Fraunhofer

IZM

FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM

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RELIABLE SYSTEM INTEGRATION FOR THE VERY BEST PRODUCTS

Fraunhofer IZM can count 2012 as a success, with an over 20 percent increase in direct contracts from industry - proof positive of the trust our customers place in us! We specialize in performing application-oriented contract research quickly and reliably and in developing the best solutions for our customers' individual requirements. Almost all industry branches draw on these expertise within our technology focus. Apart from close collaboration with German and European companies, a number of successful projects in Asia – particularly Japan – and in the USA contributed to the growth.

With its expertise in 3D integration on wafer-level, a cornerstone technology at home and abroad, Fraunhofer IZM ASSID in Dresden has come to play a key role in the institute's overall success since its establishment in 2010.

Our six business areas cover automotive and traffic engineering, medical engineering, safety and security, power, photonics and 3D integration. Each area is headed by a Fraunhofer IZM expert, whose mission it is to address the individual, market-specific technology questions of our customers and who play a vital role as first points-of-contact for our customers, facilitate rapid step-by-step development of ideas into prototypes, and ensure project management within the institute is coordinated efficiently.

Application-oriented, technologically cutting-edge development of electronic systems and microsystems will continue to be our institute's research and development focus. This includes pursuing new approaches and strategies in miniaturization, multifunctionality, energy efficiency and adaptation to the application environment. We pinpoint the best methods and develop customized solutions for optimized physical design and reliability evaluation from the first concept through to series manufacture. Even as complexity increases and loading intensifies, our know-how always makes the grade!

This year Fraunhofer IZM turns 20! Since 1993, we have dedicated ourselves to helping you turn your research and development ideas into reality, and in 2013 we are entering our second decade primed for business as usual. Help us celebrate by coming along to one of the many events scheduled as part of our special anniversary program.

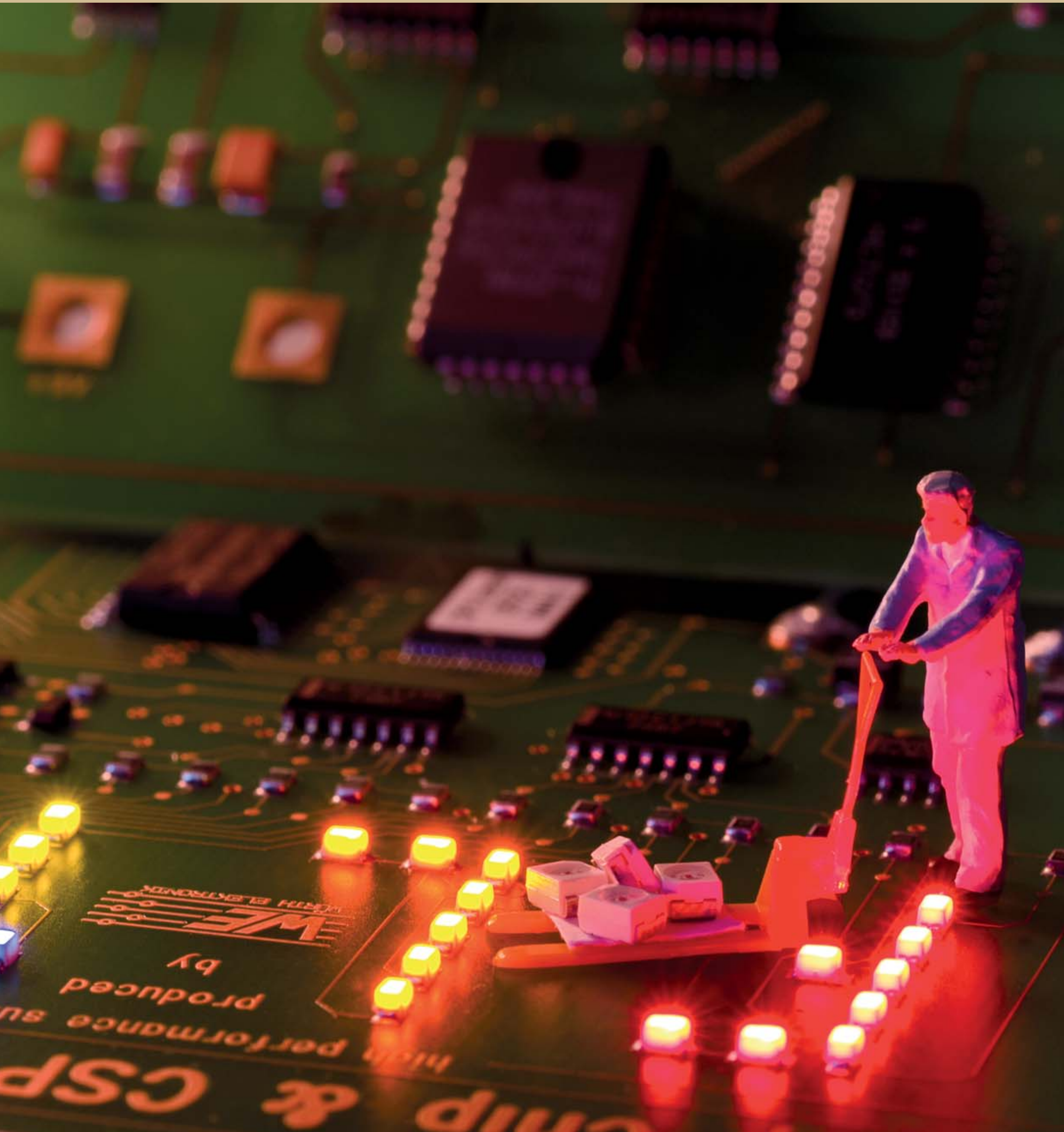
I would like to thank our partners and customers in industry and research, the federal and Länder ministries and the project coordinating bodies for their trust and the excellent collaboration throughout the previous year.

Thanks also go to Fraunhofer IZM's employees for their creativity, indefatigable commitment and outstanding support of our customers.

Yours,

Prof. Klaus-Dieter Lang

FRAUNHOFER IZM



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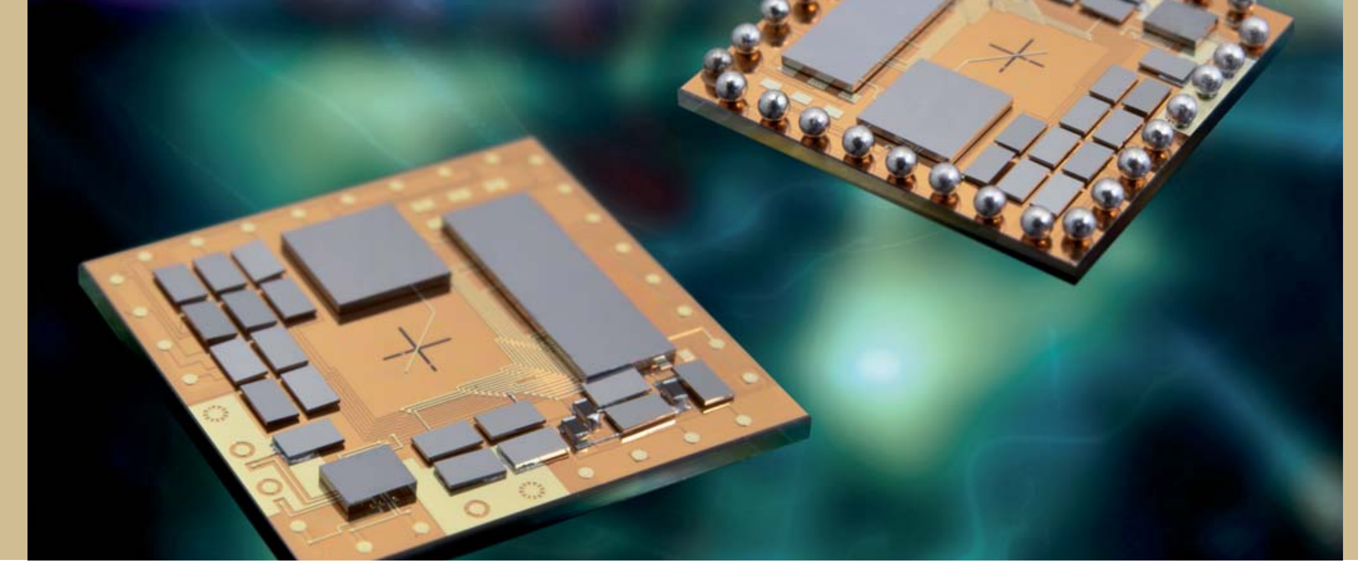


FRAUNHOFER – A STRONG NETWORK

The Fraunhofer-Gesellschaft
Fraunhofer IZM is one of 66 Fraunhofer Institutes conducting applied research predominantly in the realm of science and engineering, because research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

The majority of the more than 22,000 staff are qualified scientists and engineers, who work with an annual research budget of 1.9 billion euros. Of this sum, 1.6 billion euros is generated through contract research.

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

Fraunhofer Group Microelectronics
Fraunhofer has pooled the competences of institutes working in related subject areas in the seven Fraunhofer Groups Information and Communication Technology, Life Sciences, 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 VμE has been coordinating the activities of Fraunhofer Institutes working in the fields of microelectronics and microintegration since 1996. Its membership consists of twelve institutes as full members and three as associated members, with a total workforce of around 2,900 and a combined budget of roughly 325 million euros. The purpose of the Fraunhofer VμE is to scout for new trends in microelectronics technologies and applications and to integrate them in the strategic planning of the member institutes.

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

- Ambient Assisted Living & Health
- Energy Efficiency
- Mobility
- Smart Living

www.mikroelektronik.fraunhofer.de

FRAUNHOFER IZM – COMPETENCE IN PACKAGING

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

- Integration on Wafer Level
- Materials & Reliability
- Integration on Substrate Level
- 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 2012, our customers have six competent business development managers for individual application areas and key research topics who 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 300 and saw a turnover of 28.5 million euros in 2012, of which 85 percent was derived from contract research. It has four 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. A fourth research group is based at the Berlin technology park Adlershof, ensuring close ties to optical technology companies and research institutes.

HOW TO MAKE THE MOST OF FRAUNHOFER IZM

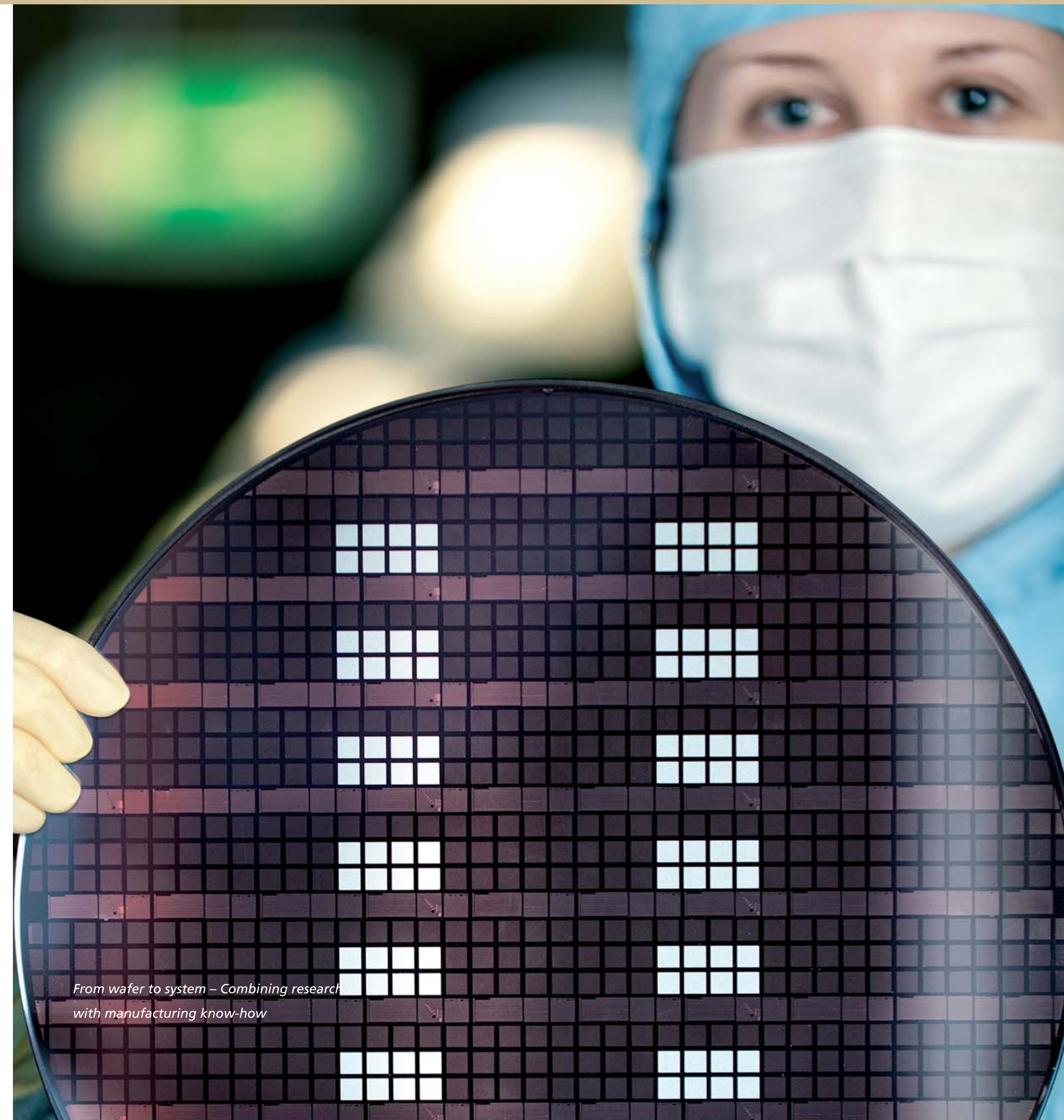
The success of our contract research model may well be due to our emphasis on treating our customers as partners and active participants in the research and development process. We can help you integrate electronics and microsystem technology into your products by developing innovative packaging and 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.



From wafer to system – Combining research with manufacturing know-how

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.

H-C3: Human Centric Communication
The Human Centric Communication Center project, H-C3 for short, was completed in 2012. Goal of this TU Berlin initiative, in which more than 50 TU Berlin departments and 11 other research institutes participated, was to facilitate the general public's intuitive access to and handling of growing amounts of information by developing suitable hardware and software technologies.

Four PhD candidates from Fraunhofer IZM and the Forschungsschwerpunkt completed their dissertations in different research areas dealing with technological, economic and sociological aspects of human communication. Specifically, the researchers developed design and integration technologies for the assembly of the required hardware, as well as energy management technologies for autarkic sensor networks.

Cooperation with TU Berlin in German Research Foundation project
In 2012 Fraunhofer IZM and TU Berlin completed a highly successfully DFG-funded project on the thermomechanical characterization of interface formation in wedge/wedge wire bonds. The two project participants developed a reliable model for determining the thickness of intermetallic phases in the interface of ultrasonically wire bonded wedge/wedge joints.

Some of Fraunhofer IZM's other university partners
Technical University of Delft, The Netherlands
Technical University of Eindhoven, The Netherlands
Technical University of Tampere, Finland
Bologna University, Italy
Cárdiz University, Spain
Tokyo University, Japan
Twente University, The Netherlands
Uppsala University, Sweden
University College London, Great Britain
Brandenburg University of Technology, Cottbus
Chemnitz University of Technology
Friedrich Alexander University Erlangen-Nürnberg
Heidelberg University
Humboldt University Berlin
Kiel University
Technical University Darmstadt
Technical University Dresden
The Berlin University of the Arts
University of Bonn
University of Freiburg
University of Potsdam
University of Rostock

INTERNATIONAL RESEARCH COOPERATIONS

Fraunhofer IZM joins the 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. A virtual brain would help clinicians both to understand the structure and processes of healthy and diseased brains and to develop and test new drugs. Robotics and so-called neuromorphic computing also stand to benefit.

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.

Further information: www.humanbrainproject.eu

German-Spanish cooperation on Ambient Assisted Living
Fraunhofer IZM has been researching Ambient Assisted Living (AAL) and medical engineering together with Spanish research and development partners for several years now. Several EU projects have already been initiated with Universidad de Cadiz, focusing on AAL and the link between the health care sector and gentle tourism.

With the Barcelona Digital Technology Center (BDIGITAL) Fraunhofer IZM developed innovative concepts in patient care as part of the joint project SAPPHO. BDIGITAL also facilitates Fraunhofer IZM's foothold in the economically strong region of Catalonia. In turn, our institute paves the way for the Spanish institute's access to Germany-based SMEs interested in international collaboration.

PhoxTroT – major European project on optical communication
Major data centres and supercomputers will soon be more cost and energy efficient, and at the same time will be even more powerful. Lead-managed by Fraunhofer IZM 18 partners from business and research in the European Union have set themselves this ambitious goal in the »PhoxTroT« project. The key is optical data transmission.

Over the next four years, the project partners will be studying synergies between existing solutions as well as developing new technologies and strategies. The goal is to cut the energy consumption by at least 50 percent, while simultaneously doubling the capacity of data connections to 2 terabits per second (Tb/s). This would also significantly reduce costs. The European Union is providing 9 million euros funding for the four-year research project, which began in October 2012.

Further information: www.phoxtrot.eu

Heterogeneous Technology Alliance (HTA)
Together with other Fraunhofer institutes and leading European microelectronics research bodies (France's CEA-Leti, Switzerland's CSEM and Finland's VTT), Fraunhofer IZM is participating in the Heterogeneous Technology Alliance (HTA). With a combined staff of more than 5,000 scientists and a portfolio of more than 3,000 patents, the HTA is de facto the largest European organization in the field of microelectronics. The research partners are working on joint research topics and responding to European tenders to extend their edge over international competitors. The alliance is combining its know-how under the title »4-Labs« for joint research projects that provide customers one-stop solutions for innovative products.

