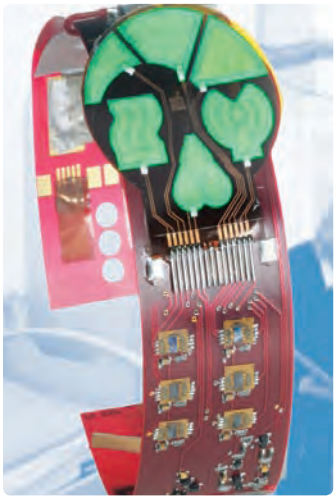
Annual Report 2007 / 2008



IZM

Fraunhofer Institut
Zuverlässigkeit und
Mikrointegration

Packaging | Quality | Reliability | Sustainability

Fraunhofer-Institute for Reliability and Microintegration IZM

Annual Report 2007 / 2008

Content
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Preface

Head of the Institute Prof. Herbert Reichl

›› The so-called Moore's law has been the proven maxim in semiconductor development for many years now. This will continue to be the case in the foreseeable future. However, progress in the semiconductor industry will not alone be able to meet the performance, functionality, miniaturization and cost-efficiency requirements of today's microelectronic systems.

For this reason, "More than Moore" strategies and system solutions are being pursued internationally, which develop synergies between different existing techniques and new technologies. These have already led to new approaches to system integration and future solutions. A particular driving force is the information and telecommunication industry, which incorporates the mobile phone and autarkic sensor networks, as well as medical technology.

Here, Fraunhofer IZM is making special contributions, one example of which is the "eGrain" concept. These "eGrains" are extremely miniaturized autarkic systems that are able to automatically record data via sensors, analyze this information and pass it on into a wireless radio network. These sensor systems have virtually unlimited possibilities and will soon be an every-day technology, featuring in many different applications.

What are the technologies of the future? In terms of packaging and system integration, so-called system-in package (SiP) technologies are required that cover the whole spectrum, from wafer-level packaging through to substrate integration technologies. The SiP approach has the added advantage of rapid introduction to the market by using state-of-the-art technologies and existing infrastructure, as well as the integration of latest technologies.

One example is the shift to 3D system architecture. This not only makes dramatic reductions in volume possible but also improves performance thanks to shorter signal propagation delay and lower energy consumption. The field of 3D integration is already expanding significantly. And this is only the beginning – this trend will continue over the coming years.

We are contributing to the development of a new packaging and smart system generation. Linking system design, technology and reliability at early stages of development has become more important than ever before to ensuring market success.

Fraunhofer IZM is working together with the semiconductor industry, materials and system suppliers internationally on all levels of design, technology, right through to reliability assessment, to develop innovative "smart systems" and provide system integration solutions for SMEs, as well as global semiconductor enterprises.

The key requirement for our continued success in research and development is, of course, the committed work and dedication of our staff, as well as cooperation with our partners, customers in industry and research, ministries at federal and state government levels and project agencies.

We will continue this approved model of cooperation in 2008. This year we look back on 15 years of successful research and technology development that would have been unthinkable without our network of partners. I would like to take this opportunity to sincerely thank all of you for your excellent and productive contributions and cooperation.

One example of such a success story is the Department Polymeric Materials and Composites that operates as an independent Fraunhofer research institution as of the beginning of this year. My thanks go to Professor Bauer and her team for the good cooperation in the field of synthesis, characterization and modification of polymers and composites and I wish her every success for the future of her research institution.

This annual report again presents a selection of our major research results of the previous year, resulting from a variety of different projects.

Happy reading!

The Fraunhofer-Gesellschaft

›› Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration. The organization also accepts commissions from German federal and Länder ministries and government departments to participate in future-oriented research projects with the aim of finding innovative solutions to issues concerning the industrial economy and society in general.

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, accelerating technological progress, improving the acceptance of new technologies, and not least by disseminating their knowledge and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, in other scientific domains, in industry and in society. Students working at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units, including 56 Fraunhofer Institutes, at 40 different locations in Germany. The majority of the 13,000 staff are qualified scientists and engineers, who work with an annual research budget of 1.3 billion euros. Of this sum, more than 1 billion euros is generated through contract research. Two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Only one third is contributed by the German federal and Länder governments in the form of institutional funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

Affiliated research centers and representative offices in Europe, the USA and Asia provide contact with the regions of greatest importance to present and future scientific progress and economic development.

The Fraunhofer-Gesellschaft is a recognized non-profit organization which takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur.

Fraunhofer Microelectronics Alliance

›› The Fraunhofer Microelectronics Alliance VµE has been coordinating the activities of Fraunhofer Institutes working in the fields of microelectronics and microintegration since 1996. Its membership consists of ten institutes as full members and two as associated members, with a total workforce of around 2300 and a combined budget of roughly €220 million. The purpose of the Fraunhofer VµE is to scout for new trends in microelectronics technologies and applications and to integrate them in the strategic planning of the member institutes. It also engages in joint marketing and public relations work.

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

- Smart System Integration
- »More Moore« and »Beyond CMOS«
- Communication and entertainment
- Mobility
- Automation technology
- Networked assistance
- Medical engineering
- Light
- Security

The central office of the Fraunhofer Microelectronics Alliance coordinates all activities, working closely with the member institutes to forge durable contacts between science, industry and politics.

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Fraunhofer IZM

›› Profile |

Invisible – but indispensable – nowadays nothing works without highly integrated microelectronics and microsystem technology. Reliable and cost-effective assembly and interconnection technologies are the foundation of integrating these in products. Fraunhofer IZM, a worldwide leader in the development and reliability analysis of electronic packaging technologies, provides it customers with tailor-made system integration technologies on wafer, chip and board level.

›› History |

Fraunhofer IZM has seen a great deal of success since its founding in 1993 from research groups of the Research Center for Microperipheric Technologies at the TU Berlin, the Humboldt-Universität Berlin and what used to be the Institute for Mechanics at the Akademie der Wissenschaften in Chemnitz. Initially, the institute saw the addition of groups in Teltow and Paderborn; later branches were also established in Munich and Chemnitz. Today, 302 scientists and technicians, as well as 170 interns and undergraduate students conduct research at seven different institute locations.

›› Technological focus |

- System integration
- Wafer-level integration
- Materials and reliability
- System design & sustainable development

Our technology-oriented research programs form the basis for transferring our research outcomes to industrial manufacturing processes, e.g. in the automotive, mechanical engineering or IT industries:

- Wafer Level System Packaging
- Photonic Packaging
- MEMS Packaging
- 3D System Integration
- RF Systems
- Large Area Electronics
- Micro Reliability & Lifetime Estimation
- Thermal Management
- Sustainable Technical Development

Cooperation with Universities

›› Cooperation with the Technische Universität Berlin |

The Berlin Center of Advanced Packaging (BeCAP) is a cooperation between the Research Center for Microperipheric Technologies of the TU Berlin and the Fraunhofer Institute for Reliability and Microintegration IZM.

The expansion of the microelectronic sector at the TU Berlin led to the set-up of the Research Center with its head Prof. Reichl in 1987, supported by the Federal Ministry for Research and Technology and the Berlin Senate.

The Center works in the field of fundamental research of packaging and interconnection for sensors, microelectronics and microsystems. The focus of the cooperation with Fraunhofer IZM and with industry is on:

- Materials and processes for chip integration technologies
- Photonic packaging
- Interconnection technologies for printed circuit boards
- System integration at wafer level
- Thermo-mechanical reliability and material characterization
- Sustainable technologies
- System design and modeling

The cooperation of TU Berlin's Research Center for Microperipheric Technologies and Fraunhofer IZM results in a common use of equipment, facilities and infrastructure and in the cooperation in research projects.

Cooperation with the Technical University Chemnitz |

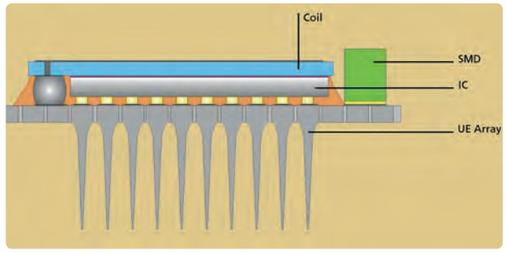
The Chemnitz department Multi Device Integration cooperates closely with the Center for Microtechnologies (ZfM) and the Institute for Print and Media Technology at the Chemnitz University of Technology. The common research activities focus on new technologies for microelectronics and microsystems as well as the development of print processes for electronics. Together with the Center for Microtechnologies the department provides R&D services and processing services for the entire semiconductor range.

The cooperation aims at generating synergies between the basic research conducted at the University of Technology and the more application-oriented research at Fraunhofer IZM. Both partners contribute their know-how and competence in packaging and technology for the development of intelligent systems.

Cooperation with BTU Cottbus |

Since 1997 Fraunhofer IZM's branch lab Polymeric Materials in Teltow has been cooperating with the Faculty of Mathematics, Natural and Computer Sciences of the BTU Cottbus in the field of polymeric materials. The BTU appointed Prof. Dr. Monika Bauer to the chair of Polymeric Materials. Since October 2000, courses and training on polymeric materials have been taking place.

Concept of an artificial, micromechatronic, eyeball as prosthesis



Neural interface developed by Fraunhofer IZM and the University of Utah

Fraunhofer IZM and the University of Utah - an example for successful cooperation |

Fraunhofer IZM and the University of Utah started their cooperation on the basis of two projects on neuronal prostheses in 2005. Fraunhofer IZM provided the technology for a wireless integration of the system into a miniaturized device. As part of this collaboration, three senior researchers were sent in succession to the University of Utah. Aside from the already running projects established in 2005 and 2006, a number of additional proposals were submitted to NIH in 2007. The focus of these was based in the field of medical microsystems.

Sensor integration to create intelligent medical systems as well as complex micromechatronic concepts like an artificial moving eyeball and the sensoric enhancement of an intelligent wheelchair for paraplegic patient monitoring showcase the range of Fraunhofer IZM´s involvement in the Utah´s medical community. With the close ties now established to the medical doctors, Fraunhofer IZM emphasizes its already strong position in supplying modern microsystems for the medical industry.

In the two years, more than 60 new contacts to US industry, ties to Utah´s policy makers and funding agencies have been established to strengthen Fraunhofer IZM´s transatlantic position in a global market.

Cooperation with universities and research institutes around the world |

The cooperation with the University of Utah is just one example of Fraunhofer IZM's close collaboration with high-profile universities and research institutes in Europe, Asia and the United States. In Europe, research activities in the area of heterogeneous system integration are pursued jointly with a number of bodies, including CEA-LETI.

Close contact is maintained with numerous other universities and research institutes via our participation in European projects and technology platforms. In Asia, a long-term cooperative relationship exists with the University of Tokyo. Recently an MoU was also signed with Tohoku University and the Sendai Cluster. Joint projects are being pursued with KAIST in Korea. Close ties also exist with China's research community. In the USA, besides the collaboration with the University of Utah discussed above, Fraunhofer IZM has long been working with Georgia Tech's Packaging Research Center.

Packaging Meets System Integration

Wolf, M. Jürgen
Reichl, Herbert

›› For many years, development in microelectronics has been following the predictions of Moore's law. While this will continue to be case in coming years, scaling alone does not address today's requirements in terms of performance, functionality, miniaturization, low production cost and time-to-market of smart electronic systems. Here, "More than Moore" approaches make possible a more compact integration of system level components at package level.

System-in-package (SiP) has evolved as an alternative to the system-on-chip (SoC) approach to electronics integration by providing advantages over SoC in many market segments. SiP should be understood as complementary to, not a replacement for, high-level single-chip silicon integration. SiP technologies and SoC provide the means for ongoing improvement in performance, power, cost and size at the system level. For some extremely high-volume applications, SoC will be the preferred approach and some complex SiP products will contain SoC components.

SiP technology is rapidly evolving from a specialty technology, used in a narrow set of applications, to a high-volume technology with a wide ranging impact on electronics markets, especially due to the high-volume and extremely cost competitive consumer and communication markets.

As with most emerging markets, a number of critical infrastructure issues must still be resolved to improve time-to-market, cost structure, reliability and performance. These include the need for new wafer-level and board-level integration technologies, low-cost, high-density substrates, improved materials, low-cost assembly equipment, chip package co-design and reliability simulation tools.

Numerous concepts for SiP are now emerging, driven largely by the demands of portable consumer products. Figure 4 provides an overview of the SiP categories defined by the International Technology Roadmap of Semiconductors (ITRS).

Today, 3D system integration is a key technology, the development of which is pushed ahead by the needs of diverse application areas, such as communication and consumer, security & safety, transport and mobility, health, energy and environment technology. These require ongoing development of components such as image sensors, ultra-small sensor nodes, high memory density and capacity, parallel processor architectures etc.

The main advantages of 3D-system integration are the reduced form factor, improved electrical performance and the possibility of high-volume low-cost production.

Various 3D system integration approaches exist. These include:

- Package-on-package (PoP) and package-in-package (PiP)
- Die stacking on printed circuit boards (PCB) with wire bonding and flip chips
- Advanced PCB with embedded electronic devices
- Stacking of functional organic layers with embedded active and passive devices
- Wafer-level packaging and system integration with through silicon vias (TSV)

3D wafer-level system integration |

One of the most promising 3D technologies is through silicon vias (TSV), with which stacked devices are interconnected on wafer level to form high-density interconnects with good electrical performance at the smallest sizes possible and heterogeneous integration of analog, digital and MEMS devices.

Fraunhofer IZM has developed a post front-end 3D integration process, which makes stacking functional and tested FE devices on wafer level possible by TSV and flip chip interconnection with solder microbumps or solid-liquid interdiffusion (SLID).

By using so-called "redistribution technologies" (RDL), passive components can be integrated effectively on the chip/wafer surface and thinned active devices can be embedded in the polymer dielectric layer.

A number of different wafer-level technologies are currently in development. Major targets for prospective wafer-level system integration development include:

- High-density and low-cost TSV with high-aspect ratio
- Wafer thinning and handling, thin interconnects
- Si interposer with TSV and high-density RDL
- Low-temperature wafer-bonding technologies
- Embedded devices (SI-InP, GaAS, SiGe), passives and MEMS integration
- Integrated cooling concepts
- Integrated shielding (RF and power)
- Optical chip-to-chip interconnects
- Integration of energy storage and converters

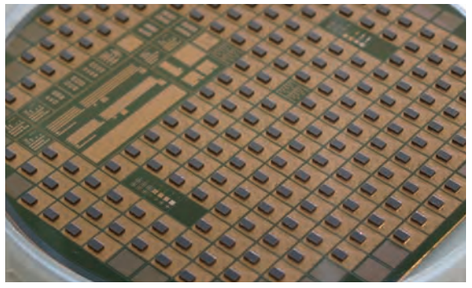
Board-level system integration |

Board-level integration concepts are also being developed. These are based on cost-effective substrate materials that are suited to flip-chip and wire-bond assembly. Based on proven single-chip solutions, multiple-chip solutions have been developed, and some of these are already in high-volume production, for instance multiple memory stacks. Future challenges include integrating optical interfaces and sensors (MEMS). Recently, numerous technologies have been developed to integrate active components into the substrate – one example here is Fraunhofer IZM's chip-in-polymer approach.

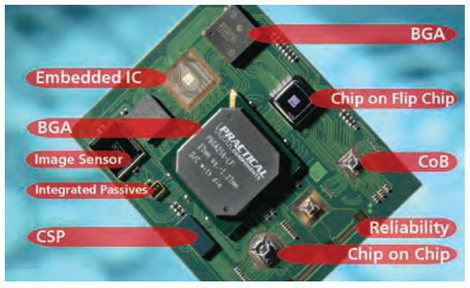
Further targets for board-level integration include the assembly of very small devices, as well as thin semiconductor components, integration of polytronic components, and the development of suitable cooling concepts and, subsequently, power-supply systems. The traditional printed circuit board will be transformed into a multifunctional, organic system board.

Summary |

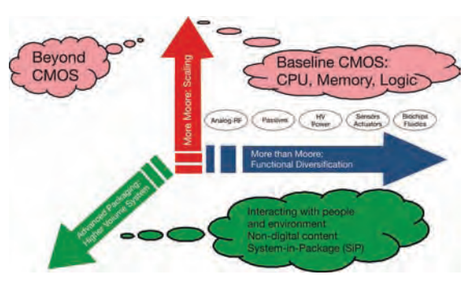
Traditional microelectronic packaging is steadily moving towards complex system integration. This trend will give rise to advanced SiP, which synergize wafer-level and board integration technologies. Advanced SiP approaches will explore the third dimension, resulting in complex system architectures. As this approach continues to be developed, appropriate system design tools and reliability models, new technologies and improved materials will be needed. Research and industry must begin meeting this challenge today.



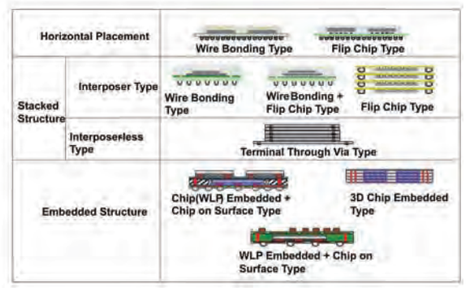
Wafer-level flip-chip assembled RF module on silicon wafer with integrated passive devices and trough silicon vias (IZM/IFX)



Multifunctional organic system board



From "More Moore" to "More than Moore" and SiP



Categories of System-in-Package (ITRS)

Encapsulation Technologies – the Key to Reliable Microelectronics

Karl-Friedrich Becker

›› Materials and processes for encapsulation play an important role in the development of reliable microelectronic assemblies. As an integral part of the production chain, encapsulation processes, too, are driven by general requirements on high-quality microelectronics and MST. Especially in the automotive area distributed intelligent sensor modules have to resist temperatures > 150 °C and aggressive media for years. Medical modules not only have to guarantee high reliability, but biocompatibility as well.

Fraunhofer IZM responds to these challenges by intensive research in the area of encapsulation, both through material qualification and adapted process development and analysis of encapsulated assemblies during reliability characterization.

Mainly highly filled epoxy systems are being used as materials for encapsulation. For special requirements polymer classes are also being employed, e.g. high temperature-stable silicones for compound of power electronics or inexpensive melting adhesives for encapsulation of electronics on textiles.

Fraunhofer IZM offers the following processes for encapsulation:

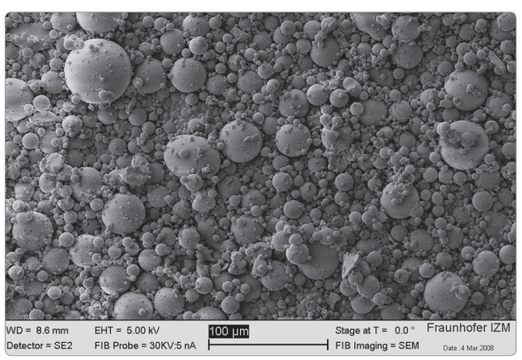
- Application of protective lacquer by varnishing for polymer electronics & industrial application
- Potting of power electronics through 2K-compound
- High-precision dispensing of encapsulants of flip chips and COB assemblies
- Jet dispensing for the contactless dosage of encapsulation materials
- Transfer molding for encapsulation of highly stressed assemblies

Apart from process development, Fraunhofer IZM also conducts material and package analysis. This covers everything from the definition of the material properties dependent on the process parameters to the examination of the aging behavior of polymers under rough environmental conditions, which is an important aspect especially for the automotive industry. Microelectronic packages are also being tested by means of ultrasound and high-resolution X-ray microscopy.

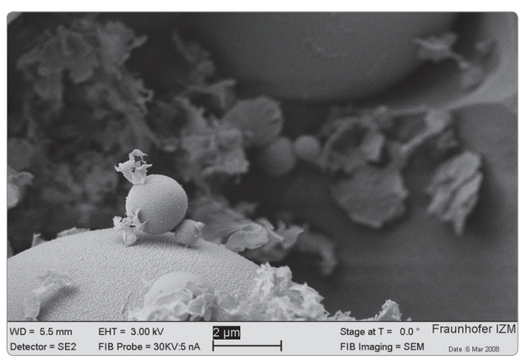
Latest highlights |

- A rapid tooling module for transfer molding suited for rapid assembly of prototypes with real materials.
- Jet processes for ultra fine dosage of high-viscous encapsulation materials – here feature widths below 250 µm have been reached.
- Application of nanotechnology for the targeted improvement/modification of the properties of polymers. Thus through the introduction of nano-scale ceramic materials into encapsulation materials, the moisture diffusion could be significantly reduced. Another highlight is the development of magnet particle-filled inks for the marking of components for contactless handling.

For his work on encapsulation technologies Karl-Friedrich Becker was honored with the IZM Research Award 2007.



SiO_2 filler particles in micro- and nano-scale for polymer / encapsulant modification



Bentonite nano & micro particle (SiO_2) enhanced epoxy resin with improved humidity barrier functionality

Evaluation of Bulk Fracture, Delamination and Fatigue within DoE and Optimization

Jürgen Auersperg

›› Especially for design optimizations and sensitivity analyses of advanced microelectronics assemblies, most of the publications utilize

- classical strength hypotheses (maximum principal stresses, peel stresses, von Mises stresses, ultimate tensile strength or strains) to estimate the cracking risk of substrates, semiconductors or encapsulations,
- accumulated equivalent plastic strains to evaluate the fatigue of metals (metallizations or lead frames, for instance), and
- Coffin-Manson-like approaches based on accumulated equivalent creep strains or volume weighted inelastic strain energy dissipated during thermal cycling to evaluate the thermal fatigue of solder interconnects.

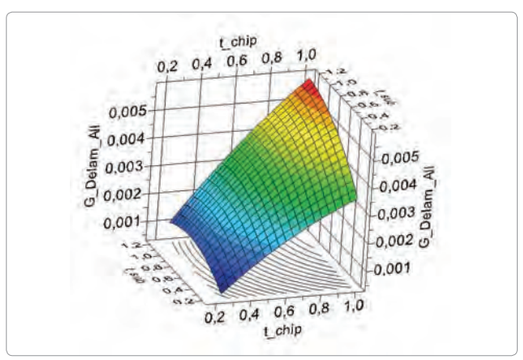
On the other hand, it is common knowledge in mechanical engineering that cracks and delaminations starting at sharp edges have to be taken into account in order to come to a conservative evaluation of the fracture toughness of the different materials and interfaces.

In view of the fact that different failure modes often compete it has to be a vital purpose of design-of-experiments-studies (DoE) to take into account all failure modes that are essential to the overall thermomechanical reliability, of a flip chip assembly for example. For that reason several failure modes have been assumed to have an effect. Simulations performed here are to show exemplarily the possibility of utilizing different failure hypotheses in parallel (integral fracture mechanics approaches, virtual crack closure technique, cohesive zone models or the volume weighted dissipated inelastic strain energy as a measure for solder fatigue for instance) to evaluate the

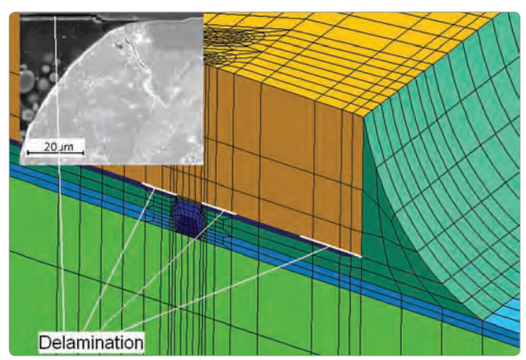
- risk of cracking of the chip, molding compound, substrate etc.,
- thermal fatigue of solder interconnects, and the
- risk of delamination, for instance of chip/underfiller and underfiller/solder interfaces.

Parameterized, highly nonlinear, transient FEM-simulations which consist of fracture, delamination or fatigue monitoring elements will then be handled by DoE-software in order to extract mathematical models which describe the response surfaces of all results data with regard to the variation of all input variables with a limited number of finite element runs. This gives an excellent basis for design and material optimization and also allows taking into account scattering of model parameters for reaching robust designs.

