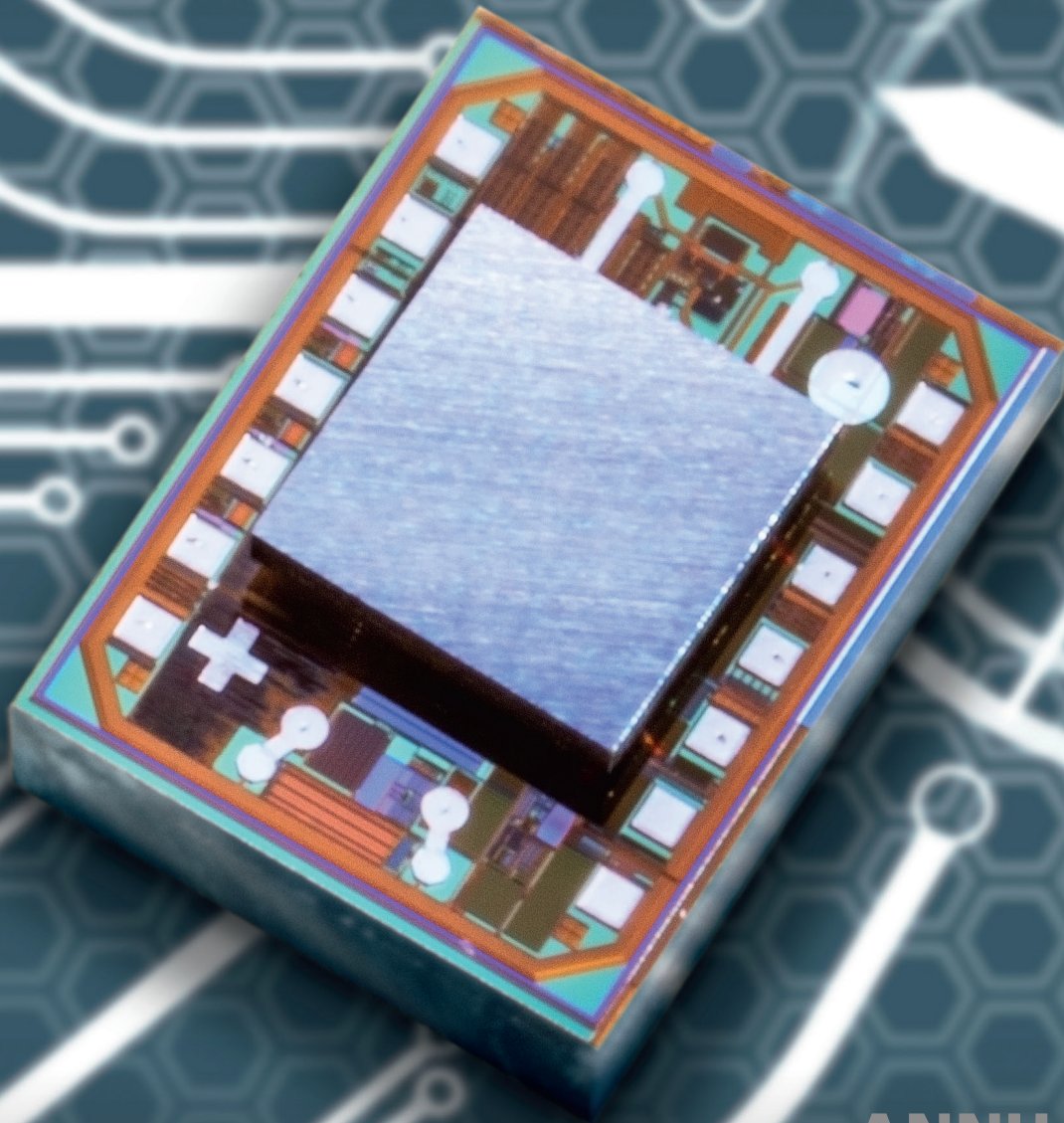




Fraunhofer

IZM

FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM



ANNUAL REPORT

15/16

ANNUAL REPORT
15/16

CONTENT

Preface	Page 4
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FRAUNHOFER IZM

Fraunhofer – A Strong Network	Page 8
Fraunhofer IZM – From Wafer to System	Page 9
How to Make the Most of Fraunhofer IZM	Page 10
Cooperation with Universities	Page 12
International Research Cooperations	Page 14

BUSINESS UNITS & COOPERATION

Fraunhofer IZM Business Units	Page 18
Fraunhofer IZM Labs & Services	Page 30
Innovation Center AdaptSys	Page 32

RESEARCH CLUSTER INTEGRATION ON SUBSTRATE LEVEL

Highlight 2015: W-Band Project – Radar packaging for 94 GHz	Page 36
System Integration & Interconnection Technologies	Page 38
Micromechatronics & PCB Technology	Page 42

RESEARCH CLUSTER INTEGRATION ON WAFER LEVEL

Highlight 2015: Intelligent light sources for adaptive headlight systems	Page 44
Wafer Level System Integration – All Silicon System Integration Dresden ASSID	Page 46

RESEARCH CLUSTER MATERIALS & RELIABILITY

Highlight 2015: Assembly and reliability assurance for temperatures up to 300°C	Page 50
Environmental & Reliability Engineering	Page 52

RESEARCH CLUSTER SYSTEM DESIGN

Highlight 2015: Wireless Power Systems	Page 54
RF & Smart Sensor Systems	Page 56

EVENTS

Events & Workshops	Page 60
Workshops 2016	Page 66
Promoting Young Talents	Page 68

FACTS & FIGURES

Fraunhofer IZM in Facts and Figures	Page 72
Awards	Page 74
Best Papers, Editorials	Page 76
Lectures	Page 77
Memberships	Page 78
Cooperation with Industry	Page 80
Publications	Page 82
Patents and Inventions	Page 88
Advisory Board	Page 89
Contacts	Page 90
Imprint	Page 93

PREFACE



DEAR FRIENDS AND PARTNERS OF FRAUNHOFER IZM!

What does it take to build the world's tiniest solar inverter? What might a technology that uses light to send data securely and to many different application levels look like? Can we reduce critical raw materials in products like LED systems even further? These are just some of the complex questions our scientists tackled in 2015 - with resounding success. Take, for example, the highly miniaturized solar inverter developed by Fraunhofer IZM and colleagues, which has been selected for the final round of Google's international design competition »Little Box Challenge«. We also fostered new initiatives in photonics, sustainability and recycling with collaborative projects like »PhoxTroT« and »cycLED«.

Not ones to rest on our laurels, we pushed the envelope in other technology areas too, particularly in system integration. A key milestone and foundation for our future work was the launch of the new Center for Adaptive System Integration (AdaptSys) in September. The center has allowed us to significantly expand and diversify our technology portfolio and services. We can now boast a new level of flexibility and cutting-edge process technologies for the design and development of wafer- and panel-level systems.

What does this mean for business and industry? It means that Fraunhofer IZM is now able to tackle system integration throughout the entire supply chain. We can process large sizes and thus also qualify cost-efficient manufacturing of small lot sizes; we can also shepherd the design and develop of a new product from earliest concept development right through to small series production stage. Particularly SMEs stand to benefit from Fraunhofer IZM's one-stop product development service.

A further highlight in 2015 and boon for the international research and industry community was the Dresden Fraunhofer IZM-ASSID Center's extremely successful maturation within the Fraunhofer Model. ASSID has developed into a leading research center for wafer-level packaging and 300 mm-Si 3D integration. In April, the center was also awarded ISO 9001 certification, passing the evaluation of its quality management systems with flying colors.

Helping the private sector make use of technology advances is a cornerstone of Fraunhofer IZM's work and, as in previous years, we cooperated intensively with industry in 2015. Our new Business Development Team is one important component in building efficient working relationships with our partners in research and industry.

Cooperation partners are teamed up with experienced Fraunhofer IZM scientists, who have keen noses for the latest technology trends and the needs of industry. They keep communication between all development stakeholders flowing, develop advanced business models and support the strategic direction of the institute.

Long-term excellence in research and development also requires training and mentoring up-and-coming researchers. Fraunhofer IZM allocates substantial resources and time to ensuring a new generation of scientists with the skills and know-how to build on today's research is on-hand. One new initiative in this area is a joint research group with the Berlin University of Applied Sciences (HTW), currently being organized as part of a Fraunhofer-Gesellschaft program. The group will focus on developing high-performance microsensors, including innovative high-temperature and gas sensors and smart sensor systems based on a variety of semiconductor materials.

To sum the year up: It was a taxing, but productive, 12 months, in which the institute advanced considerably. Taking the institute to this new level was a team effort. In light of

this, I have to thank all our staff for the creative energy and exceptional dedication they showed, even at times when the demands placed on them were great.

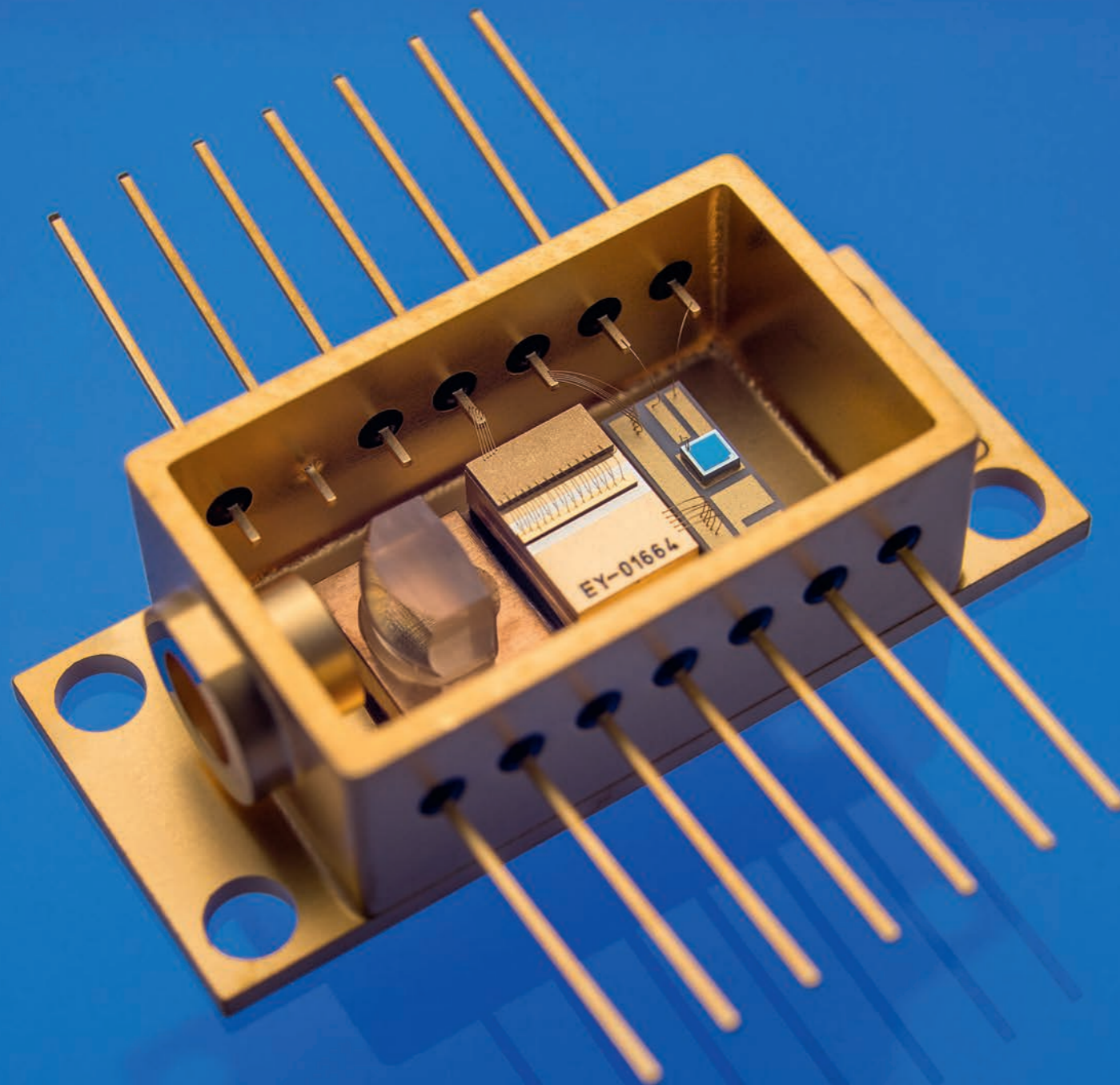
I'd also like to thank my colleagues at TU Berlin and our partners from industry and science for another year of productive cooperation – we hope to maintain last year's outstanding level of drive and commitment in our collaborations throughout 2016. Thanks also go to our project management bodies and the federal and Länder ministries for the trust they continue to place in us. We are committed to research programs that contribute to tomorrow and, in the case of the Länder, to the successful development of the service centers we jointly manage.

Fraunhofer IZM's annual reports keep you abreast of our latest research and development. But if one or another of the featured technology breakthroughs or research results also sparks a brainwave, be sure to get in touch with us, because we specialize in helping business and industry turn bright ideas into great new products.

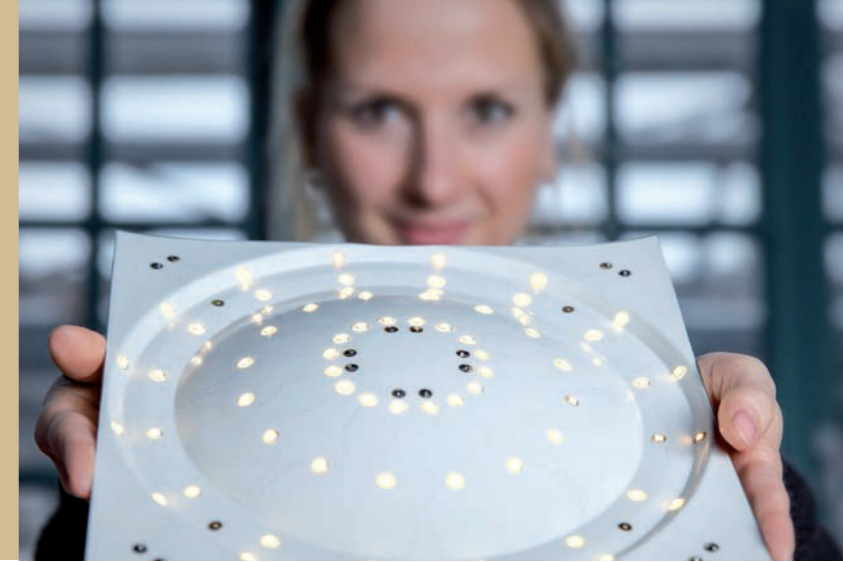
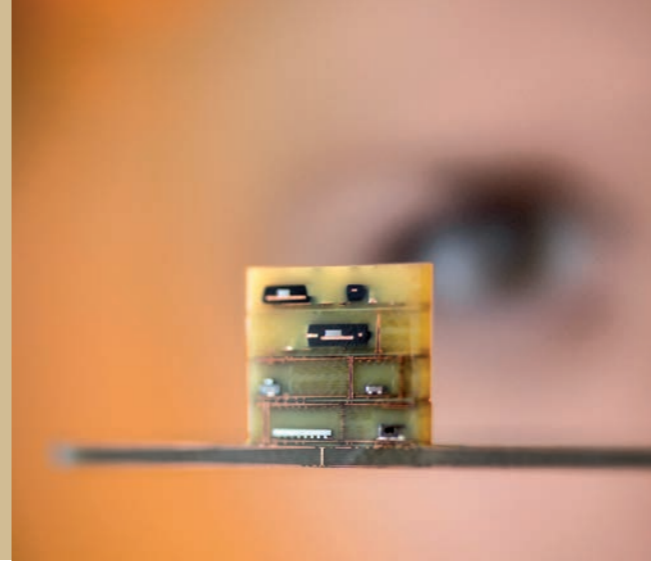
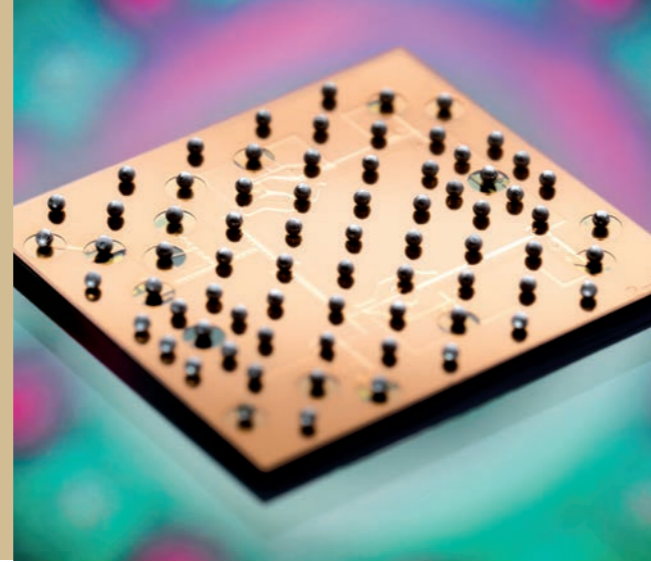
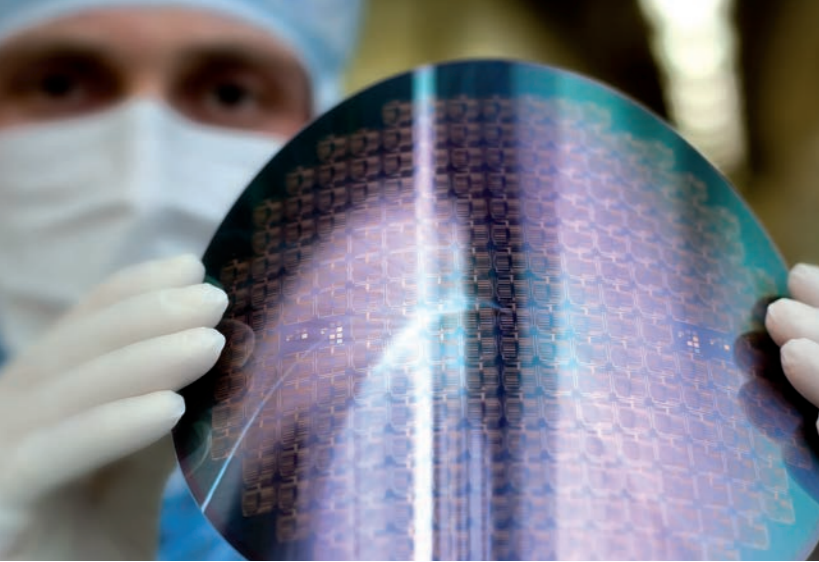
Yours sincerely,

Prof. Klaus-Dieter Lang

FRAUNHOFER IZM



Fraunhofer – A Strong Network	Page 08
Fraunhofer IZM – From Wafer to System	Page 09
How to Make the Most of Fraunhofer IZM	Page 10
Cooperation with Universities	Page 12
International Research Cooperations	Page 14



FRAUNHOFER – A STRONG NETWORK

The Fraunhofer-Gesellschaft

Fraunhofer IZM is one of 67 Fraunhofer Institutes conducting applied research predominantly in the realm of science and engineering, because research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

The majority of the almost 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.1 billion euros. Of this sum, 1.8 billion euros 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.

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

Fraunhofer Group Microelectronics

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

The Fraunhofer Group Microelectronics V μ E has been coordinating the activities of Fraunhofer Institutes working in the fields of microelectronics and microintegration since 1996. Its membership consists of eleven institutes as full members and five as associated members, with a total workforce of more than 3,000 and a combined budget of roughly 345 million euros. The purpose of the Fraunhofer V μ E is to scout for new trends in microelectronics technologies and applications and to integrate them in the strategic planning of the member institutes.

The group pools the core competences of its member institutes in the following cross-sectional fields of competence: design for smart systems, semiconductor-based technologies, system integration technologies, power electronics and energy supply, sensors and RF and communication technologies. The application-orientated business areas are:

- Ambient Assisted Living, Health & Well-being
- Energy Efficient Systems
- Mobility & Urbanization
- Smart Living

www.mikroelektronik.fraunhofer.de/en

FRAUNHOFER IZM – FROM WAFER TO SYSTEM

Fraunhofer IZM specializes in applied research that meets the needs of industry. Our four technology clusters

- Integration on Wafer Level
- Integration on Substrate Level
- Materials & Reliability
- System Design

cover all aspects of developing and integrating reliable electronics. The technologies and product solutions we develop are easily transferred to industrial processes. Moreover, the institute's equipment and infrastructure, to which all our customers have equal access, have been specifically assembled to approximate real-life industry conditions as closely as possible. We even introduce technologies on-site if requested. Our customer portfolio is as varied as the countless application areas for electronics. Although Fraunhofer IZM works with leading semiconductor firms and material, machine and equipment suppliers, we are equally focused on providing the next generation of electronics and microsystems for the automotive, medical engineering, safety & security sectors and even the lighting and textile industries.

As of 2015, our customers have a business development team of four competent managers at their disposal. They pool the resources from different departments, which ensures that the full breadth of applicable technologies is always available. The accumulated know-how is then fed into collaborations that help companies produce game-changing innovations. Fraunhofer IZM works closely with scientific institutes globally on basic research questions. In particular, we have maintained close ties with the Technische Universität Berlin since Fraunhofer IZM's founding. The relationship is reflected on an organizational level with the post of Fraunhofer IZM Director including appointment to a TU professorship.

The institute has a staff of over 350 and saw a turnover of 28.1 million euros in 2015, of which 76.6 percent was derived from contract research. It has three branches in Germany. Apart from its headquarters just north of Berlin Mitte, it also maintains sites in Dresden and Munich, both strategically important centers for electronics development and manufacturing.