Further information: www.hta-online.eu

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

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

Further information: www.ecpe.org

Cooperation with the University of Utah
Fraunhofer IZM has been closely cooperating with the University of Utah in various projects since 2005. The initiative comprises two projects in which neural prostheses are being developed, with Fraunhofer IZM responsible for the integration of wireless communication technology in the new technology.

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

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

The next meeting will take place in April 2013, later on further workshops and an exchange of students are planned.

BUSINESS UNITS AND COOPERATION

Invisible, indispensible, Fraunhofer IZM's packaging technologies have come to shape everyday life. The range of applications unthinkable without the institute's research and development is vast and the following pages provide just a brief overview of the diverse application areas and product solutions. Even though the demand for more reliable, more cost-efficient, miniaturized electronics unites all sectors, today's technology development has to set the needs of the individual application as its highest priority. Applied research is Fraunhofer IZM's specialty and as of 2012 we have six business development managers who are committed to providing the best solution for any and all applications.

FRAUNHOFER IZM APPLICATION CENTER — **Page 18**
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AUTOMOTIVE / TRANSPORTATION — **Page 20**
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MEDICAL ENGINEERING — **Page 21**
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LIGHTING / LED — **Page 22**
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SAFETY & SECURITY — **Page 23**
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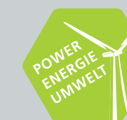

POWER ELECTRONICS — **Page 24**
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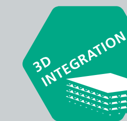


3D INTEGRATION — **Page 25**
Martin Wilke, martin.wilke@izm.fraunhofer.de

YOUR BRIDGE TO FRAUNHOFER IZM TECHNOLOGIES

Regardless of whether you are already using electronic packaging technologies or are planning to invest in it; we offer the support and collaboration you require to reach your development goals. Helping you develop your product is our main aim!

Employing advanced technology is the key to investing in the future
You already know what kind of technology you want to employ and would like to make sure you will be harnessing the latest trends? You are familiar with the technology but need assistance in development, failure analysis or with optimizing your products? In this case the Fraunhofer IZM Application Center will be your first port-of-call.

We provide access to our specialists who can discuss the entire bandwidth of technological advancement in electronic packaging. They will be happy to organize a customized workshop that offers access to our services and facilities. Our experts will discuss with you the pros and cons of your options, taking into account the current state of your company's technological infrastructure.

You will be able to benefit from our extensive range of services in the realm of assembly and interconnection technologies.

Remain one step ahead by employing cutting-edge technology
You want to upgrade your products but have not yet invested in microsystem technology or only use it to a limited extent? Despite this, you would like to make use of our know-how and technology in system-in-package and system integration?

In this case, too, you should contact the Fraunhofer IZM Application Center. Here six business development managers are the first points-of-contact for our customers. Their mission it is to address your individual, market-specific technology questions, to facilitate rapid step-by-step development of ideas into prototypes, and to ensure project management within the institute is coordinated efficiently.

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

FRAUNHOFER IZM APPLICATION CENTER

One of the application center's highest priorities is offering a broad range of developmental know-how on microsystem technology products, thereby accelerating a product's path to application. We particularly address companies planning to integrate microsystem technology into their product line.

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

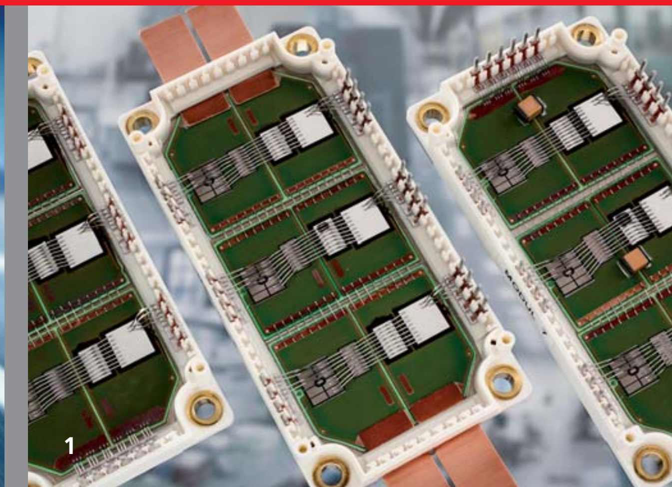
How do we support your product development?
You have an idea for a certain product and would like to develop it? But you are unsure about the feasibility, quality, development costs and time it requires?

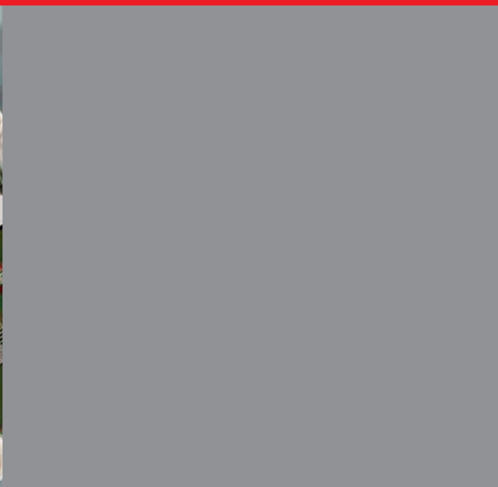
We offer consultancy and development support modules, from which you can choose according to your specific requirements at any stage of development. The product development support modules are described as follows:

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

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

1 Thanks to RFID tags customers can check whether a certain product is available at their corner store





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 tools for developers creating innovative forms of transport and traffic systems for road, rail, water and in the air.

Since Fraunhofer IZM's establishment, every department has included these application areas as core competences. The institute helps OEMs, Tier1 and in particular their suppliers include electronics in vehicles quickly and efficiently. We develop future-proof, reliable solutions, if necessary also as prototypes, to improve the safety and comfort of conventional, hybrid and electric engines and systems. Our portfolio even includes rail technology, customized for its unique parameters, not least of which are the much smaller lot sizes.

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

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

Key technologies for electromobility – 5 projects

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

Specifically, we are:

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

Services

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

- Sensor and actuator technology
- Reliability management and assurance
- Robust design
- Packaging and interconnection for harsh environments

1 *EMC-optimized power module*

MEDICAL ENGINEERING

Higher performance and smaller, finer geometries

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

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

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

Example projects

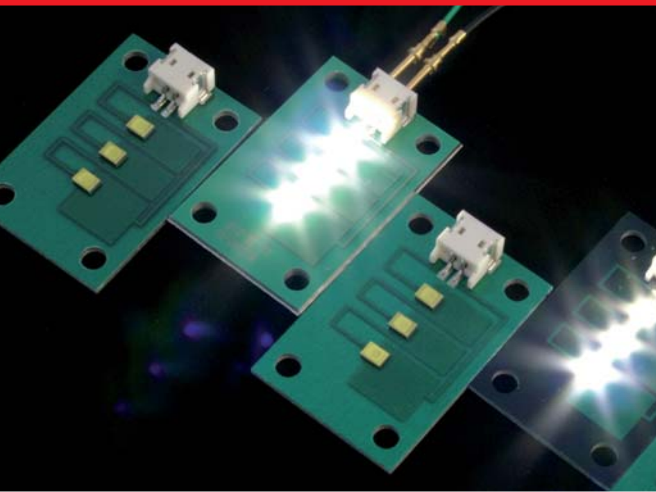
Fraunhofer IZM participates in government projects and bi- and trilateral cooperations with medical engineering companies and researchers throughout Europe and overseas. For example, in the European project Cajal4EU we are developing a fully integrated diagnosis platform that uses nanoelectronic components and covers all aspects of the diagnostic process.

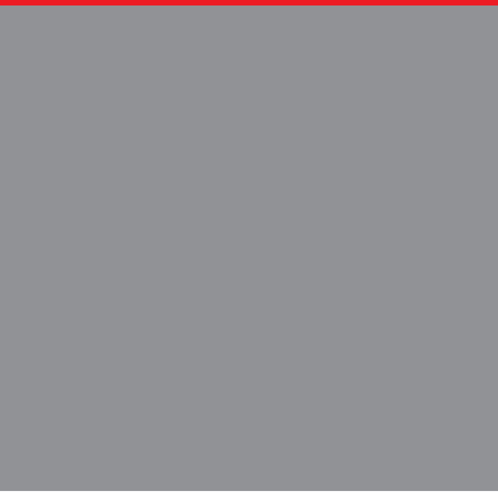
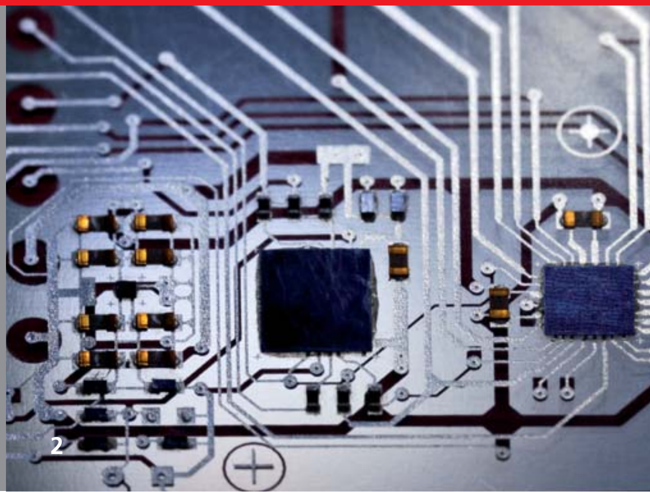
Researchers in the project CAREJack are developing textile-integrated sensors that monitor muscle activity. The overall goal is providing technical aids that facilitate nursing in the day-to-day outpatient setting. Fraunhofer IZM scientists are participating in the development of an upper-body orthosis with a smart assistance system that makes the particularly difficult conditions of everyday nursing care easier. The Saapho project is integrating sensor microtechnology into the everyday environment of seniors and other people requiring assistance so that their vital statistics and other monitored parameters can be fed into an open-standard communication platform. Here Fraunhofer IZM is contributing to the development of an intelligent medicine dispenser and a blood pressure measuring system that transmits data via the NFC protocol.

Services

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

2 *Extremely miniaturized electronics for hearing aid (flex technology and ultra-thin ICs)*



LIGHTING / LED

More light!

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

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

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

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

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

Hi-Q LED – High quality LED lighting

As part of the Hi-Q LED project, funded by the German Federal Ministry of Education and Research, Fraunhofer IZM and leading industry players like Osram OS and ASEM Präzisionsautomaten GmbH are collaborating to develop a bonding method for planar light sources using tiny LEDs (<= 70 µm). The group is developing transfer bonding methods and techniques for manufacturing planar light sources by lamination.

Simulations to investigate thermal management, the relationship between LED efficiency and size, and lastly, assessment of the probable costs of manufacturing (Osram) and assembling (Fraunhofer IZM) the chips, indicated that distributing the total target luminous output across many small LED chips was the most promising approach. Ultra-thin, miniaturized LEDs are transfer bonded by means of either daisy chaining or surface adhesion via soldering. The lamination process allows the positioning and mounting of large-area LED arrays with high precision, while at the same time making planar interconnection without wire bonding possible.

Services

Design, assembly concepts and characterization for:

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

1 *LEDs on laminated LED array*

SAFETY & SECURITY

As much as necessary, as little as possible!

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

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

We specialize in the following areas:

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

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

Highly reliable contactless identity documents

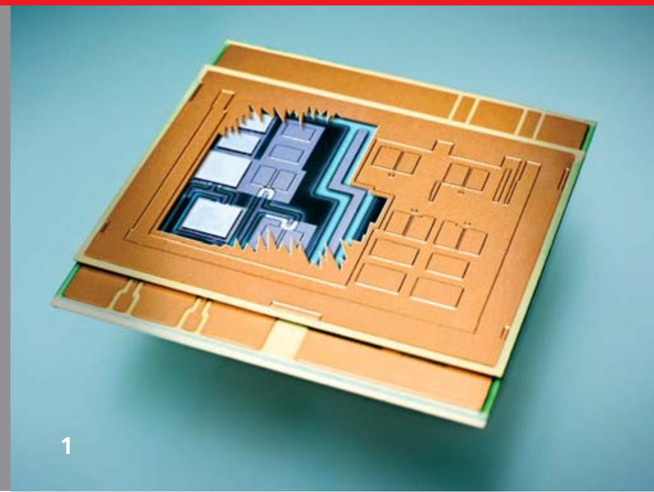
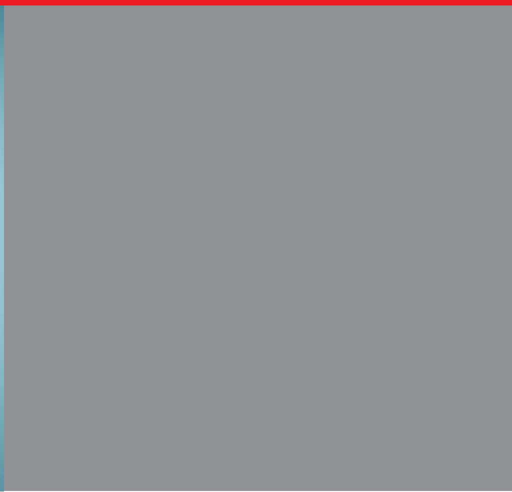
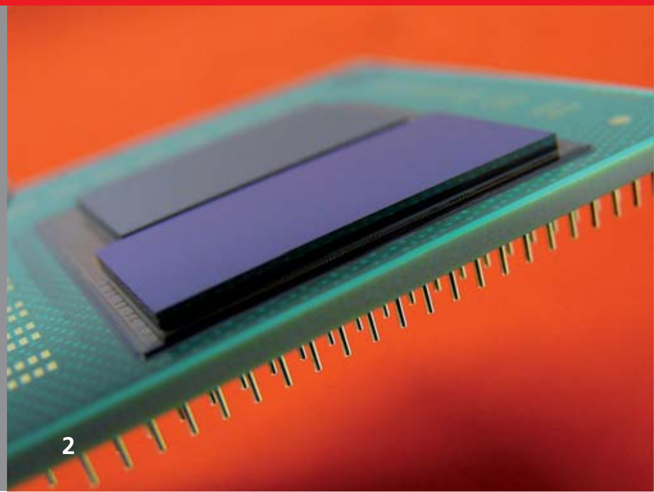
As identity documents are typically valid for many years and have to hold up against much wear and tear over this time, they have to be extremely robust, not to mention tamper-proof and reliable. Ensuring this requires chip integration technologies that feature long lifetime and are not failure-prone. New standardized tests and simulation models are also needed to assess the lifetime of such documents.

Fraunhofer IZM researchers with partners from Bundesdruckerei and Infineon Technologies AG are addressing this challenge in the German Ministry of Education and Research-funded project SeManTiK. The project results are expected to secure Germany's edge in the development of contactless identity documents. BKA and Bayer MaterialScience are participating as associated project partners.

Services

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

2 *Electronics completely embedded in polycarbonate for tamper-proof multi-functional ID documents*

POWER ELECTRONICS

The key to reducing energy and resource consumption

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

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

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

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

Ultra-low inductance package for SiCs

Silicon-carbide semiconductors feature high current spikes when switched on or off. This can be exploited to dramatically raise the switching frequency in the inverter circuitry. However, this creates unpreventable parasitic inductances in the demonstrator module, which can cause significant overvoltage during switch-off, consequently possibly damaging the chip, and lead to further fluctuation that can drive up switching losses significantly.

In this project, two modules were assembled and compared: firstly, a conventional design, with wire-bonded chip interconnection and wide busbars for the connection to the indirect converter in order to reduce the latter's inductance as much as possible, and secondly, an embedded module. In the latter, the chips were conventionally sintered onto a DCB, but the indirect converter is attached via a busbar mounted onto the DCB using PCB technology. The capacitors are mounted on top of the module. This achieves an increase in power of 4 A/ns with little overvoltage during switch-off, minimal fluctuation and commutation inductance of just 0.866 nH. As available current clamps were incapable of reliably measuring the switching currents, an inductive shunt was developed in-house to characterize the module.

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

1 *Investigation of double-sided cooling of a power module*

3D INTEGRATION

Maximum performance for optical sensors and computing

Three-dimensional integration of components is the key to improving the performance of future electronic systems. The advantages of vertical integration include:

- Improved electrical performance thanks to the faster signal speeds and higher bandwidth resulting from shorter and narrower signal paths
- Cost reduction through partitioning of large and expensive chip components
- Increased functionality due to heterogeneous integration of components, which are fabricated using different technology nodes
- Smaller form factor and easy access to sensitive surfaces for sensor applications thanks to backside contacts
- Increased optical fill factor for large-area multi-sensor applications
- Reduction of process time thanks to parallelization of production processes

Fraunhofer IZM's services include concept and process development, characterization, reliability assessment and prototyping of 3D systems. Our labs are equipped for all processes involved in TSV manufacture and subsequent packaging. We have built up, assembled and characterized (electrically and thermo-mechanically) a wide range of 3D systems for different applications, such as image sensors, logic, MEMS, silicon and glass interposers, in a number of different completed and ongoing projects.

