Packaging | Quality | Reliability | Sustainability

Fraunhofer-Institute for Reliability and Microintegration IZM

Annual Report 2005

Content
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Preface

›› Microtechnology as technology and the Internet as application platform are rapidly and comprehensively changing almost all areas of our professional and private lives. Today, all visions of the future share a common basis: communication without borders via the Internet and mobile devices, usable anywhere. Thereby, for example, the mobile phone will become a ubiquitous information and communication terminal. It will be defined by increasing miniaturization and the integration of a wide range of services, whereby actually making phone calls almost becomes a peripheral aspect.

Within this context, the task of system integration is combining a system's various component parts with modern, cost-effective technology, to produce a miniaturized, highly complex, ubiquitous and high-performance system. This is the framework for a new system integration concept, which is based on so-called electronic grains or eGrains. The project „Autarkic-distributed microsystems", successfully completed in 2005, forms the foundation for this concept.

In cooperation with the following TU Berlin institutes:

- the Research Center for Microperipheric Technologies (FSP-TdM)
- the Institute for Telecommunications Systems, Working Group Telecommunication Networks (TKN) and Working Group Open Communication Systems (OKS)
- the Institute for High Frequency Technique and Waveguide System Technologies, Working Group Microwave Techonology (MWT) and Working Group Antennas/EMC (ANT),

and the Ferdinand-Braun-Institut für Höchstfrequenztechnik (FBH), Berlin,

and under the project management of the Fraunhofer IZM, highly miniaturized autarkic microsystems with sensors were produced, which can receive, process, save and send data (sensor nodes). A radio interface makes communication between the programmable system parts possible. The organization of eGrains into a system is based on a self-organizing network, which is coupled to other local or global networks. eGrains are microsystems, realized with the most modern assembly and interconnection technology. Thus it was possible to develop a fully functioning eGrain at the IZM, that is not larger than 1 cm^3 and yet still has an integrated antennae, HF-transmitter module and analogue circuits, sensors, storage and processors with a new "functional layer technology".

Moreover, supplying autonomous electronic systems or sensor networks with power is one of the deciding challenges here and will largely determine the performance parameters and possible applications. Wireless transmission of information only makes sense if the power supply is autarkic. Either sufficiently large power storage or the option of generating power from the environment must be available. While there are technical solutions for larger systems, a multitude of problems arise in miniaturization. For this reason, a micro fuel cell was developed at IZM, with higher-density energy storage and as a wafer level technology for primary batteries. With a 1 cm^2 large, 200 µm thick prototype system, performances of 40 mW for PEM fuel cells and 5 to 20 mW for Li-polymer batteries are attained.

Through this project, it has, for the first time, been possible to create a new system solution via a cooperation between hardware and software experts and technologists. The method serves as an example for how technology may be developed in the future at IZM. The working method will help to determine new fields of application for microsystem technology.

Along with these topics of interest, this annual report again presents a selection of our latest research outcomes. I would like to take this opportunity to thank our partners in industry and research, the project agencies, and especially our organization's employees for their excellent and dependable cooperation throughout the last year.

Happy reading!

Herbert Reichl

The Fraunhofer-Gesellschaft

›› The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration. The organization also accepts commissions and funding 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.

By developing technological innovations and novel systems solutions for their customers, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. Through their work, they aim to promote the successful economic development of our industrial society, with particular regard for social welfare and environmental compatibility.

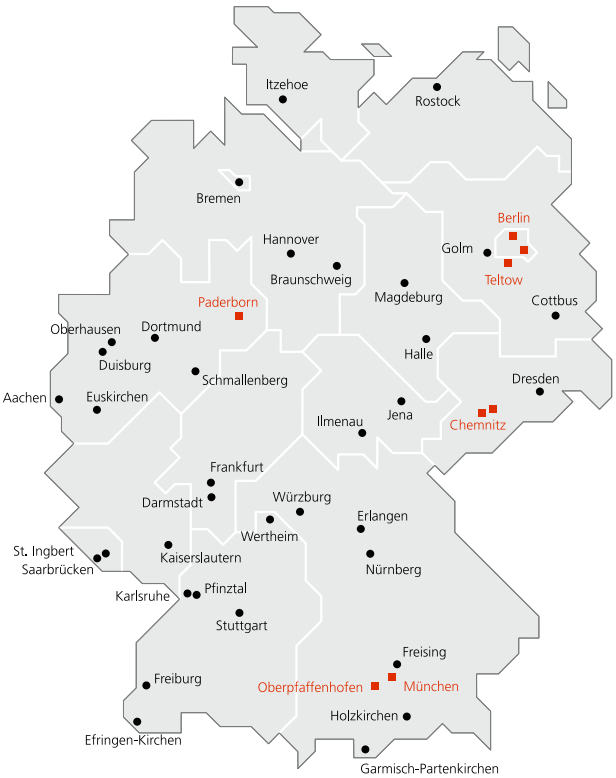
As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, in other scientific domains, in industry and in society.

At present, the Fraunhofer-Gesellschaft maintains some 80 research units, including 58 Fraunhofer Institutes, at over 40 different locations in Germany. The majority of the roughly 12,500 staff are qualified scientists and engineers, who work with an annual research budget of over 1 billion euros. Of this sum, more than €900 million is generated through contract research. Roughly two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. The remaining one third is contributed by the German federal and Länder governments, partly as a means of enabling the institutes to pursue more fundamental research in areas that are likely to become relevant to industry and society in five or ten years' time.

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 was founded in 1949 and is a recognized non-profit organization. Its members include well-known companies and private patrons who help to shape the Fraunhofer-Gesellschaft's research policy and strategic development.

The organization takes its name from Joseph von Fraunhofer (1787-1826), the illustrious Munich researcher, inventor and entrepreneur.



Fraunhofer Microelectronics Alliance

›› The Fraunhofer Microelectronics Alliance VμE coordinates the activities of the Fraunhofer institutes working in the fields of microelectronics and microintegration. Its purpose is to recognize and anticipate new trends in microelectronics applications and to incorporate them in the future strategic plans of the member institutes. This is generally done by defining joint focal areas of research and through joint projects. This method of working enables the cooperating institutes to offer their customers, in particular innovative small and medium-sized firms, access to cutting-edge research and developments in applications at an extremely early stage, thus giving them a distinct competitive advantage. The core competences of the cooperating institutes are combined in the fields

- communication and entertainment;
- mobility;
- micro- and nano technology
- automation technology
- work, living, leisure and shopping
- medicine technology
- light
- security

The office of the Fraunhofer Microelectronics Alliance serves as a central liaison point for the twelve member institutes. Acting in an advisory function, it provides support to the steering committee of the Microelectronics Alliance in matters related to the coordination of research content and the planning of future work. The office's main function is to draw up strategies and roadmaps for the member institutes and to coordinate their implementation. A further aspect of its work is central marketing and cross-institute public relations work.

Further information: www.vue.fraunhofer.de

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Fraunhofer IZM Profile

›› Aims |

The IZM deals with the research and development of methods, processes and technologies of system integration and electronic packaging. An extensive offer of services facilitates a fast transfer of the latest research results to industry. Supporting firms in the broad application of system integration technologies (e.g. microsystem technology) and reliability qualification is one of the institute's main objectives. This concerns the automotive and mechanical engineering sectors, as well as different areas of information and communication technologies.

The current focus of our work is on 3D integration, polymer electronics and the set-up of miniaturized sensors and sensor networks.

›› History |

Fraunhofer IZM was formed in 1993 from working groups of the Research Center for Microperipherics at the Technical University of Berlin as well as scientists from the Humboldt University and from the former Chemnitz Institute for Mechanics of the Academy of Sciences. Later, project groups in Teltow, Paderborn and a further group in Chemnitz joined the IZM and then were transformed into departments.

A new division of the institute was founded in Munich in 1999. In total, the institute has approximately 320 employees (at present 213 staff and about 110 students).

›› Technological focus |

- Electronic packaging at wafer and chip level
- System design and characterization
- Interconnection technologies in the micro and nano range
- Reel-to-reel manufacturing
- Development and application of high tech materials
- MEMS-, RF- and photonic packaging
- Multi device integration
- Reliability models and lifetime estimation
- Technology and product assessment under environmental considerations

Cooperation with the Technische Universität Berlin

›› BeCAP - Berlin Center of Advanced Packaging |

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 setup 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.

Reliability of Microelectronic Systems

›› The reliability of systems in application areas such as medical technology, automotives and controls is increasingly dependant on electronics. Reliability has become a competitive factor. Designers have to predict reliability more quickly and precisely. This requires new concepts for the "Design for Reliability" area: in demand is system competence, the ability to merge technology, design, function, constraints, their interdependencies and their effects on reliability in system design.

This includes the transition from considering the reliability of single components or interconnections to considering the whole system. In the design phase, reliability prediction requires dependable methods. Physics-of-failure models are needed to predict reliability with sufficient accuracy.

The research activities of the Fraunhofer IZM in the field of system reliability are divided into three areas:

- The vertical (or hierarchical) system model to reduce the complexity of the system,
- the horizontal system model (also system competence) to merge the different areas of expertise,
- the weakest link model.

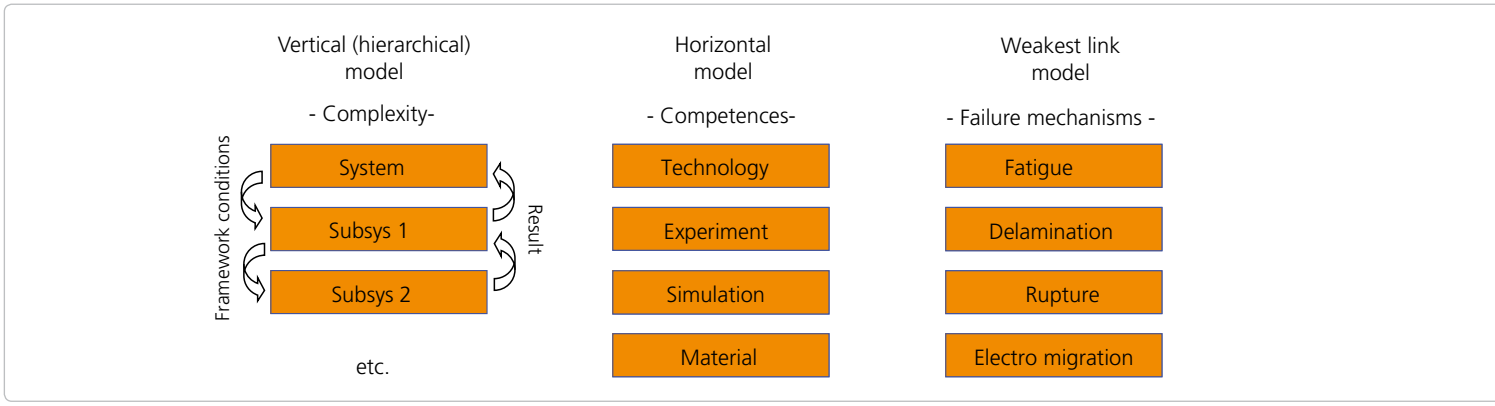
These three areas are interlinked. Thus, on each complexity level (subsystem) the parameters are set by the constraints of the next, higher level. Along with partitioning the system into subsystems, the modelling of physical mechanisms becomes more detailed (e.g. material behaviour). The highest system level is defined by the device – the lowest level subsystems are at nano-level.

The modelling and reduction of system complexity is the ongoing research issue, as until now a solution has not been found. A promising approach is the development of thermo-mechanical compact models within the context of "response-surface"-modelling. Here, the dependence of a subsystem (e.g. a flip chip bump) life cycle on constraints (e.g. bump geometry, temperature) is determined and undergoes multidimensional analysis. In this way, the physical failure models at this stage can be "inherited" as an analytical (life cycle) model by the next level of complexity.

On each level of complexity, failure modelling by theory (and, in the final phase, by simulation) enables the transfer to the next higher level. This requires knowledge about the technology's materials, influences and constraints, as well as verifying models using experimental and analytical methods. Within this context, system competence is the merging of expert skills, focusing increasingly on material structures and their influence on failure ("nano-reliability").

The description of failure mechanisms by life cycle models enables evaluation and comparison. Thus weak links in the system can be identified and assessed.

The three pillars of system reliability



O. Neß
B. Wunderle

Research activities of Fraunhofer IZM |

In line with the three pillars of system reliability, Fraunhofer IZM has expanded its research activities:

- Developing life cycle models for the most relevant failures (e.g. wire bond rupture, delaminating of adhesives and encapsulation, aging of solder and metals)
- Understanding the influences of manufacturing processes on material properties and life cycle models
- Correlating structures and attributes of polymers and interfaces under consideration of temperature and humidity
- Developing compact models, using "Design of Experiment" software
- Applying analytic methods, including on micro- and nano-scale

"Reliability of Microelectronic Systems" Workshop |

On September 20, 2005, scientists of the Fraunhofer IZM, together with the Research Center for Microperipheric Technologies at the Technische Universität Berlin, organized a one-day workshop, entitled "Reliability of Microelectronic Systems", to inform our customers in industry and research about our initial results.

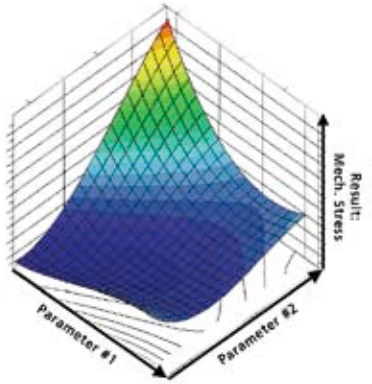
System qualification by a physics-of-failure approach in the daily-business of a "global player" was described with a practical example by Dr. Schaafhausen from Infineon Technologies to the almost 100 participants.

Fraunhofer IZM scientists presented the reliability effects of manufacturing processes and test environments by means of practical examples, e.g. die-bonding, substrates, wire bonding and encapsulation with polymers. The relevant failure mechanisms had been researched in simulations and experiments, resulting in life cycle models that enable a system evaluation.

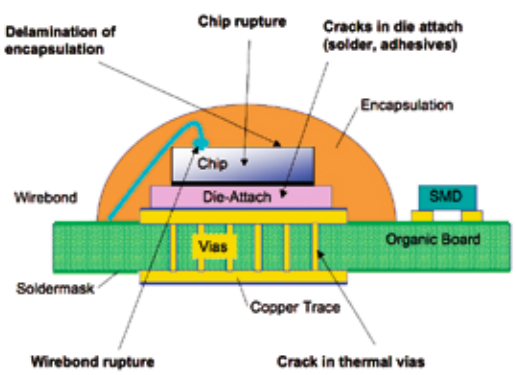
System Reliability at the Fraunhofer IZM |

In the context of the ongoing research at the Fraunhofer IZM, the three pillars of system reliability (vertical, horizontal and the weakest link model) are being investigated further. We continue to successfully support our customers in designing and manufacturing reliable microelectronic systems.

Example for a "Response-Surface-Model"



Example of chip-on-board



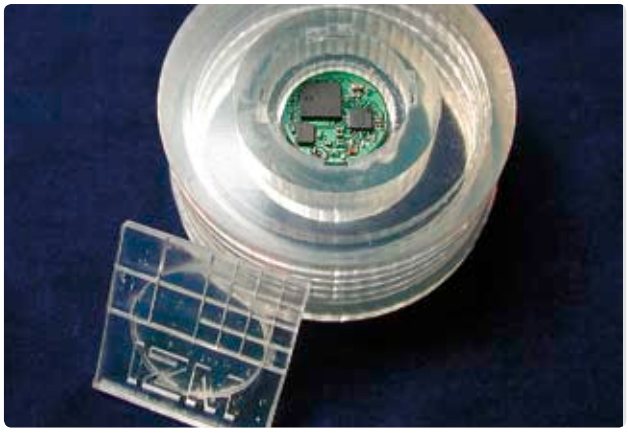
Trends in Microelectronic Packaging – from Components to Autonomous Systems

›› Along with silicon technologies, current microsystem technology and packaging utilizes a variety of different materials and manufacturing technologies to create smart systems with integrated sensors and actuators. At this point, microsystem technology is able to meet demands for high complexity and low cost. In the future, system integration will be able to deliver extremely miniaturized microsystems for a variety of applications. They will have autonomous energy, be linked via networks and have a wireless communication interface. An example of such development is so-called eGrains, which collect data from the environment, analyze it, and can – on demand - organize themselves into a wireless network.

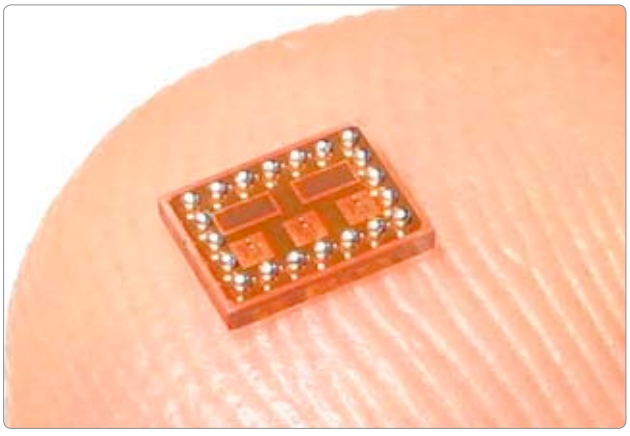
These autonomous microsystems can be used for many applications, such as in logistics, traffic control, households, all the way to functional monitoring. Microsystems will make a contribution to customized medicine and will increase quality while decreasing cost. Complete bio-laboratories on a chip, networked with practically all hospital departments, are no longer science fiction. Such multi-functional microsystems can contribute to fields such as security, in, for example, the unambiguous identification of people (biometrics) and objects and situation appraisal. Apart from developing new application areas (e.g., food quality control, health monitoring, production supervision), new low-cost microsystem-production technologies will have to be developed.

Microelectronics and microsystems technologies already use the smallest of structures. In the future, techniques will be invented to create structures which use just a few atoms. New functions in microelectronics and microsystems technology can be developed by using nanotechnology. The latter will contribute to the generation of new integration technologies and products in, for instance, sensor networks and all-encompassing applications. Creating total system solutions monolithically on a chip (SoC) involves extensive technical effort and high cost. Therefore, it is far more economical to build hybrid systems while still using the advantages of monolithic integration with regard to miniaturization and reliability. This method of integrating electronic, optical, bio-electronic and micro-mechanical functions in the smallest possible volume is called Hetero System Integration.

In Hetero System Integration, electronic components for electric and non-electric signal detection, signal and data processing, wireless communication, energy supplies and memory, which are of varying complexity, are combined into complete systems within a single package. In order to meet the requirement for high functionality with minimal size and weight, as well as low manufacturing cost, the most modern of technologies must be utilized.