Research Design & Concept Feasibility Technology Process Prototyping Reliability Evaluation Qualification & Test

HOW TO MAKE THE MOST OF FRAUNHOFER IZM

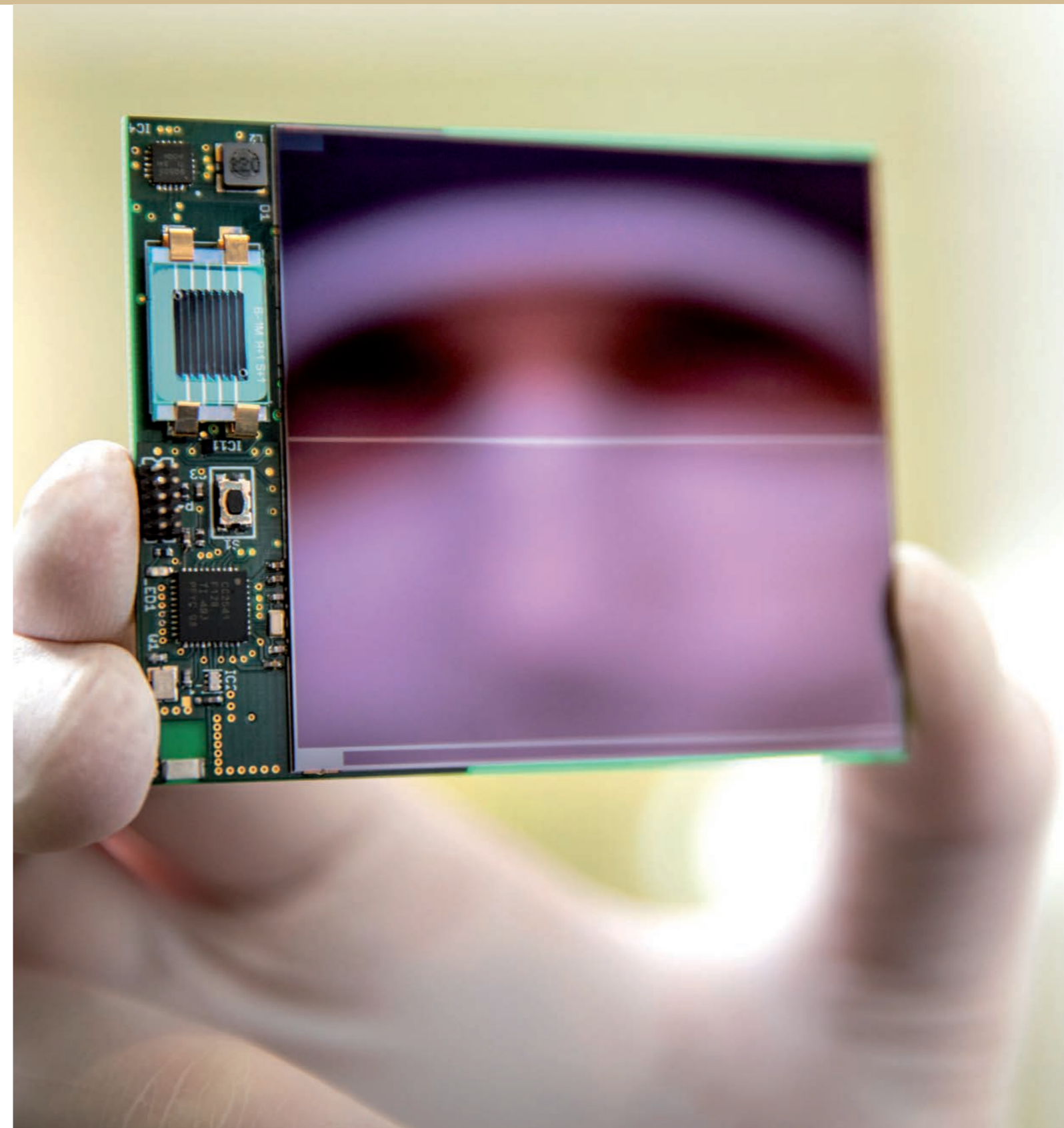
The success of our contract research model may well be due to our emphasis on treating our customers as partners and active participants in the research and development process. We can help you integrate electronics and microsystem technology into your products by developing innovative packaging and integration technology tailored to your requirements and caveats. Uncomplicated, direct access to our highly qualified, interdisciplinary research team and cutting-edge laboratory equipment ensure you get the right results.

Technology transfer in contract research

Our most common type of cooperation with industry is contract research for individual companies. For example, a Fraunhofer IZM customer might seek our help in launching a product innovation, improving a workflow, or qualifying and certifying a process. Together with the customer, we begin by broadly sketching out viable solutions and the possible parameters of cooperation with Fraunhofer IZM. We understand that transparency is paramount in any working relationship, so the associated expected expense and effort is addressed at the very beginning. Many a successful cooperation project has been kicked off with a preliminary and usually free-of-charge ideas workshop. Only once the main goal and the parameters of the cooperation are decided and the contracts have been concluded does Fraunhofer charge for its research and development. No surprise then that at Fraunhofer IZM the customer retains ownership of the contractually negotiated project's results, including the any patent and property rights or know-how developed by Fraunhofer IZM during the cooperation.

Pooling resources

We are also well-placed to help you achieve extremely ambitious goals. For example, large-scale development often requires pre-competitive research. In these cases, teaming up with companies and research institutes and public funding support is more effective than operating solo. Thanks to our wealth of experience and knowledge of the microelectronics industry in Germany and abroad, we can set you on the path to turning your wildest product development dream into a game-changing, commercially released innovation by helping you recruit like-minded partners from industry and research. Our institute specializes in helping industry conquer research and development challenges. The best starting point for working with the institute is contacting the Fraunhofer IZM Marketing division – we refer you to the right department, identify the scientists that can offer your project idea the most know-how and schedule technical discussions and workshops with our experts for you.





COOPERATION WITH UNIVERSITIES

To effectively realize its research targets Fraunhofer IZM has formed strategic networks with universities in Germany and abroad. The following pages provide an overview of our most important cooperation project. Close collaboration between Fraunhofer institutes and universities throughout Germany and internationally has always been a cornerstone of Fraunhofer's ongoing success. Universities bring their innovativeness and their expertise and know-how in basic research to the table, while Fraunhofer contributes excellence in applied research, outstanding technical infrastructure, continuity in human resources and long-standing experience in international projects.

Cooperation with Technische Universität Berlin

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

Since 2011, the traditional double appointment of Fraunhofer IZM Director and Head of the Forschungsschwerpunkt Technologien der Mikroperipherik has been held by Professor Klaus-Dieter Lang. Both institutions research and develop smart system integration with a joint goal, namely to integrate components that may have been manufactured using very different technologies on or in a single carrier substrate at high integration densities to increase flexibility and yield while reducing costs. In pursuit of these joint goals, the Forschungsschwerpunkt, in cooperation with Fraunhofer IZM, is focusing on basic research into assembly and interconnection technology for sensors, microelectronics and microsystem technology. Key areas of research include:

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

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

Fraunhofer IZM and the Berlin University of Applied Sciences (HTW) establish new research group on silicon microensors

The Berlin University of Applied Sciences (HTW) and Fraunhofer IZM are pooling their know-how and infrastructure to advance research into microensors. On July 1, 2015 HTW President Prof. Semlinger and Fraunhofer IZM Institute Director Prof. Lang agreed to establish a joint »Silicon Microensors« research group with an initial runtime of 3 years. The research group will be based at Fraunhofer IZM under the leadership of Prof. Ngo and will develop innovative, micromechanical high-temperature and gas sensors and silicon-based smart sensor systems.

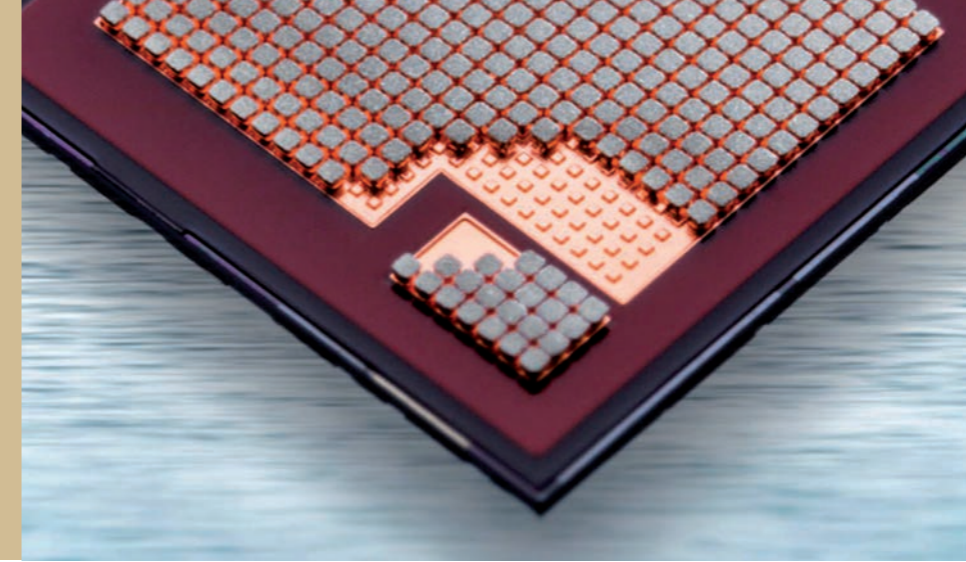
Goal of the cooperation is achieving products with concrete applications for contract clients from industry and business. HTW's students will be afforded a big role in the research group's industry-oriented research. The research results will lead to new, enticing solutions and products for the business sector, which will promote interaction with regional industry.

The Fraunhofer-Gesellschaft and the German Länder are funding Fraunhofer IZM's involvement in the cooperation, initially planned until 2018, to the tune of 1.2 million euros.

From left to right: Prof. Ha Duong Ngo (Fraunhofer IZM), Fraunhofer IZM Director Prof. Klaus-Dieter Lang, HTW President Prof. Klaus Semlinger, Fraunhofer IZM Department Head Oswin Ehrmann, and Prof. Matthias Knaut (HTW)

Some of Fraunhofer IZM's other university partners

Delft University of Technology, The Netherlands
Eindhoven University of Technology, The Netherlands
Imperial College, London, Great Britain
KU Leuven, Belgium
San Diego State University, USA
Tampere University of Technology, Finland
University of Bologna, Italy
University of Cadiz, Spain
University of Tokyo, Japan
Twente University, The Netherlands
University of Uppsala, Sweden
University of Vienna, Austria
University College London, Great Britain
Albert Ludwigs University Freiburg
Brandenburg University of Technology, Cottbus
Christian Albrechts University Kiel
Friedrich Alexander University Erlangen-Nürnberg
Humboldt University Berlin
Rheinische Friedrich Wilhelms University Bonn
Technical University Chemnitz
Technical University Darmstadt
Technical University Dresden
Berlin University of the Arts, Communications and Marketing
University of Heidelberg
University of Paderborn
University of Potsdam
University of Rostock



INTERNATIONAL RESEARCH COOPERATIONS

SmartPower – Innovative technologies for integrating Gallium Nitride power modules

In the collaborative research project SmartPower, Fraunhofer IZM works with European industry partners like Thales, Schneider Electric, and Infineon and leading research institutions across Europe on the development of new module technologies for IGBT and silicon carbide components. First tests of the modules with their doubled-sided cooling have confirmed the extremely low thermal resistance (<0.2 K14/W) and a long life of the technology, with active power cycles at temperature differences of 125 K. A second concept module for a weather radar operating in the X band (10 GHz) relies on the planar integration of gallium nitride components in a silicon substrate. While the reverse of the module accommodates sophisticated cooling solutions, the drivers, amplifiers, and capacitors embedded on the obverse side are connected with a high frequency capable rewiring technology in a BGA array layout. Thales has successfully connected multiple BGA modules for a phased array antenna with signal amplification.

www.project-smartpower.com

EU flagship project Human Brain

Approximately 250 researchers from 23 countries are working together to try achieve an ambitious goal simulating the human brain. A key strategy of the collaboration, which runs under the title Human Brain Project (HBP), is combining the strategies of neuroscience with those of IT. Entire silicon wafers (instead of just single chips) have to be linked using high-density interconnection for HBP's highly complex neuromorphic computers. Fraunhofer IZM's task is developing the technologies needed to attach these interconnection systems

on the silicon wafers and between the wafers. The institute's many years of experience in developing 3D packaging technology is a key prerequisite for taking on this design challenge.

www.humanbrainproject.eu

CarrlCool – Interposer-based 3D system solutions

As part of the European project CarrlCool, we are developing processes and technologies for the robust manufacture of modular and scalable interposers, using the smart implementation of sophisticated More-than-Moore components. The new techniques are also advancing System-on-Chip (SoC) and System-in-Package (SiP) evolution. These new packaging solutions are crucial to improving 3D and beyond-CMOS device integration density. Furthermore, they meet new system demands in terms of energy efficiency, reliability, and computational performance – key metrics in the many-core, exascale and post-CMOS era. Six European countries are represented among the nine participating research and industry partners. The three-year project, initiated in January 2014, is funded by the European Union with approximately four million euros.

www.carrlcool.eu

A More-than-Moore (MtM) pilot line for Europe

The European project ADMONT – »Advanced Distributed Pilot Line for More-than-Moore Technologies« (ECSEL JU) provides a novel approach for innovation in all sectors. It has no specific focus on particular end markets, so automotive, aerospace, industrial, food processing, health, safety, ICT and various other end markets can benefit. ADMONT supplies system integrators with a modular system for combining distinct technologies at wafer level while providing a vital and necessary platform for

new products. This encompasses not only process technology but also design and modelling capabilities. ADMONT aims to reduce manufacturing times for base components to 75 percent and reduce system costs to 70 percent of what can be achieved today. Electronics-based products will benefit from increased innovation speed and hence accelerate time to market. This will bring the benefits of innovation to the full value chain, both from a production perspective and from an end user perspective. Fraunhofer IZM-ASSID is involved in system integration tasks with an emphasis on TSV integration and silicon interposer. In the project 14 partners from six European countries are involved. The project is funded by the European Union, it started in May 2015 and runs for four years.

www.admont-project.eu

Green Economy: Research into highly efficient power electronics based on GaN

Gallium nitride (GaN) components are suitable for the significant reduction of energy loss which arises, for example, during the charging of batteries for electric cars or when feeding solar energy into the network. In the joint project »E²COGaN – Energy efficient converters based on GaN-semiconductors«, partners from industry – such as OnSemi, NXP, STMicro, Bosch, Epi-Gap, Schneider Electric, Audi und Airbus Group – as well as several research institutions are investigating materials and circuitry that could be used as a basis for energy-efficient and cost-effective GaN power electronics. In this project, Fraunhofer IZM is developing a new embedding technology into silicon wafers for a very compact module integration. The half and full bridge modules are characterized by low inductivities, low thermal resistance and high operation temperature capability. The planar module construction facilitates an efficient thermal management and is well-suited for double sided cooling. E²COGaN is part of the ENIAC initiative, which includes 24 partners from ten European countries.

Intensified cooperation with the University of Tokyo

The long history of cooperation with Professor Tadatomo Suga and his microsystem integration and packaging laboratory at the University of Tokyo is entering a new phase: In addition to continuing the bilateral academic exchange programme and joint work on industry commissions, the partnership is now developing a new connector technology that uses the unique technical capabilities on both sides of the globe to create a virtual research value chain. First trial samples are expected to be ready in approx. one year.

Long-standing cooperation with the University of Utah

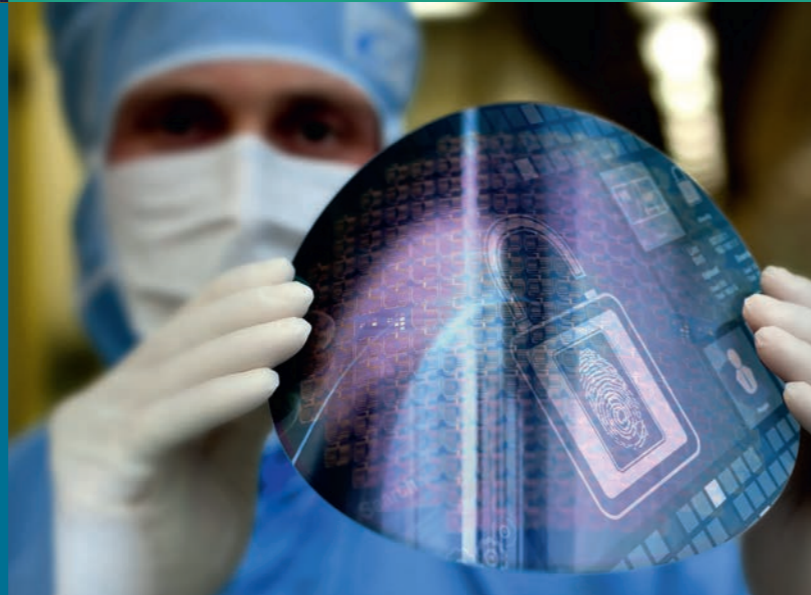
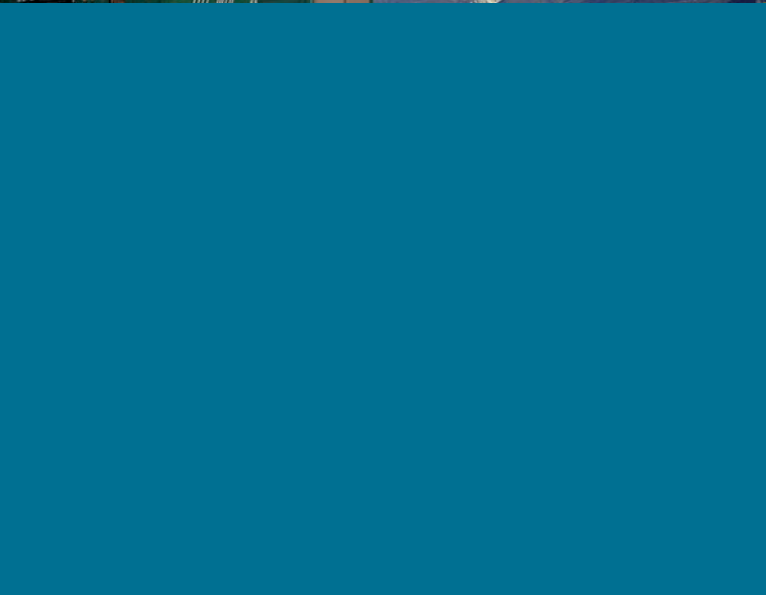
Fraunhofer IZM has been closely cooperating with the University of Utah in various projects concerning the miniaturization of neural prostheses (brain-computer interfaces - BCI) since 2005. Based on two projects on neural prostheses, where Fraunhofer IZM was responsible for the integration of wireless communication among the BCI modules, the scope of the cooperation was broadened to include work on long-term stable neural implants, optical stimulation and microintegration of complex signal processors.

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. These transatlantic research projects also allow Fraunhofer IZM to support US-American companies in the field of neural prostheses by strengthening their technological portfolio for commercial products and to improve the patent exploitation, the latter in cooperation with the Technology Commercialization Office (TCO).

SmartPower – SiC semiconductor device with copper contact structure and thin tin layer at chip frontside: Used in TLP bonding for double-sided cooling

BUSINESS UNITS & COOPERATION

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



Automotive/Transportation	Page 18
Medical Engineering	Page 20
Photonics	Page 22
Industrial Electronics	Page 24
Energy	Page 26
Semiconductors & Sensors	Page 28
Fraunhofer IZM Labs and Services	Page 30
Highlight Innovation Center AdaptSys	Page 32

The Business Development Team at the Fraunhofer IZM

Complex project initiatives move across the boundaries of disciplines and competences. They benefit from the business expertise of the Fraunhofer IZM's dedicated Business Development Team that represents the industry's specific needs in all functional areas of the institute and coordinates the work on innovative solutions. We are here for you to assist you in the strategic development of innovative areas with complex and ground-breaking technologies. Contact: BDT-Team@izm.fraunhofer.de



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AUTOMOTIVE / TRANSPORTATION

On the go safely, reliably and comfortably

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

Transportation has been a key priority and competence area across Fraunhofer IZM departments since the institute's very beginning. The institute helps OEMs, Tier1 companies and particularly their suppliers integrate the latest electronics into vehicles quickly and efficiently. We develop future-proof, reliable solutions, including prototypes, which improve the safety and comfort of conventional, hybrid and electric engines and systems. Our portfolio covers every type of transportation, be it niche market or mainstream power horse – we even develop technology for the comparatively small lot sizes and specialized parameters of the rail industry.

In aeronautics, our research and development meets the industry's stringent safety and reliability requirements and finds new solutions for integrating advanced technology into comparatively limited build space and weight. We also bring cutting-edge technology to the shipping industry by packaging the latest technology advances into solutions that operate reliably in harsh maritime conditions.

Fraunhofer IZM is the right address for all stages of development, from the initial idea, to the start of manufacturing, through to ensuring availability after commercial release.

Packaging for next-generation satellite communication

In the German Air and Space (DLR) funded project AVISAT, a mobile satellite communication module will be designed and fabricated by Fraunhofer IZM, together with IMST GmbH, and Hisatec.

A front-end transmitter and receiver architecture will be optimized for high-frequency performance in modern packaging technologies to create a high gain beam-steerable K/Ka Band antenna array. This system will allow for compact mobile satellite communications with hybrid electrical/mechanical satellite acquisition. The newest in materials and integration technologies will be investigated and implemented to achieve excellent radiation properties, high integration density, and long term thermo-mechanical reliability.

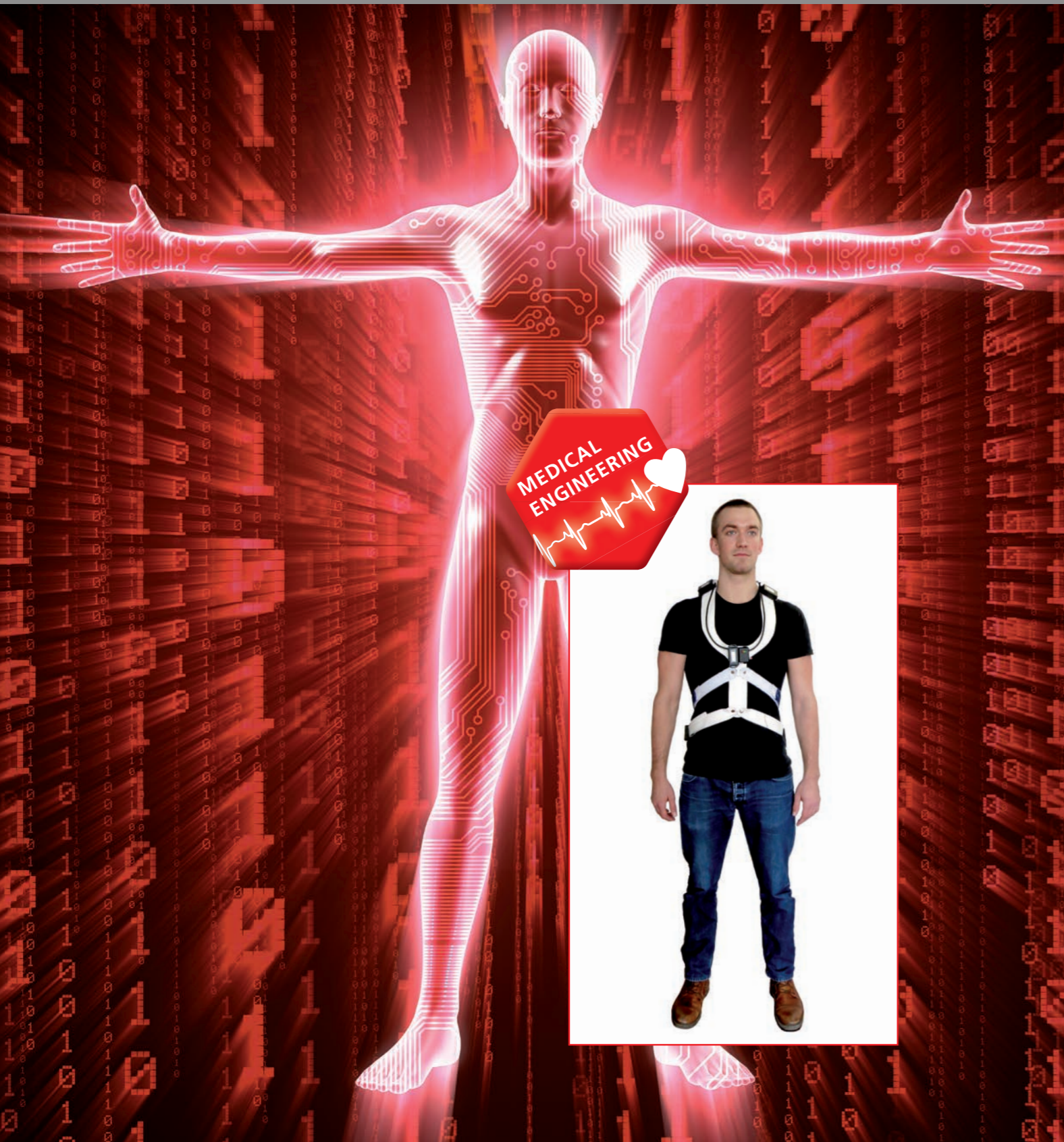
Additionally, a Q-Band demonstrator is planned to explore system integration and packaging technologies for the next generation of satellite communication devices.