Silicon interposer for photonic components

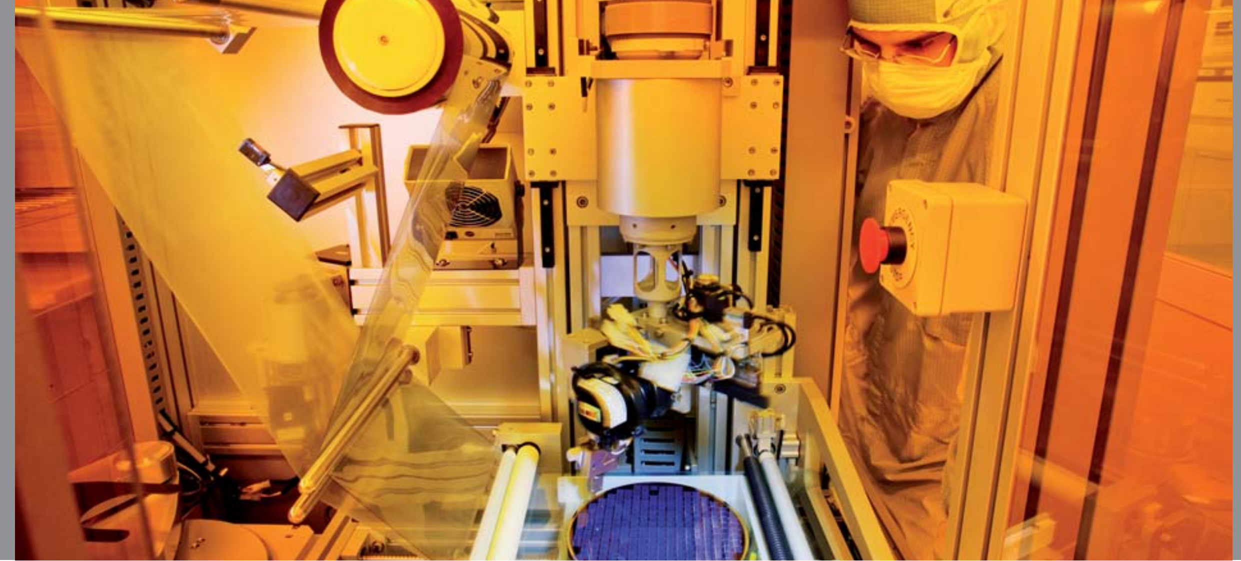
In the European project PARADIGM, we are investigating the design and manufacturing of phonic integrated circuits (PICs). One key step is the development of a platform technology for application-specific systems containing PICs. Here, Fraunhofer IZM's research efforts are working towards a II-V semiconductor-compatible silicon interposer technology. As part of this, we have developed gold-plated TSVs with a depth of 500 µm. The PICs are intended for data communication and sensor applications.

In a separate project, we are investigating backside contacts for miniaturized image sensors for the company Awaiba GmbH. A microcamera (< 1*1*1 mm³) has already been developed in an earlier project for a disposable endoscope. Now, microlenses are needed on the sensor surface to increase the sensitivity of these devices, but the currently available packaging is only suitable for larger imagers. We are addressing this issue by developing a 3D integration technology for microcameras with microlenses.

Services:
Design, process evaluation, characterization and prototyping of 3D integrated systems, including:
- TSV formation for customized CMOS wafers (via-last)
- Silicon and glass interposers
- Assembly of thinned and TSV chips
- Backside contacts for image sensors (FSI, BSI)
- 3D integration of optical interconnects
- Hybrid 3D pixel detector modules
- Hermetic MEMS packaging using TSVs

2 *3D module with TSV interposer*

FRAUNHOFER IZM LABS & SERVICES



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

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

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Qualification and Test Center (QPZ) for Electronic Components
The Qualification and Test Center focuses on application-specific qualification of new solder alloys and packaging solutions for electronic components on a wide variety of substrates. All tests are carried out according to DIN EM, IEC, IPC and MIL standards. Component inspections and failure analyses after testing include the investigation of structural alteration, intermetallic phase growth, crack propagation using metallography, SEM/EDX analysis or focused ion beam (FIB) preparation. QPZ is now offering online, optical failure analysis based on the IPC-A-610 standard. The new service provides companies that experience component failure during manufacturing or shortly after deployment in the field with fast, sound advice on the component problem and its possible cause.

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

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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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Further laboratories include:
- Flip Chip Line
- Die and Wire Bonding Center
- Micromechatronic Center
- Labory for Thermo-mechanical Reliability
- Photonics Lab
- Advanced System Engineering Lab

PCB Prototyping Process Line
The new prototyping and process line can handle substrates with a maximum size of 610 mm x 456 mm and features:
- High-precision component placement
- Vacuum lamination press for multilayer fabrication and component embedding
- UV laser drilling and structuring
- Mechanical drilling and milling
- Photolithographic patterning using laser direct imaging and dry-film photo resist
- Horizontal spray development of ultra-fine line structures
- Horizontal spray etching and photoresist stripping
- Automatic and manually operated galvanic equipment

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

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Wafer Level Packaging Line
Our wafer level packaging line in Berlin boasts a 800 m^2 clean room (classes 10 to 1000), with wafer processing of different materials (Silicon, III-V semiconductors, ceramic, glass) and sizes (4'', 6'' and 8''). For some applications prototyping equipment is also available on 300 mm.
- Thin-film deposition (sputter and evaporation)
- Photolithography (including photo varnishes, polymers and spray coating)
- Galvanic bumping, circuit tracks and through-via filling (Cu, Ni, Au, AuSn, SnAg, PbSn)
- Wet-chemical processes (etching, cleaning)
- Wafer bonding (support wafer, thin-wafer handling)
- Silicon plasma etching (through vias, cavities)

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Mold Encapsulation Lab
The mold encapsulation lab offers various encapsulation processes, related material and package analysis and reliability characterization tools as a one-stop-shop.
- Compression molding on module- and wafer level
- Compatibility to PCB-based and thin film RDL application
- 3D-redistribution by through mold vias (TMV)
- Transfer molding of leadframe-based SiPs and of SiPs organic substrates (MAP molding)
- Rapid tooling for feasibility studies with real live prototypes
- Sensor packages with exposed sensor areas by film molding
- Transfer molding of large volume packages

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

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All Silicon System Integration Dresden - ASSID
The Fraunhofer IZM-ASSID Center in Dresden is equipped with a 300 mm wafer process line for the development and processing of integration technologies with analogue-digital or digital-digital circuits on CMOS-basis. Fraunhofer IZM-ASSID provides the following services:
- Cu-TSV interposer technology
- High-density Cu-TSVs for active and passive device integration
- Wafer thinning and handling of thinned wafers
- Wafer level bumping
- Wafer level assembly
- Wafer level solder ball attach (100 – 500 µm)
- Customer-specific prototyping

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Phone +49 351 795572-12

FRAUNHOFER IZM CORE COMPETENCIES

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Micromechatronics and PCB Technology Page 36
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RESEARCH CLUSTER
INTEGRATION ON SUBSTRATE LEVEL

INTEGRATION ON SUBSTRATE LEVEL AT FRAUNHOFER IZM

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

Multi-functional security document (SECUDIS)

HIGHLIGHT 2012

Smart secure document

SECUDIS, a Federal Ministry of Education and Research (BMBF) research project completed in December 2012, has set the scene for a new generation of security documents. The main goal of the research consortium, comprising NXP, Bundesdruckerei, Bayer Material Science and Fraunhofer Institutes EMFT, IAP and IZM was developing technologies for integrating ultrathin electronic components into innovative thermoplastic substrate materials as basis for the multifunctional ID cards and other security components of tomorrow.

Our research broke new ground by investigating the assembly of conventional PCB technology on polycarbonate as substrate material. Additionally, low temperature surface mount technologies for SMT components as well as three types of flip chips and an OLED display were developed. A lamination technology for Polycarbonate inlays was optimized regarding temperature sensitive components. An advantage of using polycarbonate as substrate material is that the layers fuse into an insoluble composite that precludes tampering. The innovation is particularly called for by the next generation of ID cards (e-ID).

In the initial step, ultrathin copper foils (3µm) were laminated onto the polycarbonate substrate. Subsequently, plated through-vias and a complex double-sided circuit layout that includes antennae were fashioned using PCB technologies, including via drilling, via metallization, copper patterning with LDI. The copper traces were protected with a thin silver layer. To fulfill the form factor requirements of a smart card, active and passive components (3 thin flip chips and different passive low-profile components) were then mounted on the patterned inlay at Fraunhofer IZM, using primarily adhesive techniques (ACA, anisotropic conductive adhesive, and ICA, isotropic conductive adhesive). Low-temperature interconnection techniques were required to mount all the components onto the polycarbonate inlay. The temperature-sensitive OLED display was mounted using a low-temperature bonding technique ACF (anisotropic conductive film). To optimize the lamination process, we fabricated intermediate layers adapted for the individual components and developed a process that protects the temperature-sensitive components, while also inducing complete fusion of the above intermediate layers into a homogeneous body.

The overall system is contactless, operating at 13.56 MHz and the three integrated chips are powered solely via the antenna. A viable extension for security applications would be adding a 3x3 touch pad. User authorization could then be validated directly on the card itself by simple input of a PIN or similar security code. Two application areas standing to benefit from these new integration technologies are components for user-friendly IDs and security documents and innovative smart-sheet substrates with energy-efficient displays.

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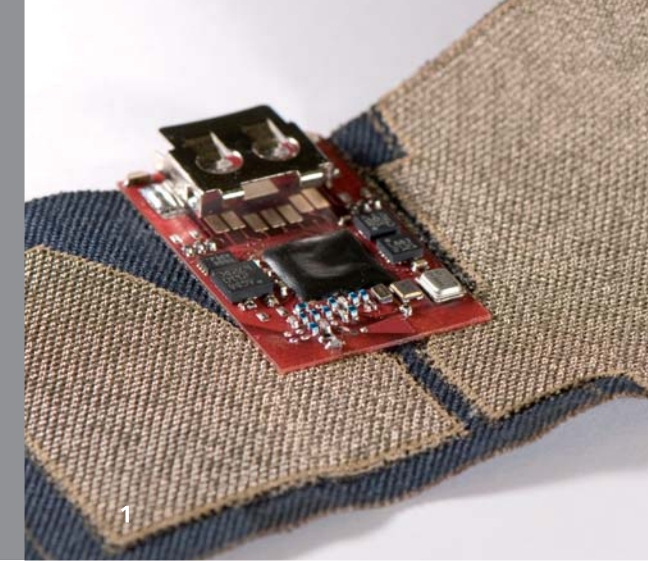

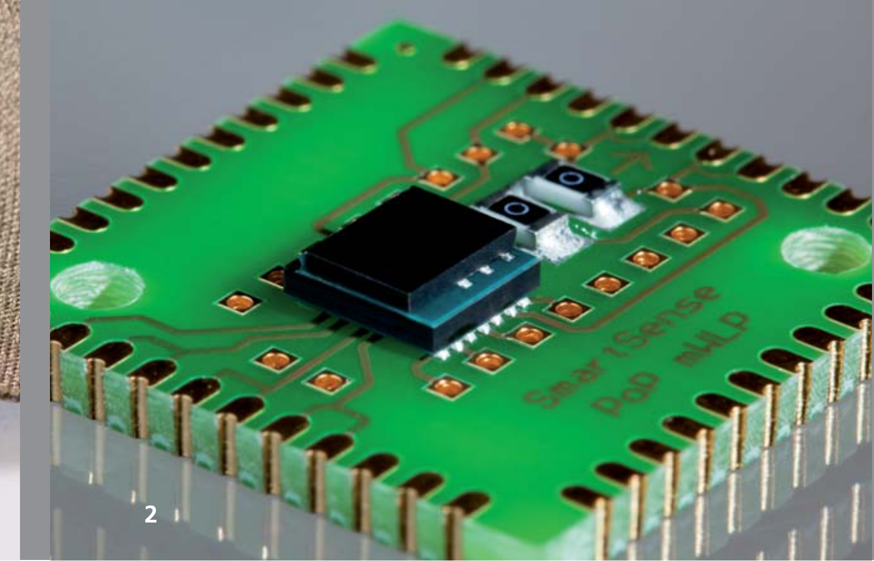

SYSTEM INTEGRATION & INTERCONNECTION TECHNOLOGIES

The Department

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

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

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

Trends

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

Our work on trends in future applications extends to:

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

RESEARCH & DEVELOPMENT HIGHLIGHTS

Textile sensor nodes

As part of the Wear-a-BAN project, we developed miniature textile sensor nodes that monitor physical activity. Because the modules can be attached to any part of the body, this exciting innovation has already been earmarked for a number of applications. It will improve and accelerate rehabilitation of stroke patients, improve the health and safety of the aged by facilitating external monitoring and even lay the ground for a new generation of gaming consoles. The development features an innovative folded packaging concept and interconnection method that uses polyurethane adhesives. Further highlights are the textile antenna and its soft and malleable surface, which maximizes user comfort.

Sensor packaging and sensor encapsulation

Packaging technology for intelligent sensor modules is one of microelectronics packaging's great challenges. Heterogeneous integration has become a key tool in mastering the escalating complexity of integrating ever more sensor functionality and, consequently, control logic into miniaturized packages. A wide variety of technologies, selected according to the intended application, the required reliability and budget, can be used to build intelligent sensor modules. Single chips on leadframe, COB on ceramic, system-in-packages on leadframe, organic substrate, even substrate-less packaging are just a few examples of the available approaches. Cost-efficient polymer is the material of choice. Typical techniques include interconnect formation by adhesive joining and glob-top or molded housing.

Our department participated in the recently completed MST-Smart Sense project, an industry-led consortium that developed the multisensor eCompass packages, which integrated magnetic, acceleration and pressure sensors, while still finding room for the related controller and passive components. Although the target application was consumer electronics, the new innovation can also easily be repurposed for high-temperature applications.

The latter are a common requirement in automotive/industrial electronics and medical engineering, and see sensors systems subjected to high operating temperature, extreme thermal cycles and aggressive media. We are working to address this issue in a number of projects, including HELP, which is developing PCBs and encapsulants for temperatures above 200 °C, ECPE Smart PowerMolding, qualifying molding compounds for applications up to 250 °C, and DianaSens, a

1 Activity sensor module on a textile antenna

2 Package-on-package stack with through mold via

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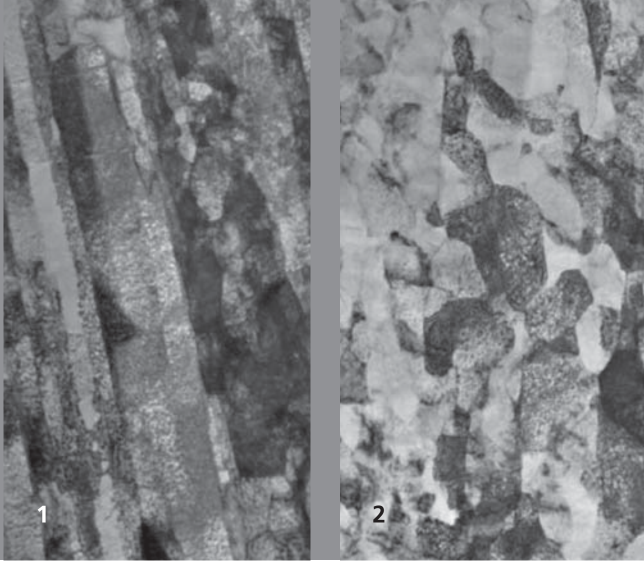
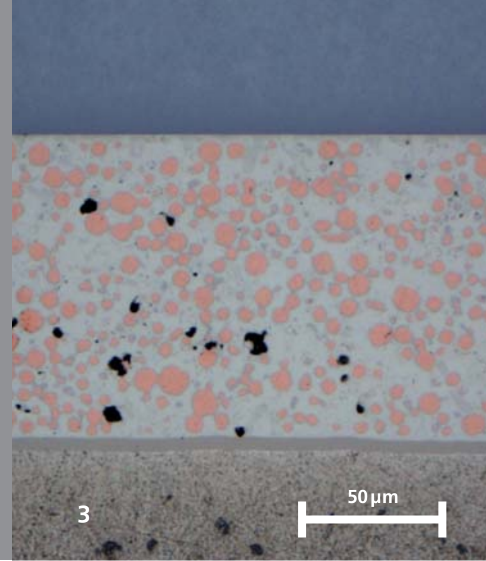
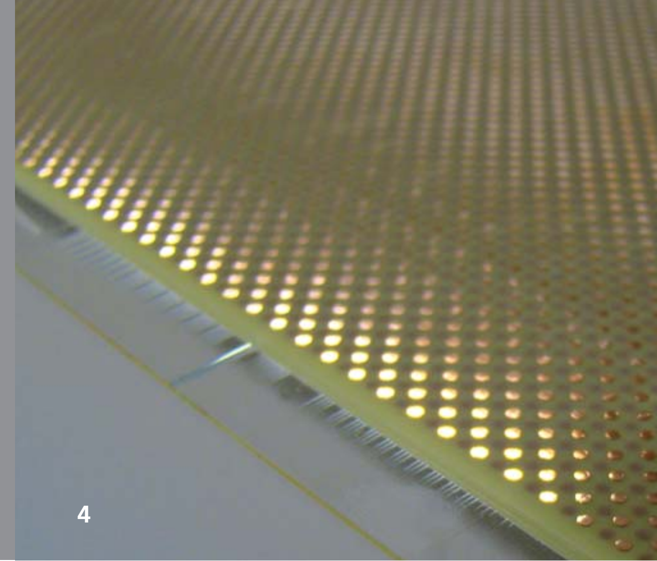
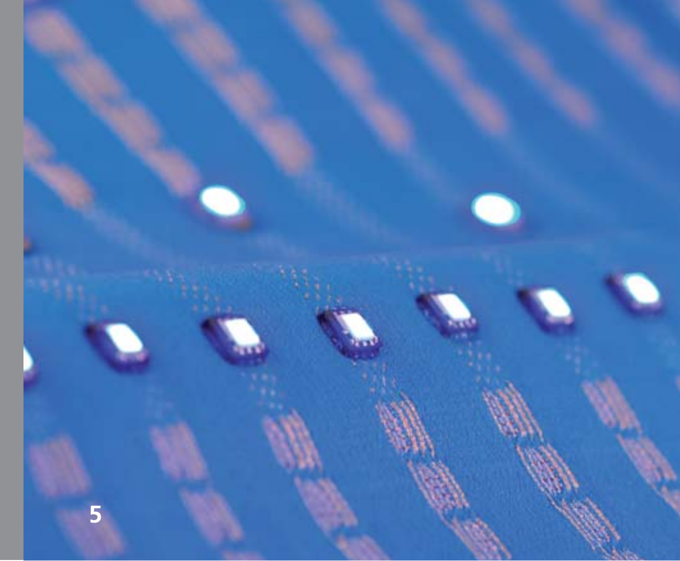



basic research project on humidity diffusion into microelectronic packages. We also carry out product-related research and development, usually in direct cooperation with partners from industry.