Innovative screw scrap with pressure sensor and ID-tag



Integrated passive component with RF-filter for bluetooth applications

Herbert Reichl
M. Jürgen Wolf
Klaus-Dieter Lang

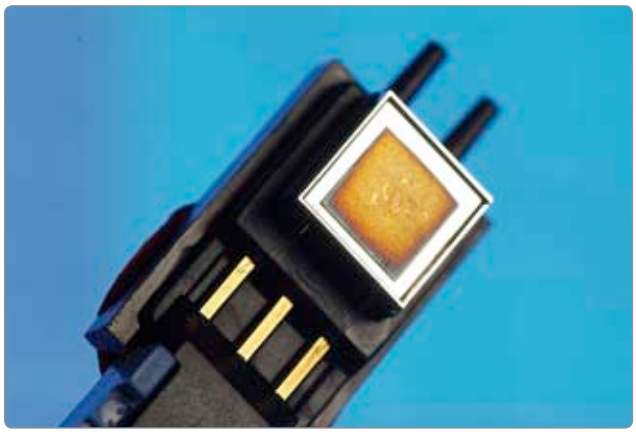
Nowadays, system integration is the key to developing modern products and is a source for innovations. Given the variety of uses for an integrated system depending on the application, selecting an appropriate technology becomes an important criterion for developing a cost-effective, efficient integrated system.

For applications in the automotive field, for example, important criteria will include meeting the stringent requirements relating to rough environmental conditions, elevated operating temperatures, high power density as well as high reliability. On the other hand, applications in telecommunications will require high functionality combined with a high degree of miniaturization. They require wireless signal transmission and optical, as well as electrical, signal transmission. System bio-compatibility and integration of appropriate sensors will be paramount in medical applications. Therefore, system integration technologies at board level, as well as at wafer level, will be selected and combined according to the requirements of the particular application field.

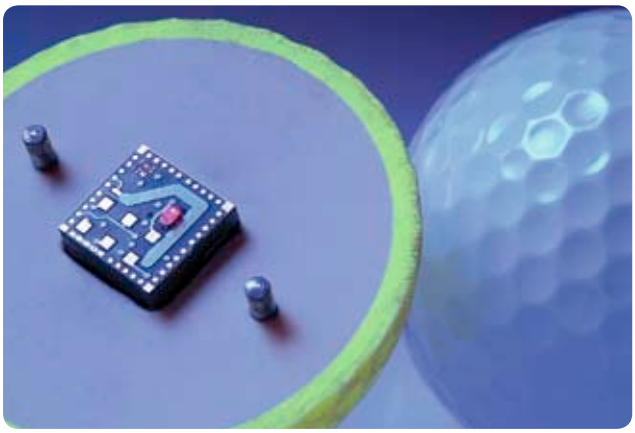
Both substrate-level and wafer-level technologies have great potential for developing and using application-specific system integration solutions to provide a foundation for innovative products.

In order to achieve small-sized, wireless, autonomous sensor nodes, e.g. eGrains, in the future, new integration technologies must also use the third dimension for systems integration. In terms of design, hardware, technology and software, system integration based on the innovative eGrain concept represents an entirely new challenge and requires a synergy of individual technologies at an exceptionally early stage.

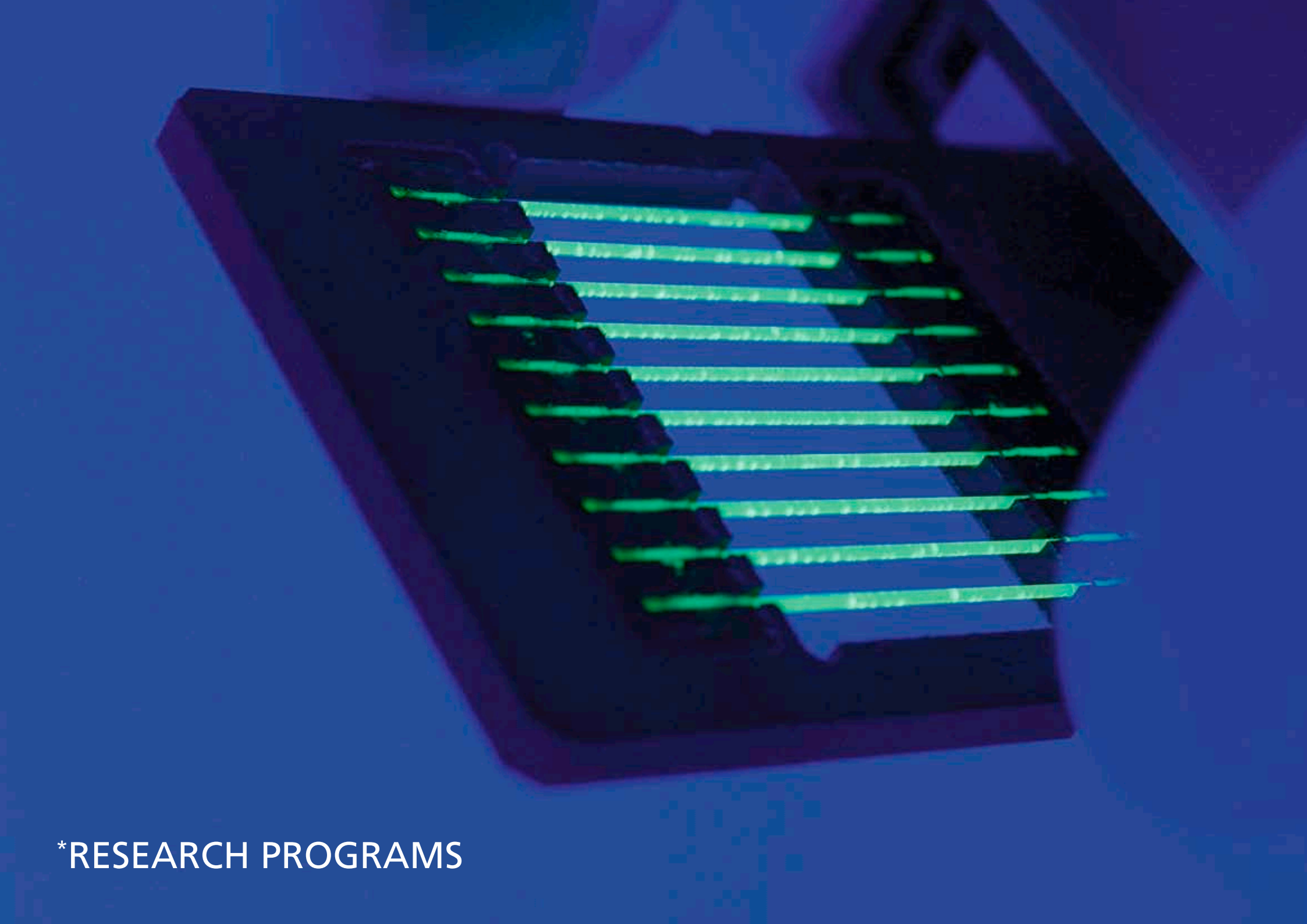
For cost and efficiency reasons, further development of individual technologies requires, therefore, an intensive interdisciplinary cooperation between scientific institutions, small and medium enterprises as well as global industrial players. The newly generated system solutions will stimulate new innovations and will play a central role in selecting new development and production sites.



Silicon micropump



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



*RESEARCH 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:

» RESEARCH PROGRAMS

018 **3D SYSTEM INTEGRATION**
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019 **LARGE AREA ELECTRONICS**
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020 **MEMS PACKAGING**
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021 **MICRO RELIABILITY AND LIFETIME ESTIMATION**
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022 **PHOTONIC PACKAGING**
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023 **RF SYSTEMS**
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024 **SUSTAINABLE TECHNICAL DEVELOPMENT**
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026 **WAFER LEVEL SYSTEM PACKAGING**
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3D System Integration

›› 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 IZM can be classified in the following categories:

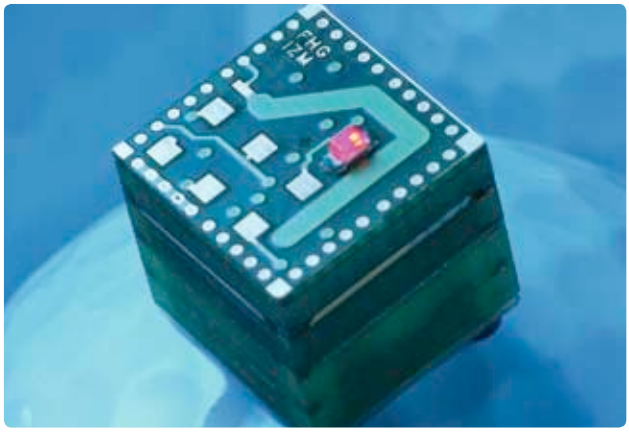
- Stacking of packages/substrates,
- Die stacking and
- Vertical System Integration (VSI®).

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

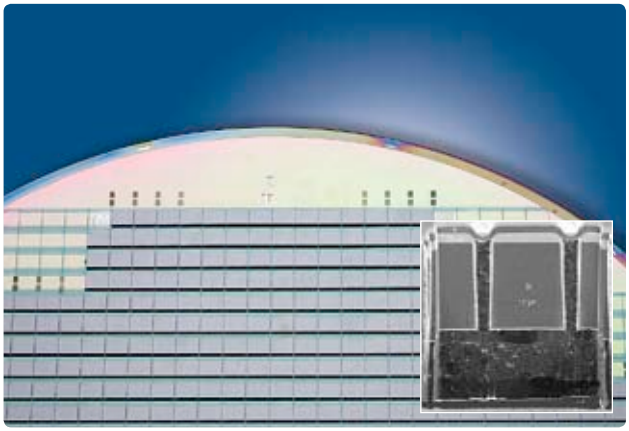
Stacked packages can be realized with the so-called chip-in-polymer technology based on embedding of thin chips into build-up layers of PCBs. The resulting chip size packages (CSPs) with copper-filled vias through the PCB are then stacked and electrically interconnected by solder balls. A smart substrate 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 IZM´s know-how by the Match-X association. State-of-the-art for stacking of dice at the 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 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 co-operations 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.



Wireless sensor system integrated in a golf ball



Vertical System Integration: ICV-SLID technology top: Chip-to-wafer stacks, bottom: 3D integrated test structure, showing a cross section (FIB) of a 10 µm thin chip with W-filled inter-chip vias connected to the bottom wafer by the SLID metal system (Cu, Cu3Sn, Cu)

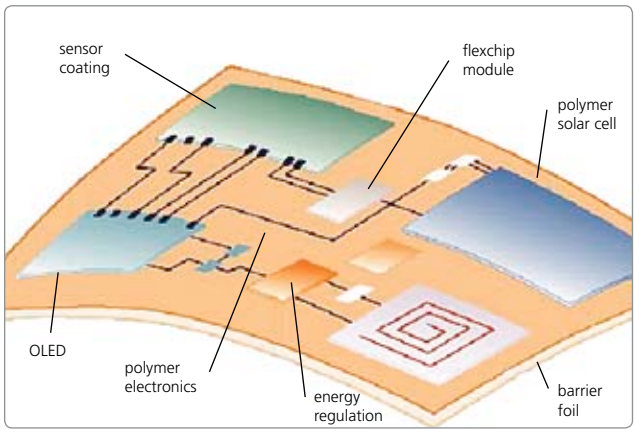
Large Area Electronics

›› 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.

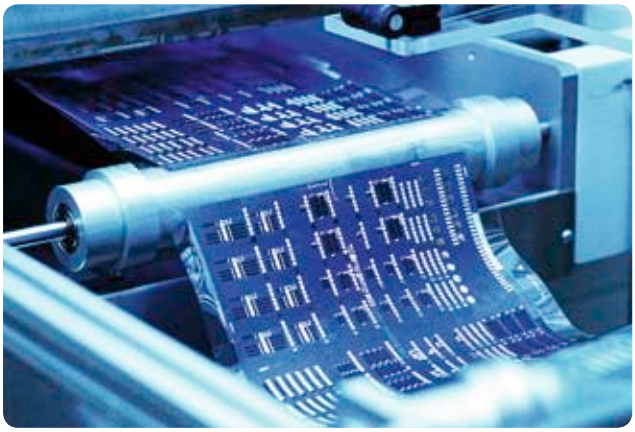
With large-area electronics, for example, electronics, displays with a sensor keyboard and solar cells for power management with conventional flexible silicon circuits can be combined. In a few years, this will result in an efficient computer on film – although initially it will be a smart card or a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



Schematic representation of a microsystem on film



Reel-to-reel manufacturing: screen printing of silver conductive paste

MEMS Packaging

›› 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

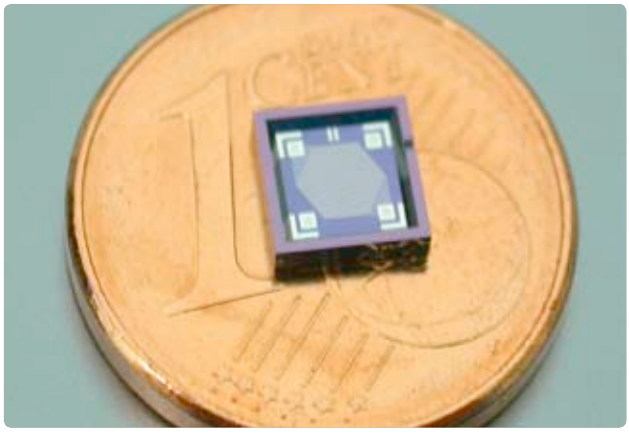
The MEMS Packaging Program therefore focuses on bringing together the expertise available at the IZM from device requirements, device manufacturing, component realization, test and qualification. The different technological departments team up to form a synergy for the development of an optimum solution 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.

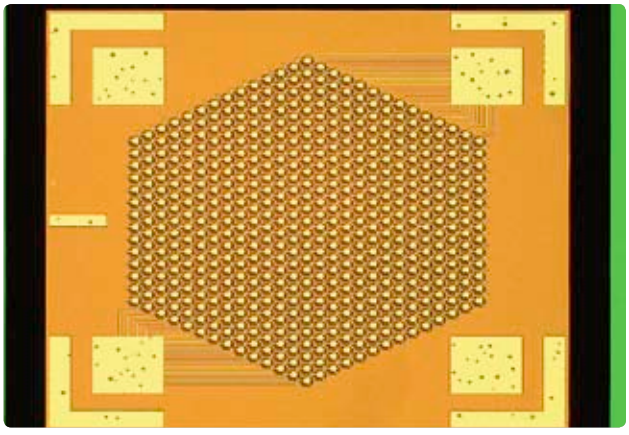
We strive to be your prime source for MEMS& sensor packaging issues.

What can we do for you:

- 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



Bonded ultrasonic transducer



Sensor array with contact pads

Micro Reliability and Lifetime Estimation

›› 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).

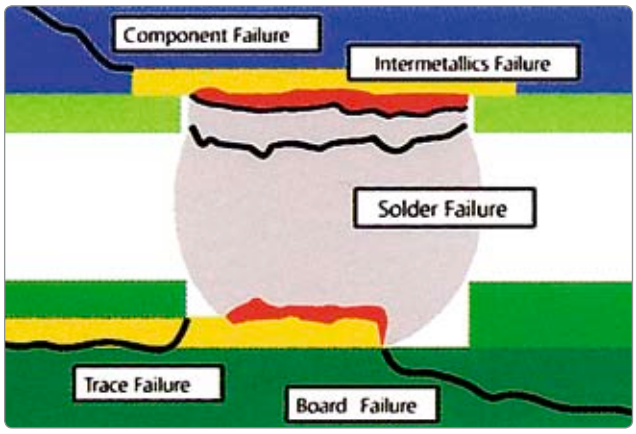
COMPETENCIES AND ACTIVITIES

The lifetime prognosis requires dealing with the following tasks:

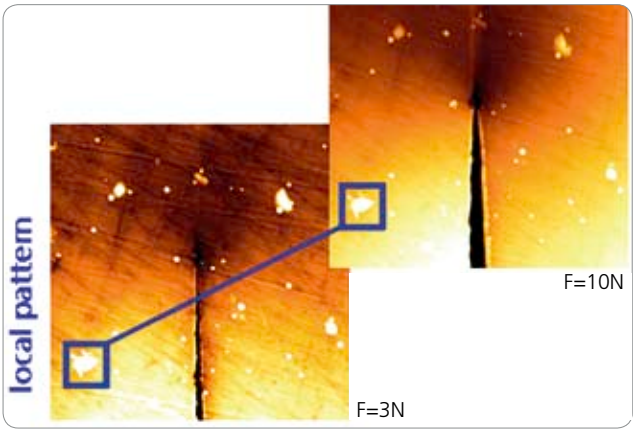
- Modeling in-situ determination of reliability parameters
- New NDE testing methods
- Identifying and verifying lifetime expectation

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



Crack avoidance strategies for electronic packages



Local crack diagnostics in an AFM

Photonic Packaging

›› 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.

Technology focus

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

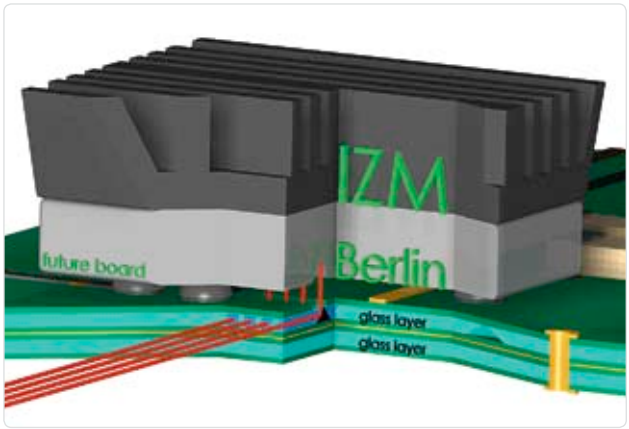
Optical backplane & EOCB |
Hot embossing or UV-direct writing, 90° beam coupling

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

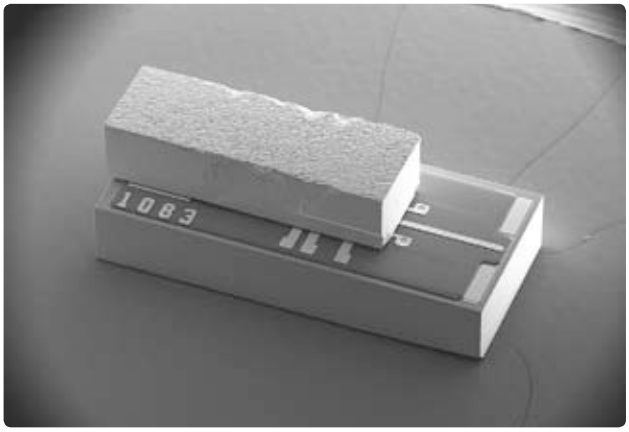
Image sensors |
Pixel detectors IR, X-ray, Wafer level OPTO-CSP for CCD and CMOS cameras

Micro devices |
Micro spectrometer, laser projection devices

Materials & reliability |
New optical polymers, reliability testing, failure analysis



Schematic drawing of a hybrid electrical-optical circuit board using 90 degree beam



100 Gb/s photodiode flip chip assembled on thin film multilayer substrate

RF Systems

›› Microsystem 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 this development's cornerstones. 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.