Services:

We provide the following services for the automotive and transportation sector:

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

MEDICAL ENGINEERING



Higher performance and smaller, finer geometries

Today's hearing aids are so small that they can be completely hidden in the ear canal. Pacemakers work better and last longer. Simulators help patients get urinary incontinence under control. Many of the innovations that have improved the lives of patients are the result of advances in microintegration technology. Diagnostics is another area that benefits greatly from such progress. Home-use rapid diagnostic tests (RDTs) for many different diseases, microcameras used in endoscopy, biosensors in contact lenses or in wristbands and capsule endoscopes which can be swallowed like a pill would not have been possible without miniaturization.

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

Now manufacturers and research partners have a one-stop contact for all of Fraunhofer IZM's services in this area, which allows them to select a technology that is precisely tailored to their individual requirements. Of course, Fraunhofer IZM also performs customized reliability analyses, usability testing, risk assessment according to ISO 14971 standards and verification according to ISO 10993-5, which are all based on an understanding of the relevant processes, materials and application-specific failures. Often simulation models that draw on this background data are also used.

As members of the Fraunhofer Alliance Ambient Assisted Living and the interinstitutional Medical Engineering Network, we benefit from the synergies of overall Fraunhofer know-how.

Example projects

Fraunhofer IZM participates in government projects and bi- and trilateral cooperations with medical engineering companies and researchers throughout Europe and overseas. For example, in the European project Cajal4EU we have developed a fully integrated diagnosis platform that uses nanoelectronic components. Together with INCITE sensors and diagnosis systems are being integrated into the top of a catheter with a diameter of just 2 mm.

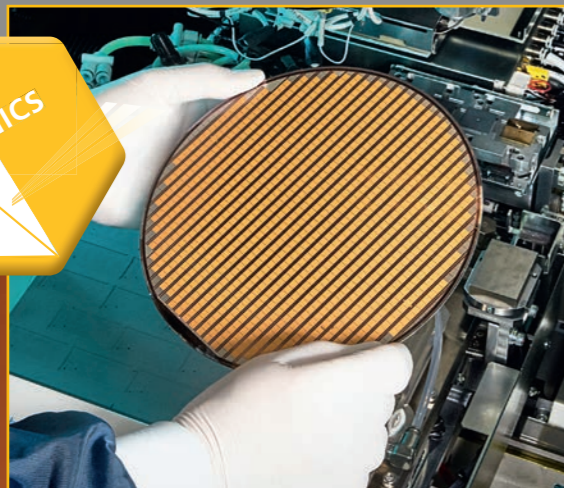
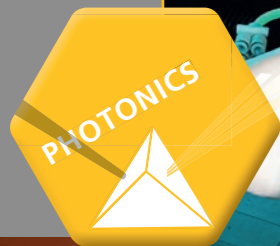
Researchers in the project CAREJack have developed textile-integrated sensors that monitor muscle activity. The new technology is now being transferred into the project PowerGrasp, with a new emphasis on preventative assistance for the prevention of long-term effects. The development goal is a power-assist device for the crucial shoulder region to the hand.

The ALUBAR project aims at improving the daily work routine of professionals by integrating »augmented reality« features, monitoring physical strain and thus helping to prevent a burn-out. In this project Fraunhofer IZM is responsible for the realization and system integration of eye tracking and stress sensors into spectacle frames.

Services

- Packaging technology and reliability analysis for miniaturized medical systems for wearable computing devices and implants
- Lab-on-substrate technologies for patient-friendly diagnostics
- Body area network (BAN) designs and solutions for networked diagnosis and treatment
- Improving the functionality of neuronal interfaces and intelligent prostheses

The CareJack vest supports the back without restricting freedom of movement (in cooperation with Orthopädietechnik Winkler, Minden)



PHOTONICS

Photonic systems for greater versatility

Phototonics have established themselves as an essential pillar of modern and efficient lighting, ultra-high-speed data transmission and processing, and modern sensor technology for environmental, traffic, industrial, and medical applications. Fraunhofer IZM possesses substantial expertise covering packaging and interconnection solutions for photonic and optoelectronic systems, including their miniaturization and reliability in diverse practical applications.

The integration of electronics for control and signal processing functions facilitates a close interaction of different semiconductor technologies and calls for new packaging and interconnection technologies in order to meet the electrical and thermal requirements as well as securing the optical functionality. This is particularly the case with imaging and display applications with high pressure for miniaturization and resulting high power densities, such as adaptive lighting with high resolution headlights.

Services:

- Development of assembly and interconnection technologies for system integration of micro-electronic and photonic components, demonstration and prototyping
- Simulation, design, and test (optical, electrical, thermal and mechanical)
- Qualification, failure, and reliability analyses

Smart light sources

OSRAM has developed innovative LEDs for a high-resolution headlight. The contacts of these thin-film LEDs are fed through vias in GaN onto a chip surface, such that the luminous area is not overshadowed by either electrodes or wire bonds and an even illumination surface is available for application of the converter. The vias make segmentation of the thin-film LEDs into pixels possible. The latter can also be controlled individually using an active matrix control. The luminance and efficiency of this LED unit meet the standards of conventional chip technologies.

Infineon's newly developed control chip allows the operation of the individual pixels by pulse width modulation, monitoring of temperature and the forward voltage drop, and communication with the vehicle's control unit to generate the luminescence pattern.

Fraunhofer IZM developed groundbreaking interconnection technologies based on AuSn solder and nano-porous gold (or nano-sponge) for the integration of the electronics and photonics into these modules. The innovative interconnection structure with high level of filling combines the advantages of flip-chip technology's surface-wide fine pitch layout of contacts with the low thermal resistance of full-surface die-bond assembly.

To demonstrate cost-effectiveness and suitability for high-volume manufacturing, the assembly technique was developed on wafer level using minimal pitch (<math><15\mu\text{m}</math>) between the LED chips. This produced a hybrid component with highly functional digitalized lighting function.

Integration of electronics and photonics on wafer level for innovative high-resolution headlight



INDUSTRIAL ELECTRONICS

Industrial Electronics – safe and reliable!

The last twelve months of R&D by the Fraunhofer IZM's industrial electronics specialists were given over to one visionary concept: Industry 4.0. Particular emphasis was placed on the work on cyber physical systems (CPS) and autonomous, specifically high-reliability radio sensors that record and process the relevant monitoring and/or video data on site and distribute it via standard interfaces when and where the user needs it. Industry 4.0 means much more than CPS integration: »The future brings the intelligent collection, recording, and distribution of data by objects and human beings at the same time« (Fraunhofer IAO, study on »The Future of Manufacturing«).

Flexible access to monitoring data is particularly vital both for location-bound controlling and management processes and ERP systems and for on-demand access via mobile devices in inspection, maintenance, or repair scenarios. In their work, the IZM researchers remember that people will remain the first and foremost controllers and decision-makers despite the advent of intelligent new technologies.

Services:

- Design, technology development and optimization, reliability tests, and technology transfer for highly integrated modules on circuit board substrates, flex-rigid, flex, and metal or ceramic substrates
- Packaging and interconnection technology for industrial electronic products
- Integration of (active and passive) electronic components in fabrics or compound materials and embedding technology for ultra-thin systems and high-security applications (invisible electronics)
- Antenna and circuit designs for industrial electronics
- Design and prototype manufacture of autonomous multi-channel radio sensors for automation solutions

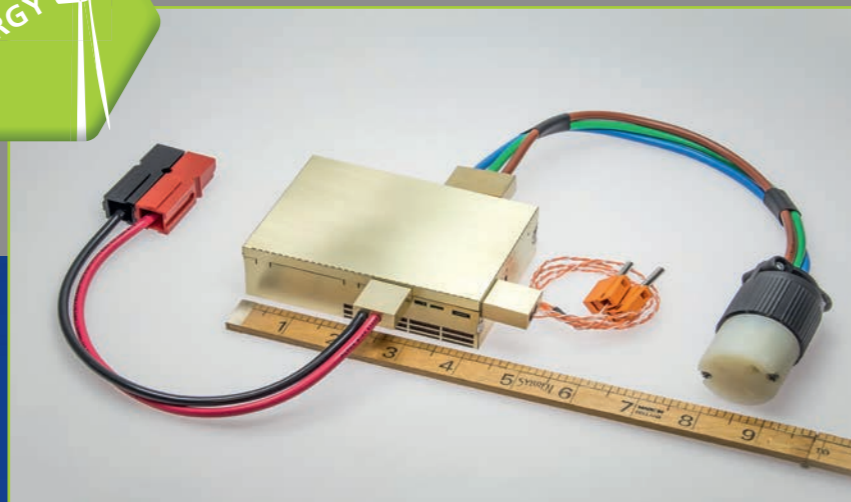
Autonomous monitoring system for overhead lines

Sensors that monitor the condition of overhead power lines need highly durable and dependable technology to meet the operational reliability requirements of these vital systems. The ASTROSE® sensor system developed in the eponymous project allow the distributed monitoring of high-voltage grids with radio sensor nodes designed for autonomous operation. The sensors track the pitch of the power lines and the changes caused by changes in temperature, or currents in the line. These indicators, which have a major impact on the maximum flow loads in the system, are measured where it matters most: on the lines themselves.

Each sensor node is given a unique ID to pinpoint its exact place in the landscape. The units include the electronic systems, the sensors, two antennas, and one antenna filter. The network formed by the nodes along the route sends the monitoring data to a dedicated feed point, from where it is transmitted to the grid operator's control systems.

Since September 2014, 59 autonomous radio sensor nodes have been successfully sending their monitoring data from the 12 km section of the route crossing the Harz mountains back to the base station at MITNETZ STROM's transformer station, where the data is received and forwarded to its destination. At the same time, a second radio system is sending a constant stream of monitoring and status data for the sensor nodes to an ASTROSE server. The server records the data and provides the right selection to match the specific application and users' queries, be it for monitoring the state of the autonomous radio sensor network itself, condition monitoring, or later maintenance purposes. With these two separate and dedicated datasets for different recipients, ASTROSE® becomes a vanguard for the purpose-specific data allocation to specific users that Industry 4.0 proponents are calling for.

Energy-autarkic sensor system to monitor the pitch of overhead power lines



ENERGY

The key to reducing energy and resource consumption

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

Fraunhofer IZM develops these innovative and reliable power electronic systems. We research the possibilities opened up by the new semiconductor materials silicon carbide (SiC) and gallium nitride. The materials require higher temperatures of up to 250°C, which has to be factored into the packaging design. Thanks to their properties, SiC semiconductors are almost perfect switches. High switching speeds combined with parasitic capacitances and inductances within the package and at the component connections create unwanted oscillation that can hamper chip function. However, EMC-optimized package design can help reduce losses and keep interference to a minimum. A good connection to the installation environment is also important.

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

Services:

- Miniaturization and system integration
- Thermal Management
- Electromagnetic compatibility
- Reliability
- Innovative packaging technologies
- Complete systems, prototypes

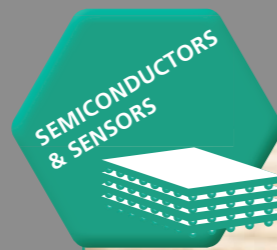
Power converter for fast switching

The rapid current rise of silicon carbide and gallium nitride semiconductors can dramatically increase a power converter's switching frequency. However, parasitic elements in modules can cause serious overvoltage during switch-off, which can damage the chip and trigger additional oscillations that significantly increase switching losses.

Solving this problem was just one of the tasks Fraunhofer IZM took on as part of their cooperation with ETH Zurich and Franc Zajc for Google's Little Box Challenge. Goal of the competition, which was launched in 2014, was developing a 15 kW solar inverter that measures no more than 655 cm³. Various industry partners offered Fraunhofer IZM and team their latest and best semiconductors; in the end, GaN semiconductors were selected. The unhoused chips were glued onto a lead-frame and two additional interconnection layers were added to the PCB. Primary DC-link capacitors placed directly on the module above the switch keep leakage inductance of the conducting path low, a gate driver is also mounted directly on the module in close vicinity to the switches. This dramatically reduces the gate inductance compared to the 33 nH a previous project was able to achieve.

Another key factor in minimizing the inverter's volume is getting the circuit design and implementation of drivers and control right. Using the control scheme with intermittent current and switching at zero current, loss is kept low, which allows for a smaller semiconductor surface and above all requires much less cooling than standard pulse width modulation (PWM). With a final design that measures just 250 cm³, the Fraunhofer IZM, ETH Zurich and Franc Zajc team was among the 18 finalists of Google's Little Box Challenge!

Fast-switching power module using embedding technology, contribution to Google's Little Box Challenge



SEMICONDUCTORS & SENSORS

3D integration & sensor integration on wafer-level

Using 3D integration of components, complex, heterogeneous system-in-packages (SiP solutions) can be developed. The major advantages of 3D system architecture include:

- High miniaturization and improved form factor
- Improved performance and power efficiency thanks to the faster signal speeds and higher bandwidth via shorter and narrower signal paths
- Increased functionality due to heterogeneous integration of components, which are fabricated using various technologies (sensor, memory, ASIC and transceiver)
- System partitioning
- Faster product implementation (also known as 'time to market')
- Higher reliability by reducing the interconnects
- Fewer costs due parallelization of assembly processes

Fraunhofer IZM's services include a closed process chain – concept and process development, characterization, as well as reliability assessment and prototyping of 3D systems. The IZM is partly certified in this area (ISO). All processes required throughout the chain for the realization of wafer-level packages, including through silicon via (TSV) formation, are available in our labs.

3D systems that meet the disparate target profiles demanded by various application scenarios, such as image sensors, sensor nodes, eGrains, can be realized and characterized. We work in close cooperation with tool and material suppliers to continuously improve applied technologies.

3D-integrated clocking MEMS module using TSV technology in CMOS

Ultra-thin HD capacitors for new packaging solutions

The growing demand on small system solutions is driving the compression of many functions into small package outline. This requires sophisticated solutions to avoid external circuitry area when integrating passive components. Moreover, decoupling capacitors need to be placed as close as possible to the active circuits in order to suppress cross-coupling between different power planes efficiently.

Together with colleagues from Fraunhofer IPMS we have developed the concept, fabrication and characterization results of ultra-thin silicon capacitors that can be integrated into chip package or embedded in PCB. High capacitance densities are achieved by using high-k materials as dielectric supporting a broad application range from RF-filtering to decoupling and energy buffering. Based on characterization results of voltage and temperature characteristics it is shown that this concept offers good electrical properties and linearity compared to conventional ceramic capacitors, like MLCC. Further, potential integration options are discussed showing the way to even thinner substrates down to 30 µm.

Services:

- 3D design
- Process development and evaluation
- TSV formation for customized CMOS wafers (via-middle, via-last)
- Backside contacts (BS via-last) for image sensors
- Silicon and glass interposers
- 3D assembly (die-to-wafer, wafer-to-wafer)
- 3D integration of optical interconnects
- Hybrid 3D pixel detector modules
- Hermetic MEMS packaging using TSVs
- Material and equipment evaluation and qualification
- Prototyping and pilot line
- Design and fabrication of pressure, gas and acceleration sensors

FRAUNHOFER IZM LABS & SERVICES



Wafer-Level Packaging Line

Our wafer-level packaging line in Berlin boasts a 800m² 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 300mm.

- 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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All Silicon System Integration Dresden - ASSID

The Fraunhofer IZM-ASSID Center in Dresden is equipped with a 300mm wafer process line and provides the following services:

- Application-oriented Cu-TSV interposer technology
- Cu-TSV-integration (via-middle-, via-last-, backside-via-process)
- Wafer-level system-in-package (development & prototyping)
- High-density thin-film-multilayer (RDL)
- Wafer thinning und thin wafer handling
- Wafer level bumping (ECD)
- Wafer-level assembly, wafer dicing (Stealth-laser)
- Wafer-level solder ball attach (100-500 µm)
- Integration of active elements (IC), thin chip integration
- Customer-specific prototyping

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Phone +49 351 795572-12

PCB Prototyping Process Line

The new prototyping and process line can handle substrates with a maximum size of 610mm x 456mm 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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Laboratory for Textile-integrated Electronics

Fraunhofer IZM's TexLab researches and develops new interconnection technologies for stretchable and textile substrates. The demands concerning functionality and system reliability are always determined by the designated application. With its extensive assembly and analytics equipment from the realm of microelectronics the TexLab is excellently equipped for advanced R&D activities.

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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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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. 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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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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Micro Battery Lab

The laboratory is fully equipped for the fabrication and coating of battery electrodes and for the electrochemical characterization of battery systems. There is a 10-metre battery development and assembly line, capable of producing miniature, custom-designed micro batteries with unparalleled precision. The batteries can either be assembled on a common substrate (up to 200 mm) or individually (reel-to-reel). Further high-purity gas containment units are available for alternative electrochemical systems as well as ionic fluids.

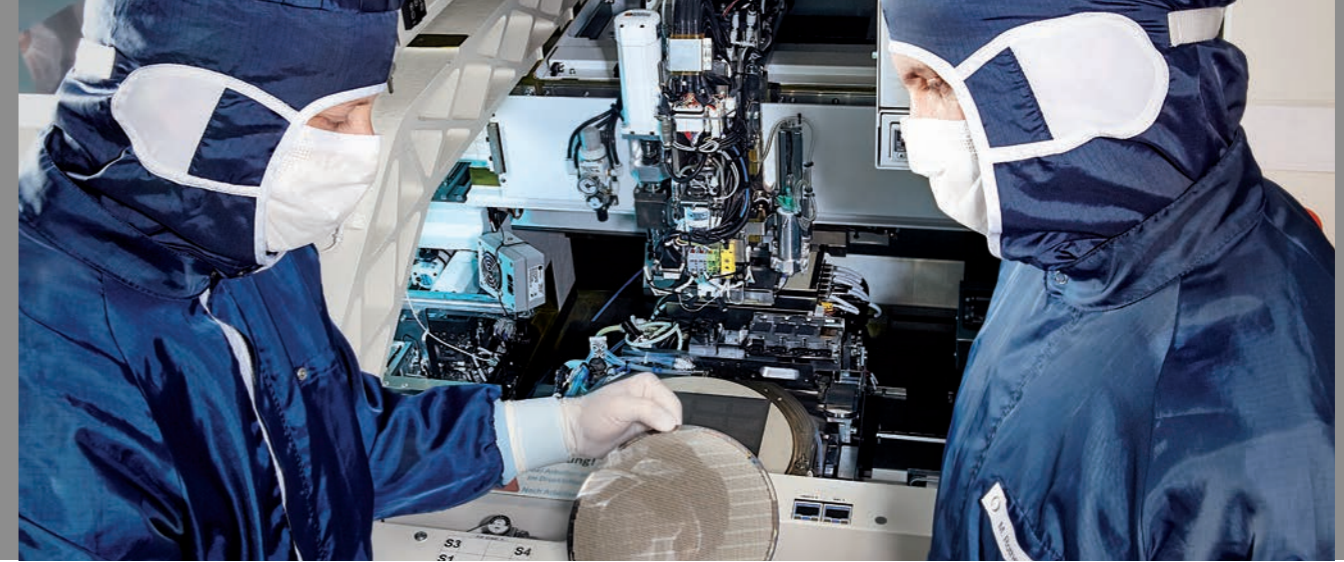
Contact:

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Further laboratories include:

- Flip Chip Line
- Die and Wire Bonding Center
- Thermo-mechanical Reliability Lab
- Thermal and Environmental Analysis Lab

HIGHLIGHT INNOVATION CENTER ADAPTSYS



On September 1, 2015, the new research and development center »AdaptSys – Multifunctional Microelectronics for Innovative Micro- and Nano-Integration Technology in the Development of Application-Oriented Systems« opened its doors at Fraunhofer IZM in Berlin. The center was funded by the European Union, the Land Berlin, the BMBF and the Fraunhofer-Gesellschaft and fosters the development of highly complex electronic systems for different areas of application. Furthermore, system integration technologies can be evaluated down to the nanometer scale and their reliability can be tested using new test and qualification processes.

SYSTEM INTEGRATION

Substrate Line

In the substrate area panel-size substrates with a size of 460x610 mm² can be prepared for resist and PCB lamination, solder resist and cover lays can be applied and developed after exposure. In our bonding lab high-precision module assembly is carried out under inert gas. New equipment in the 480m² cleanroom allows surface preparation for assembly at reduced bonding temperatures.

Our services include:

- Embedding of passive and active components
- Multilayer lamination of PCBs substrates
- Realization of smallest vias, mechanically or with a laser
- Quality assessment and X-ray microscopical analysis

Wire Bonding Lab

- Processing of Au-, Al- and Cu-based bonding wire materials for thin and heavy wire bonding
- Assembly of power modules using Al/Cu- and Cu-heavy wires for quality and reliability analyses
- Assembly of sensor packages using Cu-ball/wedge bonding for lead frames and Au/AlSi1 wires for chip-on-board (COB) processes

Soldering Lab

- Vapor phase soldering in combination with vacuum enables the manufacturing of void less large area solder joints for power electronics.
- Fluxless soldering of printed circuit assemblies (PCA) using active gas in oxygen free Nitrogen or vapor phase atmosphere
- Hermeticity test
- Leak testing including Helium bombing up to a pressure of 10 bar

Photonics Lab

- Laser structuring of glass layers with optical waveguides for electro-optical boards (EOCB)
- Shack-Hartmann-characterization of micro lenses and micro lens arrays
- Optical and thermal characterization of LEDs and LDs
- Research and development of optical packaging processes with an accuracy of up to 0.5 μm

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-, panel- 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
- Transfer molding of large volume packages
- Rheological assessment of mold compounds
- Sensor packages with exposed sensor areas by film molding

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

MATERIAL ANALYSIS

AdaptSys has considerably enhanced Fraunhofer IZM's material analysis competences in the micro-nano transient area. A »PicoIndenter« allows the in-situ experimental REM investigation of the microscopic material behavior. Focused Ion Beam technology (FIB) enables high-resolution structural analyses on the nanometer-scale of 3D packages. EBSD-EDX micro analysis software facilitates a deeper understanding of compound materials' structure-property correlation. A high resolution EDX-detector with 80 mm² provides fast processing of element analyses.

