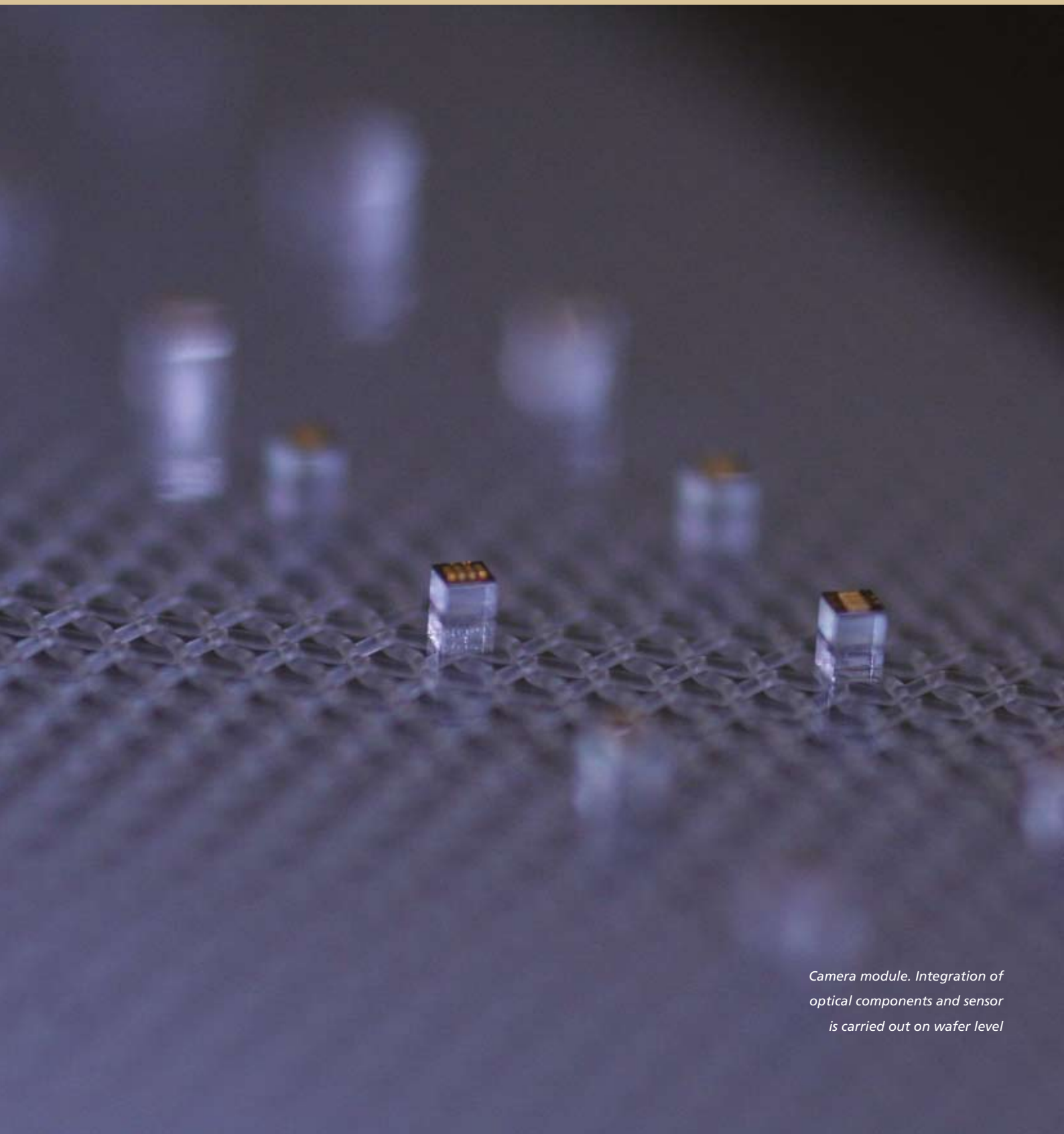
Electronic packaging: smaller – more cost-effective – more reliable
We develop electronic packaging, technology that is often invisible to users and often underestimated. Electronic packaging is at the heart of every electronic application; it interconnects the individual components, protects the electronic systems against vibration and moisture and dissipates heat reliably. In short, it ensures that electronics continue to function reliably in even the harshest conditions.

Thanks to modern packaging technologies ICs thinner than a sheet of paper can be processed. This means that the entire electronics comprising a hearing aid are so small that they can be simply hidden in the ear itself.

Clever packaging also reduces the manufacturing costs for complex electronic systems. Together with partners in industry, we are assembling the next generation of radar sensors so cost-effectively that even compact executive cars will benefit. But what would be the point of all this if these systems do not function reliably?

Our research ensures electronic systems are designed to be more reliable, so that we can accurately predict life-cycle. We test electronic systems under conditions that are as close as possible to real-life operation and get them ready for integration into applications – from wafer to system level, irrespective of the operating environment.

Cutting-edge research with tradition
Fraunhofer IZM has enjoyed an extremely successful track record since its establishment in 1993 from the research groups of the TU Berlin's key research area Technologies of Microperipherics, Humboldt-Universität and the previous Institute for Mechanics at the Academy of the Sciences in Chemnitz. It currently has branches in Berlin, Dresden and Oberpfaffenhofen, with 180 full-time employees and 123 PhD candidates, apprentices and Diplom students.



Camera module. Integration of optical components and sensor is carried out on wafer level

OUR STRENGTH:
COOPERATION WITH INDUSTRY

3D wafer level packaging of camera modules
Thanks to modern CMOS technology high resolution image sensors can be fabricated on very small chips. This progress has revolutionized the use of cameras in many consumer products such as phones and webcams. A remaining challenge in miniaturized packaging and interconnection technology is that classic flip chip mounting is not possible, because optical access to the chip surface must be maintained. For this reason, image sensors in such products are usually electrically connected using wire bonds and the optic is then individually assembled for each camera. To date the size of these systems has precluded their use in applications that require a high degree of miniaturization. Fraunhofer IZM has now developed a packaging process, in which the integration of optic and sensor is carried out on wafer level. This makes smaller camera systems possible and reduces manufacturing costs thanks to parallel manufacturing processes. The development was carried out within in the governmental research project COMIKA (BMBF joint research project 13N9412) and as part of an industry collaboration with the company Awaiba GmbH.

A key aspect of this technology is the backside redistribution of the CMOS wafer with through silicon vias (TSV). The CMOS wafer is bonded onto a glass wafer and thinned. The latter then functions as mechanical support during all processing steps, and allows the CMOS wafer to be thinned down to a few 10 microns while simultaneously protecting the sensor surface. After contacting the wafer with TSVs and processing the backside redistribution layers, wafer level bonding of the optic and CMOS wafer is performed. Depending on the application, multiple optic wafers, which contain lenses and spacer structures, are aligned with an accuracy of better than 5 µm. The wafer stacks may be up to 4.5 mm thick. After being separated, the camera modules can be directly assembled (by FCOB technique or using interposers).

This technology can be used in a wide variety of applications, including in medical technology and the automotive industry. A prototype of such a microcamera for assembly in disposable endoscopes was developed with the company Awaiba. The devices feature a resolution of 62,500 pixels at a size of just 1.0 mm x 1.0 mm x 1.0 mm. In the COMIKA project, the packaging process is being developed for cameras mounted into the armature of vehicles as a driver monitoring system for preventing microsleep. A third project is investigating using the modules as novel input devices for controlling specific functions by hand gesture. Here, the Fraunhofer Institute for Applied Optics and Precision Engineering (IOF) is supervising the optical design, while Süss Microoptics and Fresnel Optics will provide the optic wafer.

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// FRAUNHOFER IZM

Power control unit for electrical blade pitch control of a helicopter

OUR COMPETENCE:
FROM ASSEMBLY CONCEPT TO MANUFACTURE

Power electronics take to the sky
Avionics is among the increasing number of fields relying on power electronics in its applications. One longstanding project in this area has been developing a system for individually controlling helicopter rotor blades.

To date, rotor blades are primarily controlled by a swashplate, hydraulic actuators located in the fuselage and mechanical linkages between the rotating swash plate and each blade arm. But this architecture severely limits the flexibility of blade pitch motion. A more complex pitch control scheme, in which each blade arm is controlled separately, can reduce the consequent noise and vibration. Rescue operations, in particular, benefit from this, as patients do not have to endure as much jarring. Currently, individual blade control (IBC) systems, which are added on to the swashplate, meet this challenge. However, extra hardware is then required to move the blades. An electro-mechanical actuator (EMA) placed at the root of the blade arm negates the need for the extra hardware and combines the primary and individual rotor blade control into one unit.

Fraunhofer IZM developed the power electronics for controlling the EMA for ZF Luftfahrttechnik GmbH, as part of the development of a technology demonstrator within the »Aviation Research Program IV«. The system requires careful construction and high reliability standards must be met. The EMA as a whole operates redundantly, as must the power electronics. Three power control units (PCU) are assigned for one EMA and the switching topology with three full bridges allows for independent operation of every motor phase. In the event of failure, only one phase has to be put out of operation.

We designed the complete system, beginning with the selection of the power switches and calculation of the power losses and ending with the design of the thermal path, at which point the materials were chosen, as the material determines the lifetime of the packaging.

The available build space is strictly limited, so a compact construction was developed: gate drive and control, load terminals and DC link are spread over several PCBs and stacked into levels. Additionally, the DCB is embedded into the PCB, and wires are bonded directly from DCB to PCB. This reduces the assembly by one level.

For encapsulation, a housing was developed that features a latticed lid. The silicon gel can then expand without detaching under the influence of centrifugal forces. This project has been qualified and the new EMA is now in operation.

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OUR SERVICE:
FROM MATERIAL CHARACTERIZATION TO RELIABILITY ANALYSIS

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 BIDS ADIEU TO HERBERT REICHL

Microelectronics conferences, podium discussions, expert committees – Prof. Herbert Reichl's knowledge and advice was in demand at almost all industry and research events. But since his retirement in March 2010, our professional community has to learn to do without his expertise.

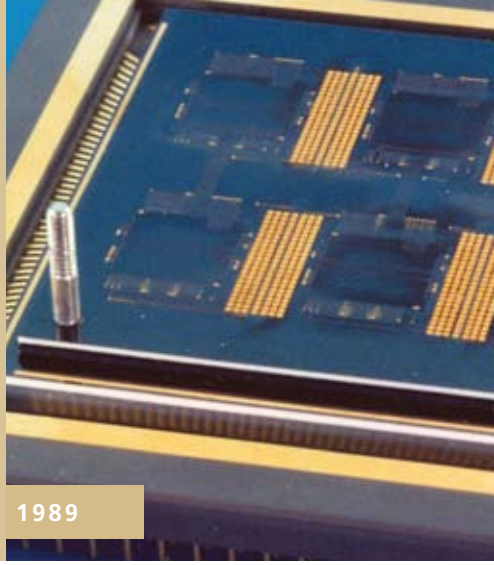
Microelectronics packaging pioneer Prof. Herbert Reichl enters retirement

Thankfully his vision and planning have ensured the shortfall will not be too great. Particularly Fraunhofer IZM, which he led for sixteen years, and the TU Berlin's »Forschungsschwerpunkt Technologien der Mikroperipherik« are very well placed to continue their excellent work. Internationally rated instruction and first-class training was always a top priority for Herbert Reichl and thanks to him highly competent scientist are employed at every level of technology and management to advance Fraunhofer IZM and the Forschungsschwerpunkt's successful track record.

Herbert Reichl is an inspiration and role model to up-and-coming scientists. Born in 1945, he completed his studies in Electrotechnology at the TU Munich with a PhD in 1974 supervised by Prof. Ruge at the Institute for Integrated Circuits. While working at the former Fraunhofer Institute for Solid State Technology, he was one of the first to recognize the importance of packaging for microelectronics and microsystem technology. His innovative, pioneering ideas forged the foundation for bringing together first-rate basic research and development for industry applications. His achievements did not go unnoticed in academia and in 1987 he was appointed Professor at the TU Berlin and Head of the »Forschungsschwerpunkt Technologien der Mikroperipherik«. In 1993 he was also appointed Director of the newly established Fraunhofer Institute for Reliability and Microintegration in Berlin, which he and his co-workers developed into one of the world's leading centers for system integration and applied development of microelectronic and microsystem technology packaging.

Scientific excellence

Herbert Reich's scientific output includes more than 900 scientific papers and books. He supervised 85 PhD candidates, of which 6 have been appointed professors. This track record clearly ranks him among the most successful scientists in microelectronics and microsystem technology internationally. His professional memberships are also proof of his reputation and tireless commitment. He headed the European Technology Platform for Nanoelectronics' Domain Team Heterogeneous Integration and was a member of the scientific board of the Eureka Initiative MEDEA+ and the council of the Eureka Initiative Euripides. He was also on the scientific boards of research institutes such as the Ferdinand-Braun-Institut für Höchstfrequenztechnik, the Karlsruhe Institute of Technology and Fraunhofer FIRST. Companies like Silicon Sensor GmbH and KSG GmbH also called on his expertise.



1989

Professor Reichl's influence extends far beyond Germany and Europe. Prestigious national and international awards, including the Order of Merit of the Federal Republic of Germany and the US IEEE's highest honor, illustrate the respect he and his team earned through his indefatigable quest for progress in the field.

Reichl's legacy: Electronics for everyday products

From anti-collision radars to chip cards and pace makers – Herbert Reichl turned countless innovative developments into cutting-edge products by integrating electronics. Over 500 patents were filed during his time as Fraunhofer IZM Director. Thanks to his commitment, sophisticated flip-chip technologies were licensed and released internationally as early as in the 1990s.

Today, this technology is firmly established globally. The first reliability models for complex chip assemblies, which could even be used to predict the lifetime of components, were developed under his leadership. Prof. Reichl and his colleagues also revolutionized PCBs with their embedding technique. The world's smallest pump, fuel cell, CMOS camera, hearing aid and autarkic sensor node were all developed during his time at Fraunhofer IZM.

1 *Prof. Herbert Reichl*

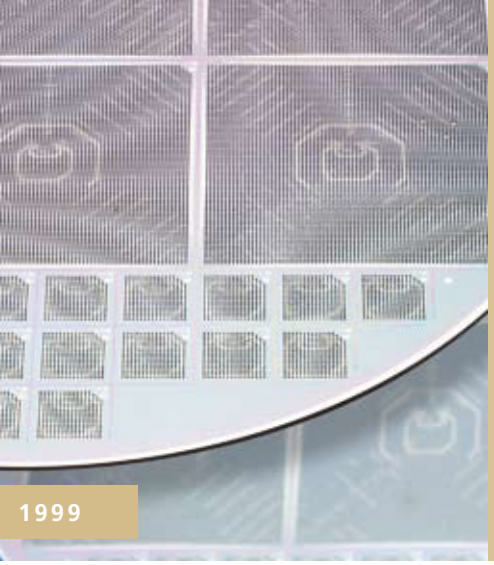
1989 *Embedding of multi-chips for thin-film hybrids*

Stepstones in Microelectronic Packaging

1989 Multichip embedding for thin-film hybrids

In 1989 at the TU Berlin, Reichl begins embedding ICs in ceramic substrates and using thin-film technology for the subsequent electrical connection. This leads to reliable, highly integrated and fast system assemblies. Individual ICs are embedded flush with the surface in laser-etched openings in ceramic substrates using a novel epoxy bonding technique that ensures the planarity necessary for multilayer wiring. The new technology is also used to embed capacitors, optical, electrical and thermal insulators.

