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CREATIVE MINDS FOR SMART ELECTRONICS

Fraunhofer IZM has delivered new and creative approaches to integrating electronics into products for over two decades. We kept up our track record in 2013, working with partners from industry and research on groundbreaking solutions for key areas of society, including health care, electric vehicles, energy efficiency, optimized manufacturing as part of Germany's high-tech strategy »Industry 4.0« and to respond to demographic change.

Just one of the year's great success stories was our ArtGuardian solution for collections care. The complex development challenge not only underlined the institute's know-how, but also proved that Fraunhofer IZM is more than capable of completing the development chain with a commercially viable product. Based on sensor systems that monitor the microclimatic conditions surrounding an artwork, the new tool is also extremely user-friendly. The sensor data is relayed via standard communication protocols to a browser-based software program. Users can access the data anywhere around the world, around the clock, and also configure the program to display the data as needed. A spin-off is planned for later in the year in response to the significant interest the product has generated in the private and public art sectors.

An audit of Fraunhofer IZM's overall strategy, conducted by a high-profile team of industry and research experts provided further positive feedback. The external assessment not only gave our approach to advancing system integration by improving multi-functionality, miniaturization, system reliability and cost minimization the thumbs-up, but also rated our institute as a key player in system integration and electronic packaging internationally.

An evaluation of Fraunhofer IZM-ASSID in Dresden attracted similar praise. The auditors emphasized that the center, which was established just four years ago, plays a pivotal role in 3D wafer-level system integration in both Germany and abroad. With this confirmation of the center's organizational and scientific maturity, ASSID transitioned fully to operating according to the Fraunhofer Model at the start of the year.



We maintained our excellent working relationships with industry throughout 2013. One of our numerous successful collaborations was the high-tech bicycle jacket »Sporty Superhero«. The innovation, which combines safety (interactive lighting to increase the visibility of cyclists at night) with sophisticated design, was awarded the »2013 Red Dot Design Award«.

Fraunhofer IZM now has three branches in Germany: Berlin, Moritzburg near Dresden and Oberpfaffenhofen near Munich. The Berlin-Adlershof site was integrated into Fraunhofer IZM's main headquarters in Berlin-Wedding last year to further improve the efficiency and continuity of our technology development chain.

This year will also see an addition to Fraunhofer IZM in Berlin-Wedding. The new Center for Adaptive System Integration (AdaptSys) involved an ambitious construction project and intensive investment. Sponsored by the EU, the German Ministry of Research and Education (BMBF) and the Land Berlin, it will develop highly reliable, multifunctional electronics tailored to the needs of applications. The expansion will allow Fraunhofer IZM to continue playing a leading role in shaping the technology and functionality trends of high-end system integration and providing clients and research collaborators with a one-stop service for innovative solutions in many application areas.

My thanks go out to all of Fraunhofer IZM's project partners, clients from industry, research, federal and Länder ministries, the project coordinating bodies and other collaborators for a productive year and the trust that was placed in us.

I would also like to thank the institute's staff for their dedication and outstanding work throughout the year.

In the hope that our annual report inspires enthusiasm and perhaps even inspiration...

Sincerely yours,
Prof. Klaus-Dieter Lang

// FRAUNHOFER IZM



FRAUNHOFER IZM

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FRAUNHOFER – A STRONG NETWORK

The Fraunhofer-Gesellschaft

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

The majority of the more than 23,000 staff are qualified scientists and engineers, who work with an annual research budget of 2 billion euros. Of this sum, 1.7 billion euros is generated through contract research.

More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding.

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

Fraunhofer Group Microelectronics

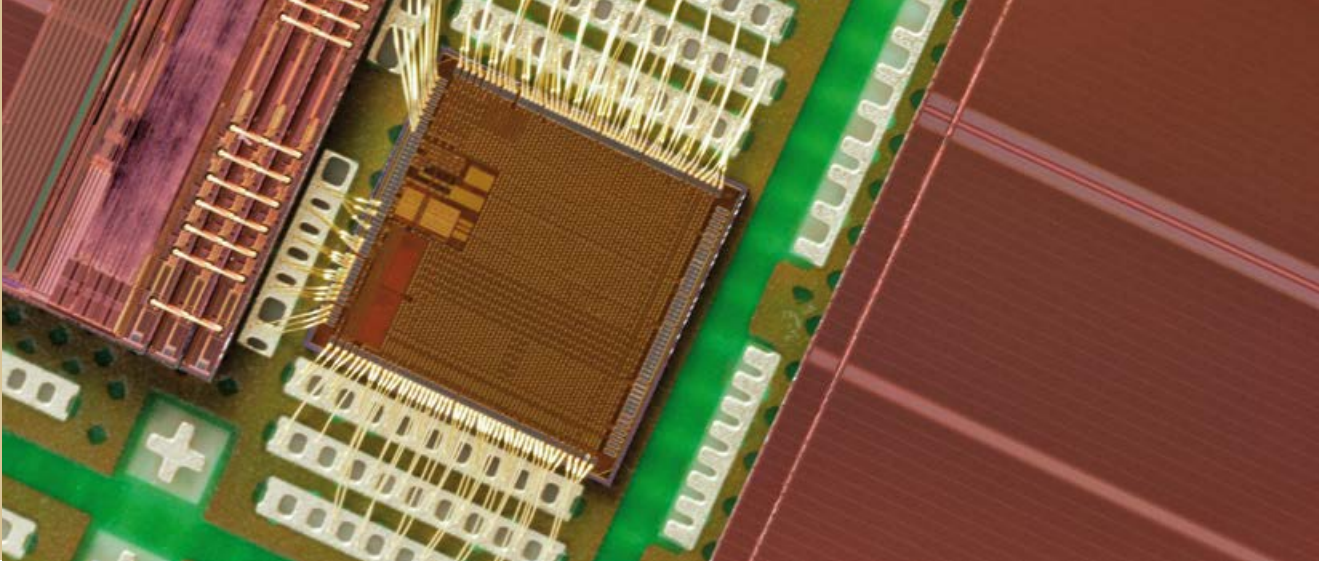
Fraunhofer has pooled the competences of institutes working in related subject areas in the seven Fraunhofer Groups Information and Communication Technology, Life Sciences, Microelectronics, Light & Surfaces, Materials and Components, Production, and Defence and Security. Fraunhofer IZM is a member of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

The Fraunhofer Group Microelectronics VμE has been coordinating the activities of Fraunhofer Institutes working in the fields of microelectronics and microintegration since 1996. Its membership consists of eleven institutes as full members and five as associated members, with a total workforce of around 3,000 and a combined budget of roughly 341 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: design for smart systems, semiconductor-based technologies, system integration technologies, power electronics and energy supply, sensors and RF and communication technologies. The application-orientated business areas are:

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

www.mikroelektronik.fraunhofer.de/en



FRAUNHOFER IZM – FROM WAFER TO SYSTEM

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

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

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

As of 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 350 and saw a turnover of 29.4 million euros in 2013, of which 77 percent was derived from contract research. It has three branches in Germany. Apart from its headquarters just north of Berlin Mitte, it also maintains sites in Dresden and Munich, both strategically important centers for electronics development and manufacturing.

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

HOW TO MAKE THE MOST OF FRAUNHOFER IZM

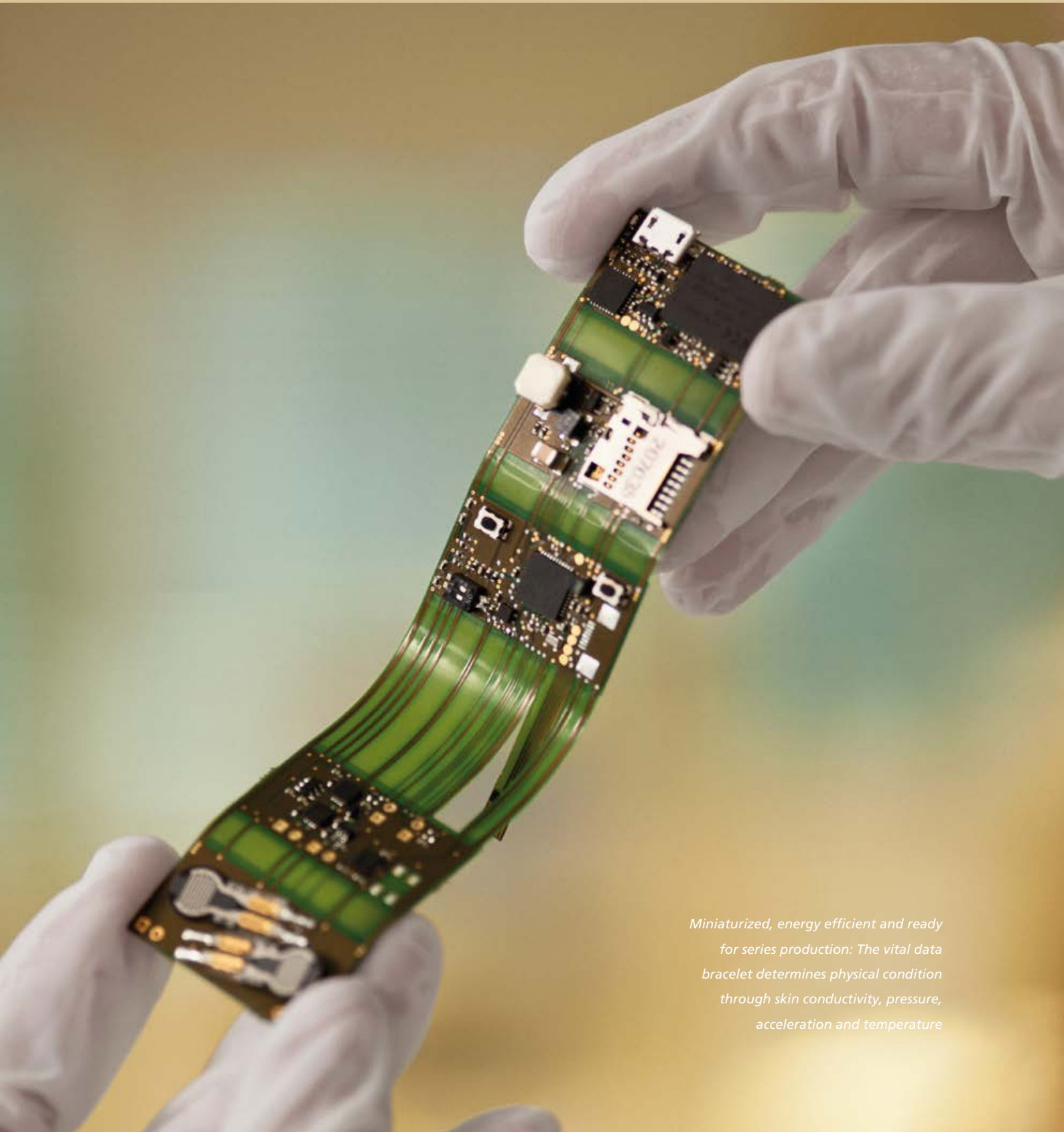
The success of our contract research model may well be due to our emphasis on treating our customers as partners and active participants in the research and development process. We can help you integrate electronics and microsystem technology into your products by developing innovative packaging and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

Technology transfer in contract research

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

Pooling resources

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



*Miniaturized, energy efficient and ready
for series production: The vital data
bracelet determines physical condition
through skin conductivity, pressure,
acceleration and temperature*

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.

Cooperation with TU Berlin in German Research

Foundation projects

Working with universities on basic research projects advances and deepens Fraunhofer IZM's skills and know-how. One example is our collaboration with Prof. Dr. Christian Schuster of the Hamburg University of Technology in the project »Electrical modeling and design of through silicon vias for integrated systems«, funded by the German Research Foundation (DFG). Together we are developing fast computation methods for calculating signal transmission using TSVs. The results help establish TSV as a technology in contract research for industry.

ZIM-projects: An Example

The project RF-KombiSCAN is developing a handheld measurement device that can read how fresh foodstuffs are. The combined Raman-fluorescence spectrometry device is able to measure whether a foodstuff is still fit to be consumed at any time and with high accuracy. The primary components of the device are two spectrometers for measuring the reflected light, a red laser and a blue laser. Together the technologies allow the combination of Raman scattering and fluorescence measurement. The development project, funded by the German Federal Ministry for Economic Affairs and Energy's Central Innovation Program SME (Zentrales Innovationsprogramm Mittelstand – ZIM), is also integrating the complete control electronics, a Bluetooth interface and a WLAN module, the power supply, including battery and charger, and a touch-screen into the end device. The measurement values can be relayed via WLAN or Bluetooth to smart phones, tablet computers, laptops or uploaded online. This ensures that the quality of food can be monitored and documented continuously.

Some of Fraunhofer IZM's other university partners

Technical University of Delft, The Netherlands
Technical University of Eindhoven, The Netherlands
Technical University of Tampere, Finland
Bologna University, Italy
Cárdiz University, Spain
Tokyo University, Japan
Twente University, The Netherlands
Uppsala University, Sweden
University College London, Great Britain
Albert Ludwigs University Freiburg
Brandenburg University of Technology, Cottbus
Christian Albrechts University Kiel
Friedrich Alexander University Erlangen-Nürnberg
Humboldt University Berlin
Rheinische Friedrich Wilhelms University Bonn
Technical University Chemnitz
Technical University Darmstadt
Technical University Dresden
Universität der Künste Berlin
University of Heidelberg
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.

German-Canadian cooperation

Fraunhofer IZM acts as a technological intermediary in the cooperation with medium-sized companies from the Alberta region in Canada. The cooperation is designed to bring regional system manufacturers into contact with German SMEs and thus strengthen the transatlantic relationships. The Federal Ministry for Education and Research and the Federal Ministry for Economic Affairs and Energy initiated this cooperation as part of their programs for economic and scientific cooperation.