Moisture Lab

- Comprehensive simulation-based reliability assessment of humidity-induced phenomena in micro-electronic components and systems
- Evaluation of surface properties and thin layers through REM, especially under the influence of water with JPK's »NanoWizard 3« Bio-AFM
- Analysis methods for sorption, permeation and diffusion of water in materials
- Investigation of humidity-induced swelling behavior and the change in thermo-mechanical and dielectric properties
- Molecular-dynamic simulation

Long-term Testing and Reliability Lab

- Fast temperature cycling tests in the range from -65 °C to 300 °C
- Temperature storage up to 350 °C

Power Lab

- Characterization of power modules and power electronic devices
- Active cycling of power modules for lifetime assessment
- Calorimetric measurement of the effectiveness of highly efficient devices

DESIGN

Advanced System Engineering Lab

- Measuring station up to 50 GHz for antennas and antenna systems
- Dielectric material characterization 1 MHz up to 170 GHz
- Measuring electrical properties of digital data transfer systems (up to 32 Gbit/s)
- Localising EMC-hot spots with near field probe up to 6 GHz
- Investigation of RF-properties of active and passive systems (impedance up to 3 GHz / S-parameter measurement up to 220 GHz)

High Frequency Lab

- Electric and functional characterization of assembly technology and electronic modules for applications down into millimeter wave bands
- Free-space measuring station for up to 170 GHz
- Temperature-controlled on-wafer stations for the measurement of miniaturized structures and assemblies
- Automated measuring station for the characterization of integrated antennae up to 50 GHz

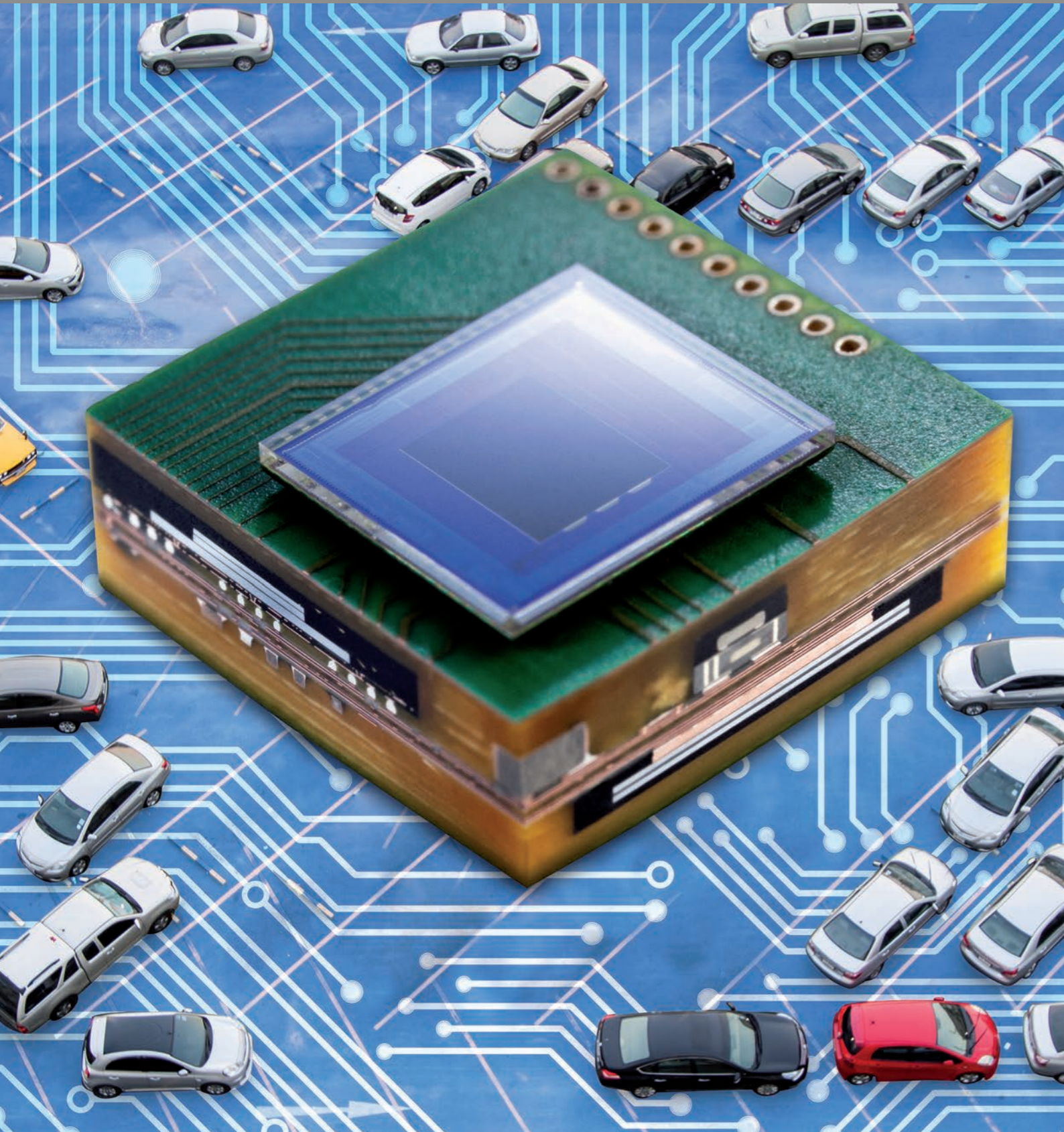
Microelectronics Lab

- Development and qualification of mechatronics systems and energy-efficient wireless sensor systems
- PXA for range calculation, conformity checks, and failure analyses; allows the recording of very fast signals (from 162 μs)
- High-performance 3D printer (Fortus 360 mc) for prototype and small-series package development (materials: ABS-M30, PC, and nylon)

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FRAUNHOFER IZM CORE COMPETENCIES



INTEGRATION ON SUBSTRATE LEVEL Page 36

System Integration & Interconnection Technologies Page 38
Heads: Rolf Aschenbrenner, Prof. Martin Schneider-Ramelow

Micromechatronics & PCB Technology Page 42
Head: Dr. Frank Ansorge

INTEGRATION ON WAFER LEVEL Page 44

**Wafer Level System Integration –
All Silicon System Integration Dresden ASSID** Page 46
Heads: Oswin Ehrmann, M. Jürgen Wolf

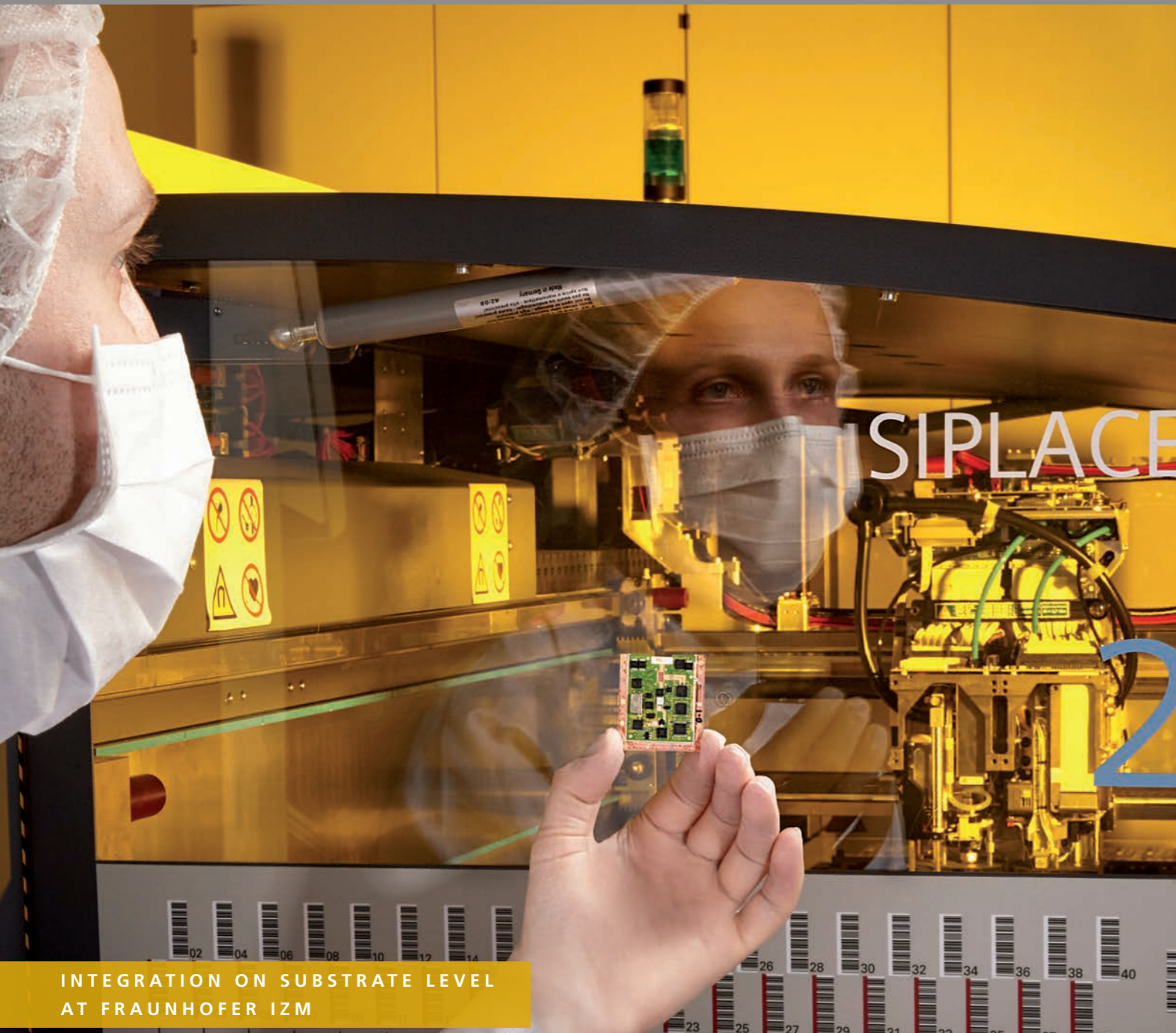
MATERIALS & RELIABILITY Page 50

Environmental & Reliability Engineering Page 52
Heads: Dr. Nils F. Nissen, Dr. Olaf Wittler

SYSTEMDESIGN Seite 54

RF & Smart Sensor Systems Page 56
Heads: Dr. Ivan Ndip, Harald Pötter

RESEARCH CLUSTER INTEGRATION ON SUBSTRATE LEVEL



INTEGRATION ON SUBSTRATE LEVEL AT FRAUNHOFER IZM

Fraunhofer IZM works at the forefront of modern substrate technology development. The institute's unique assembly facilities combine cutting-edge assembly equipment with complete large-scale circuit board (24" x 18") production. In addition to the current development capabilities such as high-precision assembly, embedding, and high reliability encapsulation solutions, the institute is currently working on innovative panel-level-packaging (PLP) technology. PLP allows the continuous production of systems-in-packages (SiP), modules, and miniaturized systems for large-format applications. This enables Fraunhofer IZM to go beyond technology and process development and offer the direct production of prototypes, sample series and model processes for immediate application by industry partners.

HIGHLIGHT 2015

W-Band Project – Radar packaging for 94 GHz

For radar applications, the W-band frequency range (75-110 GHz) is a good candidate for high-resolution distance measurement and remote detection of small or hidden objects in distances of 10cm to 20m. As electromagnetic waves in this frequency range can easily penetrate rough atmosphere like fog, smoke or dust, W-band radars are perfectly suited for automotive, aviation, industrial and security applications. An additional benefit is that atmosphere has an absorption minimum at 94 GHz, so relatively small output power is sufficient to achieve long-range coverage. By combining and enhancing knowledge from the disciplines of heterogeneous integration technology and compound semiconductor-technology, the Fraunhofer institutes IAF, IPA and IZM have developed a miniaturized low-cost 94 GHz radar module, combining radar board, controller and HDPE-Radar lens into a small metal case (42x80x27 mm³) with a total weight of only 160g.

Fraunhofer IZM contributed its packaging competencies to the project, yielding a miniaturized and highly integrated low cost system carrier suitable for volume production. Technological highlights are:

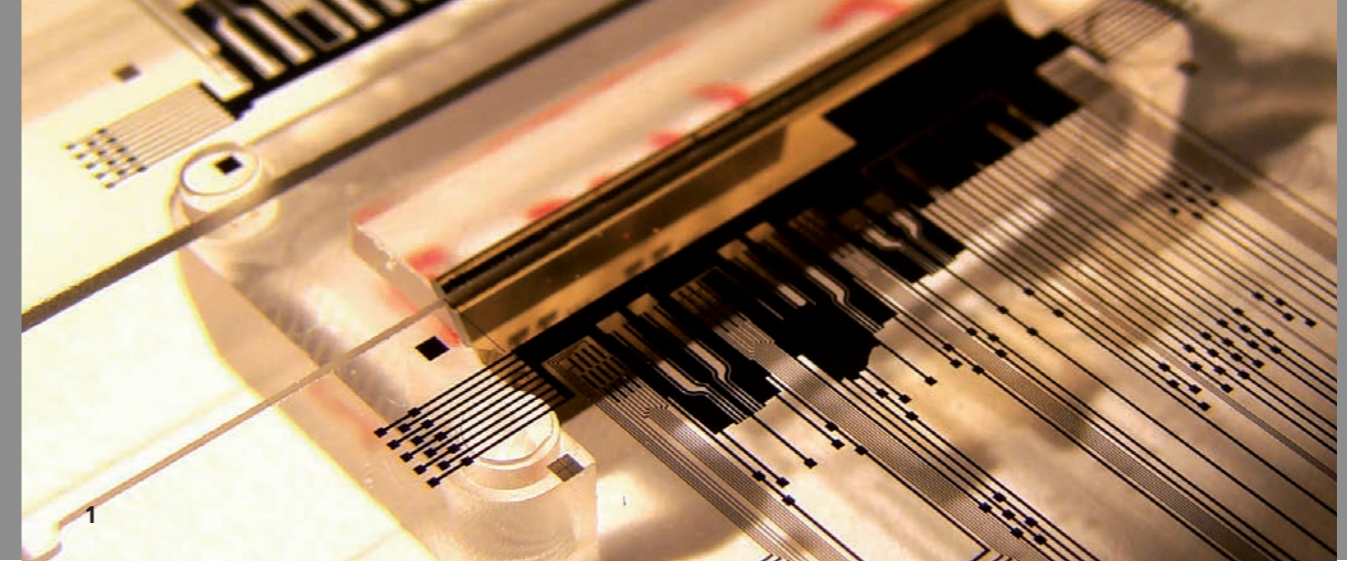
- Combination of RF-LCP layer and low cost PCB core in a 6-layer-board with an integrated thick Cu layer acting as a heat spreader
- Manufacturing of an edge emitting 94 GHz Vivaldi antenna on a wrinkle-free 50 µm thick RF-compatible LCP substrate
- Interconnection of Radar MMIC to antenna using an ultra-short, zero-tail wire bond for lowest losses
- Developing assembly processes for volume manufacturing of such highly integrated Radar modules

The module yields an evaluated distance measurement accuracy of 5 ppm (5 µm deviation per meter target distance) while its low weight and small dimensions pave the way for a variety of new applications, including mobile operation e.g. for autonomous unmanned vehicles or intelligent prosthetics. An example application could be an artificial leg knowing when to lift the knee by radar scanning the environment topography. Next steps targeted in radar packaging are further cost reduction by process simplification and the evaluation of embedding processes for use with RF circuitry. The use of current technology trends as FO-WLP/PLP incorporating RF interfaces will be addressed, with chip-package co-design as a key issue.

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High-performance 94 GHz radar
module cost-effectively manufactu-
red on fully automated production
equipment



SYSTEM INTEGRATION & INTERCONNECTION TECHNOLOGIES

The Department

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

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

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

Trends

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

Our work on trends in future applications extends to:

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

RESEARCH & DEVELOPMENT HIGHLIGHTS

Silicon photonics packaging and optical interconnection on board level

Fraunhofer IZM works to overcome the lack of single-mode optical interconnection between silicon photonics devices assembled on electrical-optical printed circuit boards (EOCB). Optical signal transmission offers superior bandwidth benefits compared to copper-based electrical signal lines that will be very important in data centers and high-performance computers for high-speed but short range interconnects in the near future. Silicon photonics provide unique bandwidth possibilities because of modulation speed and wavelength division multiplexing. Today, worldwide research focuses on implementing all important photonics building blocks in silicon such as the laser, modulator, switch, filter, and detector. For system integration, board-level integrated optical waveguide layers even have to be single-mode.

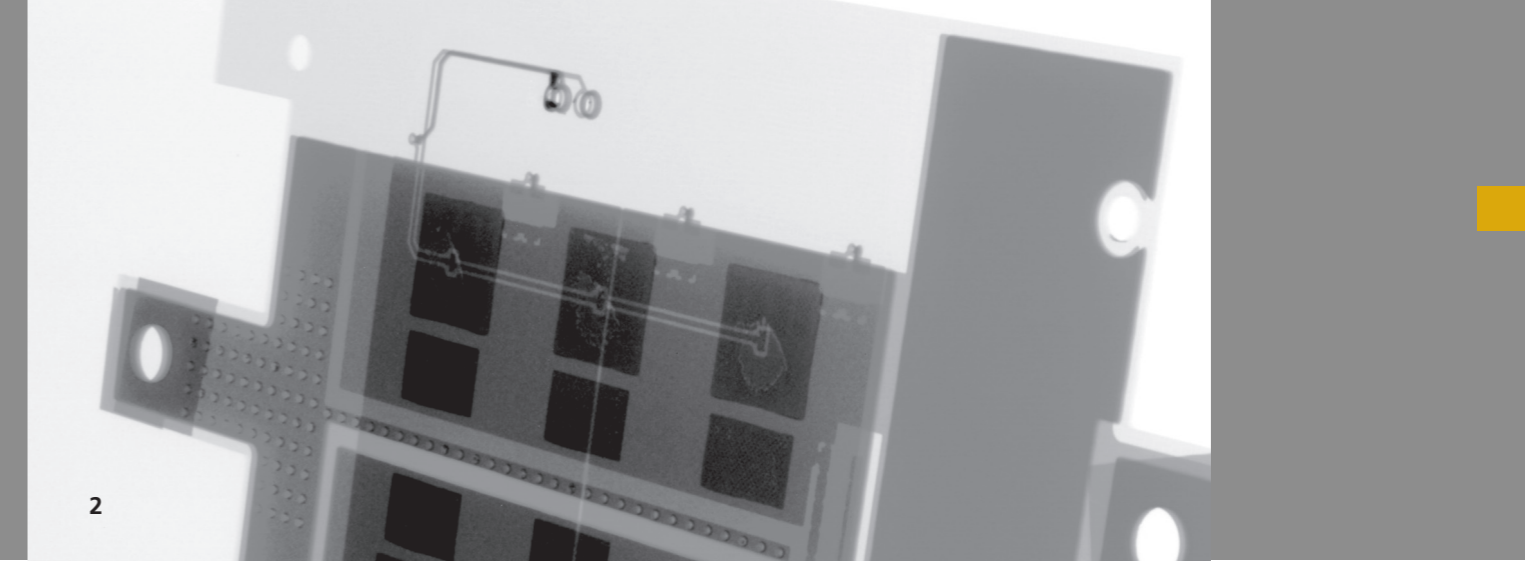
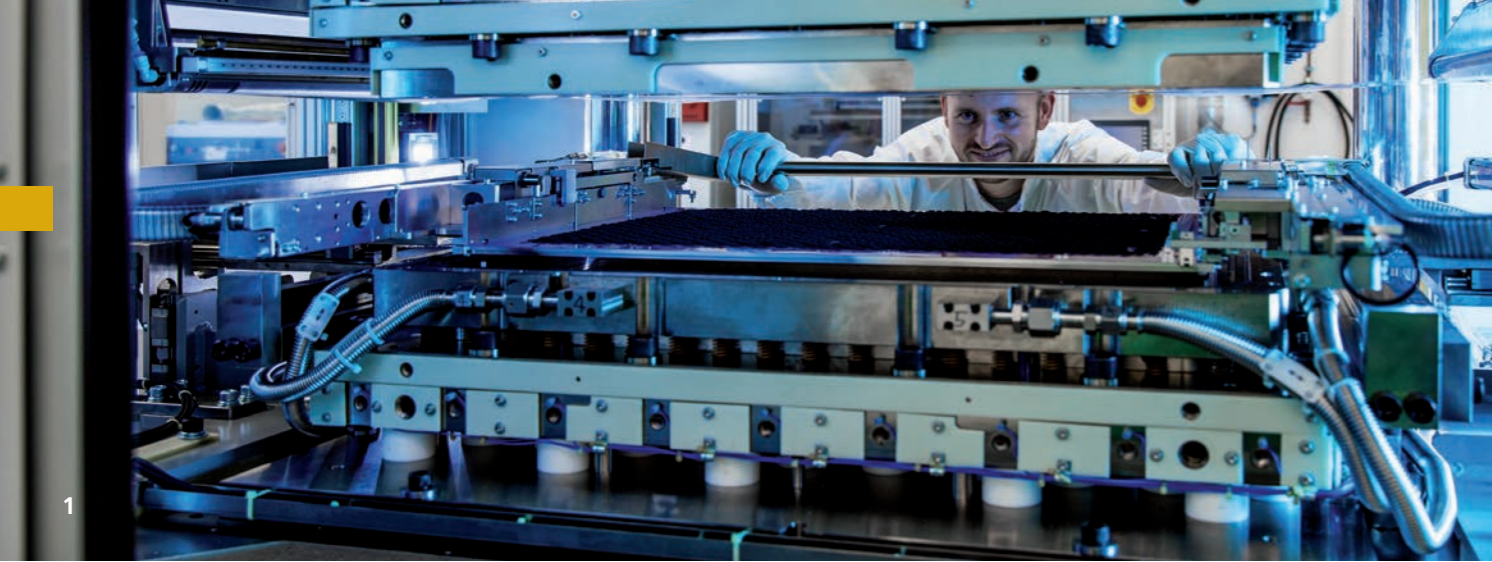
Recently, Fraunhofer IZM has developed a new single-mode planar glass-based electro-optical circuit board technology providing a silicon photonic IC platform for data center and high-performance environments. A process has been presented and elaborated for fabrication and embedding of an electro-optical glass core in a PCB by our unique ion exchange technology on large thin glass display panels. Additionally, a generic optical board-to-chip coupling interface has been developed and board-level assembly technologies have been successfully established. The assembly routine is defined by solder bonding of electrical components, thermo-compression (TC) bonding of the silicon photonic interposer directly on glass, and active alignment and adhesive bonding of fiber-to-board and chip-to-board interfaces. Coupling of single-mode optical interconnects requires a highly accurate assembly technology with sub-micron capabilities to achieve best results.

At Fraunhofer IZM, ficonTEC AL-500 pick-and-place machines are currently used to achieve low insertion loss by active alignment and short processing times. A project specific coupling element has 56 bidirectional optical channels, board-to-grating couplers, 12 one-direction optical channels, and coupling from board to the photodiodes. Ongoing work focuses on the validation of such single-mode EOCB with assembled silicon photonic ICs that are directly interconnected at the board-level with data rates of up to 40 Gbit/s per channel.

1 A coupling element fixed on the glass layer of the EOCB at bottom side. The mirror element provides a ditch to bring the spherical mirrors closer to the optical glass edge

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From Fan-out Wafer to Panel Level Packaging

Fan-out wafer level packaging (FOWLP) is one of the latest packaging trends in microelectronics. FOWLP has a high potential for significant package miniaturization concerning package volume but also its thickness. Technological core of fan-out wafer level packaging is the formation of a reconfigured molded wafer combined with a thin film redistribution layer to yield an SMD-compatible package. Main advantages of FOWLP are the substrate-less package, low thermal resistance, improved RF performance due to shorter interconnects together with direct IC connection by thin film metallization instead of wire bonds or flip chip bumps and lower parasitic effects. Especially the inductance of FOWLP is much lower compared to FC-BGA packages. In addition, the redistribution layer can also provide embedded passives (R, L, C) as well as antenna structures using a multi-layer structure. It can be used for multi-chip packages for system-in-package (SiP) and heterogeneous integration.

For higher productivity and resulting lower cost larger mold embedding form factors are forecast for the near future. Besides increasing wafer diameter an alternative option would be moving to panel sizes leading to fan-out panel level packaging (FOPLP). Here, panel sizes could range from 18" x 24" (a PCB manufacturing standard) to even larger sizes.