After this technological and strategic breakthrough and three years after the fall of the Berlin Wall, Reichl brings together the research groups of the TU Berlin, Humboldt-Universität and the Academy of Sciences of the German Democratic Republic to found Germany's first pan-German Fraunhofer institute, namely Fraunhofer IZM.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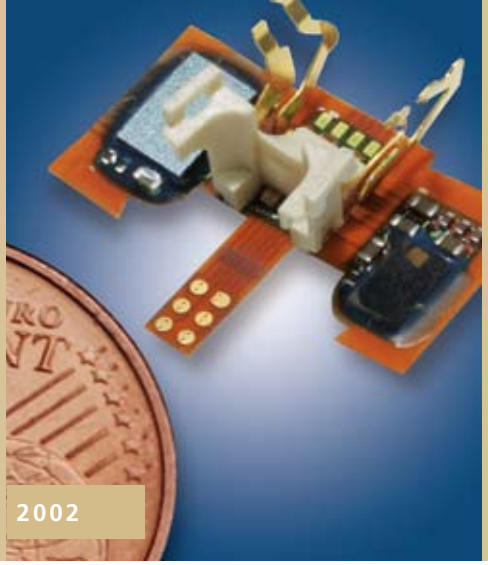
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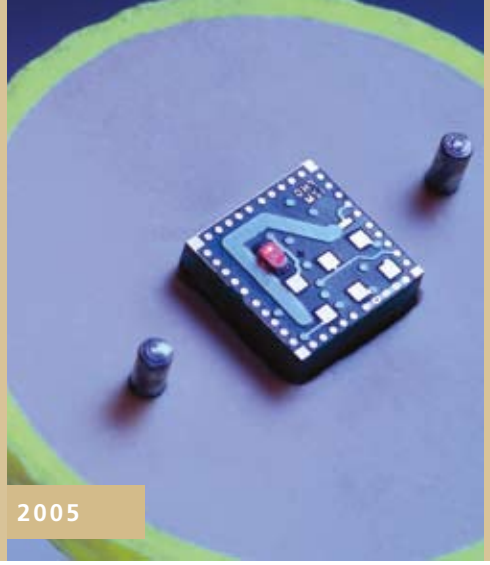

2005

1996 Environmental engineering toolbox
Over the following three years, Reichl puts environmental awareness on the agenda in microsystem technology. What consequences to product changes have on power consumption, toxicity and recycling? Long before »sustainability« became a buzzword, Fraunhofer IZM and the TU Berlin's Environmental Engineering Toolbox help companies factor environmental considerations into their product design. The toolbox is configured to allow companies to choose individual components or apply the whole set.

1998 Wafer level packaging for a new generation of medical technology
The TU Berlin and Fraunhofer IZM's scientists help the company Biotronik develop a new generation of pacemakers. The new devices are to be smaller, lighter and flatter, with more functionality at lower manufacturing costs. The result is a wafer level chip-size-package (CSP), mounted on a starrflex FR4 circuit board instead of a ceramic carrier.

1999 Chip size and assembly reliability
Increased performance demands in computing require assembly techniques for larger and faster ICs. In an internationally renown research project, Professor Reichl's team, in collaboration with colleagues from the Georgia Institute of Technology, discover that chip size alone does not determine the reliability of an assembly in the mounting of flip chips on FR4 circuit boards. The finding is a breakthrough in our understanding of reliability in complex assemblies.

2002 Highly miniaturized flexible electronics
Fraunhofer IZM and TU Berlin are turning the dream of ultra-thin ICs in identity and security documents into reality. However, the technological basis of these highly miniaturized and extremely thin systems was developed for medical applications, with Fraunhofer IZM's ultra-small in-ear hearing aid. Assembling the unhoused components on a flexible, foldable circuit board further reduces the need for build space.

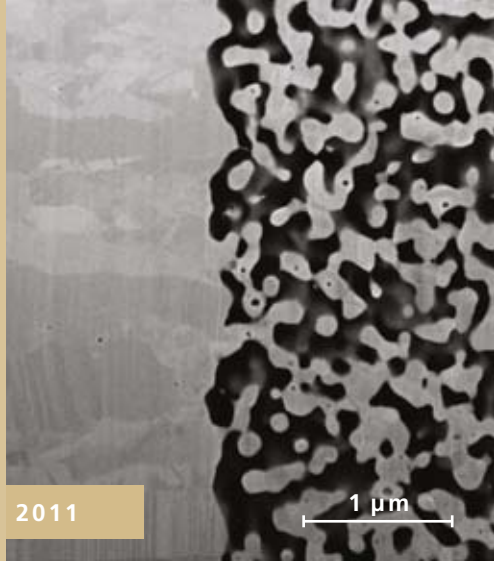
2003 / 05 Data loggers for penguins and golf balls
The IZM team, together with the company Driesen+Kern, Universität Kiel and others, develop a miniaturized measurement and data logger for penguins as part of research into the behavior and environmental conditions of sea animals. The tachograph is attached to the animal's body to record and save pressure, temperature and light measurements and the water's chemical parameters up to a depth of 800 meters. Two years later, the researchers even integrate an acceleration sensor with wireless interface into a golf ball, in which the electronics have to withstand acceleration above 1500 g.

2008 Detector modules for the CERN particle accelerator
Fraunhofer IZM and TU Berlin scientists assemble more than 1,700 detector modules for the Large Hadron Collider in the CERN particle accelerator. Together the detector modules cover 2 m^2 of the collision site's inner wall and detect the particles' trajectory and energy. Each business card-sized module has a sensor with over 46,000 pixels. The sensor and analysis electronics are connected using flip-chip technology, as the only way of reducing the geometrics and signal paths to a minimum and improving electrical, mechanical and thermal contact.

2010 Contactless mounting process (eWetting)
Reichl's team develops self-assembly technologies for the cost-effective assembly of components with less than 250 µm edge length and less than 50 µm thickness. In the contactless processes the components are placed with micrometer accuracy using chemical-physical forces.


2008


2010



2011

2011 Manufacture and bonding of nanoporous gold
Using compressible nano-sponges sensitive components can be flip-chip bonded at extremely low bonding temperatures and pressure by means of TC bonding or gluing. Because the sponges can be compressed, the surface topographies can be evened out.

Furthermore, the gold sponges show promise as biocompatible interface for cell growth and medical implants. The nanoporous gold layer is produced by galvanically depositing Ag/Au (70/30) onto a semiconductor substrate and then selectively removing the silver. The cellular structure of the gold is formed by the surface diffusion and cluster formation during the Ag etching. The porous metal sponges can be manufactured to yield a cellular structure of approximately 20 nm to 300 nm and a pore volume of 70 - 80 percent.

Fraunhofer IZM's new director: Professor Klaus-Dieter Lang
Professor Reichl's prudent leadership of Fraunhofer IZM and TU Berlin was not limited to his tenure as Director; he also made painstaking preparations for the future of both institutes.

His successor, Prof. Dr. Klaus-Dieter Lang, is an internationally renowned expert on system integration in microsystem technology and applied research into energy autarkic sensor networks. The new Fraunhofer IZM Director plans to focus on moving packaging technologies from the micro- to the nano-level. Innovative approaches and improved understanding of how to determine the interaction between integration technologies and application-related performance of complex micro-nano-systems are key research goals. As heterointegration plays a central role here from a system point-of-view, these research goals include electrical but also other types of functions, including optical and biological-chemical.

1999 *Chip structures illustrating that chip size is not solely responsible for the entire assembly's reliability*

2002 *Highly miniaturized hearing aid on flexible carrier*

2005 *Wireless sensor system in 3D PCB stack with COB integrated into a golf ball*

2008 *Looking into the detector area of the ATLAS particle accelerator at CERN in Geneva. This is where Fraunhofer IZM's detector modules are being used.*

2010 *Prof. Klaus-Dieter Lang, new director of Fraunhofer IZM*

2011 *Nanoporous gold sponge*

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 projects and networks.

Cooperation with Technische Universität Berlin

Fraunhofer IZM's cooperation with Technische Universität Berlin has been close and productive since the institute's establishment. The collaboration originated with TU Berlin's Forschungsschwerpunkt Technologien der Mikroperipherik. The latter was founded by the university in 1987, with support from the then German Federal Ministry for Research and Technology and the Berlin senate. Headed by Professor Herbert Reichl, it became one of the world's first research institutes for assembly and interconnection technology.

Since the founding of Fraunhofer IZM in 1993, there has been an intensive scientific exchange between the two institutions. With Professor Klaus-Dieter Lang taking over, the good tradition of joint leadership for the two institutions will be continued. In the area of smart system integration, the partners pursue the same aim, namely, to integrate components that may have been manufactured using very different technologies on or in a single carrier substrate. The advantages are higher flexibility and yield at lower costs along with high integration densities.

Professor Karlheinz Bock enhances the Forschungsschwerpunkt's competences in the field of polytronic microsystems. Research in this emerging field focuses on the manufacturing and characterization of technological surfaces and boundary layers for polymer components, in particular, bonding processes for different types of metal, organic conductors and semiconductors.

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.

Four 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.

Some of Fraunhofer IZM's other university partners:
Brandenburg University of Technology Cottbus
FH Senftenberg
Fudan University Shanghai, China
Jiatong University Shanghai, China
Humboldt University Berlin
Technical University Chemnitz
Technical University Dresden
Technical University Dortmund
University Bonn
University Heidelberg
University Rostock
University of Tokyo, Japan
University of Utah, USA

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.

Equipment Materials Consortium EMC-3D
Fraunhofer IZM is a technology partner in the international Equipment Materials Consortium 3D (EMC-3D). The group consists of 10 companies and 5 research institutions whose mission is to rapidly develop a cost-effective and manufacturable TSV (thru-silicon-via) for 3D chip stacking and MEMS integration.

Within the EMC-3D-Consortium Fraunhofer IZM is responsible for the process integration. With the institute's All Silicon System Integration – ASSID Center in Dresden Fraunhofer IZM can now offer product-oriented process development including the realization of prototypes for 3D systems.

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 Woundcare Initiative

Fraunhofer IZM played a key role in last November's launch of the European Woundcare Initiative at Medica in Düsseldorf. The new network is bringing together partners from medicine, high-tech research institutes and woundcare manufacturers and suppliers to jointly explore how modern electronics, sensor technology and IT can benefit this crucial topic in medical research. The participants from Germany, France, The Netherlands and Switzerland are currently combining European research initiatives to advance innovation in this area. The network's first cooperation project is to develop a sensor system that monitors the correct application of compression bandages.

International research project on patient-centered 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 and developing microsystem technologies for integrating the process control and diagnosis components into a point-of-care platform.

COOPERATION WITH FRAUNHOFER IZM

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 for 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.

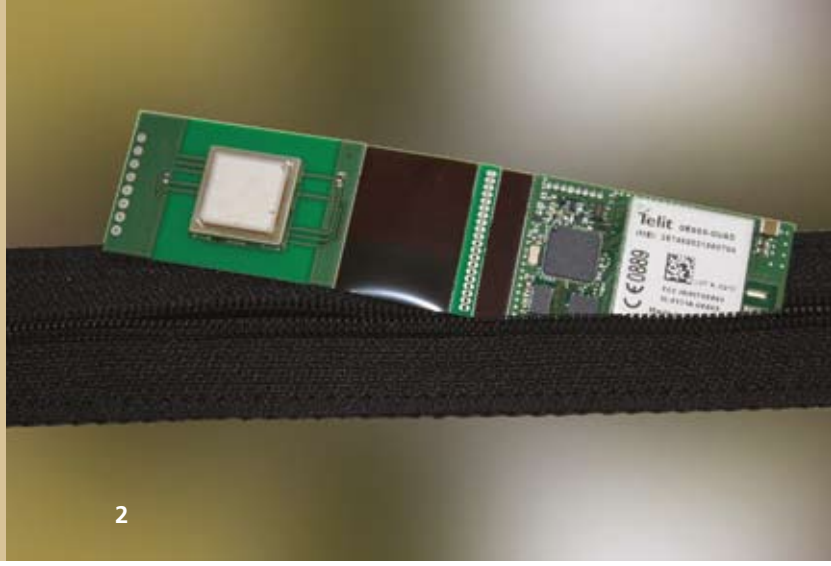
How do we support your product development?
You have an idea for a certain product and would like to develop it? But you are unsure about the feasibility, quality, development costs and time it requires?

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.

1



2

Positioning system for people with dementia

Over 1.3 million people in Germany have dementia – and the numbers are rising. Disorientation is a not uncommon consequence and can be very burdensome for family members and nursing staff, as the person with dementia has to be supervised around the clock. This led ESYS GmbH, experts in flexible remote positioning systems for vehicles and moving objects, to develop a miniaturized positioning module to be integrated into a belt. The module pinpoints the location of the patient and transmits the information to family members or carers when necessary.

The jointly developed positioning system comprises a GPS and GSM system for the receipt and transmission of the geographic coordinates, respectively, a Bluetooth module for data transmission over short distances and a power supply. The overall system comprises segments that are interconnected flexibly, compactly and cost-efficiently via partially flexible FR4 circuit boards. Currently the module can run for at least 24 hours before recharging is required thanks to a 500 mAh Li-Polymer battery.

The position data is transmitted over the GSM network via an Internet gateway to a server or directly to a mobile phone number. The system can be configured to transmit the positioning data as required – when prompted, at scheduled times or when the patient leaves a designated area (geo-fencing). To improve operating reliability the system does not employ any user interface components. Only a panic button was included, which when pushed activates the GPS/GSM system and immediately transmits the wearer's current location.

RFID wireless coupling for logistics processes

Studies show that successful retailers combine fixed location retail with Internet sales. This fact was not lost on the company gaxsys GmbH, which harnessed this synergy by linking up brand webshops, specialist dealers and consumers online. Their new project »RFID wireless coupling for logistics processes« tackles a further gap in the logistics chain. To maximize online sales, brand manufacturers need to know which brands specialist dealers are stocking offered at which locations and how many products are still in stock.

The company has developed an answer to this problem with an electronic tagging system, in which cost-efficient RFID transponders are attached securely to the product. The transponder houses non-volatile, non-rewritable memory that records the product's unique particulars (product type, color, size and so on). A temporarily assigned active wireless module (wireless chip) reads the transponder data, stores it in its own memory and transmits the data via Bluetooth, ZigBee or another energy-efficient wireless protocol to a central receiving station in the same store and from there to a central server. The active wireless module is reusable and is removed when the wares are sold, recharged and rewritten and fed back into the logistics chain.

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1 *Disorientation – a typical phenomenon in people with dementia*

2 *Miniaturized positioning system to assist relatives and carers. It consists of GPS- and GSM-module*

WORKSHOPS 2011

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:
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1] Workshop immersion silver
The workshop gives an overview of current trends in system integration. Immersion silver as finish with the strongest rates of growth will be introduced. The second part gives an in-depth insight into relevant technologies, starting with soldering and adhesive bonding on immersion silver up to Au-TS wire bonding and encapsulation.

What will you learn?
- Trends und requirements in printed circuit board technology
- Technological basics and results of practical tests
- Reliability and practical examples

Potential participants: Technicians, managers and designers.

[2] 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.

[3] 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.

[4] 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
- Substrate-level integration
- Embedding
- Interconnects, assembly and packaging
- Reliability

Potential participants: international packaging experts from all industry sectors.