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, IZM has achieved broad background knowledge regarding all RF & wireless system integration areas, available for quick and effective R&D projects with partner companies. IZM offers solution-oriented support for the entire range of RF & wireless system development and customer-oriented, bilateral R&D partnerships.

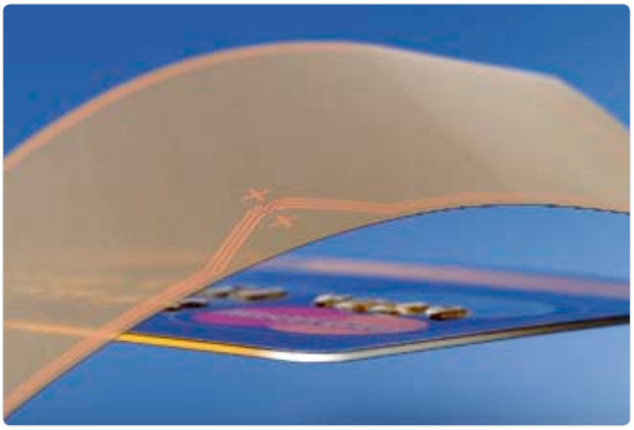
COMPETENCIES AND ACTIVITIES

IZM's support of the industry incorporates four areas of RF & wireless system integration:

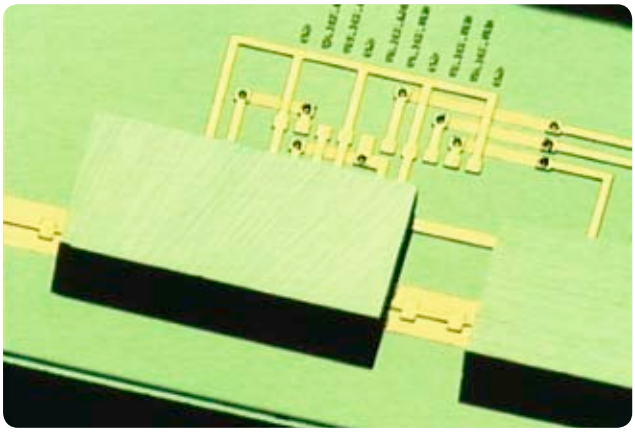
- Methodology, conceptual system development and modeling
- Board, assembly and housing
- Prototyping, processing und production
- Characterization, reliability test and certification preparation

In the context of R&D projects, IZM both analyses and evaluates present development trends, by its active presence in R&D, diversified international networks and co-operations.

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



Ultra thin RFID transponder chip on flexible antenna substrate



AuSn flip chip bonded VCO and MPA on Si substrate for 77 GHz radar sensors

Sustainable Technical Development

›› A sustainable development balances economic, environmental and social aspects to improve quality of life today while preserving resources and opportunities also for future generations. The summary trend of all technologies determines whether we are moving towards more sustainability, and electronics has a great influence and responsibility to bear in this respect.

On one hand microelectronics undoubtedly enable solutions to foster sustainable development, for example through increased efficiency, safety or by providing basic services like communication. But at the same time a growing and fast-paced industry is a potential source of increasing impacts on the environment.

The IZM has a long tradition of integrating environmental concerns and requirements into research and development processes, with the aim of balancing environmental aspects with economic results in new, most often smaller and more reliable solutions. The new IZM R&D program "Sustainable Technical Development" brings together the various competencies needed to assess and optimize complex technologies and products.

While focusing on the miniaturized domain of microsystems and integration technologies as 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, which are one pillar of the sustainability concept.

COMPETENCIES AND ACTIVITIES

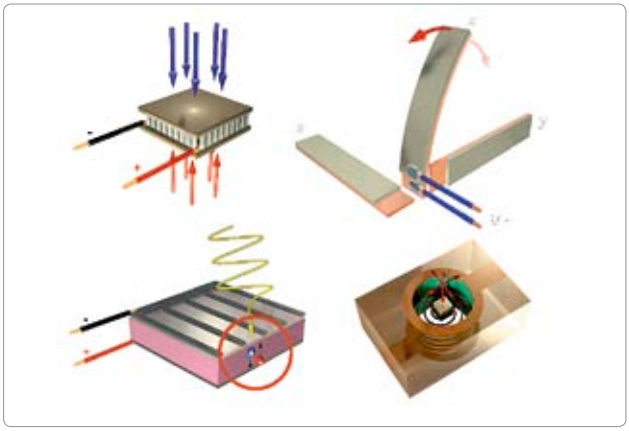
Three focal areas may represent the spectrum of our offers:

- Energy efficiency and miniaturized power supplies (for example miniaturized fuel cells)
- System reliability and lifetime prediction (e.g. using accumulated load data for predictive maintenance)
- Renewable materials in electronics (e.g. lignin based printed circuit boards)

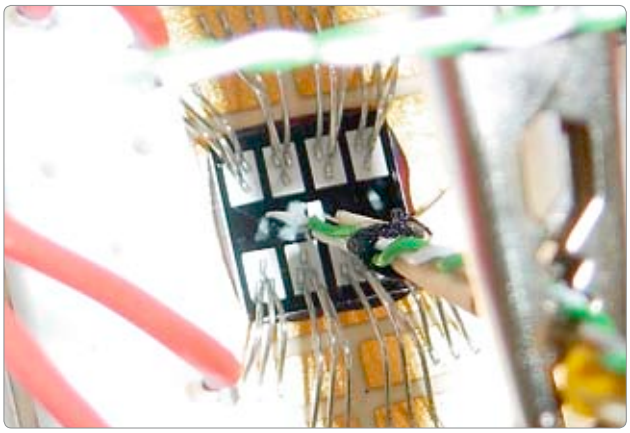
Alongside the various technical development possibilities it is equally important to be able to tailor the communication for individual recipient groups, which can be from companies, associations, politics, education (i.e. schools, vocational training, university) and from differing cultural backgrounds.

One example for targeted support for industry in the adaptation to new legal requirements is the lead-free transition process. For the RoHS as well as for the WEEE and EUP directives we organize industry workshops and networks, and we give individual support via pilot studies and implementation concepts.

To further complement our technical research, methods and tools for assessing sustainability are investigated. Prospective approaches such as trend analysis, roadmapping and scenario techniques are employed to capture and describe the longer term effects.



Energy harvesting principles - the incidental energy around a system can power small microsystems



Test setup for power cycling of IGBTs to determine and predict failure modes to improve system reliability

Thermal Management

›› 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 IZM 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:

The design for reliability unites

- 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"

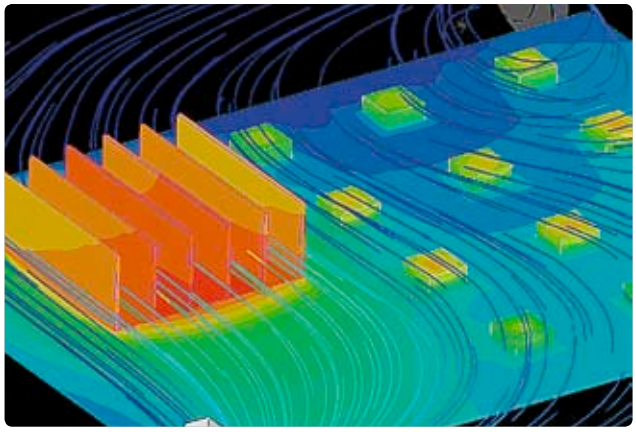
This consistent combination enables reliability-optimized thermal and thermo-mechanical design for advanced system integration and tailor-made thermal management solutions. It thus combines the key competencies of the institute's individual departments for an efficient and customer-orientated knowledge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

Available services

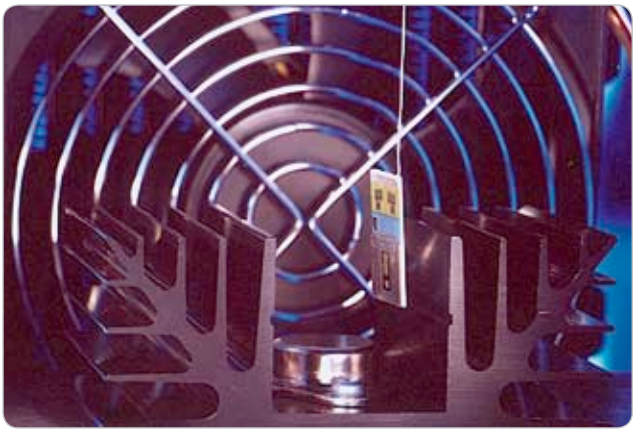
- Lifetime prediction
- Material characterization
- IR-thermography
- Rth-measurements
- Passive & active thermal cycling
- Test-station for air- and water-cooled systems
- Deformation measurements for micro- and nano-structures

Current research activities

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



Thermo-fluidic simulation of power module



Air velocity measurement for optimum choice of heatsink

Wafer Level System Packaging

›› 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 for devices like chip size packages (CSP) is, that the final package size is identical with the footprint of the die. A WLP process adds an additional routing layer to redistribute the peripheral I/O pads on the die into an area array. The fan-in IO rerouting creates solder bump pads with a larger standardized pitch. The final wafer bumping turns the component into a surface mount device (SMD), which fits into a standard assembly process (pick & place and reflow). After all packaging steps are finished, the whole wafer passes burn-in and test. Thus a Known Good Package qualification is possible, which replaces die testing and inking before packaging. The WLP is performed completely before dicing.

Package size, SMT compatibility, WL burn-in and test as well as cost reduction are major advantages driving industry towards WL solutions. Using modified IC processing techniques like thin film WLP allows to replace standard chip & wire technologies and perform WL system in package solutions. WLP as extended fab activities reduces process costs and logistic efforts as well.

Fraunhofer IZM has long term experience in thin film and interconnect processes applied in WLP. The Wafer Level 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.

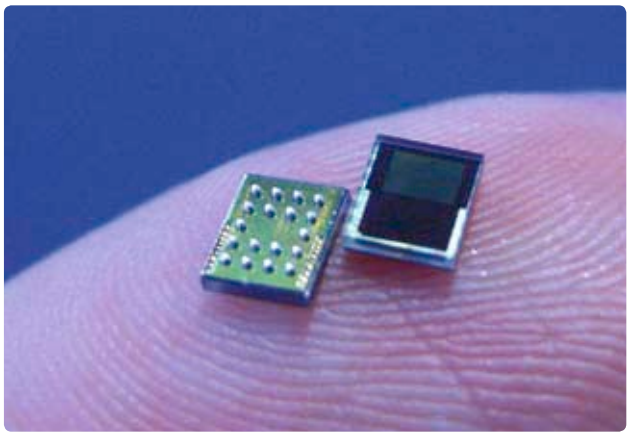
COMPETENCIES AND ACTIVITIES

Processes available:

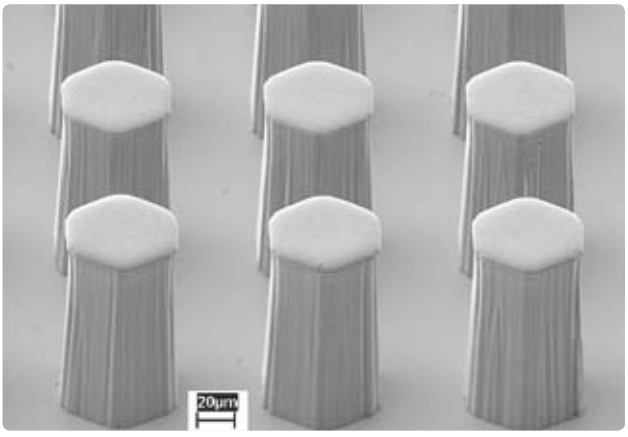
- Wafer bumping by
  - electroplating
  - electroless deposition
  - stencil printing
  - placement of premanufactured solder balls
- Redistribution technologies
  - processes using photo-definable dielectrics (BCB, Polyimide) and electroplated metallization (Cu, Ni, Au)
  - alternative processes using epoxy layers and electroless copper deposition
- Wafer level inspection
- Wafer dicing

Current research topics:

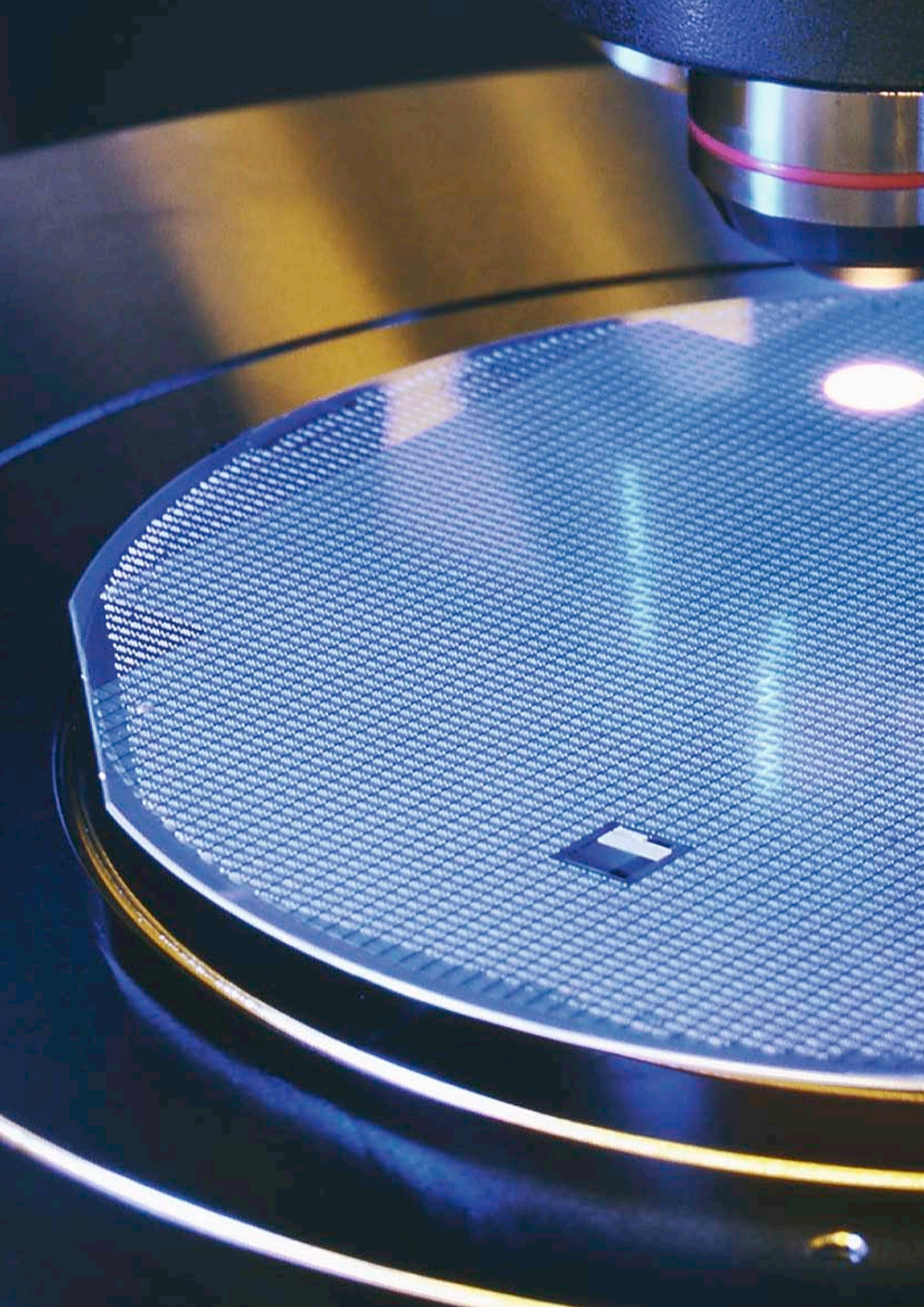
- Redistribution to the backside of the wafer
- Lead-free wafer bumping
- New UBM systems for leadfree bumping
- Wafer bumping by immersion soldering
- WL-SiP with integrated passive devices (R, L, C)
- WL-CSP for 300 mm wafers
- Transfer molding at wafer level
- Wafer level test

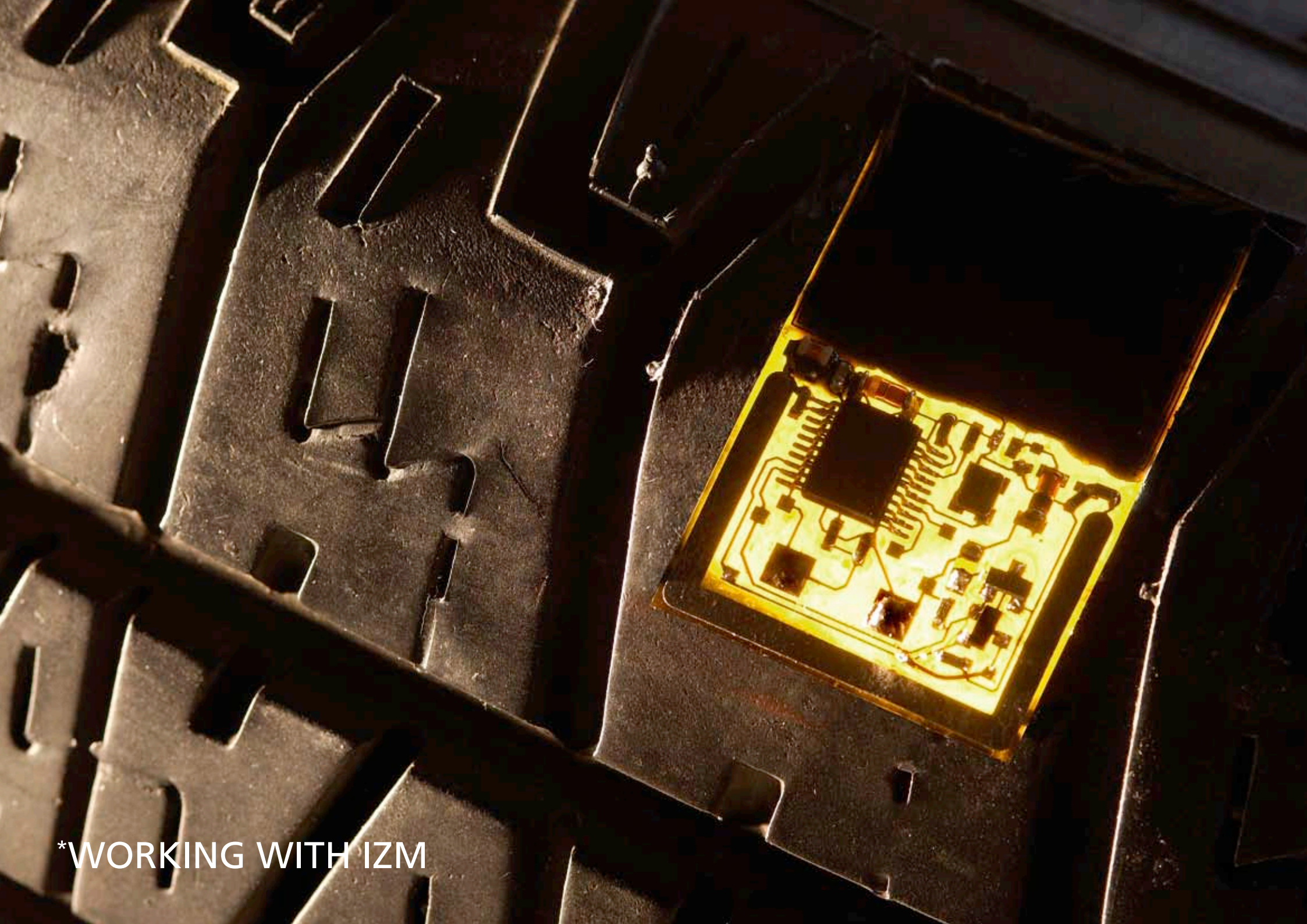


Opto wafer level package (Courtesy of Schott Electronics GmbH)



Copper pillar bumps (height 80µm)





*WORKING WITH IZM

» WORKING WITH IZM

Fraunhofer IZM Marketing – Your First Contact to Fraunhofer IZM

›› Which technologies, moreover which new products and services will ensure the success of your company? Facing global competition and even shorter product and technology cycles, the accurately timed introduction of new technologies is decisive for your company's competitive position.