In cooperation with TU Berlin Fraunhofer IZM intensively works on both topics, in publicly funded projects as well as in direct industry cooperation. Within the H2020 project smart-MEMPHIS the goal is to design, manufacture and test a miniaturized autonomous energy supply consisting of a piezo-MEMS energy harvester, power management circuitry and energy storage. Target applications are a leadless pacemaker and structural health monitoring, the packaging technology of choice for

maximum miniaturization is a fan-out panel level approach. Furthermore low cost technologies are developed in the BMBF-funded project "InteGreat", also based on large area mold embedding. Industry projects are focusing among others on the evaluation of new materials for FOWLP for RF applications and process development for optical sensor systems. Derived from the activities a large industry consortium is planned to evolve fan-out panel level packaging together with partners along the value chain as well as end-users and OSATs (Outsourced Semiconductor Assembly and Test) to a higher productivity level.

Power electronic embedding technologies

The embedding of active and passive electronic components into the build-up layers of the printed circuit board has evolved from an academic research activity into a mature leading edge industrial technology. Over the last 15 years Fraunhofer IZM has been a leading driver in the development of the basic technology and its subsequent transfer into the industrial manufacturing environment. Besides miniaturizing electronic assemblies and improving their performance, the reliability of products realized with embedding technology has proven to be much better than that of conventional electronics.

During recent years Fraunhofer IZM has focused on the development of technologies for the embedding of power electronic systems. For power applications the embedded system layout has to account for high currents and/or voltages and at the same time has to provide means to accommodate the power dissipations from the embedded components. Substrates and modules therefore contain conductor traces with rather large cross sections and even massive copper structures in order to enable the required heat spreading. Embedded components are typically semiconductor dies on the basis of silicon,

silicon carbide and gallium nitride. The required robustness and low level resistivity of the electrical back contact between chip and embedded substrate is met by silver nanoparticle sintering technology. Front contacts between chips and the subsequent wiring layer are established by micro-via technology (drilling of the vias by laser ablation followed by copper electroplating).

During the embedding process power components are enclosed into a matrix of glass fabric and epoxy resin. The choice of materials strongly depends on the foreseen use case. Examination, testing and evaluation of thermally conductive or robust electrically insulating (commercially available) materials are an essential part of the research activities for power electronic embedding. Handling, reproducibility and reliability of processes and products are presently developed so as to allow for a rapid transfer of the technology into industry.

A large variety of embedded power electronic modules has been realized so far. Size and performance of the systems differ accordingly: from modules with lateral dimensions of a few square millimeters with three embedded components for low voltage and currents of up to 50 Amperes, to complex assemblies with 24 embedded semiconductors and a module area of several square decimeters for an operating Voltage of 600 V and a total power of 150kW.

1 Fan-out panel level packaging at Fraunhofer IZM

2 DC/AC Converter with 10kW switching power (with embedded IGBTs and diodes)

MICROMECHATRONICS & PCB TECHNOLOGY

Fraunhofer IZM Oberpfaffenhofen

Our department »Micromechatronics and PCB Technology« at Fraunhofer IZM's Oberpfaffenhofen branch applies cutting-edge quantification techniques and numerical simulation to analyze and optimize mechatronic packages. We provide consultation on the reliability of electrical systems and interconnection. Moreover, we carry out in-depth qualification and failure analysis of components, assemblies, electrical contacts and electrical systems. Simulation is primarily applied to electronic encapsulation testing and development (transfer molding, injection molding, the role of fiber direction) and to optimize the packaging process.

We advance mechanical-electrical interconnection technology and transfer our insights and know-how to industry in our training courses. Our basic research employs cutting-edge electrical measurement techniques, such as contact resistance, thermography, sealing behavior of contact surfaces and the effect of stress and contaminants on reliability.

Our training courses and workshops cover packaging, soldering, crimping, and repair and acceptance criteria, in particular for certification courses (ESA, IPC, DVS). This year, we will be offering the certification course IPC/WHMA-A-620B »Requirements and Acceptance for Cable and Wire Harness Assemblies« and a practical lab course on cable interconnection techniques.

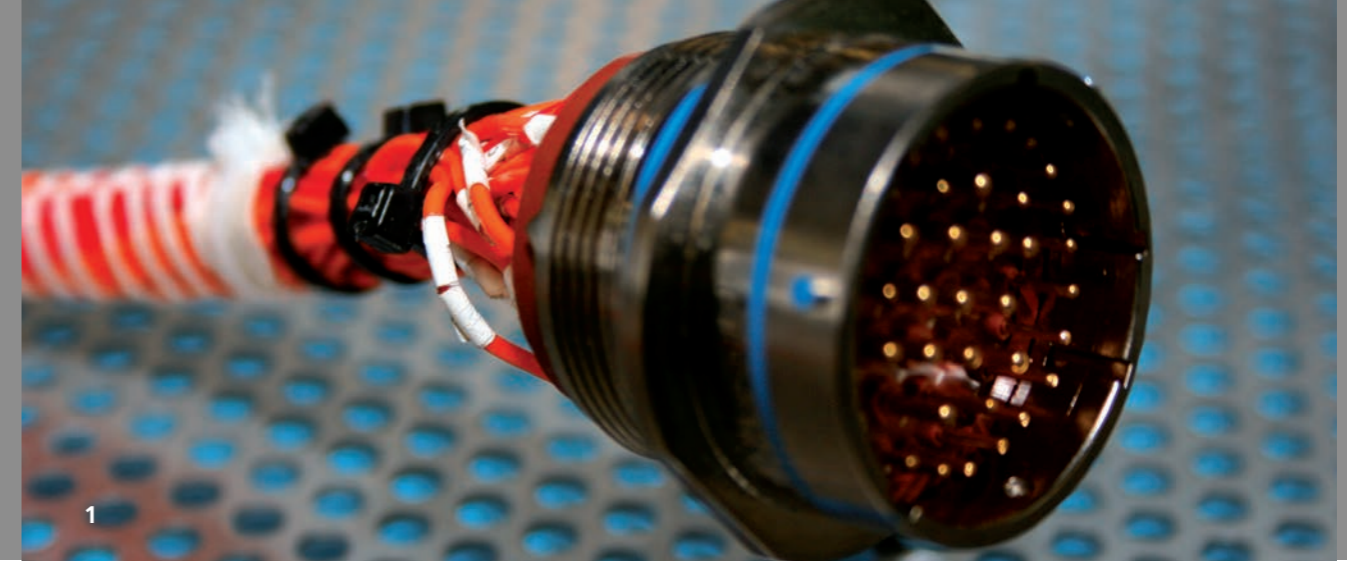
Trends

Groundbreaking advances in electronic system integration can be achieved by fusing form and function. A key innovative technique here is generative manufacturing technology. Electro-mechanical interconnection requires new interconnection, cable and shielding materials.

Multicomponent parts, so-called »smart power mechanics«, require intensive research into the surfaces of the contacts and the electronic systems integrated into the connectors. Determining the geometries actually produced by the manufacturing process are key to understanding the relevant material's local and, where applicable, anisotropic properties. Using numerical simulation, this information can be used to quantify and describe new insights into micro- and nano-electronic development.

Key development goals:

- Development of connectors and feeder clamps with integrated sensors/actuators, so-called intelligent connectors
- Cost-efficient materials for connectors, cables and shielding in electrical interconnection (e. g. aluminum instead of copper)
- Increased use of crimping, clinching and press-fitting, including for high-current applications
- Numerical simulation using true geometries and material parameters
- Development of generative technologies and ink-jet printing techniques for smart power mechanics
- Improving rework and repair processes
- Advanced training approaches (esp. for areas such as solar technology, crimping, cable harness and blended learning)



RESEARCH & DEVELOPMENT HIGHLIGHTS

Paving the way for new training opportunities with improved facilities in the Technology Hall

In cooperation with the Fraunhofer Academy and with the support of the Board of Directors of the Fraunhofer Gesellschaft, the ZVE (Centre for Electronics Connection Technology) training centre at Oberpfaffenhofen has completely restructured its technology hall and modernized and expanded its technical facilities. A range of new soldering equipment was acquired with the active involvement and support of the manufacturers. On top of the reflow facilities, the new selective soldering equipment are a highlight addition, as they cover most of the technological capabilities currently available in the field. The site now enjoys access to selective wave soldering as well as induction and hot bar soldering. The new facilities expand the site's (training) capabilities in wire harness management and connector technology and represent a natural progression in the centre's development, following the installation of the Crimp laboratory several years ago and the »Smart Power Mechanics« project supported by the State of Bavaria.

Understanding the effect of mechanical stress on analogue ASIC circuits

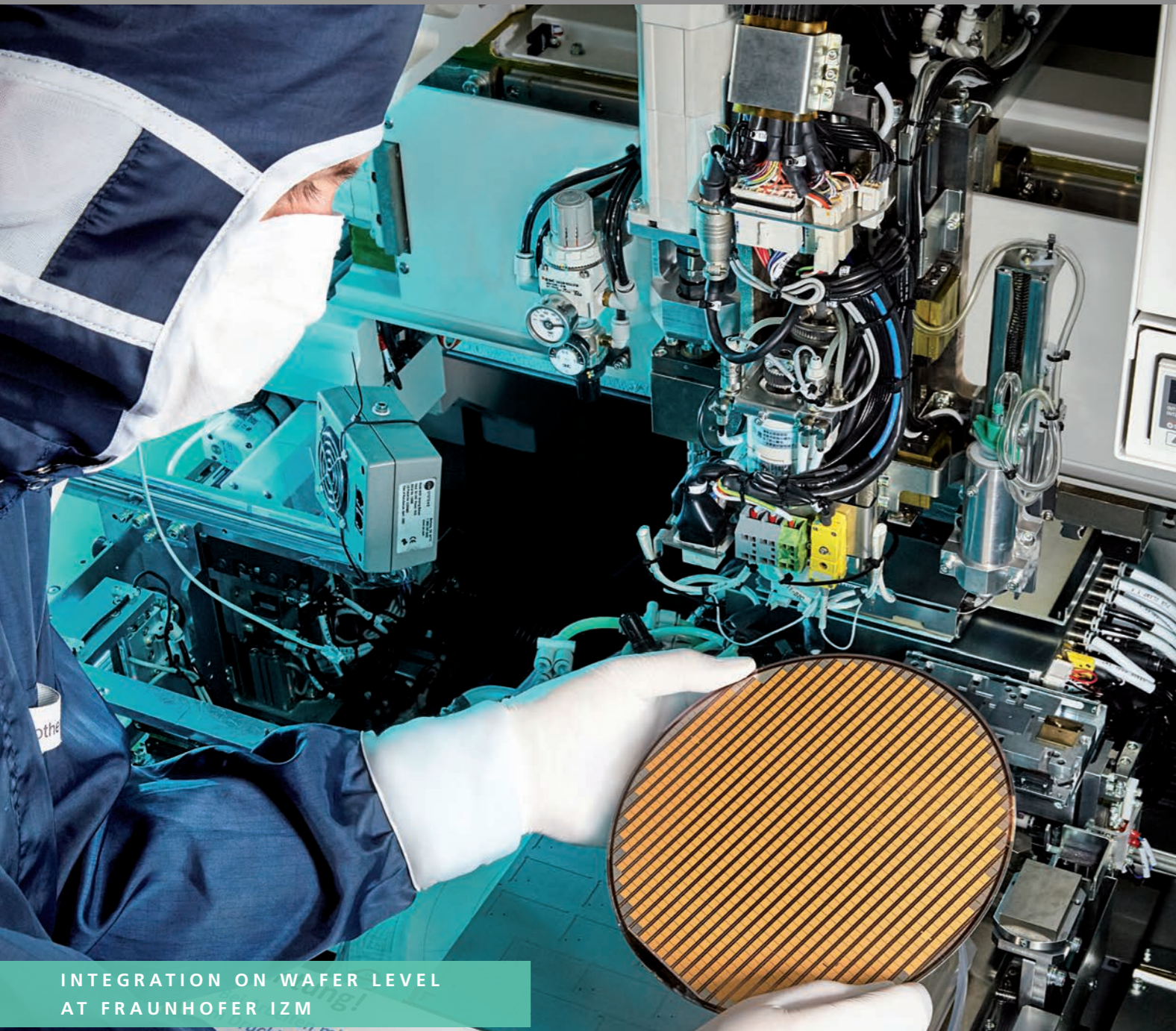
As analogue circuits are becoming increasingly miniaturized and integrated into application-specific integrated circuits (ASIC), it is becoming more and more important to be able to predict any forces and mechanisms affecting their correct functioning. By contrast with digital integrated circuits, where small deviations in the electronic conditions have no or only minimal effects, even tiny errors can cause substantial problems for analogue signals. One common cause of such disturbances is the mechanical stress that occurs in many different forms and degrees both in the original processing of the chips and in their later working life. In order to counter the issue of changing chip characteristics, circuits need to have a degree of resilience built in by design. Different stress scenarios need to be simulated for their proposed layout from the beginning.

A selection of semiconductor systems has been exposed to mechanical stress and tested to add their behaviour under stress to their SPICE models. The simulation results were compared to a test circuit built to the proposed design and exposed to the simulated forces in real life. The FEM simulation of the effects during packaging and application tests has helped improve the chip layout for a battery management ASIC produced by Atmel. The project was made possible by the support of the German Federal Ministry of Education and Research under the project name »IKEBA«.

1 Connector as a training device in a cable harness and connector course

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RESEARCH CLUSTER INTEGRATION ON WAFER LEVEL



INTEGRATION ON WAFER LEVEL AT FRAUNHOFER IZM

The highest integration densities possible in hetero-geneous 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.

HIGHLIGHT 2015

Intelligent light sources for adaptive headlight systems

The companies Daimler, HELLA, Osram, Osram Opto Semiconductors, Infineon Technologies and the Fraunhofer institutes IZM und IAF have together developed an active matrix LED light source. The collaboration was made possible by the BMBF (German federal ministry of education and research) project μ AFS (grant number: 13N12512). Fraunhofer IZM's contribution included mounting a flip-chip LED array with 1,024 pixels onto an active driver capable of controlling each pixel individually. The consortium was already able to present the first 1024-pixel light engine (the LED equivalent of a conventional lamp) at ISAL 2015, a full year before official completion of the project.

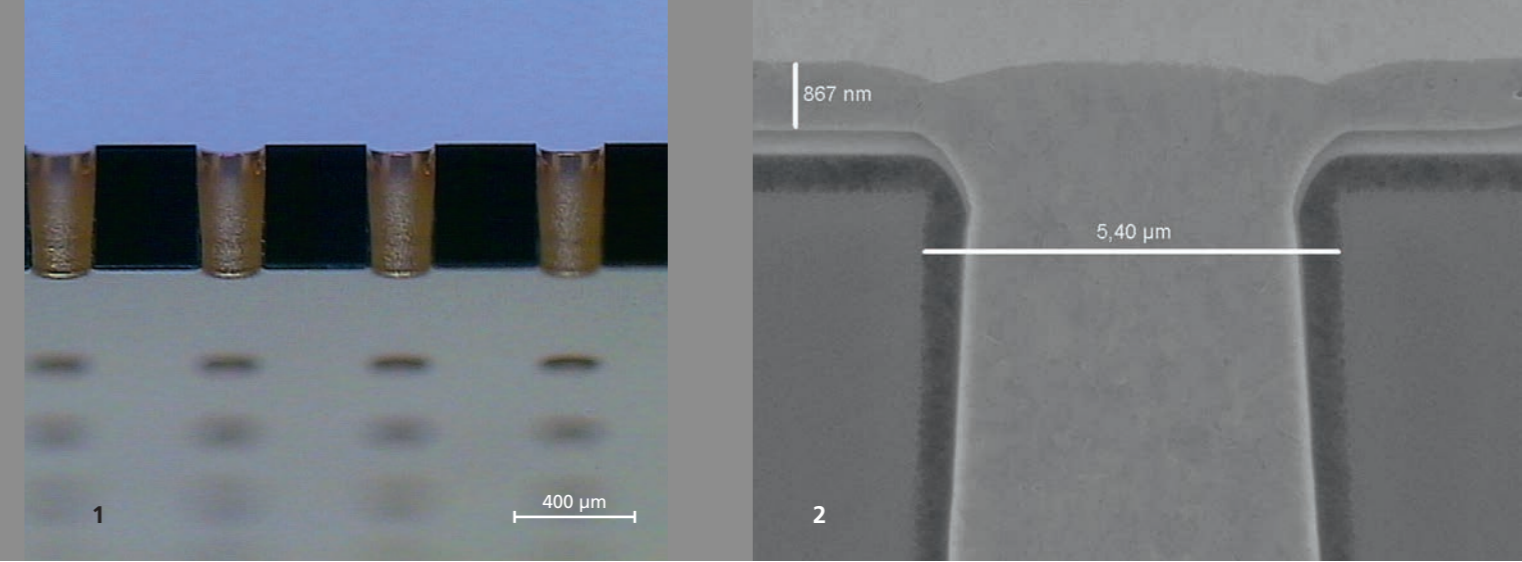
The LED chips were mounted on the silicon wafer with 15 μ m in pitch to ensure homogeneous distribution of the luminescence. The robust bond interface was specially designed for excellent thermal dissipation. The assembly's topography necessitated a bump design that could balance out height differences of several μ m. To solve this, two different technology approaches were investigated in parallel: Thermocompression bonding using nonporous gold and reflow soldering using highly reliable AuSn.

The former approach was selected, as it offers both low bonding pressure and temperature and because it allows compression. 10 μ m high porous structures were then created on the LED wafer using conventional techniques. The porous layer (also referred to as nano-sponge) was created by etching, resulting in an open-pored structure with 200 nm pores and a porosity of between 70 and 80 percent. The fact that the nano-porous gold layer (or nano-sponge) is compressible was therefore key to the success of the design, because it was able to compensate for the unevenness of the topography. Porous and almost compact interconnections were the result. AuSn solder bumps were formed on LED wafers by sequential deposition of gold and tin.

The latter solder alloy was crafted during preconditioning using a diffusion process. The pixelated LEDs were flipped onto the driver wafer by pick & place and the solder interconnects were then re-melted solvent-free in a batch oven. Both bump types and montage techniques were applied and proved to provide both high yield and a robust interface for subsequent LED processes.

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3D flip chip assembly
chip-to-wafer by AuSn
reflow soldering or ther-
mocompression bonding
with nanoporous gold



WAFER LEVEL SYSTEM INTEGRATION – ALL SILICON SYSTEM INTEGRATION ASSID

The Department

The research activities of the department »Wafer Level System Integration« and its staffs at Fraunhofer IZM in Berlin and at »ASSID - All Silicon System Integration Dresden« focus on technologies for wafer level system integration and packaging.

The process lines allow high flexibility regarding the processing of 8"-12" wafers and are characterized by a high adaptability of the individual processes.

The process line at IZM-ASSID is particularly tailored to realize production-related and industry-compatible development and processing (ISO 9001).

The focus of the scientific work is on:

- Wafer level packaging and CSP
- 3D wafer level system in package (WL SiP)
- TSV interposer
- High-density redistribution
- Ultra-fine pitch micro-bumping
- Pre-Assembly (Thinning, Dicing, Singulation)
- Die to Wafer (D2W) assembly
- 3D wafer level stacking

R&D services for customers from industry include process development, material evaluation and qualification, prototyping, low-volume manufacturing as well as process transfer. Newly developed technologies are individually adapted to customer-specific requirements.

Trends

The merging of technologies for »More Moore« and »More than Moore« is of high importance for the development of micro systems. Furthermore, cost efficient solutions for the overall system have to be developed and realized. Also, a joint view at design, technology and reliability aspects is of increasing significance. This constitutes a particular challenge for the heterogeneous integration of devices into a multifunctional, miniaturized and reliable wafer-level system-in-package while simultaneously considering cost optimization.

Respectively, the research and development goals are aligned to the following:

- Evaluation and implementation of new material e.g. polymeric dielectric (< 200°C curing)
- Development and realization of adapted fine-pitch interconnect structures (μ -bumps, Cu-Pillar, Cu-Cu) on chip/substrate level
- Development of new interconnect structures and systems (low temperatures, low force) for ultra-thin chips and wafer stacks
- BEoL-compatible TSV integration (via middle, BS via, via last) for 3D systems
- Heterogeneous integration based on interposers (silicon, glass)
- Adapted pre-assembly technologies (wafer thinning/ dicing) and thin wafer handling processes
- Development of highly reliable manufacturing-compatible 3D assembly technologies (D2W/W2W)

RESEARCH & DEVELOPMENT HIGHLIGHTS

Gold TSV technology for photonic packaging

Within the project PARADIGM (Photonic Advanced Research And Development for Integrated Generic Manufacturing), Fraunhofer IZM successfully developed a through silicon via (TSV) technology in gold featuring TSVs and a patterned double-sided metallization. Such a copper-free metallization is an important technology for photonic packaging (III-V semiconductors). Test vehicles with a coplanar waveguide and TSVs have been realized and compared to a conventional wire bonded waveguide. The TSVs have a diameter of 200 μ m and a depth of 400 μ m, the waveguide length is 100 mm. The target was to reduce the crosstalk and attenuation by using TSVs. The measurements carried out by the project partner CIP show a significantly improved performance. The attenuation was considerably lower (2 db at 40 GHz) and the crosstalk showed a more flat course.

Titan wet etch – replacement of diluted fluorhydric acid (dHF)

For shrinking pillar diameters (<40 μ m) it is becoming increasingly important to replace the currently used diluted HF for Titan (Ti) UBM etch. The optimized Ti etch process with dHF currently shows a minimum undercut of around 0.5 μ m. Different peroxide based chemistries have been tested to exchange HF. These special chemistries have to fulfill some additional requirements and have to be compatible to Copper, Nickel, Tin, Silver and Aluminium. The process development and optimization has resulted in a Ti undercut of 0-0.1 μ m. The higher price of these chemistries can be compensated by reuse. Therefore, a bath life evaluation with maximum capacity has been achieved.