[5] Flip chip assembly – a high-volume technology reaches SMEs
Different flip chip assembly processes will be presented. In the practical part participants can gain hands-on experience with industry-scale equipment in small groups.

What will you learn?
- Technological basics
- Equipment and process chain
- Manual assembly with fine placer, reflow soldering, underfilling
- Quality assurance and reliability testing

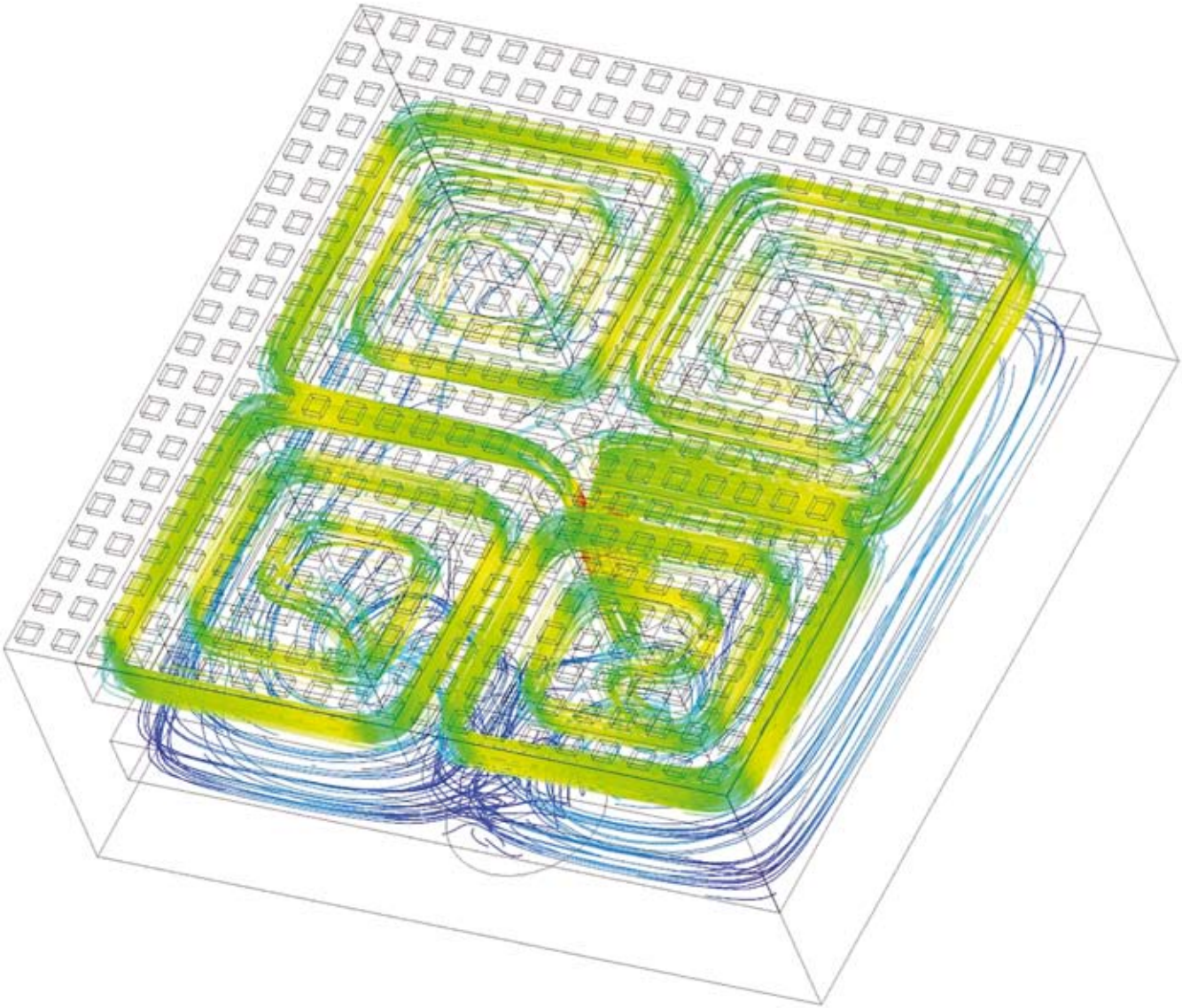
Potential participants: technology-oriented small and medium-sized companies.

[6] 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.

RESEARCH CLUSTER INTEGRATION ON SUBSTRATE LEVEL



Velocity distribution of cooling liquid within ceramic

HIGHLIGHT 2010

CooLED – Developing large LED modules with extremely high power density
Fraunhofer IZM is working hand-in-hand with two leading German partners in industry on the BMBF-funded project »CooLED«. CeramTec GmbH is developing novel water coolers, based on aluminum nitride and manufactured by means of extrusion molding. Fraunhofer IZM in Oberpfaffenhofen is optimizing the cooler's heat dissipation and the fluidic characteristics, while the Berlin branch is mounting high power LEDs onto the cooler using novel bonding technologies. Finally, Excelitas Technologies (formerly PerkinElmer Elcos GmbH) is equipping the fully functional module with electrical and fluidic connectors und optical socketing.

This project will develop light sources of up to 600 Watt in an extremely small area, which far surpass the capacity of conventional LED modules. It follows that one great challenge in this undertaking is heat dissipation. Fraunhofer IZM researched and selected the materials, while the geometrical specifications were defined together with Ceramtec. Based on this data, we designed a viable model that not only handles heat dissipation optimally, but also allows for a homogenous surface temperature. Fraunhofer IZM also performed the thermal characterization of the module using infrared (IR) thermography and electrical junction temperature measurements. Because measurement of the junction temperature according to the wavelength shift is not accurate enough in the blue and UV range, we developed a special measurement system, which can measure the forward voltage so precisely that the temperature can be determined with an error margin of less than one degree Celsius. The high power density of the module excluded the use of conventional die gluing technologies and we therefore also developed novel bonding technologies like soldering, sintering and transfer liquid phase bonding. Additionally, we designed a collective reconfigured substrate bonding method to meet the high placement accuracy required by the assembled dice. Apart from the direct goals of the project, we also qualified third-party parts and those manufactured by our project partners. Finally, we verified the viability of adapting the newly developed bonding technologies for conventional products in a series of experiments.

We also developed the cooling and packaging and interconnection for a second quadratic module now under development. This follow-up model features an even higher power density with 400 LEDs (~1200 Watt) on 16 cm^2.

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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.

// INTEGRATION ON SUBSTRATE LEVEL

SYSTEM INTEGRATION & INTERCONNECTION TECHNOLOGIES

DEPARTMENT

The System Integration and Interconnection Technologies (SIIT) department with its 110 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 packaging, including:

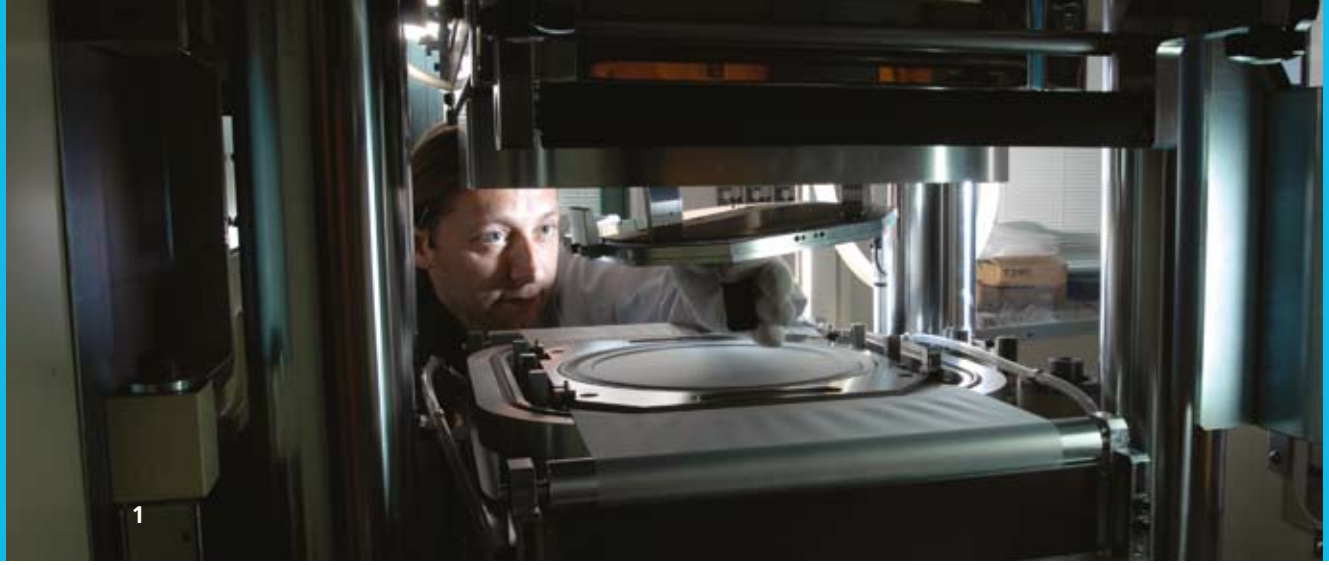
- New solders, adhesives, types of wire and bumps
- Bumping techniques (electroless Ni/(Pd)/Au, stencil printing, mechanical stud or ball bumping)
- SMD, CSP and BGA assembly
- Flip-chip techniques (soldering, sintering, adhesive joining, thermocompression and thermosonic welding)
- Die attachment (soldering,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

TRENDS

The department meets the challenges of electronic 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
- Miniaturized electronics 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 packages and substrates based on thin glass layers
- Technologies for optical chip-to-chip interconnects
- LED modules and white light conversion



RESEARCH HIGHLIGHTS

Encapsulation technologies

Over the last year our focus has been on high accuracy contactless material deposition using jetting processes and nano- and micro-functionalized materials. We successfully employed high viscosity materials from 1 Pas to >300 Pas for this, and a newly acquired high speed camera system yielded deeper insight into the process.

Reconfigured molded wafers generated by vacuum compression molding are key components in 3D integration – currently the technology is being applied to a 3D multisensor module (e. g. pressure, acceleration, magnetic field) for consumer electronics. Our work on electromobility has been concentrating on transfer molding for highly integrated power electronics modules and polymer material qualification for high temperature use (>150 °C).

Basic research was also conducted on the following topics:

- Moisture diffusion in nano-particle modified polymers (Polcap),
- Contactless handling of very small components using magnetism and electrowetting on dielectrics (Touchless)
- 3D interconnection and package stacking of molded reconfigured wafers (LowCost TMV)

These projects share the common overarching goal of achieving maximum integration of SiPs.

Medical microsystems – MMS

Medical microsystems have emerged as promising candidates to augment the life of many patients with chronic diseases or disabilities. However, such microsystems have special requirements. They must perform reliably over a long time and not impair patient comfort. Adding additional features to such devices should also be possible.

Today's microtechnology meets all these requirements and modern assembly and packaging techniques ensure the components of the integrated system remain as small as possible. The techniques of choice include bare die assembly processes, embedded component techniques and protective, biocompatible encapsulation. As part of Fraunhofer IZM's participation in the Fraunhofer Ambient Assisted Living (AAL) Alliance, MMS oversees the integration of monitoring concepts and innovative monitor and sensor integration schemes into daily life. As part of the »European HighTech Wound Care Network«, we are also working toward improving chronic wound care using advanced electronic systems.

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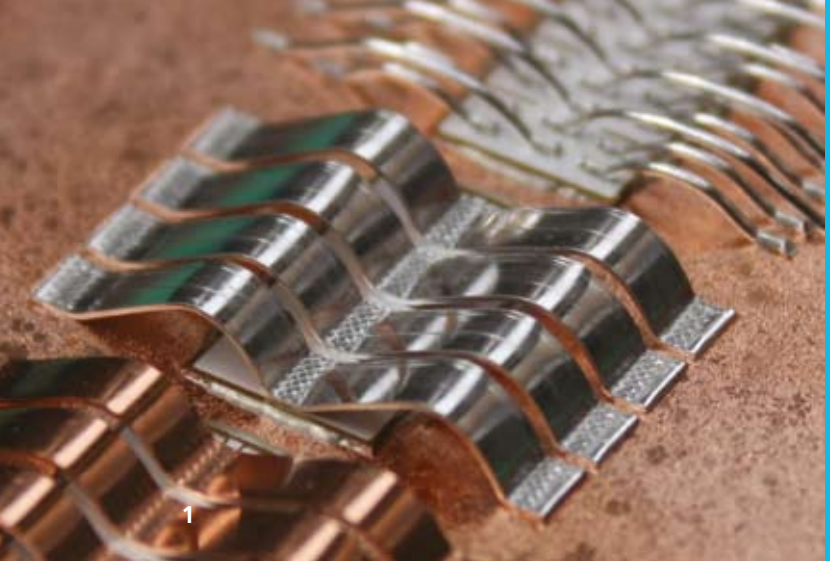
1 *Flexible Towa mold system (120 t) for transfer and compression molding; with an integrated 8'' wafer mold tool*



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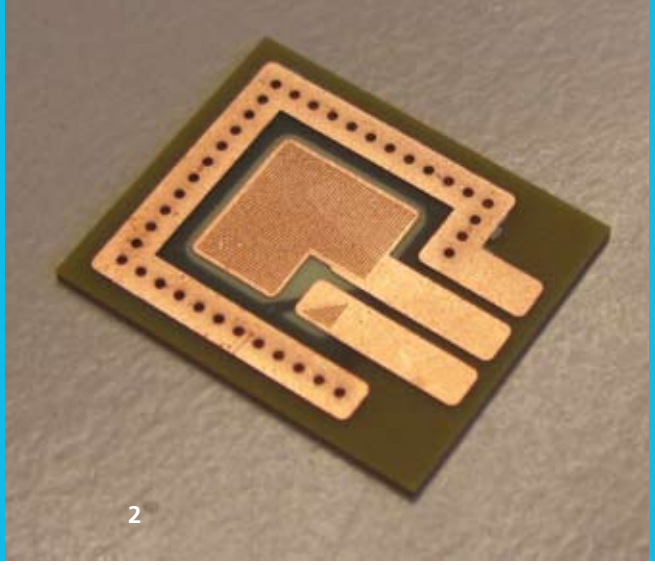


2

System on flex

We have been developing and testing UHF transponders for wood logistics as part of the joint research project »Intelligent Wood – RFID in log wood logistics«. These transponders can remain attached to the logs during subsequent processing as they consist mainly of paper and a lignin-based encapsulant. Because the transponders mimic the behavior of the wood, they do not interfere with processes or machines.

We began developing new technologies for the integration of sensors, locating systems and communication in protective clothing from mid-2010. This work is being carried out in collaboration with European partners as part of the EURIPIDES project »SINETRA«. Our main focus is system reliability and new approaches for textile integration, such as crimping.

Embedding power components into organic substrates

Embedded power chips are drawing increasing attention, especially for industrial and automotive electronics. We investigated the interconnection technology, materials, design requirements and reliability of these chips in the research project »High Current Board«. The results will be demonstrated in a soft-start circuit for industrial engines comprising two coupled thyristor elements. In the first project phase we embedded one thyristor into a FR4 substrate with thick copper backside metallization and microvia copper frontside interconnection in a prototype with full electrical functionality. The chip backside was connected using a silver adhesive.