AlX bonding wire alloy makes the grade for use in high temperature applications

At temperatures above 100 °C, grain growth, recovery and recrystallization soften the high purity aluminum bonding wires typically used in power electronic applications and early failure due to heel crack may follow. The starting point for solving this problem was found in aviation technology. Here, aluminum is alloyed with materials that are lighter and have higher melting points, producing aluminum alloys that have higher strength at both room temperature and at temperatures above 100 °C. We used this principle to develop a new scandium-based AlX bonding wire alloy, which features high mechanical strength, good bondability and a low tendency to softening at elevated temperatures. When alloyed with aluminum, scandium forms spherical and extremely temperature-resistant Al_3Sc precipitates with diameters of less than 50 nm. These finely dispersed precipitates inhibit grain growth, which maintains the strength of the AlX wire even at higher temperatures. As the microstructure imaging shows, the grains remain fine even after six hours of temperature storage at 300 °C. Thanks to age hardening at between 250-300 °C, the breaking load of the new AlX wire is even superior to that of pure copper wire at room temperature. It is a vast improvement over high purity Al wire, which would quickly fail under these conditions. Not only is Al wire bonding at operating temperatures of up to 300 °C now possible, but the mechanical strength of the new wire can also be modified using the same base alloy and temperature treatment.

Interconnection technologies for high temperatures

To accommodate power density, which has been recently begun increasing on an unprecedented level in power electronics and solid state lighting, and for the high temperature requirements of sensors, developers have to make operating temperatures above 200 °C a reality. Bumping up operating temperatures may also relieve the effort put into designing more and more elaborate cooling systems as a key line of defense against temperature-related failure. However, temperature is a particularly challenging issue in interconnection technologies and, as a chain is no stronger than its weakest link, we have made addressing this a particular goal. Our strategy is multipronged, and includes sinter technologies using Ag powder, thermocompression bonding using nanoporous Au, soldering with Au-rich solder (AuSn20) and transient liquid phase bonding/soldering (TLPB/TLPS), which produces intermetallic phases in the solder that have re-melting temperatures of over 400 °C.

Advanced thin glass-based photonic PCB integration

Electrical optical circuit boards (EOCB) based on thin glass, an approach borrowed display technology, has proven a breakthrough in microelectronics-based product development. Improved performance, higher reliability, lower costs and superior energy efficiency are just some of the benefits. The integration of optical signal transmission in the EOCB was a key element. We developed size-enlarged EOCB with holohedrally integrated glass foils, future-proofed for tomorrow's bandwidth requirements thanks to integrated optical waveguides that accommodate high-speed intra-system optical data transmission and sensor technology. As part of this, we designed structuring technologies compatible with conventional PCB manufacturing. We also evaluated a range of established processes and new approaches and applied suitable candidates in the development of the EOCB process.

Side firing optical fibers

Side firing optical fibers are crucial in medical applications and sensor technology. Conventional mechanical grinding and polishing technologies have high manual manufacturing costs and lack automation. As part of a contract research project, we developed a design-to-prototype approach based on our customer's requirements, which demonstrates high reproducibility and has the capacity for further automation level including fiber handling. Using ZEMAX™ we designed a distal end capable of steering the optical beam without any additional elements. Using rotating tools and laser structuring, the unique technique can shape a fiber end with outstandingly smooth surfaces to improve internal reflection and outcoupling at any given angle.

A miniaturized stackable transceiver module

Keeping up with the demand for ever-greater miniaturization has always been a challenge for developers, and the requirements of medical devices like cardiac pacemakers, hearing aids, cochlea implants and insulin pumps arguably place the greatest demands. The relatively recent addition of wireless technology for measurement and monitoring has not made the task any easier. As such medical devices typically have extremely limited build space, developers have to exploit the potential for integration to the fullest degree.

Our new technology makes a significant contribution to meeting current demands. Developed specifically for the requirements of medical devices, the new stackable, embedded-component modules open up new possibilities, from 3D stacks that minimize footprint to extremely planar modules. For example, we used the technology to develop a low-power 2.4 GHz-band transceiver, in which a radio chip, 3 filter chips and 15 capacitors and resistors were integrated into a build space of just 4.2 x 4.3 x 0.77 mm^3. We first manufactured a 3-layer substrate with 35 µm traces and spaces using semi-additive technology. Next, we mounted the components using flip chip technology and SMD soldering. Finally, the components were embedded in the substrate by vacuum lamination. Further modules can then be mounted on the PCB, paving the way for countless new highly compact 3D systems. The transceiver described above was developed as part of the EU project WiserBAN in collaboration with partners in the medical engineering sector.

Smart pixel integration

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

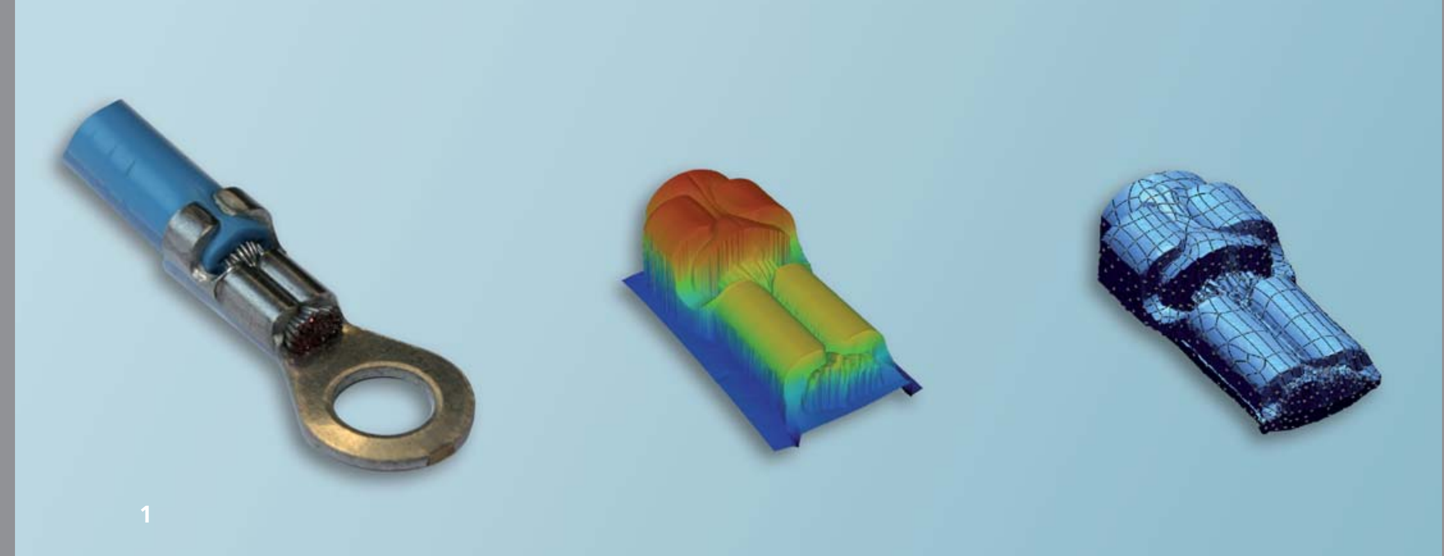
1 *AlX wire microstructure in as received state*

2 *AlX wire microstructure after temperature storage (300 °C, 6 h)*

3 *Die attach by transient liquid phase soldering (TLPS)*

4 *PCB with laminated thin-glass core*

5 *NCA-bonded RGB smart-pixels on textile circuits with embedded I^2C-LED drivers (Project: LumoLed.sys), Fabric from TITV Greiz*



MICROMECHATRONICS AND PCB TECHNOLOGY

The Oberpfaffenhofen branch
Here at Fraunhofer IZM's Oberpfaffenhofen branch we specialize in micromechatronics and training in packaging technology.

The department »Micro-Mechatronic and PCB Soldering« analyzes and optimizes mechatronic packages using the latest measurement technology and numerical simulation techniques. Reliability of the electrical systems and interconnection together with comprehensive qualification and damage analysis of components and assemblies, electrical connectors and electrical systems are our primary concerns. Simulation is mainly applied for electronic encapsulation (transfer molding, injection molding, design according to fiber direction) and optimization of the packaging processes.

We provide industry training to ensure our research into electro-mechanical interconnection finds real-life application. The foundation of our work is basic research using cutting-edge electrical measurement techniques, including in contact resistance, thermography, methods to define compression behavior of interconnection surfaces, and approaches to determine the influence of loading and contamination on reliability.

The Center for Interconnection Technologies (ZVE) in Oberpfaffenhofen holds courses and workshops on packaging technology, soldering, crimping, repair and qualification criteria, particularly as preparation for certification (ESA, IPC, DVS).

Trends
By merging form and function, electronic system integration is leading to fundamental changes, with a view to the use of generative manufacturing processes.

New materials are required for the bonds, cabling and shielding called for by electro-mechanical interconnection. Realizing multicomponent parts, so-called »Smart Power Mechanics«, necessitates intensive research into the interconnection surface area and that of the electronic systems integrated in the connectors. Determining the geometries that are actually created during the manufacturing process allows us to define local and, where pertinent, anisotropic material parameters. We feed this knowledge into numerical simulations that provide new insight into micro- and nano-technology.

We currently pursue the following key research goals:
- Development of generative processes and ink-jet printing
- Harnessing affordable materials for connectors, cables and shielding in electrical interconnection, such as replacing copper with aluminum
- Extending the use of crimp and press-fit joining
- Numerical simulation using accurate, real-life geometry and material parameters.
- Improving rework and repair processes
- Advanced training concepts (particularly for medical applications, solar technology, blended learning and others)

RESEARCH & DEVELOPMENT HIGHLIGHTS

Smart power mechanics
Smart power mechanics is a key research area in interconnect technology thanks to its potential as an approach to lightweight design and as a means of meeting overlapping development tasks.

Key areas of interest are:
- Electrical-mechanical interconnection, processes and applications
- Management, evaluation, reliability assessment and lifetime prediction
- Integration of intelligent components (sensors and signal processing, condition assessment, self-monitoring)
- Use of micro- and nano-materials, material substitution, advanced materials
- Quality assurance, custom testing, norms, custom applications

The Smart Power Mechanics initiative was funded by the Bavarian Ministry for Economic Affairs.

Direct digital manufacturing technologies in electronics
In direct digital manufacturing processes, also known as additive manufacturing, the workpiece is printed layer-by-layer. A particularly enticing feature of this manufacturing technique is that mechanical models with conductive and movable parts (integrated assembly) can be combined. This means that metallizations (including, but not limited to, silver, gold, copper, nickel and indium-tin-oxide ink) can be deposited and patterned cost-efficiently and with reliable results on almost any surface type (such as films, wafers, polymers, wood and paper), including 3D surfaces. This approach is rapidly approaching technological maturity and the assembly of complex sensor/actuator modules manufactured using generative processes is already viable.

e-Learning
Thanks to educational iPad app »Soldering and Crimping«, the Fraunhofer Academy, with whom we developed the software, can now offer its training courses via the World Wide Web. Designed to facilitate flexible, self-paced learning, the course is divided into a series of short units each covering a particular aspect of the course content. The user is free to work through the course at their own pace and convenience – be it in a break between appointments or while on a business trip – and is not even compelled to tackle the material in any particular sequence. Instead, the app presents the units as a learning map, so that the students can choose their own approach to the subject.

1 Reconstruction of a crimp interconnect to quantify local deformation

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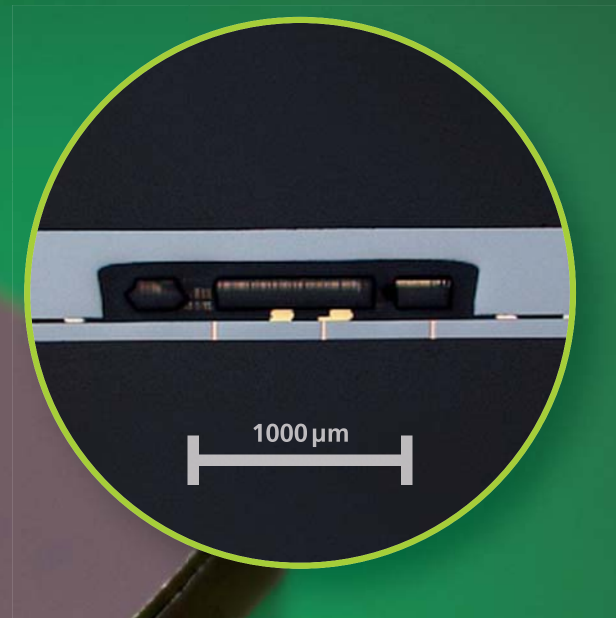
RESEARCH CLUSTER
INTEGRATION ON WAFER LEVEL

INTEGRATION ON WAFER LEVEL AT FRAUNHOFER IZM

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



Wafer level MEMS package, Cutout: Cross section

HIGHLIGHT 2012

Hermetic sealing of MEMS components by 3D wafer level packaging
For the miniaturization of electronic systems 3D wafer level integration is one of the key approaches in microelectronic packaging and system integration worldwide. Especially through silicon via (TSV) technologies facilitate the heterogeneous integration of multiple devices such as sensors, ASICs, memories and transceivers in a stacked architecture with excellent electrical performance and small form factor.

Together with its industrial and academic partners Fraunhofer IZM develops base technologies for the wafer level fabrication of low-cost, miniature, chip-scale packaged (CSP) hybrid microsystems. For this purpose, standard technologies like redistribution, TSV formation and wafer to wafer bonding are combined to obtain versatile approaches for hermetic wafer level packaging of MEMS components.

Some of these developments are funded in a collaborative project with the acronym »Go4Time« within the seventh framework program of the European Union. From the application side the project is driven by the timing market and the requirement for new manufacturing concepts for highly stable, generic, low-cost timing devices suitable for power aware, long autonomy, portable telecommunication systems such as mobile phones. One milestone in the project is the wafer level fabrication of a MEMS package based on silicon interposer wafers with vertical copper-filled TSVs and bonded cap wafers for hermetic sealing of resonator components.

The interposer wafers with vertical copper filled TSVs as well as front and backside redistribution have a thickness of 90 µm. They feature appropriate IO-terminals and seal ring structures, which were deposited by semi-additive Au and Au+Sn electroplating, respectively. After interposer processing, assembly of the MEMS components was performed by one of the project partners using Au-Au thermo sonic bonding.

The corresponding cap wafers were fabricated by another project partners using semi additive electro plating of Au seal rings followed by silicon dry etching of 200 µm deep recesses to generate the cavities for the resonator components on the opposite interposer.

Finally both cap and interposer wafers were bonded together using a wafer to wafer bonder and an adapted AuSn soldering process scheme. Subsequently, dicing of the packaged components was carried out. Based on this approach thousands of MEMS components could be properly sealed simultaneously under vacuum.

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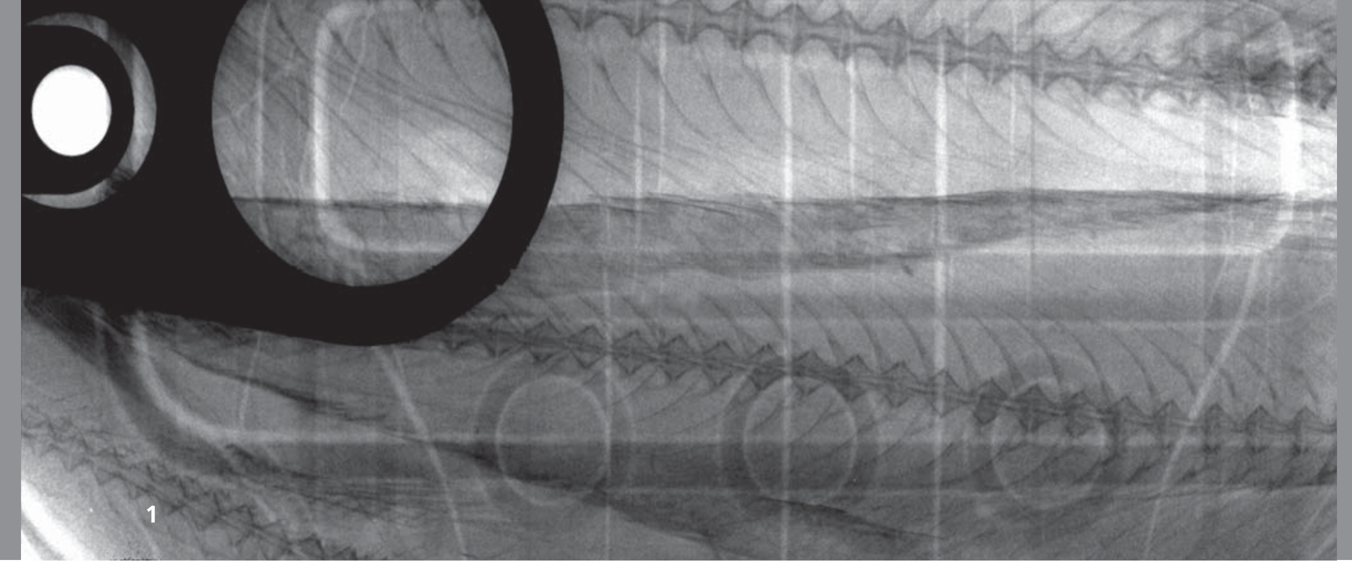

HDI & WAFER LEVEL PACKAGING – ALL SILICON SYSTEM INTEGRATION ASSID

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

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

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

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

Other foci include:

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

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

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

RESEARCH & DEVELOPMENT HIGHLIGHTS

MEDIPIX3 – Pixel sensor for synchrotron radiation
In cooperation with the Hamburg-based Deutsches Elektronen-Synchrotron DESY, we have developed a hybrid pixel detector module for X-ray analysis. Using the latest generation of MEDIPIX3 read-out chips and the largest single silicon sensor chips, the 87 x 30 mm² components were assembled at Fraunhofer IZM and subsequently tested at DESY Hamburg.