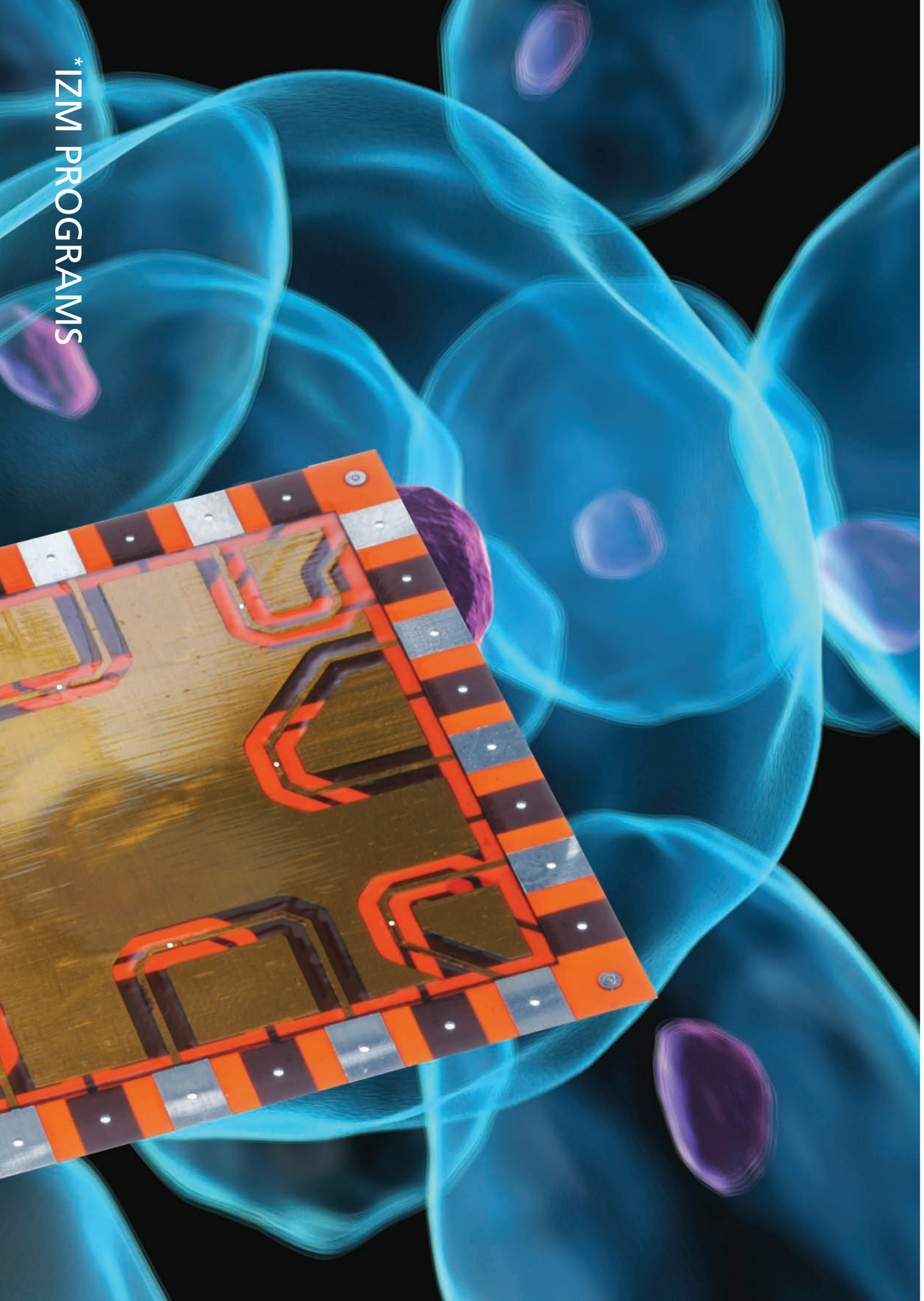
For his work on failure analysis by means of DoE and optimization Dr. Jürgen Auersperg was honored with the IZM Research Award 2007.



Dependence of the delamination risk of all material interfaces on the thickness of chip and substrate



Observed chip/underfiller and underfiller/solder bump delamination in a flip chip assembly



*IZM PROGRAMS

›› Philosophy of IZM Programs

In order to focus its application-oriented research activities and to react even faster to market and customer demands, Fraunhofer IZM has established nine programs which reflect the institute's capabilities, as well as the strategic aims with regard to future technology and application roadmaps.

Taking into account the most prevalent topics in the field of packaging and system integration, the programs concentrate on:

» IZM PROGRAMS

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Wafer Level System Packaging

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›› Wafer level packaging (WLP) is a technology concept, in which all steps of IC packaging are performed at wafer level. The basic characteristic of WLP is that the final package size is identical with the footprint of the die. The resulting components are called chip-size packages (CSP).

A WLP process adds an additional routing layer to re-distribute the peripheral I/O pads on the die over the entire chip surface. The fan-in IO rerouting creates solder bump pads with a larger standardized pitch which considerably simplifies the subsequent assembly of components. The following solder bumping enables a standard assembly process. The completely processed wafer can pass burn-in and test as a whole which allows a known good package qualification. All process steps for wafer level packages are performed completely before dicing.

Package size, WL burn-in and test, easy SMT assembly as well as cost reduction are major driving forces for WL solutions. Wafer level packaging enables high process integration, since available processes from the semiconductor industry, such as thin film technology and lithography can be used. Using modified IC processing techniques WLP allows the realization of chip-size package (CSP) as well as WL system-in-package (WL-SiP) solutions.

The integration of through silicon vias in the WLP process enables the redistribution of contact pads to the backside of the wafer. Thus, the active surface can stay free of electrical connections, e.g. on detectors, or stackable components emerge.

COMPETENCIES AND ACTIVITIES

Fraunhofer IZM has long term experience in thin film and interconnect processes applied in WLP. The Wafer Level System Packaging Program was set up to evaluate different approaches towards wafer level system packaging, to meet future requirements of system packaging as defined in technical roadmaps.

Services available |

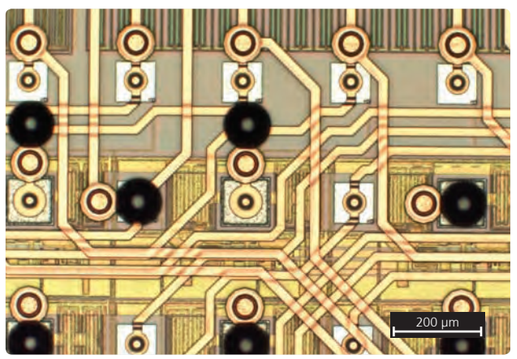
- Wafer bumping by electroplating, electroless deposition, stencil printing, placement of premanufactured solder balls
- Redistribution technologies

- processes using photo-definable dielectrics (BCB, PI, PBO) and electroplated metallization (Cu, Ni, Au)
- alternative processes using epoxy layers and electroless copper deposition

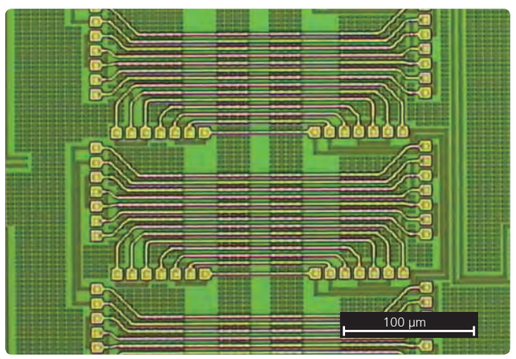
- Wafer bonding
- Wafer level inspection
- Wafer grinding, wafer dicing

Current research topics |

- Redistribution to the backside of the wafer using via-last technology
- Chip to wafer FC bonding
- Lead-free wafer bumping
- Wafer bumping by immersion soldering
- WL-SiP with integrated passive devices (R, L, C)
- Solder sealing rings for hermetic WLPs
- WL-CSP for 300 mm wafers
- Transfer molding at wafer level
- Wafer level test



2 layer fine pitch redistribution (20 µm line width)



Chip to chip interconnects (3 µm lines and space)

Photonic Packaging

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›› The Program focuses on packaging technologies for optoelectronic and photonic integration on board, package and device level. The technologies are driven today by the increasing demand for bandwidth in data- and telecommunication. Furthermore lightening and projection techniques require new concepts.

Optoelectronic or photonic modules include edge emitting laser, VCSELs or LEDs, detectors, but also passive elements as lenses, fibers, filters and polarizers. Manual assembly and alignment operation dominates today. Standard packaging methods and processes capable of automation have to be developed to reduce packaging cost drastically.

Market and technology trends |
As packaging currently contributes up to 90% to the total component cost, there is a strong interest to identify possibilities for cost reductions while improving reliability and ensuring volume production. Whereas the drivers for the long haul market are bandwidth and reliability, for the access market size, flexibility and cost are also key factors.

To achieve high bandwidth on board level hybrid electrical optical circuit boards (EOCB) with planar polymer and glass waveguides are under development.

COMPETENCIES AND ACTIVITIES

Optoelectronic assembly |
Wafer and chip bumping, fluxless flip chip bonding, self-alignment using AuSn, submount assembly

Ultra-high brightness-LEDs |
Package development, LED mounting (AuSn), converter application (foils), transparent encapsulation

Module packaging |
Fiber to chip coupling, active / passive alignment, adhesive fixing, optical design

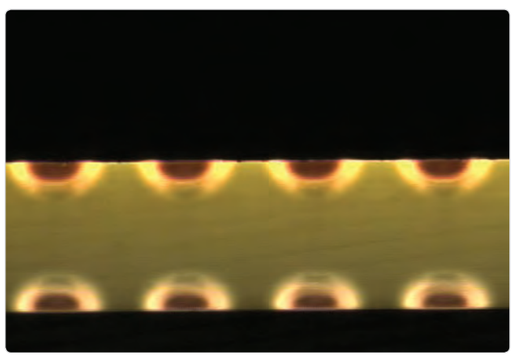
Optical backplane & EOCB |
Optical waveguides and 90° beam coupling by hot embossing, UV-direct writing, and Ion exchange

Fiber packaging |
Fiber lensing, laser fusing of fibers, photonic bandgap fibers

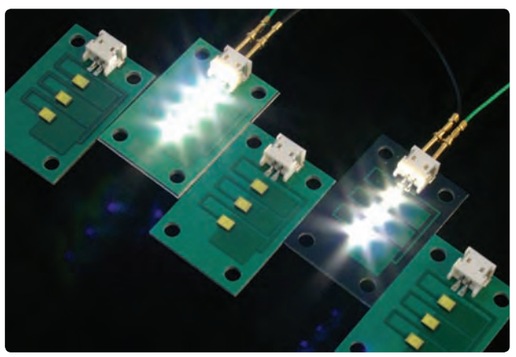
Image sensors |
Pixel detectors IR, X-ray, wafer level OPTO-CSP for CCD and CMOS cameras

Micro devices |
Micro spectrometer, laser projection devices

Materials & reliability |
Reliability testing, failure analysis



Optical micrograph (cross section) of thin glass optical foil (300 µm thickness) with double side optical waveguides (ion exchange)



Package development for white ultra high brightness LEDs with converter foils (for headlamps)

MEMS Packaging

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›› MEMS devices have become an integral part of our everyday life. Be it an airbag, a fitness device, a video projection device, an ink jet printer or a hearing aid - the omnipresent miniaturization requirements have brought those delicate devices into a large number of products. However, the proliferation of MEMS devices into the market meets barriers, not the least of which is the cost of packaging. Here, intelligent ways to minimize the cost impact of packaging are enabling solutions to allow MEMS to penetrate in fields of application they have up to now not had the opportunity to enter. Simultaneously, the required volume of a MEMS/sensor package aims from today´s 10:1 ratio towards a 1:1 ratio of package body to device volume.

COMPETENCIES AND ACTIVITIES

The MEMS Packaging Program therefore focuses on bringing together the expertise available at the Fraunhofer IZM from device requirements, device manufacturing, component realization, test and qualification. The different technological departments team up to form a synergy for the development of an optimum solution for a given application. Jointly, concepts are generated and realized to make low cost packages, capable of standardization and modularization.

Resources and technological capabilities are no more available as individual expertise but are seen in the scope of a system, where packaging is integral part of the design and manufacturing cycle. This ensures a maximum benefit for the customer and his application, whether highly customized or designed for mass manufacturing.

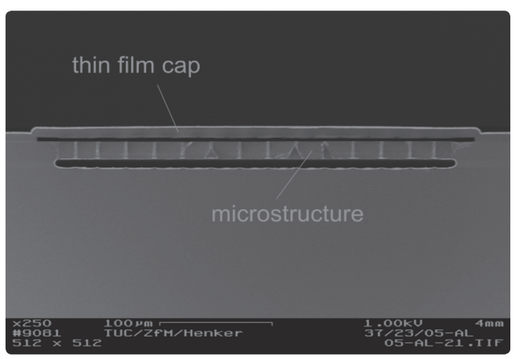
We strive to be your prime source for MEMS and sensor packaging issues.

Services available |

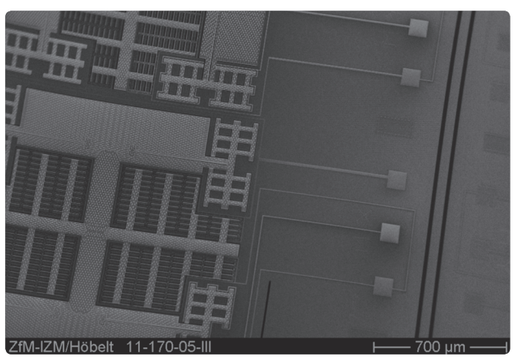
- Consultant service for emerging and existing MEMS/ sensor packaging concepts
- R&D for MEMS packages and MEMS-based SiP solutions
- Realization of packaged MEMS components

Current research activities |

- System in package integration of MEMS components with peripheral electronics
- Robust assembly of highly sensitive sensors (microphones, pressure sensors)
- Lifetime investigation of MEMS packages
- Die-2-wafer capping using adhesive joining for prototype evaluation
- Innovative protection mechanisms for sensors with media contact



SEM picture of a packaged microstructure using thin film encapsulation technologies



SEM picture of a 2 dimensional sensor structure for acceleration measurement

3D System Integration

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›› Mainstream planar technology is marked by physical and technological limitations which have a severe impact on system characteristics. Performance, multifunctionality and reliability of microelectronic systems will be mainly limited by the wiring between the subsystems (so-called “wiring crisis”). The ITRS roadmap predicts an increasing need for systems-on-a-chip. 3D integrated systems-in-package (3D-SiP) show reduced chip areas and enable optimized partitioning in contrast to conventional embedded technologies, where the highest complexity drives the process technology, leading to a cost explosion of the overall system. An additional benefit of 3D-SiPs is the enabling of minimal interconnection length and the elimination of speed limiting inter-chip interconnects.

3D integration at Fraunhofer IZM can be classified in the following categories:

- Stacking of packages/substrates,
- Die stacking and
- Vertical System Integration (VSI®).

In addition, Fraunhofer IZM provides competencies in enabling 3D technologies such as 3D system design and backend-of-line technologies (BEOL).

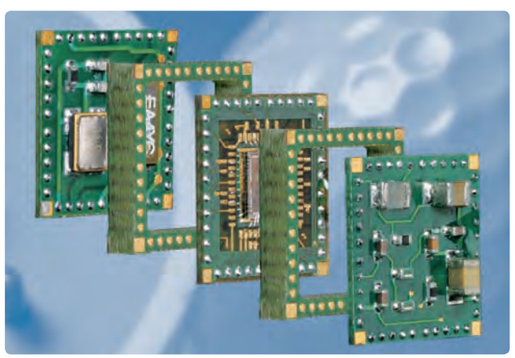
Stacked packages can be realized with the so-called chip-in-polymer technology based on embedding of thin chips into build-up layers of PCBs. The resulting chip size packages (CSPs) with copper-filled vias through the PCB are then stacked and electrically interconnected by solder balls.

A smart substrate stacking technology based on top-bottom ball grid array is available at IZM for 3D-integration of various functions. The interfaces of the modules are standardized with Fraunhofer IZM´s know-how by the Match-X association. State-of-the-art for stacking of dice at Fraunhofer IZM is mainly chip-on-chip technology based on flip-chip interconnects. Vertical System Integration – VSI® is based on thinning, adjusted bonding and vertical metallization by freely positioned inter-chip vias (ICV). Wafer level technologies for VSI have been established at Fraunhofer IZM. A new approach optimized for the capability of chip-to-wafer stacking was developed. The so-called ICV-SLID technology is based on the bonding of top chips (known good dies) to a bottom wafer by very thin Cu/Sn solid-liquid inter-diffusion (SLID) pads which provide both, the mechanical and electrical interconnect. A very high density vertical wiring between the thinned device substrates is realized by W- or Cu-filled IVCs. Systems for high parallel processing and low-cost SiPs are main applications.

The prospect of the program is to create a European competence center in the field of 3D System Integration, based on long standing experience, established cooperations with industrial partners, intellectual properties and professional equipment at Fraunhofer IZM.

Furthermore the program will help to build a common technology platform with the leading European institutes CEA-Leti and IMEC.

3D integration in chip-to-wafer technology



Acceleration sensor system for integration in a golf ball

RF Systems

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›› RF Systems integration technology plays a decisive role in the age of boundless communication with ubiquitous networks and multifunctional devices, used by numerous services. Accessing both business and private data from anywhere in the world expands to diverse electronic facilities for daily life. Universal and mobile self-configuring electronic devices are the cornerstones of this development. This trend represents a challenge for the entire range of system development technologies. Both hard- and software development must be promoted sustainably. Miniaturization is a basic requirement for realizing ubiquitous systems.

COMPETENCIES AND ACTIVITIES

Fraunhofer IZM takes up the challenge of developing advanced technologies for supporting industrial system developments' present requirements, as well as both researching and developing future technologies. Dealing with many leading international project partners, Fraunhofer IZM has gained broad background knowledge regarding all areas of RF system integration, available for quick and effective R&D projects with partner companies. We offer solution-oriented support for the entire range of RF system development and customer-oriented, R&D partnerships.

Support of the industry incorporates the areas:

- Efficient design methodologies for advanced RF system packages
- RF, signal/power integrity design & analysis of system packages and PCBs
- RF design & characterization of passive RF front-end components
- Board, assembly and housing
- Prototyping, processing und production
- Characterization, reliability test and certification preparation

In the context of R&D projects, Fraunhofer IZM both analyzes and evaluates present development trends, utilizing its active involvement in R&D, various international networks and cooperations.

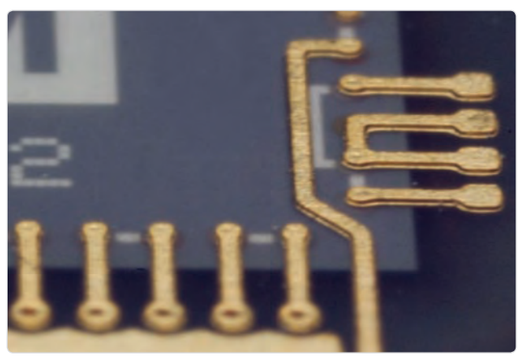
Supporting industry could consist of single process steps, ranging from consulting to developing applications tailored to industry's needs, demonstrators or prototypes with a final production qualification, or know-how transfer to the industrial partner, based on our substantial equipment and expertise.

Services |

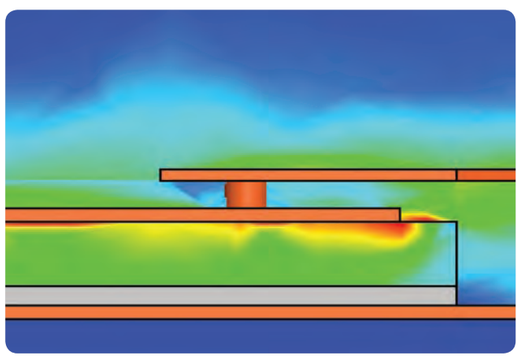
- Technology development and evaluation
- Technology-oriented RF-characterization up to 110 GHz
- Antenna development and characterization
- Technology-oriented feasibility studies for RF systems
- High-resolution high-current characterization in the time domain

Current research activities |

- Development of extremely miniaturized antennas
- Electrical modeling of carbon-nano-tube-interconnects
- Controlled impedance test solutions for RF-systems



Escape routing of embedded chip



E-field distribution from simulation of interconnect transition

Large Area Electronics

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›› Large-area electronics combines development, system integration and application of active and passive electronic and photonic components, based on large-area substrate materials, generally using organic materials. A further focus is the integration of energy-autarkic systems in terms of power generation, energy storage and power supply, as well as display and optical interface technologies and furthermore mechanics and micro-fluidics and -pneumatics.

With large-area electronics, for example, electronics, displays with a sensor keyboard and solar cells for power management with conventional flexible silicon circuits can be combined. In a few years, this will result in an efficient computer on film – although initially it will be a smart card or a simple PDA, followed by an electronic newspaper.

Using this approach, complex, but cost-efficient plastic systems can be manufactured, leading to large-area, cost-efficient production processes for bio-analysis and therapy (drug delivery dosing).

Large-area electronics' potential is expanded by the possibility of end user-defined specifications and production in their own fabrication environment, using in-line capable and mainly additive processing of large-area and low-cost systems.

COMPETENCIES AND ACTIVITIES

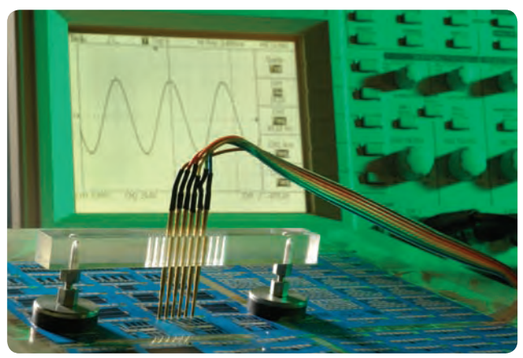
Services available |

- Design, simulation and calculation of polytronic components and systems
- Development and adaptation of manufacturing processing
- Processing of large-area substrates
- Consulting on reel-to-reel processes
- Provision of sample components, circuits and systems
- Assembly of bio sensors

Current research activities |

- Polymer electronics and microsystems
- Microsystems distributed in a foil
- Bio system integration
- Structuring and coating of large-area electronics
- Material development and modification

Reel-to-reel printed resistors for sensor applications



Ring oscillators on plastic film fabricated with polymer semiconductor

Micro Reliability and Lifetime Estimation

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›› Starting with the state-of-the-art in modern reliability analysis for microelectronics, microsystem technologies and the micro-nano transition region, the aim of the program is:

- Deducing relevant characteristics and quantities for reliability evaluation, finding out dominant features of the "reliability gap" between theoretical concepts and practical reliability and quality estimation procedures
- Establishing new reliability concepts and organizing interdisciplinary research

Within the main framework of electronic packaging activities, the following topics are being dealt with:

- Validity of failure concepts
- Comparison of different failure models beyond the present limits of application (e.g. higher temperature ranges etc.)
- Development of new testing methods for micro- and nano reliability, and system reliability estimation
- Identification of failure modes and the outline for lifetime estimation are important topics in the micro technology program. Another focus is on the micro-nano transition region (micro reliability, nano reliability).

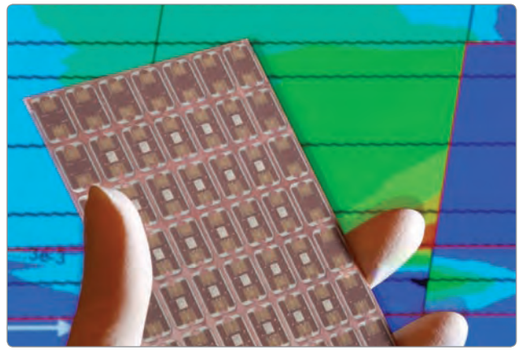
COMPETENCIES AND ACTIVITIES

The lifetime prognosis requires dealing with the following tasks:

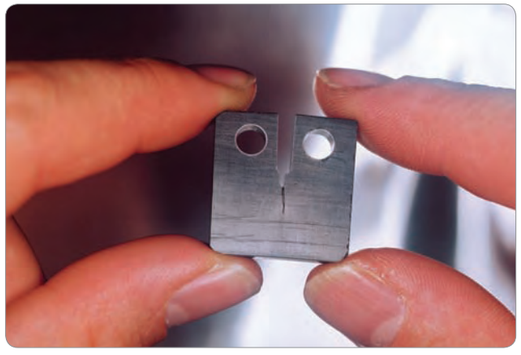
- Modeling in-situ determination of reliability parameters
- New NDE testing methods
- Identifying and verifying lifetime expectation

Activities and projects |

- Reliability and lifetime estimation of advanced packages
- Reliability of RFID solutions
- Failure mechanisms for solder interconnects (e.g. high temperature, lead-free etc.) in automotive and IT applications
- Thermo-mechanical simulation and optimization of reliability parameters
- Experimental verification of reliability concepts
- Reliability of nano materials (nano reliability)
- Reliability of MEMS
- Failure concepts for ICs
- Load history and lifetime monitoring
- Test methods and fracture concepts for interface characterization
- FE-methodology to analyze moisture diffusion
- Influence of interfaces upon reliability
- Stress analysis of HDI substrates, life of micro vias
- ESD investigations



Reliability testing of smart card module with embedded chip-in-polymer technology



Material characterization and modelling

Thermal Management

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›› Continuously increasing power and power density of microelectronic systems has become one of the most important design concerns as they pose new challenges to heat spreading and overall heat removal.

But optimum thermal performance needs to be accompanied by maximized thermo-mechanical reliability: Thermally induced stresses and strains continue to be a lifetime reducing factor as they cause failure due to e.g. die-cracking, interfacial delamination or fatigue of solder interconnects.

So for reasons of time and cost there is a need for a comprehensive approach which considers all these relevant factors already at the design stage.

COMPETENCIES AND ACTIVITIES

The Fraunhofer IZM's Thermal Management Program is a comprehensive concept to provide reliable and inexpensive solutions for efficient cooling of miniaturized electronic systems of all power categories from silicon to system level:

- Technology (process & manufacturing know-how)
- Material (characterization & failure behavior)
- Design (optimization by simulation and lifetime prediction)
- Verification (experiment & testing)
- Long term experience in "design for reliability"

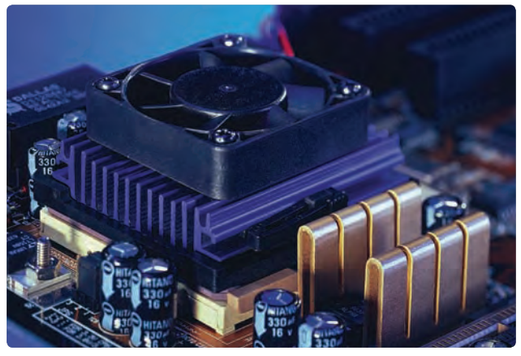
This consistent combination enables reliability-optimized thermal and thermo-mechanical design for advanced system integration and tailor-made thermal management solutions. It thus combines the key competencies of the institute's individual departments for an efficient and customer-orientated knowledge management.