Implantable elastic electrode array

As part of a collaboration with the Department of Neurology at the University of Regensburg and the Department of Biophysics at the University of Rostock, we developed stretchable and implantable electrodes to obtain nerve signals from peripheral nerves. We hope to transfer the technique into technology that helps amputees control prosthetic devices.

Gold was used for the electrode surface and conductive paths, which are embedded in a stretchable polyurethane foil. Three separated electrode heads, with two electrodes each, can be positioned three-dimensionally on the surface of a peripheral nerve.

To increase the signal yield and improve the signal-to-noise ratio, the electrode surface was coated with a micro-nano crystalline gold layer (known as »shark-teeth« gold).

Reliability of wire bonds on power semiconductors

We are evaluating the reliability of soldered, glued and sintered power semiconductors (currently MOSFETs) bonded with heavy wire (e. g. Al or Cu) or ribbon. Our current focus is on the reliability of the interface between the wire or ribbon and the power semiconductor, which can be damaged by periodic temperature cycles during routine use. The fatigue is mainly the result of CTE mismatch. Our in-house test bench can investigate up to 24 actively cycled devices simultaneously – and can be inexpensively upgraded to handle up to 250 devices. Each of these devices can be operated with different test settings, including diverse combinations of minimum and maximum temperatures and various cycling times. The intelligent control electronics maintain the test parameters even after millions of cycles. Typically, shear and pull tests are conducted after the temperature cycling. Additional cross sections deliver valuable information about the crack length.

Using recent research results, we were able to demonstrate that the testing concept generates lifetime data on a par with conventional testing concepts that can test only a small number of samples concurrently and that are often affected by superimposed failure mechanisms. Further development is extending the testing concept to the power cycling of IGBTs, solder and sinter interfaces (or the general chip interface) and even more deeply buried interfaces like thick copper on the FR4 core of a power PCB.

3

Low cost multifunctional CMOS vision sensor integration

We have developed a low cost, surface mountable, planar optical interconnect for integration in a low-cost multifunctional and multispectral CMOS vision sensor (MFOS). The latter can detect critical environmental parameters, such as fog, rain, twilight, and provide information on further driving conditions (oncoming vehicles, vulnerable road users in night conditions). This development was part of the project ADOSE, which researches challenges in accident prevention technology, focusing on functional, performance and cost limits of current sensors and advanced driver assistance systems and their optimization for extensive market penetration.

Thanks to the interconnect's 3D design, collimated light can be guided to dedicated detection regions on a CMOS imager. Consequently the sensitive image area can be divided into virtual partitions, which is not usually necessary for applications requiring frontal view monitoring, and, thus, one imager chip can be used for several sensing and imaging functions. Because the optical system can be passively assembled and is surface mountable, the fabrication costs will remain cost-efficient.

Fully automated assembly of microlenses for high power diode lasers

Microlens assembly is a crucial step in photonic manufacture. As part of the project PrOpSys, we have developed an innovative system that comprises a high precision handling system, metrology for process feedback, a powerful digital image processing system and tooling for glue dispensing, UV curing and laser operation.

The microlens adjustment is performed in a series of predefined steps monitored by cameras. Feedback from these cameras, processed by a powerful and efficient image processing algorithm, controls the axes of a precision motion system to optimize the collimation of the laser beam. The gluing process was also developed at Fraunhofer IZM. Alignment and mounting of microlenses to laser diode bars is now available at Fraunhofer IZM as a fully automated process.

1 *Cu- and Al-ribbon bonding for power semiconductors*

2 *Thyristor embedded into FR4 substrate*

3 *Fraunhofer IZM's substrate processing line*

PCB SOLDERING TRAINING / QUALIFICATION AND MICRO MECHATRONICS

DEPARTMENT

The integration of electronic systems is having a fundamental impact on applications – form and function begin to merge. Industry sectors such as aerospace, medical technology, and automotive technology prefer lightweight, integrated, low-cost, but nevertheless highly reliable alternatives to conventional functional modules, which may comprise several individual components, screwed, glued, or pinned together.

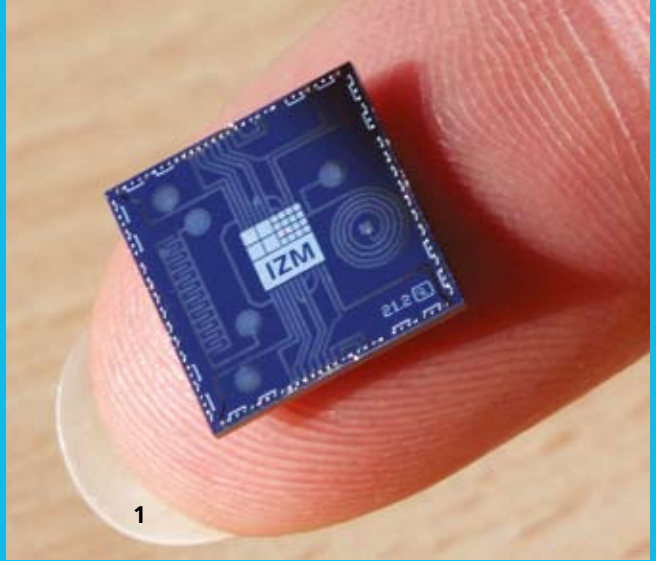
In the coming period, we plan the following:

- Product qualification innovations for electronic systems that bridge various technologies
- Setup of non-planar electronic and mechatronic systems
- Development of added manufacturing and ink-jet printing processes
- Improvement of rework and repair rework processes
- Application of solder-free interconnects like crimp and press-fit connectors
- New approaches to time- and cost-efficient in-situ monitoring of critical parameters in product qualification
- Development of novel reliability and quality criteria e. g. for wetting or and electro mobility
- Adaption of training courses to future needs of (especially for medical, solar technology, ...)

TRENDS

The Micro-Mechatronics Center (MMZ) and the Center for Interconnect Technologies (ZVE) are located at the Fraunhofer IZM site Oberpfaffenhofen. MMZ designs, develops and conducts rapid prototyping of electronic systems on novel substrates. The center also evaluates new concepts for adapting package structures to different applications. This includes a comprehensive design-flow for setup and packaging of chips, combining a system's electrical and mechanical properties with structure simulations.

ZVE evaluates interconnect technologies for electronic components with enhanced reliability requirements under demanding environmental conditions. This ranges from customer-specific system qualifications through to structural and electrical reliability tests and failure analysis of single electronic components. Additionally, practical training courses for standard and novel soldering techniques are provided, as are courses on solder-free interconnect technologies. The Oberpfaffenhofen site has been accredited as an ESA and IPC training center and is AZWV certified.



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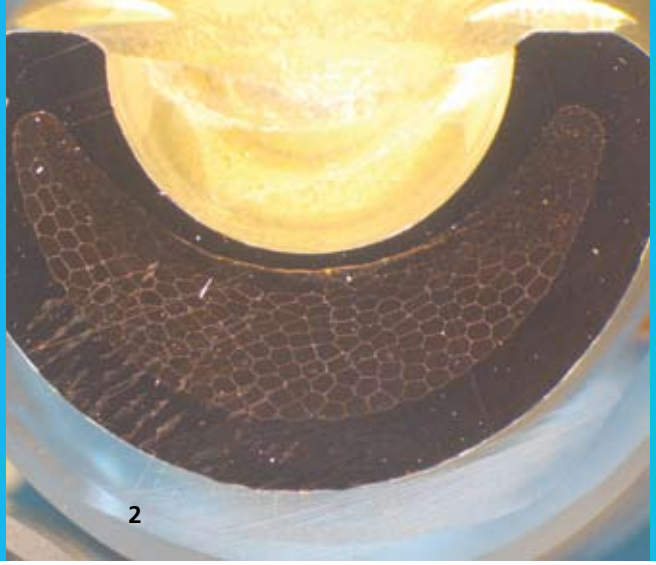

2

RESEARCH HIGHLIGHTS

Simulation and metrology

Oberpfaffenhofen now provides a numerical analysis service for determining stresses within electronic components during manufacturing processes. A broad range of simulation tools complement our extensive range of measurement facilities, with a particular focus on polymer encapsulation. Our stress measurement chip comprises up to 60 measurement cells on a CMOS chip to determine stresses within the chip plane. We have been able to measure the individual stress components σx,σsy and the shear stress component σxy for over a year now. The project »Clean Sky – Green Regional Aircraft« has led to advances in our optical and electrical strain gages, namely fiber Bragg gratings and strain gauche equipment. We also embedded sensors in carbon-fiber reinforced polymer (CFRP) laminates for use in aircrafts.

Added manufacturing technologies for electronics

The ability to combine mechanical models with conductive or movable structures (»integrated assembly«) is a key draw card of added manufacturing technologies. A major focus is cost-efficient and reliable processing of different inks (such as silver, gold, copper, nickel, ITO) for structured metallization. Printing is feasible on almost any surface, three dimensional models and different materials (such as flex, wafer, polymers, wood, paper). Additionally, complex sensor/actuator modules will soon be a reality.

Rework & Repair

New requirements for electronic assemblies, innovative components and complex substrates pose great challenges for rework and repair process technology. We have been investigating the discrete application of solder paste to tiny PCB areas. Thermal management combined with high current substrates and temperature sensitive components is also an important issue. We also research innovative solder application like sheet transfer of ink-jet technologies for areas such as molded interconnection device (MID) technology.

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1 *Ink-Jet printed redistribution layer on IC*

2 *Electromobility - highly reliable crimp for high current applications*

RESEARCH CLUSTER INTEGRATION ON WAFER LEVEL

Wafer bonding at Fraunhofer IZM

HIGHLIGHT 2010

Permanent and temporary wafer to wafer bonding

Fraunhofer IZM offers various processes for permanent or temporary wafer to wafer bonding on fully and semi automated production equipment for applications like sealing, encapsulation, MEMS fabrication, functional layer transfer, image sensor packaging as well as thin wafer handling. A versatile equipment setup allows us to perform anodic bonding, solder/eutectic bonding, thermo compression/diffusion bonding and adhesive bonding by applying either force, heat, voltage or UV light or a combination thereof to the wafers.

For achieving continuous, defect free, stable and reliable bonds over the entire wafer surface with sufficiently high alignment accuracy wafer preconditioning procedures like wet chemical removal of particles, removal of organic and metallic residues and wet chemical or plasma activation are performed. To enable best bond qualities, depending on the kind and nature of the performed process and materials to be joined, different atmospheric conditions like vacuum, formic acid, inert gas or ambient air are used during the bonding sequence. Prior to bonding both wafers are aligned to each other. When using non-structured wafers this alignment is carried out by optical wafer edge recognition to prevent strong overhang of one wafer over the other wafer. In case of bonding wafers with structures face to face or back to face alignment is used. Depending on alignment type, design of alignment marks as well as wafer condition and alignment accuracy in the range of several micrometers is obtained.

In order to support key technologies like fabrication of ultra flat devices or three dimensional architectures using through silicon vias (TSVs) Fraunhofer IZM has established various approaches for temporary bonding and de-bonding of wafers, which allows extreme wafer thinning, thin wafer handling and thin wafer backside processing. Therefore device wafers are temporarily mounted with their front side onto support wafers by adhesive bonding. Due to the stiffening support wafer, the device wafer can be extremely thinned and backside processed without the need to change running equipment, processes or handlers. The available temporary carrier solutions are highly flexible in use and compatible with a large variety of technologies like dry and wet etching, chemical mechanical polishing, chemical and physical vapour deposition, lithography, electro plating, polymer passivation etc. The final detachment of the support wafers from the device wafers is realized by means of different de-bonding techniques like laser, solvent or slide off release.

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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.

// INTEGRATION ON WAFER LEVEL

HIGH DENSITY INTERCONNECT AND WAFER LEVEL PACKAGING

DEPARTMENT

The department High Density Interconnect and Wafer Level Packaging focuses on the development and application of thin-film processes in microelectronic packaging.

Production-compatible equipment for thin film processing in an 800 m^2 clean room determines the technological possibilities. The department cooperates with manufacturers and users of microelectronic products, as well as with clean room equipment producers and material developers from the chemical industry from all over the world.

The well-established technology branches offer prototyping and small-volume production as a regular service within the realms of MCM-D, wafer-level CSP with redistribution routing, 3D integration and wafer level bumping for flip chip mounting to both industrial partners and customers.

All kinds of processes installed at Fraunhofer IZM are available for wafer sizes from 100 mm to 200 mm. Several processes are also possible for 300 mm. At our Dresden site the processing of 300 mm wafers is also available. The available services in the above areas also include technology transfer to customer-specific tools.

In numerous R&D projects, ongoing skills and know-how are being developed, which can be passed to SME-partners on a development stage.

TRENDS

We offer prototyping and small-volume production in our established technology branches as a regular service for both industrial partners and customers. Wafer sizes is range from 100 mm to 200 mm, but special formats can also be processed.

- **3D system integration**
  Silicon interposer, copper filled through silicon vias (TSV), thin chip integration, 3D packaging of image sensors, redistribution to the backside of the wafer, thin wafer handling with temporary bond on support wafers

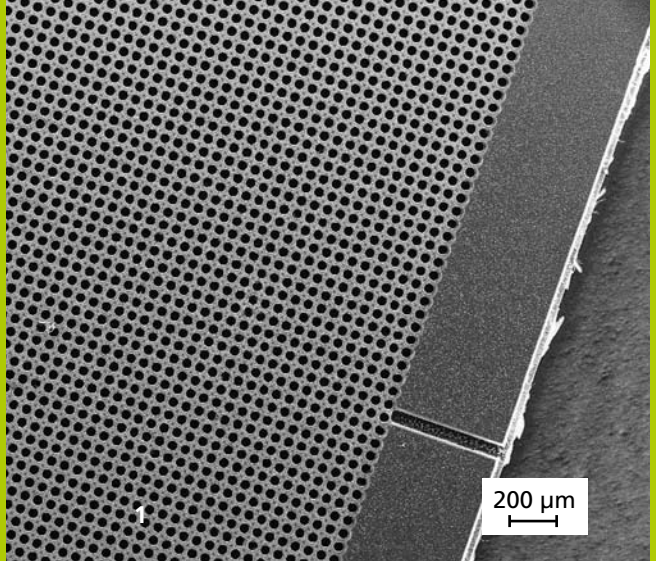
- **Wafer-level CSP**
  Thin film multilayer with Cu and Au redistribution, polymer dielectrics, glass passivation, package singulation, reliability investigation

- **Wafer bumping**
  Electroplating of structures in photo resist masks, copper pillars, micro bumping for pixel detectors, single chip bumping, Nano porous Gold bumps; optical inspection, flip chip bumping materials Cu, Ni, Au, SnAg, AuSn, SnPb, Sn, In

- **Thin film multilayer**
  Polymers, photo-resists, customer-specific layout, multilayer routing, development of integrated passive devices (IPDs), fine pitch redistribution and coils, micro electroplated magnetic layers for coils and transformers

- **Micro energy systems**
  Wafer level battery, micro fuel cell, hermetic sealing

- **Consulting and application centre for industry**



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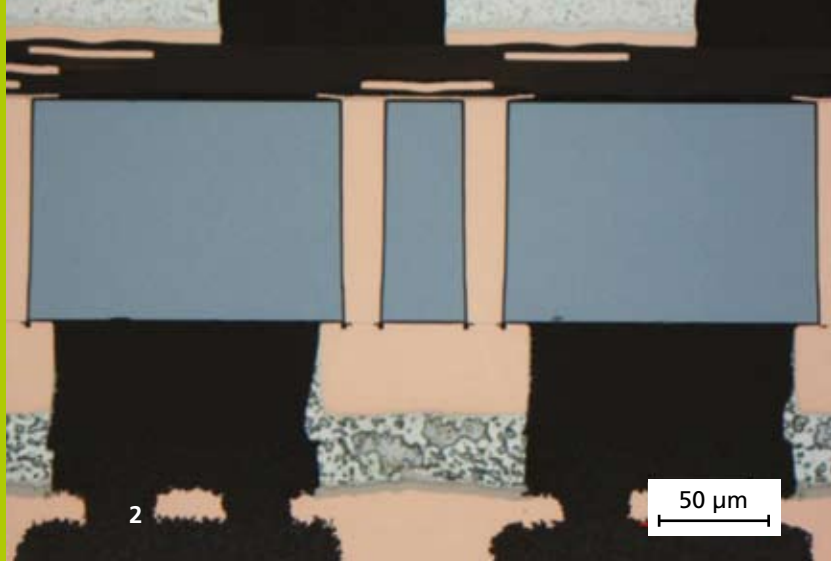

2

RESEARCH HIGHLIGHTS

High density full area wafer interconnection technology

Fraunhofer IZM made significant advances in its wafer level redistribution technology over the last year. Our ultra high density chip-to-chip connections for 200 mm CMOS wafers are used for computation clusters in neuronal networks. The high density wiring is based on polymer planarization and passivation as well as copper electroplating, and can be routed across up to 4 µm deep scribe lines of adjacent ICs on the wafers. In a first study, 56 ICs were interconnected using 159,744 chip-to-chip connections, achieving a yield of better than 99.9 percent.