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 May 2013 another meeting took place in the framework of the cooperation with the National Institute for Materials Science (NIMS) in Japan. Fraunhofer IZM's Environmental Engineering Department and the Hybrid Materials Center of NIMS exchange information on the life cycle of nano materials in products, the risks of nano materials in electronics, as well as on new nano materials in Asia and Europe.

European Center for Power Electronics (ECPE)

The European Center for Power Electronics (ECPE) 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

Condition monitoring of composite materials

In the EU integrated project PASTA, Fraunhofer IZM worked with French, Swiss, Swedish and Belgian research institutes and companies to develop techniques for measuring elongation inside a composite both locally and globally as a means. The technique is the key to monitoring excessive stress/strain

and accumulated strain in composites, which, in turn, allows prediction of a component's remaining lifetime. The global sensors are integrated into woven conductive yarn and the local sensors are small, thin strain gauges. The evaluation system is attached to the textile's conductive thread by crimping to ensure reliable mechanical connection. Applications for this technology range from prosthetics to wind power farms.

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 19 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 few 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.

With 18 deliverables and almost 30 publications PhoxTroT successfully passed the one-year-mark in 2013. In the context of setting up the European Cluster in Optical Interconnects (ECO) a workshop was held at the ECOC 2013 in London where PhoxTroT partners and invited guests presented their research on optical interconnects. In 2014 the focus of PhoxTroT's dissemination activities is on the OFC in San Francisco and the Laser Optics in Berlin (LOB). At the LOB, PhoxTroT organized a workshop together with EPIC, IEEE and ECO in March 2014.

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

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



BUSINESS UNITS & COOPERATION

Invisible, indispensable, 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

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AUTOMOTIVE/TRANSPORTATION

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MEDICAL ENGINEERING

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PHOTONICS

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INDUSTRIAL ELECTRONICS

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ENERGY

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3D INTEGRATION

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INVEST IN CUSTOMIZED INTEGRATION TECHNOLOGIES

All product development decision-makers know that electronics has become a key means of increasing product ROI and extending market reach. But making use of this potential is a daunting task for many companies. This is where Fraunhofer IZM comes in – we specialize in helping companies new to the field understand the potential and approaches involved in boosting ROI with electronic system integration.

As a first step, we analyse how state-of-the-art system integration technology can best benefit your product. With this established, we then help you apply these technology approaches at every step. We ensure efficient implementation throughout the product development process, from the design stage for new product concepts or adaptation of existing products, right through to commercial release. Helping you develop your product is our main aim!

Companies with experience in electronic integration also rely on our know-how and expertise. Ongoing product optimization and redesign is crucial in today's fast-changing market, and electronics is increasingly becoming a key factor, but keeping up with the latest technological developments is beyond most companies. Instead, they turn to our Smart System Integration Application Center to take their product to the next level. Be it extending functionality, increasing miniaturization, improving reliability, reducing production costs – our mission is helping you reach your goal.

Secure your competitive edge!

You already have a grasp of electronic packaging, but cannot stay abreast of national and international technology breakthroughs? You want to keep up-to-date on all the latest technology trends? You need help advancing your products, ex-

tending the range of suitable applications, increasing functionality or improving reliability? Then the Fraunhofer IZM Application Center is the right port-of-call!

Using Fraunhofer IZM's patents and utility models

Apart from the expertise of our scientists, Fraunhofer IZM has a vast range of patents for technology innovations in electronic system integration, testing, analysis and reliability and holds the copyright for crucial research data. We also see selected Fraunhofer IZM demonstrators and prototypes through development right up to commercial release. Many of these patents and associated technology can be made available to our customers, who may seek to apply a research project's results to their product, or make use of a Fraunhofer IZM patent, negotiate the licensing of copyright technology, or even distribute Fraunhofer IZM technology themselves. We strive to accommodate all requests and help you access the right information and tools and navigate the bureaucracy, such as licensing contracts.

The Application Center focuses on selected Fraunhofer IZM demonstrators and prototypes, right through to when the product is commercially released. Our partners, be they online retail outlets, spin-offs or suppliers have direct access to our results via direct remote connection.



FRAUNHOFER IZM APPLICATION CENTER

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System to determine the effect of stress during electronic packaging assembly

A current example of our independent development is our investigation of stress during electronic packaging assembly. During manufacturing, components like MEMS sensors and integrated circuits are exposed to high thermal and mechanical stress, which affects component properties and can even impair functionality.

As part of the iForceSens project, funded by the German Federal Ministry of Education and Research (BMBF), Fraunhofer IZM and cooperation partners have developed a system that can record the impact of stress in individual systems. The technology breakthrough comprises a measurement chip that can replace or sit alongside components, and which undergoes the same processing steps as the system under investigation.

The chip is based on piezoresistive technology in the form of current mirrors, and can measure shear stress, temperature and the two principal stress components on chip level.

Detailed quantification of thermomechanical loading and the distribution of stress across the chip surface is possible, providing a basis for nuanced product and process optimization. The data is evaluated and displayed graphically by a separate electronic system to facilitate decision-making.

Our stress quantification services are in particular demand with customers involved in the development, manufacturing or quality assurance of microsensors, including above all magnet, pressure, acceleration and inertial sensors.

Other applications for the stress measurement system

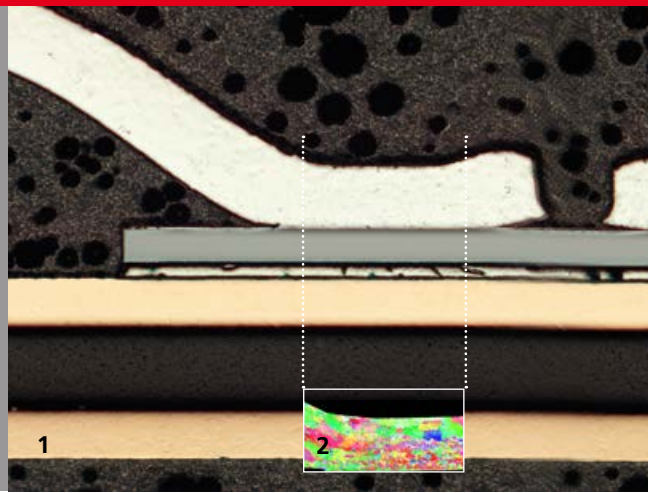
We are making the complete stress measurement and assessment system available for purchase. The system has a myriad of uses, from measuring stress during transfer molding, sintering, QFN soldering, chip card and PCB embedding, wafer thinning and chip stacking. Please feel free to contact us for more information.

The Fraunhofer IZM Smart System Integration Application Center was initiated and funded by the BMBF.

Contact:

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Phone +49 30 46403-683

1 Measurement chip to determine stress distribution in packaging. Once substituted for the customer component, it records stress during manufacturing



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 – examples

Fraunhofer IZM is participating in various 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)
- improving wire bonding reliability for power electronic systems by optimizing materials and processes (project RoBE)

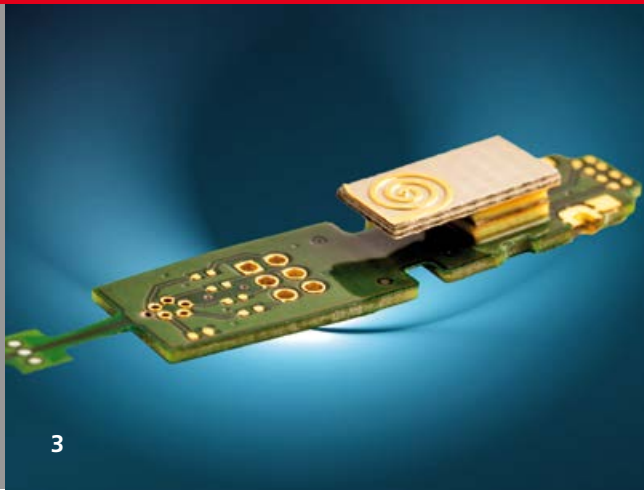
Services

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 Wire bond after 50,000 cycles

2 EBSD-Map: Crystal orientation



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

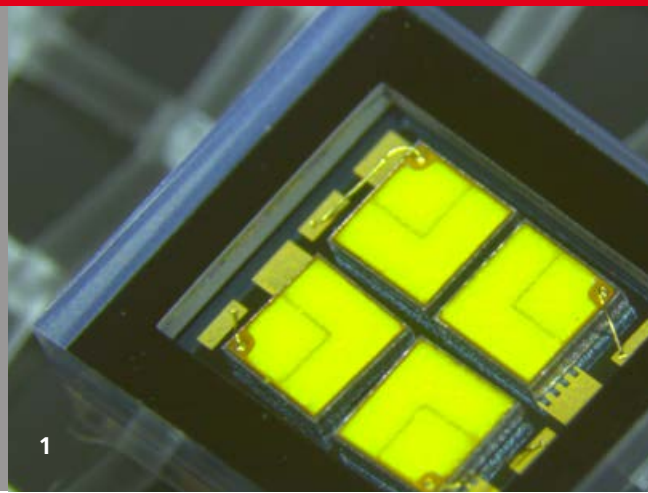
Fraunhofer IZM participates in government projects and bi- and trilateral cooperations with medical engineering companies and researchers throughout Europe and overseas. For example, in the European project Cajal4EU we have developed a fully integrated diagnosis platform that uses nanoelectronic components.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

Researchers in the project CAREJack 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. 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

3 3D system-in-package stack for hearing aid (in cooperation with TU Berlin)



PHOTONICS

Photonic systems for increased functionality

Photonic technology is the use of photons to meet human needs and today extends into every sphere of daily life. Since its first archaic use as artificial light in the form of fire, it has now come to assume a key role in modern, efficient lighting, ultra-fast data transfer and processing and in sensors for the environmental, transportation, industry and medical engineering industries. Modern materials processing is also unthinkable without photonic technology. Increasing functionality, smaller space and high power densities are the main challenges.

As a result of this complexity reliability issues become more and more important as every link in the chain has to be uniformly highly reliable. Meeting this challenge cost-efficiently, while at the same time advancing photonic technology, increasing functionality and maximizing resource efficiency, is Fraunhofer IZM's goal.

Services:

- Manufacturing and assembly of optical components
- Electro-optical circuit boards
- Packaging of electro-optical components
- Simulation, design and quantification (thermal, mechanical, optical and RF)
- Enhanced photonic and plasmonic systems
- Qualification, failure and reliability analyses
- Integration on wafer-level

Enlight – Hermetic packaging for LEDs and sensors

Fraunhofer IZM has joined forces with industry leaders, including Philips Lighting, Osram, NXP and Infineon, in the FP7 project »Enlight«. With smart sensor integration as secret weapon, the project is set to overhaul conventional LED technology and reduce power consumption even further. Fraunhofer IZM's role in the project is developing highly efficient, high LED-density, silicon-based assemblies in hermetically sealed packaging for all kinds of challenging operating conditions, from wet rooms and salt water environments to harsh industrial settings. Development is well underway, and current prototypes include transparent glass caps that can accommodate the integration of optical sensors, which could open up the potential for applications in an unlimited range of areas.

At the start of the project, we investigated thermal management in silicon substrates with and without thermal fins in simulation experiments. The results provided the foundation for a novel packaging technology that combines established techniques, such as eutectic bonding, with more recent approaches like anodic bonding and emerging processes like transient liquid phase bonding (TLPB). The unique development successfully addresses a key issue in multistep packaging, namely, precluding the possibility of detachment or melting of bonds formed at prior stages of processing and preventing thermal and mechanical challenges during further processing.

1 Hermetic package for solid state lighting and sensors



INDUSTRIAL ELECTRONICS

Industrial electronics

Globalization, cyber-physical systems, industry 4.0: buzzwords that sum up the most important economic and social developments of our age. Robustness, miniaturization, reliability, safety and security are central to the implementation of electronics into products.

Thanks to its outstanding track record in safety and security technology, Fraunhofer IZM will be increasingly active in the area of safety and security technology in the future. We will be placing the synergies created by our broad experience in this area, from equipment safety, identity verification, product traceability and the early detection of the impending failure of critical components, in the service of advancing technology for industrial electronics, particularly in the area of automation. A second key area is advancing automation technology by validating and introducing new developments from related areas in microelectronic and microsystem technology.

A current key priority is developing innovative solutions for autarkic, multi-channel wireless sensors used in control technology. Here, we are currently assessing the real-time capability of such systems, which is a key parameter for application in industry.

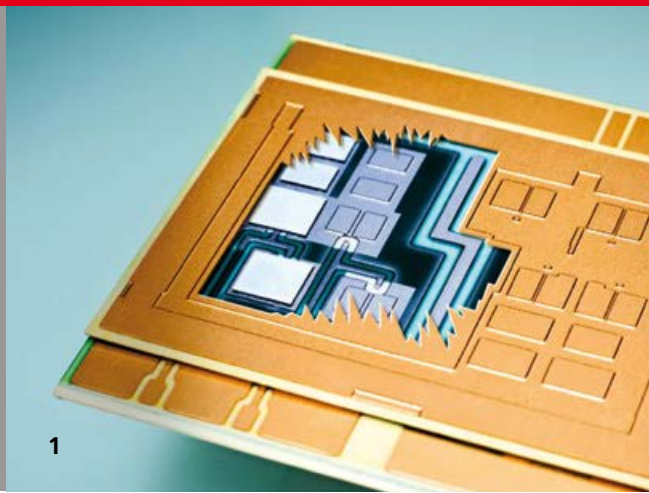
Monitoring of high-voltage overhead cables

Sensor-based monitoring of overhead cables requires highly robust and reliable technology. ASTROSE® is an excellent example of how Fraunhofer IZM delivers the goods, from the initial idea to pilot implementation. The upgradable monitoring system is based on energy-autarkic wireless sensors that measure key parameters in the field and directly at the cable. The data is relayed along the cable from sensor to sensor and is finally into a data interface and from there into the grid operator's control technology. ASTROSE® is a collaboration between Fraunhofer IZM, MPD and MITNETZ STROM. A high-voltage cable was equipped with the new technology last year as part of a pilot project.