Services available |

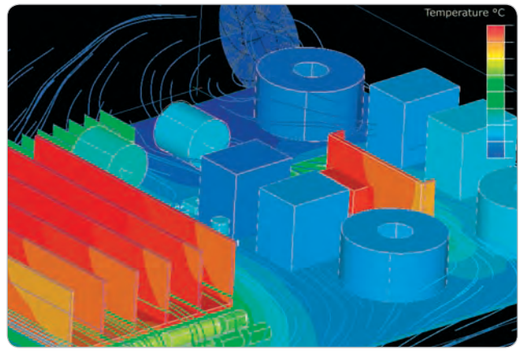
- Lifetime prediction
- Material characterization
- IR-thermography
- Rth-measurements
- Passive & active thermal cycling
- Test-station for air- and water-cooled systems
- Deformation measurements for micro- and nano-structures

Current research activities |

- Thermal/mechanical characterization of organic boards
- Compact water-microchannel-cooler micropumps
- Wind-channel (enforced air-cooling)



Enforced air cooling for CPU



Thermo-fluidic simulation of power module

Sustainable Technical Development

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›› Climate protection and sustainable development goals are currently discussed in our societies, from energy saving in private homes, to industrial action and policy making. Due to the global nature and equally due to the potential long term consequences, world wide concerted efforts are required. At the same time a lack of international harmonization should not preclude direct and sustained action on all levels.

Regarding the specific area of electronics and microsystem technologies, Fraunhofer IZM has over the years contributed to environmentally compatible alternatives and to the integration of environmental goals into technology development. The R&D program "Sustainable Technical Development" is merging in-house competencies for assessing and optimizing complex technologies and products.

On the one hand microelectronics enable solutions to foster sustainable development, for example through increased efficiency, safety or by providing basic services like communication. But at the same time the growing and fast-paced electronics industry has to cope with resource consumption, toxicity and waste generation. Against this background interdisciplinary teams work on assessment and development projects. They are addressing issues such as energy efficiency, reduction of hazardous content, recycling and re-use options, supply chain cooperation or total cost reduction. The approaches are applicable to complex electronic systems and can be tailored to individual study scopes. The aim is to balance environmental aspects with economic results in new, most often smaller and more reliable solutions.

COMPETENCIES AND ACTIVITIES

While the miniaturized domain of microsystems and integration technologies constitutes the core competence of the institute, this program by definition has to take a much broader view. This involves investigating products and their applications, with a life cycle perspective from production to recycling and even social and global effects. Scenarios, forecasts and regional studies can be added for achieving a robust and technically sound sustainability evaluation.

Available services |

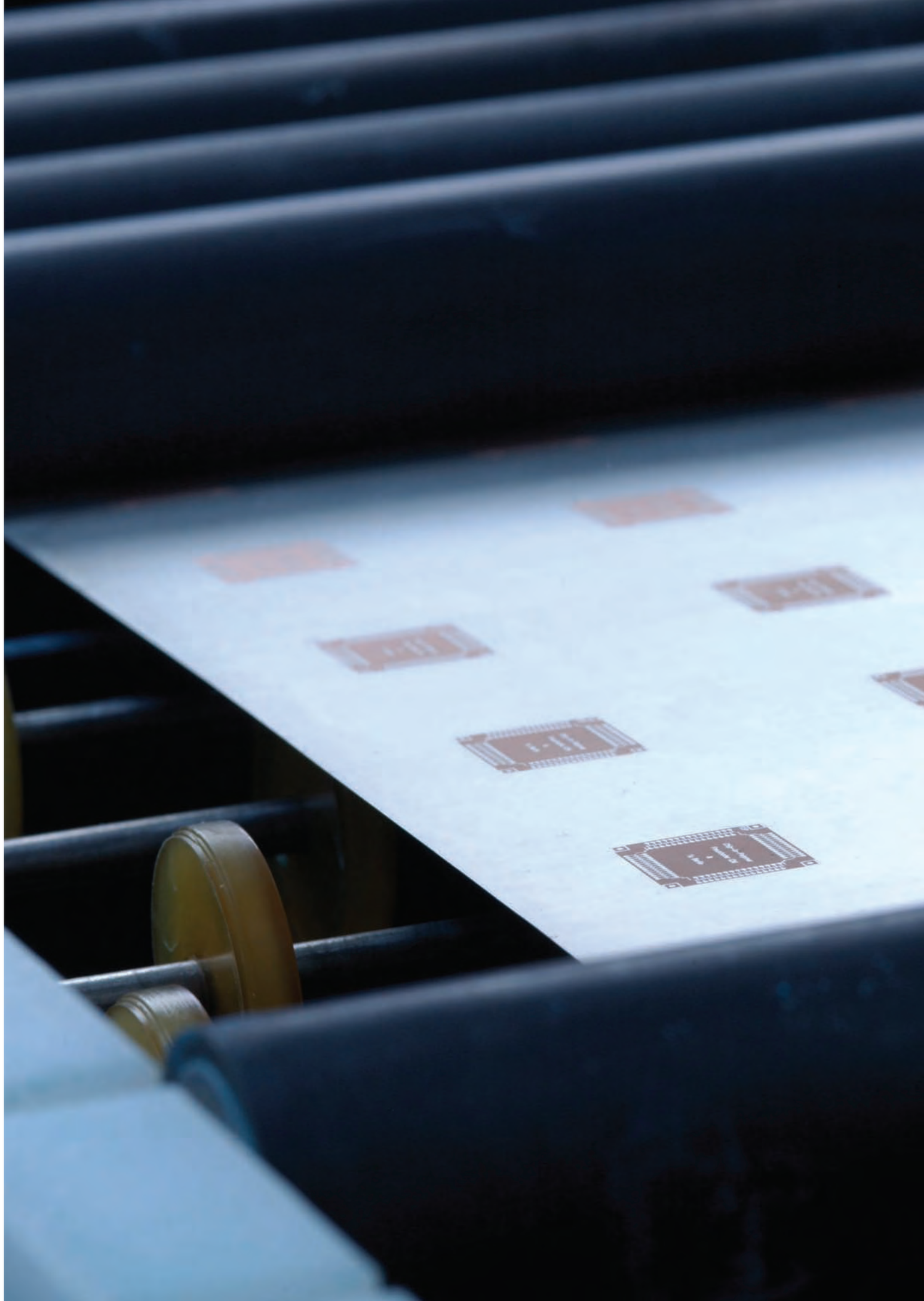
- Development of eco-efficient processes, components and products
- Environmental assessments using screening indicators and life cycle analysis
- Resource impacts of new interconnection and microsystem technologies
- LCUs (life cycle units) and condition indicators for robust electronics
- Material contents of electronics and analysis methods
- Scientific support for national and European policy making
- Environmental legislation in the electronics sector (RoHS, WEEE, EuP, and international developments)

Current research activities |

- Efficient and miniaturized power supplies
- Resource efficiency through adapted system reliability
- New eco-efficient materials in electronics
- Practical integration of environmental and sustainability aspects into design flows

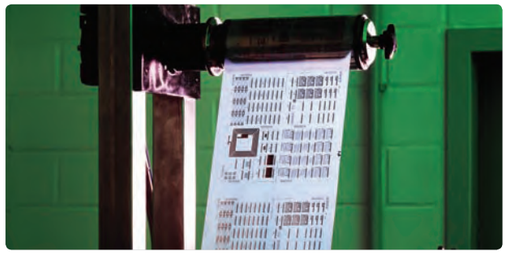
Power measurements of products and production equipment are required to tackle energy efficiency

Polymers from renewable resources are one strategy for future sustainable electronics



» COOPERATION

Fraunhofer IZM Technologies: Development for Application



Reel-to-reel processing (detail)

Sensor bracelet

›› Regardless of whether you are already using electronic packaging technologies or are planning to invest in it; we offer the support and collaboration you require to reach your development aims.

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

You already know what kind of technology you want to employ and would like to make sure you will be harnessing the latest trends? You are familiar with the technology but need assistance in development, failure analysis or with optimizing your products?

We can provide consultancy from the Fraunhofer IZM research department by organizing workshops and technical discussions.

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

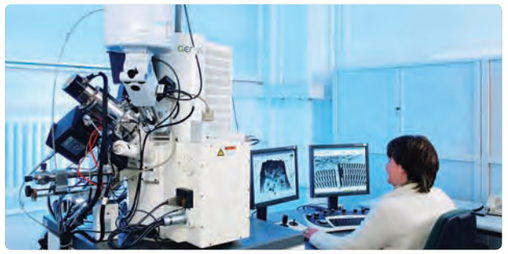
Application Center (APZ) Smart System Integration – Remain one step ahead by employing cutting-edge technology |

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

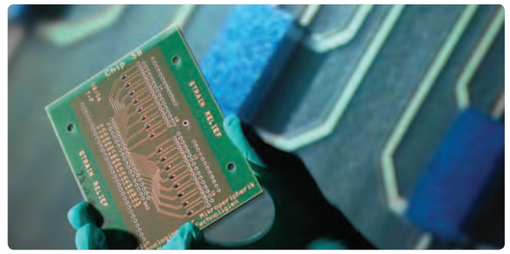
The APZ Smart System Integration links industry with Fraunhofer IZM's wider activities, including active support by the German Ministry for Education and Science. Our approach is specially designed for interdisciplinary projects that are tackled by teams of experts assembled specifically for your project aims.

We offer support and advice on varying fields of expertise in system-in-package and system Integration. We also assist you with proof of concept studies and provide conceptual designs and solutions to your technological challenges.

Fraunhofer IZM Marketing



Reliability testing at the FIB



Reliability test board

›› You face problems in developing your product and need advice but lack contact with research facilities?

You would like to expand your know-how with the help of a special technology workshop or directly benefit from our technological expertise? We offer specialty workshops on a regular basis in all our fields of expertise.

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

Specifically, our services include:

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

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

Special technology workshops |

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

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

Contact |

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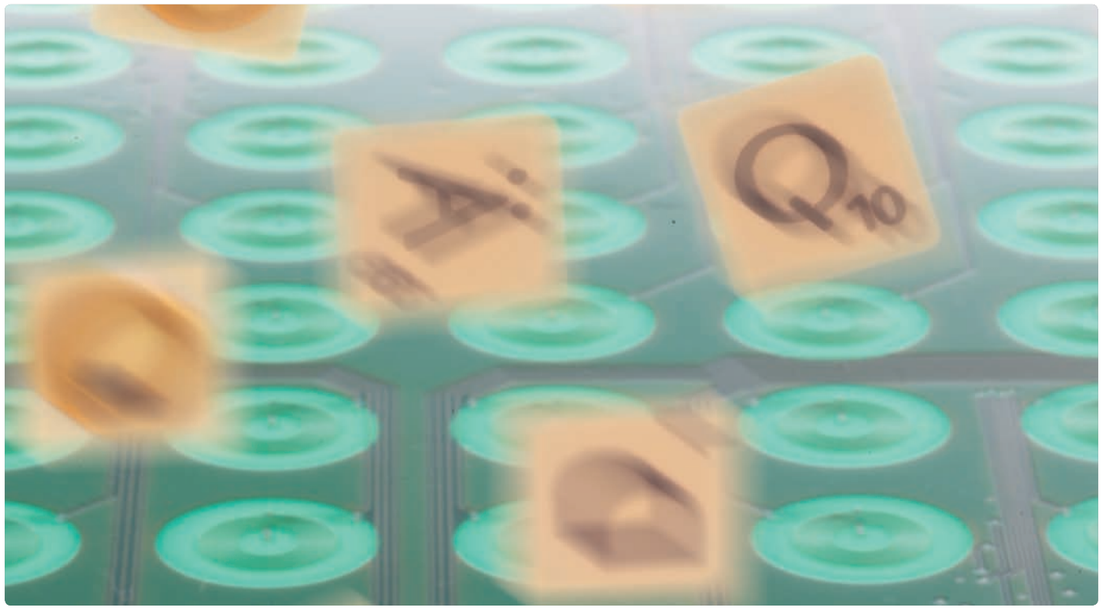
Application Center (APZ) Smart System Integration - At Your Side Every Step of the Way



eScrabble based on RFID technology

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

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

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

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

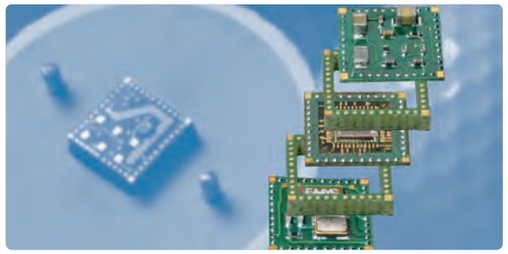
- Customized technological consultancy, e.g. on selecting feasible technologies
- Feasibility studies
- Complete technology transfer
- Provision of manufacturing capacities.

You will be accommodated with the entire range of services required, from developing your idea, through to successfully marketing the product.

Established MST companies |
For the ongoing success of your products and a firm standing in the technology market, APZ Smart System Integration ensures your access to Fraunhofer's cutting-edge technologies.

Our technology workshops and laboratory facilities are in high demand.

Technology transfer trough workshops



Realization of prototypes

›› Innovation scout |
The Application Center Smart System Integration organizes an innovation scout to act as your primary contact.

Our innovation scout will answer basic technological questions, offer advice and consultancy, and provide access to specialists for your project, assuming the role of your personal technology support throughout the project.

How do we support your product development? |
You have an idea for a certain product and would like to develop it? But you are unsure about the feasibility, quality, development costs and time it requires?
We offer consultancy and development support modules, from which you can choose according to your specific requirements at any stage of development.
The product development support modules are described as follows:

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

Application examples from the APZ include

- **eScrabble** – A standard Scrabble board has been enhanced electronically, every token is RFID-tagged and a multiplexed reading unit applied to the entire 255 squares of the board.
- **Impact detection in a ping-pong paddle** – A pressure-sensitive lamination applied to the paddle acts as a piezoelectric pressure sensor.
- **A personal transmitter bracelet** – Developed from a simple band aid, the multifunctional health-care bracelet uses polymer sensors to collect and visualize medical data such as temperature or skin moisture.

Helping you develop your product is our main aim, so please contact us for more information.

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“One-stop Service for Complex Solutions“ - Field Report from a 15-Year-Collaboration with Fraunhofer IZM

Bernhard Schuch...

... talking to Harald Pötter

›› Cars without electronics is unthinkable these days. Nowadays 90% of all innovations for automobiles are directly or indirectly influenced by electronics. Control components for power-saving drives, safety features such as the airbag and ABS or comfort features such as electronic data transmission or hands-free systems - the constant flow of innovations is ensuring that soon electronics will comprise 40% of an automobile’s production value. The increasing importance of electronics is highlighting three sometimes contradictory tasks: The employed electronics must be more reliable, more cost-efficient to produce and decrease in size with each new generation of automobile. Fraunhofer IZM is an ideal technology partner along this path.

We spoke with Bernhard Schuch, Head of the Competence Center Materials & Packaging of Continental AG, Division Powertrain, BU Transmission, about his experience with cooperative projects. Harald Pötter, responsible for Marketing at Fraunhofer IZM, conducted the interview.

IZM: Herr Schuch, Continental and Fraunhofer IZM have developed a relationship of trust through their many years of mutual collaboration. Why does a company that is so successful internationally work with Fraunhofer IZM?

Schuch: Continental has expanded rapidly in the area of automobiles over recent years and technological development in vehicle electronics has been progressing at breakneck speed. Consequently, part of the development activity has to be carried out together with external service providers, for a start due to limits in capacity. Fraunhofer IZM has assumed a key role in this area over the last 15 years, not least thanks to the wide spectrum of know-how and services offered in terms of materials, electronic packaging and reliability.

IZM: Which do you value more - the breadth of our services or their comprehensiveness?

Schuch: Both. I remember our first collaboration very well. We introduced the first engine-mounted electronic control units in PCB technology (Printed Circuit Board) for truck applications. Until then the golden rule was that an electronic control unit destined for the engine mounting place must be realized on ceramic substrates. If it was going to be used somewhere else, it could be a Printed Circuit Board. I was heading the project at the time and had to prove to the customer that this solution was more and sufficiently reliable. We proved the reliability of the solder joints together with you. The experimental setups you had available, together with the simulation of the creep behavior and knowledge of the technological parameters assisted us with this and so, even back then, we were able to determine the deformation of individual solder joints using DAC (Deformation Analysis via Correlation) experiments and then re-use the data for more detailed FEM simulations. This confirmed our own test results.

IZM: And the long-term collaboration developed out of these positive experiences?

Schuch: Exactly. The project showed us the advantaged of working in collaboration with a competent research partner that has the respective know-how and skills and - very important to us - develops these further independently. This was the key to ensuring that we would receive support quickly when we had concrete questions but also receive feedback and inspiration for our long-term problem-solving. Thus, we’ve continually expanded the collaborative areas over the years. Nowadays Continental works together with most IZM departments, particularly in the development area in Nuremberg, to directly support specific product developments and as well as new materials and assembly solutions in general. Simultaneously, IZM has been our partner for years in numerous research and funded projects to develop new solutions for our products.

IZM: Your point about collaborative development over a longer timeframe is an important topic for us. On the one hand, you require solutions to concrete daily problems, on the other, you act as our partner in long-term research aims. This means we have a direct line to what is required of our technology during day-to-day use in industry, but we also have the space to develop future technologies. Technologies, that our customer might use in their every-day tomorrow.

Schuch: You have to look at it like this: at Continental we focus on concrete product developments; the prerequisite basic developments get valuable impulses through research institutes, too. That’s why we seek out collaborations with research institutes such as yours. These types of projects have another advantage for us as well. We come into contact with suppliers and competitors that often have to solve the same types of problems. Everyone wins in these collaborations, as long as the issues don’t relate to particular products specifically. We get more results for the same amount of effort and expenditure.

Working groups even evolved out of these projects that extended far beyond the project period, for example on the topic of high-temperature electronics.

IZM: What other advantages became obvious once you’d actually embarked on the collaboration?

Schuch: One of Fraunhofer IZM’s advantages is also the continuity in staff. Sure there’s problems now and again when an team member moves on. But overall you’ve been very good at developing areas such as wire-bonding, encapsulation or solder joint reliability further in the long term. At the same time, it’s really valuable for us, as clients, to be able to define the tasks with generally only one Fraunhofer IZM employee. The complete task, including coordinating the other team members, is carried out by IZM – a really customer-friendly solution. Of course, Continental has to be able to describe the task very accurately.

IZM: What has worked really well, what could have been better?

Schuch: In individual cases, we’ve had the experience that additional contracts have not been possible due to a lack of staffing of equipment capacity. All in all, however we can say that our over 15 years of cooperation, the collaboration has been organized extremely pleasantly, efficiently and successfully – thanks, too, to the active cooperation by colleagues from the respective departments. The project results have been specific, directly applicable and usable for designing and optimizing our automobile electronics.

IZM: Mr. Schuch, thank you for your time.

About Bernhard Schuch

Bernhard Schuch studied Physics at Giessen University. He has been employed in Continental AG’s, or that is, in its forerunner companies such as Nuremburg’s TEMIC’s, automotive electronics branch since 1984.

Having started his career in semiconductor technology, Bernhard Schuch first came into contact with assembly and interconnection technology for automotive control units four years later and became captivated by the topic.

Today he is worldwide responsible for the development of materials and packaging technologies for the Business Unit Transmission, Division Powertrain.

He also represents Continental in numerous committees concerned with electronic packaging, for example in the advisory board of the Micro Materials Center Berlin.

About Continental AG

Continental AG, based in Hanover, developed from tire manufacturer to one of the world’s leading automotive industry suppliers almost unknown in the broad public sphere. As a supplier of brake systems, systems and components for drives and chassis, instrumentation infotainment solutions, automotive electronics, tires and technical elastomer products the company contributes to road safety and climate protection. Continental is also a competent partner in networking automobile communication.

The company presently has approximately 150 000 employees at almost 200 sites in 36 countries.

Research Activities and Objectives


System Integration

Chip Interconnection Technologies

- Bumping technologies such as electroless plating, mechanical stud bumping, stencil printing, immersion soldering
- Electroless redistribution, wafer-level assembly, wafer-level molding
- Flip chip, encapsulation, lead-free assembly
- Integration of passive (printing technique) and active devices (chip in polymer, chip in textile)
- Reliability investigation of interconnection technologies, electro-migration
- Application specific technologies: wireless communication, MEMS, wearable electronics, medical, automotive

Module Integration and Board Interconnection Technologies

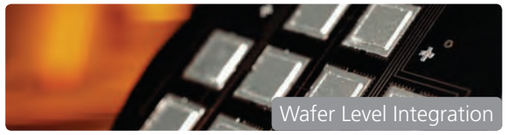
- Construction and development of microsystem packages and package interfaces
- Flip chip technology for microwave and mm-wave applications
- Electro/optical boards
- Fiber-optic sensor systems
- Automation of micro-optical assembly
- Innovative wire and ribbon bonding
- Materials and technologies for chip-on-board and power electronics
- Deposition and specification of functional layers (galvanic, electroless)
- Materials, processes and equipment development, e.g. lead-free solder alloys for high temperature application
- Low temperature assembly and interconnection technology
- Qualification of PCB packages, analysis of manufacturing failures and failed joints
- Training Center Packaging (ESA, IPC)

Polytronic Systems

- Polymer electronics and polymer MEMS
- Wafer preparation and ultra thin silicon
- Assembly of thin chips and micro components
- Self-assembly processes for chips
- Flexible Electronics Application Center (Reel to Reel)
- Hybrid integration
- Sensor systems for life science applications
- Analysis and test of integrated systems

Micro-mechatronic Systems

- Design of micro-mechatronic systems
- Interconnection technologies and encapsulation
- Thermo-mechanical reliability and electrical simulation of micro-mechatronic systems


Wafer Level Integration

Si Technology and Vertical System Integration

- 3D-integrated systems, Vertical System Integration (VSI)
- Optically adjusted bonding of ultra thin devices
- Integration of new materials and processes (e.g. piezoelectrical layers, SiGe/Si epitaxy)
- New transistor structures (e.g. strained Si, SiGe)
- Technologies for bulk acoustic wave filters

Multi Device Integration

- MEMS design & modeling
- Development of MEMS
- Advanced technology development & wafer bonding
- Back-end of line technologies for micro and nano electronics
- Process and equipment simulation
- Micro and nano reliability
- Wafer-level test and characterization
- Printed electronics

High Density Interconnect & Wafer Level Packaging

- Chip scale packaging
- Wafer level bumping
- Thin film multilayer substrates
- RF multilayer substrates
- 3D integration at wafer level
- Portable power supply

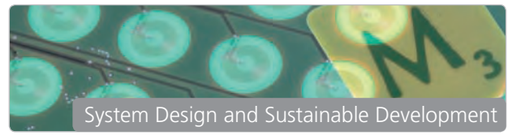

Materials & Reliability

Polymeric Materials and Composites

- Synthesis, modification, formation, processing and recycling of polymeric materials and composites
- Chemical and physicochemical characterization of monomers, oligomers and polymers
- Thermophysical and mechanical characterization of polymeric materials and composites
- Materials for micro-, optoelectronics and light weight systems

Micro Materials Center

- Deformation, reliability and lifetime analysis of complex electrical, mechanical and optical systems
- Simulation of thermo-mechanical behavior
- Crack and fracture failure mechanisms, damage behavior, lifetime predictions, e.g. for solder joints, adhesives, PCB components
- Measurement techniques such as microDAC and nanoDAC
- Microsecurity and nanosecurity
- Thermal parameters, thermal management
- European Center for Micro- and Nanoreliability (EU CEMAN)


System Design and Sustainable Development

Environmental Engineering

- Environmentally compatible product design
- Analysis and ecological assessment
- System reliability as a contribution to sustainability, lifetime estimation and reuse
- Ecological and economic analysis of technologies
- Sustainable development of ICT

System Design & Integration

- Efficient design methodologies for advanced system packages (SiP, MCM…)
- Design & implementation of highly miniaturized advanced systems (advanced RFID, wireless sensor networks, energy harvesting systems…)
- Physical and mechanical co-design of packages and heterogeneous micro- & power electronic products including 3D-visualization
- RF, signal/power integrity design & analysis of system packages and PCBs
- RF design & characterization of passive RF front-end components (filters, integrated antennas...)
- Power electronic packaging design, integration & characterization
- Electromagnetic compatibility (EMC) of power electronic systems