Silicon interposers with through silicon vias (TSVs)

Silicon interposers with through silicon vias (TSVs) have become key components in the manufacture of three dimensional SiPs by integration of multiple devices such as MEMS, ASICs. We have established an innovative wafer level fabrication process for silicon interposers based on high density copper filled TSVs, copper/polymer multilayer redistribution for front and backside wiring, thin wafer handling, and wafer level component assembly.

Wafer level integration of gas amplification stages on CMOS ASICs

Gaseous detectors with a highly pixelized readout have proven extremely effective for tracking high energetic particles. In particular, our integration of the gas amplification stage on top of pixel readout chips using post-processing methods means that single electrons can now be detected with a very high efficiency and accuracy. A new wafer based production process on wafer level has been set up and first test samples have been manufactured and tested. Signals from β and γ sources were identified.

Low cure temperature polymers

Polyimide (PI) and polybenzoxazole (PBO) dielectric materials are widely used as stress-buffer passivation layers and redistribution layers in WLP. Our innovative modified PBO formulation can be successfully cured at 175 °C, as shown by reliability investigations using test chips, and can therefore be used as a thin-film polymer in WLP for consumer applications. Using an underfiller for board assembly will render it suitable for use in automotive applications.

Microenergy – Microbattery

In order to package microbatteries using wafer processes we have already qualified new active materials such as lithium titanate and investigated how electrode thickness affects the current carrying capacity. We also analyzed the impact of material parameters, such as active particle size, conductivity, electrode dimensions, on the charge and discharge curves, and the pulse power characteristic by means of a numeric model.

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1 *GEMGrid test chip*

2 *TSV silicon interposer assembly*

ALL SILICON SYSTEM INTEGRATION CENTER DRESDEN

DEPARTMENT

Fraunhofer's Center »All Silicon System Integration Dresden« (ASSID) was established and inaugurated in 2010. Currently, it employs 29 scientists and technical staff. The IZM-ASSID is a member in the network »Silicon Saxony e. V.« and cooperates very closely with users, manufacturers of machinery and equipment, material supplier as well as different scientific organizations, networks and clusters (e. g. EMC-3D, ITRS, Sematech) in the field of 3D integration. Furthermore, close cooperation exist with several Fraunhofer Institutes and other scientific-technical facilities in the Free State of Saxony and other parts of Germany.

Fraunhofer IZM-ASSID operates a state-of-the-art 300 mm technology line for 3D wafer level system integration based on Cu-through silicon via (TSV) technology. This concept allows the application-oriented development and qualification of processes as well as the realization of prototypes and small volume manufacturing of 3D wafer level SiPs.

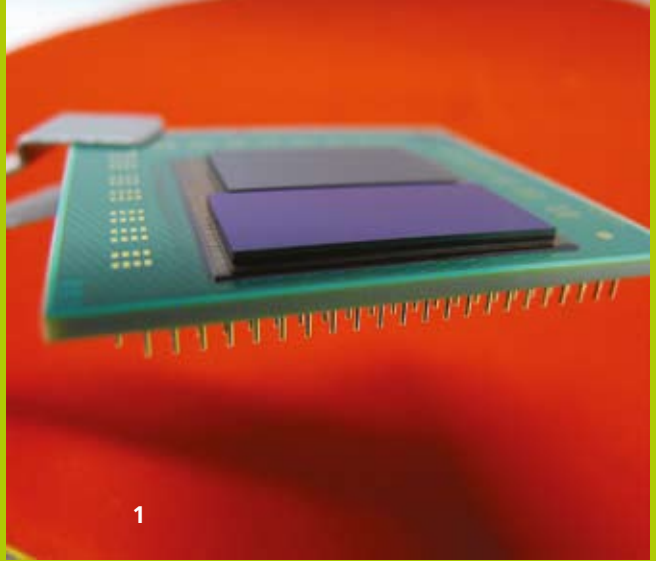
TRENDS

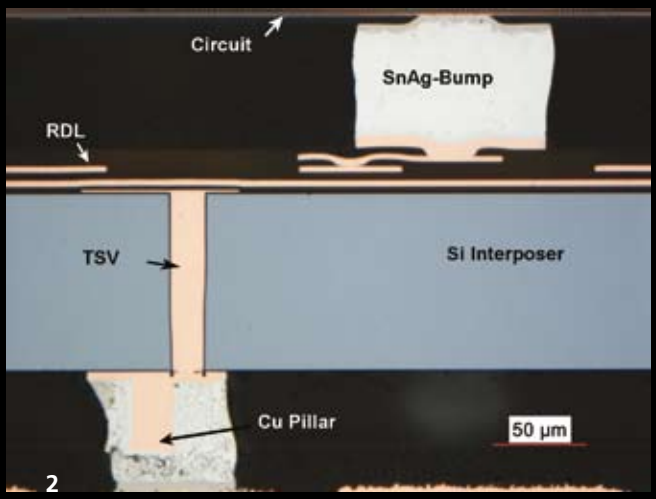
3D system integration is the key technology for driving future developments in microelectronic packaging and system integration. Heterogeneous 3D integration offers specific advantages for complex, highly miniaturized microelectronic systems especially regarding enhancement of functionality and performance as well as cost reduction.

At Fraunhofer IZM-ASSID, for the first time, a complete process line on a 300 mm wafer technology platform has been established. In cooperation with the Fraunhofer Institutes IZFP, IIS, ENAS, EMFT and other R & D institutions it is possible to realize 3D silicon systems – from design, via prototyping and to the point of small volume manufacturing including test, reliability and failure analysis.

This offers new possibilities and advantages for the development and fast implementation of new, highly functional energy efficient systems for various application areas, e. g. information & communication, health, automotive and environment, by using state-of-the-art technologies.

To exploit the full potential of 3D system integration the synergy of design, technology and reliability under application specific criteria is necessary.





RESEARCH HIGHLIGHTS

Fraunhofer IZM-ASSID's vision is the integration of heterogeneous electronic devices (MEMS, ASIC, MPU, Memory, etc.) into one wafer level system-in-package by using latest technological processes and techniques as well as materials. The system integration concepts for 3D integration are based on a 300 mm wafer technology platform.

Si-Interposer with through silicon via (TSV) and multi layer wiring

Silicon interposer with through silicon vias (TSVs) and adjusted thin film wiring form the basis of 3D integration which allows to join electronic devices of different size, form and functionality together to one three dimensional system.

Key aspects are:

- Cu-TSV and multi layer wiring
- Integration of passive components in multi layer wiring
- Integration of active elements (IC); thin chip integration (TCI)
- Adjusted contact patterns and interconnect structures for flip chip assembly and stacking

Through silicon via (TSV) technology

The through silicon via (Cu-TSV) technology is the key element of all 3D wafer level integration concepts. Essential parameters are:

- TSVs with different sizes, density and aspect ratio (diameter 5–20 µm and aspect ratio up to >30)
- TSV process integration (via middle and via last)
- TSV isolation, barrier and adhesion layers
- Via metallization by means of electroplating

3D system integration

Basic element of the integration technologies for 3D systems is the implementation of adjusted contact patterns and packaging technologies considering the functional requirements.

Subtopics are:

- Development of 3D assembly concepts and test strategies
- Pre-processing of circuit devices and components including thinning, dicing, bumping
- Handling of ultra-thin devices
- Wafer level assembly
- Test methodology

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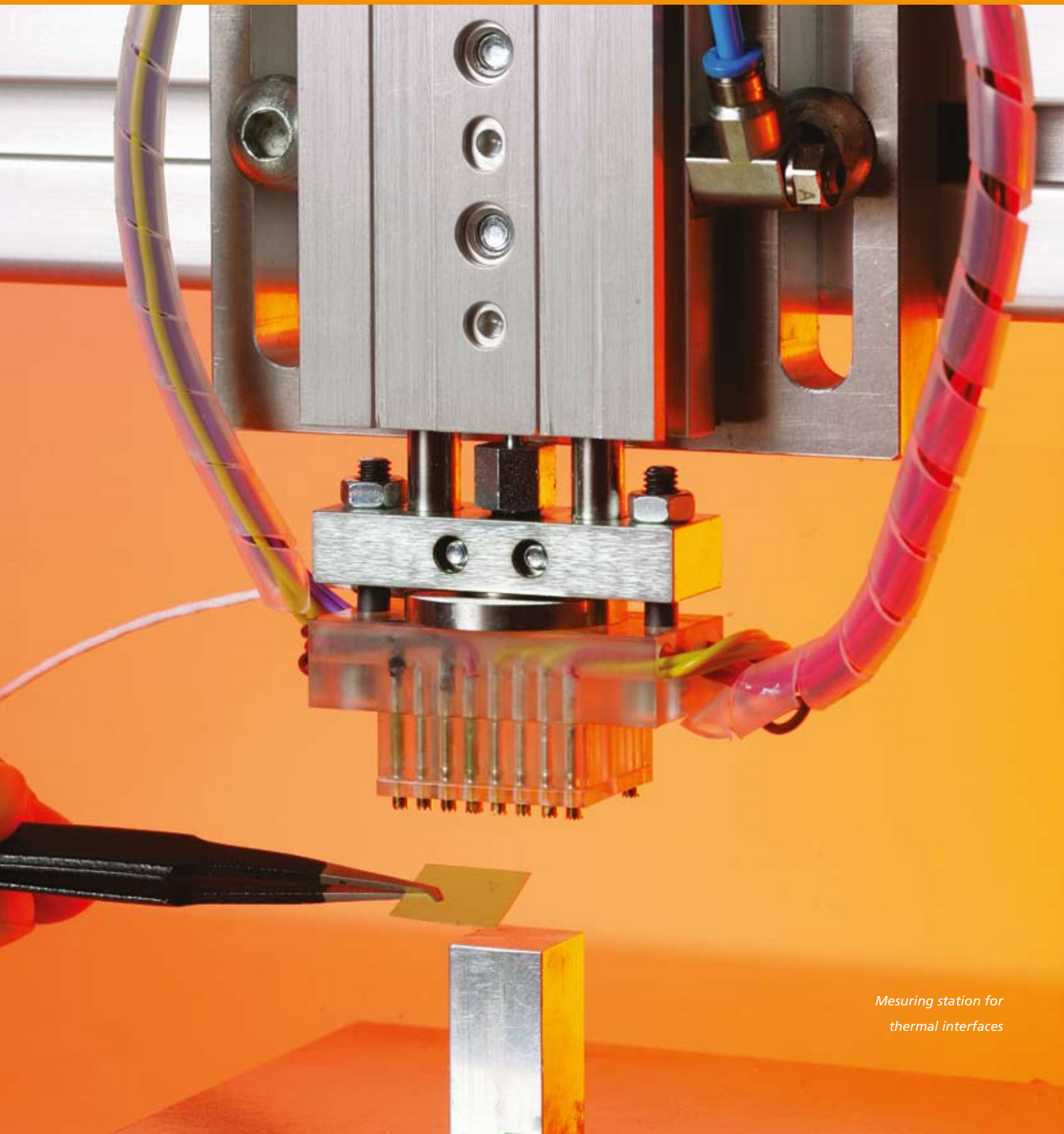
1 3D module with TSV interposer and flip chip assembled electronic devices

2 Cross section of silicon interposer with through silicon via (Cu-TSV) and flip chip assembled circuit devices

RESEARCH CLUSTER
MATERIALS, RELIABILITY AND SUSTAINABLE DEVELOPMENT



Mesuring station for thermal interfaces

HIGHLIGHT 2010

Advanced test systems for the characterization of thermal interface materials

As integration density in microelectronics increases and the use of power electronics and LEDs becomes more widespread, thermal loss is becoming a greater problem. Thermal management meets this challenge and is a key set of expertise at Fraunhofer IZM. Apart from appropriate technologies, methods are employed and advanced to optimize the product design process and create products that have more functionality while at the same time being small, light and cost-efficient.

Thermal interface materials

Heat transfer at interfaces has been identified as a bottleneck in efficient heat dissipation. The thermal interface materials (TIMs) used in this area must ensure sufficient heat dissipation and in some cases also electrical conductivity, over a product's lifetime. This highlights how important it is to know and characterize the material properties already at the design stage.

New platform for characterizing thermal interfaces

We developed an existing experimental setup into a universal TIMA platform for characterizing the most common thermal interfaces. The modules can characterize TIMs with low heat dissipation (such as glues and pastes) and can be combined with in-situ reliability testing. Furthermore, they can characterize materials with very high heat dissipation (such as sintered Ag) and extremely thin material layers (Sissy modules). Combined with modern analysis techniques (e. g. FIB cross-sections), the system also affords greater insight into the material structure based on the heat dissipation properties.

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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.