Services:

- Design, technology development and transfer, reliability assessment of highly integrated modules on PCB substrates, starr flex and flex, and metallic and ceramic substrates
- Integration of electronic components (passive and active components) into textiles and composite materials or via embedding, including for ultrathin systems and high security applications (invisible electronics)
- Antennae and circuit design
- Design and prototype manufacturing of autarkic, multichannel wireless sensors in automation technology

2 Energy-autarkic wireless sensors for monitoring of high-voltage overhead cables



ENERGY

The key to reducing energy and resource consumption

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

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

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

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

Package optimized for high switching currents

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 one of our most interesting projects the chips are 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.

In further development of this project, parasitic capacitances are being optimized as well to ensure good electromagnetic performance despite high switching frequencies. For further reduction of switching losses, zero current switching is applied. With the single modules, a 15 kW 3-phase inverter prototype is assembled. Because of the high switching frequencies of up to 250 kHz, the output choke can be reduced by a factor of 10.

Services

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

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.

Hermetic sealing of MEMS components

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 EU-project with the acronym »Go4Time«. 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.

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

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, inter-metallic 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 m² 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 and provides the following services:

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

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Phone +49 351 795572-12

// CORE COMPETENCIES



FRAUNHOFER IZM

CORE COMPETENCIES

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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.

W-band radar module with 94 GHz MMIC and free-standing Vivaldi-antenna based on a cost-effective and RF-compatible organic substrate

HIGHLIGHT 2013

Packaging of a highly integrated W-band radar module

The human eye cannot see through wood, cardboard, or plastic. But a compact radar with a modular design now makes it possible to see the invisible: The millimeter-wave sensor penetrates material that is not transparent at optical wavelengths. It transmits signals in the high-frequency range between 75 and 110 GHz and has many different possible applications, from flight safety and logistics to industrial sensors and medical technology. For instance, radar technology is an ideal landing aid for helicopters as it is able to precisely measure the aircraft's movement and altitude in relation to the ground, regardless of unfavorable conditions such as snow clouds, dust or fog.

Researchers at the Fraunhofer Institutes for Reliability and Microintegration IZM, for Applied Solid State Physics IAF, Manufacturing Engineering and Automation IPA, are working together to develop a compact and cost-effective radar able to identify small objects at a distance even in poor visibility conditions. The system can be used in any situation where other sensor technologies fail on account of high temperatures or limited visibility. In contrast to x-ray scanners, it does not pose a health hazard, and it works with short-wave beams in the millimeter range. It has a transmission power of 10 milliwatts, compared with the 1000 milliwatt range of a mobile phone.

Packaging technology contributes to the development of this highly integrated W-band radar module with integrated signal generation, frequency multipliers, a Vivaldi antenna and data processing by using a cost-effective and RF-compatible organic substrate. This is generated by combining a low-cost FR4 base substrate and a thin RF-compatible LCP layer, that also integrates the free-standing Vivaldi antenna.

The GaAs-MMIC is mounted into a laser cavity level with the coplanar waveguide and interconnected by ultra-thin zero-tail-wirebonds to ensure lowest signal loss. Combining these efforts, the whole radar system can be brought down to the size of a pack of cigarettes!

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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

SmartPixels

Fraunhofer IZM's primary focus in the LumoLED project was fabric display technology. We developed special individually configurable RGB light sources (known as SmartPixels) for integration into textile circuits. These tiny printed circuit boards are each equipped with a high-end RGB LED and four top-side passives, as well as an embedded QFN (quad flat no leads package) I²C LED driver, which can be described as the 'brain' of the pixel. Using a bus as I²C bus was a viable option due to the limited wiring possibilities on a textile circuit and the need to control each pixel and its colors individually. We also developed the interconnection technology necessary to attach the SmartPixels to the textile circuit and tested the reliability of the new innovation. For the former, we applied thermoplastic adhesive bonding, in which a non-conductive adhesive film forms the electrical and mechanical connection between the SmartPixels and the textile circuit. By the completion of the project, we were able to produce a preliminary flexible, fabric-based display with 64 SmartPixels, which will be integrated into a coat. Our long-term vision is developing large-area textile, fully flexible displays.

Optical gyroscope for microsattellites in near Earth orbit

Interferometric fiber optic gyroscopes (IFOG) are highly accurate rotation rate sensors employed in inertial measurement units for manned and unmanned vehicles, such as submarines, ground vehicles, planes and satellites. IFOG technology is based on the relativistic Sagnac effect, in which the signal of one light source is split and coupled in both clockwise and counterclockwise direction into an optical fiber coil that is the main component of the sensor. After both signals have propagated through the fiber coil, they are recombined and, finally, the rotation rate is determined by analyzing the resulting interferometric signal.

A simple regression model is used to compensate the rotation rate error with temperature measurement at the outside of the fiber coil. Thanks to this corrective calculation, predictions can be made about the ideal fiber coil housing design and the effect of different coil winding schemes. The regression model we developed was tested with a quadruple wound fiber coil with panda fiber and a cylindrical wound fiber coil with single mode fiber.

1 Textile display based on thermoplastic adhesive bonding of RGB-LEDs

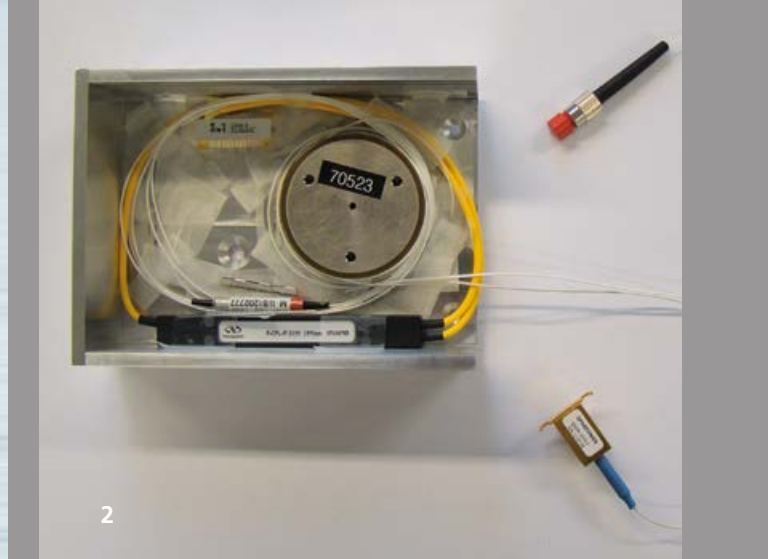
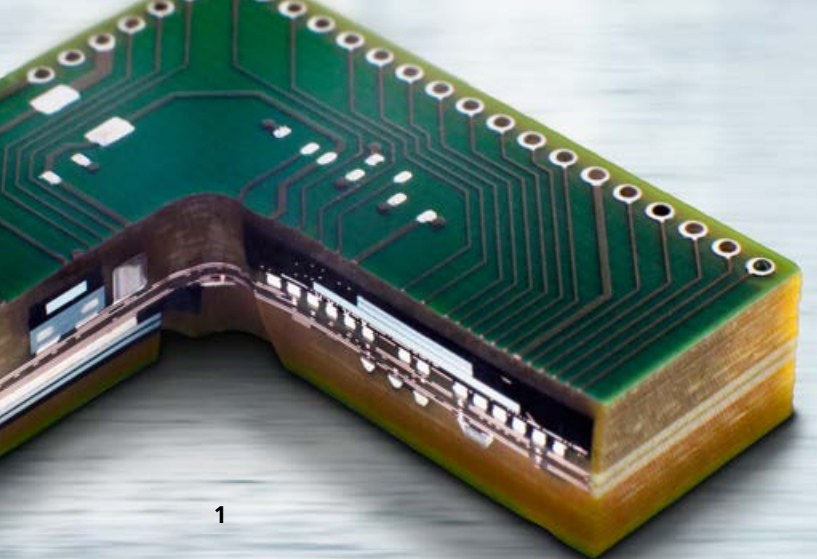
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Other components, including the light source, phase modulator and signal analysis electronics are also important for the stability of the IFOG system. Here we are developing a source monitoring and stabilization approach using with Bragg grating, monitor photodiodes, Lyot depolarizer and optical isolator.

Modular sensor kit with embedded components

Modular sensor systems provide a high degree of flexibility and variety. The set of suitable sensors can be quickly set up to capture properties and to regulate or control individual parameters of an application-related system. As part of the in-house research project MoMiKa, we are developing a modular micro-camera system, all of whose sensor elements are interchangeable.

The diversity of system types possible for this technology is thanks to individual modules with specific sensors that are able to preprocess captured measurements. Each module transmits the data to the base module using a standardized protocol (I²C). Moreover, sensor elements with a high data volume (such as cameras) are equipped with a USB connection to the base module. All the data collected throughout the system is processed via a software application installed on the base module. The base module's results can also be exported to a computer by USB interface. Furthermore, the applications running on both the base module and the computer can be customized using GUI programming.

Each module contains one or more sensors and is equipped with power conditioning, a microcontroller, and several passive components. The microcontrollers serve as interface to the overall system and perform the data pre-processing. All components are integrated into the circuit board using PCB em-

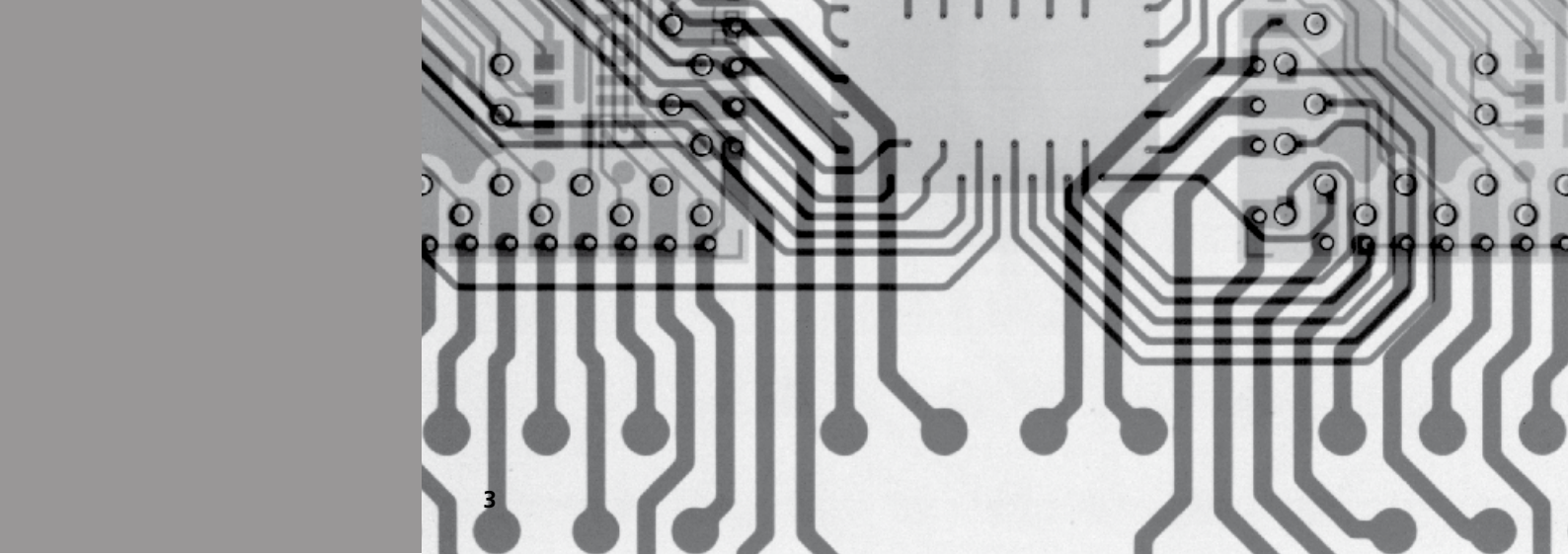
bedding technology. This method allows replacing of single or multiple modules, due to the even and identical top and bottom surfaces. The module selection as well as the order is application-oriented. For permanent usage they can be soldered or cemented. However, for temporary or variable usage requirements, the modules can be stacked with specially designed connectors.

One very special sensor element is the miniaturized intelligent camera. It includes an integrated processing engine for both still and moving images. At a volume of 3 cm³, the camera module is significantly smaller than comparable modules from other manufacturers (e. g. Microscan Vision Mini – which is 20 times larger). The high integration density of the components makes countless applications possible, such as for:

- Motion detection (protection against theft)
- Pattern detection (traffic signs)
- Edge detection (character recognition)
- Artefact filtering and image editing
- Automatic lighting control
- Real-time image processing
- MPEG2/MPEG4 – video compression

Sensor packaging and sensor encapsulation

Packaging for intelligent sensor modules is one of the most challenging tasks in microelectronics packaging. The trend towards the integration of ever more sensor functionality and related control logic into a miniaturized package defines these modules as typical example for heterogeneous integration.



Depending on the area of use, reliability demands and economical boundary conditions, such modules are built using a wide variety of technologies – from single chips on leadframe via COB on ceramic, SiPs on leadframe or organic substrate, or even substrate-less packaging. Polymer materials are often used to facilitate competitive pricing. Typical technologies are adhesive joining for interconnect formation and housing by glob top or molding.