However, which innovative technologies will have the potential for optimizing your company's technology portfolio? Which upcoming technologies do you have to look at to be there, when that technology appears on the market?

Fraunhofer IZM is one of the leading research institutes worldwide in the field of system integration for both microelectronics and microsystems. Our competence includes material developments, new packaging technologies as well as solutions for quality, reliability and environmental tasks.

Our advantage is the combination of basic and advanced research and its implementation in industrial applications. You will find examples of both our technological competence and our services in the following pages.

Our experts will be happy to help you with selecting technologies, which will bring optimal benefits for your company and your products.

If you are interested in our experience, please do not hesitate to contact us. The Marketing Team will be glad to help you.

We offer support in following tasks:

Company-specific workshops |
Do you wish to test your technologies or do you want to know, which technologies could be relevant for your company in future?

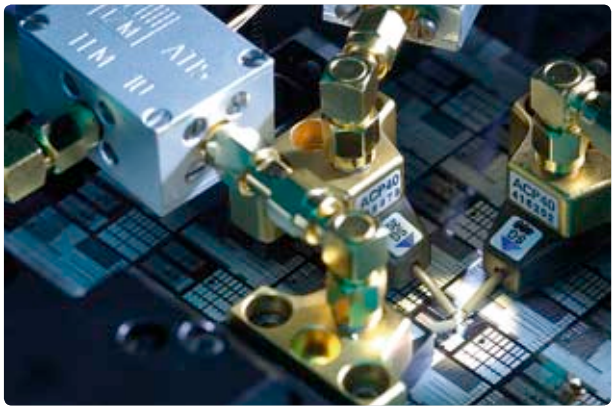
We offer company-specific workshops. Our experts present the whole spectrum of technological developments in the field of electronic system integration and packaging, starting with materials and ending with reliability and environmental aspects. Together we will discuss, which technologies could be relevant for you.

Technology-specific workshops |
You know, in which field of technology you are willing to invest. Your company needs support by selecting the best available technology. Our experts will discuss the advantages and the disadvantages of the chosen technologies with your technicians, strictly oriented to the needs of your company.

Assistance concerning product/ technology-specific tasks |
Does your company need assistance with current technical tasks, however, you don't know whom to contact at Fraunhofer IZM? Simply contact the Marketing Team. We will connect you to the best experts at Fraunhofer IZM.

Please Don't Hesitate to Contact:

IC parameter measurement



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Collaborating with Fraunhofer IZM

Intelligent katheter

Fraunhofer IZM cleanroom

›› Competence from a single source |
Whether you are an electronics company or user –Fraunhofer IZM is your competent partner for all aspects regarding electronics packaging. Together with you, we develop customized solutions for both miniaturizing and integrating microelectronic systems into your products.

Application is our strength |
Our developmental palette orients itself upon the requirements of industrial practice. Together with manufacturers of both electronic components and systems, we work upon further miniaturizing and integrating either optical or mechanical functions. For electronics users, we provide application-specific solutions for integrating electronics into final products. The spectrum of our customers ranges from the automobile industry, to mechanical engineering, up to medicine and safety engineering. In addition, we have already successfully supported enterprises ranging from clothing, lighting and food to logistics in improving their products by integrating electronics.

Ways of collaborating |
We offer both detail as well as system approaches. Quickly transferring technology via:

- Consulting
- Feasibility studies
- Industrial projects up to realizing prototypes
- Solving quality, reliability and environmental issues ranks among the most important goals of our work.

Extend your competence – contract-research advantages |
Contract research means that we execute goal-oriented and innovative technologies or product-oriented problem solutions for you.

Via direct access to a highly-qualified, interdisciplinary research team, you gain:

- Security of results
- Time and cost savings
- Professional project management
- High quality standards

Satisfied customers in midsized business |
Both research and high-tech development are not just issues for large enterprises. Numerous midsized enterprises take advantage of our experts' competence. One of the best criteria for deciding upon collaborating with us are our many satisfied customers. Their numerous repeat orders speak for themselves.

Our competence – your advantage |

- Competence in electronics packaging from a single source
- We deliver electronics both reliably and economically to your application
- Save both time and money by accessing our long-standing expertise

Research Activities and Objectives


System Integration

Chip Interconnection Technologies

- Bumping Technologies such as electroless plating, 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 on interconnection technologies, electromigration
- Application specific technologies: wireless communication, MEMS, wearable electronics, medical, automotive

Photonic and Power System Assembly

- Construction and development of microsystem packages and package interfaces
- Photonic components and measurement techniques
- Packaging of optoelectronics: laser detectors, high brightness LEDs
- Flip chip assembly for microwave and millimeter-wave applications
- Electro/optical boards
- Advanced chip and wire bonding
- Materials and technologies for chip-on-board
- Power module packaging
- Technological failure analysis

Board Interconnection Technologies

- Deposition and specification of functional layers (galvanic, electroless)
- Materials, processes and equipment development, e.g. lead-free solder alloys for high temperature application
- Innovative soldering and preparation processes with plasma and laser treatment
- Biomimetic for plating and joining technologies
- Qualification of PCB packages, analysis of manufacturing failures and failed joints
- Training center for the European Space Agency
- Introduction of the ISO 9000 to ISO 9004 oriented to PCB-assembly

Polytronic Systems

- Polymer electronics and polymer MEMS
- Wafer preparation and ultra thin silicon
- Assembly of thin chips and microcomponents
- Flexible Electronics Application Centre (Reel to Reel)
- Hybrid integration
- Biosensors and bioanalytical systems
- Sensor systems for liquids with signal evaluation

Micro-Mechatronic Systems

- Design of micro-mechatronics systems
- Interconnection technologies and encapsulation
- Thermo-mechanical reliability
- Electrical simulation


Wafer Level Integration

Si Technology and Vertical System Integration

- 3D-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

Micro Devices and Equipment

- MEMS Design and Modeling
- Development of MEMS
- Development of advanced technologies
- Wafer level test
- Process and equipment simulation
- Back-End-of-Line BEOL
- Micro and Nano Reliability
- 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
- Microsystems
- 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
- Nanomechanics
- 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)

Analysis and Test of Integrated Systems

- Development and characterization of ESD protection circuits (vf-TLP)
- Device characterization from fA-DC to GHz-RF
- Concepts for mixed signal testing
- Product analysis and design debugging
- Process monitoring tests


System Design and Sustainable Development

Environmental Engineering

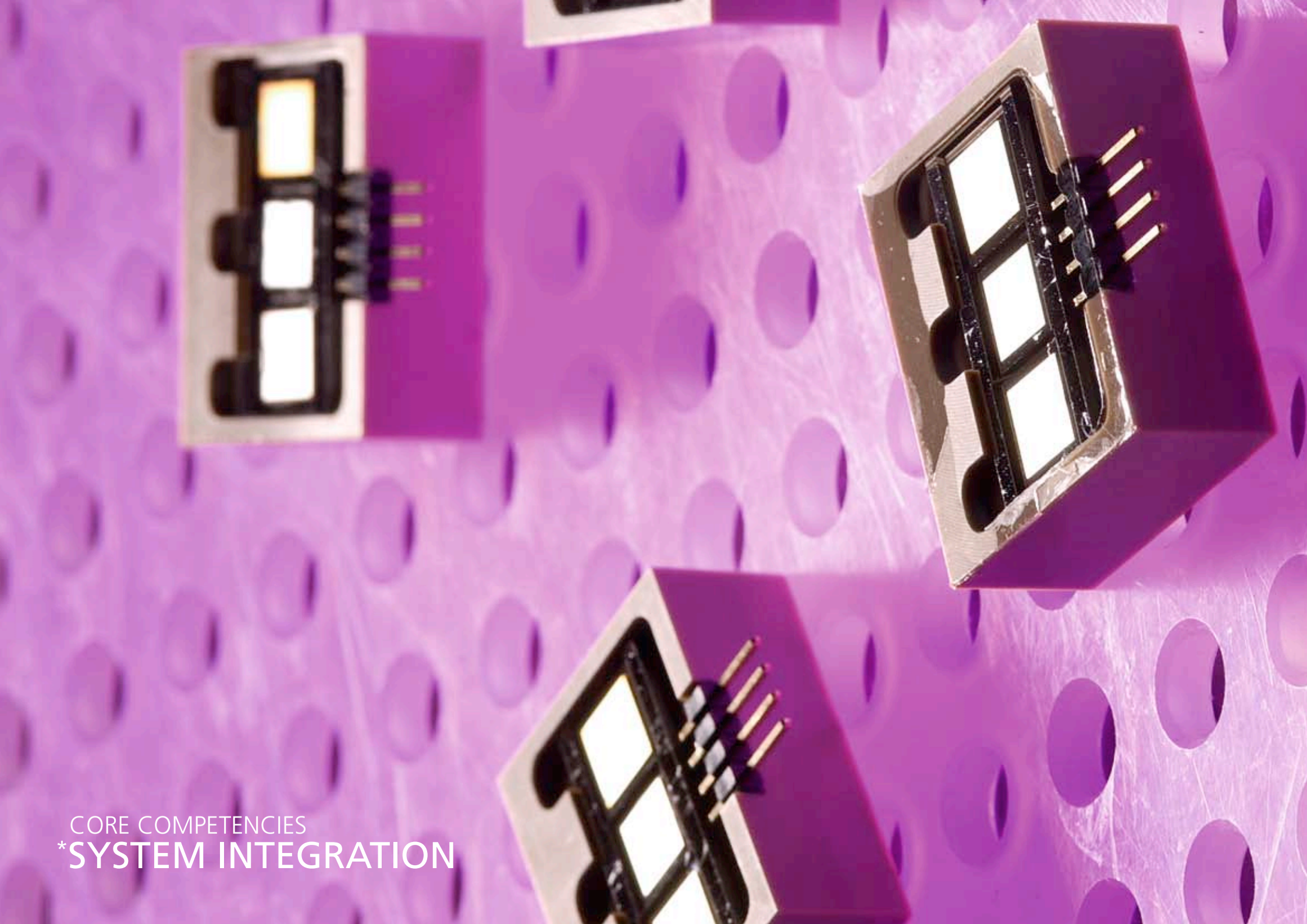
- Environmentally compatible product design
- Analysis and ecological assessment
- Lifetime estimation and reuse
- Ecological and economic analysis of technologies
- Demonstration Center »Product Cycles«
- Sustainable development of ICT

Advanced System Engineering

- Wireless systems/ RFID system development
- EM field calculation and analysis
- Analogue design and simulation
- EMC on chip and off chip
- EMC and power electronics
- Power/ground analysis and modelling
- RF analysis and modelling of passive devices and packages
- EMC/SI/RF analysis and modelling of packaging structures
- AddOn tool development

Microfluidic Systems

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



CORE COMPETENCIES

*SYSTEM INTEGRATION


R. Aschenbrenner


Dr. K.-D. Lang

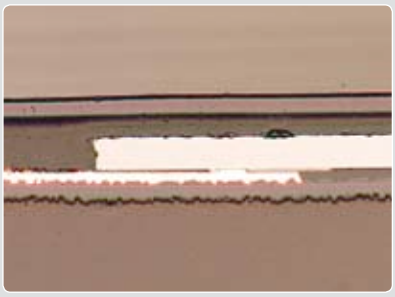

Prof. Dr. W. Scheel


Dr. K. Bock

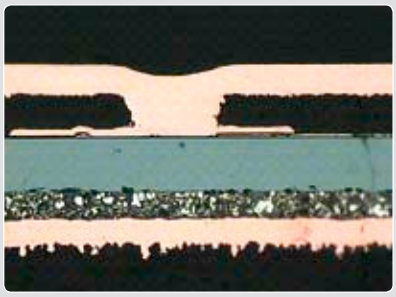

Dr. F. Ansorge

» SYSTEM INTEGRATION

Chip Interconnection Technologies



Thin chip embedded in flexible substrate



Cross section of an interconnect to an embedded chip

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

›› SHORT PORTRAIT

The department has 20 employees 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.

›› VISION

Research topics for the coming years are:

Microbonding |
- Flip chips with pitches < 40 µm, ultra-thin flip chips (20 µm thickness) with contact heights < 5 µm
- Die bonding of ultra-thin chips for embedding technology
- Low-cost bumping by stencil printing (80 µm pitch) and immersion solder bumping (20 µm pitch)
- Chip assembly at low temperatures (< 80 °C) for biochips

System packaging |
- Assembly and encapsulation technology (e.g. for wafer level CSPs)
- Direct package metallization by chemical plating
- MEMS and sensor packaging

Integrated components |
- Integrated resistors and capacitors for flex and printed circuit boards
- Integrated active chips (chip in polymer)
- Integration of discrete components by encapsulation

Wearable electronics |
- Connection of textile integrated antenna, detachable electrical contacts, flexible systems in textiles, assembly of ultra-thin transponders

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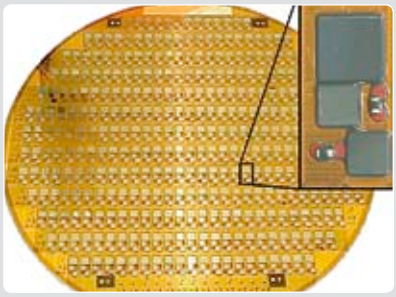
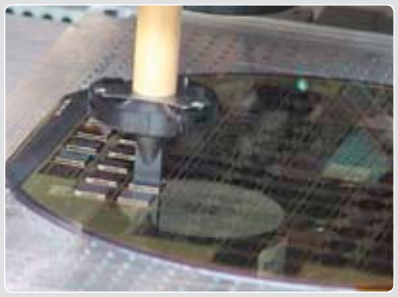
HIGHLIGHTS

- Ultra-miniaturization by silicon hybrid integration
- Partitioning of systems allow modular re-use of the integrated sub-systems
- Easy implementation using SMD compatible processes
- High level of compatibility with non-silicon devices ("More Than Moore"), in contrast to SoC
- Embedded resistors: 1 Ω – 10 kΩ with electroless Ni(P), and 100 Ω up to 100 kΩ with polymer paste printing.
- Embedded capacitors: 50 pF to 300 nF
- 20 µm chips embedded into flex substrate (size 5mm x 5mm, pitch 100 µm).



8" system-in-package demonstrator with flip chip on wafer technology



Flip chip assembly of semiconductors on a prepared 8" silicon wafer

›› RESEARCH RESULTS

Transfer molding for system in package generation |

Transfer molding is the standard process for the highly reliable encapsulation of leaded and advanced packages. New materials and process developments now allow the use of transfer molding technology for an encapsulation with added functionality. The direct encapsulation of flip chips with extremely high reliability is possible, as well as a Duromer-based MID technology. By adding and structuring a metallization layer on the encapsulant and by realizing vias through the package a generation of a 3D molded package is feasible.

Flip chip technology at wafer level |

In recent years flip chip technology has found many uses based on laminate PCB, flex circuits and ceramic substrates. However, the decreasing pitches of modern ICs challenge conventional board assembly techniques for FC; therefore, redistribution technologies at wafer level have emerged to compensate for these issues and enable maximum miniaturization. Using redistribution technology not only for contact re-routing of the IC but for circuit routing of a subsystem, highest integration can be achieved directly at wafer level by using this thin film process and following up with precision flip chip and SMD assembly. Such ultra-integrated, wafer level assembled subsystems lend themselves for easy testing and -after wafer dicing- to straightforward use in conventional interconnect processes, providing maximized function per area and volume.

Chip in polymer |

The chip in polymer technology enables a highly increased level of miniaturization and electrical performance for the coming generations of products. It is based on the embedding of thin chips into layers of printed circuit boards. Electrical contacts to the chips are formed by laser drilling followed by galvanic Cu plating. The embedding technology has been demonstrated on panels up to 18"x24" format. It is ready for the implementation in printed circuit board production lines.

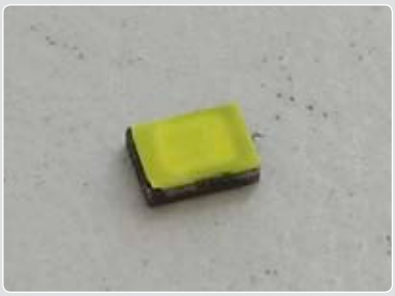
Flexible substrates with embedded components |

A considerable further increase in electronic system integration will be achieved by embedding components into the wiring board substrate.

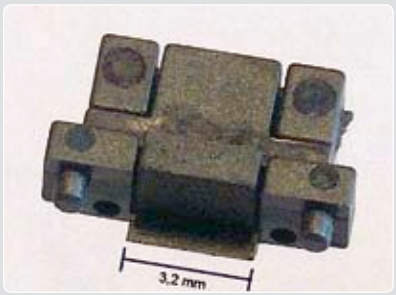
IZM Berlin has built up sound competences in the embedding of passive as well as active components into rigid and flexible wiring board substrates.

Chips with a thickness of only 20 µm were flip chip bonded onto the substrate by thermal compression. Electrical contact and mechanical stability are realized by ultra thin interconnects. Subsequently the chip is buried into the build up-layer by lamination of a covering foil. Reliability tests showed promising results.

Photonic and Power System Assembly



High brightness LED



Optical coupling module for 90 degree beam deflection for electro-optical circuit board and optical back plane with laser written waveguides

COMPETENCIES

Technology:
- Ultra fine pitch flip chip (AuSn, leadfree)
- Die soldering and gluing
- Wire and ribbon bonding,
- Chip on board (3D assembly)
- Developing electro-optical boards

Design, assembly and test:
- Microsystems
- Image sensors
- Power modules
- Laser and power LED modules
- RF modules

›› SHORT PORTRAIT

The department offers system design and development as well as function-oriented assembly and packaging technologies for microsystems, optical modules and power electronics.