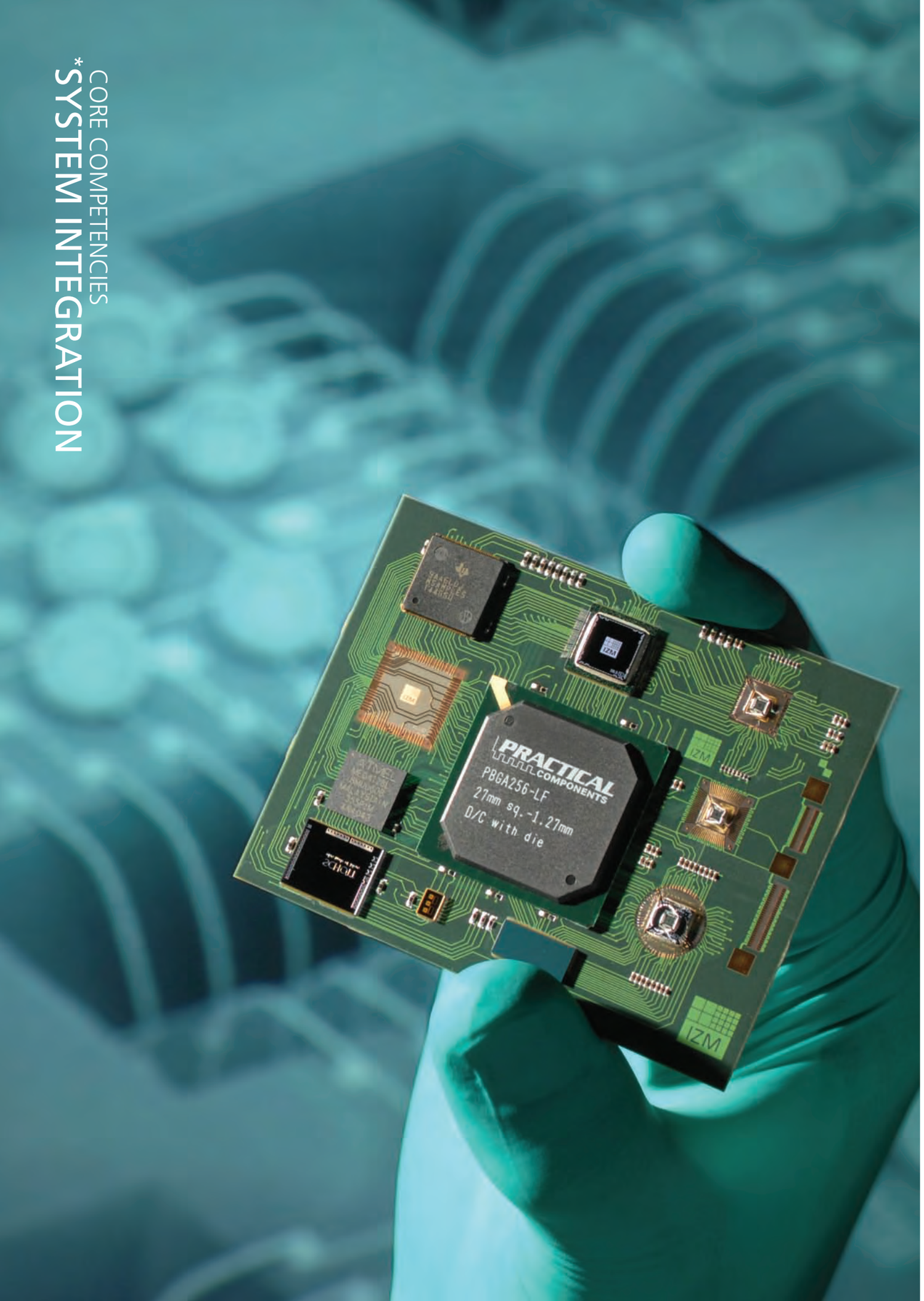
Advanced System Engineering

- Wireless systems/ RFID system development
- Analogue design and simulation
- EMC on chip and off chip
- Power/ground analysis and modelling
- AddOn tool development

Microfluidics Systems

- Design and development of microfluidic components and systems
- Component and system processing, assembly and testing

CORE COMPETENCIES
*SYSTEM INTEGRATION




R. Aschenbrenner


Prof. Dr. W. Scheel


Dr. K. Bock


Dr. F. Ansorge

» SYSTEM INTEGRATION

Chip Interconnection Technologies

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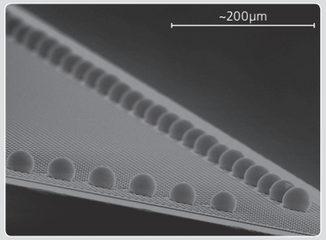
Ultrathin polycarbonate card with integrated transponder



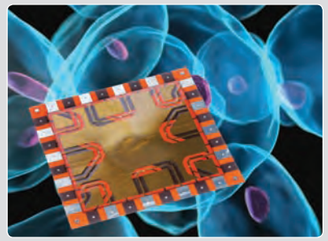
Chip with 60 µm pitch peripherically printed solder bumps

COMPETENCIES

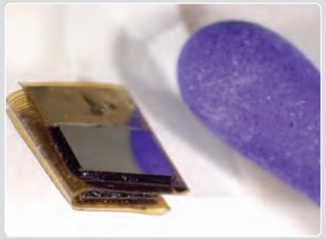
- Encapsulation technologies
- Assembly of optoelectronics, RF components and sensors
- Flip chip processes and manufacturing
- MEMS packaging
- Flex circuit application
- Chemical metallization and advanced printing
- Technology transfer
- Technologies for medical systems

HIGHLIGHTS

- Textile electronics: LED integration, EMG sensors, UHF transponders
- Integration of thin chips into foldable flex modules and multilayers
- Integration of ultrathin chip into security cards
- Jetting process for nano-functionalized materials
- Rapid prototyping processes for molded SiP realization
- Technology development for single cell handling using PCB processes
- Ultra fine pitch stencil printing: 60 µm
- Encapsulation and embedding of 77 GHz radar modules



Lab on a substrate module



Folded flip-chip-module for a hearing aid

›› SHORT PORTRAIT

The department has 31 employees and 21 students and offers business activities that reach from consultancy and process development to technological system solutions. The researchers are principally concerned with the development of new process steps and methods for chip assembly and encapsulation as well as aspects of system integration (system in package). Further priorities are the development, application and licensing of electroless metallization processes and the development of low cost-bumping methods. We assist companies with application-oriented pre-competitive research as well as the development of prototypes and small quantity production.

We cooperate closely with the TU Berlin (Center for Microperipheric Technologies), for example within the scope of European joint projects and especially in the area of basic materials research for the packaging of integrated circuits. The department's research has an excellent international reputation. In the realm of electroless deposition of nickel/gold and stencil printing to produce solder bumps the department is the worldwide leader. The core competence in flip chip processes was shown at production lines during international exhibitions. Similarly successful are our contributions to system integration, which serve the formation of electrical and other interfaces between specific system components as well as between the system and the environment. Especially our projects concerning the integration of active components and passive devices should be mentioned.

›› TRENDS

System in package |

- Complex systems with embedded components
- Integrated sensors in organic materials
- Integration of nano-packaging technologies (self-assembly, self-organization, nano interconnects)
- Wireless interconnects (capacitive coupling)
- Heterogeneous assembly for SiP (MEMS, ICs, passives...)
- Concept of functional layers
- Non-destructive package analysis

Thin chip assembly and micro bonding |

- Ultra thin interconnects (< 5 µm) for thin chips (< 10 µm) with solder and adhesives
- Low temperature joining (Carbon Nanotube interconnects and low melting solder)

Wearable electronics |

- Assembly and interconnection in textiles: integrated antenna, detachable electrical contacts, flexible systems in textiles, assembly of ultra-thin transponders
- Large area systems in organic materials (z.B. rubber, textiles ...)

›› RESEARCH RESULTS

Thin Interconnects |
The integration of thin chips on and in flexible modules was advanced for different applications. In doing so the height of the solder and adhesive joints could be reduced to a few µm. A chip thickness of < 10 µm allows the lamination for example into thin polycarbonate cards. Up to four chips were integrated on top of one another in multilayer flex substrates. These new technologies are also applied for the assembly of small folded packages.

Ultra fine pitch (60 µm) solder printing with type 8 pastes (2-8 µm) has been achieved using advanced electroformed stencils (20 µm thick). Feasibility studies on 6 inch wafers yielded bump heights of 28 µm ± 3 µm.

Assembly |
Concerning assembly processes the group's focus was on MEMS and sensor integration. One example is the realization of a multisensory-stack for an avionic application. Contactless handling processes were used to analyze the positioning of delicate components, principles used were magnetic handling and electrowetting.

Encapsulation |
Within encapsulation technologies emphasis was put on high accuracy contactless material deposition using jetting processes and nano- and micro-functionalized materials. This way underfilling through trenches of 250 µm width and deposition of 200 µm dots of viscous ICA were possible. Enhanced analytical possibilities in rheological and diffusion related material characterization yielded a highly improved understanding of processing and reliability.

Lab-on-Substrate |
A lab on a substrate for investigation of living cells was realized. A biocompatible module made of an Aluminum/Polyimide composite containing microwells was manufactured. A final hydrophobic/hydrophilic surface modification allows for the controlled guiding of fluids.

77GHz radar frequency module |
An assembly technology for a 77 GHz radar frequency module was developed. A SiGe chip was embedded into an HF-antenna module by transfer molding and PCB processes. Compared to conventionally assembled modules these showed a vastly superior RF performance.

Electronics in textiles |
In the area of electronics in textiles new processes for the realization of textile UHF-transponders have been developed and qualified. In funded projects technologies for the production of luminescent textiles, textile EMG sensors and the integration of sensors in car seats are developed.

Module Integration & Board Interconnection Technologies

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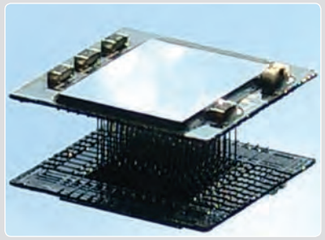
Courses in die- and wire bonding



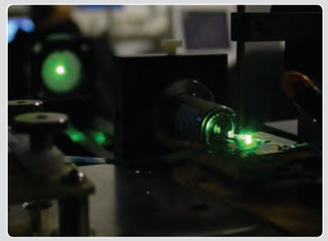
Neural interface

COMPETENCIES

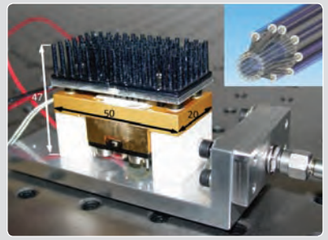
- Material and process development
- Assembly solutions
- Technology service and transfer
- Quality assurance and troubleshooting
- Prototype and small series assembly
- Industry-oriented seminars
- Training courses for wire bonding and PCB packaging (ESA, IPC)

HIGHLIGHT

- Green laser technology
- Miniaturization
  - Laser source
  - SHG Crystal
  - Thermal management
  - Electrical interconnects
  - Housing



Green emitting laser module



Sub-module with cooling, optical interconnection and light source, and fiber optical sensor (design scheme)

›› SHORT PORTRAIT

The R&D activities of the department Module Integration & Board Interconnection Technologies focus on material, process and equipment development, as well as assembly technology for the packaging of microelectronic and micro-technical structures.

The department's performance spectrum comprises:

- Metallization & surface finishing
- Metallic nano-structured surfaces
- Solder materials and innovative soldering processes
- Die attach and gluing
- Fine-pitch flip chip, wire and ribbon bonding
- Assembly of optical sensors and detectors, HB-LEDs, laser modules, power modules, HF modules
- Development and simulation of optical systems and interfaces
- Electrical-optical PCBs
- Nanoparticle-based assembly and integration techniques
- Application of biopolymers
- Qualification/testing of microelectronic, microtechnical assemblies

Furthermore, the department has a demonstration centre for PCB packaging (ZVE), as well as laboratories for bonding within the Center for Microsystems (ZEMI).

›› TRENDS

Today, the technical sophistication of printed circuit assemblies (PCAs) determines the quality of electronic systems. The driving force for the steady improvement of PCAs in functionality and complexity has been continuous innovation in the semiconductor industry. Greater system integration will in the future see the PCB become an active system platform. Photonic and power electronic systems must also meet modern requirements. Above all, this means reducing size and energy consumption.

The department meets these challenges by combining system development and advanced interconnection technologies.

We focus on the following:

- Advancement in the design of and interconnection technologies for multifunctional PCBs
- Development of technologies for optical chip-to-chip interconnects
- New solders for high-temperature applications
- Fine-pitch flip chips for optical and HF modules
- Advanced assembly methods for high-brightness LEDs and laser modules
- System development, assembly technologies based on high-performance 3D-PCB-technologies
- High-brightness LED packaging, including a new color conversion method
- Microwave-supported soldering
- Alternative power module assembly

›› RESEARCH RESULTS

Optical sensor for food quality monitoring |

Spectroscopic methods are useful for food quality monitoring. Furthermore, miniaturized hand-held devices are necessary for field use throughout the logistic chain of meat, for instance. Fiber optical sensors (FOS) are used in fluorescence and raman spectroscopy.

They are flexible and, by varying the fiber properties and the configuration of the different fibers, various optical designs are possible. Furthermore, they are robust and suitable for remote sensing.

The excitation fiber has a large numerical aperture and core diameter to capture all available light (200 mW) coming from the light source itself and to project it onto the food sample surface.

Numerous detection fibers are packaged around the large core excitation fiber to collect the signal light to guide it to the wavelength selective detector array.

The required sensor probes have been designed and realized. The light source itself (semiconductor laser or LED, developed externally) is packaged into a specially designed sub-module with cooling, electrical connection and optical interconnection.

The sensor is suitable for use with all types of fluorescent materials.

Neural recording interface |

The project "Neural Recording Interface" is a joint project of Fraunhofer IZM and the University of Utah to develop an interface between human being and prosthetic. Fraunhofer IZM focuses on packaging the interface with respect to miniaturization, biocompatibility and reliability. The neural interface has already been successfully tested using an electrode array connected by wires. Our new challenge is transferring the signals wirelessly. A signal processor IC amplifies the detected signals and transmits them to a coil mounted on top of the packages. The same coil is also used to power the interface by inductive coupling.

To meet miniaturization requirements, the IC is AuSn-bumped and flip chip bonded by Fraunhofer IZM. The IC is then underfilled and the SMDs and the coil, which is designed and manufactured at Fraunhofer IZM, are assembled. Additionally, a ferrite plate is placed between IC and coil to protect the IC from the electro-magnetic field on the one hand and to increase the efficiency of the inductive coupling on the other.

Apart from recording nerve signals, this interface will also be used in future for the stimulation of nerves. Combining stimulation and recording interfaces should make bypassing separated nerves possible.

Polytronic Systems

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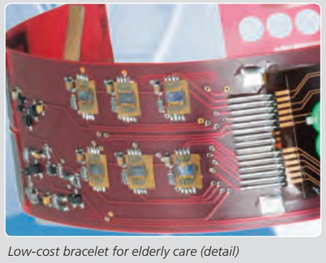
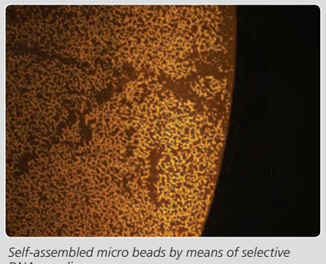


Low-cost bracelet for elderly care (detail)



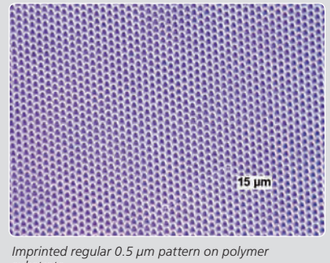
Self-assembled micro beads by means of selective DNA coupling

COMPETENCIES

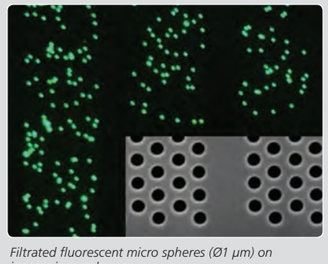
- Polymer electronics and MEMS
- Ultra-thin silicon devices
- Handling and packaging of thin chips and micro components
- "Smart plastic" - integration on plastic films
- Reel-to-reel processing for flexible electronics
- Biosensors
- Analysis and testing of integrated circuits

HIGHLIGHTS

- Selective processing for large-area applications
- Reel-to-reel fabrication of fine-pitch wirings
- Micro machining of plastic films
- Immunodetector with reference channels
- Optical waveguides in hydrogels for biosensors



Imprinted regular 0.5 µm pattern on polymer substrate



Filtrated fluorescent micro spheres (Ø1 µm) on inorganic membrane
Detail screen: SEM micrograph of filter membrane with 0.45 µm holes

›› SHORT PORTRAIT

The department develops processes, components and hetero-integration technologies for large-area electronics, ranging from low-cost disposables to applications for complex communication electronics.

Large-area applications such as sensor skins and distributed polymer-based microsystems require integrating electronics onto flexible plastic films. This is only made possible by developing a specific type of electronics – one that uses organic semiconductors and sensors on plastic films, which are produced by reel-to-reel processes. An key aspect of our approach of system design by heterointegration is advanced fabrication processes for thin-silicon substrates. These substrates cover the full range of thickness, from commercial through to flexible silicon of less than 10 to 30 µm, and the fabrication processes have been combined to a closed thinning, handling and separation technique. Our reel-to-reel application center provides unique possibilities for developing and producing flexible systems using industrial equipment, which, in turn enables cost-efficient manufacturing of electronics and microsystems development on conventional and large-area substrates.

We work on integration of electronics with peripheral components, such as sensors, displays, batteries, fluidic elements etc., to enable fabrication of inexpensive microsystems on plastic films, like medical disposables, lab-on-chips or polymer MEMS.

›› TRENDS

Ubiquitous systems in a human-based ambient intelligence environment require cost-effective multi-functional distributed systems. Here, electronics need to be produced in large volumes, cost-efficiently on large-area substrates.

Autarkic sensor networks in combination with RFID technology have already resulted in new applications for logistics, processing and medical technology.

Coating, patterning and micromachining technologies are used for large-area electronics to fabricate electronic multilayer systems into which functional layers such as polymeric foils, organic electronics and sensors are integrated by means of heterointegration. Thinned classical components such as ultra-thin silicon chips, sensors or MEMS integrated in flexible substrates are also interesting options for such applications.

The reel-to-reel application center develops these technologies, focusing on producing cost-efficient microsystems. One example of such microsystems is disposables, which are of particular interest due to rapid progress of technology in, for example, the life sciences.

Fraunhofer IZM's new approaches to health, environment and process monitoring are based on developing fully integrated, highly functional, polymer-based (bio-) sensor systems.

›› RESEARCH RESULTS

Sensor bracelet |

The possibilities of system integration on plastic films have been demonstrated by a circuit sample that combines an ultra-thin IC, printed display, sensor and polymer resistors. A possible future application may be monitoring bodily parameters in health care. This development is one example of the work carried out in the Application Center Smart System Integration, funded by the German BMBF. To showcase the potential of the design area, known as "smart plastic", a flexible bracelet has been developed. The latter is equipped with an electroluminescent display and sensors for temperature, humidity and electrosmog, which were produced using roll-to-roll technology. The electroluminescent display is printed in 5 steps on a copper-patterned polyimide film. For temperature measurement, a copper meander with a line width of 30 µm on polyimide was fabricated. A processed interdigital capacitor was integrated to measure humidity of the skin, as was an etched coil to detect electrosmog.

Self-assembly |

Assembling very small electronic components will require new technical concepts in the future. As part of the project "Assemble!", selective wetting of a glue and aligned bonding of a silicon chip was demonstrated as a first milestone. Within the research project "BIASS", a new method for selectively bonding small particles by means of DNA molecules was developed.

Selective large area processing |

Patterning in selective areas is a priority development in processing on µm-scale on large substrate areas. Novel structuring techniques for fabricating integrated microsystems are being developed within the BMBF-supported research project HADPEP.

This project addresses the problem of joining the very different dimensions that may be involved in a large-area system. Typical techniques include microimprinting, micro-contactprinting, ink-jet printing and embossing.

Rapid detection of bacteria in water |

A biosensor for the rapid detection of bacteria in water will be developed in the joint project Optozell, which is funded by the BMBF. Current tests are based on the cultivation of bacteria on agars in incubators for a period of 24 to 72 hours. Subsequently the colonies are counted under a microscope. In this project bacteria are enriched on the surface of a micro-machined silicon filter membrane with uniform pore size. Afterwards the bacteria are marked with a fluorescent dye. The fluorescent light will be detected by a high-sensitivity measuring setup. The automated measurement will take 1 to 2 hours. The outcome delivers a test result, in which fluorescent micro-spheres are used as a model of bacteria.

The project partners are EADS, Institute for Water research (IFW), University of Regensburg (RIMMH).

Micro-Mechatronic Center

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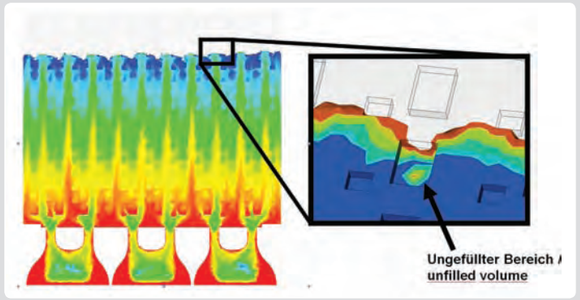


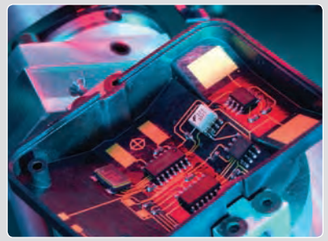
Left: Degree of polymer gelation during transfer molding (numerical simulation)
Right (detail): Time dependent polymer filling behavior near electronic components

COMPETENCIES

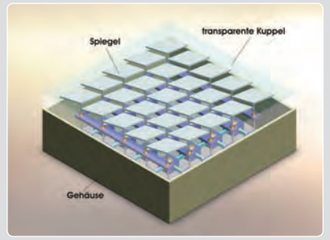
- Process simulation for assembly, interconnection & encapsulation processes
- Design, assembly and qualification of micro-mechatronic packages
- Functional rapid technologies

HIGHLIGHTS

- Simulation of complex mechatronic systems
- Process simulation of the encapsulation of microsystems
- Transfer-molding of high-reliability modules
- Embedding of mechanical/electrical systems using Rapid Technologies



3D MID assembly



Microhelix: Prototype made by rapid processes

›› SHORT PORTRAIT

The Fraunhofer IZM department Micro-Mechatronic Center develops technologies for mechatronic systems with mechanical, optical, electrical, power, chemical and software functions. Mechatronic assembly technology is the key to high performance mechatronic devices.

We conduct advanced research, focusing in particular on process simulation, novel interconnection methods designed for mechatronic applications and a variety of different encapsulation methods. The application of simultaneous mechanical and electrical design combined with novel rapid prototyping concepts facilitates the fast development of cutting-edge technologies. Interconnection of the modules with electrical, mechanical and optical interfaces is possible, as well as assembly on 3-dimensional substrates. Advanced packaging solutions for electronic systems, including the use of high performance polymers, are a second focus of our department. Finally, we also perform detailed reliability investigations, measuring thermal, dynamic, mechanical and chemical stresses.

Fraunhofer IZM's Micro-Mechatronic Center represents a synergistic cooperation between industrial partners and recognized IZM-specialists, to meet the demands and market requirements of small, medium and large enterprises.

›› TRENDS

Over the last year, mechatronics has emerged as a key technology in many branches of industry. Mechanical systems will increasingly provide intelligent system behavior through the integration of electronics.

Metrology and control technology have proven to be essential for engineering systems.

For medical equipment, extremely miniaturized modules are crucial in the development of sensitive robots, as well as self-determining, self-sufficiently operating sensor modules.

Along with the automotive industry, the mechanical engineering and plant construction industry has also adopted the superior performance and efficiency of our intelligent micro-mechatronic modules.

In the future, our research and development will focus on:

- Combination of system simulation and process simulation
- Functional polymers for micro-mechatronic packages
- White mechatronic technologies
- Rapid production technologies for embedding of electronics

›› RESEARCH RESULTS

Process simulation for encapsulation |

The department develops advanced methods for optimizing the polymer encapsulation of mechatronic and microelectronic systems. A particular focus is on QFN (Quad Flat No Leads) packages, which have several advantages, including superior design flexibility, scaling possibilities and excellent thermal behavior. Numerical simulation of the encapsulation process provides answers to many key questions regarding optimizing tooling geometry and choosing materials. To minimize stress on electronic components, we optimize critical failure sources during industrial encapsulation processes. These failure causes include forces acting on sensors due to polymer flow, as well as stresses caused by polymerization shrinkage, CTE mismatch and during the ejection of the part from the mold tool. Additionally, stresses during the entire encapsulation process can be measured using fiber-optic Bragg grating sensors and this data used to optimize the respective processes.

Implantable hearing aid |

One focus over the past year has been on medical technology and bio-mechatronics. In close collaboration with the University Hospital „rechts der Isar" and the TU Munich, we are investigating the technology requirements of future implantable closed-loop hearing devices. A particular target has been developing intelligent solutions for detecting middle-ear vibrations in vivo. This will provide the basis for a novel means of conducting sound in future implantable hearing devices. A challenge has been the fact that the middle ear works as a highly sensitive pressure receptor, with vibrations of amplitudes in the order of several nano- to picometers. The highly sensitive measuring method required means innovative sensor technology has to be developed and specific modulation processes applied. In particular, requirements with regard to the biocompatible, biofluid-dynamic, system integration and packaging aspects of the electronic components will be investigated.

Microhelix |

The project Microhelix was a collaboration between our department and the German Aerospace Center (DLR) and the Solar Institute Juelich (SIJ). One goal of this project was developing an alternative heliostat for solar tower power stations. The new heliostat with its compact construction was to replace the heliostats used to date, which are stiff and easily impacted by wind. The developed so-called Microhelix comprises 25 individual mirrors. These are interconnected by a suitable actuator, which moves the mirrors over approx. 45° in elevation and azimuth, such that the mirrors are able to follow the sunlight over the course of the day. Various concepts were tested for the actuators, with a view to optimizing the overall accuracy and adjustment of the mirrors. Individual parts and assemblies of the Mikrohelix were manufactured using established Rapid Prototyping procedures.