A classic example of heterogeneous integration is the technology developed in the MST-Smart-Sense project, where multisensor eCompass packages, with integrated magnetic, acceleration and pressure sensors plus related controller and passive components, were developed. Various technological approaches were selected to build a PCB-based SiP using adapted SMT/COB-technologies and – to maximize integration density – a wafer-level molding technology was applied in combination with laser-drilled through-mold vias. This reconfigured wafer with integrated sensor/ASIC combinations was the basis for a package-on-package multisensor system. In a two-pronged approach, embedding was used, again to optimize cost-efficiency. Firstly, active components were embedded into the PCB and, secondly, compression-molding processes were used to manufacture reconfigured wafers and even panels (450x600 mm²). Together, these techniques allowed us to build highly integrated and cost-effective microsystems.

Successful integration of biosensors and microfluidics using the reconfigured wafer approach was demonstrated in the EU-funded project Cajal4EU. Here wafer molding, z-axis wiring and microfluidic functionality were applied to develop a novel, highly integrated sensor module for point-of-care applications.

After medical applications, the most frequent use of such sensor systems is in automotive/industrial electronics – due to their ability to withstand high operating temperatures, thermal cycling and aggressive media. Current research projects dealing with development of PCBs and encapsulants for temperatures > 200 °C (the HELP project), with qualification of molding compounds for applications up to 250 °C and with humidity diffusion into microelectronic packages (the DianaSens project) are providing vital insight for product-related research and development work, which is mostly performed in direct cooperation with partners from industry.

1 Camera module with embedded components

2 Optical path of an interferometric fiber-optic gyroscope with SLD, LiNbO₃ phase modulator and quadrupole wound fiber coil

3 X-Ray image of a Cajal 4EU demonstrator, FOWLP packaged CMOS sensor with two TSV dies for 3D routing

MICROMECHATRONICS & PCB TECHNOLOGY

Fraunhofer IZM Oberpfaffenhofen

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

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

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

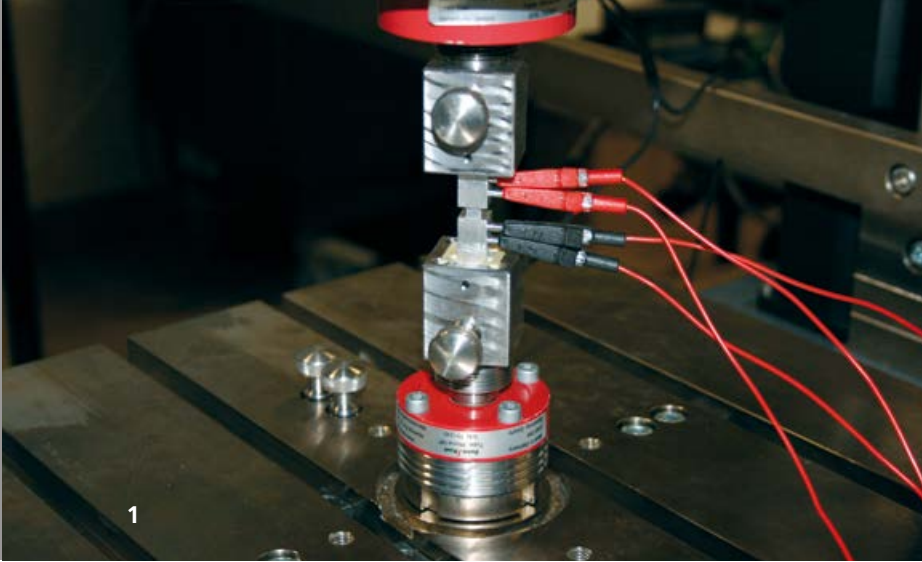
Trends

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

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

Key development goals:

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



RESEARCH & DEVELOPMENT HIGHLIGHTS

Qualification of high-current Aluminum joints

Although aluminum alloys hold great potential for lightweight design, they present challenges in manufacturing and qualification. Compared to copper or steel components, their long-term behavior is more difficult to characterize – mechanisms like creep and electro-chemical corrosion have to be considered. Conventional testing methods such as for steel components are inadequate, because they cannot reliably pinpoint faulty components. To address this issue, our Fraunhofer IZM Oberpfaffenhofen branch has developed a power cycling technique that specifically targets the typical failure mechanisms of such materials. Vibration and salt spray testing of the alloys under electrical loading is also possible. In combination with research on »smart power mechanics«, we developed efficient techniques for characterizing the thread flanks of grounded bolts under loading. Thermography and confocal microscopy techniques provide a deeper understanding of the system variables affected by low-friction lubricants and simultaneous conduction. The new insight facilitates reliability in interconnection and lightweight engineering design. The research was partially funded by the Bavarian ministry of economic affairs and media, energy and technology.

Fretting corrosion in solar panel connectors

Defective contacts in individual photovoltaic panels can be a fire hazard for entire photovoltaic plants. Together with Suncycle, a test and repair service provider for the solar industry, our Oberpfaffenhofen branch successfully solved this problem through elaborate analysis tests, new repair methods and integrated training. We developed a fast, yet accurate, testing method to, firstly, identify the contacts' underlying fault, namely »fretting corrosion«, and to, secondly, quantify the problem by precisely measuring contact resistance. Together with Suncycle we then developed a practical repair solution that satisfied the applicable regulatory stipulations.

New training series: IPC/WHMA – A-620B workshops at Fraunhofer IZM ZVE

Fraunhofer IZM's Oberpfaffenhofen Training Center for Interconnection Technologies (ZVE) is launching the training series IPC 620 »Requirements and Acceptance for Cable and Wire Harness Assemblies« in 2014. The course will provide an in-depth understanding of the IPC norm, including standards for the entire range of crimp connections, solder joints and interconnection possibilities, insulation displacement contacting, insulation encapsulation and labeling. Final assembly of connectors, mechanical interconnections and casting systems will also be a key focus.

1 *Assembly prototype for the high-precision measurement of contact resistance and mechanical stress*

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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.

*Highly planar contacts:
Cu/Sn pillars, 80 μm high,
total height variation less than 0.5 μm*

HIGHLIGHT 2013

New techniques for wafer-level packaging and chip assembly for power electronics

Just as microelectronics permeates more and more application areas, the demand for better and better electrical, thermal, and thermo-mechanical reliability appears similarly unstoppable. Increasingly aggressive operating conditions require wafer level packaging and interconnect technologies that deliver both electrical pathways with high current-carrying capacity and that have thermal resistance of above 250°C.

We have developed a solution that meets these demands. The technology is based on massive copper and copper/tin structures on semiconductor substrates, which can be fabricated by electrochemical deposition onto lithographically printed photoresist masks. The required manufacturing processes are all compatible with common wafer-level packaging techniques and are essentially based on conventional wafer bumping using electrodeposition. The wafers to be coated are first sputtered with a thin galvanic starting layer, then lithographically structured with a thick photoresist, and finally electroplated with Cu and Sn electrolytes, which were specially developed for this application. Either dry photoresists or liquid resist systems can be used to pattern the wafers, allowing for metal deposition of up to 200 µm with excellent structure resolution and low mechanical stress. Purpose-built electroplating chambers ensure processing times remain short and height tolerances do not exceed +/- 0.5 µm across the whole wafer. For certain semiconductor materials, gold and gold/tin, deposited at varying volume, is used instead of copper.

Apart from conventional silicon wafers, Fraunhofer IZM's thin-film technology can handle almost all types of semiconductor materials, from SiC, GaN, GaAs, Ge, InP, through to glass and polymer wafers of up to 300 mm. Special technology for temporary and permanent bonding of thin wafers is also available.

Such highly planar contact structures are suitable for transient liquid phase bonding of Cu-Sn and Au-Sn with minimal formation of intermetallic phases. Due to the excellent uniformity of the bump shape, even larger chips can be mounted with a negligible defect rate and regardless of lateral dimension. Minimal roughness and surface modifications extend the technology's possibilities to Cu-Cu and Au-Au thermocompression and ultrasonic bonding at reduced bond force and low temperature.

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WAFER LEVEL SYSTEM INTEGRATION – ALL SILICON SYSTEM INTEGRATION ASSID

The Department

The research activities of the department »Wafer Level System Integration« and its staff in Berlin and Dresden focus on technologies for wafer-level system integration and packaging which are exclusively related to wafer processing.

The process lines allow high flexibility regarding the processing of 6" – 12" wafers and are characterized by a high adaptability of the individual processes.

The process line at the center ASSID is particularly tailored to realize production-related and industry-compatible development and processing.

The focus of the scientific work is on:

- Wafer level packaging and CSP
- 3D integration technologies
- Silicon interposers
- High-density and ultra-fine pitch interconnect formation
- Interconnects
- Pre-assembly
- 3D wafer-level stacking

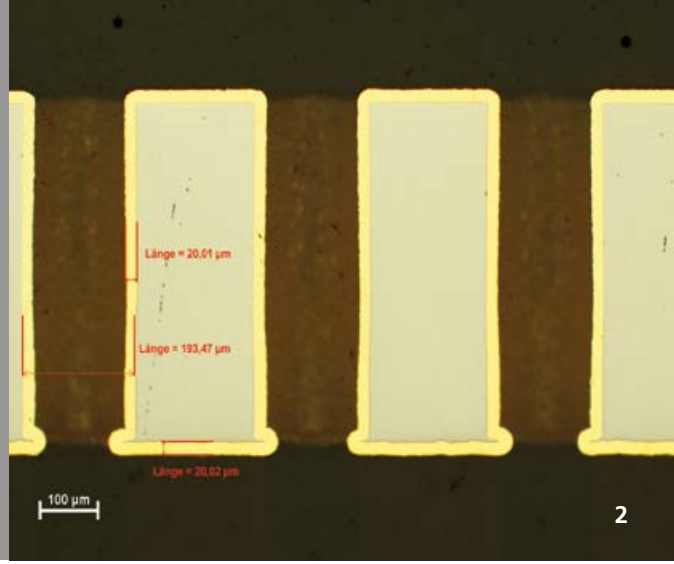
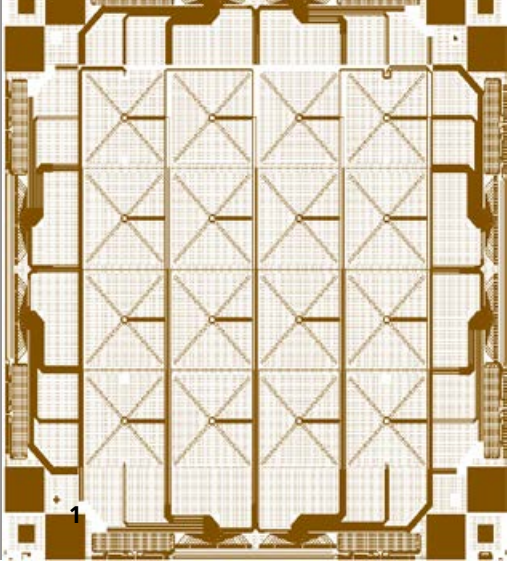
R&D services for customers include process development, prototyping, low-volume manufacturing as well as process transfer. Newly developed technologies are adapted to customer-specific requirements and qualified correspondingly.

Trends

The merging of technologies for »more Moore« and »more than Moore« is of high importance for the development of micro systems. Furthermore, cost efficient solutions for the overall system have to be developed and realized. Also, a synergetic approach covering design, technology and reliability aspects is of increasing significance. This constitutes a particular challenge for the heterogeneous integration of devices into a multifunctional, miniaturized, cost-optimized and reliable wafer-level system-in-package (WL-SiP).

Accordingly, the research and development goals focus on:

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



RESEARCH & DEVELOPMENT HIGHLIGHTS

BeOL-compatible Cu-TSV via middle process integration

Our department has developed a novel copper through silicon via (TSV) process (5 µm / 10 µm diameter, ASR 10-12), which we are applying for TSV middle and interposer applications.

The process development particularly focused on investigating and optimizing the complex correlations between Si etching, oxide isolation, barrier layers and electrochemical deposition.

Another key area was the impact of copper electroplating for TSV metallization (electrolyte type and process management) and its interdependency with subsequent annealing processes, on the one hand, and planarization (CMP), on the other.

Test chip strategy for process development and verification of processes for 3D systems

Our test chip portfolio includes numerous designs for D2D and D2W stacks with TSVs. We draw on these to investigate ultrafine pitch µ-bump interconnect technologies and the influence of TSVs.

The interconnect structures under development (bump size: 25 µm pitch, 13 µm diameter) fulfill the requirements of 3D systems (technology node) and the latter's demands on future bonding technologies.

Moreover, the test chip designs feature high-resolution structures with line/spaces of 4 µm, which meet industry demand for assembly processes that use a bonding force of < 400kN, while maintaining flexibility and density in wiring layout.