Simulation and measurement tools are often the first step for optimized assembly solutions according to the current application case. Experience in system integration, material science and substrate handling are fundamentals for sophisticated and cost effective assembly processes regarding electrical, optical and thermal constraints.

Generally, integrating semiconductors (e.g. Si, SiGe, SiC, AIIIBV,) and photonic components are the focus. For interconnection soldering (e.g. void free), mainly welding and gluing (e.g. functionality-oriented) are used. High quality interconnects based on wire and ribbon bonding, flip chip (e.g. AuSn, SnAg, Au TC/TS) as well as micro-resistance and laser welding can be realized via automatic equipment and under production conditions. The results are transferred to the industry very easily. Reliability investigations guarantee required long-term stability.

Application areas are for example sensor systems, high-brightness LEDs, RF modules or power electronics.

Developing functionality-adapted interfaces and packages complete the activities.

›› TRENDS

Today's industrial demands, including miniaturization, higher performance, reducing power consumption, low cost, etc. also have to be fulfilled for photonic and power electronic systems. Strategically orienting P2SA considers these aspects.

Therefore, the following research and development topics for future requirements are the focus:

Photonic |
- Developing technology for optical chip-to-chip interconnects and OSiPs
- Enhancing competencies in the assembly of optical sensors and detectors as well as HB-LEDs and laser modules
- Improving design and simulation tools for optical subsystems and interfaces
- Allocating integrated manufacturing processes for electro-optical boards
- Prolonging facilities for functional tests and failure analysis

Microelectronics/Microsystems |
- Enhancing 3D assembly technologies for hybrid microsystems (electrical, optical and fluidic)
- Reinforcing activities for RF-system assembly technologies (f > 10 GHz)
- Design of power electronics
- Improving packaging technologies for power and high temperature electronics

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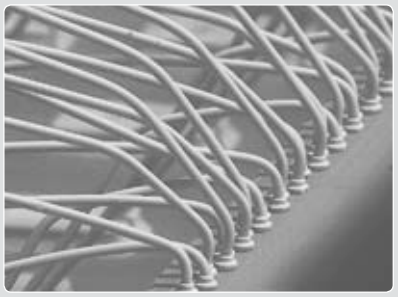
HIGHLIGHTS

- System development, assembly and interconnection technology on the basis of high performance 3D printed circuit board technology for autarkic miniaturized sensor systems
- High performance packaging for high brightness LEDs, including a new method method for color conversion



Ball-wedge wire bonding with ultra fine pitch < 50 µm

4-port measuring station for HF characterization of coupled structures at diffential stimulation

›› RESEARCH RESULTS

Developers of highly complex systems require suitable design methods, based on the characteristic technological parameters. Using these methods, the department designs and fabricates e.g. wireless sensor systems for various application areas, to demonstrate the potential of these new technologies.

Technological developments, in e.g. in the automotive area, include bonding power semiconductors through heavy wires or ribbons (0.1- 0.5 mm) using hybrid assembly on modern, high-performance PCB substrates. Along with ultra fine pitch connectors (< 50 µm) in ASIC and controller chips, these are used in industrial electronics.

Void-free joints, without vacuum and flux, are now possible, thanks to developments in the die-bond soldering process. Large chip areas, low joint clearance and higher working temperatures are also important boundary conditions, as is replacing the high-lead HT solder with high-tin solder alternatives for mass production.

Highly reliable power electronic systems are designed, fabricated and characterized, based on established and innovative assembly technologies. One important focus of the work is evaluating and ensuring electromagnetic reliability during the initial design stage.

High-precision system assembly in optoelectronics, HF technology and in microsystem products is distinguished by the use of Au/Sn or low-temperature solders, as well as high-performance adhesives. Flip chip solder and thermocompression technologies, as well as stud and ribbon bonding, are used and qualified for the electrical bonding of highly complex and 3D systems. The P2SA department develops new methods of efficient HF design for characterizing and analyzing system packages (e.g. SiP, MCM), circuits, their substrate technologies and integrated components.

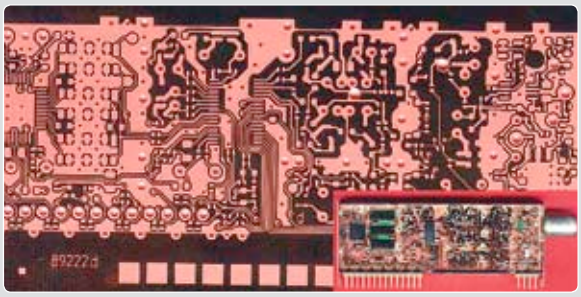
Polymer semiconductors are used to obtain high bit-rate, optical signal paths. One focus is, amongst others, achieving a reliable output and input signal coupling. Hot embossing and direct laser writing are used as structuring technologies. The polymer waveguides' attenuation and reliability meet industrial requirements. Recently, waveguides were successfully produced in a display glass, via ion exchange, which opens the possibility for a new generation of electro-optical packaging.

Assembly and function simulations and measurement methods mean all process steps can be optimally configured for the application.

An important overarching research area is the structural analysis of electrical and optical bonds in the micro- and nano-region.

Board Interconnection Technologies

"Aufbau- und Verbindungstechnik in der Elektronik - aktuelle Berichte", published by W. Scheel, K. Wittke and M. Nowottnick



Double sided PWB/ device with plated through holes based on renewable resources

COMPETENCIES

- High temperature solder joints
- Nano scaled surface structures
- Solder materials
- High temperature solder joints
- Innovative soldering processes
- Chemical deposition
- Biomimetical layer deposition
- Testing and qualification of electronic assemblies

›› SHORT PORTRAIT

The »Board Interconnection Technologies« Department is aiming its research and development in the field of material, process and equipment development at issues resulting from system integration. The main focus of the department's work is on:

- Generation of functional metal layers by electroless, biomimetical and galvanic deposition on semiconductors, dielectrics and metals
- Joining technologies for thermo-mechanically highly stressed electronic assemblies
- SMT process development and quality assurance
- Carrier for wiring, made of renewable materials

Furthermore the Qualification & Test Center (QPZ) for electronic assemblies in Berlin and the Demonstration and Training Center for Interconnection Technology in Electronics (ZVE) in Oberpfaffenhofen are both part of the department.

›› TRENDS

The driving force for the continuous development of electronic assemblies and their functionality and complexity is the constant innovation of the semiconductor industry.

The electronic products of the next decade will mainly be characterized by their multifunctionality, i.e. by processing functions of different physical principles. The focus is on system integration of micro system components. The electronic assembly is increasingly transforming into a system platform. The current wiring carrier has the following disadvantages:

- the integration of all functions into one carrier cannot be optimally achieved
- because the functions influence each other, generally in a negative way, they are less reliable,
- the used materials and combinations of materials are not loadable and usable in their limits.

The consequence is that complex components can no longer be assembled with a materialistic homogeneous wiring carrier. Therefore a further development of electronic assemblies as system platform is needed.

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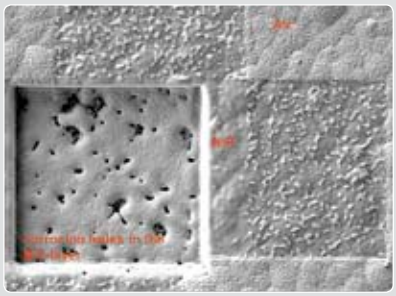
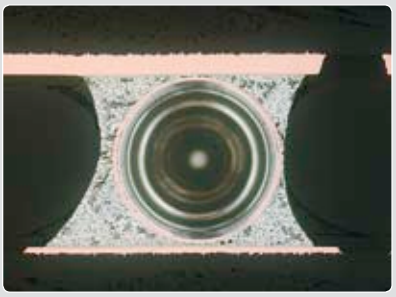
HIGHLIGHTS

- Reliability of lead-free surface metallizations
- Polymer balls for higher reliability in BGA solder joints
- Vol. 2 of the book series "Aufbau- und Verbindungstechnik in der Elektronik – aktuelle Berichte", published by W. Scheel, K. Wittke and M. Nowottnick



FIB area etching on an ENIG surface showing the layer interface and Ni corrosion caused by increased stabilizer content



Solder joint with higher stand-off by polymer ball and sufficient amount of solder paste

›› RESEARCH RESULTS

Reliability of lead-free surface metallizations |

Our department has investigated electroless metallization systems in several research projects over the past few years. They are important as PCB surface finishes for fine-pitch assemblies. Their main advantage is their layout-independent plating technology, in conjunction with the contact pads' excellent coplanarity. Furthermore, the high thermal and long-term stability required for lead-free packaging is of central importance.

Particularly due to the latter, the reliability-related properties of the immersion tin and electroless nickel/immersion gold (ENIG) metallization systems are under investigation.

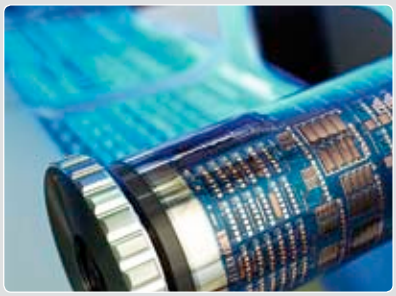
High-resolution field-emission electron scanning microscopy, combined with focused ion beam technique (FIB) was used to identify the influencing factors. With this technique, layer sequences and failures, depending on process parameters, could be demonstrated. The factors influencing reliability, as well as process recommendations for electroless plating, will be summarized in a manual.

Polymer balls for higher reliability in BGA solder joints |

During the project "Joining with polymer shapes for high temperature applications up to 200 degrees", polymer balls were developed, which exhibit high suitability for array joints. The focus of the investigations was the substitution of massive solder balls in such joints. By using metallized polymer balls, a higher reliability, especially in high temperature applications, could be realized. Firstly, a suitable polymer, which best met the requirements for thermal, chemical and mechanical stability, as well as the possibility of metallization of these polymers, was selected. Then, modules for reliability investigations were developed. Such polymer balls can be applied using conventional processes. During testing, it was observed that many factors have a noticeable influence on reliability. The main factors were the thickness of metallization, as well as the amount of solder paste used for joining. The best reliability results were achieved with a thin metallization that did not hinder the deformation and allowed for compensation of the expansion differences, combined with a higher amount of solder paste. By using such dimensionally stable polymer balls, a concave solder meniscus, as well as an increased stand-off can be realized. These characteristics improve the reliability of such joints.

Polytronic Systems

Mobile electrostatic carrier with thinned wafer



Reel-to-reel manufacturing

COMPETENCIES

- Polymer electronics and MEMS
- Ultra-thin silicon
- Packaging of thin chips and micro components
- Hybrid integration
- Reel-to-reel application center for flexible electronics
- Biosensors

›› SHORT PORTRAIT

The "Polytronic Systems" Department develops components and hetero-integration technologies for cost-effectively producing flexible systems, ranging from low-cost electronic disposables to applications for the most complex communication electronics.

Production processes for thin and flexible silicon substrates in the range of less than 10 µm to 30 µm have been integrated in thinning, handling and separation processes suitable for all substrate thicknesses.

Companies engaged within the area of electronic product survey, electronic seal-in-safety paper and multi functional smart cards find support in the hybrid integration of electronics in thin substrates. Also to be mentioned are applications in combination with other components such as sensors and batteries as well as in the microsystems' area, such as medical disposables, lab-on-chip and plastic MEMS and bio-analyical systems.

The development of ICs, based on organic semiconductors produced by reel-to-reel low-cost processes, enables integrating simple electronics on flexible plastic foils.

The reel-to-reel application center provides a unique possibility for both developing and producing flexible systems by industrial equipment, enabling low-cost reel-to-reel development for electronics and microsystems on flexible substrates.

›› TRENDS

The further development of innovative handling techniques for ultra-thin semiconductor components will enable the future integration of a multifunctional electronic system, consisting of ultra-thin layers of different semiconductor materials.

So, by combining only a few microns thin layers of silicon, gallium arsenide and optical active semiconductor levels, extremely small electronics with high computing power and high speed data transfer could be realized.

Autarkic sensor nets in combination with RFID technology result in new applications in logistics, process and medical technology. The technologies for cost-efficient application incorporate ultra-thin silicon chips as well as polymeric-electronic layer systems.

The reel-to-reel application center's main foci are combining RFID and sensor as well as flexible electronics.

Further developing these technologies up to cost-efficient microsystems, i.e. for disposables, is of very high interest, considering the rapid progress e. g. in life sciences.

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

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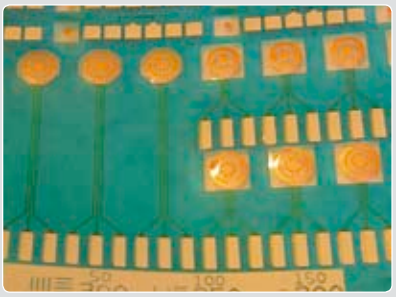
HIGHLIGHTS

- Flexible polymer ring oscillator circuits
- Reliability investigations of polymer circuits
- Wafer thinning process which enables high performance, infrared sensors
- Immunodetector for 10 parameters
- DNA-hybridization unit in plastics

Ten channel immunodetector for on-site operation



Electrochemical electrodes on plastic foil

›› RESEARCH RESULTS

Polymer integrated circuits |

Integration of electronic circuits based on polymer semiconductors is strongly related to the development of inline-capable fabrication methods. IZM has here developed a manufacturing process that combines a high-resolution photolithographic process with cost-effective printing steps. With the help of these reel-to-reel methods, polymer circuits can be fabricated solely by means of coating and patterning processes, without any assembly steps.

Such systems' functionality is measured using ring oscillator circuits, where 7 inverter stages, made of 14 transistors, are switched together in a ring. The resulting output signal oscillation demonstrates that integration of digital logic circuits is possible and also represents a successful initial test of the suitability of the process for manufacturing. These circuits are the basis for a more complex integration of electronic functions in foils.

Reel-to-reel processing additionally offers the potential for ongoing, cost-effective system integration together with sensoric, fluidic and optical elements. It is therefore a central technology platform for fabricating ubiquitous elements. The electrical and integrated optical sensor systems on flexible substrates developed at IZM demonstrate the potential of this new field.

Multiplex sensor systems for bioanalytics |

The simultaneous determination of several biochemical parameters is becoming increasingly important in analytical biochemistry. The biochip technology developed at IZM, targeted at the diagnosis of infectious diseases, is able to analyze complex disease patterns with a single test. The biochip system comprises the cartridge, which contains the biochip and a miniaturized fluidic system, the fluidic station for up to five biochip cartridges, in which the fluorescence immunoassays are automatically processed, and a fluorescence reader unit for evaluating the processed cartridges. For PCR-based diagnosis, a multiplex PCR flow through a microsystem in plastic with an integrated reader unit for amperometric measurements is being developed. In contrast to medical diagnostics, which requires parallel analysis of a high number of parameters, biological agent detection aims for the highest possible sensitivity. A dedicated, fully automated immunodetector was developed for on-site operation at the IZM. It allows for the simultaneous, highly sensitive and rapid detection of up to 10 different analytes in an aqueous sample. Its operating principle is based on a chemiluminescence capillary enzyme immunoassay (EIA) technique, in combination with integrated microfluidics.

Micro-Mechatronic Systems

iRob - functional MID-demonstrator

Intelligent ball bearing

COMPETENCIES

- Synergistic 3D design
- Electrical, mechanical, thermal and flow simulation
- Rapid prototyping by stereolithography & vacuum casting
- 3D micro assembly and realization of microsystems
- Transfer molding, injection molding and hot melt
- Reliability investigations
- Analytics (accusto microscopy, 3D x-ray inspection)

›› SHORT PORTRAIT

The Fraunhofer IZM Micro-Mechatronic Systems Department develops technologies for mechatronic systems containing mechanical, optical, electrical, power, chemical and software functions.

Mechatronic assembly technology is the key to high performance mechatronic devices. Advanced research is performed with the focus upon process simulation, novel interconnection methods focusing mechatronic applications and a variation of different encapsulation methods. The application of simultaneous mechanical and electrical design combined with novel rapid prototyping concepts lead to the shortest development times. Interconnection of the modules with electrical, mechanical and optical interfaces is available, as well as assembly upon 3-dimensional substrates. Advanced packaging solutions for electronic systems, including the use of high performance polymers, are the second focus of mechatronic system assembly. Detailed reliability investigations measuring thermal, dynamical, mechanical and chemical stresses complete our profile.

Fraunhofer IZM's Micro-Mechatronic Center is embedded in this department and represents a synergistic cooperation between industrial partners and acknowledged IZM specialists for both covering and fulfilling the demands and market needs of small and medium-sized enterprises as well as large companies.

›› TRENDS

Mechatronics has emerged as a key technology in many branches over the last years. Product design will increasingly provide mechanical systems with intelligent system behaviour through the integration of electronics.

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

Miniaturized modules have become exceptionally important for medical technology, to produce both sensitive robots, as well as sensor modules, which are able to make decisions and operate self-sufficiently.

Along with the automotive industry, the mechanical engineering and plant construction industry is availing itself of intelligent micro-mechatronic modules' high performance capabilities. Future R&D will primarily focus on:

- Process-simulation and 3D multi-body engineering-technologies
- Extreme miniaturization
- Rapid prototyping and rapid production
- New interconnects: electrical, mechanical, fluidic, optical and wireless
- 3D assembly and mechatronic encapsulation
- Design for reliability

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HIGHLIGHT

Cohesive design chain and rapid prototyping for intelligent µ-mechatronic 3D-MID systems

The IZM's Micro-Mechatronic Center has designed a process for cost-effectively and quickly developing prototypes for mechatronic component groups and systems in 3D-MID technology with a cohesive design chain.

The procedure's functionality has been verified using an intelligent walking robot.

By combining complex sensors, innovative actuators and sophisticated information technology in different ways, mechatronic products can be introduced into ever-increasing areas of life.

iCap - intelligent sensor concept

›› RESEARCH RESULTS

Process control through mold inner pressure measurement in the MicroSym project |

Overmold experiments with pressure-sensitive electronic components were carried out as part of the Bavarian Research Foundation's MicroSym project. The MMZ designed a test instrument for these, intended for molding substrates in the Map-Type procedure. An inner pressure sensor was integrated into the top mold's tool cavity. Thereby the pressure in the cavity, created by the molding process, can be measured and displayed as a pressure curve. Using mold inner pressure measurements improves process control.

New procedure for rapid models |

Multi-jet modeling (MJM) is, along with stereo lithography, a further generative manufacturing process in the Oberpfaffenhofen branch's Rapid Prototyping Technologies area. It can be used to produce patterns, prototypes and parts from formless material without utilizing specialty tools. Materials with defined properties are applied using a print head with multiple spray nozzles. High-quality models for exact prototypes can thus be prepared extremely quickly and cost-effectively for subsequent processing. Furthermore, objects made of several parts, e.g. gear units, can be manufactured in a single step and are ready for implementation and movable after the support material has been melted off. In the future, it will be possible to manufacture objects not merely for observational purposes, but as functioning prototypes. For this, three-dimensional structures are assembled parallel to embedding functional components and produce, around the latter, a matrix with a defined structure. In this, several materials are utilized simultaneously, which, for example, conduct the electrical current or dissipate heat.