CORE COMPETENCIES

*WAFER LEVEL INTEGRATION

Dr. P. Ramm

Prof. Dr. T. Geßner

O. Ehrmann

» WAFER LEVEL INTEGRATION

Si Technology and Vertical System Integration

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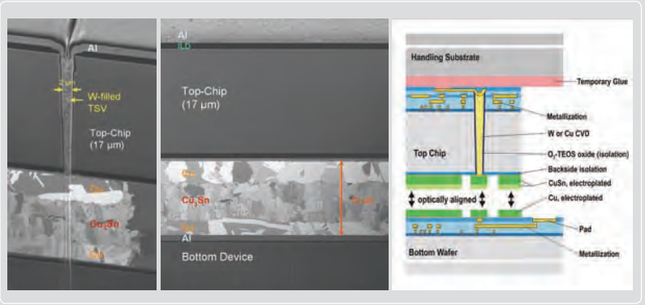


ICV-SLID technology – 3D decive stack with CVD-tungsten TSV; FIB left: Region with TSV; FIB right: Cu/Sn SLID bond in detail; Right: Schematic diagram

COMPETENCIES

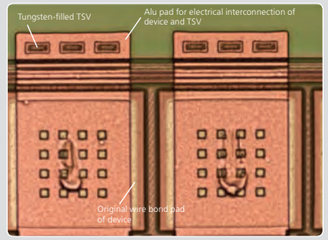
Research Units
- Wafer technology
- Functional layers
- Process & design integration

Competences
- Innovative Si and SiGe technologies
- Vertical system integration
- Customer-specific solutions
- Development of test structures and process integration

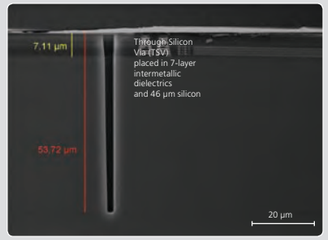
R&D Technology Line
- 200mm CMOS process technology

HIGHLIGHTS

- 3D System integration of industrial product devices
- Fabrication of CMOS-compatible electrostatic carrier wafer for 3D process application
- Extension of physical analysis for SiGe-layers with high Ge content (competence center SiGe technology)
- CMOS-compatible processing of mobile electrostatic carrier, 3D-integration of product devices



Interconnection of product device and TSV with aluminum pad



50 µm TSV etched through 7-layer intermetallic dielectrics

›› SHORT PORTRAIT

The department´s objectives are the integration of new materials and processes for Si-based semiconductor technologies as well as the development and optimization of CMOS-compatible technologies for fabrication of 3D-integrated micro/nano-electronic systems: Vertical System Integration - VSI®.

New micro/nano-electronic systems can be realized by VSI® of fully processed device substrates by means of low-cost back-end processes. For the industrial user VSI® offers a maximum of flexibility by using existing mainstream technologies in combination with maximum density of electronic functionality. Minimal interconnection lengths and low parasitics improve the system performance. Device layers – independently manufactured and tested – are vertically integrated into a 3D chip by using standard CMOS wafer fabrication processes (wafer-level 3D integration).

Second main competence of the department is development and analytics of Silicon-Germanium epitaxial layers (CVD process) for innovative CMOS applications and new integration methods for photonic systems.

The charge carrier mobilities of CMOS transistors are substantially improved by using strained silicon (sSi) as semiconductor substrate resulting in significant improvement of speed rates.

›› TRENDS

The potential for low-cost fabrication will be the key for future applications of 3D integration. Today fabrication of systems-on-a-chip (SoC) is based on embedding multiple technologies by monolithic integration, but there are serious disadvantages. The chip partition with the highest complexity drives the process technology, leading to a cost explosion of the overall system. In contrast, suitable 3D integration technologies enable the combination of different optimized base technologies with the potential of low-cost fabrication through high yield and smaller IC footprints: Device stacks (e.g. controller and memory layers) fabricated with optimized 3D integration technologies will show reduced production costs compared to monolithically integrated SoCs.

Furthermore, new multi-functional micro-electronic systems can be realized by 3D system integration: Ultra small smart systems for applications like e.g. distributed wireless sensor networks. For future applications, such systems for ambient intelligence will be highly miniaturized: so called e-CUBES®. The advantages of 3D integration technologies include: Extreme system volume reduction, reduction of power consumption (for lifetime enhancement), reliability improvement and low-cost fabrication for meeting mass market requirements.

›› RESEARCH RESULTS

Using our longstanding experience in the design of 3D-integrated test devices as basis, our department has been focusing on fabricating functional 3D-ICs. In a research breakthrough, we were able to apply the complete 3D system integration sequence of the ICV-SLID process to an industrial product with a complex CMOS layer structure. If free space is not designed into the device for placing the through silicon vias (TSVs), they have to be realized within the dicing frame between the chips.

For the specific application in question, an ASIC wafer, the TSV must first be etched through 7 µm intermetallic dielectric layers, including silicon nitride, fluorinated oxides (low-k material) and cobalt silicides. Subsequently, the silicon of the device substrate is etched with Bosch-type chemistry to a depth of approximately 50 µm. The TSV is isolated by oxide CVD and filled with metal, preferably CVD-tungsten. A supplementary aluminum metal pad next to the bond pad ensures the electrical interconnection between TSV and device.

Efficient handling and processing of thinned Si-substrates is becoming increasingly important in Vertical System Integration. An efficient method for fabricating 3D ICs is using suitable adhesives to temporarily bond device wafers to a rigid handling wafer – as long as the material satisfies a set of stringent requirements. In the future this technique may be replaced or at least supplemented by a novel handling process that employs mobile electrostatic carriers (“mobile e-Chuck”), fabricated by processing a standard Si-wafer. The corresponding principle is based on electrostatic forces between the e-Chuck wafer, serving as a mobile handling substrate, and the thin device wafer or chips.

A DC voltage is applied to the backside of the e-Chuck carrier wafer, which is routed to two electrodes on the front side, enabling an electrical field between the top dielectric layer of the e-Chuck wafer and the thin Si wafer or chip. Briefly, the fabrication sequence of the CMOS-process e-Chuck wafer is as follows: 200 mm Si wafers are isolated by thermal oxidation, coated with a conducting layer pattern and finally covered with a dielectric layer. The backside contact is realized by a so-called “poly-strap” around the wafer edge. Sufficient electrostatic forces to hold thinned substrates for 3D processes are realized by DC voltages of up to 400 V (depending on the dielectric layer’s thickness and type).

A model for the dispersion-relation of a SiGe-layer with a Ge-content up to 60% has been developed by the Competence Center SiGe Technology in order to extend the physical analytics. For example, the starting layers of a SiGe-stack, which is used as a resonator within a MEMS device, can be analyzed using inline spectral-ellipsometry.

Multi Device Integration

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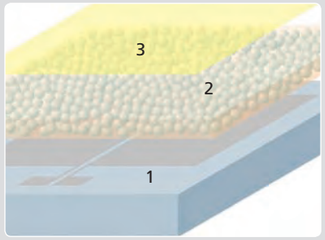
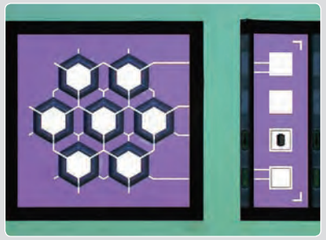


Nano-composites

1: Flexible substrate with bottom electrode
2: Nanocomposite
3: Top electrode



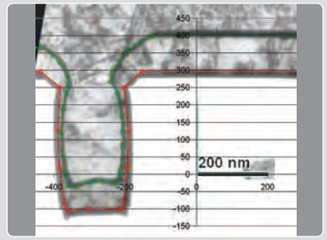
Low-frequency capacitive micromachined ultra-sonic transducer

COMPETENCIES

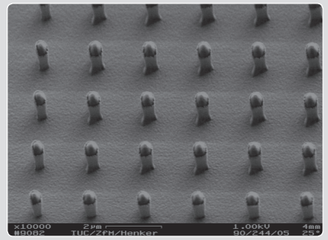
- High-temperature processing
- Layer deposition by CVD and PVD
- Wet and dry etching
- CMP, wafer bonding
- Chip and wire bonding
- Wafer lithography
- Mask design and fabrication (3" to 7")

HIGHLIGHTS

- Low-temperature bonding
- IC-compatible wafer-level packaging
- Nano-structured bonding surfaces
- Polymers with magnetic properties for microfluidic actuators
- Nanocomposites with enhanced dielectric properties
- Piezoelectric polymers for low-cost sensor and actuator applications
- Metallization for 3D-integration
- Airgaps for low parasitic capacitances in nano-interconnect systems



Simulation of the deposition of a copper starting layer by means of PVD



Dielectric nano-needles (d~400 nm)

›› SHORT PORTRAIT

The main activities of MDI systems and component design are MEMS/NEMS design and development, system integration and prototyping of sensor and actuator devices as well as testing and characterization of MEMS/NEMS.

Research work within the group "Technologies/Waferbonding" concentrates on the development and application of wafer bonding processes for MEMS packaging on wafer-level and 3D-patterning technologies for silicon and non-silicon materials.

The main activity area of the "Back End of Line (BEOL)" group includes the development of materials, processes and technologies for fabrication of on-chip-interconnects. Additionally, the simulation and modeling of processes and equipment are key topics. The group also focuses on chemical-mechanical planarization (CMP) processes.

The "Printed Electronics" group utilizes inkjet and mass-printing technologies to develop efficient industrial fabrication processes for printed components used in smart systems. Major applications developed here are in the area of printed electronics and microfluidic components, as well as stand-alone energy systems.

›› TRENDS

Over 2007 the new structure of the institute's Chemnitz branch and its department MDI was consolidated and research topics were expanded to an even greater extent. Micro- and nano-technologies, as well as system integration and reliability are playing key roles in smart systems throughout industry.

System integration in smart products will determine the economic success of manufacturers and users in near to all markets. Particularly the automotive, aeronautics, consumer electronics, telecommunication, mechanical engineering, and medical technology industries will require rapidly progressing technological innovation to maintain competitiveness.

The new department Back-End of Line (BEoL), lead by Dr. Stefan Schulz, has been founded to follow-up on this area of development. Furthermore, the Fraunhofer IZM department Advanced System Engineering is working in close collaboration with MDI.

Last but not least, construction of a new building for the Chemnitz branch of Fraunhofer IZM has begun, with the foundation stone laid in a special ceremony at the close of 2007.

›› RESEARCH RESULTS

Process development for nanoelectronics |

Metallizations in nanoelectronics require ultra-low k (ULK) dielectrics or airgaps to cope with increasing parasitic capacitances. We develop processes for Cu interconnect systems with low-k and ULK dielectrics for AMD Dresden's 45 and 32 nm micro-processor technology. Our research on the airgap approach has also seen the department develop and successfully demonstrate a specific process flow for multilevel architectures. Here, wet etch as well as CMP processes were addressed. Moreover, the potential of airgaps has been analyzed by electrical, thermal, and mechanical simulations. In 2007, SIMKON, a 3-year R&D project was initiated to investigate multi-scale modeling of CMP in collaboration with the market leader Qimonda. Together with AMD in Dresden, several investigations are carried out regarding the scalability of PVD films and reliability parameters in the fabrication of future metallization systems.

Integration of nanomaterials |

Nanomaterials promise a wide range of possible applications thanks to their novel properties. However, to benefit from their many advantages, such as low material costs, scalable technologies and innovative properties, the mainly polymer-based materials have to be properly integrated into existing technology platforms. For this reason, the department researches nanomaterials, as well as other materials, and technologies required for integration with smart systems.

Waferbonding and packaging technologies |

This investigation focuses on joining wafers or chips at low temperatures (e.g. 150~200 °C) with the help of nano-scaled metal needles. Research shows that crystal grains of Au and other metals can grow at relatively low temperatures, and the growth rate is inversely proportional to the scale of the material. By forming and contacting densely allocated metal needles, joining or even sealing micro-devices at low temperature is possible.

Two methods have been developed for the formation of metal nano-needles. In the first variant, Au is selectively grown on a gold-plated substrate, with pre-deposited PE-oxide acting as a formation-mould and sacrificial layer.

In the second technique, dielectric needles are first formed through masked plasma etching and then coated with a gold layer to form conductive and adhesive shells. Both methods demonstrate advantages. In the galvanic processing forming the metal needles with a high-aspect ratio is possible but the uniformity of the needles is low.

On the other hand, in the sputtering process, a uniformly distributed needle-array is formed but their aspect ratio cannot be large to prevent lateral underetching destroying the structures. These problems can be solved by choosing appropriate process parameters. Further experiments are continuing.

High Density Interconnect & Wafer Level Packaging

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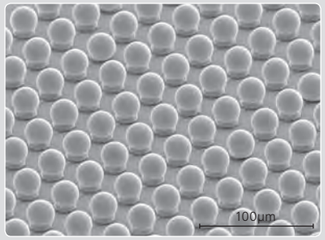
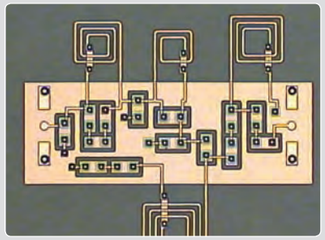


Fine pitch AnSn bumps (bump size 20µm, pitch 35µm)



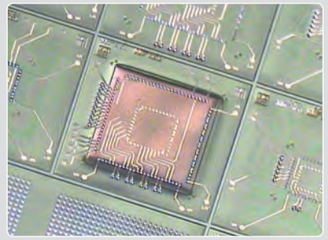
Integrated passive device (IPD) with coils and capacitors

COMPETENCIES

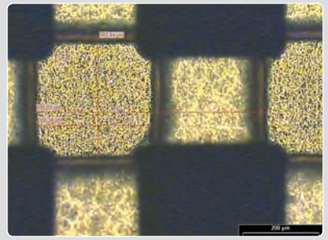
- **Wafer-level CSP**
  - Cu redistribution, polymer dielectrics, reliability investigation
- **Wafer bumping**
  - Electroplating of structures in photoresist masks, bumping materials Cu, Ni, Au; PbSn, AuSn solder; lead-free solder, optical inspection
- **Thin film multilayer**
  - Customer-specific layout, multilayer routing, chip-first, flip chip
- **Micro energy systems**
  - Wafer-level battery, micro fuel cell, hermetic sealing

HIGHLIGHTS

- ATLAS Supplier Award received for processing of 1300 pixel detector modules for the CERN LHC particle accelerator
- Development of copper filled through silicon vias
- Development of a numeric model for a PEM fuel cell to optimize the micro-structured current collectors with integrated flow field
- Realization of planar PEM gas cells without gas diffusion layer (GDL) with maximum power densities of 160 mW/cm² at ambient temperature



Thin chip integration with a BCB layer as planarization (thickness of the die: 40 µm)



Cathode current collector with integrated flow field structure

›› SHORT PORTRAIT

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

Production-compatible equipment for thin film processing in a 800 m² clean room determine the technological possibilities. The department cooperates with manufacturers and users of microelectronic products, as well as with clean room equipment producers and material developers from the chemical industry from all over the world.

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

Processable wafer size is limited from 100 mm to 200 mm. In cooperation with some equipment manufacturers, 300 mm tools are being introduced step by step. The service in the above areas can also include a technology transfer even to customer-specific tools.

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

›› TRENDS

- Redistribution to the backside of the wafer
- Copper filled through silicon vias
- Fine pitch redistribution
- Chip-on-chip devices
- Integration of R, L, C in wafer level redistribution
- Process integration of high-K-materials
- Development of integrated passive devices (IPDs)
- Polymer layer for RF applications
- Autonomous power supply for microsystems
- Micro fuel cells (1 cm³)
- Integrating micro batteries on wafers and foils
- DC/DC converter based on integrated magnetic materials
- Assembly of ultra fine pitch pixel detectors
- Technology for compliant bumps
- Consulting and application center for industry

›› RESEARCH RESULTS

Thin chip integration |

There is a continuous trend to accommodate more functions in the same microsystem package volume. At the same time the pressure to decrease costs increases. To achieve higher integration densities and lower manufacturing costs, a holistic view of microsystem design, manufacture, and packing is required. As an alternative to discrete integration over intermediate packing, the current state of the art, Fraunhofer IZM developed thin chip integration. Thin chip integration is currently used in several projects.

One example is the use of a completely processed MEMS-wafer as the substrate. A thin layer of BCB is deposited on the wafer and photolithographically structured. The BCB layer is opened over the contact pads of the base wafer using this method. In the following step the polymer layer serves the purpose of bonding to thinned ASIC chips with the contact side up. The bonded ASIC chips are then embedded with a further layer of BCB. Then the contact pads of the base wafer and the embedded chips are opened. Electroplated copper conducting lines connect and rewire the pads. An additional BCB layer covers the redistribution layer. To finish a final metallization is produced and solder balls are electroplated.

Micro fuel cells |

The goal is to manufacture small fuel cells that will be cost effective and competitive with batteries for small applications. Using basic wafer level packaging and circuit board technologies this goal can be achieved. From the basic thin film and wafer level packaging technologies PEM micro fuel cells with an active surface area of 1-2 cm² were developed. For this purpose a numeric model was developed which describes the coupled relationship between electro-chemical and fluid-dynamic reactions. Two opposing limiting influences in the fuel cell were shown by the simulation.

The first concerns electrical losses due to the film resistance of the catalyst electrode layer, which resulted from the lateral dissipation of the electrical charge carriers over the channel width. The second limiting influence is transport relative to supply problems dependent on the width of the reaction areas in the channels and the maximum power density of the fuel cell. Using these models the anode- and cathode-side current collectors with integrated flow field were optimized for fabrication using microstructuring and thin film technologies. This made possible a working fuel cell without gas diffusion layers which obtained power densities of over 160 mW/cm²

CORE COMPETENCIES
* MATERIALS AND RELIABILITY

Prof. Dr. M. Bauer

Prof. Dr. B. Michel

» MATERIALS AND RELIABILITY

Polymeric Materials and Composites

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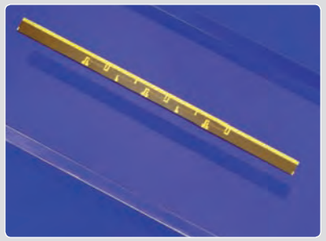


Thermooptic switch (polymer). Visible is the switching

Development of optical devices – from the monomer, prepolymer and polymer to the athermal all-polymer AWG

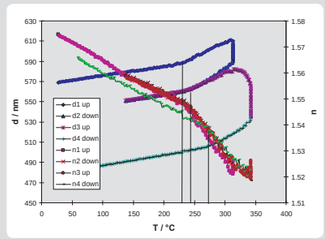
COMPETENCIES

- Synthesizing, modifying and recycling both polymeric materials and composites
- Analytical and physical-chemical characterization of monomers, oligomers and polymers
- Thermophysical and mechanical characterization of polymers and composites
- Composite technology and structural parts' construction
- Display technology and pilot production of displays (for test samples)
- Developing adhesives, casting resins, laminate resins and coatings
- Barrier and isolating layers
- Polymers for integrated optical devices

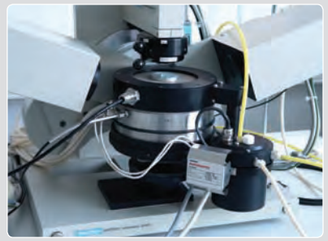
HIGHLIGHT

Properties of polymers in thin film state, such as low-k dielectrics, determined by nano-TMA/TGA/DVS:

- Thermal expansion behavior
- Thermal stability
- Glass transition temperature
- Degree of curing
- Water uptake



Thermal expansion behavior of a polycyanurate co-polymer showing the increase in glass transition temperature during successive heating and cooling scans and thermal degradation at higher temperatures



Nano-TMA/TGA/DVS Device

›› SHORT PORTRAIT

Fraunhofer IZM's Polymeric Materials and Composites Branch Lab is located in Teltow (Federal State Brandenburg). Materials integration has become increasingly important for developing both new components and products in recent years. The Teltow Group's research field is therefore developing polymeric materials and composites. These polymeric materials are applied as adhesives, binders for laminates, coatings, casting resins etc. in various branches, e.g. (micro-, opto-) electronics, aerospace, automotives and lightweight construction.

Developing new characterization methods is complementing material research; industrial tests are accompanying material development. Last but not least the accumulated knowledge is used in consultancy, e.g. within the frame-work of the Application Labs.

The personal union of the head of the Branch Lab and the professorship at the "Polymeric Materials" Department at BTU Cottbus enable a close and fruitful cooperation between research and science. The opto- and microelectronic industries are the main cooperation partners for Fraunhofer IZM Teltow. The professorship concentrates upon lightweight engineering applications.

We hold key patents in these research fields. As of January 2008 the Branch Lab Polymeric Materials and Composites of Fraunhofer IZM in Teltow operates as the independent Fraunhofer Research Institution for Polymeric Materials and Composites PYCO.

›› TRENDS

New low-cost products, with novel characteristic profile will be made accessible through specific design of polymeric materials and composites.

New polymeric materials for micro- and opto-electronics lead to both chips and devices with higher integration levels, thus to new products with higher performance.

Nano technology plays a key role in this area. For instance: nano technology leads to transparent polymer materials for optical integral component parts, barrier layers with a high content of nanofillers, excellent scratch resistance, mechanical strength and hardness.

All polymer design for athermal arrayed-waveguide-gratings and printed circuitry, among many other areas, is a further research work objective at Fraunhofer IZM Teltow.

Flame resistant materials, novel core materials and a special surface design will be made available primarily to the light weight construction branch.

Sustainability will be taken into account for all developments, as has already been shown in the case of halogen-free base materials for printed circuit boards.

›› RESEARCH RESULTS

Characterization of low-k materials by nano-TMA/TGA/DVS |

Apart from the use of materials with chemical bonds exhibiting low polarizability, development of low-k dielectrics was pushed ahead primarily by reducing the dipole density of the material through the incorporation of pores (subtractive porosity) or enhanced free volume (constitutive porosity). Integration of pores is essential to reaching very low dielectric constant values, however it does pose technical problems in the damascene process (e.g. reduced elastic modulus, requires thick diffusion barrier layer). As a workaround, we investigated reducing the dielectric constant of polycyanurates by enhancing the free volume via copolymerization with monofunctional cyanate monomers.

Thermophysical characterization of low-k layers was performed by means of nano-thermo-mechanic analysis/thermo-gravimetric analysis/dynamic vapor sorption (nano-TMA/TGA/DVS) to determine the influence of copolymerization on the free volume of the polymer network and the resulting properties.

Using nano-TMA/TGA/DVS, various thermophysical properties of the polymer can be measured on the one sample in thin film state, replacing what normally requires several methods and several samples to characterize the bulk state. The thermophysical properties collected using the new technique were correlated with the value of the dielectric constant.

Our investigations showed that the degree of curing strongly affected the free volume and thus the dielectric constant. Disregarding the effect of the curing degree could lead to the dielectric constant values being incorrectly interpreted.

Enhancement of the free volume by copolymerization was less successful. Only co-monomers which had a very bulky shape have led to a distinct reduction of the dielectric constant.

Other results of copolymerization included a reduced glass transition temperature, reduced thermal stability but also a reduced water uptake in an almost linear dependence of the amount of co-monomer.

Micro Materials Center

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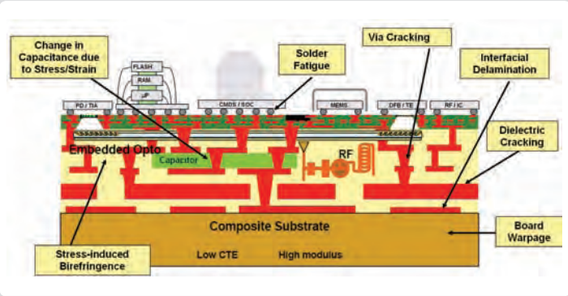


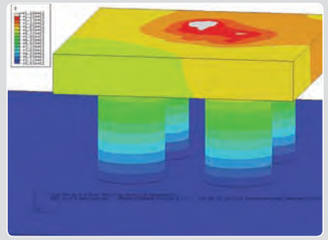
Potential failure mechanisms in microsystems

COMPETENCIES

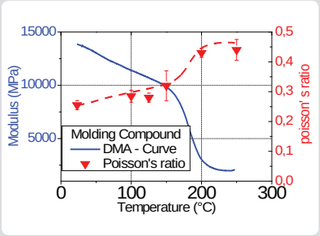
- Mechanical and thermal reliability analysis
- Micro- and nanomaterials testing and simulation
- Microreliability
- Nanoreliability
- Security research (micro- and nanosecurity)
- Solder joint reliability
- Thermal management of electronic systems
- Micro- and nanodeformation analysis
- Lifetime estimation and optimization of components in microelectronics and automotive electronics

HIGHLIGHTS

- New test methods for microcomponents, micro- and nanomaterials under complex loading (mechanics, thermal behaviour, humidity, vibration)
- Combined simulation and experiments in micro- and nano-electronics, sensor technology and automotive applications
- The publication series “Micromaterials & Nanomaterials” (editor: B. Michel), published by the Micro Materials Center Berlin at Fraunhofer IZM, has attracted worldwide attention. Issues of M&N can be found in more than 100 libraries world-wide, among others in The Library of Congress in Washington or the libraries of Harvard and Berkeley



Temperature distribution on a VCO and the thermal vias



Temperature-dependent poisson’s ratio of a mold compound

›› SHORT PORTRAIT

The department’s key research area is the thermal-mechanical reliability of microcomponents and micro-systems. We also work on problems involving nano materials (nanoreliability).