1 Design of ASSID test chip (TC4)

2 TSVs with gold metallization, 200 µm x 500 µm; homogeneous gold deposition with 20 µm thickness

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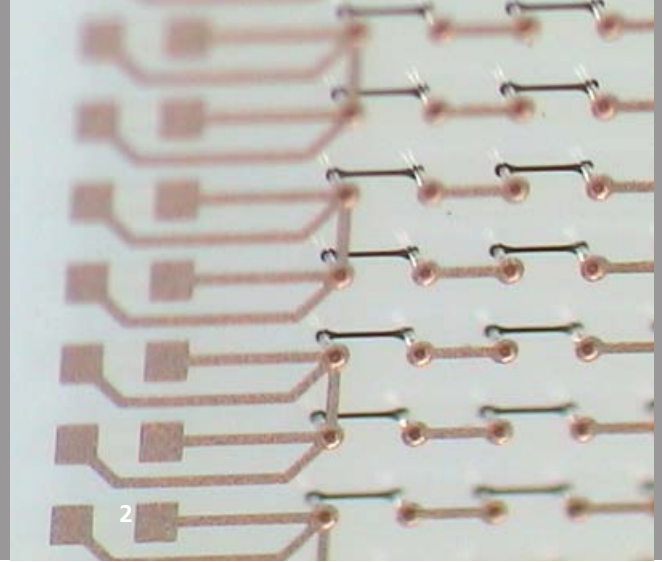
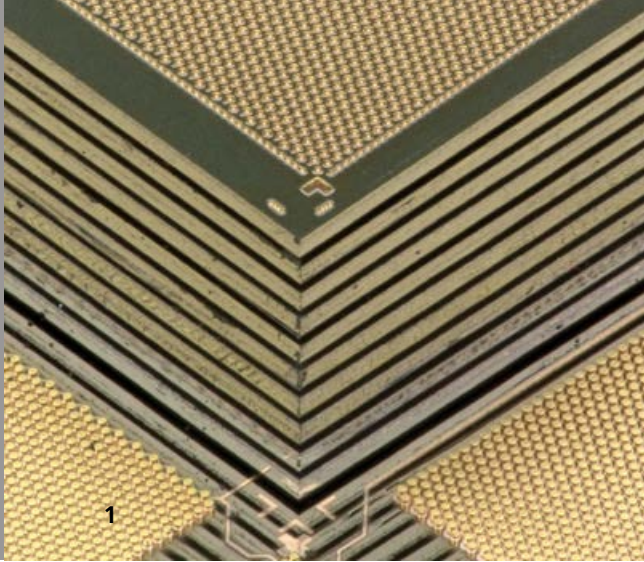
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3D device stacking

Our key development area is 3D die stacking with extremely high placement accuracy (up to $3\ \mu\text{m}$ @ 3 sigma) using chips with a maximum size of $10 \times 10\ \text{mm}^2$. An key accomplishment to date has been our application of flux-activated reflow soldering to assemble 3D die stacks with up to 10 die layers. Each stacked die has $\sim 35,000$ I/Os at $55\ \mu\text{m}$ pitch, an interconnect diameter of $25\ \mu\text{m}$, and a chip thickness of $100\ \mu\text{m}$. The underfill gap varies between $30\text{--}50\ \mu\text{m}$, as we are concurrently investigating properties of diverse underfill technologies. To date, we have applied capillary and no-flow underfill technologies and tested various materials and process parameters.

Copper filling of through glass vias (TGVs) and electrical validation at up to 100 GHz and above

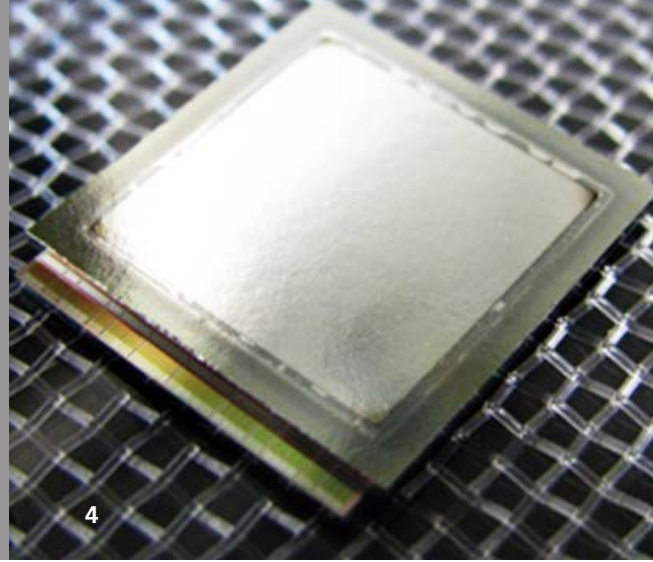
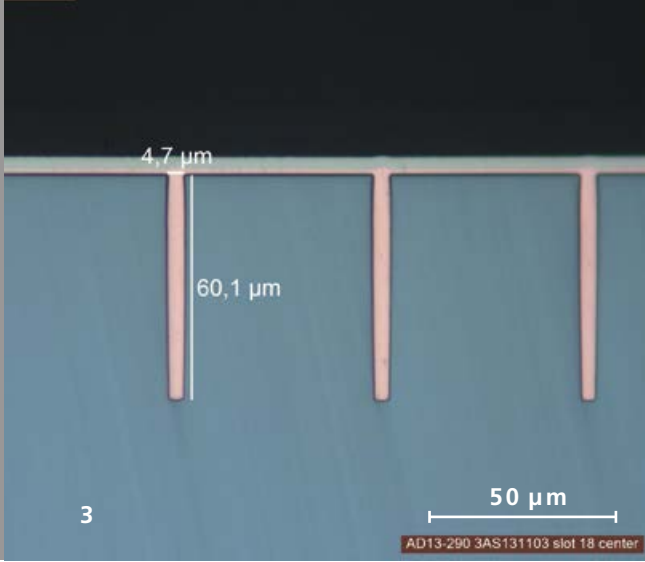
Thanks to superior mechanical and electrical performance, glass interposers increasingly appear to be a highly promising alternative to organic or silicon-based interposers.

Together with the company AGC (Japan), we performed an electrical validation of the technology using different test structures for DC and ultra-high frequencies. As a first step, we applied via chains and 4-point test structures to measure via yield and the electrical resistance of single TGVs, which proved to range between $14.5\text{--}19$ mohms. We then optimized the test structures for a frequency range of up to 100 GHz. Measurement of the metalized glass interposers (200 mm wafers) demonstrated outstanding electrical conductivity. The reliability of TGVs was confirmed by air-to-air thermal cycling (-55°C ; room temperature; 125°C). At the time of writing, testing has exceeded 2,000 cycles without a single failure. The investigation is ongoing.

X-Ray detector with Germanium sensor

Materials with a high atomic number are common in synchrotron radiation sources applied in material analysis. We hypothesized that they would be similarly suitable for detectors in high energy X-Rays.

In cooperation with the company Canberra and the Hamburg research institute DESY, we developed X-Ray detectors with pixel sensors based on ultra-pure germanium chips. Because such materials are more temperature-sensitive than the commonly used sensor material silicon, we developed a special, low-temperature bonding technique, based on electrodeposited indium micro-bumps, to mount the electronic read-out chips.



In the subsequent assembly process, each of the read-out electronics' 256 x 256 cells were electrically connected to individual pixels of the sensor in a pattern of only 55 x 55 μm^2 . The completed detector modules were tested in the DESY laboratories at a temperature of -100°C in vacuum. The results confirmed uniform detection behavior at high pixel yield.

Inline metrology for a TSV technology platform

Metrology at ASSID is always placed at the service of the overall system – we work closely with metrology tool suppliers to continually and comprehensively adapt materials, measurement methods and tools to the needs of the development at hand. The advantage of this dynamic approach is best illustrated by the unique requirements of bump analysis (100% coverage) and TSV inspection.

We are developing new approaches for non-destructive inline-monitoring in ongoing projects, such as the EU project Master_3D. A special focus is the correlation between the results of inline measurement and those of destructive (but more detailed) testing methods. The results will provide deeper insight into the influence of specialized process setups and into defect mechanisms.

We are also evaluating other inline monitoring techniques, particularly in terms of their ability to accelerate the inspection process (through-put).

Fraunhofer Cluster 3D Integration

With its wide-ranging, unparalleled skills and know-how in so many aspects of technology, design and reliability, the Fraunhofer Gesellschaft is well-placed to commercialize 3D systems and facilitate their adoption by German and European industry.

To do justice to this ambitious and technologically complex aim, five Fraunhofer institutes (IZM, ENAS, IIS/EAS, IKTS and IPMS) have bundled their know-how and resources into a network that offers industry (SMEs and large enterprises) a comprehensive, yet uncomplicated introduction to the potential and implementation of 3D integration in innovative products.

1 3D chip stack with copper TSVs

2 Copper metallized glass vias

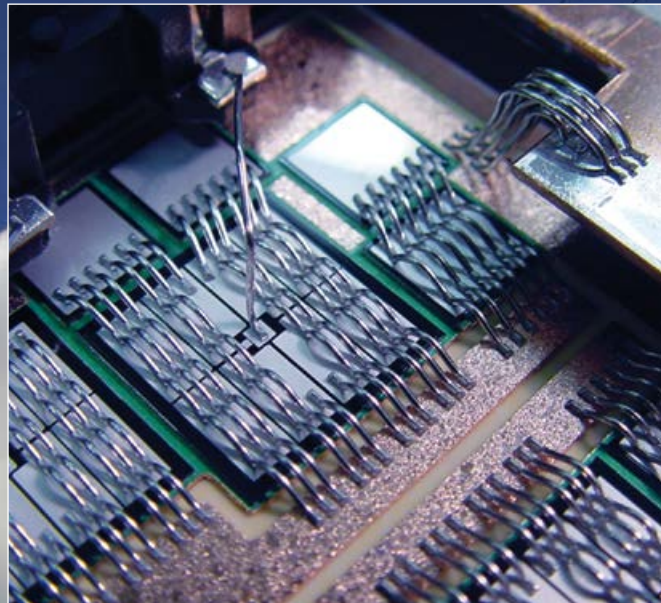
3 Copper through-silicon vias (Cu-TSVs, 5x60 μm)

4 X-ray detector module consisting of Germanium sensor chip (top) and electronic readout-chip (bottom). Source: DESY

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.



*Condition monitoring for
power electronics in photovoltaic
applications (CoMoLeFo)*

HIGHLIGHT 2013

Condition monitoring and lifetime prediction of IGBTs for photovoltaic inverters

Insulated gate bipolar transistors (IGBTs) are key to the state-of-art inverters used in photovoltaic equipment. Their main function is converting the variable direct current (DC) produced by solar panels into alternating current (AC). Thermomechanical stress induced by cyclic loading is a main cause of semiconductor degradation. IGBT lifetime is primarily dependent on the frequency and amplitude of this cyclic loading.

Against this background, the main goal of CoMoLeFo, a joint project between industry and the Fraunhofer IZM, was to develop a reliable means of assessing system condition and an intelligent technique for predicting the remaining lifetime of power electronics. Condition monitoring and the lifetime prediction that this makes possible can warn of impending age-related failure. This increases the reliability of the entire photovoltaic system and reduces the need for maintenance routines.

CoMoLeFo takes two mutually complementary approaches: IGBT chip temperature is determined by indirectly measuring relevant electrical parameters during operation. To assess the associated stress on the system, the results are evaluated using a mathematical lifetime model. At the same time, diverse parameters and how they change due to aging are monitored in real time. Using these techniques, CoMoLeFo developed software specifically for predicting IGBT remaining lifetime, which is transmitted to customers and service providers by remote access.

Availability, efficiency and reliability are key strategic concerns in the provision and operation of power plants. Increasing power plant efficiency and reliability improves competitiveness. For example, planning servicing is easier and downtimes decrease. Beyond the primary goals of the CoMoLeFo project, power electronic systems equipped with condition monitoring systems can be applied in a wide range of other areas.

The project was carried out in cooperation with imc Meßsysteme GmbH, First Sensor AG, General Electric Company and the TU Berlin. It was co-sponsored by the TSB Technologiestiftung Berlin (Eng.: TSB Technology Foundation Berlin) using funding from the Land Berlin's Zukunftsfond (Eng.: Funding for the Future) program and by the EU European Fund for Regional Development (EFRE) program.

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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-characterization through to evaluation and optimisation on the system level.

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

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

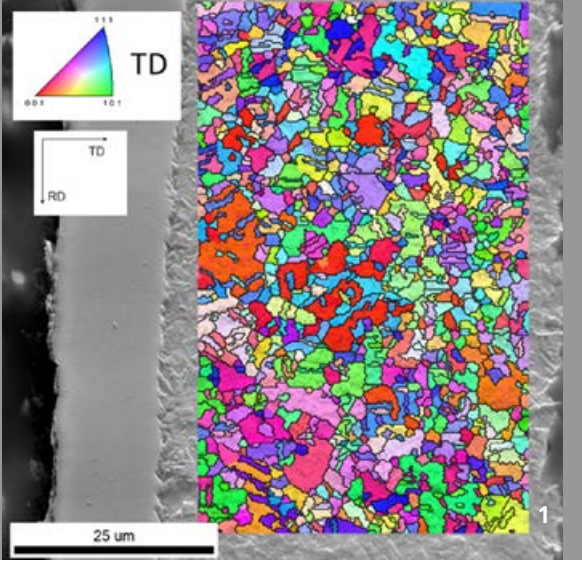
Trends

Electronic systems are being used in more and more diverse application areas. Consequently the task of maximizing reliability while using the least possible resources becomes increasingly complex.

Improving the modeling of how an innovation is used, known as mission profiling, is of central importance here. Mission profiling brings systematic understanding of applicable operating conditions together with cutting-edge technology. In the past, roadmaps set down norms agreed on in broad, consensus-based processes for wide-sweeping areas such as »industry« or »medical engineering«. Today, more detailed and diverse operating conditions have to be considered in order to specify the concrete maximum loads that may occur in the various combinations of application types.

To address this, Fraunhofer IZM has developed the following techniques: Using the application scenarios and the functionality, whose reliability has to be secured as basis, system analyses are carried out and suitable load profiles, known as mission profiles, are developed to ensure optimized planning of reliability testing throughout the supply chain.

Using physics-of-failure approaches, reliability experts can assess various designs and application environments. The resulting data are crucial to making design decisions in a timely fashion and avoiding reliability risks. Both the described application scenarios and the reliability predictions are also important bridges to more precise environmental assessment. Consequently, the interplay between environmental optimization and reliability assurance is potentially an important foundation for improving how we use resources.