Advanced plating metal TSV ECD process

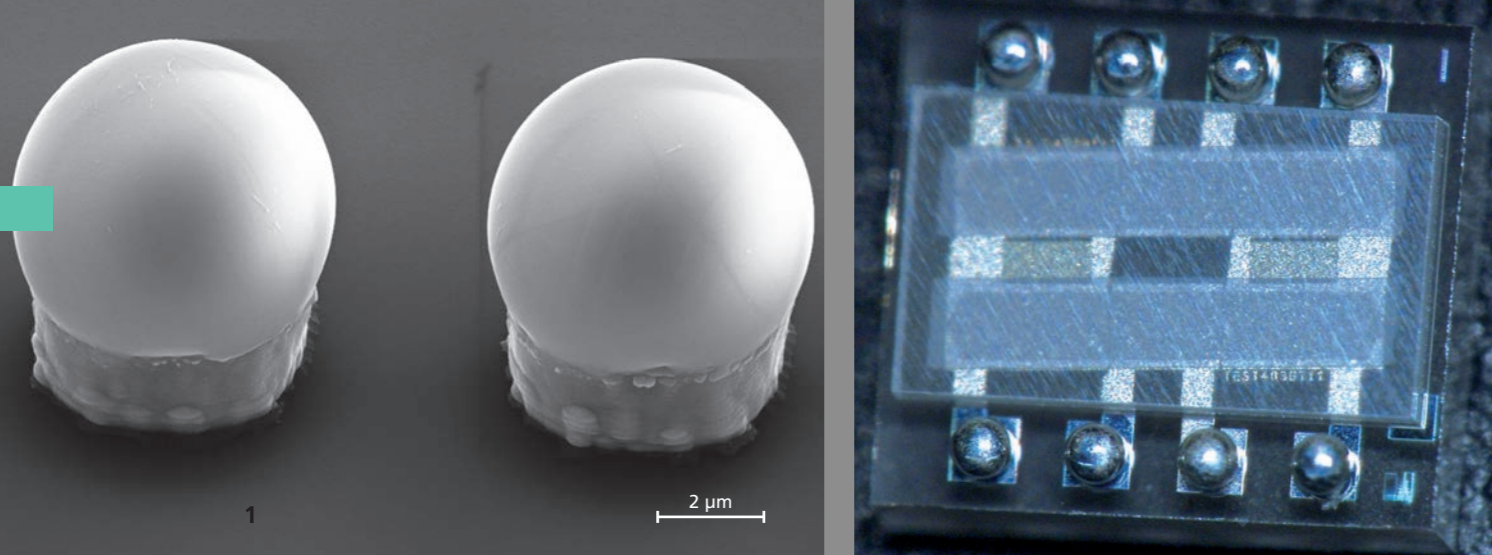
TSVs with the dimension of 5x50 μ m can be filled within only 19 minutes by keeping the copper overburden to less than 1 μ m on a 300mm wafer. For the metallization of large TSVs a copper liner is commonly used – a very uniform conformal liner was deposited into large TSVs with dimensions of 80x260 μ m. Using the TSV plating tool the copper overburden and the process time could be reduced by more than 50 percent. Also, the roughness was minimized. The high throughput makes this process industry-compatible.

1 Coplanar waveguide with gold TSV's to improve the gighfrequency performance (cross section)

2 TSV (5x50mm) with overburden (< μ m), 19 min ECD

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Indium flip chip bonding for X-ray pixel detectors

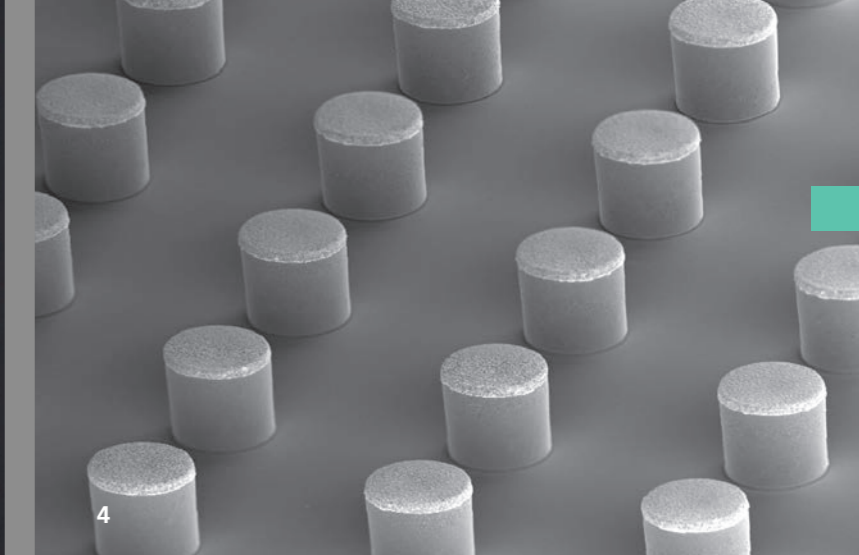
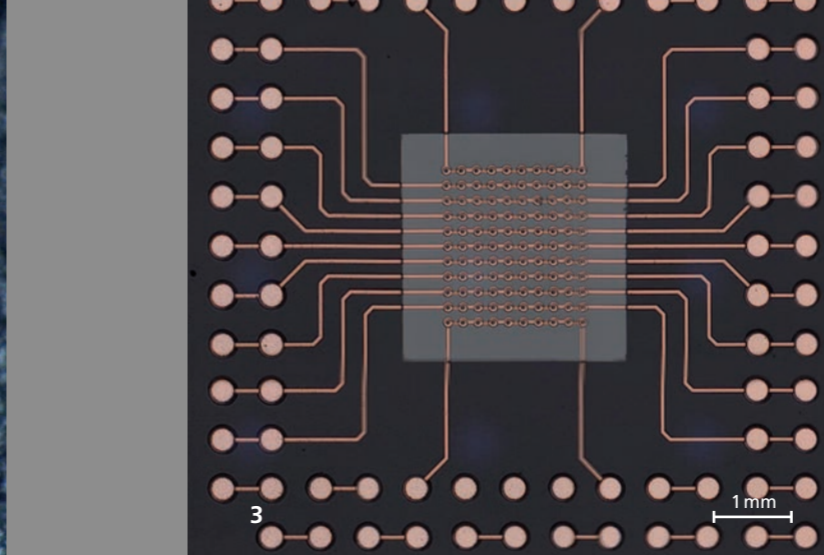
In various application areas, e.g. material analysis, detector materials are required that show a better absorption of high energetic X-rays than silicon. Those are semiconductor materials e.g. GaAs, CdTe, CdZnTe or germanium. In this field, Fraunhofer IZM is working with national and international research institutions such as CERN or DESY and focuses its activities on the deposition of electroplated micro bumps and flip chip assembly of the detector modules. The maximum processing temperature of those special detector materials are partly limited to 150°C. Therefore, special low temperature solder materials have to be used for the flip chip bonding. To meet this challenge, Fraunhofer IZM has developed indium bumping processes for 100-200mm wafers as well as bonding processes for the required temperature range. Furthermore, alloys of indium and tin have been investigated which have a particularly low melting point of just 117°C, thus offering the chance for an even lower bonding temperature in the process. The developed structuring and bonding processes can now be reliably offered for pixel pitches of 55 μm. Beyond that, another optimization process could already demonstrate a deposition of bumps with the size up to 6 μm and with a pitch of 10 μm.

Capping technology for wafer level chip size packaging of SAW filters

Fraunhofer IZM has expanded its wafer level capping technologies for wafer level packaging of SAW (surface acoustic wave) filters. The approach is based on quasi hermetic wafer to wafer bonding for partial capping of the SAW components at the lithium tantalate (LiTaO₃) device wafer leaving the peripheral IOs of the devices accessible. To enable such a process scheme the latter cap structures are pre-processed on blank LiTaO₃ wafers by fabrication of adhesive bonding frames followed by removal of the areas around the frames using partial cut dicing. The pre-processed wafers provide LiTaO₃ post structures with bonding frames on top. Size, positions and pitch of the frames and posts were defined according to the layout, size and pitch of the SAW structures on the device wafers. Now the wafers are bonded to the SAW device wafers using a thermo-compression type wafer to wafer bonding process. A following back grinding of the bonded LiTaO₃ wafers with the posts separates all cap structures from each other. Solder balling and singulation of the device wafers finalizes the packaging process. As SAW structures, we used 403 MHz devices designed for a MICS (Medical Implant Communication Service) band application. The size of a final SAW filter device packaged with the described technology is 1.7x1.5 x 0.45 mm³. The work was initialized and funded by Vectron International GmbH, Teltow.

Fan-out wafer level packaging (FOWLP)

The embedding of chips in a mold compound and the implementation of wafer level technologies in such kind of substrates is a very topical issue. This technology not only enables simplified solder bumps routing of single chips, but also allows the integration of heterogeneous chip types in a package in the narrowest of spaces. For this, demonstrators have been realized for a



customer. Here, the electrical interconnects between the chips are realized directly in thin film redistribution layers. By avoiding wirebonds or bumps the parasitic effects could be noticeably minimized compared to conventional setups. These characteristics make this approach attractive for embedding especially for HF systems. The low softening point of currently used mold compound requires a continuous low-temperature processing for the realization of the redistribution layers. In a joint project together with DOW it could be demonstrated, that DOWs photosensitive dry film dielectric is especially suitable for FOWLP. The material is applied in a lamination process (similar to a PCB process) which allows more flexibility considering substrate size and surface conditions. For FOWLP, this BCB material is especially appropriate, because it can be hardened at low temperatures, shows a high resolution and allows – with a permittivity of 2.7 – a low-loss signal transmission also for high frequencies. Within the project high frequency structures have been realized in embedded chips. Due to the low dielectric loss of the material it could be demonstrated that at 40 GHz a signal transmission of more than 90 percent with a conduit length of 6 mm can be reached.

Glass via and glass interposer technology

Glass is well established as wafer or panel substrate for applications like capping of image sensors or as low loss carrier for integrated passive devices. Glass substrates with higher functionality also become more attractive for advanced packaging due to the improvement of glass processing and the increased implementation of photonic packaging which is demanded for higher data transfer rates. The usage of glass for applications such as high density interposers is significantly promoted by improvements in the forming process of vias into the glass by laser drilling, electrical discharge or alternative technologies. The developed metallization technology allows the formation of small glass vias with high aspect ratio and low pitch. Together with industry partners, Fraunhofer IZM has developed a glass via metallization on 300 μm thick glass. High yield and excellent reliability have been achieved and demonstrated on 200 mm wafers by using different test structures. The technology can also handle glass substrates with a thickness below 300 μm down to 50 μm. The technology allows to generate a hermetically closed via which was demonstrated by helium leakage test. To prove the advantages of glass based packages for RF system design, the electrical parameters of the glass substrates were characterized for frequencies up to 100 GHz by resonator structures on wafer level.

Process development for advanced Cu-Cu-hybrid bonding

A new CMP process was developed to achieve an excellent planarization behavior across a 300 mm wafer in presence of copper and oxide (DBI). Beside the step height, also a very good surface roughness for both materials was required and achieved. New CMP materials and tight process control facilitate this Cu-Cu-hybrid bond technology (patent-registered by Ziptronix) on 300 mm wafers.

1 Fine-pitch-interconnects: Indium micro bumps (6 μm diameter, 10 μm pitch)

2 SMT compatible wafer level chip size package of a SAW filter with cap on active area

3 Wafer-level packaging of embedded silicon chip

4 Plated Cu pillars with SnAg cap before UBM etch

RESEARCH CLUSTER MATERIALS & RELIABILITY



MATERIALS & RELIABILITY AT FRAUNHOFER IZM

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.

HIGHLIGHT 2015

Assembly technology and reliability assurance for temperatures up to 300°C

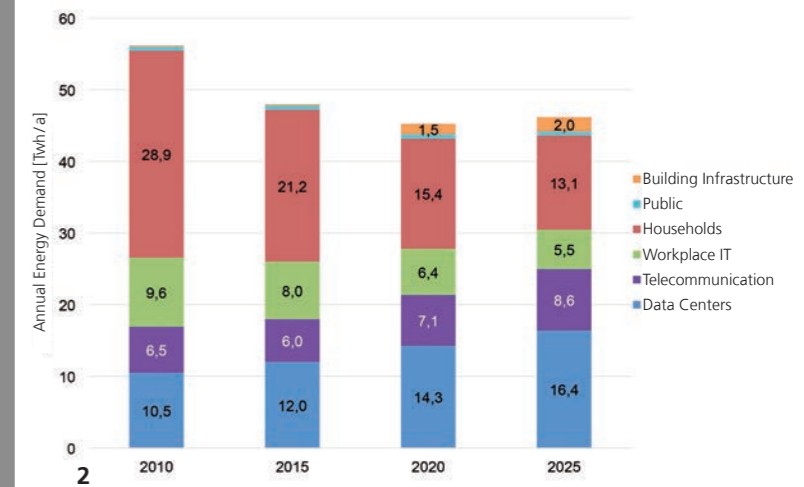
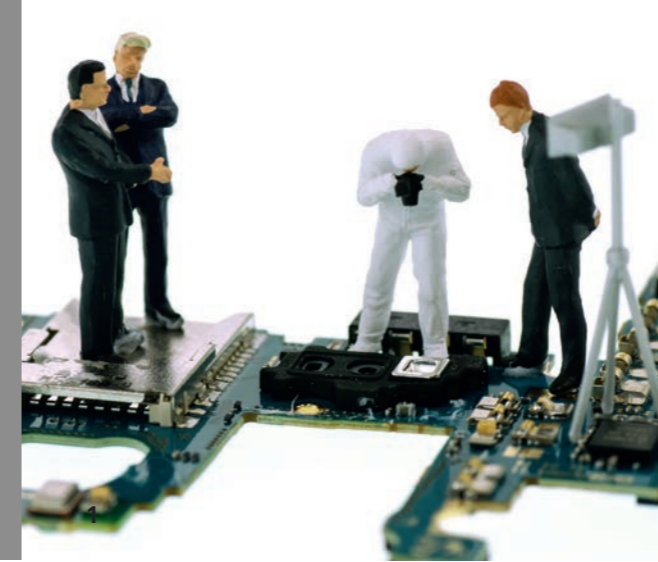
Sensor operation and data pre-processing at temperatures over 200°C places unique demands on semiconductors, packaging as well as, substrate and housing materials. The research consortium comprising the Fraunhofer institutes IMS in Duisburg, ENAS in Chemnitz, IKTS in Dresden, IWM in Halle and IZM in Berlin addressed this problem in the project HOT-300. The project goal was ensuring reliable operation at temperatures up to 300°C for sensor components, integrated circuits and capacitors on ceramic carriers. A key focus was developing a reliability optimization approach, including testing, material qualification and simulation, which is not only able to verify such high-temperature resistance, but which can also facilitate the design of future innovative high-temperature systems.

Fraunhofer IZM's contribution to the project covered packaging technology and reliability testing. A number of interconnection technologies potentially suitable for 300°C operating temperatures had already been identified previously. The primary task now was to determine chip shapes and dimensions, metallizations, packaging technologies and substrate metallizations, which could be combined into an assembly able to withstand such high stress levels, including temperature drops from 300°C to -40°C. This question was systematically investigated in the project. The newly developed reliability optimization technique was applied using a combination of concurrent technology development, testing and modeling. The results allow faster and more cost-efficient development of technology with customer specific temperature resistance goals and boundary conditions in follow-up cooperations with Fraunhofer IZM.

In detail, flip-chip interconnection technologies were assessed using a new test chamber and an in-situ monitoring system developed in-house. Failure mechanisms were analyzed and a suitable variant based on AuSn metallization was identified. Here, the semiconductors were first metallized on wafer-level and subsequently processed individually. For face-up chip assemblies silver sintering was used for the die attach to a lead frame. Key design and material characteristics were determined in the modeling and experiments. Operation was reliable over 1,000 temperature cycles at temperatures from 300°C to -40°C.

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Temperature cycling with
online monitoring for
applications up to 300°C



ENVIRONMENTAL & RELIABILITY ENGINEERING

The Department

Reliability and environmental requirements are meanwhile an acknowledged quality characteristic, over and beyond compliance with legal requirements. The »Environmental and Reliability Engineering« Department supports engineering developments for the market by carrying out environmental and reliability investigations, from nano-characterization through to evaluation and optimisation on the system level.

Interdisciplinary approaches are developed further and specific industrial questions are addressed:

- System reliability from the packaging technology to the product level
- Design for reliability and lifetime simulation
- Material characterisation and modelling
- Thermal design, thermal interface characterization
- Combined and accelerated load testing
- Ageing and failure analyses, sample preparation and analysis
- Testability and online-monitoring of accelerated ageing
- Methods and hardware for condition monitoring
- Reliability management in R&D
- Eco-reliability for microelectronic concepts
- Carbon footprint, Green IT, use of renewable raw materials
- Eco-design, life-cycle modelling
- Environmental legislation (e.g. RoHS, WEEE, EuP/ErP)

Trends

In the past, environmental protection measures focused on preventing the introduction of harmful substances into the environment and increasing the energy efficiency of manufactured goods. However, in fact, the manufacturing process itself largely determines the environmental footprint of a product in terms of energy and materials consumed. For this reason, the global focus has turned to improving energy and material efficiency by means of the so-called »circular economy«. In 2015, the European Commission released a comprehensive package of measures for this approach in 2015 and it is also an increasingly hot topic in the private sector. The goal is planning and optimizing product life cycle, as part of which many aspects of the following areas require rethinking and restructuring:

- Recycling
- Processing
- Capacity for and ease of service and repair
- Modularization
- Durability

Fraunhofer IZM is increasingly introducing the above aspects of sustainability and durability into its current and planned cooperation projects with partners from science and industry. Whether individually and combined, these questions are considered across the board, from efficiency evaluation, to technical implementation, right through to reliability assurance. The following application areas are of key importance here:

- Mobile devices
- ICT and network engineering
- Autonomous sensor technology (i.e. with sensors with self-sufficient power supplies)
- Power electronics
- Photonics and lighting

RESEARCH & DEVELOPMENT HIGHLIGHTS

Trends in Germany's ICT power consumption

Fraunhofer IZM joined forces with the Borderstep Institute in a project for the German federal ministry for economic affairs and energy (BMWi) to analyze ICT (information and communication technology) power consumption in Germany for the time period 2010 to 2025. Thanks to increasingly efficient end devices, power consumption by ICT is actually declining, because end devices have become more and more energy efficient. In 2015, an estimated total of 48TWh was consumed. However, significant increases in data centers and telecommunication networks will see this trend reverse in the medium term. Thanks in no small part to the European Ecodesign Directive, end devices have already been advanced as far as technologically possible and energy consumption has been minimized. Fraunhofer IZM's product-specific preliminary studies played a key role in this process. The focus is now shifting to optimizing the power consumption of ICT networks and data centers.

Modular design and recycling of mobile end devices

Fraunhofer IZM has brought together industry players in a European project applying the principles of the circular economy to mobile end device design. For example, modular design simplifies replacing defective parts, which increases product lifetime. Moreover, for some individual assembly units, combining embedding technology with innovative interconnection technologies can reduce resource consumption, improve reliability and facilitate the recycling of expensive semiconductors. Component value can be maximized by automating disassembly processes that recycle electronic parts for reuse in other products. The companies contributing to this project include Fairphone, Circular Devices, iFixit, AT&S and ProAutomation.

Reliable piezoelectric power supply for (energy) self-sufficient sensor modules

The German ministry for education and research (BMBWF)-funded project PETra is developing processes for designing reliable, durable piezoelectric harvesters. Using modeling and inspection techniques that take application requirements into account, the project is rethinking the entire production process, from piezoceramics to power conversion and assembly. Together, the Berlin-based consortium covers the entire supply chain, from research by Fraunhofer IZM, to development (AMIC and AEMtec), right through to application-level (Yacoub Automation). The first demonstrators and models have now been proven and will be an important foundation for a great variety of wireless and autarkic (energy self-sufficient) sensor applications.

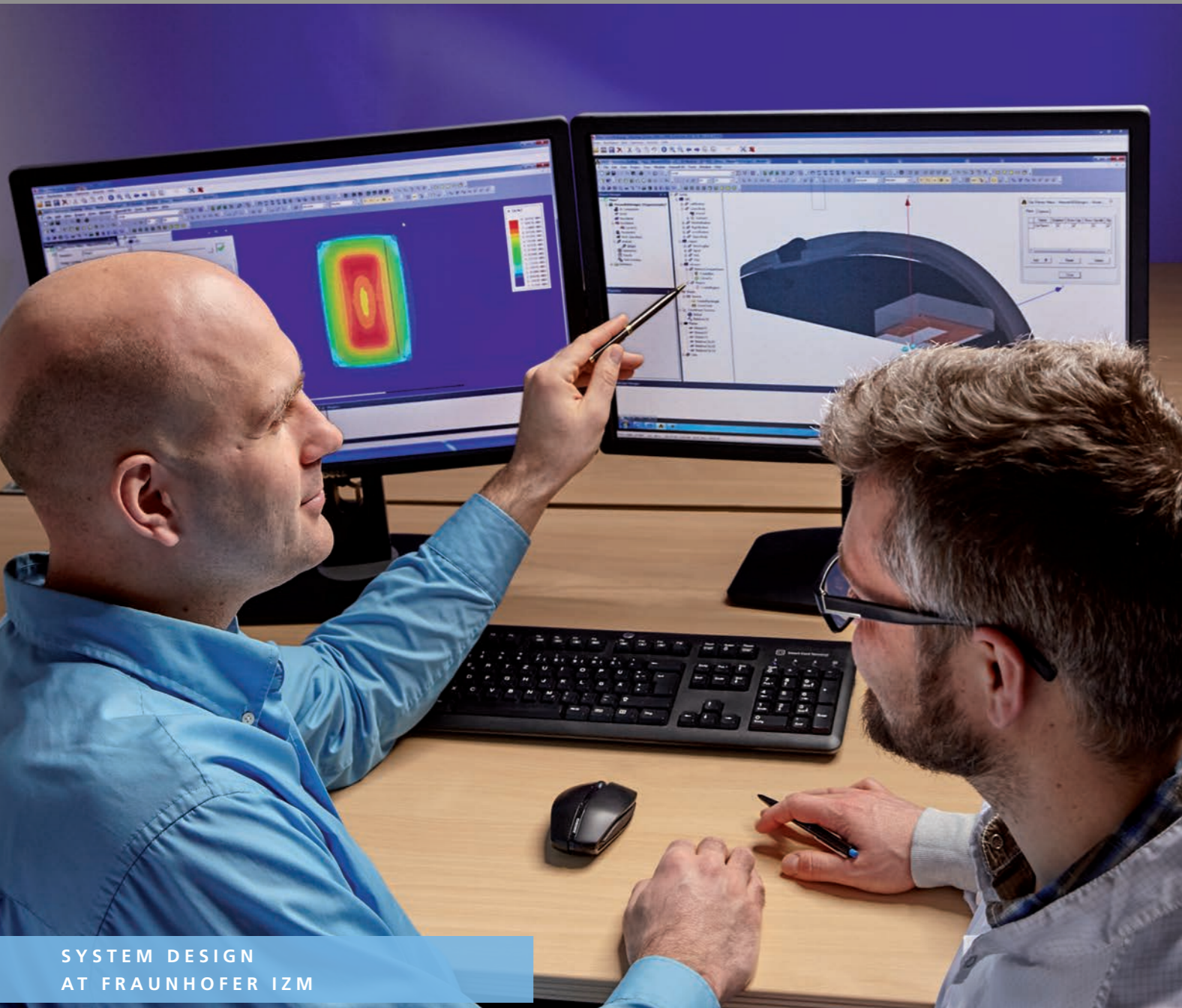
1 Investigation of commercially available smart phones as first step towards developing an automated disassembly process

2 Analysis and predicted development of ICT power requirements in Germany

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RESEARCH CLUSTER SYSTEM DESIGN



SYSTEM DESIGN AT FRAUNHOFER IZM

Packaging and system integration technologies are central components in all modern microelectronic systems. They determine every aspect of systems, from physical properties, to electrical functionality, through to reliability. Packaging and system integration technologies have to keep pace with ongoing miniaturization, increasing complexity, ever-higher frequencies and growing data volume. A key future task will be more precise characterization and optimization of electrical, thermal and thermo-mechanical properties. Fraunhofer IZM is uniquely placed to meet the challenge of combining excellent technology development with electrical, thermal and thermo-mechanical modeling, simulation and analysis. Moreover, Fraunhofer IZM's system design expertise bridges the gap between technological progress and the systems that can put it to use.