ENVIRONMENTAL & RELIABILITY ENGINEERING

DEPARTMENT

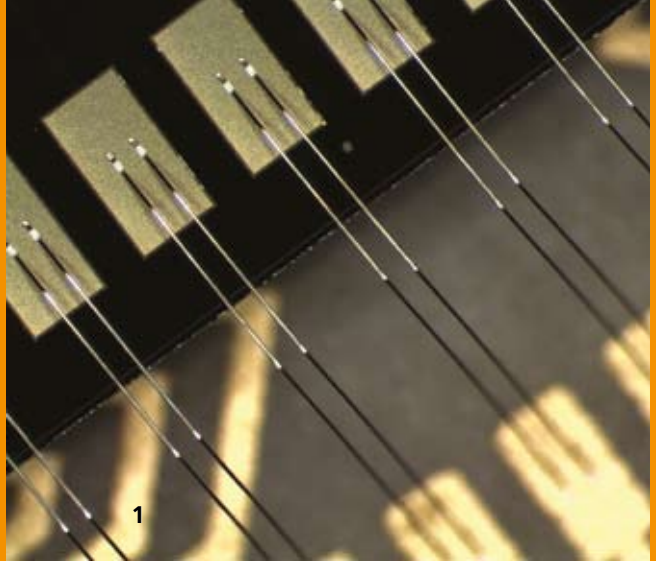
New products and technologies have to meet more and more diverse and difficult requirements, while at the same time remaining cost-efficient and environmentally friendly. Our department helps get technology developments into commercial release by providing wide-ranging environmental and reliability tests, from nano-characterization through to analysis and optimization at system level. Jointly headed by Dr. Nils F. Nissen and Dr. Olaf Wittler, the new department combines established interdisciplinary expertise in reliability and sustainability from the two departments »Environmental Engineering« and »Micro Materials Center Berlin«, including:

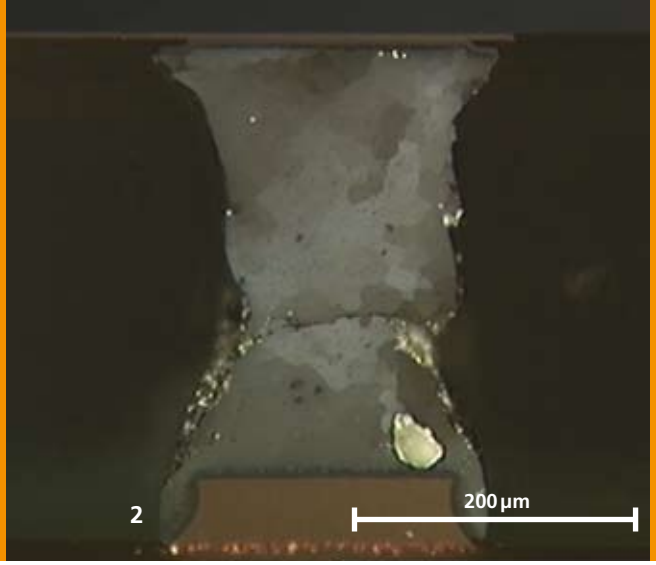
- Ecodesign, lifecycle modeling
- Environmental legislation and guidelines (including RoHS, WEEE, EuP/ErP)
- Carbon footprint, green IT and the use of renewable materials
- Eco-reliability in microelectronic concepts, such as energy harvesting
- System reliability from packaging through to product level
- Simulation for reliability optimization
- Material characterization and modeling
- Thermal design and thermal interface characterization
- Combined and accelerated load testing
- Aging and failure analysis, sample preparation and analysis
- Testability and online monitoring for accelerated aging
- Condition monitoring methods and hardware
- Reliability management in development

TRENDS

As miniaturization and functional integration continue to progress, electronic systems are becoming more complex. Quality and reliability requirements are intensifying because the probability of an overall system failing rises dramatically as more electronics are integrated if counter-measures are not taken. Thermal and mechanical stress on electronic assemblies also increases when electronics is integrated in new areas of machines and equipment. Additionally, high-tech is turning into green-tech. Apart from the key task of contributing to climate protection and energy efficiency, fundamental issues include scarce resources, international competitiveness and jobs. Green, or eco-efficient, technologies in electronic applications and in the electronics industry itself are therefore on the way to joining the industry mainstream.

Our two-pronged, interdisciplinary approach is best illustrated by our work on LED technology in lighting systems. We carried out thermal characterizations and simulations to determine and ensure reliability. At the same time, the predicted lifetime and diminishing efficiency were decisive parameters in the lifecycle modeling we performed. Here we determined which combination of LEDs and ballast electronics really offer environmental advantages. The threat of dwindling resources for a range of high-tech elements necessitates additional risk minimization methods.





RESEARCH HIGHLIGHTS

Minimizing standby: Zero watt inside (ZeWIn)
Several billion euros are spent each year to run electronic devices in standby and idle mode, and the superfluous power also contributes to global warming. Our ZeWIn system removes ethernet-capable devices from the grid completely when not in use and only switches them back on as needed. The system does not have any additional power requirements and, in the case of a typical laser printer for example, can save consumers up to 50 euros a year. An intelligent control system prevents the devices from switching off, if further use is expected shortly. This ensures the devices are not switched on and off frequently, which would cause unnecessary delays and even higher power consumption. We plan to extend the ZeWIn to other standard connections, including USB.

Energy-autarkic condition monitoring system (ECoMoS)
Sensor systems in complex machines and equipment are at the core of advanced condition monitoring concepts to prevent failure and effectively plan maintenance cycles. We are developing an autarkic microsystem for the wireless diagnosis of machines in the harsh industrial environment of a paper factory in ECoMoS. System-oriented development methods for reliable and environmentally friendly power supply of electronic systems from the immediate environment (energy harvesting) are our key focus of this collaborative project.

Interface simulation
Stability of the interfaces in packaging is a central prerequisite in electronic system reliability. We have developed a number of experimental and simulation processes for evaluating and improving interfaces, including molecular simulation, which represents the physical interactions on atomic levels. Studying these nano-scale phenomena in experiments is impossible, or at best, difficult, but such simulation processes allow us to examine these processes and correlate changes in properties with structural alterations in materials. We are currently investigating interactions as a result of moisture in the chip-mold compound interface in a number of national and European projects.

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1 *Double-side processed test chip on AlN substrate for thermal interface characterization with full area thin film micro heater, temperature sensors and capacity sensors*

2 *Cross section of a concave flip chip solder joint under combined loading of thermal cycling and vibration. Microstructure visualized by polarized light. Better distribution and minimization of the mechanical stress improve the reliability of the interconnection*

RESEARCH CLUSTER
SYSTEM DESIGN

Handheld scanner for
the spectral analysis of foodstuff

HIGHLIGHT 2010

FreshScan: Technology and module platform for the spectral analysis of foodstuff

The basic research for autarkic optical analysis devices was carried out in the BMBF preliminary research project »FreshScan«. The project's goal was to demonstrate, including using prototypes, how the food supply chain from producer to consumer can be designed more transparently. The solution involved advancing the development of RFID technology. Active sensor tags monitor the foodstuffs throughout the food chain. Autarkic hand-helds fitted with mobile optical functionality for the spectral analysis of foodstuffs were developed for the read/write devices required for the sensor tags. The system's construction design and technological feasibility was verified by measuring the microbacterial contamination of pork test samples.

Platform components

With a view to potential market appeal, the product was based on a platform and module concept. The developed electronic, optical and mechanical solu-tions designed for the system components were tested and verified using prototypes.

The platform for active sensor tags features the following fully integrated functions and characteristics:

- cold store-suitable energy storage
- contactless recharging of the energy storage
- temperature and moisture sensors
- variable data storage
- bistable display

The handheld device's features include: RFID read/write module, 2.4 GHz Bluetooth, multichannel laser and light source control, microlaser and fiber optode, fluorescence and Raman spectroscopy, ARM9-based system electronics, touch-screen operation, user-specific operating software, ergonomic system housing.

Service and application

The prototypes were extensively tested at Fraunhofer IZM in 2010 and have now been released for external user tests. Current research is concentrating on extending the prototypes for other measurement tasks in foodstuff analysis by modifying the optical components. Configuration of the system for applications in medical technology is already underway.

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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.

SYSTEM DESIGN & INTEGRATION

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

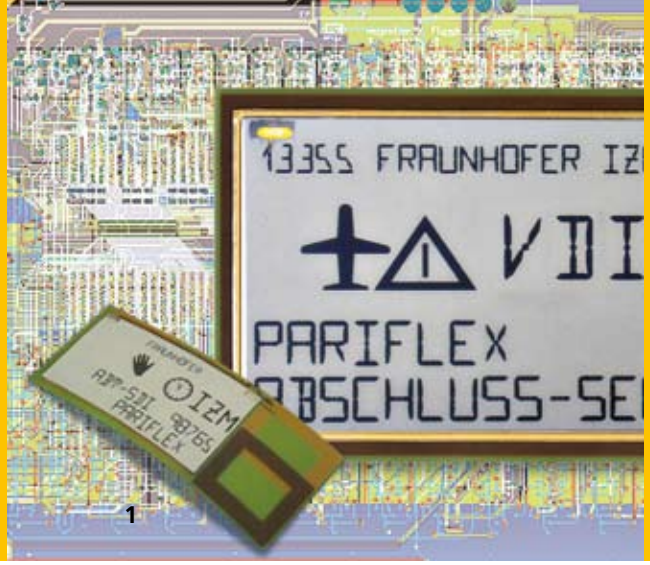
The convergence of system and technology is becoming increasingly central to the development of reliable and highly miniaturized products.

Guaranteeing the reliability of energy storage is of paramount importance in the design of autonomous microsystems. It follows that optimal use of available energy and the exploitation of energy in the environment will be a very important future research topic.

In design automation, we have now developed tools that enable 3D-SIP layouts. In the future, newly developed technologies must be integrated into the tools.

Systems with very high frequencies pose special challenges for reliability design. We have addressed this issue by developing the so-called M3-Approach, which will likely lead to a range of new developments, including waveguide structures with integrated transmission lines that transmit both the TEM and TE modes.

In power electronics, new developments in fabrication and interconnection technology are expected that will fundamentally reframe development of new systems in the future.



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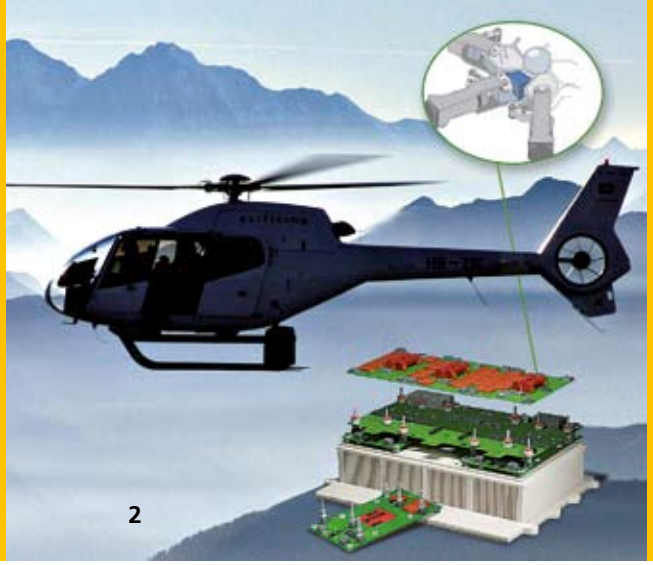

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RESEARCH HIGHLIGHTS

Microelectronic systems and microsystems

We realized first applications using bistable display technologies and verified them successfully. This opens up new possibilities in hardware/software co-design for minimizing energy consumption in self-sufficient systems. In technology-oriented product design, we concentrated on increasing the multi-functionality and robustness of miniaturized multi-sensors. System-in-package (SiP) integration is becoming more and more important, but automation tools for designing 3D-SiP are still lacking. Component placement remains a time-consuming task for such systems. In cooperation with Fraunhofer ITWM, we successfully developed a placement tool based on a multi-criteria optimization engine.

RF and high-speed systems

Our department has developed new methods for the electrical modeling of packaging structures to optimize electromagnetic reliability. An adapted filament model was applied to accurately model transmission lines with significant surface roughness and non-rectangular cross-sections.

New TSV configurations, based on the coaxial transmission line configuration, were designed to overcome the limitations of conventional TSVs due to the lossy nature of silicon. We also designed new techniques to reduce parasitic interaction with other integrated components, based on the results of our preliminary investigation into electromagnetic field distribution in the immediate vicinity of antennas.

Power electronic systems

The department has again been very active in power electronics. New fields of activities requiring highly sophisticated power electronic systems were discovered: the development of an inverter for actuators in avionics with highest redundancy was one of them. Our broad know-how in electromagnetic compatibility in power electronics was successfully employed in several electric vehicle projects.

Work also continued on piezoelectric energy conversion and harvesting, which includes high-voltage generators for electro-rheological applications in sports, industry and car dampers, as well as off-line power supplies for LED lighting and mobile phone chargers. We also established techniques for the ASIC design of power control ICs with a universal driving IC for resonant converters.

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1 *PARIFLEX – Passive RFID-label with bistable display*

2 *Power control unit for electrical blade pitch control of a helicopter*

EVENTS

EVENTS & WORKSHOPS

Packaging Day 2010

A German proverb says, »When the winds of change blow, some build walls while others build windmills«. Fraunhofer IZM said farewell to one of the great »windmill builders« in microelectronics and microsystem technology, Professor Herbert Reichl at Packaging Day on July 6th, 2010.

Over the years since its foundation, Prof. Herbert Reichl developed the institute into a leading center for electronic packaging. Without him, cutting-edge, internationally recognized technologies in the assembly and reliability of electronic systems would not have been possible. Together with almost 300 guests and associates of Prof. Reichl, we reviewed research highlights from his time in Berlin and Munich, highlighting those that have already found their way into industrial application. In the afternoon, the visitors learnt more about the direction Fraunhofer IZM is heading in – the key assembly and packaging areas of tomorrow, system integration for more functionality and better adaptation to applications.

As part of the farewell celebration, high-profile representatives from research, politics and industry thanked Prof. Reichl for his impressive contribution to both research and research-related infrastructure and organizational development during his professorship in packaging at the TU Berlin and as Director of Fraunhofer IZM. Fraunhofer President Prof. Hans-Jörg Bullinger spoke of a «truly historical moment for the Fraunhofer-Gesellschaft.« In recognition of his services, Prof. Reichl was presented the Fraunhofer IZM Research Award, the TU Berlin's Golden Honorary Pin and the Microelectronics Award from the Fraunhofer Association of the same name.

ESTC 2010 - a resounding success!

From September 13 – 16 the third Electronics System Integration Technology Conference took place at the Maritim pro arte Hotel in Berlin. With 160 presentations, 4 poster sessions, a 3-day industry exhibition, workshops and short courses, ESTC 2010 was truly an immersive experience for the 500 conference delegates participating.

The conference was organized by IEEE-CPMT, IMAPS Germany and Fraunhofer IZM. The organizers were particularly pleased that the conference participants, representing 34 different countries, came from industry and academia in equal part. »Based on the networking I observed on the conference floor and at the social events, it seems everyone went home with new contacts, insights and inspiration« says CPMT president and conference chair Rolf Aschenbrenner.

Besides the extensive conference program the event also boasted several workshop covering a variety of topics on the day preceding the conference. Particularly popular was a workshop on 3D Wafer Level Packaging, which showed that 3D packaging is a big topic in the research labs of all big players in the industry. Many conference delegates took the time to explore the concurrent exhibition, where 30 exhibitors from all over the world presented their technological services and new products.

Among the many highlights of the conference the gala dinner at Meilenwerk stood out, with car fans and aesthetes alike marveling at classic cars from bygone eras.

1 *The place to be – ESTC 2010 in Berlin*

2 *The Saxonian State Minister for Science and the Arts, Prof. Sabine Freifrau von Schorlemer, at the official opering of Fraunhofer IZM-ASSID in Dresden*

»The feedback from visitors and exhibitors from Germany and abroad has been overwhelmingly positive«, comments conference chair Rolf Aschenbrenner, »not only with regard to the quality of the presentations and the overall organization, but also because of the pleasant and relaxed atmosphere of the conference«.