RESEARCH & DEVELOPMENT HIGHLIGHTS

Tablet reparability and recyclability

Although tablet computers only hit the market a few years ago, sales are already set to overtake laptops. Compact and thin design is a key concern in tablet development. But at this same time this emphasis makes the devices harder to repair and recycle. We investigated how easily the battery and circuit boards of commercially available tablets could be removed. Even though product returns are still low, tablets may be a significant source of secondary raw materials in the future. For example, the tablets released globally in 2013 alone contain approximately 2000 tonnes of magnesium and around 5000 tonnes of valuable PCBs.

However, the high integration density and increasingly robust design of tablets will make fractionation and battery removal difficult. The findings of our disassembly analysis will be fed into future tablet design with the upcoming development of development criteria by the environmental rating system EPEAT.

Local material properties of copper structures before and after cyclic loading

Assessing thermomechanical reliability using modeling requires a firm grasp of elastic-plastic material behavior. One approach to determining material behavior locally is applying nanoindentation to force-imprint depth curves. By combining experimental and simulated nanoindentation, we were able to evaluate the altered local elastic-plastic properties of microscopic copper structures.

In the case of cyclic loading of through vias, we observed a reduction in yield point, which diminished the solidity of the copper. Electron backscatter diffraction microstructure analysis (EBSD) revealed that deformation had affected texture and that granularity was coarser, which explained the change in mechanical properties.

1 EBSD determination of grain boundaries: Inverse Pole Figure Map (IPF) of copper through vias in initial state

2 Resource consumption of mass-produced goods: analysis of how easily tablets can be disassembled and recycled

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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.

ArtGuardian originated as part of Fraunhofer-Gesellschaft's 4D (Discover, Define, Develop, Deploy) research approach, which aims to recoup development costs by marketing new products through spin-offs. The latter are established in close collaboration with Fraunhofer Venture and with input from the Fraunhofer Gesellschaft as company shareholders.

HIGHLIGHT 2013

From bright idea to commercial spin-off: ArtGuardian set to hit the market

Regular readers of the Fraunhofer IZM annual report will remember that ArtGuardian, a new preventive conservation tool for the art world, was mentioned in these pages two years ago, when we announced that the product development stage had been completed and field testing was about to commence. As part of the latter, the ArtGuardian sensor system was installed in internationally renowned and respected museums and galleries, including Berlin's Hamburger Bahnhof, Basel's Art Museum and the headquarters of HISCOX Insurance in Munich. The results of the field tests are now available.

Developing a sensor system for the conservation of artworks presented Fraunhofer IZM's SDI researchers with a complex challenge. The sensor had to monitor climatic conditions, including temperature, humidity, and light, but also record movement and vibration during transport. Moreover, the sensor system had to be small and not detract from the art work. However, by working together with restorators, art experts, IT specialists and product designers, we developed a product that met all these special requirements. The final sensor system measures just 118 mm (l) by 11 mm (h) by 81 mm (w). The sensor unit, which features a self-sufficient power supply, is attached to the back of a painting and monitors the temperature and relative humidity in front of and behind the artwork 24/7. The sensor data is then transmitted to the user-friendly ArtGuardian software-platform, which can be configured to evaluate and display the data as required. This IT-platform was developed together with our project partner Fraunhofer ISST. In close collaboration with the Rathgen Research Laboratory of the Berlin State Museums, a specially compiled set of preventive conservation standards was integrated into the program as a cyber-assistant that helps users select the best settings and measures based on the prevailing microclimate.

Over the last two years, ArtGuardian has developed into a comprehensive monitoring system for cultural objects and art works. Apart from its in-built alarm system and documentation of climatic conditions, it can also evaluate complex parameters affecting an artwork and help curators and gallerists make the right decisions on how to store and exhibit valuable pieces of art. The ArtGuardian solution has been hotly anticipated since it was first presented as final product in 2013 at Exponatec in Cologne and at the Berlin Kulturforum's conference on risk and disaster management in museums. This year, ArtGuardian will finally hit the market.

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SYSTEM DESIGN & INTEGRATION

The Department

The department »System Design & Integration« advances Fraunhofer IZM's system expertise using novel technologies. Microsystems with self-sufficient power supplies are one key example of the department's know-how. From e-grains, to autarkic sensor nodes, through to cyber-physical systems, this ongoing development towards the Internet of Things has been shaped significantly by our work.

Our department develops and advances techniques and tools for the efficient design of technologically sophisticated electronic systems. We strive for an integrated design process that draws on the simulation of electrical, magnetic and electro-magnetic coupling.

The simulation results are fed into function, volume, reliability and cost analyses, which are all used to make design decisions during product development. Thanks to our research into energy harvesting, conversion and management, along with energy-efficient programming, we can provide a one-stop know-how and expertise service that covers the gamut of related technology areas.

- Miniaturized wireless sensor systems (cyber-physical systems)
- RF and high-speed system design
- Power supplies for miniaturized systems

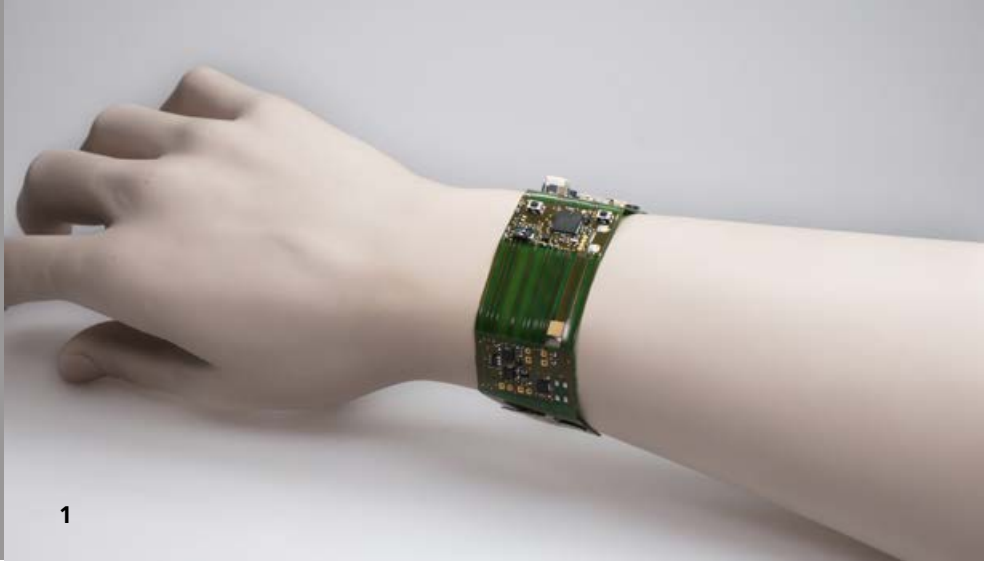
The department's commitment to advancing research is manifest in its participation in key industry conferences and a wide range of development projects.

Trends

The holistic approach to product design demanded by customers today is leading to a closer interplay between circuit design and technology development. However, this rather recent industry-wide shift has been long established and continually advanced at Fraunhofer IZM in its approach to developing autarkic wireless sensors. Moreover, our department, in collaboration with Fraunhofer IZM's thermomechanical reliability experts, is increasingly providing system concept design and consultation. A new focus will be the development of electro-optical systems, particularly interfaces between subsystems.

The latter will also be a key focus in the integration of nanotechnology into microelectronic systems. Promising technologies in this research include silicon-based 1D components. Once the first challenge of developing laboratory samples is met, our second challenge will be applying these nanosystems to existing systems and manufacturing processes, such as wafer-level production. The maximum frequency for RF testing, including dielectric material characterization, will increase from 110 GHz to 220 GHz, which will allow investigation of the range around 122 GHz, considered to be crucial for the technology of tomorrow. Measuring technology will also take great strides in terms of time domain quantification, particularly, the monitoring of high data rates.

The distinction between cyber-physical systems and »conceptual« systems blur in cyberspace. Hardware-software codesign will be just as indispensable as power-supply concepts for autarkic sensor nodes. Here, key research topics include low-power design, multimode energy harvesting and miniaturized voltage transformers.



RESEARCH & DEVELOPMENT HIGHLIGHTS

Autarkic sensor systems

The networking of mobile devices in health and safety has catapulted communication between man and machine to a new level. For example, by tracking movement, temperature and cutaneous electrical resistance, a recently developed bracelet can now provide an overview of a wearer's physical condition. The bracelet interfaces with a host of interactive support services via Bluetooth. An SD card is used to store the sensor data when the bracelet is off-line.

1 *Bracelet to monitor vital signs*

Energy management for autarkic sensor systems

Our department improved the energy efficiency of compact wireless sensors. Now high-performance monitoring in harsh industrial environments can almost do without regular battery replacement. We also developed acceleration sensors with an analog bandwidth of 0.1 to 15 kHz to monitor the harmonic component of speed-constant drives. By then applying analysis algorithms, we can accurately predict component failures in machines. Within Industry 4.0 activities such sensors can also be coupled with a maintenance cloud.

Customized micro-batteries

Not all sensor nodes can be charged by environmental energy alone. Uninterrupted power supply continues to require batteries. To address this, we developed a co-planar design for highly miniaturized batteries. Testing has shown good reproducibility. Batteries of identical design have an identical charge-discharge characteristic. The achieved capacity: 0.5–1 mAh/cm²; current carrying capacity: 2–5 mA/cm².

Automated power supply

Our development of miniaturized power supplies using piezoelectric transformers builds on groundbreaking results of up to 40 watts from piezoelectric transformer-based high-voltage generators of over 5 kV and modular master-slave power supplies for wide-range and high-temperature applications.

RF and high-speed systems

Our development of antenna technology has produced new solutions for robust autarkic sensors. Antennae can be adapted to build space using conformal antennae on flexible substrates. We also produced new concepts and technology for wireless power supplies. The M3 approach was applied to optimize signal paths for data rates above 100 Gbit/s using connector adapters.

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// EVENTS



FRAUNHOFER IZM EVENTS

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EVENTS & WORKSHOPS

450 well-wishers gather to celebrate Fraunhofer IZM's anniversary

Last year marked 20 years of Fraunhofer IZM and 25 years of the TU Berlin Research Center for Microperipheral Technologies. Fraunhofer IZM celebrated the anniversaries with a special event at Berlin's Maritim proArte on November 6th, 2013.

The anniversary symposium with around 250 guests included presentations by long-term partners in industry on the challenges facing electronic packaging for their individual industry areas. Fraunhofer IZM scientists then discussed how technology could master these challenges in the future.

The subsequent anniversary celebration was attended by 450 guests, including many past and present Fraunhofer IZM staff members. After Fraunhofer IZM Director Prof. Klaus-Dieter Lang opened the event, Guido Beerman, Permanent Secretary in Berlin's Department for Economics, Technology and Research was first to offer formal congratulations, followed by Prof. Wolf-Dieter Lukas, Director-General in the German Federal Ministry of Research and Education (BMBF).

Prof. Raimund Neugebauer, Fraunhofer-Gesellschaft President, and Prof. Jörg Steinbach, President of the Technische Universität Berlin discussed the vital role of Fraunhofer IZM and the TU Berlin Research Center for Microperipheral Technologies in the two institutes' research strategies. Dr. Reinhard Ploss, CEO of Infineon Technologies AG, brought in the industry perspective with his presentation entitled »From Product to System – More than Moore at Infineon«.

In a discussion with the event host Natasha Walker, Prof. Klaus-Dieter Lang closed the symposium with an overview of how application-centered multifunctional electronics is likely to develop in coming years.

Afterwards, the Berlin University of the Arts (UdK) choir led the many well-wishers in a rousing rendition of the birthday song. The subsequent less formal festivities included a host of small surprises – as a nod to the trend towards embedded electronics, the evening included a wide range of »embedded entertainment«.

Long Night of the Sciences in Berlin and Dresden

For Berlin's Long Night of the Sciences on June 8th, 2013, Fraunhofer IZM and the TU Berlin Research Center for Microperipheral Technologies collaborated on an exhibition entitled »Interactive Microelectronics«. As in previous years, visitors loved the clean-room tours, which offered fly-on-the-wall insight into state-of-art microelectronic assembly techniques. Aspiring surgeons tried their hand at endoscopic investigation of stuffed toys using the world's smallest camera, a Fraunhofer IZM innovation, and Fraunhofer IZM's TexLab »smart textiles« were also made available to visitors on the night.

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



Following up on the success of their debut participation in 2012, Fraunhofer IZM ASSID participated in the 11th Dresden Long Night of the Sciences on July 5th, 2013. Again, the wildly popular clean-room tours, the microcamera and hands-on microscopy gave the many visitors a unique glimpse into the world of microelectronics.

Parallel to the »Long Night of the Sciences«, Fraunhofer IZM ASSID invited approximately 70 local up-and-coming scientists to complete their »junior PhD« in record time by completing a circuit of interactive exhibits, as part of an initiative of the network »Dresden – City of Science«. The youngsters were treated to a colorful journey through the world of microscopy and microchip analysis.

Future Technologies Workshop: 3D Integration, Dresden

On April 16th 2013, the Dresden-based Fraunhofer Gesellschaft microelectronics institutes joined with companies including Infineon, Bosch and Globalfoundries to discuss the potential of 3D system integration. Saxony's Minister for Science and Art, Prof. Sabine Freifrau von Schorlemer was among those to open the event, which was attended by high-profile research and industry players. Fraunhofer IZM-ASSID presented the key issues involved in implementing 3D integration as technology approach and showed how adapted materials and related analysis and testing techniques can be used to optimize the performance and reliability of innovative, specialized applications using customized materials and adapted analysis and testing techniques.