The new technology will be integrated into a powerful novel protein X-ray crystallography system, which can record the diffraction images of crystals to facilitate reconstruction of their molecular structures.

1 X-ray image of tinned fish using the new single-module technology

New packaging process for RF MEMS switches
We have developed a new packaging process for RF MEMS switches. The MEMS switch used as basis for the design was fabricated at the research institute IHP (Innovations for High Performance Microelectronics). The development was carried out as part of projects funded by the German Ministry of Education and Research (BMBF) and the European Union's NANOTEC project (NanoTec, FP7 ICT 2011-7).

Either single switches or entire circuits can be packaged on wafer-level using the new process. As first step, a glass support wafer is bonded to a silicon wafer. The latter is then thinned and cavities are etched to form the silicon caps that are surrounded by an adhesive frame. The support wafer with silicon caps is then bonded wafer-to-wafer to the MEMS wafer. In the final step, the support wafer is released by laser debonding.

New improved battery design
Our recently completed wafer-level process promises a new generation of significantly smaller lithium ion micro-batteries. We developed a novel battery design, in which anodes and cathodes are mounted side-by-side in a planar lay-out. Electrolyte thickness, electrode separation, width and depth were the keys to achieving sufficient current capability and capacity. A two-step lithography process was used to fabricate separator walls between the anodes and cathodes, while the required side-wall slopes in x- and y-direction were fabricated by wet etching of the silicon substrate.

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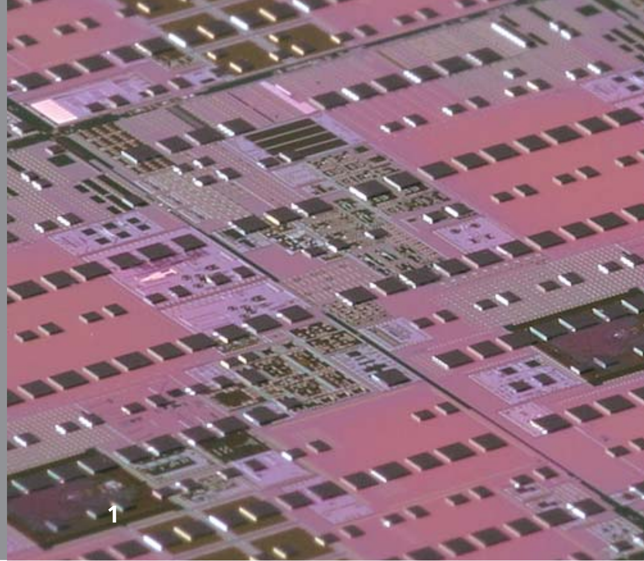

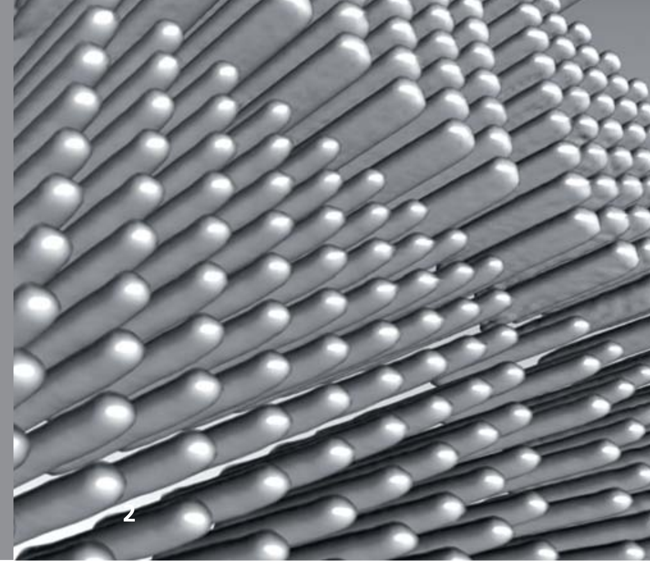

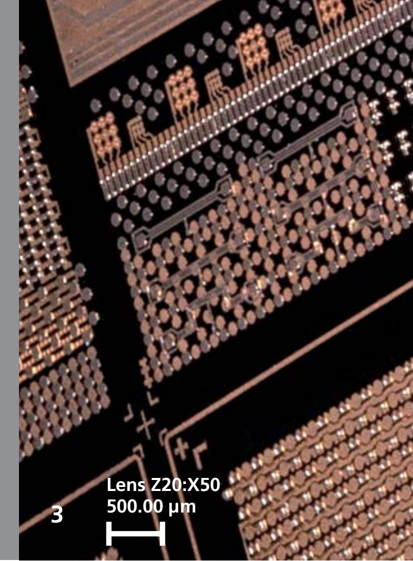

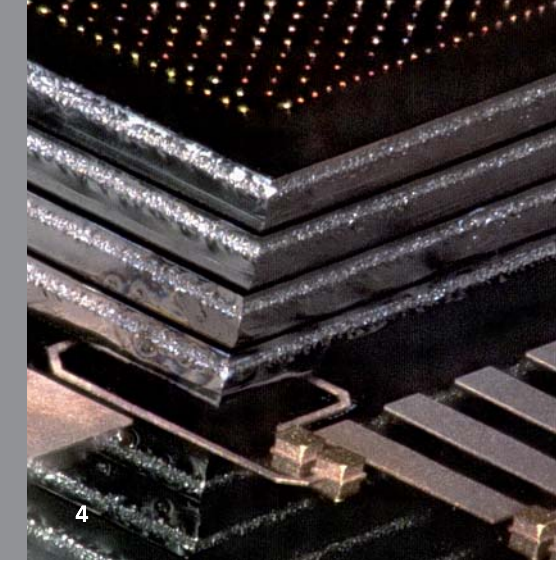

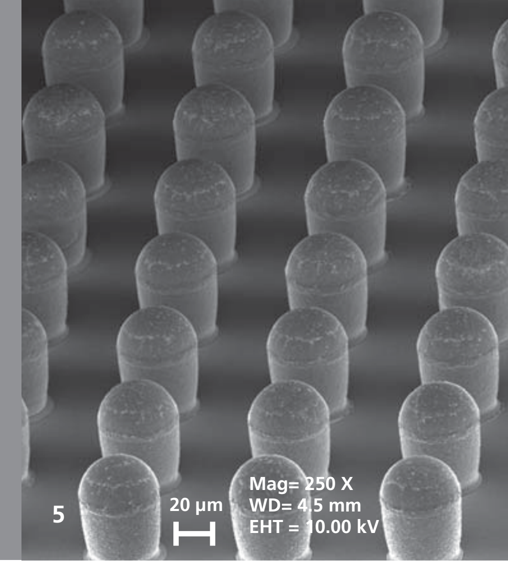

Cost-efficient and simple fuel cell concept for industrial mass production
As part of the joint project 4WZell, we are further simplifying a concept for miniaturized PEM fuel cells, originally developed by Fraunhofer IZM, in cooperation with four innovative SMEs (Witte+Sutor GmbH, Fritz Stepper GmbH & Co. KG, Herbert Kaut GmbH & Co. KG, and jvi GmbH).

Together, we have developed an integrated component, design and manufacturing approach based in part on microsystem manufacturing. The PEM fuel cells have an electrical output capacity of 4 - 8 W in continuous operation.

Advanced 300 mm interposer approach
We optimized and stabilized the design and processing of silicon interposers with polymer RDL. With high density multi-layer wiring applications particularly in mind, we introduced a new space-saving via design and a homogeneous layer stack beneath the micro bumps.

Additionally, passive elements (resistors, capacitors) have been integrated into the multi-layer wiring and first electrical test structures were fabricated to characterize these passive elements. We have also begun the process of implementing CVD oxide dielectrics for multi-layer interposers.

Cu TSV implementation in functional devices
As part of the ENIAC project JEMSiP_3D (»Joint Equipment and Materials for System-in-Package and 3D-Integration«, FKZ: 13N10427), we developed a Cu-TSV process on 300 mm in cooperation with Atotech Inc. After verification and characterization, the process was adopted as part of Fraunhofer IZM's standard repertoire of Cu-TSV approaches. It has already proven its mettle as a via-last process for a 3D system-in-package demonstrator from NXP, with functional devices comprising a 3D stack for a microcontroller (smart card controller) as host device and flash memory as guest device. Additionally, we researched a through-encapsulant via (TEV) approach for Infineon's eWLP technology.

Inline metrology for TSV technology platform
Fraunhofer IZM ASSID has developed an inline metrology solution for 3D stacking with through silicon vias on 300 mm technology. The technology tackles disparate measurement needs, including TSV depth, remaining silicon thickness, bump height, CD, defect inspection, layer uniformity and overlay measurements. Cooperation with metrology tool suppliers is also being investigated to extend the application's uses even further.

We also optimized measurement parameters for accurate, effective handling of process variations and changes in wafer structure. An additional emphasis was reasonable measurement times in large-volume manufacturing by sampling or 100 percent coverage, as required.

Development and qualification of a Cu-TSV via middle process
We have stabilized and optimized our copper TSV process to meet the required processing time for manufacturing. One focus was systematically investigating different barrier layers and their individual interactions with subsequent processes, including TSV plating, annealing and CMP. We also improved the electrical characterization of TSV insulation layers, and have tested it on numerous ASSID test layouts.

1 *Wafer to wafer MEMS Packaging*

2 *X-ray of copper-TSV test field (10 µm diameter) after ECD*

3 *Test assembly with through silicon vias*

4 *Stacked silicon chips with integrated through silicon vias*

5 *Fraunhofer IZM-ASSID – Interposer test chip with Cu-Pillar and SnAg flip chip*

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.

Combined test stand for swelling of polymers under humidity and heat

HIGHLIGHT 2012

New method for determination of humidity-induced swelling

With the increasing miniaturization of microelectronic components it becomes increasingly important to understand the way in which moisture can penetrate materials and the bonding interfaces of composite materials. Considering future package developments, it is apparent that with an increasing integration density, the effects on interface areas between the various materials will dominate over the bulk materials. This is very important for the reliability assessment of highly integrated components, e.g. because absorbed moisture can cause the polymers to swell. This humidity-induced swelling leads to strains in the compound materials, which can cause premature loss of functionality of components. It is therefore extremely important to know about the absorption and desorption behaviour of the polymers used.

In order to obtain realistic assessments of absorption and desorption behaviour, an existing measuring device was modified so that humidity-induced swelling can be registered in-situ. A thermo-mechanical analyser was used together with a moisture generator. The thermo-mechanical analyser has a high resolution and can reproducibly register path differences in the nm-range, which is necessary for determining humidity-induced swelling. By combining this with the humidity generator and a temperature chamber, the swelling of small components can be investigated at constant humidity and temperature.

First results show that the humidity-induced swelling of selected polymer materials reaches complete saturation more quickly than was determined previously using the measurement of weight changes.

Together with these experimental results and the findings from molecular-dynamic (MD) simulations, it will be possible in the future to provide better descriptions of the diffusion behaviour of moisture at interfaces. In turn, this will make it possible to adopt targeted optimisation measures.

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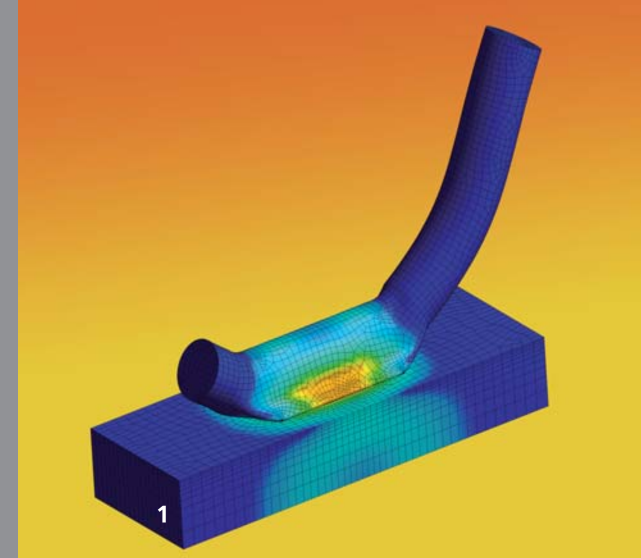

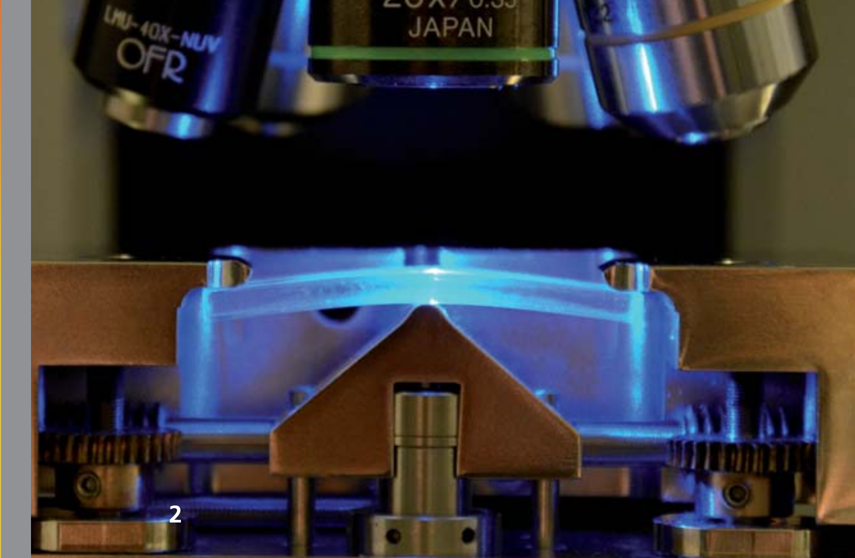

ENVIRONMENTAL & RELIABILITY ENGINEERING

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-characterisation 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 characterisation
- 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 political field, and even more so in the media, resource utilisation and the operating life of high-tech products are increasingly topics of interest. This is exactly one field in which Fraunhofer IZM operates. Many of our services and further developments under the heading of »Eco-Reliability« are closely related to product life and resource deployment.

Examples where this plays a key role include:
- LED lighting (recycling, thermal management, durability)
- Energy harvesting (energy efficiency, durability, environmental trade-offs)
- Power electronics (selection of materials, efficiency, failure mechanisms, thermal optimisation)
- Sensor integration (FEM-simulations for low-stress packaging, material characterisation)
- Material availability e.g. of rare earths (evaluation methods, optimisation, substitution)
- Resource efficiency, with a shift of emphasis from energy efficiency to other efficiency aspects
- Evaluation of reparability and recycling-potential of IT products
- Mission profiles and long-term application-specific tests (e.g. automotive industry, safety and security technology, medical engineering, industrial applications)
- Obsolescence due to unavailability of components
- Load-dependent failure predictions (integrated condition monitoring)

RESEARCH & DEVELOPMENT HIGHLIGHTS

Long-term availability of electronics
In the Fraunhofer Innovation Cluster MRO, considerable progress has been achieved in the LangzEl Project, which has now been concluded. The goal of the project was to efficiently ensure or restore the availability of electronic systems. To this end, a systematic and strategic approach has been modified for users in the fields of energy and transport.

A key aspect is the potential to implement methods for fault recognition and condition identification so as to be able to begin targeted repair measures. A methodology was developed at Fraunhofer IZM for the use of IR measuring technology, and a practical user's manual was developed. It was also possible to show that high-quality repair measures have no negative impact on the durability of soldered connections.

RESCAR 2.0 – Robustness in the field of electromobility
In the RESCAR 2.0 project, supported by BMBF, manufacturers of cars and semiconductors work together on a joint approach by which the specification profile of the automotive industry in terms of robustness can for the first time be taken into consideration reliably in the design of components for control devices. Fraunhofer IZM supports its partner AUDI AG with the development of methodologies for the formulation of specification profiles.

Better characterization of crack formation in packages
Crack formation is one of the most common causes of failures in IC-packages and related SiPs (system-in-package). In order to be able to predict delamination, it is necessary to determine experimentally the bond strength of the interface in question. This is done using the button shear test with a triangular cross-section and the mixed-mode bending test. In combination with simulations and experiments it is then possible to evaluate key mechanical parameters dependent on temperature, humidity, and angle of load.

1 New FEM simulation model for thick wire bonds combining processing influences with degradation assessment

2 3-point bending sample examined under a Raman spectroscopy microscope

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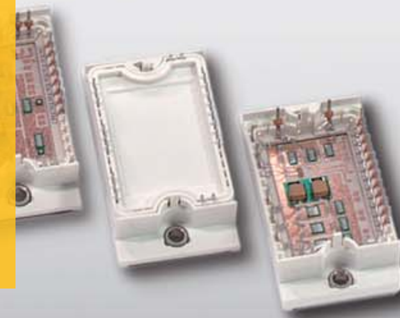
RESEARCH CLUSTER SYSTEM DESIGN

SYSTEM DESIGN AT FRAUNHOFER IZM

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



SOlar – Simulation and optimization techniques for designing power electronic systems: Efficient, robust and compact

HIGHLIGHT 2012

Developing a highly efficient SiC solar converter

Developing commercially viable power electronic systems involves meeting diverse, even contradictory requirements. The technology has to be highly efficient, robust, reliable and inexpensive, but also have high lifetime, power density and electromagnetic compatibility (EMC). Each of these requirements has to be assessed both individually and in relation to the other parameters for every new application.