Over the past year we have obtained outstanding results, including:

- Reliability analysis of microelectronic and nanoelectronic systems
- Evaluating components in automotive electronics
- Developing and expanding the Fraunhofer Micro Materials Center Berlin (MMCB), funded by Berlin State and the German Federal Government
- Publishing both the “Microsystem Technologies” journal and the “Micromaterials & Nanomaterials” series
- Running the “European Center for Micro- and Nano-reliability” (EUCEMAN) headquarters, see www.euceman.com
- Eight Ph.D. students, several of them from private enterprise (IBM, Infineon, Bosch, Qimonda) researched their theses at MMCB
- Space and aviation microcomponent reliability has been established as a new field of MMCB research

›› TRENDS

- Applying modern field coupling and multiscale modeling in reliability prognoses
- Inclusion of combined field interactions in both reliability analysis and lifetime estimation (mechanical loading, temperature, humidity, vibration, electric fields etc.)
- Establishing microDAC, nanoDAC and FIBDAC deformation techniques as industrial measuring tools for broad application in various fields
- Physics-of-failure approach for understanding reliability concepts with direct coupling to simulation
- Further advances in the micro- and nanosecurity field (combining security research, miniaturization tasks and reliability estimation)

›› RESEARCH RESULTS

As part of the program „Driver Assistance Systems“, funded by the German BMBF, Fraunhofer IZM is helping develop a cost-effective radar sensor. Here, the Micro Materials Center closely cooperates with the Chemnitzer Werkstoffmechanik GmbH.

Numerical investigations by means of FEM have been carried out for a thermal pre-optimization of the electric circuits as well as of the manufacturing process and its specifications. We were able to demonstrate that the real heat source distribution at the active chips has to be taken into account to accurately describe and not overestimate heat dissipation. For the sub-module and its casting into the demonstrator a series of thermal-mechanical FE-models were generated. The unpreventable warpage from the manufacturing process was determined without the use of real parts. The results were compared by microDAC deformation analysis performed on the first available specimens. Very good correlation was obtained due to reaction shrinkage in the mold compound. Finally, we were able to pinpoint recommendations for the further design process and carry out initial reliability assessments.

In microsystem technologies, a wide range of polymer materials are used to realize electronic components. This means that, alongside the enhancement of performance and multifunctionality, the demands on reliability for higher operating temperatures increase.

In our Micro Materials Lab we have developed an advanced measurement method for the determination of moisture-dependent parameters for micro- and nanoscale samples. In combination with FE-analysis, these tools (involving time, temperature, and humidity) ensure a high degree of reliability.

Through the use of an advanced image-correlation tool (microDAC), temperature-dependent and local deformation fields can be examined on a variety of miniaturized sample surfaces.

The influence of humidity on materials behavior shows that the humidity diffusion not only effects a shift in the glass transition temperature and a reduction in the modulus, but also significantly influences the viscoelastic properties.

CORE COMPETENCIES

SYSTEM DESIGN & SUSTAINABLE DEVELOPMENT

Dr. N. Nissen

Dr. S. Guttowski

W. John

Dr. M. Richter

» SYSTEM DESIGN & SUSTAINABLE DEVELOPMENT

Environmental Engineering

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COMPETENCIES

- Sustainability strategies for the electronics sector
- Environmentally benign product design – analytics, assessments, and engineering
- Industry working groups: "Lead-free interconnection technology in electronics", "Design for compliance with WEEE / RoHS / EuP"
- Environmental and economic process optimization
- System reliability and lifetime estimation
- National and international networking activities
- Green Electronics activities for education and training

HIGHLIGHTS

- Successful completion of preparatory studies for EuP implementing measures with broad stakeholder involvement from the international electronics industry
- Worldwide requests for presentations about European legislation
- Trials and assessments for new materials from renewable resources for electronics applications
- 2nd Workshop on the Chinese RoHS

Low power loss ballast: Ecodesign realizes size and material reduction

H. Griese (2nd f. r), department EE, moderates the Symposium on innovative environmental technology at the „Woche der Umwelt" in Berlin

›› SHORT PORTRAIT

Our research activities support conscious design of electronic products and technologies for sustainable development. We aim to find innovative solutions for the industry. Therefore, we work in close collaboration with companies from the earliest stages of product and process development.

To achieve more sustainable development, it is necessary to assess the positive and negative impacts of technology trends. Within this context we are working on quantitative and qualitative assessment methodologies, which address economical and ecological issues. We apply these together with partners from industry for continuous improvement of products. Our research focuses, in particular, on supporting the development of SMEs. Saving non-renewable resources by increasing energy efficiency, avoiding resource losses during disposal and the further reduction of potentially hazardous substances in electronics are typical starting points for our investigations. The use of renewable resources in electronic devices is a means of developing long term perspectives.

The demand for leadfree interconnection technologies still continues, particularly for SMEs and in Eastern Europe, with a shift from production transitioning to many open reliability issues. In the course of the gradual implementation of the EuP directive Fraunhofer IZM is not only very successful with studies for the European Commission, but is tackling ecodesign aspects directly for customers.

›› TRENDS

Climate protection and CO_2 reductions are now established among the top priorities in policy and in industrial practice. Sustainable development, ecodesign, extended producer responsibility and closed material loops are concepts that have entered the management of many enterprises in the electronics sector. This trend is driven by legislation, and to an increasing extent by market changes, that is, higher demand for environmentally benign technologies and products.

According to a life cycle oriented approach to product design (or life cycle design in short) the reliability of electronic systems is an increasingly important contribution to sustainability. Interest in miniaturized product health monitoring is especially visible in automotive electronics, but also for production technologies or for other transportation engineering from trains to helicopters.

We are convinced that thoughtful design, production, use and reuse of electronics can significantly contribute to a worldwide increase in quality of life. Environmental and sustainability strategies are preconditions for realizing this vision. Through international networking activities we contribute to both human-oriented and sustainable development, as an ethical backbone of globalization.

›› RESEARCH RESULTS

Environmental Engineering on behalf of the EU |

During 2007 the Preparatory Studies for the implementation of the EuP directive have been successfully completed for the product groups Lot 4 "Imaging Equipment", Lot 5 "Television", Lot 6 "Standby and Off-mode Losses", and Lot 7 "Charger and External Power Supply". Feedback from external participants has been very good for these studies, especially regarding the fitting combination of neutrality, open discussion style and profound technical knowledge.

The earlier integration of stakeholders into a legislative procedure, which in the end will set binding technical requirements for a large number of products, is a new element of European legislation. The EuP is the framework directive for setting Eco-design requirements for the majority of all energy using products. After the first rounds of preparatory studies have now finished, additional product groups will successively undergo investigations. Fraunhofer IZM is currently working on the study for „complex set-top-boxes".

Between 2005 and 2007 the department Environmental Engineering has also examined more than 100 applications for exemptions from the substance restrictions according to the RoHS directive. In successive consultation rounds recommendations for accepting or rejecting exemption requests were prepared for the Technical Adaptation Committee (TAC). In 2007 and 2008 Fraunhofer IZM together with Ökoinstitut will now review all RoHS exemptions, which have been granted so far. In a separate investigation all material ban exemptions from the end-of-life vehicles directive will be reviewed, such as the continued use of lead in automotive electronics or in ceramics.

Condition monitoring for electronic assemblies |

In continuation of the research work on capturing load states during product use (via small integrated sensor blocks called LIM or LCU) sustainability strategies involving system reliability aspects are now developed.

Depending on product characteristics short life cycles require minimal resource use and high end-of-life recovery, while for long use cycles the focus shifts to failure mode prediction and predictive maintenance. The methods to assess the technical condition of electronics during use will first be implemented for higher value, long lived products.

System Design & Integration

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Worldwide smallest sensor-node with ad-hoc capability (Mica-Z-Chipset)

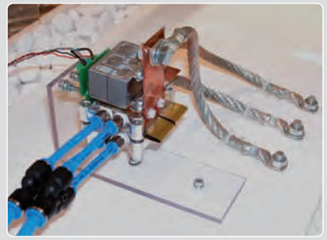
4-port measuring equipment for RF characterization of coupled structures

COMPETENCIES

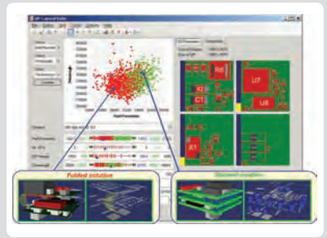
- Technology-oriented development of heterogeneous micro- and power electronic systems, from feasibility studies and cost estimates, to technology evaluation, package design and construction, right through to realization and characterization of prototypes
- RF- & EMC-aware development and characterization of technologies and systems
- Antenna development and characterization

HIGHLIGHTS

- Demonstrators for advanced RFID-Solutions
- Demonstrators for new packaging technologies for power electronic systems, double-sided cooling of power semiconductors
- Characterization of antennas for mobile applications
- Design methods for highly integrated EMC filters
- M3-approach to optimal and cost-effective design of system packages & PCBs
- Novel method for defining the electrical boundaries of all geometrical discontinuities



Power semiconductor assembly with double-sided cooling



3D-SiP-Expert: A tool for the multicriteria physical design of vertically integrated systems in package

›› SHORT PORTRAIT

The department System Design & Integration develops methods and tools used for customized and technology-oriented design of electronic systems. Theoretical methods form the basis for simulations of all kinds of electromagnetic and thermal and mechanical behavior and coupling. Using such a characterization approach makes analyzing, evaluating and comparing different technologies right in the design phase possible. In other words, the design flow is optimized and the particular specifications of the systems to be designed considered.

Function, volume, reliability and costs can be analyzed according to technological parameters as early as the design stage, resulting in economic and technological benefits.

The main research activities of the department center on microelectronic and microsystem development, in particular focusing on wireless sensor systems, package design and characterization, RF and high-speed system design, as well as EMC and the packaging of power-electronic systems.

›› TRENDS

Design automation for vertically integrated heterogeneous systems is one future key EDA challenge. Not only simultaneous calculation of several different design and integration alternatives, but also concurrent estimation of thermal, RF and manufacturability parameters as early as the design stage will be among our main activities in the near future.

Starting from models of the geometric, electric and thermal behavior of components that take into account the wiring as well as technological aspects, we will explore theoretical base for system-specific technology decisions and placement of components.

Furthermore, issues related to the electrical design of highly miniaturized wireless mixed-signal systems will be of prime importance. Particularly, we will focus on the optimal design of signal & power distribution networks and microantennas, while exploring the possibilities of new packaging technologies.

Novel techniques for characterizing the electrical behavior of mesoscopic structures will be developed.

In the near future, we will also be researching the application of new technologies for power electronic systems to increase power density and reliability and the integration of suitable switches with sensor and logic components. This will involve investigating technological solutions as well as design methodologies for mechanical and electromagnetic co-design.

›› RESEARCH RESULTS

The Department of System Design and Integration (SDI) is meeting the growing need for technologically-oriented system know-how within Fraunhofer IZM.

As part of the R&D preproject “AVM“, the first step was taken toward integrating self-sustaining microsensor systems into applications.

Devising a methodology for the cost-efficient design of wireless sensor networks could push ahead development of low-cost radio sensor nodes significantly. This means that cost and miniaturization factors can be considered during the design phase, along with the fabrication constraints. For this purpose, a cost analysis platform was implemented, consisting of a modular test platform for wireless sensor nodes, as well as a design tool for the technology selections based on cost models.

In the area of design automation for 2.5D SiP, the first software prototype to encompass constrained component placement and technology selection, 3D-SiP-Expert, has been successfully debuted in industry circles.

A further coup has been the development of the “M3“ approach, which facilitates the optimized and cost-effective design of packages and PCBs for RF and high-speed applications. First of all, novel methods were developed to extract accurate electrical models. These models are then used to perform numerous RF, signal and power integrity analyses. Based on the extracted results, optimal design measures were extracted to improve performance and minimize cost.

For various encapsulation materials, the permittivity and loss tangent were measured in dependence on both frequency and temperature.

The department’s overlapping research activities within the field of new packaging technologies for power semiconductors, such as soldering and embedding technologies, have been bolstered.

Several methods for electrical and thermal characterization by simulation, as well as practical experiments with new packaging technology demonstrators are now being employed.

Furthermore, a test bench has been developed allowing the analysis of fatigue mechanisms and lifetime models of power modules under real operating conditions.

Especially the new challenges from integrating hybrid automotive traction have led to an increased demand for our newly developed methodology.

For the same application a packaging concept with double-sided cooling was developed, tested and presented to the public. It has doubled the performance of power semiconductors.

Advanced System Engineering

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Smart label (electronic information carrier - Passive RFID system - 2nd generation bistable display)

COMPETENCIES

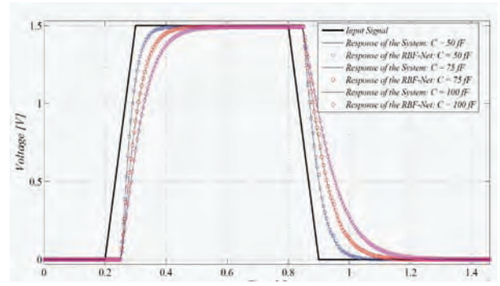
- Mobile wireless intelligent sensory systems
- RFID antennas and circuits
- Modeling and analysis of EMC- and SI-effects (HDI/HDP/PCB)
- EMC/EMR at the IC-level
- EMC/EMR of micro- and nano-electronic systems
- Design for multiple device integration
- Model-based development methods for heterogeneous systems and SiP (MoreThanMoore)
- Knowledge-management for micro-electronics

HIGHLIGHTS

Passive DRFID system
- Display for the variable information of the passive RFID system
- Preservation of information over a long period of time (6 months)
- 180° readability/simple solution for reading- and writing-devices
- EMC compliant for industrial engineering and IT infrastructure

Black box modeling
- System identification, model-based development

Near-field scanning system
- High precision for the positioning of field probes (< 1 µm resolution)
- Fast measurements in the time and frequency domain
- Extraction of emission models and source reconstruction



Behavior of an output-driver as a function of time and the load (original vs. RBF-net)

›› SHORT PORTRAIT

The Fraunhofer IZM department Advanced System Engineering (ASE) in Paderborn conducts research and development for the design, electronic simulation and characterization of micro- and nano-electronic systems and microsystems.

The department has more then ten years experience in the fields of system integration and electromagnetic reliability of miniaturized electronic modules and systems.

The department ASE's core competencies of design and modeling have been systematically enhanced since the beginning of 2006 for the business areas electromagnetic reliability (EMR – chip/module/system level) and MDI (RFID antennas and circuitry/model-based development/technology modeling (cost, data, parameter/3D-design methods)).

The main focus of the research is on modeling parasitic electromagnetic effects (electromagnetic compatibility, electromagnetic reliability, signal integrity and high frequency), not only for the IC-level but also for packages, modules and PCB. The work makes a crucial contribution to the development of reliable miniaturized systems.

Methods for the measurement and calculation of electromagnetic fields, as well as circuit simulations, at an analogue level are employed to analyze the transmission behavior of micro- and nano-electronic systems (cross-talk, reflection, changing of the nominal signal shape) in the time and frequency domain.

Furthermore, the department ASE develops RFID systems and antennas for use in harsh conditions.

The application areas EMR (electromagnetic reliability) and model-driven design are the ASE Department's specialty. These areas have been systematically developed and their success is reflected in the numerous R&D-projects acquired in collaboration with industry, specifically PARACHUTE (MEDEA+), EMCpack (PIDEA+), E-CAB (EU) and PARIFLEX (BMBF).

Additionally, the department closely cooperates with the University of Paderborn (Faculty of Electrical Engineering, Computer Science and Mathematics) and the Leibniz University Hanover (Institute of Electromagnetic Theory) within the competence network Future EMC/RF-Modeling and Simulation Methodologies.

The department's broad range of services facilitates the fast and effective employment of research results in industrial environments. Supporting industry to use innovative packaging techniques in versatile ways is one primary goal of the Department of ASE.

›› RESEARCH RESULTS

Passive RFID system with a bistable display |

A consortium of industry partners and the University of Paderborn, headed by Deutsche Post AG, is developing a new RFID system designed to replace paper-based information carriers used for tray management with a re-writable information system. Scientific guidance of the research project is provided by the Department of Advanced System Engineering (ASE). This new generation of information carrier comprises an RFID tag and display. The RFID tag holds a fixed identification of the tray and flexible data regarding the contents, both of which are required for controlling the tray. The display ensures the saved data can be read without an electronic reader. The saved data and the readable information on the display are stored without a separate energy supply over a long period of time.

An electromagnetic field produced by the RFID tag writer supplies the required energy to write on the display. Using a model (model-based development), the whole system can be calculated in terms of the transmitted energy (secondary side); the geometry factors that define the inductive coupling have to be determined by numerical field calculations.

Black-box modeling |

Black-box modeling is an efficient method for modeling and simulating complex HDI/HDP systems and integrated circuits. Combined with appropriate reduction methods (model order reduction), it is possible to efficiently simulate the signal integrity of complex systems. The results of the black-box modelling (input and output behaviour in the time domain - different terminating impedances) of an output driver (130 nm CMOS technology) by the parameterization of a RBF-net are depicted in the figure above.

Novel near-field scanning system |

A universal measurement procedure for the EME/EMS at IC- and PCB-level has not been available to date. As part of the project PARACHUTE, a novel near-field scanning system is being researched.

This system is intended to replace conventional scanning methods and will deliver high spatial resolution and sensitivity, as well as an increased measurement speed. It will be able to detect the propagation characteristics of RF- and pulse-interferences for emission and noise immunity measurements.

The resolution of the field probes in the range of micrometers necessary for ICs requires a mathematical post-processing-method to ensure precise physical measurements.

To minimize the scattering influence of circumjacent metallic bodies, the measurement object is placed beneath a fixed field probe. To optimally determine the traverse paths, the contour of the object is detected by a specially developed laser system.

Micromechanics, Actuators and Fluidics

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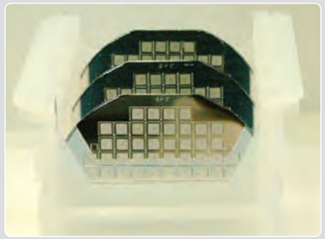
Silicon micropump in plastic housing



Micropumps, full wafer assembly

COMPETENCIES

Development of
- Micropumps
- Microdosing systems,
- Micromixers,
- Microvalves,
- Microreactors
- and flow sensors

Microfluidic actuators for
- Tissue Engineering

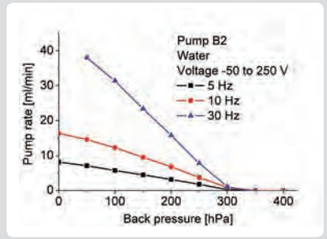
HIGHLIGHT

As part of a joint project between PARItec and Fraunhofer IZM, a novel high-performance micro pump is being developed for the humidification of therapeutic gases.

The micro pump consists of a piezo-electrically driven membrane and a pump chamber made of metal in this prototype phase. An injection-molded pump chamber is under development. The outer diameter of the round pump body is 30 mm, the thickness 4 mm.

The micro pump was tested with water and air. A flow rate of 50 ml/min with water was achieved, which is considerably higher than any other micro pump described in literature.

High-performance micro pump



Pump rate over back pressure

›› SHORT PORTRAIT

The department Micromechanics, Actuators and Fluidics develops intelligent solutions for the active handling of small quantities of liquids and gases. Micro devices especially for microfluidic applications can be applied to a wide variety of industrial solutions.

Seven experts of the department Micromechanics, Actuators and Fluidics undertake design, simulation and prototyping of microfluidic components.

With more than 15 years experience in the field the department can guarantee optimal solution for the realization of individual applications.

Key competencies of the department include the development of micropumps, microdosing systems, micromixers, microvalves, microreactors and flow sensors as well as combinations of these for the use in biotechnology, chemistry and medicine.

›› TRENDS

Currently, the department is focusing on the following strategic areas:

It is establishing the capacity to manufacture prototypes of silicon micropumps in cooperation with the company Tronics, Grenoble. These micropumps will then be applied in lab technology and fuel cells. For our industrial partners these micropumps are central to the future development of successful products.

Furthermore, a new platform to manufacture plastic devices is currently built-up to address cost-efficient applications. Using this new platform, micropumps and microcompressors will be developed for application in cooling systems, fuel cells and medicine.

A new working group is currently being set-up to address the use of microfluidic actuators for tissue engineering.

›› RESEARCH RESULTS

High-performance micro pump | Microfluidic devices for medical applications have to meet stringent requirements regarding biological compatibility, safety, and, contrary to wide-spread assumption, market price. One application expected to benefit from innovation in micofluidic devices is the humidification of therapeutic gases. As part of a joint project between PARItec and Fraunhofer IZM, a novel high-performance micro pump is being developed for just such a system.

Making the micro pump available at the targeted price means using low-cost materials wherever possible. However, materials such as plastics or metal are often not optimal for micro-mechanic components such as micro valves, due to inhomogeneous material prop-erties and/or unsuitable production technologies.

Silicon, on the other hand, is a material of choice for high-performance microfluidic components, thanks to its micro-machinability and ideal elastic properties. In the current design of the pump, silicon is employed for the valve parts, thereby reducing the cost of the overall device.

The micro pump consists of a piezo-electrically driven membrane and a pump chamber made of metal in this prototype phase. An injection-molded pump chamber is under development. Two check valves arranged on a chip make use of the decisive advantages of the silicon at the crucial point in the system. The outer diameter of the round pump body is 30 mm, the thickness 4 mm. The silicon valve chip (size: 6x6 mm^2) is attached to the pump body by gluing. The piezo is glued onto a thin metal membrane, which in turn is glued to the pump body. The electrical connection is wire bonded.

The micro pump was tested with water and air. For both media, the pump rate increases linearly with the actuator frequency until viscous effects appear. A flow rate of 50 ml/min with water was achieved, which is considerably higher than any other micro pump described in literature. At an operational voltage of +250V / -50 V, a back pressure of 300 hPa was achieved.

The same micro pump is equally efficient in the case of air. More than 0.3 liters per minute and a maximum pressure of 250 hPa were achieved. Based on this behavior the micro pump is of course self priming and bubble tolerant.

The micro pump has already met the targeted maximum flow rate of 2.2 ml/min at 250 hPa in its current design stage. Therefore, further development steps will focus on finding the optimal manufacturing processes with regard to cost and stability.

*EVENTS

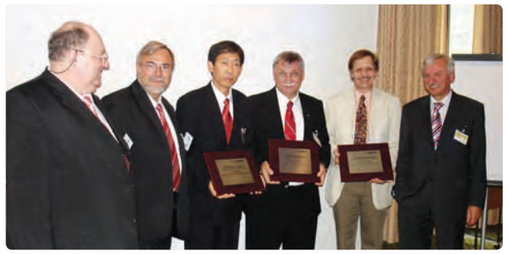
» EVENTS

Events

Security Lab Berlin

Representatives of Fraunhofer IZM and Panasonic Factory Solutions at the opening of the Panasonic Microlectronics Technology Center at Fraunhofer IZM in Munich

Long Night of the Sciences



Opening ceremony of the 1st MicroNanoReliability world congress

›› Bundesdruckerei and Fraunhofer IZM launch Security Lab Berlin |

Bundesdruckerei GmbH and the Fraunhofer IZM jointly launched Security Lab Berlin on July 11, 2007. The cooperation aims to develop new technologies for chip-based secure ID documents.

Bundesdruckerei employs internationally renown experts in secure identification and is already developing concepts for secure ID documents of the coming generations. Fraunhofer IZM has the technological expertise required to assemble highly complex electronics at a degree of miniaturization that allows them to be integrated in a security document. Thus, the two cooperative partners complement each other perfectly.

Ulrich Hamann, CEO of Bundesdruckerei GmbH, comments: "The Bundesdruckerei is technologically and thematically in pole position when it comes to the secure identification of persons. Only by continually developing innovative technologies further can we extend our system portfolio and bring out new applications."

Professor Herbert Reichl, Head of Fraunhofer IZM, adds: "These types of research collaborations make fast-tracking cutting-edge technologies onto the market possible." The Berlin Security Lab can quickly evaluate ideas for even more secure documents and test their market suitability.

By working together, Bundesdruckerei and Fraunhofer IZM increase their innovative power. At the same time, they support the city of Berlin's drive for innovation and Berlin-Brandenburg's role as a leader in industry and science.

›› Microelectronics Technology Center at Fraunhofer IZM in Munich |

Since May 2007, Fraunhofer IZM's Munich branch is making its state-of-the-art infrastructure, such as laboratories, workshops and equipment, available to high-tech companies. Panasonic – the first innovative company building on a close collaboration with Fraunhofer IZM's scientists – opened the "Microelectronics Technology Center" – M-TeCe – in Fraunhofer IZM's facilities in Munich on May 15, 2007.

The launching of M-TeCe sees Panasonic Factory Solutions Europe advancing its already strong position in the area of SMD mounting.

A laboratory for process development and evaluation of microelectronic processes was also established in Fraunhofer IZM's facilities. All types of flip-chip processes, new assembly technologies, as well as plasma applications for the European market, can be further developed here under the best possible conditions. Panasonic now covers a variety of back-end areas and is also distributing this equipment in Europe.

The company decided on Munich as its base to develop the technology in close consultation and together with its customers in Europe.