Workshop: Microsystems for Harsh Environmental Conditions, Berlin

Microsystems are being employed in more and more diverse, but also harsher settings. The parameters of conventional electronics and microsystem technology cannot keep up with the demands of biocompatibility, non-electronic applications like smart textiles and, above all, high temperatures. Nevertheless, we know that condition monitoring and control sensors will soon be needed for industrial processing at significantly higher temperatures. Fraunhofer IZM and the international professional association IVAM addressed this problem in a workshop on June 13th 2013. Together with 50 industry representatives, the event provided an overview of the processes and technologies best suited to producing assemblies that operate reliably in harsh operating conditions.

Science Lab Weeks at the Science Center Berlin

Together with Otto Bock HealthCare, Fraunhofer IZM participated in the Science Lab Weeks between June 8th and 28th, 2013. Our institute contributed interactive exhibits that illustrated the

1 Prof. Johanna Wanka, Federal Minister of Education and Research (r.) and Prof. Sabine Freifrau von Schorlemer, Saxony's Minister for Science and Art (l.) visiting Fraunhofer IZM-ASSID in Dresden. Between them Fraunhofer IZM's Catharina Rudolph

2 Fraunhofer IZM's director Prof. Klaus-Dieter Lang welcomes 450 guests at the institute's 20th anniversary celebration



innovative potential of electronic packaging in medical engineering. The general public and industry insiders alike were amazed by a neuronal interface developed by Fraunhofer IZM, University of Utah and others, with which prostheses can be controlled by thought alone. Apart from the workshops, Fraunhofer IZM also contributed to a seminar series.

Workshop: Mixed COB/SMT Assembly, Berlin

Understanding and mastering all aspects of joining techniques and failure mechanisms, whether related to materials, surfaces or packaging processes, is a key step towards zero-error electronics manufacturing. Fraunhofer IZM bundled this know-how into an in-depth, two-day workshop on the ins-and-outs of mixed COB-SMT assembly (October 22nd–23rd), covering everything from PCB surfaces, to die attach, through to wire bonding and encapsulation.

The workshop also included background information on materials and analysis processes. Common microelectronic failures due to issues like Kirkendall voids and material fatigue were discussed along with the appropriate destructive and non-destructive testing methods (e. g. X-ray CT and FIB/SEM/EDX). High-profile machine manufacturers like F&K Delvotec, Viscom and Hesse were also on hand to discuss how their technology accommodates quality monitoring during series production.

Forum: Trends in Interconnection Technology. Mechanical High-Current Connectors, Oberpfaffenhofen

Reliable interconnection lies at the crux of the interface between electronics and mechanics, be it reliable aluminum interconnects in the lightweight design of automotive technologies or extremely durable finishes.

A Fraunhofer IZM forum (November 4th – 5th, 2013) addressed this challenge with a detailed look at emerging trends in electrical-mechanical interconnection. Background know-how was presented on the aluminum used for electrical interconnects in

the BMW i3, innovative manufacturing and characterization of interconnect surfaces, cutting-edge analysis and testing and recent developments in numerical simulation.

Microelectronics Meets Medicine

In November, Fraunhofer IZM together with other Fraunhofer institutes, held a two-hour workshop on the many applications for microelectronics in medical engineering at Düsseldorf's 2013 Compamed, one of the world's leading trade fairs for medical engineering suppliers. The workshop's presenters gave a convincing overview of the advantages of highly integrated electronics for everything from diagnostics and drug dispensing to implants and intelligent prostheses. Fraunhofer IZM makes the electronics for these applications smaller and more flexible, and extends their functionality, which increases reliability at the same time.

»Fast Runnin' Scientists« and Fraunhofer IZM's soccer team victorious

The Berlin-Brandenburg Fraunhofer institutes are always well-represented in terms of number and athletic prowess at Berlin's annual Corporate Marathon. In late May 2013, Fraunhofer IZM, HHI, FOKUS, IPK and Golm's IBMT sent 180 »Fast Runnin' Scientists« to the starting block. For the third time in a row, the team won silver. The day was also a great chance for the various institute staff to catch up informally on mutual research interests, in this case over a barbeque and beer organized by Fraunhofer IZM and HHI staff.

The next success was just around the corner. On June 1st, Fraunhofer IZM scooped the trophy at Fraunhofer's annual soccer tournament in Bonn. In a nail-biting final against Freiburg's Fraunhofer IAF, the score was 1:1 at the end of the 12-minute, half-field match. A penalty shoot-out from the nine-meter zone was needed. All 22 players had to step up, but in the end, Fraunhofer IZM took home the trophy and the honor of hosting the 2014 Fraunhofer Soccer Tournament.



European Center for Power Electronics (ECPE)

Fraunhofer IZM has contributed to organizing and holding workshops and seminars for ECPE and the industry cluster Power Electronics Bavaria a number of times. The institute is in charge of hosting regular events on EMC in power electronics, including a lab course, which primarily comprises hands-on exercises in measurement, modifying circuits by soldering and optimizing circuits.

1 Surgical precision for young and old – the Long Night of the Sciences gave youngsters an early start in a demanding career

2 Cheers all round – Fraunhofer IZM's team takes the championship in the final against Fraunhofer IAF

3 Knowledge and technology transfer: Institute Director Prof. Klaus-Dieter Lang discussing condition monitoring and micro-energy harvesting

Events with Fraunhofer IZM participation 2013 (Selection)	
Technology Forum: Additive Manufacturing in Electronics	March 2013, Oberpfaffenhofen
Forum MicroTechnology - Smart Systems for Automation Monitoring	April 2013, Hannover
Future Workshop 3D Integration	April 2013, Dresden
Research Ship MS Wissenschaft »All generations in one boat«	April 2013
AMA-Seminar: Autarkic Sensor Networks	May 2013, Berlin
Workshop: Systems Integration - Microsystems for Harsh Environments	June 2013, Berlin
Otto Bock Science Days	June 2013, Berlin
Press tour for Berlin's Department for Economic Affairs, Technology and Research	September 2013, Berlin
Workshop: Mixed COB-SMT-Assembly	October 2013, Berlin
Workshop: Trends in der Verbindungstechnik	November 2013, Oberpfaffenhofen
Symposium: Creative Minds for Smart Electronics	November 2013, Berlin

FRAUNHOFER IZM AT TRADE SHOWS

As lynchpin between research and industry, Fraunhofer IZM is always a willing and welcome participant at trade fairs. Last year was no exception – almost every month included an event in Germany, Europe or abroad.

The year kicked off with an opportunity to showcase the institute's international reach at San Francisco's Photonics West, optical technology's premier professional gathering. Together with German colleagues, Fraunhofer IZM's presentation in the »German Pavilion« included the latest innovations in photonics and 3D integration. At April's SMT in Nuremberg, we showed how microelectronics can be optimized for extreme environmental conditions. Europe's largest trade fair for microelectronic system integration proved a great success for Fraunhofer IZM, by providing a forum for the very latest Fraunhofer IZM research on thermal management at high temperatures and groundbreaking reliable, stable interconnection techniques and materials. We also presented new innovations in high-power LEDs, automotive electronics and substrate integration for medical engineering.

Nuremberg also played host to another highlight: May's PCIM, which brought experts in power electronics and its application in automotive engineering together. Here, Fraunhofer IZM presented its entire spectrum of services and know-how to an audience of professionals from around the world. A particular highlight was our solar inverter, developed in a game-changing BMBF-funded research project together with Bosch. The device not only sets new benchmarks in efficiency, but also is just half the size of the most popular comparable technology currently commercially available.

The end of the traditional summer hiatus was marked by Semicon Europe in Dresden, which is one of the world's largest trade shows for semiconductor devices, materials and services. Here we teamed up with other institutes in the Fraunhofer Group for Microelectronics to showcase our entire range of wafer level packaging technologies and services.

At Productronica, Europe's leading trade show for cutting-edge electronics manufacturing, held last November in Munich, Fraunhofer IZM joined forces with Germany's foremost industrial association, Deutscher Maschinen- und Anlagenbau (VDMA) for a special exhibit on automotive electronics, titled »New Technologies and Extreme Parameters«. Here, we presented



1 Fraunhofer IZM at PCIM 2013

solutions for the challenges currently facing electronics for vehicles and heavy equipment, including power electronics, cutting-edge sensor technology, high-performance LEDs and flexible electronics plastics that improve efficiency and pave the way for new functions, such as a touch-screen center console. Nine leading mechanical engineering companies presented their latest products in a specially assigned exhibition area of approx. 200m². Uncontested favorite of the trade show visitors was a large excavator from the company Liebherr.

Live Production at SMT – Fraunhofer IZM’s pedal power for slot cars

Fraunhofer IZM’s Application Center organized the Future Packaging Production Line and joint booth at Nuremberg’s SMT for the fourth time in 2014. With »Electric mobility in rehabilitation technology« as the year’s focus, the joint booth exhibits and daily tours of the live production line provided focal points for discussions on current issues in designing and manufacturing PCBs for medical engineering and technology for the aged, with visitors asking an unusually high number of detailed questions.

Another popular attraction at the joint booth was our slot-car track. Proving that you only get out what you put in, visitors to the booth had to power the vehicles themselves – by working up a sweat on a bicycle. At the widely popular Slot Car Cup, the research center emerged victorious over the other competing company and university teams.

Fraunhofer IZM at Trade Shows 2013 (Selection)

AAL-Congress	January 2013, Berlin
Photonics West	February 2013, San Francisco, USA
Smart Systems Integration	March 2013, Amsterdam, NL
SMT Hybrid Packaging	April 2013, Nuremberg
PCIM	May 2013, Nuremberg
Sensor+Test	May 2013, Nuremberg
ECTC	May 2013, Las Vegas, USA
IMAPS	September/October 2013, Orlando, USA
Semicon Europa	October 2013, Dresden
MST-Kongress	October 2013, Aachen
Productronica	November 2013, Munich
Compamed	November 2013, Düsseldorf

WORKSHOPS 2014

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.

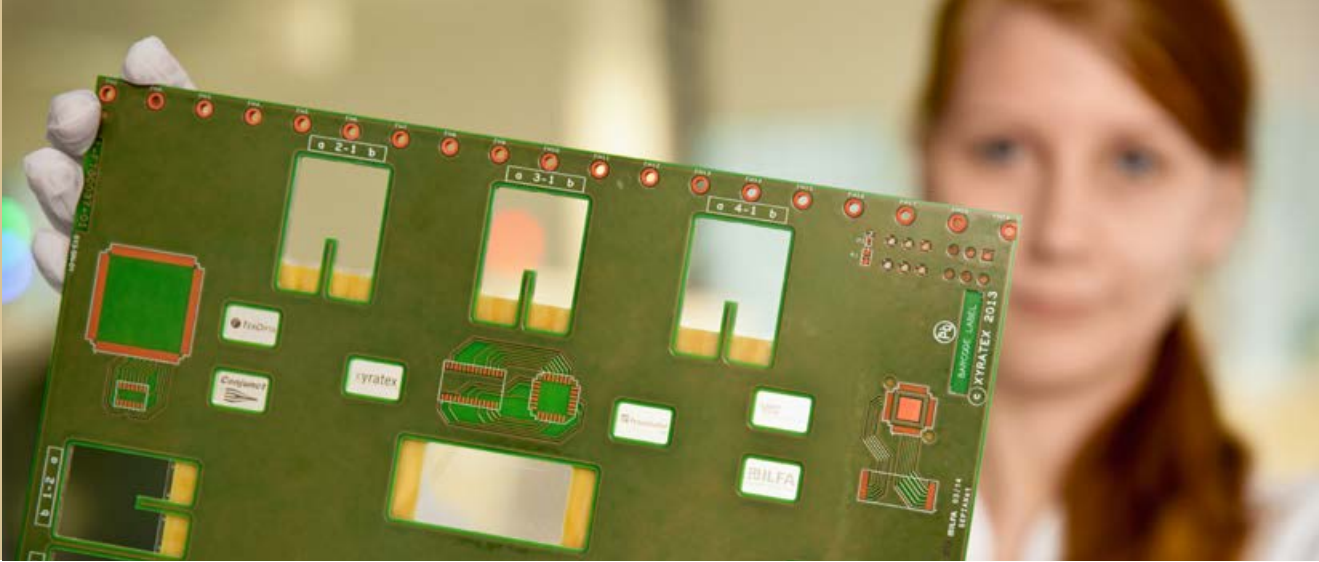
[2] Innovations in medical engineering through intelligent packaging

This Fraunhofer workshop presents the state-of-the-art and current trends in wireless sensor networks as well as other aspects of medical applications.

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.



[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] 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.

[5] LEDs – Application, reliability and technology

From design through interconnection to reliability analyses this workshop provides a comprehensive overview of LEDs.

What will you learn?

- Assembly and interconnection technology
- Analytics
- Thermal management and reliability

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

[6] Autarkic wireless sensor networks

On May 8th, 2014 a seminar on Autarkic wireless sensor networks will be taking place in Berlin. IZM-scientists have been organizing this event in cooperation with AMA Weiterbildungs GmbH for the past four years. Starting from the basic question of »What are autarkic wireless sensors networks?« the seminar provides application examples and highlights current trends.

What will you learn?

- Design rules
- Sensor elements, assemblies and network topologies
- Energy harvesting and energy management
- Software
- Cost-efficient design
- Manufacture of wireless sensor nodes
- Hands-on report: Application in an industrial environment

Potential participants: Developers, researchers, manufacturers and users of measurement systems who develop or use wireless sensors or are planning to do so.

PROMOTING YOUNG TALENTS

For more than 15 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 now also works with students from Berlin's 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.

Highschool workshops

Physics students from Max-Planck-Gymnasium visited Fraunhofer IZM in March. Instructed and supervised by a Fraunhofer IZM researcher, the youngsters were treated to a tour of the cleanroom and an introduction to how microchips are manufactured. Afterwards, the students sampled real-life microelectronics production by testing their new knowledge using the flip-chip line. In November, St.-Marien-Oberschule paid a visit. The ten chemistry students performed experiments to deter-

mine the properties of solar panels and validated their research by testing the alignment of the panels in a parking meter machine.