The joint project SOlar has developed a simulation and design technique that makes designing highly efficient power electronic systems faster and more efficient. Using validated simulation models and optimization techniques, designers will be able to feed key parameters in to the design process at the earliest stages, preventing superfluous (and expensive) revision further on. Existing simulation tools used for structural, thermal, electrical and electromagnetic design have been improved and more closely interconnected.

To analyze the new models, a number of different Fraunhofer IZM departments worked together to develop, assemble and test a 15 kW solar inverter mounted with silicon carbide (SiC) chips. We are aiming for a peak efficiency of 98.5 percent, above that of the EU's 97.5 to 98 percent. Thanks to SiC chips, the inverters have a switching frequency of 48 kHz, which allows for much smaller passive components, particularly the output inductors for the mains filter and the DC-link capacitors, while the component layout has been designed to minimize power loss. The new technology promises to keep devices affordable, because while the price of copper is rising, the cost of SiC components is falling.

The total volume of the demonstrator is approx. 70 percent less than that of the current leading commercially available solar inverter of the same power output, and the total weight is approximately 15 kg.

The project is a collaboration with Robert Bosch GmbH, CST AG, TU Berlin and Adapted Solutions GmbH. Initiated in 2010, the three-year project was completed in April 2013.

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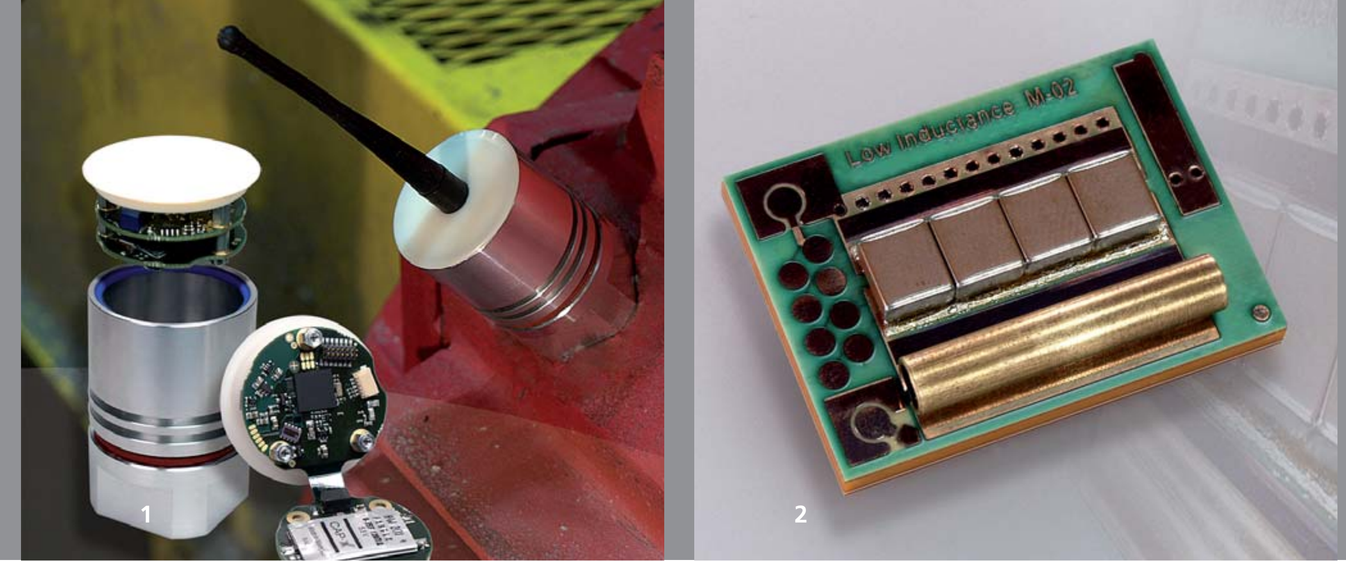

SYSTEM DESIGN & INTEGRATION

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

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

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

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

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

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

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

RESEARCH & DEVELOPMENT HIGHLIGHTS

Design tools
Our development of EDA tools focuses on component placement. We are currently pursuing a semiautomatic process, which gives the designer more control by providing for manual tweaking of the solution. Such an interactive design will require specially designed, sophisticated software. We are also integrating algorithms developed by our colleagues into user friendly environment including GUI. Once completed, the new technology can be used for tasks like designing signal paths despite discontinuities like bends or vias.

Microelectronics and microsystem technology
In 2012, we continued to make headway in our ongoing project to further miniaturize power supplies. We have begun development of a new generation of modular power supplies housed in conventional IC-packaging, which are capable of up to 10 W and do without external passive or active components. In sensor technology, we have designed miniaturized radio sensors for harsh industrial environments that can measure and monitor tasks in production facilities. Similarly, our new sensor network is used to monitor motors and bearings in industrial environments. One example of its potential is as vibration sensor network that detects damage to paper mills and relays the results to a higher-level control station.

RF and high-speed systems
We have designed packages for Mach-Zender modulators. Here, the antenna integration was specifically designed to minimize electromagnetic interference between the antennas and their environment. Apart from signal integrity, we have always maintained a strong focus on power integrity. In this area we adapted the contour integral method to investigate on a theoretical basis and compute the radiation generated by a PCB. For automotive applications, we investigated electrical interconnection systems suitable for the extreme »under hood« conditions.

Power electronic systems
Over the last year we have advanced our system expertise by manufacturing a prototype of a highly integrated solar inverter with silicon carbide (SiC) semiconductors. Other areas included research on low-inductance packages for SiC semiconductors for high-temperature applications and power modules with optimized electromagnetic characteristics. We also provide ongoing support to automotive manufacturers and suppliers seeking to minimize electromagnetic interference in electric and hybrid vehicles. Here, we were able to provide innovative solutions for active and passive filtering and shielding.

1 Wireless sensor node with energy harvesting from temperature differences for condition-based maintenance of machines and facilities

2 Prototype of a 1200 V half bridge with SiC-JFETs in embedded technology, Fraunhofer IZM in cooperation with ECPE

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FRAUNHOFER IZM RESEARCH AWARD 2012

FRAUNHOFER IZM RESEARCH AWARD GOES TO DR. IVAN NDIP

Each year, the Fraunhofer IZM Research Award acknowledges outstanding scientific achievement by an institute scientist. In 2012, the award went to Dr. Ivan Ndip, head of the research group RF & High Speed System Design for his work on »Methods, Models and Design Measures for the Electromagnetic Optimization of RF- and High Speed Systems«. The award ceremony was held on December 19th, 2012 at Kosmos Berlin.

RF measurement of test structures on glass wafer in thin film technology

Technical background

Unimaginable amounts of data crisscross the world at ever faster speeds today, while at the same time the reliability of the transmitted data is maintained and interference is prevented. How is this possible? Antennas are one of the most important components in wireless electronic devices. They enable wireless data exchange and also have a huge impact on the quality of the transmitted signals. However, before data can be wirelessly exchanged between electronic devices, it must first be processed reliably and without interference by system components. Signal paths, which interlink these components, play a decisive role in this intra-system communication. For chips to be able to process large amounts of data very quickly, their operating frequencies are increased with each new generation of products. However, at these high frequencies, it becomes increasingly difficult to successfully design complete signal paths in electronic systems to be capable of enabling faster and reliable data transmission without degrading the signals beyond acceptable limits.

Dr. Ivan Ndip
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Optimized, reliable and cost-efficient design

Ivan Ndip developed novel methodologies for accurate and efficient electromagnetic modeling of complex signal paths in electronic systems under consideration of signal integrity effects at multi-GHz frequencies. Using his approach, the impact of parasitic effects of each interconnecting segment on the performance of the entire signal path can be identified and minimized. This enables a systematic design and optimization of complete signal paths in the GHz frequency range. Thanks to his research, system designers are now able to identify critical interconnecting segments along complex signal paths at very early stages in the development phase – even before layout design – and prevent signal integrity problems. Ndip's so-called M3-approach (Methods, Models and Measures) prevents re-designs, reduces the development cost and enhances the system performance. Using the new approach, integrated antennas and other system components can be optimally and cost-effectively designed.

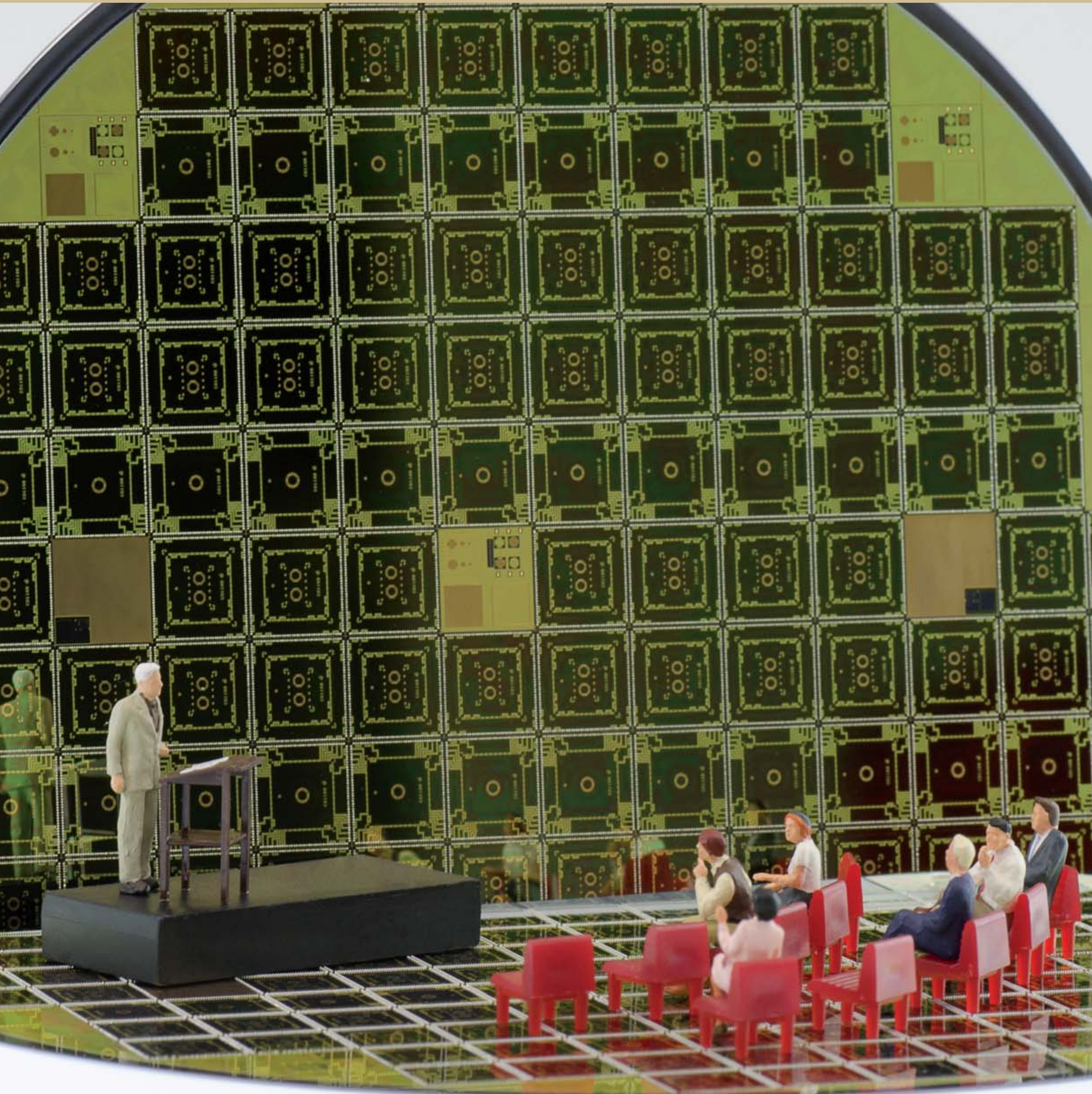
Areas of application

Ivan Ndip's research addresses the big questions facing today's microelectronics industry. His expertise is not only called on by the information technology (IT) industry, but where ever data has to be transmitted reliably and without interference, such as in medical applications, safety and security as well as applications in the automotive industry.

About the 2012 Research Award recipient

For more than ten years now, Ivan Ndip has been researching modeling, design and optimization methods for complete signal paths, he is an internationally acclaimed expert in his field. Ivan Ndip is a senior member of the IEEE and has authored and co-authored more than 115 scientific publications and has won many best paper awards.

FRAUNHOFER IZM EVENTS



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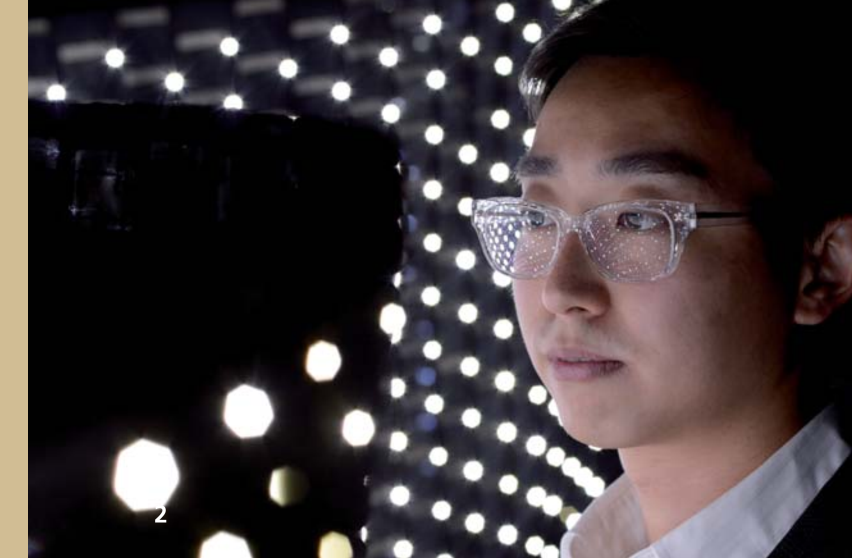

EVENTS & WORKSHOPS

450 participants at Electronics Goes Green 2012+
This year's Electronics Goes Green, jointly organized by Fraunhofer IZM and TU Berlin's Forschungsschwerpunkt Technologien der Mikroperipherik, marked a new milestone in the electronics industry's commitment to sustainability and environmental responsibility.

The four-day event was attended by 450 conference delegates with a wide range of backgrounds in technology development, industry management and environmental policy. Together the participants contributed six keynote speeches, 155 presentations over five parallel sessions, 30 posters and immeasurable know-how and experience during the discussions and networking sessions.

A particularly popular topic in 2012, in terms of both session number and size, was resource management. Several speakers emphasized the importance of dealing with all stages of the supply chain, not just those traditionally associated with materials. Two other key conference foci were firstly, new materials and technologies and secondly, recent legislative developments.

The organizers were particularly pleased by the variety of conference participants. Attendees from over 36 different countries and an equal mix of industry and academia professionals and experts took full advantage of the conference's networking opportunities, on the conference floor as well as at the exhibition and the social events. In terms of the latter, the conference dinner on Monday evening was a particular highlight, held at the fitting location of the Berlin's Botanical Gardens.

Berlin Business Forum at Fraunhofer IZM
In March, Fraunhofer IZM played host of the Berlin Business Forum for the second time. More than 30 guests from business and industry discussed microelectronic system development and reliability with Fraunhofer researchers. Apart from future microsystems for medical products and automation in industrial electronics, practical introductions to the labs were given – making for a day of scientific communication that doesn't go in one ear and out the other.

Long Night of the Sciences in Berlin and Dresden
On June 2, 2012, Fraunhofer IZM and TU Berlin's Forschungsschwerpunkt Technologien der Mikroperipherik participated in the Long Night of the Sciences. It was the seventh time that the two institutions presented their latest developments at the annual event that gives the lay public a first-hand look at the latest in scientific research. The TU's cleanroom drew the biggest crowd. Many of the well over 500 visitors seized the chance to glimpse behind the scenes of microchip manufacturing and take home their very own chip. Other highlights included the world's smallest microcamera, a lens-free chip microscope that was developed in-house and an especially energy-efficient tablet computer that has a wood casing and is up to 98 percent recyclable.

The Fraunhofer IZM center »All Silicon System Integration Dresden« (ASSID) participated for the first time in Dresden's Long Night of the Sciences and met with an overwhelmingly positive response. From 6 pm onwards, visitors to the event streamed into the center's Moritzburg headquarters for an inspiring behind-the-scenes look at the world of 3D microintegration. The talks and also the microscope station were well received and provided the guests with cutting-edge information and excellent opportunity for discussion. A clear highlight for both young and old was the extremely informative presentation of the smallest-ever microcamera. The latter exhibit called for a bit of teamwork, with one visitor operating the endoscopic camera to examine the tummy of a very out-of-sorts stuffed lion, while the other performed microinvasive surgery to remove an accidently »swallowed« piece of foam from said patient.

Particularly in demand were the clean room tours, which gave the participants a rare close-up of the technology area. Despite the patchy weather, Fraunhofer IZM-ASSID was able to welcome about 140 enthusiastic night owls through its doors – a great success all-round.

Workshop on »Energy Autarkic Sensor Networks«
Wireless solutions are one of the biggest trends in automation technology and consequently a key research topic at various Fraunhofer institutes. Five of these joined together in Berlin on February 16th to present the current state of research in wireless sensor technology at the Fraunhofer workshop Energy Autarkic Sensor Networks. Key foci of the workshop organized by Fraunhofer IZM were power supply, network formation, communication and packaging. About 70 participants took part in the one-day event.

»Empowered Living in Old Age«
Over 50 experts from the electronics industry, MEP and medical engineering, nursing care, ICT, social sciences and trades from throughout Germany met on October 17th at Fraunhofer IZM to discuss new technologies in ambient assisted living (AAL).