HIGHLIGHT 2015

Wireless Power Systems

In the office, at home, or out and about: Mobile devices are our constant companions. As the devices have become more widespread, they have also become more powerful, and more energy-hungry. Batteries need to be recharged all the time. This is usually done with a plugged-in AC adapter, taking away the liberty of mobile use: There is no power outlet to be found; the charger won't fit despite recent advances in standardization; or the mobile application requires a sealed or even explosion-proof design that cannot accommodate a power plug.

One solution to this all too common problem is wireless inductive energy transfer, which is already being used in a number of cell phones. Integrating the required charging technology needs considerable knowhow in electronic system and circuit design and in the layout of effective induction coils.

The European research project on »Wireless Power Systems« (WIPOS) has developed a systematic approach to empower companies to develop and implement efficient inductive, wireless charging systems for their products. The work has focused on electronic circuit and mounting technology.

A wireless computer mouse design was used to explore problems of component selection, energy efficiency, and coil layout, and the results were processed to help companies in the field streamline their R&D efforts. One key aspect was the design of planar coils for cost-efficient circuit board production. The findings were integrated in software tools for improved circuit development and coil design. The project concluded with a demonstration prototype of a wireless charging station and charger module, integrated in the battery slot of a standard mass produced computer mouse.

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PC based design of
receiver coil for wireless
charging system integra-
ted into computer mouse



RF & SMART SENSOR SYSTEMS

The Department RF and Smart Sensor Systems

The »RF & Smart Sensor Systems« department stands for technology-driven system competence at Fraunhofer IZM. This competence can be experienced in action e.g. in the autonomous microsystems that have played a key role in the development of groundbreaking solutions, from the eGrain to autonomous sensor nodes or full-scale cyber-physical systems in the Internet of Things. The department develops methods, models, and design concepts for innovative microelectronic components and modules as well as complete systems for communication, radar, and sensor applications. The right tools for optimum designs are an indispensable part of our offerings. The focus of the department's work lies on:

- HF characterization of packaging materials and optimization of technologies in the field
- Design and integration of miniaturized wireless sensor systems
- Power supply and power management in microelectronic systems
- HF and high-speed system design
- Physical design tools and software

The services of tomorrow are made possible by the research and development efforts of today. The department's intensive commitment to research is evident in our regular presence at leading academic and industry conferences and our contribution to numerous research projects.

Trends

The buzzwords of our time – the Internet of Things, Industrie 4.0, or Cyber Physical Systems – are also influencing the nature of our work. Machine-to-machine communication is becoming increasingly relevant, as is security in the remote transmission of data. Sensor technology is seeing increasing demand for autonomous wireless sensor system with operating systems designed for energy efficiency and the efficient processing and consolidation of sensor data. Users are particularly interested in closed data streams from the sensor to their IT infrastructure.

Real-time capabilities, robust designs, security, and high data rates are becoming important criteria in wireless networking. 5G mobile communication networks and 60 GHz communication systems offer promising new vistas. Controllable antennas promise new functionalities, with potential for radar sensor technology. As in the case of wireless interfaces, great potential for innovation seems to lie in the combination of different interface frequencies.

System concept development is gaining in prominence and pushing the trend towards greater integration of circuit design with technology development. Hardware-software co-design seems as indispensable as the innovation of new concepts for power supply in autonomous sensor nodes.

RESEARCH & DEVELOPMENT HIGHLIGHTS

Satellite communication platform up to 75 GHz

An innovative design concept for a satellite communication platform was developed in cooperation with IMST GmbH and HISATEC, focusing on frequencies in the K/Ka band (18-40 GHz) and Q/V-Band (40-75 GHz). The optimum technological solution was chosen for each frequency range; design concepts were prepared, and demonstration units produced, showcasing a complete communication setup with antenna module, RF frontend, and baseband.

Autonomous sensor networks for monitoring high voltage overhead lines

The autonomous sensor network ASTROSE monitors critical parameters for the operation of high voltage overhead lines to make full use of their transmission capacities. Field trials have revealed that active capacity can be increased by 20 percent with the new system. The system developed in cooperation with colleagues at Fraunhofer ENAS provides a software toolkit to record the sensor data in a relational database, with a user interface designed for better visualization and sophisticated data analyses.

Silicon-integrated microbatteries

With an ingenious application of the processes used in silicon wafer technology, the Fraunhofer IZM is producing hundreds of miniature lithium microbatteries in a single production run. The batteries can achieve capacities of approx. 1 mAh/cm² and can accommodate currents high enough to complete discharge within ten minutes. The electrodes for the microbatteries are produced in strips of interdigital electrodes. Another innovation is the use of a microfluidic electrolyte filling technology and encapsulation on a wafer level.

Developing a stress monitoring system to track mechanical stresses on semiconductors and microsystems in packaging and production

A sensor IC is used to monitor the stresses exerted on components during production and the environmental forces affecting them during their working life by measuring and quantifying the forces in the packages themselves. The solution relies on an industrial PC, a standard monitoring card, and custom hardware components. The power supply, signal generator, and frontend for the measuring chip have been optimized for improved accuracy, miniaturization, and power intake.

1 Energy-autarkic sensor system to monitor the pitch of overhead power lines

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FRAUNHOFER IZM EVENTS



Events & Workshops

Page 60

Workshops 2016

Page 66

Promoting Young Talents

Page 68



EVENTS & WORKSHOPS

Fraunhofer IZM opens new AdaptSys Center

Fusing product manufacturing with microelectronic system integration – that's the bold goal of AdaptSys, a new center at Fraunhofer IZM in Berlin. Almost 40 million euros has been allocated to the initiative by the European Union, the Land Berlin, the German Federal Ministry of Education and Research and the Fraunhofer Gesellschaft.

Together with 150 partners from science and industry the institute celebrated the opening of AdaptSys on September 1, 2015. Special guests and long-term partners were there to take a look at the new laboratories and give short welcoming speeches – Cornelia Yzer, Senator for Economics, Technology and Research, Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft and Dr. Stefan Mengel, head of division »Electronic Systems, Electromobility« in the Federal Ministry of Education and Research.

AdaptSys promises to overhaul how microelectronic technology is integrated into products. Despite microelectronic technology's central role in modern-day product functionality and the value-added chain, most products are still retrofitted after the manufacturing process has been completed. The new center will develop techniques and processes for integrating electronics and sensor technology during the manufacturing process itself in almost all types of products, including car seats, tools, kitchen aids and even fabric. This new approach to manufacturing has numerous benefits: it will improve system integration, because the product design can be optimized to accommodate or enhance the microelectronic functionality and/or assembly. Like Fraunhofer IZM as a whole, AdaptSys will prioritize the needs of industry by cooperating with local product manufacturers, who stand to benefit from the

center's new process innovations. The center will also provide 200 new jobs at Fraunhofer IZM Berlin alone. Cornelia Yzer, Senator for Economics, Technology and Research: »AdaptSys puts Berlin on the map nationally and internationally as a top address for electronic system integration. The state-of-the-art laboratories facilitate new innovations and technological developments for the Internet of Things. Thus AdaptSys plays a key role in the digitalization hub Berlin.«

Signal and Power Integrity (SPI) Workshop 2015

From May 10-12, 2015 Fraunhofer IZM hosted the 19th IEEE-Workshop on Signal & Power Integrity in Berlin. More than 80 participants from 21 countries gathered at the event to present and discuss their current work from the realm of signal and power integrity. The main focus was on developments in the areas of interconnect modeling, simulation and measurement on chip, board and package level. The workshop was chaired by Fraunhofer IZM head of department Ivan Ndip.

ITG-Workshop »Optical Components for Cloud-DataCenter«

The Information Technology Society in the VDE (ITG) and the University of the Harz in Wernigerode hosted a workshop on »optical components for cloud data centres« on 20 May 2015 at the Fraunhofer IZM in Berlin. International speakers offered the participants a look at the newest trends and developments in photonic components and mounting technologies for optical sensors, optical communications, and silicon photonics.

1 From left to right:
Prof. Reimund Neugebauer, Dr. Stefan Mengel,
Cornelia Yzer, Prof. Klaus-Dieter Lang at the festive
opening of the AdaptSys-Center





Research Network »Functional Integration in Micro and Nanoelectronics«

In presence of the prime minister of the Free State of Saxony, the president of Fraunhofer Gesellschaft, further involved parties as well as guests from industry and politics the Research Network »Functional Integration in Micro and Nanoelectronics« was inaugurated on June 17, 2015 in Dresden. This research network is set up as a pilot project and unites researchers from four Fraunhofer institutes, the Technical Universities in Dresden and Chemnitz as well as from companies to help accelerate the implementation of research results into innovative products.

The overall goal is to strengthen the economic location Dresden/Chemnitz, to promote the competitiveness and innovation capacities of industry in the field of sensor and actuator technology, metrology as well as mechanical and plant engineering and to expand existing research excellence. Fraunhofer IZM's center »All Silicon System Integration – ASSID« will be contributing its extensive know-how in the field of heterogeneous system integration.

Workshop Micro Battery and Capacitive Energy Harvesting

Rechargeable micro batteries are an enabling technology for energy autarkic systems such as wireless sensor nodes and medical sensors. In the European project MATFLEX-END durable flexible energy harvesters are developed that are especially intended for wearables, including smart textiles, shoes and other applications where mechanical compliance is needed.

The project's results were presented in the framework of a workshop on April 27, 2015. The entire production chain was discussed, including novel materials for battery electrodes and printable separators, high-k dielectrics and flexible electrodes, micro battery packages based on ceramics (LTCC), silicon and

flex laminate technologies, and ultra-low power electronics for harvester and battery management. A special highlight for the 52 participants were the IZM-exhibits, for example a low-energy bluetooth radio module that runs on solar energy with a silicon micro battery as energy storage.

Fraunhofer IZM at the Electronic Components and Technology Conference (ECTC) in San Diego

The 65th Electronic Components and Technology Conference (ECTC) attracted more than 1,500 experts from assembly and connector technology and microsystems engineering to San Diego, CA, from May 26-29, 2015. As one of the world's premier conferences in the field, Fraunhofer IZM was proud to maintain a strong and versatile presence and contribute substantially to the proceedings.

In dedicated half-day seminars, Ivan Ndip and Michael Töpfer (»Fundamentals of Electrical Design and Fabrication Processes of Interposers Including Their RDLs«) and Tanja Braun and Hans Walter (»Moisture and Media Influence on Microelectronic Package Reliability«) offered their audiences in-depth insights into their fascinating research endeavours. Five other colleagues also gave talks at the conference. The Fraunhofer IZM booth at the exhibition accompanying the conference drew in many interested attendees and was a great opportunity for showcasing the many and versatile competences of the institute.

Wafer & Waffles – Long Night of the Sciences 2015

For this year's Long Night of the Sciences on June 13, the Fraunhofer IZM invited people of all ages to come and get a look behind the scenes at the Institute. The cleanroom tours have already become a popular evergreen and were even more attractive this year with the »Wafer & Waffles« motto. The numerous visitors – kitted out in professional cleanroom gear – watched how large silicon wafers were made, mounted

Events with Fraunhofer IZM participation in 2015	
OTTI Fachforum: Protective Measures for Climatic Protection of Electronic Assemblies	March 2015, Regensburg
Symposium 3D Integration	April 2015, Dresden
Girls' Day	April 2015, IZM Berlin
Workshop: Micro Battery and Capacitive Energy Harvesting	April 2015, IZM Berlin
Signal and Power Integrity (SPI) Workshop	Mai 2015, Berlin
XII. ITG-Workshop »Optical Components for Cloud Data Center«	May 2015, IZM Berlin
FED-Workshop »Quality and Reliability of Boards and Assemblies«	May/ November 2015, Düsseldorf /Nürnberg
Long Night of the Sciences	June 2015, IZM Berlin
EIPC Summer Conference Berlin	June 2015, Berlin
Cluster Seminar: Pressfit Technology for Power Electronic Assemblies	July 2015, Nürnberg
PhoxTroT – 3rd Symposium on Optical Interconnect in Data Centers	September 2015, Valencia, Spain
Workshop: Reliability in Power Electronic Packaging	September 2015, Berlin
Course: Basics of Wave Soldering and Selective Soldering	October 2015, Wessling-Oberpfaffenhofen
Fraunhofer Talentschool: Mechatronics: Technology of the Future	November 2015, Munich
ECPE Workshop: Advances in Thermal Materials and Systems for Electronics	December 2015, Nürnberg
Workshop: Secure High Speed Data Transfer	December 2015, IZM Berlin

1 From left to right: Thilo von Selchow, Chairman of the Board of Zentrum Mikroelektronik Dresden AG; Stanislaw Tilič, Prime Minister of the Free State of Saxony; Prof. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft; Prof. Hubert Lakner, co-ordinator of the research network; Prof. Hans Müller-Steinhagen, Rector of the Technical University of Dresden; and Prof. Arnold van Zyl, Rector of the Technical University of Chemnitz at the opening of the research network »Functional Integration in Micro and Nanoelectronics«

2 Looking good - Fraunhofer scientists participating in a Berlin company run



with tiny micrometer-sized structures, and cut into recognizable chips. And just in case anybody got hungry after watching wafer after wafer being processed, real waffles were ready and waiting outside the cleanroom.

Aspiring surgeons tried their hand at endoscopic investigation of stuffed toys using the world's smallest camera, a Fraunhofer IZM innovation, and Fraunhofer IZM's TexLab »smart textiles« were also made available to visitors on the night.

The intensive focus on environmental protection and sustainability was reflected in the exhibition, including the presentation of diverse tablets being researched in a project by the institute's material scientists to determine how easily tablets can be repaired and recycled.

EMPC 2015 – 20th European Microelectronics and Packaging Conference

From September 14-16, 2015 the 20th European Microelectronics and Packaging Conference (EMPC) took place in Friedrichshafen on Lake Constance, organized by the German chapter of the »International Microelectronics and Packaging Society« IMAPS.

Fraunhofer IZM was involved in the event in multiple ways - first, as co-organizer through Martin Schneider-Ramelow, who heads both IMAPS Germany and the IZM department System Integration and Interconnection Technologies, second, as an exhibitor with a booth at the concurrent fair, and, last not least, with several presentations in the conference program.

With three keynote speeches, 84 presentations in 22 sessions and 25 posters, EMPC 2015 was a truly immersive experience for the more than 300 delegates from 30 countries. A special highlight of the event was the concurrent exhibition, where 45 companies and research institutions from all over Europe and even overseas presented their equipment and services to the conference participants.

Workshop Reliability in Power Electronic Packaging

Over recent years power electronics has developed into an increasingly important area of microelectronics. As an interdisciplinary technology it plays a key role in a multitude of applications, from automotive and safety to information and communication technologies.

On 17 September 2015 experts from all over Europe gathered in the Berlin Fraunhofer Forum for the Workshop »Reliability in Power Electronic Packaging« to discuss current trends and developments in packaging and interconnection technologies for power electronics. Topics were, among others, power electronics in harsh environments, factors influencing the reliability of power modules and failure mechanisms.

Secure high speed-data transfer

The rise of digital integration and digital controls in essential infrastructure, such as power grids or communication networks, paves the way for new levels of flexibility, greater functionality, and new monetization options. At the same time, the security, resilience, and reliable and efficient management of such infrastructures are becoming increasingly relevant.

These new challenges were the topics of a discussion about secure high speed data transfer and photonics-based data centres, hosted at Fraunhofer IZM on December 8, 2015. The attendees discussed a range of issues in the field, covering everything from tap-proof communication lines to Tb/s data connections or innovative data centre and network architectures.



Fraunhofer IZM at Expos and Exhibitions

From Nürnberg to Grenoble, San Francisco to Tokyo, and Moscow to Dresden – the IZM's scientists and researchers travelled around the globe in 2015 to showcase the newest IZM innovations at international conferences and exhibitions.

One perennial highlight was the SMT in Nürnberg, where the Fraunhofer IZM introduced new trends in packaging for harsh environments, sensor networks, wafer and circuit board technologies, and wearable electronics. In addition to running its own booth, the Fraunhofer IZM organized the sixth incarnation of the »Future Packaging« production line, with this year's presentation dominated by the new possibilities offered by Industry 4.0.

You can find an overview of all expo activities in the following table.

Fraunhofer IZM at Trade Shows 2015	
European 3D-TSV Summit	January 2015, Grenoble, France
Photonics West	February 2015, San Francisco, USA
Smart Systems Integration	March 2015, Kopenhagen, Denmark
SMT Hybrid Packaging 2015	March 2015, Nürnberg
Sensor & Test 2015	March 2015, Nürnberg
PCIM Europe	March 2015, Nürnberg
ECTC	March 2015, San Diego, USA
Semicon Russia	June 2015, Moskau, Russia
Silicon Saxony Day	July 2015, Dresden
Semicon West	July 2015, San Francisco, USA
EMPC	September 2015, Friedrichshafen
MEMS	October 2015, Karlsruhe
BMBF-Presentation »Assisted Care of Tomorrow«	December 2015, Erlangen
Semicon Japan	December 2015, Tokio, Japan

1 At EMPC 2015: Technical Chair Dr. Markus Detert, Grace O'Malley (iNEMI), General Chair Prof. Martin Schneider-Ramelow, General Co-Chair Ernst Eggelaar (from left to right)

2 Talking points – Institute Director Prof. Klaus-Dieter Lang speaking to attendees at the IZM's booth at the SMT



WORKSHOPS 2016

Regular workshops at Fraunhofer IZM

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.izm.fraunhofer.de/events

[1] Workshops on die and wire bonding

Quality and reliability aspects of wire bonds are discussed 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.

[2] Design Conformity for WEEE / RoHS / EuP

At the meetings which regularly take place at Fraunhofer IZM, companies prepare for the development and production of products which conform with the WEEE, RoHS and EuP Directives.

What will you learn?

- Current trends in international law
- Methods and tools for the development of environmentally compatible products
- Declaration of substances

The working group is supported by ZVEI, BITKOM and FED, and is organised and coordinated by Fraunhofer IZM.

Potential participants: Managers and technicians responsible for development and production processes conforming with the directives.

Dates: June 16 and November 22, 2016

[3] Working Group System Reliability of Packaging Technologies

For several years the workgroup has served as a forum to discuss and scrutinize challenges and solution approaches of industrial applications and research with partners from industry.

What will you learn?

- Process influences, whisker forming, electromigration
- Long-term reliability
- Filed behavior of complete systems

The working group is supported by ZVEI and FED. The meetings are organized and coordinated by Fraunhofer IZM.

Potential participants: Packaging experts from research and industry.

[4] Energy Autonomous Connected Systems for Industry 4.0

Energy autonomous sensor networks help manage and monitor systems by providing a reliable stream of data even from hard-to-reach or mobile sources. The technology has great promise for transport, industry automation, and product / production monitoring applications. The PETra project consortium invites interested participants to a networking event at the Fraunhofer IZM.

What will you learn?

- Autonomous sensors and robust system integration
- Cyber physical systems and Industry 4.0
- Innovative sensor concepts
- Use cases for autonomous sensors
- Opportunities and prospects for further innovation
- A discussion of public funding options for innovative projects with uncertain outcomes

The event is perfect for companies engaged in developing, constructing, or using energy autonomous sensor grids.

Date: June 24, 2016

[5] Material Characterization for Millimeter Wave Applications

The workshop explores the opportunities and limitations of different material characterization technologies.

What will you learn?

- Principles of HR measuring technology
- Principles of electrical fluctuation in dielectric material properties
- An introduction to state-of-the-art methods for materials analyses
- Testing procedures in practice

This workshop has been developed for material supply / RF designers.

[6] Electronics Goes Green 2016

From September 6-9, 2016 Fraunhofer IZM is hosting the international conference Electronics Goes Green 2016 in Berlin, for the fifth time after the years 2000, 2004, 2008 and 2012. The conference is the most important event on microelectronics and the environment worldwide and will provide experts from science, industry and politics with a forum to discuss state-of-the-art technologies and current political trends with regard to microelectronics and its impact on the environment.

Under the slogan, »Inventing Shades of Green«, the program will feature exciting new approaches in green IT, life-cycle engineering, new technologies and all the latest issues in legislation and regulation, corporate social responsibility and managing critical resources and sustainability.

The conference will be taking place in the Seminaris Dahlem Cube Hotel in the Berlin district of Dahlem.

The focus of the conference will be on:

- Technology towards sustainability
- Lifetime management
- Energy efficiency
- Material efficiency
- Software and data
- Technologies for the future
- Business models: from linear to circular thinking
- Innovative value creation
- Sustainability management
- Compliance and certification

Date: September 7-9, 2016



PROMOTING YOUNG TALENT

The future of our research area depends on an ongoing influx of young talent from the life sciences. Fraunhofer IZM has been supporting up-and-coming researchers and technicians for almost 20 years and has long been reaping the rewards. Our tours and internships are also designed to introduce youngsters to the possibilities of a career in the life sciences, be it as technician or scientist. A particular and welcome development over recent years has been the increasing number of girls and young women participating.

Girls to the front - Girls' Day at Fraunhofer IZM

Fraunhofer IZM has hosted a special Girls' Day program for well over a decade. In 2015, 11 girls visited the institute for a fun and inspirational day of microelectronics. After a short introduction, the girls disassembled mobile phones, and reassembled them after a short discussion of the various components. They were then treated to a tour of the Fraunhofer IZM labs and got to try their hand here and there - including automated PCB soldering, embedding and analyzing electronic components. The girls were even front-and-center for the assembly of an electronic circuit and the metallization of a structured PCB, including polishing and cross-section microscopy. The day ended with a tour of the grey room, which provides a birds eye view of the work in the various cleanrooms.

IZM-colleague participates in Research Training Group in Shanghai

In 2006, the International Research Training Group »Materials and Concepts for Advanced Interconnects« was established, jointly sponsored by the Chinese Ministry of Education and the German Research Foundation (DFG). In 2010 the project was extended to cover the area of »Materials and Concepts for Advanced Interconnects and Nanosystems«. Four universities and two Fraunhofer institutes are involved in this program: TU Berlin, TU Chemnitz, Fudan University (Shanghai), Shanghai Jiao Tong University and Fraunhofer Institutes ENAS and IZM.

Fraunhofer IZM's Piotr Mackowiak has been participating in the program since 2013 with a research focus on »Via technology for silicon carbide«. In 2015 he attended a three-month-summer school at Fudan University and thus had the opportunity for a direct exchange with scientists and students.