M-TeCe's two-day grand opening in the Fraunhofer IZM Technology Center kicked off with a special ritual. Leading figures of both companies, Panasonic Factory Solutions Presidents Mr. Kanzaki, Mr. Okuda and Mr. Kawase, as well as Fraunhofer IZM Institute Director Prof. Reichl, and Deputy Directors Dr. Lang and Dr. Bock cut the blue ribbon according to Japanese custom. The joint ritual sought to fortify and symbolize a new bond between the two companies.

›› Long Night of the Sciences – the smartest night of the year! |

Fraunhofer IZM and the Research Center for Micro-peripheric Technologies at the Technische Universität took part in the Long Night of the Sciences for the fourth time in 2007. From 5 pm to midnight, visitors to the TU's Department of Mathematics were treated to a fascinating world of autonomous sensor nodes and wearable electronics.

Using a logistics scenario, the mainly young crowd was shown the potential of tiny microsystems that can be networked and exchange data wirelessly. Critical temperatures and weights triggered an alarm in a network. While they may have looked like toys to the visitors, these sensor nodes can actually play critical roles in disaster management, building management and countless other application areas.

The youngsters were particularly impressed by the communications jacket, in which almost all mobile phone components had been integrated. The show stopper: each visitor with a mobile phone could request a call from the mobile apparel.

Smart Systems Integration in Paris |

The Smart Systems Integration 2007 European Conference & Exhibition in March, co-organized by Fraunhofer IZM (chair: Prof. Thomas Gessner) as part of the EPoSS activities, provided an international communication platform for research and development concerning system integration.

Almost 300 enthusiastic conference participants, exhibitors and visitors took the opportunity to network and to find a basis for successful research co-operations with focus on Europe.

›› 1st World Congress MicroNanoReliability was a great success |

Under the heading "Reliability in Micro and Nano Technologies for High Tech Applications" the 1st World Congress „MicroNanoReliability" took place in Berlin from September 2 - 5 in Berlin.

The event was organized by Fraunhofer IZM's MicroMaterials Center and co-organized by the newly-established "European Society for Micro- and Nanomaterials".

More than 400 participants from 41 countries came to Berlin to get up to date with current trends in reliability research. Besides 210 presentations and 40 poster presentations, there were also several special tutorials on offer.

From all over the world leading experts on reliability in micro and nano technologies had come, e.g. from Stanford and Berkeley, M.I.T. and the Tokyo Institute of Technology.

The presentation of NASA's Meyya Meyyappan, president of the IEEE Nano Technology Council, was met with special interest by the visitors.

The feedback from the participants was overwhelmingly positive. Many not only commented on the high quality of the presentations, but also gladly took the opportunity to exchange information on current trends with colleagues from all over the world.

The conference was chaired by Prof. Bernd Michel, head of the MicroMaterials Center at Fraunhofer IZM Berlin. He was supported by his co-chairmen M. Pecht, Maryland, G.Q. Zhang, Eindhoven and K. Kishimoto from Tokyo.

Events

Prof. T. Gessner (left) and Min. DIR. Dr. W. Lukas (right) at the 2nd German MST Congress

Speakers and organizers of the IEEE Workshop 3D System Integration

Workshop System-in-Package Reliability

Participants of the workshop Microdosing Systems

›› Workshop 3D System Integration |

The 2nd international workshop on 3D System Integration took place on 1-2 October 2007 at the Fraunhofer-Society, Munich, co-organized by IEEE CPMT.

The workshop was chaired by Peter Ramm and Rolf Aschenbrenner of Fraunhofer IZM. More than 90 engineers, scientists and entrepreneurs attended the 2-days workshop and discussed world-wide R&D activities, perspectives and challenges of 3D integration.

Second German MST Congress in Dresden |

The second German Congress on Microsystem Technologies, organized by the Federal Ministry for Education and Research (BMBF) and the VDE/VDI-Gesellschaft Mikroelektronik, Mikro- und Feinwerktechnik, was held from October 15-17, 2007 in Dresden. For more than 1000 participants from research and industry the 3-day-congress, consisting of plenary sessions, lectures and poster sessions, an exhibition and a young scientist´s forum, was a platform to catch up on current developments in microsystem technology. The focus of the 126 presentations was on assembly and interconnection technologies, test and reliability as well as the integration of new functions. The application areas discussed included ambient assisted living, health, RFID, autonomous sensor networks and micro fuel cells.

The opening address was given by Annette Schavan, the Federal Minister of Research and Education and Prof. Peter Grünberg, the German Nobel Laureate in Physics 2007. The congress was chaired by Prof. Thomas Gessner, Head of the Chemnitz Branch of Fraunhofer IZM.

›› 3rd Leibniz Conference Nanoscience 2007 |

In October 2007 the Micro Materials Center Berlin, IZM organized the 3rd Leibniz Conference on Nanoscience in Lichtenwalde/Saxony (see www.nanoscience2007.com).

The conference dealt with basic research, applications and risks of the various fields of nanoscience and technology.

Main topics were the reliability of nano components and the social impact of nano technologies.

Workshop System-in-Package Reliability |

System-in-packages (SiP) make new functions and applications for automobiles, industrial controls and medical technology possible. But what about the reliability of these highly integrated systems?

Which reliability-related lifecycle models and solution concepts apply for assembly and interconnection technology? These questions were addressed in the second workshop on system reliability, held in Berlin at the end of November 2007.

Approximately 40 experts from high-profile suppliers and developers such as Siemens, Bosch and Liebherr spent the day the reliability of microelectronic systems with Fraunhofer researchers.

And, because the discussion topic will continue to be significant, another workshop has already been planned for 2009.

The Application Center (APZ) Smart System Integration holds practical workshops and technology discussions on a regular basis focusing on a variety of themes in reliability and product development.

›› Workshop “Forum 2007 - Be flexible” |

This international workshop, addressing manufacturing and applications for thin semiconductor devices and technology and production processes for flexible electronic systems, again took place in November 2007 at the hotel “Le Meridien” in Munich. More than 150 participants from 13 countries exchanged information about latest technological results on the way towards flexible electronic systems. Due to the ongoing great interest and the extraordinarily positive feedback this workshop will be scheduled again in 2008.

More information at www.be-flexible.de.

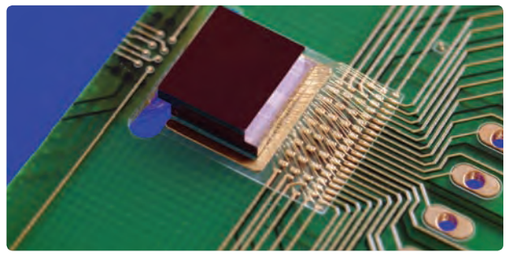
›› Workshop Microdosing Systems in South Korea |

A growing interest in microfluidic actuators by Korean companies led Fraunhofer IZM’s department Micromechanics, Actuators and Fluidics to hold a workshop on microdosing systems in South Korea on November 26, 2007.

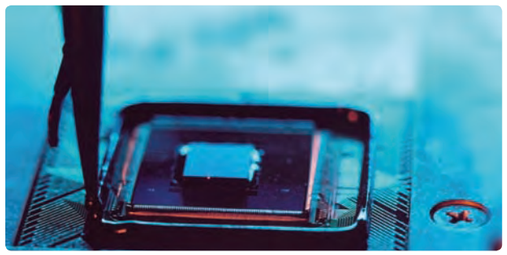
Dr. Martin Richter, head of the department, and Markus Herz gave an overview on the latest development trends of microfluidic actuators. 20 participants from various industrial sectors such as fuel cell research (Samsung), medical dosing (KMH) and machine tools (Parker) attended the workshop held at the Yousung Hotel in Daejeon, Korea.

Fraunhofer IZM Events 2007 (Selection)		
April 2007	Berlin	Girls Day
June 2007	Paris	PARACHUTE-ROBIN Workshop, MEDEA+ Office
	Hannover	Eda Workshop 2007
September 2007	Berlin	Microsystems Summer School
October 2007	Budapest	MEDEA+ Forum
	Munich	Workshop Microdosing Systems
	Berlin	Workshop China RoHS
	Taipeh	Workshop Industrial Applications for Microfluidic Actuators
	Sendai	Sendai Symposium
	Berlin	Highly Reliable Encapsulation of Microelectronic Systems
November 2007	Berlin	Workshops Die- and Wirebonding
	Munich	Workshop on Embedding Components

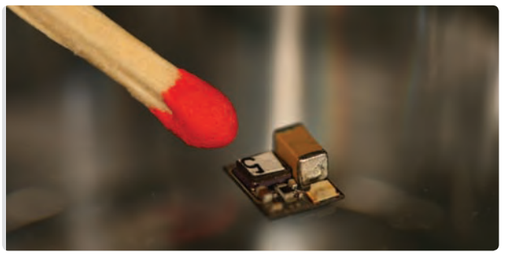
Workshops 2008



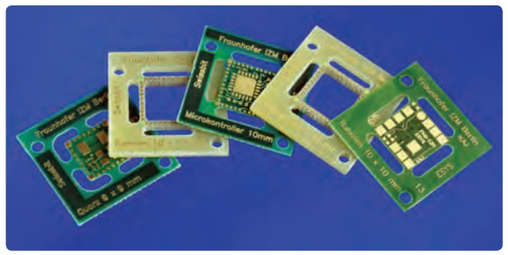
Die- and wirebonding



Highly reliable encapsulation of microelectronic systems



System-in-package



3D integration

Regular workshops at the Application Center Smart System Integration |

We are holding several workshops this year, focusing on transferring know-how from our experts to you. Each workshop takes a different development potential as its topic and includes the following aspects:

- Latest international technological trends, focusing on current technological developments with regard to designing future technology.
- Trends for medium-sized businesses regarding fully-developed technologies already in application.
- Hands-on-workshops, in which market-relevant knowledge transfer is combined with practical aspects.

The following pages list the workshops already planned for 2008. Please contact us as early as possible if you would like to participate.

For more information, go to http://apz.izm.fraunhofer.de/cms/workshops.phtml

Multi Functional Board Technology |

The workshop aims at illustrating advances in the field of circuit board technology with respect to different technologies attached to the board.

What will you learn?

- Integrated active electronic devices
- Wire-bonding technology, flip chip technology
- Electrical optical circuit boards
- Reliability

Potential participants: Circuit-board manufacturers, electronic component manufacturers and suppliers, other manufacturers, developers, specialists in packaging integrated circuits for the automotive industry, electronics and the aerospace industry

Molding and System Integration |

Practical workshop elucidating the transfer molding process for cost-efficient and flexible production processes for a supply chain optimization.

What will you learn?

- Molding for packaging integrated circuits
- Materials, processes and simulation
- Package qualification
- Technology case study: flip-chip molding

Potential participants: Small and medium-sized businesses using these processes

Concepts and Technologies for Power Electronics |

From design through assembly and interconnection to reliability analyses this workshop provides a comprehensive overview of power electronics.

What will you learn?

- Design and electromagnetic compatibility
- Assembly and interconnection technology
- Encapsulation and analytics
- Thermal management and reliability

Potential participants: developers and manufacturers of power electronics from all industry sectors

System-in-Package |

This workshop is designed to discuss international research and development trends in the area of system integration.

What will you learn?

- SIP-design, wafer level integration
- Substrate level integration
- Interconnects, assembly and packaging
- Reliability

Potential participants: international packaging experts from all industry sectors

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

Workshops on Die and Wire Bonding |

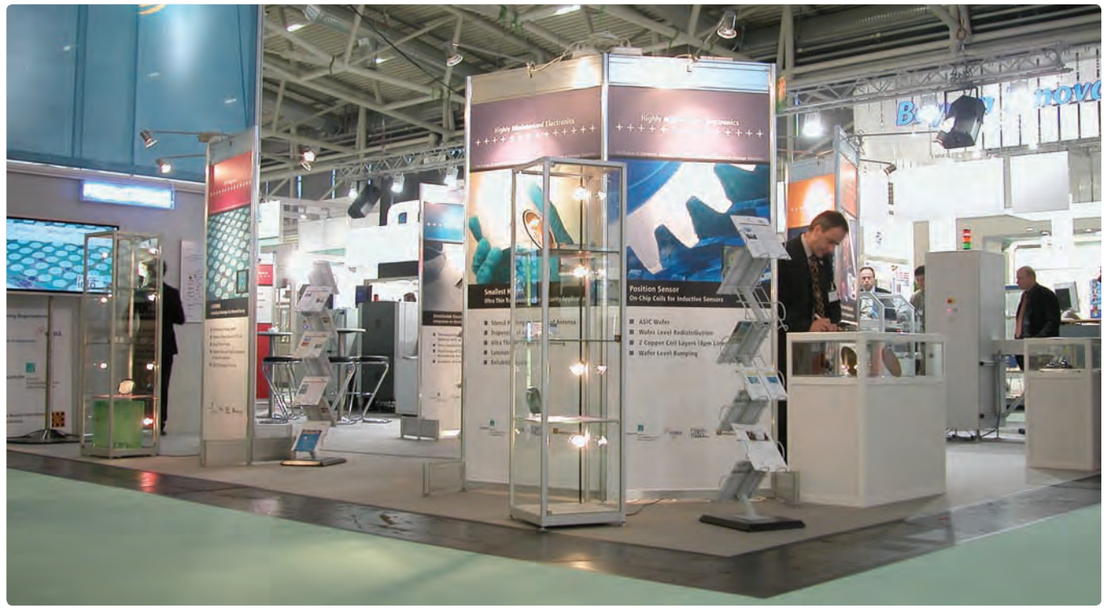
Quality and reliability aspects of wire bonds are discussed in this workshop and practical bond tests are carried out on test substrates.

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

Fraunhofer IZM's Fair Activities 2007



Booth of Fraunhofer IZM / Application Center Smart System Integration at Productronica 2007

›› Roundabout a dozen times Fraunhofer IZM presented its manifold activities at trade shows in Germany and abroad this year.

The year kicked off at the microSys in early March. Many visitors from Berlin and Brandenburg took the opportunity to acquaint themselves with the new Fraunhofer Application Center Smart System Integration (APZ), which for the first time presented its activities. The APZ aims at helping small and medium-sized businesses to bring microsystem technologies into new and innovative applications. The presentation focused on application-oriented developments, like intelligent pieces of clothing, so-called wearables.

From March 27-28, the packaging community met up in Paris for the Smart Systems Integration. Fraunhofer IZM participated by holding approximately 20 conference presentations and also held a booth at the trade show. The many visitors were particularly interested in the latest developments of so-called eGrains. These sugarcube-sized micro-sensor systems with autonomous power supplies can communicate wirelessly and thus form independent networks. Also in March the institute presented its activities in the areas of MEMS packaging and MEMS sensors at the SMT China.

This year's presentation at the SMT in Nürnberg was all about the multifunctional PCB, a brand new development by Fraunhofer IZM's scientists. This intelligent board integrates several fine wire-bonded chips, various flip chips, including integrated passive components and an optical camera module, along with conventional SMD components and BGA modules. The 4-layer PCB also has a thinned chip and corresponding interconnects embedded. The board is the first example of a development that showcases all of Fraunhofer IZM's main technological know-how, from system design, to packaging and interconnection, through to system reliability.

For the first time Fraunhofer IZM presented its research results at PCIM, the trade fair for Power Conversion and Intelligent Motion in Nürnberg. A set-up for the double-sided cooling of power semiconductors for automotive hybrid drives generated a lot of interest among visitors and the media alike. The demonstrator comprises a half bridge with two IGBTs and diodes, which are soldered onto DCBs (direct copper bonds) on both sides. Through the additional thermal dissipation on the upper surface, static thermal resistance is reduced by 40% compared to one-sided cooling assemblies.

Physics Nobel Laureate Peter Grünberg hits Fraunhofer IZM's intelligent golf ball

Stefan Schmitz of Fraunhofer IZM with Almuth Nehring-Venus, state secretary at the Senate for Economy, Technology and Women at µSys 2007

In May the international 4th BMBF Forum for Sustainability titled Sustainable Neighbourhood took place in Leipzig. Fraunhofer IZM presented ongoing research work and current results focused on sustainability at an own booth: Besides printed circuit boards made of renewable materials and miniaturized efficient power supplies, systems for condition monitoring and methods supporting sustainable supply of spare parts were shown.

After the summer break the institute presented its activities in the realm of wafer level packaging at the SEMICON Europa, which this year for the first time took place in Stuttgart. Besides the smart carrier technology developed at Fraunhofer IZM an ultra-fine pitch microcoil on ASIC for position sensors, developed together with the Swiss POSIC Company, met with lively interest from the visitors.

At the Microsystem Technology Congress and Fair Peter Grünberg, Nobel Laureate in Physics, couldn't pass up the opportunity of experiencing Fraunhofer IZM's intelligent golf ball in action. After opening this year's Congress in Dresden together with dignitaries such as the German Federal Minister of Research and Education Annette Schavan, Grünberg drove a golf ball with an autonomous sensor system. The final stop in this year's trade show circuit was the Productronica in Munich, where again the multifunctional board was at the center of attention, albeit this time with a focus on production aspects. Simultaneously, Fraunhofer IZM, together with VDMA, was also responsible for the special exhibition „The Future of System Integration". Here a new electronically enhanced Scrabble game, developed by researchers of the Application Center (APZ) together with their colleagues at Fraunhofer IZM, proved a runaway success with visitors. What looks from the outside like a normal Scrabble game is in fact packed with highly complex recognition and analysis electronics. Visitors not only got a first glimpse of eScrabble but also played live games and, with a bit of luck, won an iPod.

Fraunhofer IZM at Trade Fairs 2007 (selection)		
February 2007	Tokyo	Nano Tech
March 2007	Berlin	µSys
	Chemnitz	SIT
	Shanghai	Semicon China
April 2007	Nürnberg	SMT
	Hannover	HMI Micro Technology
May 2007	Nürnberg	Sensor & Test
	Nürnberg	PCIM
	Leipzig	4. BMBF Forum Sustainability
July 2007	Tokyo	Micromachine
October 2007	Dresden	Mikrosystemtechnik
	Stuttgart	SEMICON Europa
November 2007	Munich	Productronica

» FACTS & FIGURES

Fraunhofer IZM in Facts & Figures

Financial status |

The year 2007 saw Fraunhofer IZM's turnover increase by 13 % to 31 million euros. External proceeds accounted for 86 % of the operating budget. A total of almost 27 million euros was procured externally, which is an increase of 17 % compared to the previous year.

Contracts from German and international industry and trade associations reached just under 11 million euros, or in other words, 35 % of the total turnover.

Equipment and laboratory investment |

Equipment investment to the tune of 12 million euros meant a significant number of infrastructure was realized last year.

The development of the European laboratory for micro- and nanotechnology component and system reliability was completed with 0.6 million euros from the Berlin local government, co-financed by EFRE.

Since 2006 the BMBF has been funding the development of a young researchers group at Fraunhofer IZM, as part of its hightech strategy Innoprofile. This aims at improving collaboration between regional up-and-coming research groups and the regional economy.

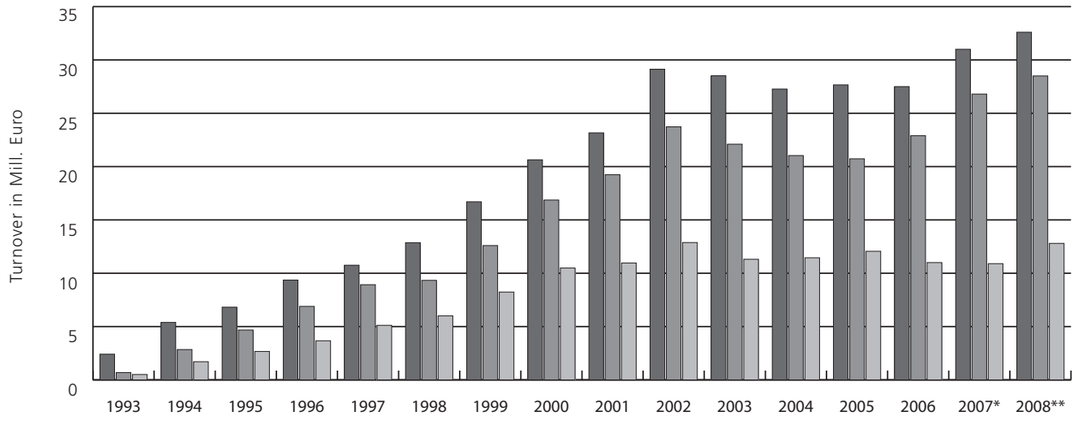
As part of this project, a new laboratory, valued at 1 million euros, was built in 2007 for assessing the reliability of micro- and nanoelectronic material composites.

An initial volume of 3.3 million euros was also spent to equip the new Chemnitz branch building.

As a matter of priority, the areas back-end-of-line and the Chemnitz Micro Materials Center were furnished with state-of-the-art devices. Equipment included a high-performance computer tomograph for analysis and reliability assessment.

Using strategic funds from the Fraunhofer Gesellschaft the institute was able to install a patterning system for large substrate surfaces and an integration platform for system-in-package modules in Berlin and a film-coating machine in Munich.

The remaining new devices were purchased using Fraunhofer IZM's own funds. Here, a 1.7 million euro line for wafer-level packaging of optical components and a device for plasma-supported deposition of thin glass layers were bought, among other purchases. These glass layers can be employed as dielectric or passivation layers.



* 2007 actual
** 2008 projected

Human resources development |

Due to the higher turnover, staff levels increased again last year, continuing a trend begun in 2006. Overall, 36 new employees joined the team, bringing the total staff at all Fraunhofer IZM branches to 302 at the end of 2007.

The Institute also continues to support students with the opportunity of combining their studies with practical scientific work in the Institute's laboratories and offices. With 49 additional contracts compared to the prior year, Fraunhofer IZM was able to take on an annual average of 170 interns, undergraduates and student assistants. The latter are proving to be a growing source for up-and-coming new scientists and technicians. Finding new staff is becoming increasing difficult at the Fraunhofer IZM branches that do not have a direct connection to universities (Munich and Oberpfaffenhofen). The remuneration packages available through the public service's wage agreement are not competitive in the free market of this economically strong region.

Fraunhofer IZM is committed to continuing its training program. In 2007, 12 trainees completed vocational training as microtechnology engineers, IT specialists, mechanical engineer for precision tools and business administrator.

New building development |

In November 2007 a special ceremony was held to lay the foundation stone for the Chemnitz branch's new building in the recently opened technology park near the university. This construction is being funded by the European Fund for Regional Development, the Federal Ministry for Education and Research (BMBF) and the regional government of Saxony. The development is a primary step towards successfully shaping the Chemnitz branch to support Saxony's industry in increasing its competitiveness with application-oriented know-how. The new building will be part of the Smart Systems Campus, to which belong the newly constructed Institute for Physics, the new clean room of the Center for Microtechnologies of the Technical University and a start-up building for new entrepreneurs. The approach "Smart System Integration" will be given special consideration in the development of the Chemnitz branch.

Contact |

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Awards

IZM Research Award laureates Karl-Friedrich Becker and Dr. Jürgen Auersperg

›› Fraunhofer IZM Research Award 2007 goes to Dr. Jürgen Auersperg and Karl-Friedrich Becker |

In December Fraunhofer IZM presented the Research Award for outstanding achievements in the realm of packaging and interconnection technology to Dr. Jürgen Auersperg and Karl-Friedrich Becker.

Jürgen Auersperg uses non-linear Finite Element Simulation and researches fractures and damage mechanics, as well as failure processes in microelectronic and microsystem technology components at the Fraunhofer IZM's Micro Materials Center in Berlin.

Auersperg has collectively analyzed a great variety of such failure mechanisms to develop new methods with which such predictions can be made for microelectronic systems.

The research prize was awarded for his use of innovative concepts for thermal-mechanical prediction analysis in specialized statistical test designs.

Karl-Friedrich Becker, this year's other Research Award recipient, was honored for his work on encapsulation technologies in microelectronics. To coat the steadily shrinking microsystems with epoxy resins and other polymers, countless parameters, such as the used materials' different coefficients of thermal expansion, must be considered in the calculations.

Becker also researches nano-modified materials, the physical properties of which can be used to assign functions to the encapsulation materials themselves.

The awards ceremony was held at the Radisson SAS Hotel in Berlin-Mitte, where the award recipients were presented with certificates by Institute Director Prof. Herbert Reichl.

Dr. Ivan Ndip (left) and his PhD adviser Prof. Herbert Reichl

›› Dr. Ivan Ndip honored with the 2007 Tiburtius-Preis |

Fraunhofer IZM researcher Dr. Ivan Ndip has been awarded the 2007 Tiburtius-Preis for his outstanding Ph.D. dissertation. His thesis, entitled "Novel Methodologies for Efficient and Accurate Modeling and Optimization of System-in-Package Modules for RF/High-Speed Applications", was ranked second best Ph.D. dissertation of all Ph.D. dissertations in all Universities and Colleges in the State of Berlin in 2006. His dissertation received the highest academic distinction (Summa Cum Laude).

The Tiburtius-Preis is sponsored by the "Landeskonferenz der Rektoren und Präsidenten der Berliner Hochschulen (LKRP)". It is awarded each year to outstanding Ph.D. dissertations and Master's Theses.

First prize for world's smallest silicon pump |

For its marketing concept for the world's smallest piezoelectric micromembrane pump the research group of Fraunhofer IZM's Dr. Martin Richter won first prize for in the Development Stage and second prize for the Excellence Stage of the Munich Business Plan Competition.

A need for such a pump and dosing systems capable of handling miniscule volumes of liquid has existed for years in laboratory technology and exciting new applications are now also possible in medical technology.