Official opening of Fraunhofer IZM-ASSID in Dresden

On Monday, May 31st 2010, Fraunhofer IZM – ASSID All Silicon System Integration Dresden opened. Around 200 guests from throughout Germany came to Dresden-Moritzburg to celebrate the opening of the new center with high-profile guests from politics and industry. Fraunhofer IZM-ASSID's engineers develop technologies and materials for systems that incorporate several electronic components in miniaturized housing. Using wafer level system-in-packages (WL-SiP), the performance of microelectronic systems will be increased by stacking components in several layers and electrically connecting them, rather than simply assigning them all to one level.

The resulting small, complex systems are required wherever fast signal processing is a priority, for example, in image processing and analysis in medical devices or security. Other applications include controls in mechanical engineering, robot systems, as well as for energy-efficient vehicle control systems in electric cars. »Our goal is developing customized solutions for a wide variety of customers in industry and research,« explains Prof. Klaus-Dieter Lang, Director of Fraunhofer IZM. The German Ministry of Education and Research (BMBF), the EU and the Free State of Saxony are funding the establishment of the new center, including the equipment and infrastructure. The BMBF is funding the first R&D project to the tune of €13 million.

Workshop in Munich on energy-autarkic sensor networks

From monitoring containers in global logistics networks or measuring fine dust over large areas in congested urban centers – energy-autarkic sensor networks make countless applications more efficient and save resources. Approximately 50 participants from industry and research took part in Fraunhofer Gesellschaft's »Energy-autarkic Sensor Networks« workshop in Munich on November 16th 2010, where the entire range of these tiny, multifunctional all-rounders was presented. In his introductory presentation, IZM Director Professor Klaus-Dieter Lang outlined the current state of research and presented first application examples.

The subsequent dual parallel sessions dug deeper into the topic – how can we improve communication protocols even more? What requirements do sensors actually have to meet, for example, in structural monitoring? How can we optimize network architecture and integrate it into existing infrastructure? These and many more questions were discussed by the participants and lecturing experts.

In a session on sensor node packaging, IZM researchers also presented current projects to use sensor networks for machine and power network monitoring. A get-together at the end of the day gave participants and speakers a chance to discuss the day's topics in a more informal setting.

TSB Technologiestiftung holds event at Fraunhofer IZM
Around 50 Berlin entrepreneurs visited Fraunhofer IZM in Wedding on March 8th 2010 at the invitation of the TSB Technologiestiftung Berlin (Eng. TSB Technology Foundation Berlin). The event was held to offer local companies an introduction to the institute's laboratory infrastructure and services.

After an introductory presentation by Dr. Stephan Guttowski, the participants were then treated to a tour of two of the institute's new laboratories. The Electronics Condition Monitoring Laboratory, set up in 2009, allows IZM researchers to model and analyze combined loading, including temperature (cycling), moisture and vibration. Christine Kallmayer's presentation of the new textiles laboratory also drew a lot of interest. The lab bundles the institute's skills and infrastructure for the integration of electronics in textiles.

Overall, both participants and the organizers judged the event as a success. According to Stephan Guttowski »The interest in IZM services was really high and we were surprised at how many ideas came up in the discussion for new applications in mobile sensor technology.«

Mobile sensor technology – 80 participants attend the TSB Elevator Pitch Technology Day at Fraunhofer IZM
Together with TSB Technologiestiftung's Science and Technology Transfer project, Fraunhofer IZM held a technology day with accompanying exhibition entitled »Mobile Sensor Technology« on March 18th 2010.

The event at Fraunhofer IZM afforded soft- and hardware users and manufacturers from all industry branches an overview of the fascinating possibilities of modern mobile sensor technology. After an introduction by Fraunhofer IZM's Dr. Stephan Guttowski, the participating companies and research institutes gave the 80 attendants their »pitches«, short summaries of their technological services or research. Feedback for the event was so good that Fraunhofer IZM and TSB Technologiestiftung are now considering a series of similar events on more specialized topics.

Workshops at the European Center for Power Electronics
Fraunhofer IZM has helped prepare and run the ECPE cluster workshops on EMC in power electronics a number of times. In 2010, two workshops were held, a spring workshop in Erlangen and a fall event in Zurich. EMC in hybrid and electric cars was a particular focus, as the automotive industry is currently putting the most resources into EMC research in power electronics.

Seminar on autarkic wireless sensors
Fraunhofer IZM, TU Berlin and the AMA Fachverband Sensorik again organized two seminars on the essentials of autarkic wireless sensors in Berlin this year. The main focus of the seminar was on the technology-oriented design of autarkic wireless sensors, other topics were energy harvesting and low-energy radio communication. The hands-on approach of the energy harvesting seminar lecture met with particular interest from all the participants.

Due to the overwhelmingly positive response, the event will be held again in May and November 2011, this time with an additional session on Sofware and Software Protocol.

Take one: Futuristic research for a film project
Thanks to reliable public funding, cutting-edge research equipment and facilities are a cornerstone of successful research at Fraunhofer IZM.

While for Fraunhofer employees the laboratories are routine, visitors are sometimes awed by all the bells and whistles. Reason enough for the student association »filmArche« to exploit the institute's otherworldly charms as a set for a science fiction movie. In February 2010 Fraunhofer IZM's Electronics Condition Monitoring Laboratory made its debut in the short film »Kallocain«. The film is about the development of a truth serum as a tool for self-discovery. Dry ice and colorful chemicals were used to maximum effect, and the labs were transformed into a setting that IZM scientists barely recognized. Movie fans and lab buffs alike are advised to keep an eye out for the movie's upcoming release.

1 *Workshop energy-autarkic sensor networks in Munich*

2 *Filming at Fraunhofer IZM*

Events with Fraunhofer IZM participation 2010 (Selection)	
JEMA/JEITA Industry Workshop on EuP Lot 26 Networked Standby	March 2010, Tokyo, Japan
Erster Mikroelektroniktag des Fraunhofer-Verbunds Mikroelektronik	April 2010, Berlin
Abschlussseminar der InnoProfile Nachwuchsforschergruppe TeSiMat	May 2010, Berlin
5th European Conference »Safety and Security Systems in Europe«	June 2010, Postdam
Workshop: 3D Wafer Level Packaging	September 2010, Berlin
Elektronik Ecodesign Congress	October 2010, München
Workshop »Electronics for Medical Products«	November 2010, Düsseldorf

FRAUNHOFER IZM AT EXHIBITIONS

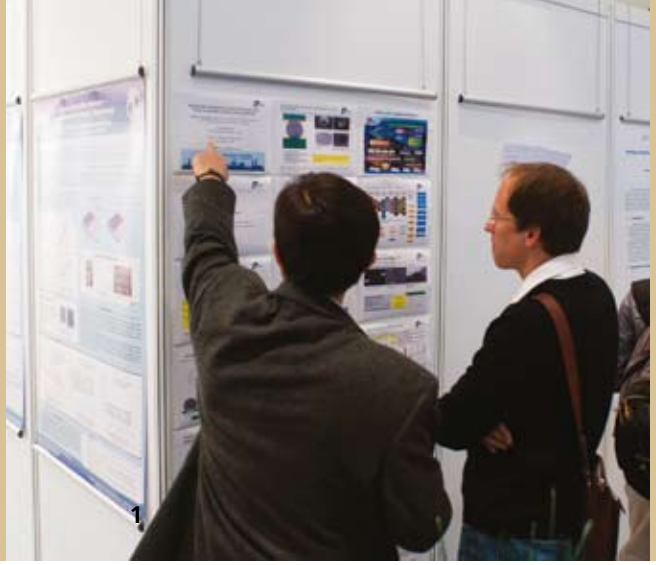
With a total of nine events in Germany and abroad, 2010 turned out to be a busy year for Fraunhofer IZM exhibition-wise, leading IZM colleagues from Berlin via Nürnberg and Como all the way to Las Vegas.

For the fifth time running Fraunhofer IZM exhibited at the Laser Optics Berlin in March 2010. Under the heading of Photonic Packaging optical and optoelectrical packaging and interconnection technologies were presented. The proverbial »highlight« at the booth was a historical gas lantern in which the gas mantles have been replaced by HiTec-LED-mantles. The lantern was presented by courtesy of BRAUN Düsseldorf GmbH and it impressively demonstrated how the use of efficient LEDs not only significantly reduces the cost for operation and maintenance, but also reproduces the color rendering of the original gas lantern.

Springtime saw the IZM colleagues travel to Nürnberg three times – the city played host to the PCIM power electronics fair, the Sensor + Test measurement fair and, finally, the SMT/HYBRID/PACKAGING Conference and Exhibition. Fraunhofer IZM's booth at this latter event was all about the institute's new prototyping and process line that was set up in Berlin earlier this year. Using the new equipment, substrates with a maximum size of 610 mm x 456 mm can be continuously processed. The first substrates with ultra fine line structures processed with the new manufacturing line were presented at our booth in Nürnberg.

Another crowd puller at the SMT were electrically functional demonstrators made using a recently developed optical interconnection technology. Polymer fibers bonded to SMD-LED components were used for a communication scenario from the realm of data transmission, where the fibers are bonded onto optical transmitter components.

Also in June the biggest conference in electronic packaging, the Electronic Components and Technology Conference ECTC took place in Las Vegas. Like every year, IZM scientists contributed their know-how to the conference and the institute presented its current activities at the concurrent exhibition. A lot of our US-American partners and customers took this opportunity to get an update on recent developments in packaging and assembly technologies. Particularly the work carried out by IZM scientists in cooperation with Bundesdruckerei GmbH on ultrathin chips met with a lot of interest.



1 *Visitors at the ESTC Conference and Exhibition in Berlin*

2 *SMT 2010 – »Future Packaging« production line*

The exhibition season closed in November with the Medica Fair in Düsseldorf. In a workshop titled »Electronics for Medical Products«, which was being held as part of the IVAM forum IZM researchers presented the main current trends in designing microsystems for medical technology that are smaller, more intelligent and, above all, more durable.

»Future Packaging« production line at SMT

For 13 years now the live manufacturing production line has been the biggest draw card of the Nürnberg SMT congress. In 2010, the joint booth »Future Packaging« Production Line was for the first time organized by Fraunhofer IZM's Smart System Integration Application Center. Titled »Medical electronics – technological and logistical challenges in component manufacturing«, 30 exhibitors from industry and research showed how modern component manufacturing can meet the requirements of medical technology.

Medical technology is an interesting market for electronic components, both technically and commercially. Innovation is a top priority in this area, with about a third of products having hit the market within the last three years. Live demonstrations on the production line gave visitors a taste of all that the modern circuit board has to offer this area of industry. For example, the embedding of components in a circuit board's intermediate layer has been drawing a lot of attention recently, as it provides for a higher degree of miniaturization, improved reliability and better high frequency characteristics. IZM scientists Christine Kallmayer and Erik Jung explained the manufacturing process and the equipment requirements to approximately 1200 visitors over the three-day event. Some lucky few even got to take home a customized circuit board fresh off the production line!

Fraunhofer IZM at Exhibitions 2010 (Selection)	
Embedded World 2010	March 2010, Nürnberg
Laser Optics Berlin	March 2010, Berlin
Smart System Integration	March 2010, Como, Italien
PCIM 2010	May 2010, Nürnberg
Sensor + Test	May 2010, Nürnberg
ECTC 2010	June 2010, Las Vegas, USA
SMT 2010	June 2010, Nürnberg
Semicon Europe	October 2010, Dresden
Medica 2010	November 2010, Düsseldorf

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.

Internships for students and voluntary ecological year
A high school student from the Max-Taut-Schule, a technically-oriented College, completed an internship at Fraunhofer IZM's EMC laboratory. In other departments, too, students took the opportunity to participate in hand-on work experience. Since September 2010 a high school graduate is currently completing a voluntary ecological year in the Environmental and Reliability Engineering department. Besides learning about sustainability aspects of electronics manufacturing the year is also designed to provide some guidance with regards to professional training and an exchange with scientists and students. This year's student has put her personal focus on the artistic aspect of electronics by making sculptures dealing with the subject.

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.

10. Girls' Day: Encouraging up-and-coming young researchers
The tenth annual Girls' Day enjoyed record participation, with more than 9,600 events throughout Germany. Fifth-graders and over had free rein to explore technical, life-science, manual and IT professions at more than 122,000 sites.

As in previous years, Fraunhofer IZM Berlin 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 in Berlin:

- Ants and mobiles – what gets electronics up and running? (introduction to microelectronics)
- What do ocean waves and antennas have in common? (introduction to RFID)
- A candle without flame – how to build an electronic circuit

1 *Girls' Day 2010 at Fraunhofer IZM*

2 *Junior researchers inspecting Fraunhofer IZM's flip chip line at the talent take-off*

Talent Take Off 2010 – young scientists visit Fraunhofer IZM

Last August 25 students from grades 10 to 13 participated in a life science and technical degree preparatory course in Berlin. Apart from technical workshops and laboratory experiments at other research institutes, the one-week course included a visit to several Fraunhofer IZM labs on 5th August.

In the microenergy laboratory, the teenagers learnt how hydrogen is produced, how electrolysis works and why a fuel cell car exploding is less dangerous than one with a petrol engine. The day was also exciting for all those who had decided on a career in microcomponent assembly. Using a Fineplacer, the students placed tiny capacitors on circuit boards, mounted chips using special glues and got a feeling for what industrial assembly machines can accomplish in just a few hundredths of a second. At the end of a long day and lots of interesting questions, the students were unanimous in their feedback to the institute: »Thanks for the inspiring visit; we'd love to come again.«

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 2010, 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 third 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.

Job application training

How do I write a proper job application? Fraunhofer IZM has a long-standing tradition of providing job application training to high school graduates. This year twenty 10th formers from the Carl-Friedrich-von-Siemens-Gymnasium benefitted from a one-day course that was rounded off by a guided tour of the IZM laboratories.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FACTS & FIGURES

FRAUNHOFER IZM IN FACTS AND FIGURES

Since July 1st 2010 Fraunhofer IZM's Munich branch is a standalone institute – the Fraunhofer Institution for Modular Solid State Technology (EMFT). Thus, the performance overview below only covers the Berlin and Dresden/Moritzburg IZM branches.

Financial situation *

Fraunhofer IZM's balance sheet in the economic year 2010 was very healthy. The considerable shortfall in industry returns in 2009, the year in which the economic crisis peaked, was recouped in 2010.

Overall, the institute's turnover increased by 25 percent in 2010 to €23.1 million. Returns from German and international industry and business associations had a growth rate of 51 percent, reaching a total of €7.5 million.

This excellent close to the year not only reflects the general economic recovery, but is also evidence of the Fraunhofer IZM team's efforts to transfer outstanding research and development results into products.

Thanks to reliable public funding, boosted in 2010 by federal and state economic stimulus packages, Fraunhofer IZM was able to tackle new areas of research. Public funding amounted to €13.8 million last year.

Equipment investment

Investment begun in 2009 into the infrastructure for the project group IZM-ASSID at the Dresden/Moritzburg site continued. In total, €49.9 million was released by the »European Funds for Regional Development (EFRE)«, the Land Saxony and the Federal Ministry of Education and Research (BMBF). Tools and equipment to the tune of €36.5 million were purchased, installed and put into operation in 2010.

Fraunhofer IZM-ASSID can now provide the following services:

- Cu TSV interposer technology
- Cu TSVs for active device integration
- Wafer level multilayer redistribution technology/CSP
- Wafer level bumping, assembly und stacking

A testing laboratory for highly reliable plastic-metal composites in mechatronics under extreme conditions was also established. The new lab is primarily based at Fraunhofer IZM's Oberpfaffenhofen site and was funded with €1.2 million by the Fraunhofer Gesellschaft's strategic funds with some supplementary financing from the institute's own funds.