The workshop marked the completion of the project SELBST (Self-determined Living in Old Age with Microsystem Technology), in which Fraunhofer IZM's Application Center collaborated with experts from Berlin's ESYS GmbH to develop an ICT system for homes. The specific target group was aged people living alone and their relatives living outside of the area.

Instead of focusing on detecting emergencies, the new system aims to increase overall sense of security by supporting the elderly from behind the scenes and alerting family when necessary.

1 *Fraunhofer IZM's director Prof. Klaus-Dieter Lang at the Electronics Goes Green 2012+*

2 *Hightech in Textiles – Fraunhofer-Forum in Munich*

Smart Textiles – fashionable and practical
»High-tech in Textiles« was the slogan of the Fraunhofer Forum in Munich on October 22nd. What the term »smart textiles« actually means, what research has to be conducted and what the most interesting ideas for the future are, were presented by experts from industry and research over an evening attended by approximately 300 at Fraunhofer Haus. Speakers included Fraunhofer IZM Director Prof. Klaus-Dieter Lang on »Interactive clothes and alarm textiles«, which is one of the institute's key research areas.

In the concurrent exhibition, various clothing items designed by students and professors of the Weißensee Academy of Art and implemented in cooperation with IZM researchers were displayed. The pieces included a coat with an interactive lighting pattern and the blue silk dress Klight, which translates its wearer's movements into patterns of light. A particular highlight was the sound installation Soundscape by Paula van Brummelen, comprising 5228 hand-folded pieces of fabric covered with graphite that emitted different tones when touched.

Workshop »Electronics for Medical Products«
Medical engineering products like pacemakers, hearing aids, microfluidic systems and retina implants are now simply unimaginable without microsystems. Held during COMPAMED 2012 in November, the workshop »Miniaturized Electronics for Medical Products« presented the innovative products just around the corner thanks to Fraunhofer IZM's technologies, including sensor-actuator components with wireless interfaces that literally disappear into the body, bandages with integrated sensors and point-of-care diagnostic systems.

The University Clinic Heidelberg, the US company Blackrock Microsystems, and Jena's MicroFluidic ChipShop participated in the forum at COMPAMED and supplied practical examples of the technologies presented by Fraunhofer IZM.

European Center for Power Electronics (ECPE)
Fraunhofer IZM has helped organize and present tutorials and seminars for ECPE and the industry cluster Power Electronics Bavaria a number of times in the past. In 2012 a new type of training was developed for the ECPE: the lab course. Here, practical work in the laboratory, including measuring, modification of circuits by means of soldering and circuit optimization, forms most of the training. The new style of training has proved popular, with the course Parasitics in Power Electronics already run three times thanks to popular demand.

The ECPE workshop Integrated Power Boards was opened by a keynote lecture by Fraunhofer IZM this year, who also contributed a presentation on Ultra-Low Inductance Packages for SiC Switches.

IZM stay ahead of the pack – brainy and sporty
To balance out the hours in front of the computer or in the labs, many IZM employees like to keep fit in their spare time. Especially the runners and the soccer players join in the competitions against other companies and research institutes held each year.

A total of 154 »Fast Running Scientists« from the Berlin Fraunhofer institutes IPK, HHI, FIRST, FOKUS and IZM competed in the 12th Berlin Corporate Marathon on June 1st 2012, of which 21 were Fraunhofer IZM employees. Hitting 12th and 18th place (of a total of 5573 runners), Fraunhofer IZM improved its results over previous years.

The institute saw similar success in the relay races at the Berlin Marathon on November 18th. The institute's runners arranged themselves in teams of 5 across the marathon course (12+10+5+10+5 km). From a total of 1000 teams, two Fraunhofer IZM groups placed in the top 100.

Fraunhofer IZM soccer players did not see quite the same success, even though the institute sent two teams to the Fraunhofer Championship in June. But the teams had assessed their chances realistically from the start, as reflected by their team names: »Torpedo Torlos« (Eng. »Torpedo Goalless«) and »Blackouts Berlin«.

1 Having a go is what it's all about: »Torpedo Torlos«

Events with Fraunhofer IZM participation 2012 (Selection)	
mro-Workshop »Reliability Through Condition Monitoring«	January 2012 , Berlin
Workshop: Energy-autarkic Sensor Networks	February 2012, Berlin
Exhibition: Power Electronics for e-mobility	March 2012, Frankfurt
Berlin Business Forum	March 2012, Berlin
Tutorial: Printed Electronics and Photovoltaics	April 2012, Berlin
Exhibition: Safe Identity at EuroID	April 2012, Berlin
Research Ship MS Wissenschaft »Nachhaltigkeit«	May 2012
Seminar: Reliability Management	May 2012, Berlin
Exhibition: TSB-Reception	September 2012, Berlin
Workshop: Empowered Living in Old Age with MST	October 2012, Berlin
Fraunhofer-Forum: Hightech in Textiles	October 2012, Munich
Exhibition: »Berliner Wirtschaftskonferenz«	November 2012, Berlin
Workshop: Medical Innovations by Miniaturized Electronics	November 2012, Düsseldorf

FRAUNHOFER IZM AT TRADE SHOWS

Fraunhofer IZM covered a lot of miles in 2012, showcasing its technology and expertise at approximately a dozen trade shows in Germany and abroad. Laser Optics Berlin (LOB) and µSys, which took place concurrently and in the same city, namely, Berlin, were our first ports of call. While our booth at µSys covered the institute's entire breadth of technology, the LOB exhibit honed in on our research and development of photonics.

In mid-May we hit the Smart Systems Integration conference, which was held in Zurich this year. As in previous years, Fraunhofer IZM scientists contributed lectures to the conference program, while the institute presented its electronic packaging research at the accompanying trade show.

However, as always, the highlight of the season was SMT in Nuremberg. This year, we pushed our system-in-package technology firmly into the spotlight. Using SiP demonstrators developed at the institute, our exhibit provided an overview of the entire manufacturing chain, from sensor integration, to integrated power supply, through to RF optimization of highly miniaturized packages. One highlight was a power-electronic SiP module for maritime applications that was specially designed for harsh environmental conditions such as salt spray, splash and high temperature. The smart power module also dissipates thermal loss reliably even at minimal temperature difference between the module and the surrounding environment.

May also saw a second trip to Nuremberg, this time to Europe's largest trade fair dedicated solely to power electronics, PCIM, where Fraunhofer IZM presented all the latest in power electronics for e-mobility. Electromagnetic interference is a leading cause of disruption to power electronic devices in electric and hybrid vehicles. Typical phenomena are impaired radio signal reception or malfunctioning control devices. Our exhibit at PCIM included diverse power modules and a charger for hybrid vehicles in which interference was significantly reduced.

At May's ECTC, the world's largest packaging conference, which was held in San Diego in 2012, local customers and cooperation partners as in past years gathered around the Fraunhofer IZM booth, eager to hear all about the latest development directions and hot topics in Europe's electronic packaging community. Here our exhibits included embedded power semiconductor systems and new developments in smart power molding.

The year closed with a home game at SEMICON Europe in Dresden, where Fraunhofer IZM-ASSID (All Silicon System Integration Dresden) is also based. Together with other institutes in the Fraunhofer Group for Microelectronics, we pulled out all the stops, exhibiting the full breadth of our expertise and services in 3D wafer-level packaging.

Ready, steady, go – live manufacturing at SMT organized by Fraunhofer IZM
The Fraunhofer IZM's Application Center again organized the Future Packaging line at SMT in Nuremberg. The slogan »Ready, steady, go« highlights the fact that the entire production line was assembled and operational in just a few days. This was only possible thanks to the smooth cooperation between the 17 participating machine manufacturers and Fraunhofer IZM's scientists.

Guided demonstrations of the production line were held three times a day. Technology consultation sessions were also held, which gave conference participants the chance to chat to the exhibitors about the issues that crop up on the everyday factory floor. Key topics included underfilling and encapsulation, inline inspection (AOI), destructive testing, repair, solder techniques and traceability. Another hit was our »Technology Breakfast«, which we held for the first time in 2012. Many seized the opportunity to learn more about manufacturing over coffee, with a bit of luck even walking away with their very own PCB hot off the live production line.

Fraunhofer IZM at Trade Shows 2012 (Selection)	
AAL-Congress	January 2012, Berlin
EBL-Workshop	February 2012, Fellbach
Laser Optics Berlin	March 2012, Berlin
µSys	March 2012, Berlin
Smart Systems Integration	March 2012, Zurich, CH
Hannover Messe	April 2012, Hanover
SMT	May 2012, Nuremberg
PCIM	May 2012, Nuremberg
ECTC	May 2012, San Diego, USA
Electronics Goes Green	September 2012, Berlin
ESTC	September 2012, Amsterdam, NL
Semicon Europa	October 2012, Dresden

1 *Prof. Klaus-Dieter Lang at the opening of the Laser Optics in Berlin 2012*

2 *The house was packed for the Future Packaging Line demonstration at SMT*

WORKSHOPS 2013

Regular Workshops at Fraunhofer IZM's Application Center
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

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

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

Potential participants: international packaging experts from all industry sectors.

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

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

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

[3] Trends in electronics for automotive applications – new packaging concepts
This workshop is designed to discuss international research and development trends in electronics for automotive applications.

What will you learn?
- High-temperature electronics
- Sensor packaging
- Packaging and EMC of power electronics
- Reliability

Potential participants: international packaging experts and developers, particularly from the automotive sector.

[4] Innovations in medical engineering through intelligent packaging
This Fraunhofer workshop presents the state-of-the-art and current trends in wireless sensor networks.

What will you learn?
- Miniaturized sensors, pressure sensors, chemical sensors
- Microsystems for medical logistics and homecare support
- Miniaturized sensors for intelligent prostheses
- Challenges and opportunities of implants
- Wireless sensor networks

Potential participants: technology-oriented small and medium-sized enterprises from the medical sector.

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

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

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

20 years of Fraunhofer IZM – What better reason to celebrate?
The world's smallest camera, the tiniest micropump, the littlest fuel cell, the most minuscule hearing aid and the teensiest wireless sensor – Fraunhofer IZM's first 20 years have been full of superlatives.

For 20 years, the institute has been working with high-profile partners from industry to extend the properties of microelectronics. Thanks to our contribution to sophisticated integration technologies, we now have flexible, washable PCBs and smaller sensor modules that are heat-resistant at up to 250 °C. Automotive suppliers, medical engineers, semiconductor manufacturers – an extremely diverse range of electronics developers benefit from Fraunhofer IZM's know-how. We would like to invite you all to help us mark our anniversary by coming along to our bumper-packed program of professional and public events.

Fraunhofer IZM's trade show exhibitions will also be highlighting the occasion. As in past years, we are especially looking forward to SMT in Nuremberg. But this year we are also inviting all our collaborative partners and customers to a special celebration after the trade show's closing on April 17th, and hope you too can join us.

The anniversary year's premier event, Packaging Day, will be held on November 6th. Fraunhofer IZM scientists and renowned industry movers-and-shakers will present the latest innovations and emerging technologies in automotive technology, medical technology and 3D integration. The day will close with a special ceremony in the afternoon.

Find out more: www.izm.fraunhofer.de/20years

1 Fraunhofer IZM exhibits on the »MS-Wissenschaft«

2 High school students at Fraunhofer IZM's flip chip line, observing the assembly of a printed circuit board

PROMOTING YOUNG TALENTS

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

Fraunhofer IZM extends its school partnership program

Recruitment problems, skilled worker shortages - many see education and training as stagnating. Fraunhofer IZM is making a positive contribution to countering this perceived downward spiral by expanding its partnership program with schools. The institute has already maintained a cooperation with the Diesterweg Gymnasium, a high school in the Berlin district of Wedding, for the past six years and now also works with students from Berlins Heinrich-Hertz Gymnasium, which has strong focus on math and natural sciences. The partnership program is intended to prepare students for the realities of the workplace and, above all, to encourage them to choose careers in technology and research. At the same time, Fraunhofer IZM will find out how to better tailor its vocational training program to the needs and requirements of the school system and thereby make careers in engineering more attractive to girls in particular. The time for such an initiative has never been better, with studies showing that only 10 percent of German high school students consider embarking on a career in engineering.

Job search training

15 high-school students from Spandau's Heinrich-Böll-School prepared for their first steps into the working world by training in job hunting skills at Fraunhofer IZM. After the workshop, the youngsters spent time in the clean room with the microtechnologists and lab assistants for firsthand experience of everyday life in the lab.

Internships at Fraunhofer IZM

As part of a work experience program designed to familiarize youngsters with experimental research, two Advanced Physics students from Fraunhofer IZM's partner school, the Heinrich-Hertz-Gymnasium, spent a week at the institute performing tensile tests to determine and analyze material properties under the supervision and guidance of a Fraunhofer IZM researcher.

Workshop: Micro-Mechatronics – The technology of tomorrow

In November 2012, the Fraunhofer Micro-Mechatronics Center (MMZ) in Bavaria invited talented youngsters to learn more about the integration of sensors and actuators in robots, vehicles and machine elements. It was the fifth time the Center hosted the workshop that is carried out in the framework of the Fraunhofer Talent School. What is micro-mechatronics really? How does the holistic design of electronics and mechatronics work? MMZ Director Dr. Frank Ansorge answered these and many other questions using examples and case studies.

In two practical workshops supervised by MMZ scientists, the teenagers picked up soldering irons to help assemble the MMZ IR BOT, a µ-processor controlled robot. Together the participants individually programmed their MMZ robot and learned about the interplay between sensors and actuators.

MS Wissenschaft – journeys in research

On May 30th, the »MS Wissenschaft«, an exhibition ship currently showing the exhibition »Future Earth«, set sail on almost 6-month voyage through Germany and Austria. As in past years, Fraunhofer IZM was on board with two interactive exhibits entitled »Hidden Gems in the Game Console«. Visitors got a close-up look at a gaming console's internal workings and learnt all about scarce resources in electronics via a touch screen display. How much paper can be replaced by e-books was another topic. Via a touch screen display, visitors received an overview of the potential savings, but also the possible negative effects on the environment (so-called boomerang effects).

Visit by the Microtechnology Professional Training Center

30 microtechnology students, including graduates undertaking advanced training, cast a collective expert eye over Fraunhofer IZM and its labs during their visit. The tour included the clean room, the substrate processing line and the Electronics Condition Monitoring lab. The visitors were able address questions very specific to their area of expertise, and many expressed interest in joining the Fraunhofer IZM technology team.

Fraunhofer Talent Take Off and Shadowing Day – Young scientists visit Fraunhofer IZM

Fraunhofer IZM opened its doors in August to those keen for a closer look at the finer points of applied research as part of »Talent Take Off – Prepped for Study«. The event also was also preparation for tertiary study in life-sciences or technology at Berlin's universities. The up-and-coming scientists found out how chips end up on a circuit board and how microsystem reliability can be measured. Physical parameters and measurement techniques were demonstrated in experiments using small examples. Talent Take Off is a network for promising high-school and tertiary students and is part of the »National Pact for Women in MINT Careers«, funded by the German Federal Ministry of Education and Research (BMBF). MINT is an acronym for the professional areas mathematics, IT, life sciences and technology.

Shadowing Day was also a great opportunity for six students. As the event's title suggests, the youngsters got to observe junior researchers at work, in a smaller setting and with plenty of time to ask questions.

Summer School

Fraunhofer IZM is clearly a world leader in all things small after all, to date it's given us the world's smallest microcamera, hearing aid, autarkic sensor nodes and, last but not least, the world's tiniest fuel cell. As part of the Berlin Microsystems Summer School, Fraunhofer IZM researchers let the public in on the packaging secrets that underpin their wafers, chips and PCBs.

FRAUNHOFER IZM FACTS & FIGURES

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FRAUNHOFER IZM IN FACTS AND FIGURES

Financial situation

The year 2012 saw marked expansion at Fraunhofer IZM, thanks in no small part to the on going establishment of IZM-ASSID in Dresden/Moritzburg and an overall upturn in external revenue across all sites.

The institute's turnover in 2012 was 28.5 million euros, which is an 18 percent increase over the previous year.

Contract research from German and international industry and trade associations rose by 21 percent, totaling 9.6 million euros. Project-specific public funding by the German federal government, Länder governments and the EU remained steady at the prior year's the high level.

In total, Fraunhofer IZM was able to finance 24.1 million euros or 85 percent of its operating budget from external revenue.

Investment

In 2012, the institute budgeted 2.5 million euros from internal funds for ongoing maintenance and replacement. Here, a wide range of individual measures were taken to improve Fraunhofer IZM's infrastructure and to increase the efficiency of existing equipment.

Another 500,000 euros were allocated to the area »Wafer Level Assembly and 3D Chip-to-Wafer Stacking«, thanks to which the institute now has the equipment and expertise for 3D chip stacking on 200 and 300 mm wafers. These active wafers can be used for thin-chip integration with wiring, or for the mounting of temporary carriers in transfer bonding on active wafers or 3D silicon interposers and for wafer molding. This chip-to-wafer assembly technique is currently being integrated into the institute's 3D-silicon integration service portfolio, which is being extended to 300 mm processing at Fraunhofer IZM - ASSID in Dresden. In Berlin, the focus was primarily on heterogeneous system integration, which opens up new possibilities for the established technologies thin-chip integration and wafer-to-wafer bonding by using reconfigured chips on handling wafers. Our investment in this area provides a precise assembly platform for wafer-level encapsulation that advances the development of molded fan-out packages and PCB embedding.

A laboratory for laser materials processing in the assembly and packaging of sensor SiPs was established with an investment of 1.2 million euros. These measures are part of a larger commitment to promoting the institute's development and manufacture of highly miniaturized 3D SIP sensor packages and advancing Fraunhofer IZM's research into and development of 3D system integration, which covers the entire supply chain, from design to reliability analysis.