Bavarian Competence Network in Mechatronics (BKM) and Mechatronic.net. e.V |

The project "Push for a HighTech Future, Bavaria" supported the "Bavarian Competence Network in Mechatronics (BKM)" with over 30 million euro over the years 2000 - 2005. The participating industry partners represent the areas of automotives, robotics, automation technology and medical technology, amongst others. The Micro-Mechatronic Center in Oberpfaffenhofen was also established as part of this initiative. The equipment includes rapid prototyping technology, 3D-assembly technology, encapsulation technology and reliability analysis. The Center has developed light-weight robots, intelligent pixel headlamps, door modules and haptic displays, amongst others. The newly founded "mechatronic. net e.V." will continue to pursue the key activities.

CORE COMPETENCIES

*WAFER LEVEL INTEGRATION

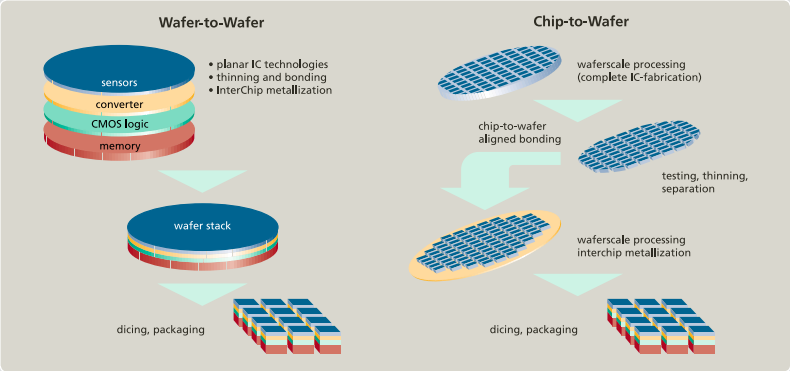

Dr. P. Ramm


Prof. Dr. T. Geßner


O. Ehrmann

» WAFER LEVEL INTEGRATION

Si-Technology and Vertical System Integration



Vertical System Integration - VSI®

COMPETENCIES

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

Competences
- Innovative Si and SiGe technologies
- Vertical System Integration
- Customer-specific solutions
- Developing test structures and process integration

R&D Technology Line
- 200mm CMOS process technology

›› SHORT PORTRAIT

The department's objectives are integrating new materials and processes for Si-based semiconductor technologies as well as developing and optimizing CMOS-compatible technologies for fabricating 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 maximum flexibility by using existing mainstream technologies in combination with maximum density of electronic functionality. Minimal interconnection lengths and low parasitics improve 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).

The department's main competence is developing and analyzing Silicon-Germanium epitaxial layers (CVD process) for innovative CMOS applications and new integration methods for photonic systems.

CMOS transistors' performance is substantially improved by using so-called strained silicon (sSi) as the semiconductor substrate.

For CMOS applications, a relaxed SiGe buffer layer is fabricated on a Si wafer for realizing a so-called virtual substrate. In a second step, the strained-silicon layer with a thickness of up to 20 nm is deposited on top of the SiGe buffer. The strained-Si layer shows significantly enhanced charge carrier mobilities, which improve the speed of CMOS transistors.

For photonic applications in the IR range up to 1310 nm wavelength (used e.g. for long distance transmission in telecommunication) the introduction of SiGe technologies can replace commonly used techniques based on III-V semiconductors. SiGe technologies utilizing high fractions of Germanium enable e.g. low cost fabrication of Si-integrated optical receivers.

Integrating both active and passive devices into one system is becoming more and more important. Therefore, the department has initiated a research topic on Si technologies for RF-suitable passives. The objective is embedded system integration of active devices and innovative Si-based passive components with the potential for low cost fabrication.

Both small and medium-sized enterprises developing RF-components, as well as semiconductor companies, e.g. fabricating innovative discrete devices, are invited to bring in their application specifications to our R&D work.

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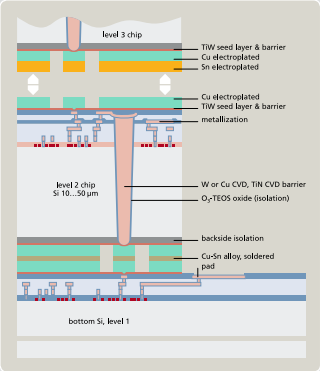


Fig. 1: Chip-to-wafer technology ICV-SLID Schematic for the formation of multiple 3D-integrated device stacks

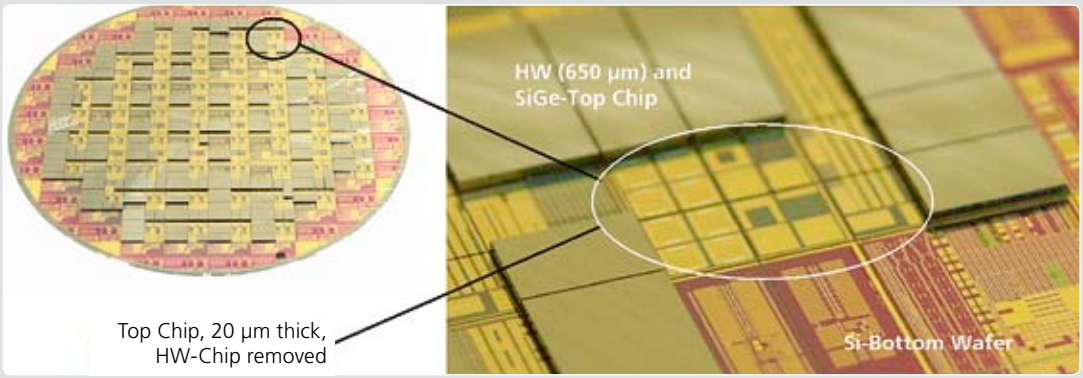


Fig 2: 1st Vertical System Integration of sSi/SiGe and standard Si CMOS

RESEARCH RESULTS

Vertical System Integration VSI® |

The spectrum of 3D integration has been substantially enlarged by chip-to-wafer technologies, driven by yield issues and by the increasing need for system integration of dice with non-identical chip areas.

Fraunhofer IZM's so-called InterChip Via / Solid Liquid Inter Diffusion technology (ICV-SLID) is based on adjusted SLID soldering of thinned and vertically metallized device substrates and allows the formation of multiple device stacks. The schematic cross section of a corresponding 3D integrated circuit with a Cu/Sn layer system as mechanical and electrical interconnect is shown in Fig. 1. The applied thinning process keeps device substrates down to 20 µm of remaining Si thickness. Such ultra-thin Si-layers can be processed by using a temporary handling wafer (HW), which holds the thinned device substrate in place. Cu/Sn structures on the backside of the thinned substrate and corresponding Cu structures on the topside of the bottom wafer are required for the soldering process. After optical alignment, the wafers are soldered using the SLID process and the handling wafer can finally be removed. Active devices were 3D-integrated with the above described ICV-SLID technology by chip-to-wafer stacking. Strained Si (sSi) CMOS devices, fabricated with our SiGe technology, were here located on the top chip and the standard silicon CMOS devices on the bottom wafer. Fig. 2 shows the stacked devices on wafer-level with partly removed handling substrates (1st VSI® of sSi/SiGe-devices and standard CMOS-Si).

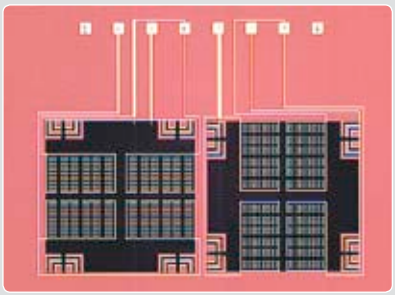
Si/SiGe layer systems |

Test devices, suitable for the evaluation of Si/SiGe layers grown epitaxially on standard silicon wafer, have been realized within the 200 mm R&D line of Fraunhofer IZM's Munich division. The devices are characterized electrically on wafer-level. MOS transistor measurements show an increase in charge carrier mobility of up to 85 % in strained silicon layers grown on stress-relaxed SiGe-buffer layers. Also an enhanced system performance of 25 % for small CMOS circuits, such as a ring oscillator, could be demonstrated.

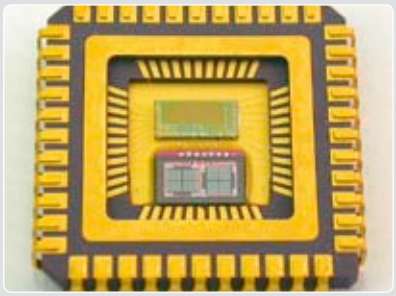
The integration of PIN-diodes into the SiGe-buffer layers with a typical Ge-content of 24% leads to an enhanced photo responsivity in the immediate infrared region. Compared to silicon, an 80-fold enhancement in photo responsivity was measured for a wavelength of 1310 nm, which is used in telecommunication applications. Low-leakage current of the reverse-biased PIN-diode demonstrates the high crystal quality of the SiGe buffer layer. The potential for low-cost manufacturing of photonic systems for the immediate infrared region is proven.

Physical analysis of Si/SiGe-layer systems, using in-line spectral ellipsometry and high resolution XRD and XRR, is well established within the Fraunhofer IZM, Munich Division and can be provided as a service to external partners.

Micro Devices and Equipment



Acceleration sensor elements manufactured in microsystem technology



Acceleration sensor made in microsystem technology (low g)

COMPETENCIES

- MEMS design and modeling
- Development of MEMS
- Development of advanced technologies
- Process and equipment simulation
- Backend-of-Line BEOL
- Micro and nano reliability
- Printed electronics

›› SHORT PORTRAIT

The department Micro Devices and Equipment is located in Chemnitz, Saxony and its basic fields are the design and the development of micro-electro-mechanical systems (MEMS), technologies and equipment for manufacturing micro systems mainly in silicon but also with other materials like glass,
polymers, and metals.

MEMS design and modeling |
Low-level system simulations based on simplified analytical models, Device simulations based on FDM, FEM or BEM, System simulations employing, for example, VHDL-AMS

Development of MEMS |
Sensors, actuators, and electronics (gyroscopes), transducer and analyzer systems (spectrometer), characterization & test

Development of advanced technologies |
3D-patterning, deep silicon etching, chip and wafer bonding technologies, MEMS packaging technologies, chemical-mechanical polishing (CMP) of Si, SiO_2, and Cu

Process and equipment simulation |
Improvement of deposition and etch rates, uniformity and fill behavior of vias and trenches by optimizing process conditions and reactor design

The department cooperates closely with the Center for Microtechnologies at the TU Chemnitz.

›› TRENDS

In the near future microsystems will become increasingly multifunctional and allow, for example, the integrated combination of electronics for signal and information processing with sensors and actuators in silicon and non-silicon technologies. The so-called multi device integration into smaller and smarter systems requires further research fields, such as backend-of-line technologies for micro and nano electronics, printed electronic systems for ubiquitous low-cost applications and investigation of micro and nano reliability for smart systems.

Backend-of-Line BEOL |
- Spin-on dielectrics, air gap structures, and integration of low-k dielectrics
- Copper interconnect metallization systems (e.g. 45nm pitches) and diffusion barriers,
- Scaling effects, reliability, modelling and simulation

Micro and nano reliability |
- Combination of reliability, miniaturization and micro security e. g. for automotive and IT
- Thermomechanical simulation and reliability for nano-electronics

Printed electronics |
- Circuit design for organic electronics
- Simulation of circuits and components of organic electronics
- Spin coating and printing of reference layers
- Material and layer characterization

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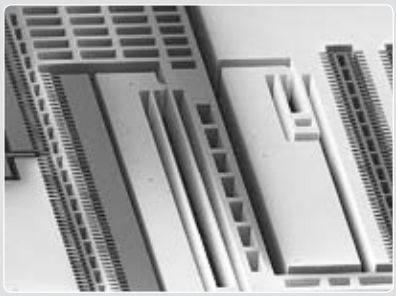
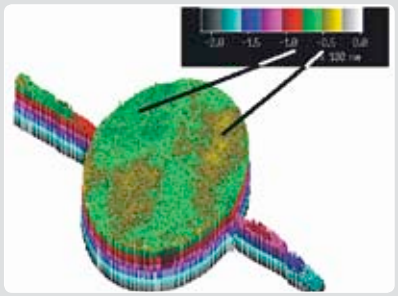
HIGHLIGHT

In 2005 a new micromachined ultra sonic transducer array could be developed and manufactured. The capacitively working transducer is made for both water and air applications. With new silicon technologies the device can be produced very reliable, efficient and at least as an array.

Possible applications are sound navigation and ranging (SONAR), robot vision, car anti collision systems and ultrasonic testing for medical applications.



Detailed view of the coupled vibration sensor system



Planarity of mirror surface better than ±15 nm

›› RESEARCH RESULTS

Vibration monitoring |

Vibration monitoring is an important means for wear state recognition and process control of industrial machinery such as cutting tools, bearings, gears, pumps or engines. The majority of mechanical vibrations used to identify the process conditions are found in the frequency range from a few Hertz to 10 kHz. Inherently, resonant microstructures have frequencies above 1 kHz, otherwise one needs excessively large chip area or weak suspension to lower the stiffness to mass ratio. To overcome this bottleneck, we have investigated and manufactured a new type of resonant sensors. With the help of an electrostatically coupled oscillator, the mechanical signals obtained at low frequencies are transformed to a higher frequency range where they can be detected by means of resonant amplification. The sense frequency can simply be adjusted voltage tuning mechanisms.

MEMS technologies |

Packaging for microelectronics has a long history of R&D for the specific needs of the microelectronic industry. MEMS bring much more challenging issues to the package. Not only should the package protect the device from external influence, but it must also serve as a filter element for the device to selectively allow parameters to be measured to penetrate into the package (e.g. fluids, gases or light) while blocking access to undesired influences.

The application of different, wafer level based bonding processes at the Fraunhofer IZM enables us to research and develop advanced technologies for packaging. These technologies are being used to package passive devices like inertial sensors or gas sensors and active devices like micro mirrors and ink print heads.

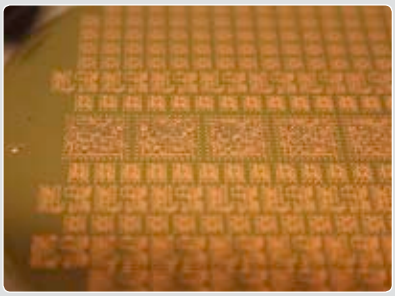
RF MEMS |

The utilization of micro electro mechanical systems (MEMS) instead of conventional semiconductor devices can obtain fundamental improvements in microwave circuits with respect to signal attenuation and DC power consumption. The development of civil radar systems for automotive applications would strongly gain from the advantageous characteristics of RF MEMS. Mechanical antenna scanning can be replaced by low loss electrical beam steering. MEMS technology has great potential for the fabrication of low loss 360° phase shifters required for this application.

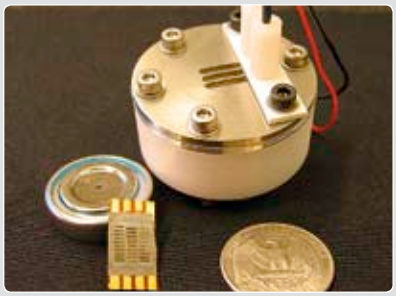
Wafer level test and identification of geometry and of material parameters |

A monochrome laser projection system with XGA resolution has been constructed in order to test various MEMS laser scanners. It incorporates two electrostatically driven MEMS-scanners for fast horizontal and vertical deflection of the modulated laser beam resulting in an image with 800 lines and 60 frames per second. Images from a computer are directly written to a screen with size of 0.3 m x 0.2 m with high brightness and clarity.

High Density Interconnect & Wafer Level Packaging



Thin chip integration (chips [40 µm thin] integrated into redistribution BCB/Cu)



Hydrogen evolving cell, mirco fuel cell and test sample holder of the fuel cell system

COMPETENCIES

- **Wafer level CSP**
  - Cu redistribution routing, polymer dielectrics, PbSn solder deposition, reliability investigation
- **Wafer bumping**
  - Photoresist processing, micro electroplating, bumping materials Cu, Ni, Au, PbSn, AuSn; lead-free solder, optical inspection
- **Thin film multilayer**
  - Customer-specific layout, substrate processing, component preparation, multilayer routing, high-density integration
- **Micro energy systems**
  - Wafer level battery, micro fuel cell, hermetic sealing

›› SHORT PORTRAIT

The department is focusing on the development and application of thin-film processes in microelectronic packaging. Production-compatible equipment and technological expertise support thin film processing in a 800 m² clean room. The department cooperates world-wide with manufacturers and users of microelectronic products, with clean room equipment producers and material developers from the chemical industry.

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. Beyond the regular service technology, the department is engaged in numerous R&D projects, whereby ongoing skills and know-how are being developed, which could be applied together with SME-partners on a development stage. Among the main topics are integrating passive components into high density circuits, MCMs or wafer level packages and the mobile power supply for microsystems.

›› TRENDS

- Redistribution to the backside of the wafer
- Vias through the silicon wafer
- 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
- Optical inter-chip connection with thin film technology
- Assembly of ultra fine pitch pixel detectors
- Technology for compliant bumps
- Consulting and application center for the industry

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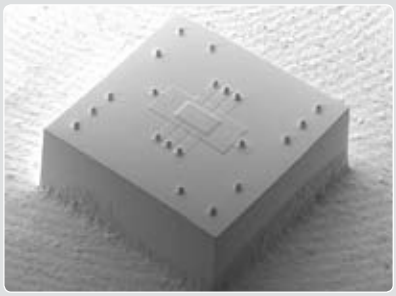
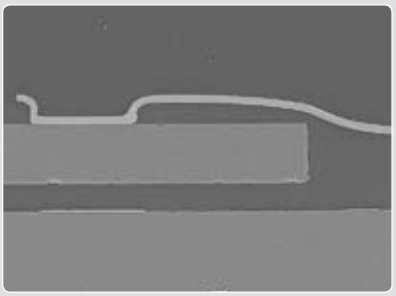
HIGHLIGHT

Wafer level packaging of MEMS devices

Developing complex microsystems involves not only the integration of active semiconductor chips (Si, SiGe, GaAs) but also integrating 3D MEMS devices. Until now, these chips have been used as single components and accordingly encapsulated as individual parts. The task of the cooperation with LETI was to process a RF-MEMS-device at wafer level and mounting it using flip chip technologies. The MEMS device was a micro-mechanical RF-switch developed at LETI. The moving parts are protected by a cap formed from a sacrificial layer and the deposition of oxide layers. The interconnects are routed underneath the cap and the metallization process was carried out in a flip chip-compatible way. The micromechanical switch is designed to function under vacuum conditions.