If such micropumps could be implanted in the human body, treatment of countless chronic diseases would become much more effective, as they could dose lifesaving medicines and hormones and release these into the blood stream.

Dr. Michael Toepper (center) with the head of the award committee Mart Graef (left) and SEMI Europe's president Heinz Kundert (right)

›› European SEMI Award for 2007 Goes to IZM-Scientist Dr. Michael Toepper |

Dr. Michael Toepper of Fraunhofer IZM was honored with the European SEMI Award for 2007 for his leadership in the BCB-based redistribution technology in advanced wafer level packaging. The award was presented on May 23 during the SEMI Europe Member Forum, the annual meeting of SEMI Members in Europe. Dr. Toepper played a key role in implementing the concept of wafer level packaging into manufacturing.

"Today, the chip package is no longer a commodity, it is an enabler for the interconnectivity of integrated systems, as a result of a number of bright ideas and innovations," said Heinz Kundert, president of SEMI Europe. "SEMI is honoured to grant the European SEMI Award to one of the greatest innovators in the field of packaging." Dr. Toepper holds a PhD in material science from the Technical University of Berlin and heads a research group at Fraunhofer IZM, which specializes in wafer level processes.

Fraunhofer IZM receives ATLAS Supplier Award |

In recognition of its excellent performance in the production of 1300 silicon modules for the ATLAS Pixel Detector at the Large Hadron Collider (LHC) CERN in Geneva Fraunhofer IZM has received the ATLAS Supplier Award.

For each module 16 radiation hard readout chips were flip chip bonded by 46,080 lead-tin solder bumps to one sensor substrate.

With a total module yield of 98% Fraunhofer IZM well exceeded the contractually required 90%. The Pixel Detector will be put into operation in 2008.

Rao Tummala, Phil Garrou, Prof. Herbert Reichl and Yim Myung-jin at the Electronics Manufacturing Technology Award Ceremony

›› IEEE Honors Herbert Reichl with Electronics Manufacturing Technology Award |

At the occasion of the ECTC Conference in Reno the IEEE's CPMT Society honored Fraunhofer IZM's director Professor Herbert Reichl with the Electronics Manufacturing Technology Award on May 31, 2007.

Every year the Component Packaging and Manufacturing Technology Society (CPMT) presents the Electronics Manufacturing Technology Award to an outstanding scientist to recognize major contributions to electronic manufacturing technology in fields encompassed by the Society.

This year's award was being presented to Herbert Reichl for his outstanding contributions in research and education in the field of microelectronics packaging and for his pioneering role in the integration of reliability aspects.

According to the Award Committee, Reichl "was first to point out the importance of system integration technologies on a chip/wafer level for industry with the extension of the 3D packaging activities. He has focussed on the development of solutions that can be immediately applied and produced."

Florian Ohnimus honoured with Study Award |

For his outstanding course achievements Fraunhofer IZM's Florian Ohnimus was honoured with the Study Award 2007 of the Electrical Engineering Department at Technische Universität Berlin. Each year the Study Award of the Faculty IV is given to the students with the best academic record in the subjects electrical engineering, computer engineering and computer science.

Training & Education

Microtechnology Engineer of the Year Janine Scholz with Markus Kutsch, head of metallography at Fraunhofer IZM

The Fraunhofer IZM introducing their apprenticeship training position at the fair „Berlin Career Days of professional training"

Screen printing

Experimenting with bacterial dilution series

Professional training at Fraunhofer IZM |

Fraunhofer IZM aims to reawaken young people's interest in technical development, as well as careers in technology and research. The professional training the institute offers is based on the dual education model, combining apprenticeship with study at a vocation school. Fraunhofer's training programs both meet both the institute's responsibility to the younger generation and deliver the highly qualified employees the institute requires. Fraunhofer IZM offers training programs in three recognized professions in technology and administration in which young trainees receive a qualified education in a research environment.

As part of a cooperation between Fraunhofer IZM, the TU Berlin, Berlin research institutions and small and medium enterprises in the training of microtechnology engineers, two external trainees are also completing part of their internship at the Institute.

For the second time in a row, a Fraunhofer IZM trainee has been selected as Microtechnology Engineer of the Year. Janine Scholtz was presented with the award by IHK president, Dr. Schweitzer, at a special awards ceremony. She also received a certificate as Fraunhofer Gesellschaft's best apprentice, presented by Fraunhofer executive board member Dr. Polter in Munich.

At the trade fair "Berlin Career Days" in the expo halls of the Berlin Funkturm (radio tower), Fraunhofer IZM passed on information about its internships and professional training to a steady stream of teenagers, parents, teachers and potential trainees. More than 20,000 students and teenagers took the opportunity to find out more about potential professions and application procedures for jobs and training courses.

Encouraging up-and-coming scientists |

Fraunhofer IZM has a long-standing cooperation with Diesterweg Secondary School. This year, several senior classes had the chance to participate in Fraunhofer IZM's job application training, receiving detailed information about application etiquette and standards. Using role play and checklists, the students were given in-depth training on what counts in written applications and job interviews.

Two teachers and three students of German from the Friskola-Schule in Sundsvall, Sweden visited Fraunhofer IZM to find out more about our dual education system and the institute's work. After surveying the clean room, the visitors met students and teachers at the Diesterweg Gymnasium to exchange information about teaching methods and professional orientation and finished their visit by taking part in classes.

At Fraunhofer's Environmental Engineering Department, two teenagers are undertaking their voluntary ecological year under the supervision of scientists. Learning about the possibilities of renewable energy and assisting in projects on increasing the energy efficiency of electronic devices, the two are gaining not only professional orientation but also professional experience.

Encouraging girls to join the sciences |

A group of 12 teenage girls participated in a workshop entitled „wireless: more fab than a jab", which was part of the Paul Cézanne EU Project. The workshop's topic was "The function and development of a glucose sensor". To start with, the students took over the labs of Fraunhofer IZM in Munich. The teenagers performed tests for bacteria and determined the fluorescence of various dyes' dilution series. This demonstrated the principles behind the new method of measuring glucose, which are to be used in the new application. After these practical exercises, the teenagers began researching conventional glucose-detection processes and got in touch with experts from medical institutes and health-service providers. The team also examined the question: „How is an EU project initiated?".

The girls were awarded the second prize in the Multiline media competition for their comprehensive research and website displaying their results.

Girls´ Day at the Fraunhofer IZM laboratories |

As in years past, twelve female students aged 11 to 15 were given the opportunity to dive into the world of microsystem technology.

The topic "The glass mobile phone – hi tech, eco and trendy!?" was used to introduce the young visitors to Fraunhofer IZM's work. Various cell phone generations were weighed to demonstrate the ongoing miniaturization. The girls were also allowed to disassemble the cell phones to look at the assembly. Then the girls applied themselves to a challenging practical task - under the guidance of an IZM colleague, they themselves welded together and tested an electronic tea candle. As a comparison, the girls were then shown the automatic assembly process at an SMD line. As was the case last year, the tour through the clean room was a big hit, with the "dressing-up" in the clean room overalls and caps a source of much amusement.

Finally the girls were shown a multifunctional jacket for bicycle couriers, as a prelude to the young researchers designing their own clothing with integrated electronics, so-called wearable electronics.

MST initiative on career orientation |

Fraunhofer IZM-M kicked off an initiative on career orientation in microsystem technology in 2007. Project modules were developed for career orientation internships to enthuse students for innovative jobs in various areas of microsystem technology. Above all, participation by female students was encouraged.

The concept is being put into practice with one to two-week work-experience units, in which two new topic areas are introduced to the students each day, which they then work on as independently as possible. The training units include the assembly of electronic circuits, polymer electronics, semiconductor technology (silicon technology, clean-room technology, wafer processing), micromechanics (sensor systems, actuators, fluidics), assembly and interconnection technology and analysis, and reliability. Evaluation has shown that the 9 students that participated were overwhelmingly positive about the supervision and selection of topics.

In the future, more emphasis will be placed on theory, as requested by the students. Regular evaluation will be performed to ensure the ongoing improvement of the educational implementation and contents of the units.

Lectures, Editorials

›› Lectures (Selection) |

TU Berlin

Prof. H. Reichl
- Technology and Materials for Microsystems

Prof. H. Reichl, O. Bochow-Neß
- Selected Topics of Hetero System Integration

Prof. H. Reichl, O. Bochow-Neß
- Packaging and Interconnection Technologies

Prof. H. Reichl, B. Bouhlal, O. Bochow-Neß
- Basics in Electronic Circuits

Prof. H. Reichl, Dr. S. Dieckerhoff, Dr. B. Wunderle
- Design and Simulation of Microsystems

Prof. H. Reichl, Dr. M. Töpper
- Basic Principles of Physics and Chemistry

Prof. H. Reichl, Dr. N. Nissen
- Environmental Design of Electronic Products

Dr. S. Guttowski
- EMC in Power Electronic and Electric Drives

Dr. S. Dieckerhoff
- Design and Technology of Power Electronic Modules
- Power Electronic II

TU Chemnitz

Prof. Dr. T. Gessner, Dr. R. Streiter
- Prozess Simulation / Equipment Modeling

Prof. Dr. T. Gessner, Dr. S. E. Schulz
- Technologies for Microelectronics

Prof. Dr. T. Gessner
- Technologies of Microsystems and Devices

Dr. S. Kurth
- Control Engineering (Microsystem Technology)

BTU Cottbus

Prof. M. Bauer
- Organic Chemistry
- Polymeric Materials

Prof. B. Michel, Dr. B. Wunderle
- Characterization of Micro- and Nanomaterials

Editorials |

Publication Series Micromaterials and Nanomaterials, Fraunhofer IZM Berlin
Prof. B. Michel (Editor)

Aufbau- und Verbindungstechnik in der Elektronik – Aktuelle Berichte
Prof. W. Scheel, Prof. K. Wittke, Prof. M. Nowottnick

PLUS Journal (Eugen G. Leuze Verlag Saulgau)
Dr. K.-D. Lang (Head of Editorial Board)

ZEMI Microsystems Summer School Berlin 2007: Systemintegration am Beispiel AVM
Großer, V.; Schmitz

Handbook of 3D Integration
Wiley-VCH, Weinheim, 2008
Dr. P. Ramm (Co-Editor)

Dissertations, Best Paper Awards

›› Dissertations |

Déplanque, S.
Lebensdauervorhersage für (SAC- und SnPb-) aufgelötete Leistungshalbleiter mittels primärem und sekundärem Kriechen, BTU Cottbus, 2007

Deubzer, O.
Explorative Study into the Sustainable Use and Substitution of Soldering Metals in Electronics
PhD thesis TU Delft, January 2007

Niedermayer, M.
Methodik zum Entwurf von miniaturisierten, energieautarken, verteilten Funksensorknoten
Dissertation, Technische Universität Berlin, 2007

Weber, S.
Effizienter Entwurf von EMV-Filtern für leistungselektronische Geräte unter Anwendung der Methode der partiellen Elemente
Dissertation, Technische Universität Berlin, 2007

Zimmermann, S.
Entwicklung einer Technologie zur Herstellung eines neuartigen Substrates mit strukturierten vergrabenen Kobaltdisilizidschichten für eine gemeinsame Integration bipolarer und unipolarer Bauelemente auf einem SOI-Wafer, Dissertation Technische Universität Chemnitz, 2007

›› Best Paper Awards |

Dr. Jürgen Auersperg, Mathias Klein, Prof. Bernd Michel
Optimization of Electronics Assemblies towards Robust Design under Fracture, Delamination and Fatigue Aspects
NXP Semiconductors Best Paper Award, Shanghai 2007

Ciaglia, C.
Massnahmen zur Effizienzsteigerung externer Netzteile - Untersuchung und Bewertung mittels EuP EcoReport-Methode
Diploma thesis, honored as most innovative research paper with regard to EuP by the Swiss IG exact

Ndip, I.; Guttowski, S.; Reichl, H.
Development of an M3-Approach for Optimal Electromagnetic Reliability in System Packages
40th International Symposium on Microelectronics (IMPAS 2007) in San Jose, CA, USA

Cooperation with Industry (Selection)

Company	Location
3D-Micromac	Chemnitz
AEMtec GmbH	Berlin
AIM GmbH	Heilbronn
Airbus Deutschland GmbH	Hamburg, Laupheim
Aktiv Sensor GmbH	Berlin
AMD Saxony LLC & Co. KG	Dresden
Amitronic GmbH	Seefeld
Andus Electronic GmbH	Berlin
Atmel Germany GmbH	Dresden, Heilbronn
Atotech Deutschland GmbH	Berlin
Brose Fahrzeugteile GmbH & Co KG	Coburg
Campus Micro Technologies GmbH	Bremen
Casio Computer Co. Ltd.	Tokyo (J)
Chemnitzer Werkstoffmechanik GmbH	Chemnitz
Colour Control Farbmesstechnik GmbH	Chemnitz
Continental Automotive Systems	Nürnberg, München, Nürnberg
Daimler AG	Stuttgart, München
Degussa AG Creavis Technologies & Innovation	Marl
Dilas Diodenlaser GmbH	Mainz
Directif GmbH	Erlangen
Dow Chemical Company	Midland, MI (USA)
Drägerwerk AG	Lübeck
Dyconex AG	Bassersdorf (CH)
EADS	Paris, Toulouse (F), München, Ulm, Dresden
Emerson & Cuming	Westerlo (BE), Bridgewater (USA)
EMZ GmbH & Co KG aA	Nabburg
Endress & HAuser Conducta GmbH	Gerlingen
EPCOS AG	München, Berlin
ESYS GmbH	Berlin
First Sensor GmbH	Berlin
General Electric, Medizintechnik	USA
Global Light Industries GmbH	Kamp-Lintfurt
HARTING Mitronics AG	Biel (CH)
Häusermann GmbH	Gars am Kamp (A)
Hella KG aA Hueck & Co	Lippstadt
Hirschmann Laborgeräte GmbH & Co KG	Eberstadt
Hitachi PERL	Yokohama (J)
hmp Heidenhain Mikroprint GmbH	Berlin
Hymite Deutschland GmbH	Berlin
IBM Zurich Research Laboratory, Halbleiter	Zürich (CH)
IMC	Berlin
Infineon AG	München, Regensburg, Dresden
Infratec GmbH	Dresden

Company	Location
KSG Leiterplatten GmbH	Gornsdorf
Laser Components GmbH	Garching
LG Thermo Technologies GmbH	Annaberg-Buchholz
Liebherr-International Deutschland GmbH	Lindau
LTI Drives GmbH	Lahnau
Magna Donnelly	Winzendorf (A)
Magotteaux International	Vaux-sous-Chèvremont (B)
Mandigo GmbH	München
Mikrogen GmbH	Neuried
MPD Microelectronic Packaging Dresden GmbH	Dresden
Nanotest und Design GmbH	Berlin
Numerik Jena GmbH	Jena
NXP Semiconductors GmbH	Hamburg
OREE, Inc.	Tel Aviv (IL)
OSRAM Opto Semiconductors GmbH	Regensburg
Paritec GmbH	Weilheim
PerkinElmer Elcos GmbH	Pfaffenhofen
Qimonda AG	Dresden
Raumedic AG	Helmbrechts
Ricoh Company Ltd.	Yokohama (J)
RKT GmbH	Roding
Robert Bosch GmbH	Stuttgart, Berlin, Reutlingen, Hildesheim
Rohde & Schwarz GmbH	München
SCD Semi Conductor Devices	Haifa (IL)
Schefenacker Vision Systems Germany GmbH	Schwaikheim
Schott Electronics GmbH	Landshut
Schweizer Elektronik AG	Schramberg
Sensata Technologies Holland B.V. Almelo	Almelo
Sentech Instruments GmbH	Berlin
Siemens AG	Amberg, Karben, Forchheim, Regensburg, Berlin, München
Silex	Järfälla (S)
Smart Fuel Cell AG	Brunnthal
Sony	Tokyo (J)
ST Microelectronics	Agrate Bianza (I); Tours (F)
Süss Microtec GmbH	München
Swissbit Germany AG	Berlin
Tanaka Denshi Kogyo Co. Ltd.	Tokyo (J)
Texas Instruments	Freising
Tronic's Microsystems S.A	Grenoble (F)
TÜV Bayern	München
Volkswagen AG	Wolfsburg
Wacker Chemie AG	München
X-Fab GmbH	Erfurt
Zuken GmbH	Hallbergmoos

Memberships (Selection)

Academy of Sciences of New York	Prof. B. Michel	Member
Academy of Sciences of Saxony / Leipzig	Prof. T. Gessner	Member
Advanced Metallization Conference AMC	Dr. P. Ramm	Executive Committee
Arnold Sommerfeld Gesellschaft zu Leipzig	Prof. B. Michel	Scientific Committee
Deutscher Verband für Schweißtechnik (DVS)	Dr. K.-D. Lang	Executive Board
Deutscher Verband für Schweißtechnik (DVS) Working Group „Bonden"	Dr. S.-Ramelow	Vice Chairman
GMM/DVS Konferenz EBL	Dr. K.-D. Lang	Chairman
Electronics Goes Green 2008 Conference	Prof. H. Reichl	Conference Chairman
ENIAC- European Technology Platform Nanoelectronics, Domain Team Heterogenious Integration	Prof. H. Reichl	Domain Team Leader
EMC Europe - International Symposium on Electromagnetic Compatibility	W. John	International Steering Committee
ESD Association	Dr. H. Gieser H. Wolf	Technical Program Committee
EURIPIDES Scientific Advisory Board	Dr. K.-D. Lang	Member
Ferdinand Braun Institut für Höchstfrequenztechnik	Prof. H. Reichl	Advisory Council
German Science Foundation	Prof. T. Gessner	Referee
International Microelectronics and Packaging Society (IMAPS)	Prof. H. Reichl	Fellow
International Microelectronics and Packaging Society Germany	R. Aschenbrenner	Board Member
International Microelectronics and Packaging Society (IMAPS)	Dr. I. Ndip	National Technical Committee Member
International Technology Roadmap Semiconductors (ITRS) (Technical Working Group Assembly and Packaging)	J. Wolf	Chairman Europe
International Zurich Symposium and Technical Exhibition on Electromagnetic Compatibility	W. John	Technical Program Committee
KoWi, Service Partner for European R&D funding, Bruessel	Prof. T. Gessner	Member of the Board of KoWi
LEIBNIZ-SOZIETÄT e.V.	Prof. M. Bauer	Member
Materials Research Society (MRS)	Dr. P. Ramm	Executive Committee
MEDEA+, Scientific Committee	Prof. H. Reichl	Member
SEMI Award Committee	Dr. K.-D. Lang	Member
Senatsausschuss Evaluierung der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (WGL)	Prof. T. Gessner Prof. M. Bauer	Member
Silicon Sensor	Prof. H. Reichl	Advisory Board
Smart Systems Integration Conference	Prof. T. Gessner	Conference Chair
Stiftung Industrieforschung	Prof. M. Bauer	Reviewer
The Institute of Electrical and Electronics Engineers, Inc. (IEEE), USA	Prof. H. Reichl	IEEE Fellow
IEEE Component, Packaging and Manufacturing Technology Society Technical Committees: Green Electronics, Manufacturing and Packaging MEMS and Sensor Packaging Wafer Level Packaging	R. Aschenbrenner N. Nissen E. Jung M. Töpper	Vice President Conferences Technical Chair Technical Chair Technical Chair
VDI/VDE- Gesellschaft für Mikroelektronik, Mikro– und Feinwerktechnik (GMM) Technical Committee Packaging and Interconnection Technologies	Dr. K.-D. Lang	Chairman
Wissenschaftlich-technischer Rat Forschungszentrum Karlsruhe	Prof. H. Reichl	Member
Wissenschaftlich-technischer Rat der Fraunhofer-Gesellschaft	D. Bollmann	Representative of IZM
Zentrum für Mikrosystemtechnik Berlin	Dr. K.-D. Lang	Chairman of the Board of Directors

Publications (Selection)

›› *Ansorge, F.*
Mikro-Mechatronik auf dem Weg zur Nano-Mechatronik
Nanoscience 2007, Lichtenwalde Germany, Oktober 2007

Ansorge, F.; Badstübner, K.; Reichl, H.
Novel Rapid Prototyping Processes - Building Movable Parts
Conference on Virtual and Rapid Prototyping, September 2007 Leiria, Portugal

Ansorge, F.; Rebholz, C.; Schreier-Alt, T.; Reichl, H.
Electronic Packaging Technologies of High Temperature Applications
2nd European Advanced Technology Workshop on Micropackaging and Thermal Management, La Rochelle France, 2007

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New Sensor Packaging Concept for Avionic Application
Proc. ICEPT 2007, Shanghai, China

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Chapter 11.2 in: Grellmann, W.; Seidler, S. (eds.): Polymer Testing, München: Hanser 2007

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Printing Solder Paste in Dry Film - A Low Cost Fine-Pitch Bumping Technique
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Bertz, A.; Fendler, R.; Schuberth, R.; Hentsch, W.; Gessner, T.:
A New Method for High-Rate Deep Dry Etching of Silicate Glass with Variable Etch Profile
Transducers07, Lyon, June 2007

Bochow-Ness, O.; Fujino, M.; Middendorf, A.; Reichl, H.
Condition Indicators for Reliability Monitoring of Microsystems
Micro-Nanoreliability 2007

Boeffel, C.; Müller, J.; Müller, R.; Bauer, M.
The Calcium Test: A Versatile Tool for the Investigation of Barrier Properties of Polymers and Reliability Tests of Encapsulation Processes
Micromaterials and Nanomaterials, June 2007

Bock, K. et. al.
Large-Area Cost-Efficient Electronic System Integration
Proceedings Electronic Components and Technology Conference ECTC 2007, Reno, USA

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IEEE Power Electronics Specialists Conference, Orlando, 2007

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Siegener Periodicum zur Internationalen Empirischen Literaturwissenschaft, Heft 1, Verlag Peter Lang Frankfurt/M, Berlin, Bern, 2007

Griese, H.; Mueller, J.; Nissen,.; Reichl, H.; Stobbe, L.:
Global Sustainable Development Needs Advanced Electronics
EcoDesign 2007 - 5th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Tokyo, Japan, December 2007

Hahn, R.; Kreidler, B.; Krebs, M.; Wagner, S.; Krumbholz, S.; Niedermayer, M.; Reichl, H.
A Passive Micro Fuel Cell with Hydrogen Generator as a Battery Replacement
NanoPowerForum 2007, San Jose, USA, June 2007

Heinrich, K.; Richter, M.; Herz, M.
Back Pressure Independent Nanoliter Dosing of Oils with Micropumps
Fraunhofer IZM-Munich, Proceedings Workshop Microdosing Systems, October 2007

Hiller, K.; Nestler, J.; Gessner, T.; Gavillet, J.; Getin, S.; Quesnel, E.; Martin, S.; Delapierre, G.; Soechtig, J.; Voirin, G.; Buergi, L.; Auerswald, J.; Knapp, H. F.; Stanley, R.; Bigot, S.; Dimov, S.; Ehrat, M.; Lieb, A.; Beckers, M.-C.; Dresse, D.; Victor-Pujebet, E.:
Integration aspects of a polymer based SPR biosensor with active micro optical and micro fluidic elements
Smart Systems Integration 2007, Paris, March 2007

Hoene, E.; Lissner, A.; Guttowski, S.; Reichl, H.
Methodical Design of EMI Filters for Power Electronics
2nd International Automotive Power Electronics Conference, Paris, France, 2007

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Proceedings Symposium VLSI Technology, Systems and Applications, pp. 1-2, 2007

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Design for Miniaturization of Wireless Sensor Nodes Based on 3D-Packaging Technologies
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Ostmann, A.; Manessis, D.; Neumann, A.; Reichl, H.
Lamination Technology for System-in-Package Manufacturing
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wt Werkstattstechnik online, Düsseldorf, Springer-VDI-Verlag, 2007

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Future Fab International, Issue 23, 2007

Ramm, P.; Takahashi, K.
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Warrendale, Pennsylvania, 2007

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Proceedings ECTC 2007, Reno, NV, USA

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German Technology - Electronics Production Equipment, Frankfurt, VDMA Verlag GmbH, 2007

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Efficient Antenna Design of Inductive Coupled RFID-Systems with High Power Demand
Journal of Communications, Vol. 2, NO. 6, November 2007

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The normally double closed (DNC) microvalve, a novel component to avoid free flow of micropumps
Fraunhofer IZM-Munich, Proceedings Workshop Microdosing Systems, October 2007

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Mikroverbindungstechnik DVS Jahrbuch 2007/2008. S. 3, 17-29, 57-62, 207-222, 223-232, 233-259, 260-274

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Der Weg zu Ökodesignanforderungen für externe Netzteile - Entstehung und Inhalt der vorbereitenden EuP-Studie
Elektronik - Sonderheft Ecodesign, WEKA Fachzeitschriften-Verlag GmbH, 2007

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High temperature and element alloying influences on Kirkendall voiding in Au ball bond interconnects on Al chip metallization
Proceedings of the 40th IMAPS International Symposium on Microelectronics, San Jose, CA, USA, November 2007

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Polymers and Adhesives in Microelectronics and Photonics 2007, Polytronic 2007, 6th International IEEE Conference on Polymers and Adhesives in Microelectronics and Photonics, Odaiba-Tokyo, Japan, January 2007

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8th International IEEE Conference on Thermal, Mechanical and Multiphysics Simulation and Experiments in Micro-Electronics and Micro-Systems, EuroSime 2007, London, UK

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