Thanks to the new lab, Fraunhofer IZM can now provide the following additional services at the Oberpfaffenhofen site:

- Selective metallization of plastics by means of ink-jet printing
- Investigation of the fracture mechanics parameters of plastic-metal composites for temperatures between 20 °C and 170 °C
- Simulation of fiber-reinforced plastics in electronic assemblies (such as stresses, deformation, failure prediction)
- Variable pressure scanning electron microscopy for the analysis of sensitive micro-mechatronic components.

Institute funds of €1.6 million were used for ongoing maintenance and upgrades. One example was the institute's acquisition of a wafer molding system for €0.5 million.

Staff development

Thanks to the income growth in 2010, the institute was able to employ additional staff. The number of employees increased from 170 to 180 at the Fraunhofer IZM sites 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. Over the year the institute hosted 123 interns, Masters' students and student assistants.

Fraunhofer IZM also continued its commitment to providing apprenticeships. In 2010, two additional apprenticeships were created, bringing the total number of microtechnology technician and business administration trainees to ten.

* *Because the 2010 annual statements were due shortly after print deadline, the revenue figures listed for 2010 are only preliminary*

MANAGEMENT NEWS

Professor Klaus-Dieter Lang appointed Director of Fraunhofer IZM

Professor Klaus-Dieter has been officially appointed Director of the Fraunhofer Institute for Reliability and Microintegration IZM as of February 1, 2011. Prof. Lang, an internationally recognized expert in miniaturization technologies and system integration in microsystem technology, had already held the position as Acting Director since April 2010.

He is also Professor of Nano-Interconnect Technologies at the TU Berlin and will head the Forschungsschwerpunkt »Technologien der Mikroperipherik«. Professor Lang has taken on these duties following last year's retirement of Professor Herbert Reichl, who had led the institute and the Forschungsschwerpunkt from Fraunhofer IZM's establishment in 1993.

Fraunhofer IZM has gained one of the world's leading experts in electronic packaging with the appointment of Professor Lang. His stated aim is further boosting the institute's research focus on systems and applications. Increasing reliability, integrating sensors and actuators and miniaturization and adaptation to available build space will continue to be key priorities, however clear emphasis will be placed on the applications and the manufacture of industry-ready prototypes.

Lang sits on numerous scientific and research boards and commissions. He is Vice-Chair of the advisory board of the journal »PLUS«, and is scientific coordinator of the »SMT/HYBRID/PACKAGING« conference, held annually in Nuremberg.

Rolf Aschenbrenner is Fraunhofer IZM's new deputy head

The Fraunhofer-Gesellschaft's Executive Board has appointed IZM-scientist Rolf Aschenbrenner deputy head of Fraunhofer IZM. Together with Martin Schneider-Ramelow Aschenbrenner also heads the department System Integration and Interconnection Technologies at the institute.

As a member of the IEEE Components, Packaging and Manufacturing Technology (CPMT) Society Board of Governors Rolf Aschenbrenner has worked as a European representative on the Conference Advisory Board Committee, and has played an active role in the globalization of IEEE CPMT in terms of membership and chapter development. He is a Senior Member of IEEE and served as IEEE CPMT Vice President, Technical and IEEE CPMT Vice President, Conferences.

In 2010 he became IEEE CPMT President and in this capacity chaired the CPMT's 2010 Electronics System Integration Technology Conferences ESTC in Berlin. IEEE CPMT is the leading international forum for scientists and engineers engaged in the research of microsystems packaging and manufacture.

Rolf Aschenbrenner has authored and co-authored more than 80 articles for journals or proceedings in the area of electronic packaging and he holds numerous patents in the field of microelectronic packaging. In 2005 he received the »iNEMI International Recognition Award«.

From nanostructure to system reliability – Prof. Bernd Michel passes the torch to Dr. Olaf Wittler

His work prevented costly vehicle recalls and gave us mobiles that could withstand the occasional fall. Prof. Bernd Michel established reliability as a key area of electronic system packaging. As founding member of Fraunhofer IZM and Head of the Micro Material Center Berlin, he pushed forward the development of methods for determining the thermomechanical reliability of microcomponents, the analysis of micromechanical behavior and the development of new tools for micro- and nano-deformation analysis.

In November 2010 Bernd Michel returned to his roots in Chemnitz, where he will be contributing his many years of experience to establishing a new department at the recently founded Fraunhofer ENAS. Fraunhofer IZM thanks Prof. Michel for his input and enthusiasm over the years and wishes him all the best in his personal and professional life.

Prof. Michel has passed the torch to his long-term collaborator Dr. Olaf Wittler, who is an internationally recognized expert on the simulation and testing of electronics and microsystems. Although research into diverse topics, from nano-characterization through to simulation, evaluation and optimization on component and system level, will continue, the department will extend its areas of focus to condition monitoring, remaining lifetime prediction and sustainability. This broader scope, crucial for sophisticated products, has been made possible by the merging with the department »Environmental Engineering« into the new department »Environmental and Reliability Engineering«. Jointly headed by Dr. Nils F. Nissen and Dr. Olaf Wittler, the new department will help bring innovative, reliable, cost-efficient and environmentally friendly products onto the market and into industry more quickly thanks to its interdisciplinary expertise in reliability analysis and sustainability.

1 *Prof. Klaus-Dieter Lang*

2 *Rolf Aschenbrenner*

3 *Prof. Bernd Michel*

AWARDS

Prof. Herbert Reichl receives SEMI Europe Award 2010
Professor Herbert Reichl received the SEMI Europe Award in October 2010 for his extraordinary contribution to the field of semiconductor and microsystem packaging. The award was presented to Professor Reichl by SEMI President Stan Myers and SEMI Europe President Heinz Kundert at the SEMICON Europa Conference and Exhibition in Dresden. In his tribute speech, the chair of the Semiconductor Technology Program Committee, Mart Graef, singled out Herbert Reichl's pioneering research in the development of integration technologies (hetero integration), which laid the foundation for current trends such as vertical system integration. Many of the technologies and processes developed or advanced by Professor Reichl and his colleagues are widely used in the industry today, among them flip chip interconnection technology and electroless Nickel bumping.

Fraunhofer IZM and Berlin University of the Arts reach third place in textil + mode Innovation Award
Stephanie Hornig of the Berlin University of the Arts (UdK) and Fraunhofer IZM's Christian Dils and Manuel Seckel reached third place in the category »Technical Textiles« in this year's textil + mode Innovation Award. They were honored for the project Canvas, a textile light using LEDs. The design study Canvas was developed in 2010 at the UdK in collaboration with Spectral Lichttechnik and Fraunhofer IZM. The concept of a textile light using LEDs, which can be adopted to different shapes and spaces was designed as decorative lighting for the public inside and outside. Fraunhofer IZM supported this technology development and realization of large-area substrates based on SCB (stretchable circuit board) technology. Canvas is particularly suitable for large indoor spaces such as lobbies, stairwells and transition areas and could provide these places with a certain dynamism and lightness.

SSI Award 2010 goes to Prof. Herbert Reichl
For his extraordinary contribution to the development of integration technologies for intelligent systems Professor Herbert Reichl received the first Smart Systems Integration Award on 23rd March 2010. The award was presented to Professor Reichl by the program committee of the Smart Systems Integration Conference and EPoSS, the European Platform for Smart Systems Integration as part of the SSI Conference 2010 in Como, Italy. In his tribute speech, Prof. Gessner, Head of Fraunhofer ENAS and Chairman of the SSI Conference, singled out Prof. Reichl's pioneering research in the development of microsystems and strategy development for intelligent system integration.

Jens Göhre honoured with ECPE Young Engineer Award
Fraunhofer IZM's Jens Göhre was named as recipient of the ECPE Young Engineer Award at the CIPS 2010 (International Conference on Integrated Power Electronic Systems) in Nürnberg. Martin Schneider-Ramelow, Ute Geißler and Klaus-Dieter Lang were co-authors of his paper, entitled »Interface Degradation of Al Heavy Wire Bonds on Power Semiconductors during Active Power Cycling Measured by the Shear Test«. The study presented in the paper investigated the influence of temperature ranges and levels on the lifetime of Al heavy-wire bonds on power semiconductors. Using a sophisticated experimental assembly, the authors decoupled the heavy-wire degradation from the effects of other degradation mechanisms that typically occur in temperature cycles in a power module, such as temperature increases resulting from solder fatigue.

Best Paper Award for Florian Ohnimus at the LAPC 2010

Florian Ohnimus of Fraunhofer IZM was awarded the LAPC 2010 Best Paper Award for his paper »Design and Characterization of a Small Encapsulated UHF RFID Tag for Wood Log Monitoring«. The 6th Loughborough Antennas & Propagation Conference took place on November 8–9 in Loughborough and is the most prestigious antennas conference in the UK. The paper presents research results from the project »Intelligent Wood – RFID in Wood Log Monitoring«. In the framework of this project, Ohnimus and his colleagues are responsible for the development of new UHF TFID tags.

ECTC Best Paper Award for Fraunhofer IZM researcher Michael Töpper

Fraunhofer IZM's Michael Töpper received a Best Paper Award at the 2010 Electronic Components and Technology Conference (ECTC) for his paper »Novel multi-layer wiring buildup using electrochemical pattern replication (ECPR)«. Together with his co-authors Mikael Fredenberg and Patrik Möller from Replisaurus Technologies (Sweden), Töpper has been working on new ideas for nanoscale electrodeposition of metal patterns for the past five years. Using ECPR, the accuracy of metallization for microelectronic applications can be increased at the same time as the cost can be significantly reduced compared to using traditional lithography based processes. Dr. Michael Töpper heads a Fraunhofer IZM research group specializing in wafer-level processes.

Outstanding Paper Award for Bernhard Wunderle at Itherm 2010

Bernhard Wunderle received the Outstanding Paper Award in the category «Thermal» at this year's Itherm conference. Wunderle and his co-authors received the award for their paper »Advances in Thermal Interface Technology: Mono-Metal Interconnect Formation, Process and Characterization«. At the occasion of the award ceremony Wunderle commented that awards such as these show »just how important cooperation between technology, characterization and simulation is for developing innovative solutions for thermal management« and called for more efforts in this area. The prizewinning paper was produced as part of the EU project »Nanopack« (http://www.nanopack.org).

IMAPS Best Paper of Session Award for Ivan Ndip

Fraunhofer IZM's Ivan Ndip seems to have a subscription for awards at the US-American IMAPS Conference – following 2003, 2007 and 2009 he and his co-authors received the Best Paper of Session Award for the 4th time at this year's conference. This year Ndip and his IZM-colleagues Christian Tschoban, Stefan Schmitz, Andreas Ostmann, Martin Schneider-Ramelow, Stephan Guttowski, Herbert Reichl and Klaus-Dieter Lang were honoured for their paper »Modeling and Optimization of Bond Wires as Transmission Lines and Integrated Antennas at RF/Microwave Frequencies«. In the project described here wire bonds are modelled as 3D antennas and systematically optimized for RF-applications of up 60 GHz.

1 *Prof. Reichl (2nd from left) together with SEMI Europe's President Heinz Kundert (left), SEMI President Stan Myers (2nd from right) and the chair of the Semiconductor Technology Program Committee Mart Graef (right)*

DISSERTATIONS, BEST PAPER AWARDS

Best Paper Awards

Göhre, J.; Schneider-Ramelow, M.; Geißler, U.; Lang, K.-D.
Interface Degradation of Al Heavy Wire Bonds on Power Semiconductors during Active Power Cycling Measured by the Shear Test
ECPE Young Engineer Award, International Conference on Integrated Power Electronics Systems, CIPS 2010, Nürnberg

Kallmayer, Ch.; Aschenbrenner, R.; Haberland, J.; Reichl, H.
New Packaging and Interconnect Technologies for Ultrathin Chips
Best Paper Award, Pan Pacific Microelectronics Symposium 2010, Kauai, Hawaii, USA

Ndip, I.; Tschoban, Ch.; Schmitz, S.; Ostmann, A.; Schneider-Ramelow, M.; Guttowski, S.; Reichl, H.; Lang, K.-D.
Modeling and Optimization of Bond Wires as Transmission Lines and Integrated Antennas at RF/Microwave Frequencies
Best Paper of Session Award, IMAPS International Symposium on Microelectronics 2010, USA

Ohnimus, F.; Haberland, J.; Tschoban, Ch.; Ndip, I.; Heumann, K.; Kallmayer, Ch.; Guttowski, S.; Lang, K.-D.
Design and Characterization of a Small Encapsulated UHF RFID Tag for Wood Log Monitoring
Best Paper Award, 6. Loughborough Antennas & Propagation Conference 2010, Loughborough, UK

Töpper, M.; Fredenberg, M.; Möller, P. (Replisaurus Technologies)
Novel multi-layer wiring buildup using electrochemical pattern replication (ECPR)
Best Paper Award, Electronic Components and Technology Conference ESTC 2010, Las Vegas, NV, USA

Wunderle, B.; Klein, M.; Dietrich, L.; Abo Ras, M.; Mrossko, R.; May, D.; Schacht, R.; Oppermann, H.; Michel, B.; Reichl, H.
Advances in Thermal Interface Technology: Mono-Metal Interconnect Formation, Process and Characterization
Outstanding Paper Award, ITherm 2010, Las Vegas, NV, USA

Dissertations

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Entwicklung und Aufbau einer Monitorstruktur für Lotkontakte bei kombinierter Belastung

Klein, M.
Beschreibung der Modellbildung des Thermokompressions-Bondvorganges an galvanisch abgeschiedenen Strukturen

Niedermayer, M.
Methoden zur Kostenoptimierung von Sensornetzwerken

LECTURES, EDITORIALS

Lectures

Technical University Berlin

Dr. Robert Hahn
- Miniaturized Energy Supply Systems

Prof. Klaus-Dieter Lang
- Technologies for Multi-functional Systems
- Hetero System Integration Technologies

Dr. Ivan Ndip
- Numerical Techniques in Electromagnetics

Dr. Ivan Ndip, Bouchaib Bouhlal
- Electromagnetic Reliability of Microsystems

Dr. Nils F. Nissen
- Design of Environmentally Compatible Products

Dr. M. Schneider-Ramelow
- Materials of System Integration

Dr. M. Töpper
- Physical/Chemical Foundations of MST

Brandenburg University of Technology Cottbus

Dr. Otmar Deubzer
Visiting Professor, Chair for Industrial Environmental Protection
- Corporate Environmental Protection
- Material Management

HTW Berlin, University of Applied Sciences

Dr. Nils F. Nissen
- Environmental Engineering

Editorials

PLUS Journal (Eugen G. Leuze Verlag)
K.-D. Lang (Vice Chairman of the Editorial Board)

Smart Systems Integration and Reliability, Honorary Volume for the 65th Birthday of Herbert Reichl
B. Michel, K.-D. Lang (Editors)

Congress Proceedings SMT/HYBRID/PACKAGING 2010
K.-D. Lang (Editor)

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Vishay Beyschlag GmbH	Heide
Volkswagen	Wolfsburg
WABCO	Hannover
Wehrle/Magna	Waldshut-Tiengen
WRS Materials	San Jose (USA)
Würth Electronic	Niedernhall, Rot am See
Xyratex	Auerbach
Zarlink	Ottawa (CA)
ZF Friedrichshafen AG	Friedrichshafen

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