RF-MEMS-device with SnAg solder bumps



Cross section of TCI (SEM) chips [40 µm thickness] integrated into redistribution

›› RESEARCH RESULTS

Thin chip integration (TCI) |

The trend towards smaller, lighter and thinner products requires steady miniaturization, which has seen the concept of wafer level packaging (WLP) emerge. The latter enables FC assembly on PWBs without interposers. Integrated passive components will further extend WLP. New and improved micro-electronic systems require significantly more complex devices, which could limit performance due to the wiring of the subsystems on the board.

SiP packaging, using the existing WLP infrastructure, is one of the most promising approaches. Stacking of chips for chip-on-chip packages can be done by wafer-to-wafer stacking or by chip-to-wafer stacking which is preferable in terms of yield and die size.

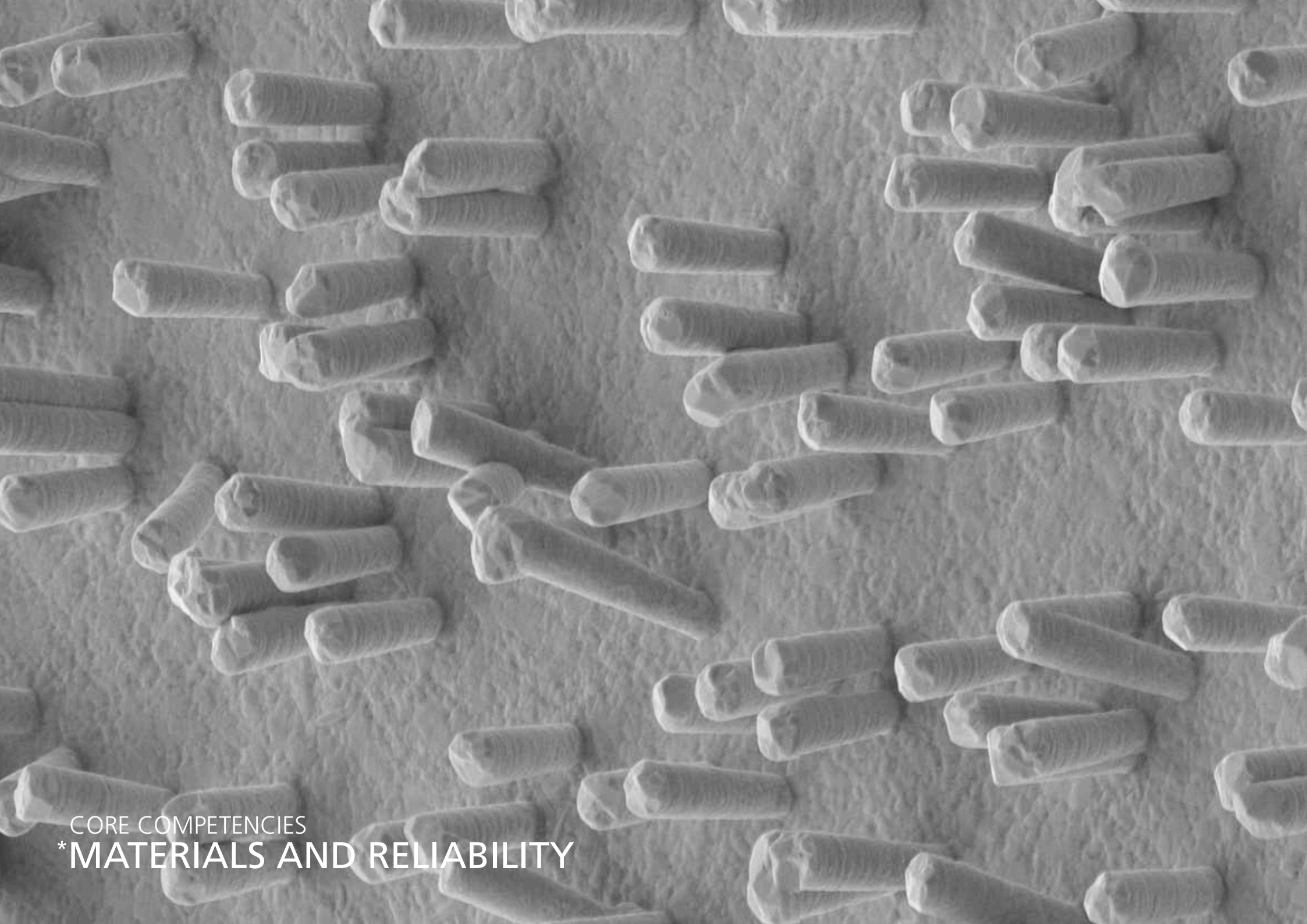
This chip-on-chip packaging requires a base die with redistribution traces to match the I/O layout of both dice. To bypass the flip chip bonding process, the thin chip integration (TCI) concept can be used. A key element in this approach is extremely thin ICs (down to 20 µm thickness) which are incorporated into the redistribution. This technology offers excellent electrical properties of the whole microelectronic system. These integration steps will bring WLP to SiP.

Micro fuel cell with a hydrogen evolving cell |

The main goal of the fuel cell research is developing a system with a higher energy density than batteries. Based on the planar PEM micro fuel cell, a complete system with a volume of only few cubic centimetres has been developed.

This system has a significantly higher energy density than batteries. In addition, the production technology, derived from electronics manufacturing, allows for extremely economical mass production. For the on-demand hydrogen generation, a gas evolving cell is used, which is already available. Finally, the zinc air batteries' energy density is produced by combining the gas evolving cell and micro fuel cell. The short durability of the zinc air batteries, which is their main disadvantage, has been extended by a few weeks. This is achieved by placing two membranes between the chemically active masses and the ambient air (the hydrogen-permeable membrane of the gas evolving cell and the membrane of the fuel cell). The penetration of water vapour and oxygen into the gas evolving cell is thereby prevented as far as possible.

It will now be possible to use this form of high energy density in many applications. The present system already represents almost a doubling of energy density when compared to Li-polymer batteries of the same size.



CORE COMPETENCIES

*MATERIALS AND RELIABILITY

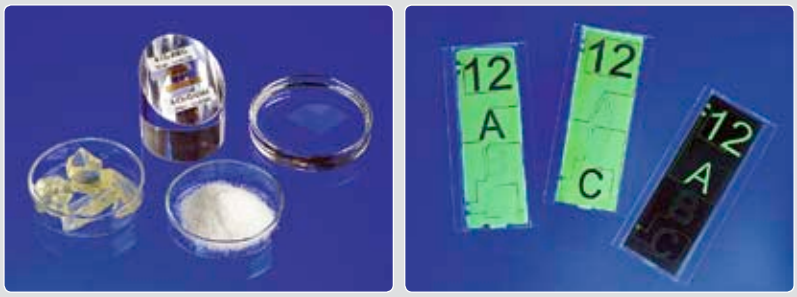

Prof. Dr. M. Bauer


Prof. Dr. B. Michel


Dr. H. A. Gieser

» MATERIALS AND RELIABILITY

Polymeric Materials and Composites



Bistable display

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

›› SHORT PORTRAIT

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 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 framework 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 IZM-Teltow. The professorship concentrates upon lightweight engineering applications.

The IZM Teltow holds key patents in these research fields.

›› 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.

Nanotechnology plays a key role in this area. For instance: nanotechnology 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 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.

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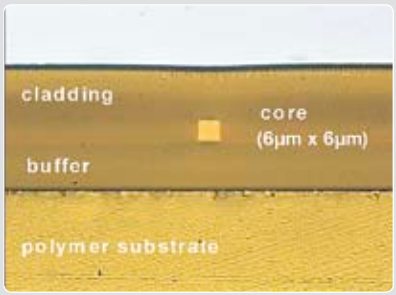
HIGHLIGHTS

- Patent applications for two new polymer classes (triazine acrylates and PFCB-triazine-copolymers)
- Optical loss < 0.3 dB @1550 nm
- High refractive index contrast (0.020), resulting in miniaturization of the integrated optical devices and increase in their yield



Polymer waveguide on polymeric substrate

Polymer based waveguide materials and substrates

›› RESEARCH RESULTS

High Performance Polymers for Integrated Optical Devices |

In close cooperation with the Fraunhofer Institute for Telecommunication, Heinrich-Hertz-Institute, Berlin, Germany, optical polymers have been developed as waveguide materials for photonic networks. The complete development chain, beginning with the synthesis of monomers and polymers, to the processing, characterization and design of integrated optical devices, and finally, the operationally ready prototypes of integrated optical devices, are being studied by researchers, technicians and engineers of both institutes.

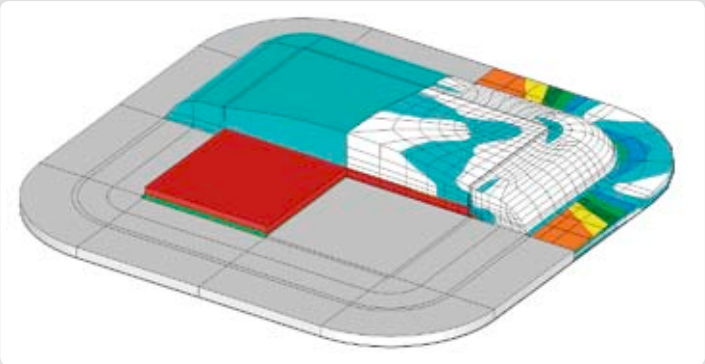
Due to our extensive experience in developing optical polymers, a great pool of materials is available, to meet the individual requirements of optical and light guiding applications, if necessary with further modifications.

Various classes of polymers are used, depending on the particular application.

In the infrared wavelength region (especially at 1300 and 1550 nm), highly fluorinated systems are implemented, whereas in the visible range (400 – 800 nm), inexpensive fluorine-free polymers come into use. In the year 2005, patent applications for two new classes of polymers were filed: the triazine acrylates class, with optical loss values below 0.4 dB/cm @1550 nm, which are also curable via e-beam, as well as triazine containing perfluorocyclobutane (PFCB) polymers, exhibiting loss values below 0.3 dB/cm @ 1550 nm and refractive index contrasts of up to 0.020, which were developed in cooperation with Prof. D. W. Smith, Clemson University, SC, USA.

Due to the excellent optical properties and the high refractive index contrast, the size of different devices was shrunk to the size of a match, resulting in a higher number of devices and also a higher yield per wafer. Adjusted polymeric substrates were produced for specific optical devices (like arrayed waveguide gratings [AWGs]), to systematically influence the properties of the devices.

Micro Materials Center



Thermo-mechanical simulation of microelectronic components

COMPETENCIES

- Mechanical and thermal reliability analysis
- Thermo-mechanical evaluation
- Micromaterials and nanomaterials testing and simulation
- Micro reliabity
- Nano reliability
- Security research (microsecurity) problems
- Solder joint reliability
- Thermal management of electronic Systems
- Micro- and nano deformation analysis
- Lifetime estimation and optimization of components in microelectronics and automotive electronics

›› SHORT PORTRAIT

The department's key research is in the field of thermo-mechanical reliability of micro components and microsystems. Increasing problems in the field of nano materials are also examined (nano reliability). The research includes both simulation and combination with modern experiments.

Outstanding results were obtained in:

- Evaluating components and systems in automotive electronics reliability optimization
- Developing a new measuring technique for analyzing deformation in nanomaterials (nanoDAC - Fraunhofer Award 2005)
- Developing and expanding the Fraunhofer Micro Materials Center Berlin (MMCB), funded by the Berlin State and the German Federal Government, especially the Berlin-Adlershof Science and Technology Park
- Publishing both the "Microsystem Technologies" journal and the "Micromaterials & Nanomaterials" series
- Foundation of a European network called European Center for Micro- and Nanoreliability (EUCEMAN), see www.euceman.com

›› TRENDS

- Developing and applying modern digital image correlation analysis (DIC), for estimating reliability and lifetime in micro- and nanoregions (micro reliability and nano reliability)
- Physics-of-failure approach for understanding reliability concepts with direct coupling to simulation
- Applying modern field coupling and multiscale modeling for reliability prognoses
- Further advances in the micro security field (combining security research, miniaturization tasks and reliability estimation)
- Establishing microDAC, nanoDAC and FIBDAC deformation techniques as industrial measuring tools for broad applications in various fields
- Inclusion of combined field interactions in both reliability analysis and lifetime estimation procedures (load, temperature, humidity, vibration, electric fields etc.)

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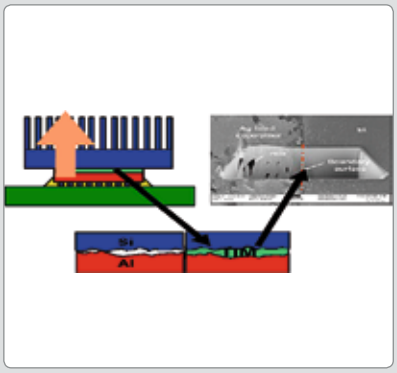
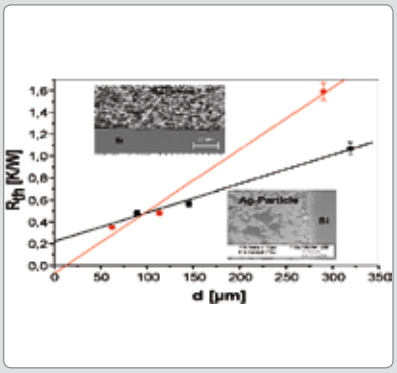
HIGHLIGHT

New measurement method

- determines the thermal resistance of TIM layers, bulk conductivity and thermal interface resistances as a function of layer thickness and pressure force
- enables analysis of very thin TIM layers
- allows quick and inexpensive measurements and efficient TIM selection
- applies surfaces as in real assembly applications
- allows insight to interface behavior through FIB and SEM analysis
- is universally suitable for all commercially-available going TIM



Application for thermal interface materials (TIM) – interface structure (FIB)



Thermal resistance dependence on TIM layer thickness for two adhesives

›› RESEARCH RESULTS

New measurement method for characterizing thermal interface materials |

Thermal management of electronic products relies on the effective dissipation of heat under the given boundaries and possibilities. The thermal resistance of the thermal interface material (TIM) is the bottleneck of the thermal heat flow from the active device junction to the cooler. TIM as paste, pads, gels, adhesives or solders are used to fill the air-filled gap between two surfaces to optimize the thermal path between them. In comparison to the other materials in the heat path, TIM have lower thermal conductivity.

It is useful and common, if possible, to reduce the TIM thickness. Often a TIM consists of a polymer matrix filled with thermally conductive particles.

For very thin TIM layers, the thermal interface resistance in the boundary surface between TIM and the adjacent materials is no longer negligible. This is the result of a lower number of heat conductive particles at the interface. Therefore it is essential to account for this effect in determining the TIM conductivity.

In the system design process, thermal simulation is used, along with other tools, to select the thermal interface material, in order to find the optimum situation.

To design the simulation model and get a suitable solution it is very important to know the accurate geometry data and thermal material parameters.

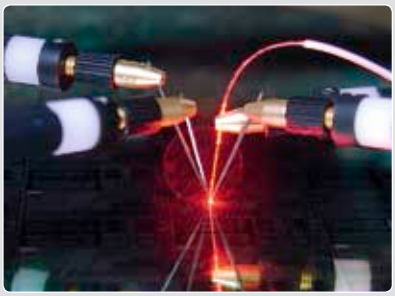
At IZM, a new measurement method was developed, which characterizes this very important thermal material data for the simulation. It derives the thermal resistance of a TIM layer, bulk conductivity and thermal interface resistances as a function of layer thickness and pressure force for all commercially-available TIM (e.g. adhesive, solder, pads, or pastes). It enables the analysis of very thin TIM layers and is applied to surfaces which occur in real assembly applications.

The new measurement method was successfully tested on several commercially available TIM materials. Tests on silver-filled heat conductive adhesives have shown that the thermal resistance of a very thin layer is dominated by its thermal interface resistance. This effect is allowed for in the chosen measurement principle, which enables the preparation of a specimen with a very thin TIM layer. It is possible to observe the behavior in the interface region by SEM cross section analysis. FIB cuts into the SEM cross section boundary region allow a more detailed look into the cross-linking behavior of the particles, as well as the polymer matrix.

The new measurement method enables quick and inexpensive measurements and allows for efficiently selecting a TIM.

It, therefore, supplements the IZM system know-how as an integral part of the design methodology.

Analysis and Test of Integrated Systems - ATIS



Electro-optical measurement of Fraunhofer IZM PIN diodes

RF-measurements of an amplifier up to 110 GHz

COMPETENCIES

- Electrical and electrooptical wafer level test
- Electrostatic discharge (ESD)
  - Protection
  - Qualification
- Pulsed high current characterization
- High frequency characterization
- Wafer level reliability
- Wafer level test & burn-in (known good die)
- Failure analysis

SHORT PORTRAIT

Test, analysis, and reliability of integrated circuits and systems with growing complexity are an increasing challenge for the development and manufacturing of advanced electronic systems. Since 1990 ATIS has been a reliable and cost effective partner for analyzing existing weak spots as well as developing and implementing advanced solutions in a very sensitive and competitive international environment. Our sound technical and scientific experience becomes part of a long term relationship with our partners. To characterize and harden various technologies against electrostatic discharges (ESD) is one of our core competencies. We develop methods and equipment for the electrical characterization and stress of integrated structures and products in the ESD-relevant domain. We also develop structures and concepts in order to protect circuits specific to their application.

Furthermore, we support the development of semiconductor processes on substrates up to 300 mm by means of our electrical and electrooptic metrology in wide ranges of temperatures (-55 to 300 °C) and frequencies up to 110 GHz. Weak spots and failures surfacing during verification, reliability investigation, or in the field are analyzed with various failure analysis techniques. In view of the physics of failure and reliable Known Good Dies (KGD), ATIS develops concepts to contact, test, and screen bare dies on the wafer and to monitor their function.

TRENDS

The increasing complexity of systems together with shorter product cycles, and the international supply chains makes it increasingly difficult to guarantee their reliable function. More and more functions are integrated into one chip (SoP) or as a multitude of dies into a device package (SiP). Costs for redesign and belated market introduction explode. In this scenario the sophisticated detection and analysis of weak spots and their early elimination is of utmost importance. One key is the systematic and application-oriented protection of all interfaces against electrostatic discharge. Equal or increasing energy is released within nanoseconds into nanoscale structures of advanced technologies operating at voltage levels around 1 V, that require well-protected broadband and RF interfaces to the environment (USB 2.0, GSM).

In order to yield reliable systems single bare dies for further integration must be functional during the intended mission. To make these known good dies (KGD) available, whether as a passive device or a complex mixed signal circuit, universal cost effective methods and equipment for test and pre-aging need still to be developed or at least improved. Reliable electrical contact systems are part of these. Otherwise this could stop the show for further successfully integrating ultrasmall systems in the not too distant future.