Training

Fraunhofer IZM is a member of the association proMANO, which advances microsystem technology training in Berlin and Brandenburg. Their mission is to expand the profession's training network and to promote the profession of Microtechnologist as a career choice.

In 2013, three Fraunhofer IZM apprentices graduated as Microtechnologists (with a special focus on microsystem technology), while the year's one business administration was recruited as a permanent member of the institute's staff.

Voluntary ecological year

For the eighth year running, Fraunhofer IZM offered an internship in Environmental and Reliability Engineering as part of the Voluntary Ecological Year (FÖJ) program. Here, a single, lucky highschool graduate is provided a unique opportunity to learn about the research area's professional opportunities and to contribute to the investigation of environmental issues in electronics. Additionally, a Mecklenburg-Western Pomerania FÖJ participant with a passion for medical engineering visited the institute's Medical Microsystems research group for two weeks.



EnterTechnik – A technology training year for young women

In September 2013, Fraunhofer IZM joined 17 other companies in Berlin-Brandenburg participating in EnterTechnik – A Technology Training Year for Young Women. The scheme offers young women the chance of getting to know Berlin technology companies and institutes involved in a range of areas, from mobility, medical and precision engineering, urban planning to hightech and communication technology.

At Fraunhofer IZM, the interns learn what being a Microtechnologist means in different types of laboratories. A four-month internship is offered in one of the following areas: cleanroom processing (wafer patterning, measurement technology), material inspection (reliability testing, thermography) or substrate technology (PCB etching, testing).

10th anniversary of Girl's Day at Fraunhofer IZM – an educational adventure just for girls

April 25th 2013 marked the 10th anniversary of Fraunhofer IZM's participation in Girls' Day. As always, it was a great chance for young, female technology enthusiasts to find out more about scientific investigation at a research institute. The newly expanded program was greeted enthusiastically. Several girls helped disassemble an electronic device and then analyze its individual components using thermography techniques. But the workshop on electronics in clothing proved to be the biggest hit. Here, one of the girls sewed a dress, in which LEDs, a sensor and a control unit were integrated using conductive yarn.

Fraunhofer IZM bridges the generation gap with MS Wissenschaft

On April 30th 2013, the floating science exhibit MS Wissenschaft, an initiative of »Wissenschaft im Dialog« (WiD, Science in Dialogue), which had been berthed in Berlin, hoisted its sails for a tour of 40 cities and towns throughout Germany and Austria. The ship attracted around 70,000 visitors during its journey and included exhibits on a wide range of topics troping the year's special theme: »All generations in one boat«.

Fraunhofer IZM was on deck with an exhibit showcasing its current research program SELBST, in which assisted living aids that can be easily upgraded and operated are being developed for the aged. The project's centerpiece is a modular toolkit for developing electronic systems, comprising sensors and data processing, remote transmission and actuator components.

1 Students visiting the cleanroom at Fraunhofer IZM

2 Hard at work at Girls' Day 2013

// FACTS & FIGURES



FRAUNHOFER IZM FACTS & FIGURES

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FRAUNHOFER IZM IN FACTS AND FIGURES

Financial situation

Establishment of the center All Silicon System Integration Dresden (ASSID) at the Moritzburg-Dresden site was successfully completed in 2013. The four-year project was funded by the EU, the German Ministry of Education and Research (BMBF) and the Land Saxony. Auditing evaluated the results to date and the strategy of the center positively. Consequently, Fraunhofer IZM-ASSID will be fully funded within the Fraunhofer Model as of 2014.

The institute's turnover in 2013 rose by 3 percent to 29.4 million euros, while contracts from German and international industry and professional association increased by a significant 12 percent to a total of 10.7 million euros.

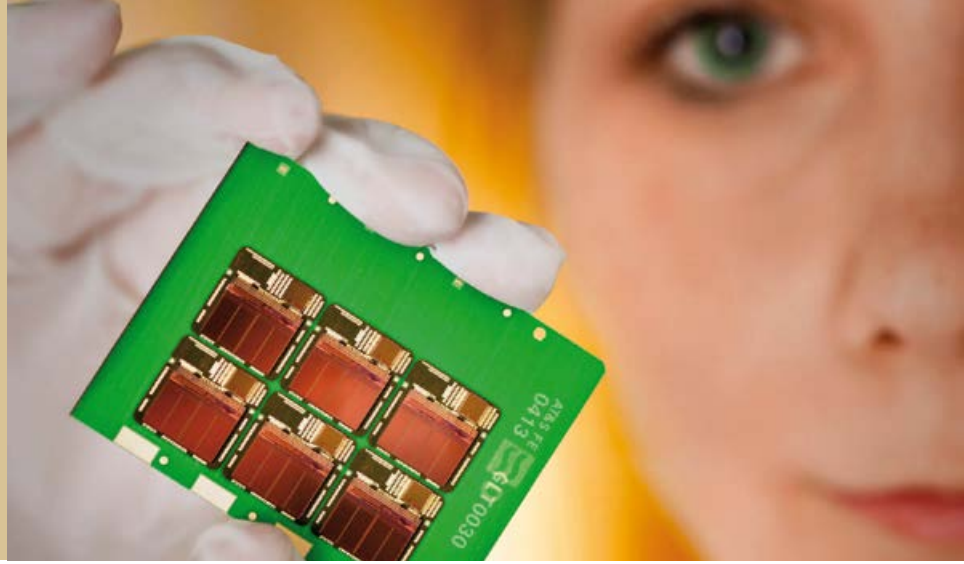
Income from projects publically funded by the German federal government, Länder and EU was a little higher at 12 million euros.

Fraunhofer IZM was able to cover 77 percent of its operating budget (equaling 22.7 million euros) from external revenue.

Investment

In 2013, the institute spent 2.3 million euros from internal funds for ongoing maintenance and investment upgrades. Specifically, the institute's technical infrastructure was improved with a wide variety of individual measures and the efficiency of existing equipment increased.

Fraunhofer IZM also expanded its headquarters to include the ground floor of its main site in Berlin-Wedding, laying the foundation for gathering all of the institute's Berlin offices and laboratories in one location.



Additional state-of-art laboratories have also been set up in the new space, which was furnished and equipped with institute funds to the tune of 3.7 million euros in 2013. Apart from expanding the infrastructure for analysis, the complete processing chain is now available for manufacturing large-surface substrates for panel-level integration.

The new laboratories are also part of the establishment of the new research and development center »AdaptSys – Multifunctional Microelectronics for Innovative Micro- and Nano-Integration Technology in the Development of Application-Oriented Systems«. The three-year project to build the new center will be completed in 2014 and is being funded by the European Fund for Regional Development (EFRE), the Land Berlin and the BMBF.

AdaptSys will focus on four main topics:

1. Nano-scale process and material development
2. Researching, developing and qualifying innovative system integration techniques adapted to the needs of individual applications

3. Supporting the industries that employ these technologies with product development
4. Failure analysis, quality and reliability assurance, lifetime prediction models and condition monitoring

Human resources

Fraunhofer IZM again managed to expand its workforce in 2013. Thirteen new positions were created across the sites Berlin, Moritzburg-Dresden and Oberpfaffenhofen, with the total number of staff now numbering 230.

The institute also offers students the option of combining their studies with practical scientific research at Fraunhofer IZM's offices and laboratories. At the year's close, Fraunhofer IZM had supervised 151 interns, Masters students and student assistants.

The institute maintains a commitment to providing apprenticeships. In 2013, a total of 8 apprentices were trained as micro-technology technicians or business administrators.

Fraunhofer IZM in 2013	
Turnover	29.4 millionen euros
External revenue	22.7 millionen euros (77 % of total turnover)
Sites	Berlin, Dresden and Oberpfaffenhofen
Number of staff	389 (including 151 student assistants, master students, interns and 8 apprentices)

AWARDS

Rolf Aschenbrenner honored with David Feldman Outstanding Contribution Award

The Institute of Electrical and Electronics Engineers (IEEE) honored Rolf Aschenbrenner, head of the System Integration & Interconnection Technologies department at Fraunhofer IZM, with the David Feldman Outstanding Contribution Award for his commitment to IEEE's Components, Packaging and Manufacturing Technology Society CPMT.

With the Award, IEEE recognizes Aschenbrenner's over 13 years of leadership, including serving as the Society's first President from Europe, and extending CPMT's global technical reach through strategic collaborations and establishment of new conferences. IEEE CPMT-president Ricky Lee presented Rolf Aschenbrenner with the David Feldman Award at the occasion of the CPMT Luncheon at this year's ECTC in Las Vegas.

IEEE names Dr. Martin Schneider-Ramelow Senior Member

IEEE has also granted Fraunhofer IZM's Dr. Martin Schneider-Ramelow »Senior Member« status. Senior membership is the highest attainable level of IEEE membership and is only awarded to scientists widely regarded as experts by their peers. Schneider-Ramelow, also head of the Fraunhofer IZM System Integration & Interconnection Technologies department, is a world-renowned expert on the wire-bonding quality and reliability.

Fraunhofer IZM catches some rays – Best Poster Award for life cycle assessment of solar power units

What about the sustainability of photovoltaic systems, designed to draw environmentally friendly power from solar energy? How can the environmental performance of solar

power systems be optimized? Fraunhofer IZM's Karsten Schischke investigated these questions in two European research projects.

He won the 2013 Best Poster Award at the 28th European PV Solar Energy Conference and Exhibition (EU PVSEC) in Paris for his research results. The poster on which Schischke and his colleagues from Poland and Spain presented their results was titled »PV Systems with Lower Environmental Impact: New Strategies and Analysis Tool«.

The joint project was selected as winner from 1200 entries in the topic area »PV – A Major Electricity Source« by the EU PVSEC Scientific Committee.

Guaranteed reliability: Michael Niedermayer wins Sensorcomm's Best Paper Award

How can expensive equipment failure in industrial settings be prevented? Is energy-efficient condition monitoring of this equipment possible? Fraunhofer IZM's Dr. Michael Niedermayer found some surprising answers to these questions. He presented his results in a poster titled »Early-Warning System for Machine Failures: Self-sufficient Radio Sensor Systems for Wireless Condition Monitoring« together with his Fraunhofer IZM colleagues, the Gesellschaft für Maschinendiagnose mbH (GfM) and the Berlin Center of Advanced Packaging (BeCAP, TU Berlin).

The International Academy, Research, and Industry Association (IARIA) committee selected their innovative solutions as winner of the 2013 Best Paper Award at the 7th International Conference on Sensor Technologies and Applications (Sensorcomm) in Barcelona.



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Stereo micro camera wins DEVICE Med Award at MEDICA in Düsseldorf

A miniature size stereo camera module of only 1x2.2x1.6 mm³ size was recognized as the most innovative electronics component for the medical industry at the annual industry gathering MEDICA in November 2013. The camera module was developed by image sensor provider AWAIBA, supported by Fraunhofer IZM who contributed the wafer level technology for the assembly process.

The miniaturized 3D stereo camera module enables the integration of 3D vision into the finest category of medical endoscopes used for micro invasive surgery in organs like lung, kidney or the brain and reproductive tract.

Fusing technology and fashion - High-tech cycling jacket wins Red Dot Design Award

The cycling jacket Sporty Supaheroe has won the renowned Red Dot Design Competition's 2013 Best-of-the-Best Award in the category »Design Concept«. Wolfgang Langeder (UTOPE) designed the jacket with Fraunhofer IZM und Stretchable Circuits GbR. The award was presented at a ceremony with an international audience of several hundred guests from design, media and industry on October 25, 2013, in Singapore.

Sporty Supaheroe is a high-tech cycling jacket for urban nomads, who value function as much as style. The jacket integrates a microelectronic system that makes bicycle riders more visible at night and includes LEDs, sensors, control components, an on/off switch and a rechargeable battery. The electronic system is as flexible as fabric and its packaging is designed for maximum robustness and moisture resistance. The new development was possible thanks to close collaboration with Fraunhofer IZM Berlin's TexLab. The jacket's electronic system is based on a flexible PCB comprising a flexible foil made of thermoplastic polyurethane, which was developed at Fraunhofer IZM.

Best Paper Award for Eckart Hoene at PCIM 2013

At the PCIM Conference in Nuremberg IZM-researcher Dr. Eckart Hoene was honored with the Best Paper Award in May 2013. PCIM is Europe's largest application-oriented conference in the realm of power electronics.

Hoene and his colleagues Andreas Ostmann, Binh The Lai, Christoph Marczok, Andreas Müsing and Johann Kolar received the award for their paper »Ultra-Low Inductance Power Module for Fast Switching Semiconductors«. In their paper the authors develop optimized packaging strategies for fast switching semiconductors.

1 Prof. Leo Lorenz of PCIM Europe honors Dr. Eckart Hoene with PCIM's 2013 Best Paper Award

2 High-tech cycling jacket Sporty Supaheroe wins Red Dot Design Award

DISSERTATIONS, BEST PAPERS, EDITORIALS

Dissertations

Braun, T.

Humidity Diffusion in Filled Epoxy Resins for Microelectronics Applications

Göhre, J.-M.

Development and Implementation of an Improved Active Power Cycling Test Method for Experimentally Determining the Reliability of Heavy Wire Bonds in Power Semiconductor Modules

Domurat-Linde, A.

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Editorials

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

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

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

Congress Proceedings SMT/HYBRID/Packaging 2013

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Best Paper-Awards (Selection)

Arranz, P.; Anzizu, M.; Vallvé, X.; Schischke, K.; Schneider, J.; Den Boer, E.

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		ZF Luftfahrt AG	Calden

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