Approximately 1.5 million euros were invested at the institute's Wedding branch to overhaul and revamp its power supply and cooling system. The new system is highly efficient, even during part-load operation, and uses free cooling in winter. The reduced energy consumption during processing not only benefits the environment, but also drives down the institute's energy bills.

Human resources

The institute's positive balance sheet was also reflected in human resources, with 13 new positions created in 2012 and an across-the-board rise in staff numbers at Fraunhofer IZM's branches in Berlin, Dresden/Moritzburg and Oberpfaffenhofen increased to a total of 217.

The institute also offers students the option of combining their studies with practical scientific research at Fraunhofer IZM's offices and laboratories. In 2012, Fraunhofer IZM opened its doors to 138 interns, Masters students and student assistants.

The institute also maintained its commitment to providing apprenticeships. In 2012, a total of 9 apprentices were trained as microtechnology technicians and business administrators.

The Fraunhofer IZM 2012	
Turnover	€ 28.5 million
External revenue	€ 24.1 million (equivalent to 85 percent)
Branches	Berlin, Dresden and Oberpfaffenhofen
Staff	217
Interns, Master students, student assistants	138

AWARDS

Dr. Ivan Ndip receives 2012 Fraunhofer IZM Research Award
In today's information age, in which everyone is online around the clock, unimaginable amounts of data crisscross the globe in mere seconds. More and more data can be sent and received at ever faster speeds, while at the same time all-important reliability is maintained and interference is prevented. How does technology make this possible? Dr. Ivan Ndip's answer to this question is one reason he received the 2012 Fraunhofer IZM Research Award in December 2012.

Each year the award is presented to a Fraunhofer IZM scientist in recognition of outstanding achievement in the research and development of electronic packaging, with 2012 marking the eleventh year of the tradition. Ivan Ndip, who has researched antenna design for high-frequency applications for over 10 years, received the Fraunhofer IZM Research Award for the work presented in his paper »Methods, models and design strategies for the electromagnetic optimization of high-frequency and high-speed systems«. Particularly the information and communication security sector stands to benefit from his work. Fraunhofer IZM Director Prof. Klaus-Dieter Lang presented the research award to Dr. Ndip at the awards ceremony held in Kosmos Berlin on December 19th 2012.

iNEMI recognizes outstanding cooperation with Fraunhofer IZM
The International Electronics Manufacturing Initiative (iNEMI) is one of the world's largest associations of companies and research centers focusing on microelectronics. iNEMI's key areas of interest are miniaturization, sustainability, medical engineering and alternative energy, which they pursue by contributing to international roadmaps, organizing professional conferences and providing a forum for networking to their members. Fraunhofer IZM has worked closely with iNEMI over many years. A number of Fraunhofer IZM scientists participate in iNEMI projects and joint events have been hosted. In recognition of this close collaboration, iNEMI Vice-Chair Bob Pfahl presented Fraunhofer IZM honorary membership in September 2012.

Awards for four Fraunhofer IZM scientists
Fraunhofer IZM's profile within the world's largest professional association of engineers »Institute of Electrical and Electronics Engineers (IEEE)« was high in 2012, with four of the institute's scientists singled out for special recognition. Ivan Ndip, Tolga Tekin and Michael Töpper were promoted to Senior Members and Rolf Aschenbrenner was named IEEE Fellow.

Tolga Tekin heads the Fraunhofer IZM research group Photonic and Plasmonic Systems, which focuses on the use of photonic systems in ICT. Michael Töpper is the current Chair of the IEEE Technical Committee of Wafer Level Packaging. His Fraunhofer IZM research group investigates and develops wafer-level processes. He was also appointed Research Associate Professor by the University of Utah in 2006. Ivan Ndip's area of specialty is high-frequency technology. He heads the research group RF & High-Speed System Design and was recently named Technical Chair of IMAPS 2013, which will be held in Orlando this October. Since the start of the year, all three hold IEEE Senior Member status, which is the most senior level of IEEE membership and is only awarded to scientists widely regarded as experts by their peers.

Fraunhofer IZM Deputy Director Rolf Aschenbrenner was singled out for a special honor – in recognition of his considerable contribution to microelectronic packaging, the scientist was named IEEE Fellow. Just 300 of IEEE's 400,000 members are named Fellows each year. His showed indefatigable commitment to internationalizing the CPMT (Components, Packaging and Manufacturing Technology Society) while serving as member of IEEE chapter's Board of Governors by working to expand membership and establish new chapters. Rolf Aschenbrenner has held various senior posts within IEEE CPMT since 2003, including as Vice President Conferences (2005 - 2009) and as IEEE CPMT President (Jan. 2010 - Dec. 2011).

Fraunhofer IZM apprentice wins award
Former Fraunhofer IZM Microtechnology apprentice Pascal Graap, along with 12 apprentices and their instructors from other Fraunhofer institutes, has been named Apprentice of the Year in his field by the Fraunhofer-Gesellschaft's Executive Board for outstanding achievement in his final apprentice's exams. In fact, being a cut above the rest has become tradition at Fraunhofer IZM. Pascal Graap is no less than the fifth Fraunhofer IZM apprentice since 2006 to win an award for excellent final exam results. He now holds a position as Microtechnologist in the Fraunhofer IZM Department of System Integration and Interconnection Technologies.

SMTA International 2012 - Best International Paper Award for Lars Böttcher
Fraunhofer IZM scientist Lars Böttcher took home the Best International Paper Award at SMTA International 2012 in Orlando, Florida. Böttcher and his colleagues Dion Manessis, Stefan Karaszkiewicz and Andreas Ostmann received the award for their paper »Development of Embedded Power Electronics Modules for Automotive Applications«. Over 1000 professionals from around the world gather each year to discuss the latest issues in packaging at the Surface Mount Technology Association SMTA conference.

1 From left to right: Dr. Martin Schneider-Ramelow (Chairman of the Prize Committee), Dr. Ivan Ndip, Prof. Klaus-Dieter Lang (Director of Fraunhofer IZM)

2 Supervisor Jens Hofmann receives the certificate for IZM-apprentice Pascal Graap from Alexander Kurz, responsible for human resources at the Fraunhofer-Gesellschaft

DISSERTATIONS, BEST PAPERS, EDITORIALS

Dissertations

Brusberg, L.
Development of Single Mode Waveguide Technology for Thin Glass Substrates for Photonic System Integration

Curran, B.
Loss Modeling in Non-Ideal Transmission Lines for Optimal Signal Integrity

Yang, Y.
Comparative Analysis of Load Resonant Converters for a Normalized, Control and Integration Suitable Design Concept

Jaeschke, J.
Evaluation of Solder Joint Lifetime - the Failure Mechanism of Electromigration

Editorials

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

Mechatronik (Verlag I.G.T. Informationsgesellschaft Technik mbH)
F. Ansorge (Editorial Board)

Electronics Goes Green 2012+ Conference Proceedings
K.-D. Lang, N. F. Nissen, A. Middendorf, P. Chancerel (Editors)

Smart System Integration 2012 Conference Proceedings
K.-D. Lang (Co-editor)

Congress Proceedings SMT/HYBRID/Packging 2012
K.-D. Lang (Editor)

Best Paper Awards

Aschenbrenner, R.; Becker, K.-F.; Braun, T.; Ostmann, A.
Panel Level Packaging - A Manufacturing Solution for Cost Effective Systems
Best Paper Presentation Award, Pan Pacific Microelectronic Symposium 2013, Maui, Hawaii

Böhme, C.; Vieroth, R.
A Novel Packaging Concept for Electronics in Textile UHF Antennas
Best Paper of Session Award, IMAPS 2012, San Diego, USA

Böttcher, L.
Development of Embedded Power Electronics Modules for Automotive Applications
Best International Paper Award, SMTA International 2012, Orlando, FL, USA

Kallmayer, C.; Simon, E.
Large Area Sensor Integration in Textiles
Best Paper Award, International Conference SSD 2012, Chemnitz

Schmidt, R.; Zwanzig, M.; Marcos, D.; Wirth, A.; Seckel, M.; Löher, T.
Flexible Mikroverdrahtungsstrukturen für implantierbare Elektroden
Best Paper Award, EBL 2012 Elektronische Baugruppen und Leiterplatten

LECTURES

Lectures

Technical University Berlin

Dr. R. Hahn
- Miniaturized Energy Supply Systems

Prof. K.-D. Lang
- Hetero System Integration Technologies
- Assembly of Multi-functional Systems
- Assembly and Interconnection in Microelectronics

Dr. I. Ndip
- Electromagnetics for Design and Integration of Microsystems
- High-Frequency Measurement Techniques for Electronic Packaging
- Numeric Computation of Fields

Dr. M. Niedermayer
- Design Methods for Smart 3D Microsystems

Dr. H. Ngo
- Manufacturing Technologies for Micro Sensors
- FEM Simulation of Micro Sensors and Actuators
- Actuators
- Sensor Technology

Dr. H. Ngo, Dr. M. Töpper
- Technologies and Materials for Microsystem Technologies

Dr. N. F. Nissen
- Design of Environmentally Compatible Electronic Products

Dr. M. Schneider-Ramelow
- Basic Materials for System Integration

Dr. T. Tekin
- Design, Simulation and Reliability of Microsystems
- Photonic Packaging
- Antenna Simulation
- Antenna und Wave Propagation

Dr. O. Wittler
- Reliability of Microsystems

Beuth Hochschule für Technik Berlin

Dr. H. Schröder
- Optoelectronics

HTW, Hochschule für Technik und Wirtschaft Berlin

Dr. H. Walter
- Basic Materials
- Basic Materials for Microsystem Technologies

Hochschule für Wirtschaft und Recht Berlin

Dr. U. Geißler
- Material Engineering

MEMBERSHIPS (SELECTION)

Organization	Name	Function
4M Multi Material Micro-Manufacture Association	E. Jung	Representative of Fraunhofer IZM
AMA Fachverband Sensorik, Wissenschaftsrat	Dr. V. Großer	Member
Bayerisches Innovationscluster »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«	Dr. M. Schneider-Ramelow	Chairman
EcoDesign 2013	Dr. N. 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
IEEE Component, Packaging and Manufacturing Technology Society	R. Aschenbrenner	Fellow
Technical Committees:		
Green Electronics	Dr. N. Nissen	Technical Chair
Emerging Technologies	E. Jung	Technical Chair
Wafer Level Packaging	Dr. M. Töpper	Technical Chair
IEEE CPMT German Chapter	Prof. K.-D. Lang	Chair
IMAPS (Signal/Power Integrity Subcommittee)	Dr. I. Ndip	Chair
IMAPS Deutschland	Dr. M. Schneider-Ramelow	President
International Electronics Manufaturing Initiative iNEMI	R. Aschenbrenner	Representative of Fraunhofer IZM
International Technology Roadmap Semiconductors (ITRS)	M. J. Wolf	Chairman Europe
JISSO European Council	M. J. Wolf	Member
Lange Nacht der Wissenschaften e. V. Berlin	H. Pötter	Representative of Fraunhofer
Optec Berlin Brandenburg	Prof. K.-D. Lang	Executive Board
Photonics West Optical Interconnects Conference	Dr. H. Schröder	Chair
SEMI Award Committee	Prof. K.-D. Lang	Member
Semiconductor Manufacturing Technology Sematech	M. J. Wolf	Member
Silicon Saxony e.V.	M. J. Wolf	Member
SMT/HYBRID/PACKAGING Congress	Prof. K.-D. Lang	Head of Scientific Committee
Technologiestiftung Berlin (TSB)	Prof. K.-D. Lang	Member of the Board of Trustees
VDI/VDE-Gesellschaft für Mikroelektronik, Mikro- und Feinwerktechnik (GMM) Technical Committee Packaging and Interconnection Technologies	Prof. K.-D. Lang	Vice Chairman
VDMA, Fachverband Mikrotechnik, Vorstand Modulare Mikrosysteme	Dr. V. Großer	Member
Wissenschaftlich-technischer Rat der Fraunhofer-Gesellschaft	K.-F. Becker	Representative of Fraunhofer IZM
Zentrum für Mikrosystemtechnik Berlin	Prof. K.-D. Lang	Spokesman of the Board

COOPERATION WITH INDUSTRY (SELECTION)

Company	Location
Advanced Semiconductor Engineering	Kaohsiung (TPE)
AEMtec GmbH	Berlin
Agilent Technologies Inc.	Santa Clara (USA)
Alenia Aeronautica SpA	Rome (I)
alpha-board gmbh	Berlin
AMO GmbH	St.Peter/Hart (A)
Andus Electronic GmbH	Berlin
Applied Materials Inc.	Santa Clara (USA)
Astrium GmbH	Bremen
A.S.T. Group	Wolnzach
AT&S AG	Leoben (A)
Atotech Deutschland GmbH	Berlin
AUDI AG	Ingolstadt
Austriamicrosystems AG	Unterpremstätten (A)
Awaiba GmbH	Nuremberg
B/E Aerospace Inc.	Lübeck
Baker Hughes INTEQ GmbH	Celle
Baumer-Hübner GmbH	Berlin
Balluff GmbH	Neuhausen a.d.F.
BIOLAB Technology AG	Zurich (CH)
Blackrock Microsystems LCC	Salt Lake City (USA)
BMW AG	Munich
Brose Fahrzeugteile GmbH & Co. KG	Coburg
Bundesdruckerei GmbH	Berlin
COGO Optronics GmbH	Berlin, Boulder (USA)
Compass EOS	Netanya (IL)
CONTAG GmbH	Berlin
Continental AG	Nuremberg, Munich, Frankfurt, Regensburg
Converteam SAS	Berlin
Daimler AG	Berlin, Bremen
Datacon GmbH	Radfeld (A)
Denso Corporation	Japan
Deutsche Bahn AG	Berlin, Frankfurt, Munich, Dessau
DIEHL Stiftung & Co. KG	Nuremberg, Frankfurt, Wangen
Disco Corporation	Tokyo (J)
Doublecheck GmbH	Berlin
Dupont	USA, Japan, Germany
EADS/Cassidian	Ulm
Elbau GmbH	Berlin
Endress & Hauser GmbH & Co. KG	Maulburg
Enthone Inc.	West Haven (USA)
ESW GmbH	Hamburg-Wedel
ESYS GmbH	Berlin
EVG Group	St.Florian am Inn (A)
Excelitas Technologies Corp.	Pfaffenhofen
FiconTEC Service GmbH	Achim
Fujitsu Technology GmbH	Augsburg
GESAA Service GmbH	Berlin
Gesellschaft für Maschinendiagnose mbH	Berlin
GlobalFoundries Inc.	Dresden
Heraeus Holding GmbH	Hanau
Hirschmann GmbH	Rankweil (A)
Höft & Wessel AG	Hanover
Hytech AG	Brügg (CH)
IMC GmbH	Berlin
Infineon Technologies AG	Mayence, Munich
Jenoptik/ESW GmbH	Hamburg-Wedel
John Deere & Company	Mannheim
Kayser-Threde GmbH	Munich
KSW Microtec AG	Dresden
LEM SA	Geneva (CH)
Leuze electronic GmbH & Co. KG	Owen
LEWICKI microelectronic GmbH	Oberdischingen
Maxon Motor AG	Lucerne (CH)
MAZeT GmbH	Jena
MDISchott Advanced Processing GmbH	Mayence
MED-EL GmbH	Innsbruck (A)
METALLEX AG	Uetikon (CH)
Microelectronic Packaging (MPD) GmbH	Dresden
Microepsilon GmbH	Ortenburg
MSEI Micro Systems Engineering Inc.	Lake Oswego (USA), Tel Aviv (IL)
Nanotron Technologies GmbH	Berlin
NXP Semiconductors AG	Hamburg, Eindhoven (NL)
Oclaro Technologies Inc.	San Jose (USA)
OC Oerlikon Balzers AG	Balzers (LI)
Olympus Deutschland GmbH	Hamburg
Oree Inc.	Ramat Gan (IL)
Osram Opto Semiconductors GmbH	Regensburg
PANalytical B.V.	Almelo (NL)
Paulmann Licht GmbH	Springe-Völksen
Philips Technology GmbH	Aachen
ProTec Carrier Systems GmbH	Siegen
Ramgraber GmbH	Hofolding b. Brunnthal
Robert Bosch GmbH	Stuttgart, Reutlingen, Hildesheim, Waiblingen
SABCA	Brussels (B)
Samsung Advanced Inst. of Technology	Suwon (ROK)
Schaeffler Technologies GmbH & Co. KG	Herzogenaurach
Schaffner Holding AG	Luterbach (CH)
Schleifring GmbH	Kaufbeuren
Schlumberger AG	France, USA
Schweizer Electronic AG	Schramberg
Semikron GmbH	Nuremberg
Sensitec GmbH	Lahnau
Siemens AG	Karlsruhe
Söhner GmbH	Heilbronn
SPTS Technologies Ltd.	Newport (UK)
Süss MicroTec AG	Garching, Munich
Sumida GmbH	Obernzell
Swissbit Germany AG	Berlin
Taubmann Elektronik GmbH	Heilsbronn
TDK-EPCOS AG	Munich
Thales Group	France
The Dow Chemical AG	USA
Valeo GmbH	Wemding
Vectron Systems AG	Havant (UK)
Vishay Beyschlag GmbH	Heide
Volkswagen AG	Wolfsburg
WRS Materials	San Jose (USA)
Würth Electronik GmbH & Co. KG	Niedernhall, Rot am See
X-Fab Semiconductor Foundries AG	Erfurt
Xyratex AG	Auerbach
Zarlink Semiconductor Inc.	Ottawa (CA)
ZF Luftfahrt AG	Friedrichshafen

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Proceedings ESTC 2012, Amsterdam, the Netherlands

Töpper, M.; Oppermann, H.; Boettcher, M.; Zoschke, K.
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Walter, H.; Bauer, J.; Hölck, O.; Wunderle, B.; Wittler, O.
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