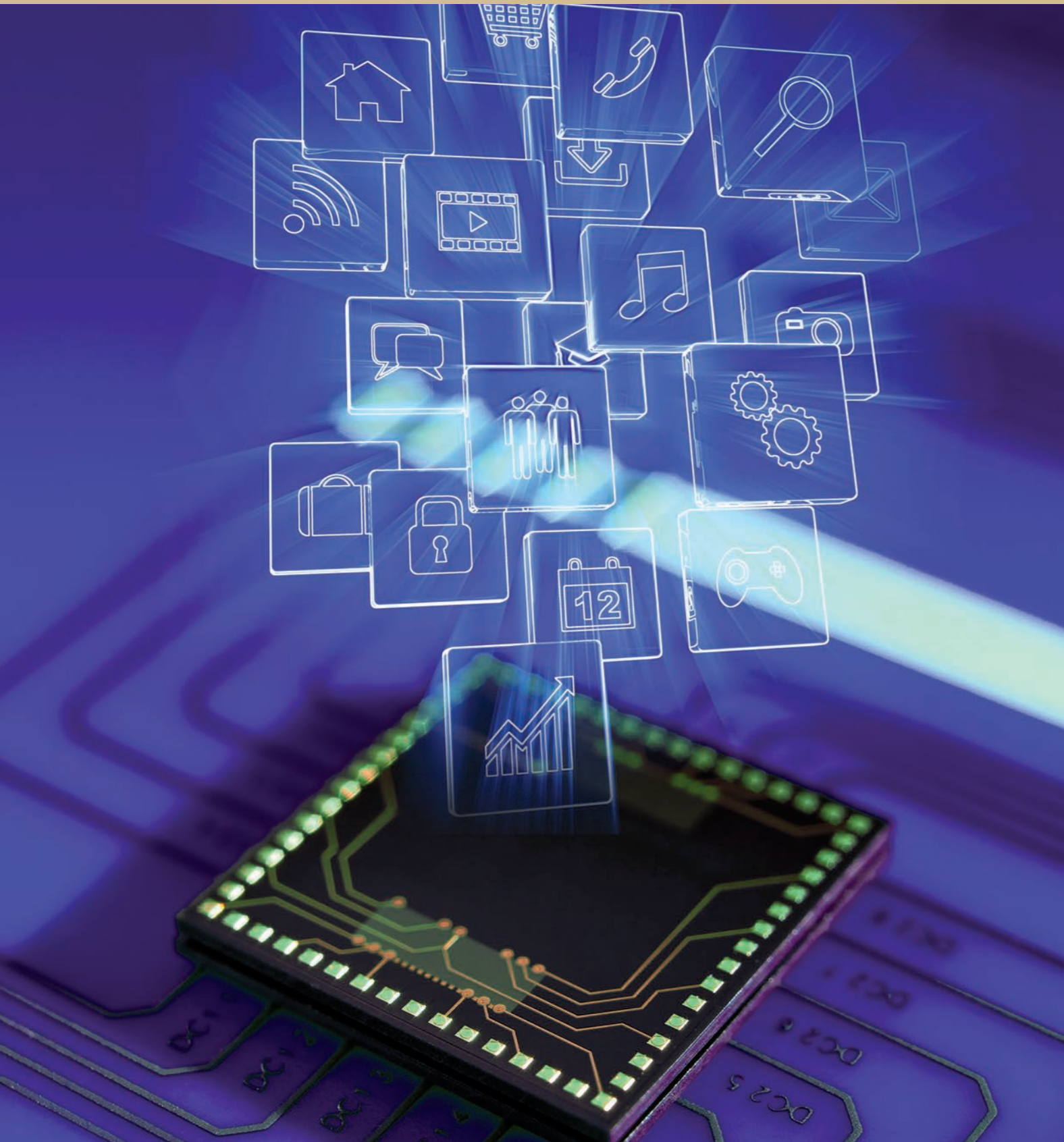
Apprentice Julia Langberg finishes at the top of her class

Beginning one's working life at the Fraunhofer IZM is a perfect springboard for winning recognition and accolades at an early stage in one's professional career. This has been proven again by Julia Langberg, who completed her education as microtechnologist in the summer of 2015 at the top of her class in the chamber of commerce's examinations. Going from strength to strength, she was also ranked among the year's best apprentices of the Fraunhofer Gesellschaft. On 23 November 2015, Professor Dr Kurz, Director of the Fraunhofer Gesellschaft, presented Ms Langberg with her award in the Munich head offices of the society. Julia Langberg has meanwhile taken up a degree course in material science. We are particularly pleased about her decision to remain with the Fraunhofer IZM and to keep contributing and expanding her knowledge as an undergraduate assistant.

1 Fraunhofer Board Member Prof. Kurz (right) honors Julia Langberg (center) who came top in her class and was one of the top Fraunhofer apprentices 2015. On her left training supervisor Volker Bader



FRAUNHOFER IZM FACTS & FIGURES



Fraunhofer IZM in Facts and Figures	Page 72
Awards	Page 74
Editorials, Best Papers	Page 76
Lectures	Page 77
Memberships	Page 78
Cooperation with Industry	Page 80
Publications	Page 82
Patents and Innovations	Page 88
Advisory Board	Page 89
Contacts	Page 90
Imprint	Page 93



FRAUNHOFER IZM IN FACTS AND FIGURES

Financial overview

Fraunhofer IZM carried the success of 2014 into 2015 with an increase in turnover by a further 1.5 percent to 28.1 million euros. This was mainly the result of revenue from German and international industrial companies and trade associations, which grew by 2.8 percent to 11.1 million euro. Income from publicly funded projects decreased somewhat from that in 2014 to 10.4 million euros.

Fraunhofer IZM financed 76.6 percent of its operating budget through external contracts in 2015. A total of 21.5 million euros were invested into financing current projects.

Core infrastructure investment

The institute allocated 1.8 million euros of internal funds for ongoing maintenance and upgrades in 2015. These funds were largely used to complete and begin operation of the larger investment projects of previous years, including set-up of the Crimping Technology Lab in Oberpfaffenhofen and the innovation center AdaptSys (Heterointegration Technologies for Application-Specific Multifunctional Electronics) in Berlin. The funds were also used to improve Fraunhofer IZM's infrastructure with disparate targeted investments and to increase the efficiency of existing equipment.

A further 1.8 million euros were allocated to various minor construction projects. One of these was a new institute lobby, better designed for receiving and hosting guests to Fraunhofer IZM. The area also includes newly designed presentation boards, which summarize highlights of Fraunhofer IZM's service spectrum for customers. Directly adjoining the revamped lobby are new event spaces and training rooms, which facilitate better traffic to other institute areas, for instance when providing event participants with close-ups of the technological possibilities boasted by the new AdaptSys lab spaces or the cleanroom

Human Resources

Thanks to last year's positive balance sheet, Fraunhofer IZM was able to again create additional positions. The institute's staff increased from 223 to 227 at Fraunhofer IZM's branches in Berlin, Dresden/ Moritzburg and Oberpfaffenhofen.

The institute also offers students the option of combining their studies with practical scientific research at Fraunhofer IZM's offices and laboratories. The institute took a total of 119 interns, Masters students and student assistants under its wing in 2015. Furthermore, it maintained its commitment to providing apprenticeships, by training a total of 10 apprentices as microtechnology technicians and business administrators.

Fraunhofer IZM 2015

Turnover	28.1 million euros
External revenue	21.5 million euros (76.6 percent of total turnover)
Sites	Berlin, Dresden and Oberpfaffenhofen
Number of staff	356 (including 119 student assistants, master students, interns and 10 apprentices)



AWARDS

ArtGuardian solution wins 2015 iF Design Award

The sensor unit at the heart of the ArtGuardian, a game-changing solution for preventive conservation in the art and museum world, has won the 2015 iF Design Award. It was icing on the cake for the team behind the product, who were busy shepherding the system into the first run of series manufacture when the announcement came. ArtGuardian micro-climatic monitoring combines cutting-edge Fraunhofer IZM technology with clever design into a sensor system that allows art custodians to safeguard the condition of artworks in their care around-the-clock, anywhere in the world.

Demand for the product and its viability has already been established in a number of pilot projects, including (climatic) monitoring of the Land Hesse's most valuable painting, Rembrandt's 1656 Jacob Blessing the Sons of Joseph, which is currently on loan in Amsterdam. The iF Design Award ceremony was held at the Munich exhibition center BMW Welt on February 27.

IZM-ASSID certified corresponding to ISO 9001

Since April 2015, Fraunhofer IZM's center »All Silicon System Integration Dresden – ASSID« works with a certified management system for the scope of application »Research, Development and Services on Electronic Packaging« that is in accord with the standard DIN EN ISO 9001:2008. The Auditing was conducted by the International Certification Group (ICG). The established management system guarantees high quality standards for cooperation customers and represents an important milestone for a qualified, customer-specific process development.

Fraunhofer IZM team wins ISECM Research Image Competition

The winners of the Research Image Competition at the fourth ISECM (International Symposium on Energy Challenges & Mechanics) are Berlin locals. The research team of Robert Hahn, including Krystan Marquardt, Katrin Höppner and Marc Ferch scooped the prize for their interdigitated electrode design for a lithium-ion battery. Apart from the technical innovation, the prize was awarded for the sophisticated communication campaign around the development, particularly photographer Volker Mai's on-point photo depicting the new design.

High-Temperature Plastic Wins Innovation Award

More trophies have been bagged by Berlin thanks to Fraunhofer IZM's scientific know-how. The AVK, Germany's oldest group representing reinforced plastics, in September 2015 premiered a new innovation award for cutting-edge research into plastics and their manufacture. Düren-based Isola GmbH won 3rd prize in the category »Product and Applications« for their new high-temperature, benzoxazine matrix PCB.

The multilayer PCB developer and manufacturer Isola is part of the German Federal Ministry of Education and Research (BMBF)-funded HELP consortium, which is research reliable and cost-efficient electronics for electromobility. Fraunhofer IZM is providing scientific support to the consortium. Together with the University Bayreuth, the institute investigated aging in the benzoxazine-based high-temperature resin. The results are key to the commercial introduction of the material. Congratulations to Isola GmbH for their win!

Prof. Martin Schneider-Ramelow New Chair of IMAPS Europe and IMAPS Germany

Martin Schneider-Ramelow was singled out for particular honor at September's EMPC 2015 conference in Friedrichshafen. The Fraunhofer IZM department head was voted Chair of the European Liaison Committee (ELC) of IMAPS (International Microelectronics and Packaging Society) Europe. IMAPS is one of the world's largest associations of microelectronics companies, engineers and scientists, with about 1,000 members across Europe.

Germany has the largest European chapter with approximately 300 members. Martin Schneider-Ramelow has been Chair of IMAPS Germany since 2009 and has made increasing the membership base his particular focus over this period. At the society's general meeting on September 14, 2015 he was unanimously voted First Chair for the fourth time. As such, he will be continuing to steer IMAPS on German and European level for another two years.

Hansjörg Griese wins the EcoDesign Award

In recognition of his contributions to scientific progress in ecologically friendly design, Hansjörg Griese, former department head at the Fraunhofer IZM, was awarded the »EcoDesign Award for Distinguished Scientific Contributions« in December 2015 in Tokyo. Hansjörg Griese is one of the founding fathers of the Fraunhofer IZM and driving force behind the institute's eco-friendly electronics department, which he managed until his retirement in 2008. The award was presented by Professor Tadatomo Suga, his long-time companion in the field, on the occasion of the 10th EcoDesign Conference in Japan.

1 Lifetime achievement: Professor Tadatomo Suga presenting the EcoDesign award to Hansjörg Griese

2 Champion design: ArtGuardian winning the IF Design Award 2015 – a great achievement for product designer Johannes Rojahn and Fraunhofer IZM researcher Stephan Guttowski

3 Award winner: Development and photonic production of a lithium-ion battery with interdigital electrode layout

BEST PAPERS, EDITORIALS

Best Paper

Best Paper for Andreas Ostmann at EMPC 2015

Fraunhofer IZM scientist Andreas Ostmann took home the Best Paper Award at the 20th European Microelectronics and Packaging Conference (EMPC 2015). Ostmann and his co-authors Christian Boehme, Kai Schrank und Klaus-Dieter Lang received the award for their paper »Development of a Microcamera with Embedded Image Processor Using Panel Level Packaging«. The award was presented at the end of the conference by technical chair Markus Detert and general chair Martin Schneider-Ramelow.

»Outstanding Presentation« Award for Dr. Yujia Yang at APEC 2015

Fraunhofer IZM's Dr. Yujia Yang has received the Outstanding Presentation Award at APEC 2015 in Charlotte (North Carolina, USA) for her contribution »An accurate back to front design methodology for PT based load resonant converters«.

The IEEE's annual Applied Power Electronics Conference and Exhibition (APEC) is one of the world's leading conferences on this technology area. Dr. Yang works on new methods and tools for the efficient, technology-oriented design of electronic system within the Fraunhofer IZM department RF and Smart Sensor Systems.

Editorials

PLUS Journal (Eugen G. Leuze Verlag)

Lang, K.-D. (Member of the Editorial Board)

International Journal of Microelectronics and Electronic Packaging

Ndip, I. (Associate Editor)

Mechatronik (Verlag I.G.T. Informationsgesellschaft Technik mbH)

Ansorge, F. (Editorial Board)

Smart Systems Integration 2015 Conference Proceedings

Lang, K.-D. (Co-Editor)

European Microelectronics and Packaging Conference Proceedings

Schneider-Ramelow, M. (Co-Editor)

LECTURES

Technische Universität Berlin

Prof. K.-D. Lang

- Hetero System Integration Technologies
- Assembly of Multi-functional Systems
- Assembly and Interconnection in Microelectronics
- Assembly technologies for Microelectronics and Microsystem technologies

Dr. R. Hahn

- Miniaturized Energy Supply Systems

Prof. K.-D. Lang, S. Backhove, J. Günther, Dr. B. Curran

- Project-oriented Internship

Dr. B. Curran

- Design, Simulation and Reliability of Microsystems
- Electromagnetics for Design and Integration of Microsystems

Dr. B. Curran, Dr. I. Ndip

- High-Frequency Measurement Techniques for Electronic Packaging

Dr. I. Ndip

- Electromagnetics for Design and Integration of Microsystems
- Numeric Computation of Fields

Dr. J. Jaeschke

- FEM Simulation of Micro Sensors and Actuators
- Reliability of Microsystems

Dr. M. Töpfer, Dr. J. Jaeschke

- Technologies and Materials for Microsystem Technologies

Prof. H. Ngo, Dr. J. Jaeschke

- Manufacturing Technologies for Semiconductor Sensors

Dr. N. F. Nissen, Dr. A. Middendorf

- Design of Environmentally Compatible Electronic Products

Prof. M. Schneider-Ramelow

- Basic Materials of System Integration

Dr. T. Tekin

- Photonic Packaging
- Antenna Simulation
- Antennas

Dr. T. Tekin / Dr. D. Pouhè

- Architecture and Cell Design for Mobile Communication Systems

Beuth Hochschule für Technik Berlin

Dr. H. Schröder

- Optoelectronics

German University in Cairo, Campus Berlin

Dr. T. Tekin

- Photonics

HTW, Hochschule für Technik und Wirtschaft Berlin

Dr. H. Walter

- Basic Materials for Microsystem Technologies

Dr. R. Hahn

- Miniaturized Energy Supply Systems

Hochschule für Wirtschaft und Recht Berlin

Dr. U. Geißler

- Material Engineering

MEMBERSHIPS (SELECTION)

4M Multi Material Micro-Manufacture Association	E. Jung	Representative of Fraunhofer IZM
AMA Fachverband Sensorik, Wissenschaftsrat	Dr. V. Großer	Member
Bayerisches Innovationcluster „Mechatronik und Automation“, Fachgruppe Mikro-Mechatronik	Dr. F. Ansorge	Chairman
CATRENE – EAS Working Group on Energy Autonomous Systems	Dr. R. Hahn	Member
Deutscher Verband für Schweißtechnik DVS	Prof. K.-D. Lang	Executive Board
Deutscher Verband für Schweißtechnik DVS Arbeitsgruppe »Bonden«	Prof. M. Schneider-Ramelow	Chairman
EcoDesign Japan 2015	Dr. N. F. Nissen	International Co-Chair
Electronic Components and Technology Conference ECTC	Dr. H. Schröder	Optoelectronics Committee Chair
EOS European Optical Society	Dr. H. Schröder	Member
EURIPIDES Scientific Advisory Board	Prof. K.-D. Lang, M. J. Wolf	Member
European Photonic Industrial Consortium (EPIC)	Dr. H. Schröder	Representative Fraunhofer IZM
European Technology Platform on Smart System Integration (EPoSS)	Harald Pötter	Member Executive Committee
IEEE Component, Packaging and Manufacturing Technology Society	R. Aschenbrenner	Fellow
Technical Committees:		
Green Electronics	Dr. N. F. Nissen	Technical Chair
Emerging Technologies	E. Jung	Technical Chair
Wafer Level Packaging	Dr. M. Töpfer	Technical Chair
Photonics - Communication, Sensing, Lighting	Dr. T. Tekin	Technical Chair
IEEE CPMT German Chapter	R. Aschenbrenner	Chair
IMAPS (Signal/Power Integrity Subcommittee)	Dr. I. Ndip	Chair

IMAPS International 2015	Dr. I. Ndip	General Chair
IMAPS Deutschland	Prof. M. Schneider-Ramelow	President
International Electronics Manufacturing Initiative iNEMI	R. Aschenbrenner	Representative of Fraunhofer IZM
International Technology Roadmap Semiconductors (ITRS)	M. J. Wolf	Chairman Europe
International SSL Alliance (ISA)	Dr. R. Jordan	International Liaison Chair China SSL
Lange Nacht der Wissenschaften e. V. Berlin	H. Pötter	Representative of Fraunhofer
OpTec Berlin Brandenburg	Prof. K.-D. Lang	Executive Board
Photonics21 – Work Group Emerging Lighting, Electronics and Displays	Dr. R. Jordan	Member
Photonics West Optical Interconnects Conference	Dr. H. Schröder	Chair
SEMI Group Award Committee	Prof. K.-D. Lang	Member
Semiconductor Manufacturing Technology Sematech	M. J. Wolf	Member
Silicon Saxony e. V.	M. J. Wolf	Member
Smart Lighting	Dr. R. Jordan	Steering Committee
SMT/HYBRID/PACKAGING Kongress	Prof. K.-D. Lang	Head of Scientific Committee
Technologiestiftung Berlin (TSB)	Prof. K.-D. Lang	Member of the Board of Trustees
VDMA, Fachverband Electronics, Micro and Nano Technologies	Dr. V. Großer	Member
Wissenschaftlich-technischer Rat der Fraunhofer-Gesellschaft	Dr. N. F. Nissen	Representative of Fraunhofer IZM
Zentrum für Mikrosystemtechnik Berlin	Prof. K.-D. Lang	Spokesman of the Board

COOPERATION WITH INDUSTRY (SELECTION)

Advanced Semiconductor Engineering Inc.	Kaohsiung (TPE)
AEMtec GmbH	Berlin
Agilent Technologies Inc.	Santa Clara (USA)
AIM Infrarot-Module GmbH	Heilbronn
Airbus Defense & Space	Ulm
Alenia Aeronautica SpA	Rom (I)
Allegro Micro Systems LLC	Worcester (USA)
alpha-board gmbh	Berlin
Altatech	Montbonnot-Saint-Martin (FR)
AMO GmbH	St.Peter / Hart (A)
Apple Inc.	Palo Alto (USA)
Applied Materials Inc.	Santa Clara (USA)
Asahi Glass Co., Ltd.	Chiyoda (J)
Astrium GmbH	Bremen
AT&S AG	Leoben (A)
Atotech Deutschland GmbH	Berlin
ATV Technologie GmbH	München
AUDI AG	Ingolstadt
Austriamicrosystems AG	Unterpremstätten (A)
Awaiba GmbH	Nürnberg
B/E Aerospace Inc.	Lübeck
Baker Hughes INTEQ GmbH	Celle
Baumer-Hübner GmbH	Berlin
Balluff GmbH	Neuhausen a.d.F.
Besi Netherlands B.V.	Duiven (NL)
BIOLAB Technology AG	Zürich (CH)
Blackrock Microsystems LCC	Salt Lake City (USA)
BMW AG	München
Brose Fahrzeugteile GmbH & Co. KG	Coburg

Bundesdruckerei GmbH	Berlin
COGO Optronics GmbH	Berlin, Boulder (USA)
Coinbau GmbH	Dresden
Compass EOS	Netanya (IL)
CONTAG GmbH	Berlin
Continental AG	Nürnberg, München, Frankfurt, Regensburg
Converteam SAS	Berlin
Corning Glass	Corning (USA)
Daimler AG	Stuttgart
Datacon GmbH	Radfeld (A)
Denso Corp.	Kariya (J)
Deutsche Bahn AG	Berlin, Frankfurt, München, Dessau
Disco Corporation	Tokyo (J)
Elbau GmbH	Berlin
Endress & Hauser GmbH & Co. KG	Maulburg
ESYS GmbH	Berlin
EV Group (EVG)	St. Florian a.I. (A)
Evatec Advanced Technologies AG	Trübbach (CH)
Excelitas Technologies Corp.	Pfaffenhofen
FiconTEC Service GmbH	Achim
Finisar	Sunnyvale (USA)
Fujifilm Electronic Materials	Tokio (J)
Fujitsu Technology GmbH	Augsburg
Gesellschaft für Maschinendiagnose mbH	Berlin
GLOBALFOUNDRIES INC.	Dresden
HELLA KGaA Hueck & Co.	Lippstadt
Heraeus Holding GmbH	Hanau
Hitachi Dupont	USA, J, D

Höft & Wessel AG	Hannover
Hytech AG	Brügg (CH)
IBM Research	Rueschlikon (CH)
Idex	Fornebu (NO)
IMC GmbH	Berlin
IMST GmbH	Kamp-Lintfort
Infineon Technologies AG	Mainz, München
Isola USA Corp.	Chandler (USA)
Jenoptik/ESW GmbH	Hamburg-Wedel
John Deere & Company	Mannheim
Leuze electronic GmbH & Co. KG	Owen
Luceo GmbH	Berlin
Maicom Quarz	Posterstein
MDISchott Advanced Processing GmbH	Mainz
MED-EL GmbH	Innsbruck (A)
METALLEX AG	Uetikon (CH)
Microelectronic Packaging GmbH	Dresden
Micro Systems Engineering Inc.	Lake Oswego (USA), Tel Aviv (IL)
Nanotron Technologies GmbH	Berlin
Nexans SA	Paris (FR), Bethel (USA)
NXP Semiconductors AG	Hamburg, Eindhoven (NL)
Olympus Deutschland GmbH	Hamburg
ON Semiconductor Belgium BVBA	Oudenaarde (B)
Optocap Ltd	Livingston (GB)
Osram Opto Semiconductors GmbH	Regensburg
Pac Tech Packaging Technologies GmbH	Nauen
PANalytical B.V.	Almelo (NL)

Philips Technology GmbH	Aachen
Ramgraber GmbH	Hofolding b. Brunnthal
Robert Bosch GmbH	Stuttgart
Rohde und Schwarz	Berlin
Samsung Advanced Inst. of Technology	Suwon (ROK)
Schaeffler Technologies GmbH & Co. KG	Herzogenaurach
Schaffner Holding AG	Luterbach (CH)
Schleifring GmbH	Kaufbeuren
Schlumberger AG	F, USA
Schneider Electric	Grenoble (F)
Schweizer Electronic AG	Schramberg
Semikron GmbH	Nürnberg
Semsyco GmbH	Salzburg (A)
Sensitec GmbH	Lahnau
Siemens AG	Karlsruhe
SPTS Technologies Ltd.	Newport (UK)
Süss MicroTec AG	Garching, München
Swissbit Germany AG	Berlin
TDK-EPCOS AG	München
Thales Group	Frankreich
The Dow Chemical Company	USA
TRUMPF Deutschland GmbH	Ditzlingen (DL)
Valeo GmbH	Wemding
Vectron Systems AG	Havant (UK)
Vectura Group plc	Chippenham (GB)
Volkswagen AG	Wolfsburg
Würth Elektronik GmbH & Co. KG	Niedernhall, Rot a.S.
X-Fab Semiconductor Foundries AG	Erfurt
Xyratex AG	Auerbach

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Thomas, T.; Voges, S.; Fliess, M.; Becker, K.-F.; Reiners, P.; Koch, M.; Bauer, J.; Braun, T.; Lang, K.-D.
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