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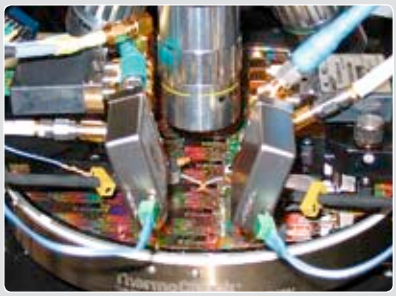
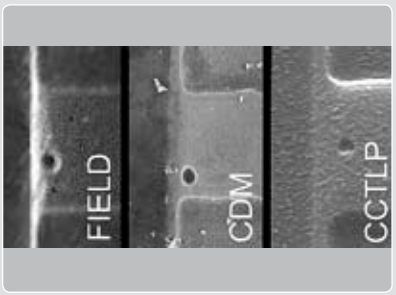
HIGHLIGHTS

- Capacitive-coupled TLP
- Combined ESD and RF test setup of up to 10 GHz
- Transient latchup setup for wafers and packaged ICs



Set-up for ESD-stress and measurement of RF-parameters up to 10 GHz



Failure signatures of gate oxide damage from the field, after CDM-Test, and after CC-TLP stress

RESEARCH RESULTS

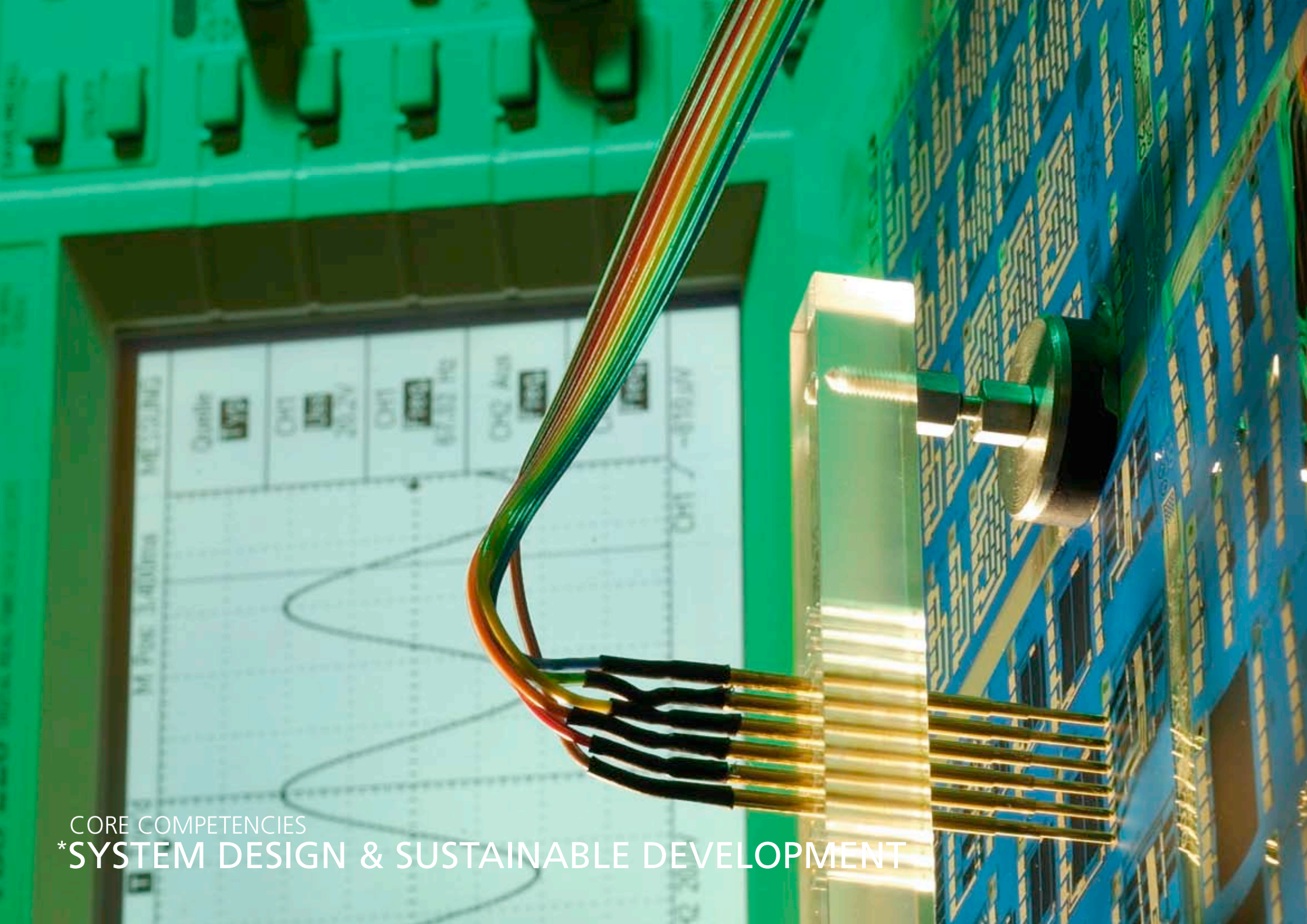
One core competency is developing and applying improved and new test methods for the characterization of ESD protection with ps resolution and high currents.

Recently, ATIS has successfully demonstrated the correlation between its arc-free capacitive coupled transmission line pulsing CC-TLP, the standard CDM testing, and field failures originally caused by a CDM-like discharge.

The discharge (sp)arc of the charged device model (CDM) stress test is responsible for severe errors in reproducibility and correlation. The goal was to eliminate the spark without significant change in the discharge characteristic within the integrated circuit (IC). The new cc-TLP method firstly establishes the contact from the pulse cable to the IC and then injects remotely generated, fast-rising, reproducible pulses into a single pin. For the IC in a PLCC52 package, we found good correlation between the three failure signatures of CC-TLP, CDM, and Field as well as for the failure threshold currents of the CC-TLP and the CDM. This points the way to a better alternative to the CDM-test. It has received positive response from industry and an award at a conference. The method will now be studied at wafer level in order to obtain an early indication of the CDM ESD robustness that can be expected before the device has been packaged. The research is being funded by the BMBF in the MEDEA+ project T104 SIDRA.

Within the same project, a setup and method for studying the susceptibility to latch-up, triggered by a fast transient were developed and successfully applied to different test structures and devices. The gained insights were directly fed into the current design of integrated circuits. Transient latch-up, for which no standard qualification test such as JEDEC 78 exists, is a key EOS failure mechanism.

In response to the increasing number of ICs with RF–interfaces that also need sufficient integrated ESD protection, a reliable method for RF-ESD co-design and co-characterization is required. Funded by the Bayerische Forschungsstiftung, a set-up has been developed that allows for cycles of ESD stress by means of high current square pulses, followed by measurement of leakage, and S-parameter or noise measurement of up to 10 GHz. Together with Infineon and TU Munich, the wafer level test set-up was successfully applied to low-noise amplifiers built in 90 nm CMOS technology, as well as to passive devices for another industrial partner. The set-up and software will be further improved and methods for multiple contacts studied.



CORE COMPETENCIES

*SYSTEM DESIGN & SUSTAINABLE DEVELOPMENT


H. Griese


W. John


Dr. M. Richter

» SYSTEM DESIGN & SUSTAINABLE DEVELOPMENT

Environmental Engineering

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"
- Information hotline for lead-free transition
- Environmental and economic process optimization
- System reliability and lifetime estimation
- National and international networking activities
- Green Electronics activities for education and training

›› SHORT PORTRAIT

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

In order 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 economic and ecological issues. We apply these together with partners from industry for continuous improvement of products. Our research focuses in particular on assisting in the development of SMEs.

Further research topics include technical approaches to improving energy and resource efficiency. A new aspect is the application of renewable materials in electronics.

Reliability of electronics is an important aspect, from an environmental viewpoint as well. However, we see the necessity of understanding and influencing reliability of electronics on a larger system level.

International collaboration and industry support is an important aspect of our work. Activities include lead-free transition, environmentally friendly processes, and recycling. Our network ranges from California to Japan, China, and Eastern Europe.

›› TRENDS

Sustainable development, extended manufacturer 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, such as a greater demand for environmentally benign technologies and products.

Human society and our natural environment should become the deciding factor and focus of technology development. Within the context of ubiquitous electronics, future technologies and products must provide maximum user benefit while keeping environmental impact at a minimum.

Supporting industry in that aim at all levels of production – research and development, manufacturing, quality control, and marketing – requires not only technical know-how but interdisciplinary skills. Our team at Green Electronics provides that wide range of expertise and is a neutral and trusted partner of industry.

We are convinced that thoughtful design, manufacturing, 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.

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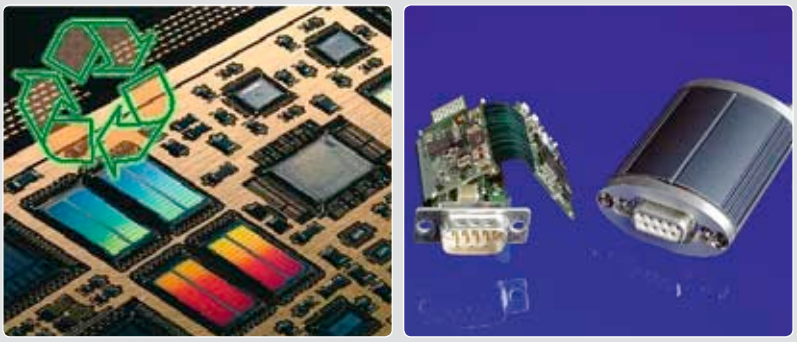
HIGHLIGHTS

- International lead-free project EFSOT accomplished
- Projects concerning renewable resources for electronics application
- European Union eco-design awareness raising campaign
- System reliability workshops
- Sustainability Award for Kayoko Tsunezawa
- BMBF funded Project „Microsystem Technologies Education in North-East Germany" (MANO) accomplished



Realization of measurement module with galvanic isolation (Source: imc Berlin)

›› RESEARCH RESULTS

From WEEE/RoHS to EuP |

Environmentally-benign design of electronics will gain in importance following the adoption of the EuP Directive in 2005. On behalf of the EC, we conducted an Eco-Design awareness-raising campaign, with 28 workshops throughout Europe, aimed particularly at SMEs. We compiled a range of information material, including the legal requirements and basics of Eco-design. This material is available in the Internet, at: www.ecodesignarc.info

Our department was also awarded various EuP preparatory studies, to be conducted for the EC.

Renewable resources |

In the ARBOFORM project, we investigated possibilities for substituting traditional substrate materials with renewable resources. The objective was to modify lignin-based Arboform™ for use as printed circuit boards, similar to FR2. Thermal, form, and flame resistance, as well as the adhesion properties of the substrate and copper layers, were improved during the project. Our investigation concluded that steps are being taken to employ renewable resources in electronics across the globe. Amino-acid based semiconductor materials are even being studied for use in display technology. The adaptation of bio-polymers for use in electronics is the focus of the new projects BioFun and BioPro.

Reliability of microelectronics systems |

In the field of microelectronics system reliability, we developed demonstrators for failure indications, as well as a life-cycle data sensor/processor unit. Here, we integrated specific structures at points of common failure mechanisms, which function like predetermined break points in the system. These points are monitored and measured in order to identify usage-related information about the actual status of the structure. We developed structures for identifying solder fatigue, sensors including circuits for failure detection, as well as methods for statistical modeling of failure indicators. In further research, we will develop structures for "delamination" failures, as well as optimize the energy efficiency and precision of sensors for failure detection.

Networking |

Consulting services and technology transfer for eco-friendly and particularly lead-free electronics were developed in national and international network projects including GREENROSE, ELFNET, EFSOT. Mostly sponsored by the European Commission, these projects aim to improve the technical know-how of SMEs. Furthermore, our staff members were invited to give expert lectures around the world on the new RoHS and EuP European Directives.

Advanced System Engineering

Test setup at EMC measuring station in absorber chamber

COMPETENCIES

System Integration

- System/architecture Co-Design
- System design, RF system design
- Model based development
- Energy autarkic microsystems
- Design of system-in-package (Package Co-Design)
- Technology assessment

Electromagnetic Reliability

- Emission and immunity analysis and optimization of IC, modules and systems
- RF characterization of packages
- EMC optimization of power modules
- Modeling and analysis of EMC/SI effects at board level

›› SHORT PORTRAIT

IZM's Advanced System Engineering (ASE) Department has more than 10 years of experience in the area of system integration and electromagnetic reliability of miniaturized electronic modules (automobile/ telecommunications/ logistics (RFID)/ medicine technology/industrial electronics) at its disposal. Apart from the processing of R&D-tasks in these areas, providing both services and the necessary infrastructure for the design, the development as well as the production of microelectronic systems are the main focus.

Microelectronic components' users are supplied with optimized system concepts and solution approaches (demonstrators / prototypes) which are based upon the latest developments in packaging technology. Within the framework of this system design, opti-mized module development is supported by the application of commercial and non-commercial design and simulation tools.

One particular focus of the ASE Department lies in research works in the area of parasitic electromagnetic effects (electromagnetic compatibility; signal integrity; radio frequency) not only at the IC-level, but also at package and module, or board level. These are necessary for developing miniaturized systems.

For optimally processing both EMC/SI-questions and tasks concerning the package-elements' RF-characterization, complex field calculations and circuit simulations are carried out.

›› TRENDS

The ability to reliably, cost-effectively and time-optimally integrate system components into one complex system solution has become a location factor. Concerning the efficient use of the macro-, micro- and nano-systems' innovation potential, a paradigm shift within the system integration field is becoming apparent. This change depends on the various physical component features, which must be considered at all system levels. A consistent linking of the system architecture and design methodologies as well as tools, system integration technologies and production (both producability and reliability) according to the respective company-specific value-added chain, has to meet the requirements of the necessary paradigm shift. This presupposes a holistic consid-eration of the system features in the development process (top-down design approach by model-based development). Upon the basis of this approach, system-specific analyses can be carried out and design statements can be made, which exceed the respective system domains (partial models). Therefore, the focus on the model-based development approach, for instance, allows making statements in the future concerning the electromagnetically influenced failure behavior of entire systems (resulting system reliability). Bearing this in mind, it is necessary, apart from other aspects, to entirely solve the question of model development, parameterization and validation of models for microelectronic construction components from the nano area.

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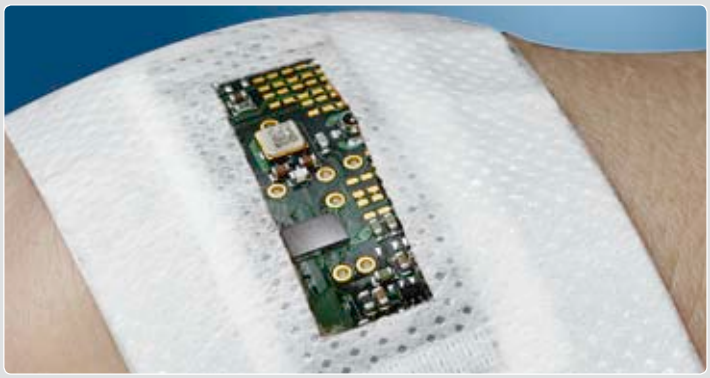
HIGHLIGHTS

System Integration

- BMBF-Project AVM (16 SV 1658)
- Behavior models for chosen system architectures
- Miniaturized wireless sensor modules

Electromagnetic Reliability

- BMBF-Project MESDIE (01M 3061)
- Dynamic current analysis for the emission analysis of integrated circuits
- High density interconnect modeling and simulation
- Developing a new near-field-scanning procedure



Sensor band aid

›› RESEARCH RESULTS

Holistic system design of self-sufficient distributed microsystems |

Developing distributed microsystems requires new efficient design methodologies, which extend the procedures of the hardware-software co-design by the technological degrees of freedom regarding system integration. For analyzing suitable design methodological approaches, AVM-sensor-wireless modules are currently realized within the BMBF-project in different miniaturization steps. During the conception phase, the requirements were specified and the necessary functionality was analyzed. In order to set the miniaturization focus appropriately, behavior models of the selected system architectures are currently being developed. With the decision for an especially suitable architecture, the structure decisions were made and appropriate components were chosen. For mastering higher design complexity regarding the miniaturized sensor-radio modules, the physical design had to be extended in such a way that the lateral and vertical coupling effects can be entirely characterized.

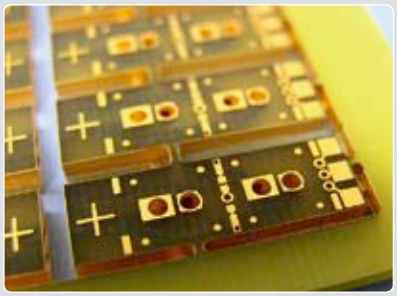
High-speed transmission in HDI multilayer backplane |

Typical telecommunication systems are conceived as bus systems with a central back plane. The backplane makes up a critical point regarding system reliability, since it is not hot-pluggable and cannot be set up redundantly.

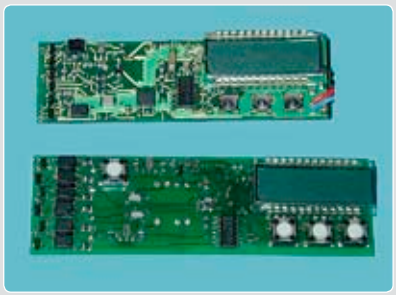
Therefore, the work concerning the topic mentioned above in the BMBF-MESDIE project has been focused on the following aspects: High speed transmission in HDI-multilayer structure (skew in differential pairs, skew compensation, impedance tolerances in high-speed backplane, differential pair stackUp and material combinations) and power ground (fractal structures, distributed power-ground-systems). Despite an increased disturbance insensitivity of the differential transmission, one must bear in mind that a time displacement of the signal skews can negatively influence the signal quality in the receiver (discontinuities). This problem can be solved with appropriate layout adjustments.

In order to acquire information during the design phase regarding losses occurring during transmission, several different material combinations and layer constructions must be compared with each other. The high frequency features of the current supply systems must be considered as well. Via special forms of the supply areas, a displacement of the resonance behavior is possible. The future emphases lie for instance in further developing approaches for distributed supply systems, and in the contactless measuring of high-frequency signals (transmission rate: 10 GB).

Micromechanics, Actuators and Fluidics



Board with integrated fluid channels and fluid ports



Control electronics for pipetting, generation 1 and 2.

COMPETENCIES

Devolopment of

- Micropumps
- Micro dosing systems
- Micromixers
- Microvalves
- Microreactors
- and flow sensors

›› SHORT PORTRAIT

The "Micromechanics, Actuators and Fluidics" Department focuses on 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.

Six experts of the department Micromechanics, Actuators and Fluidics carry out design, simulation and prototyping of microfluidic components. The department has more than 12 years experience in that field and guarantees optimal solution for the realization of individual applications.

Key competencies of the department are the development of micropumps, microdosing systems, micromixers, microvalves, microreactors and flow sensors and their combination for the use in biotechnology, chemistry and medicine.

›› TRENDS

Currently, the department focuses on the following strategic areas:

A capability to manufacture prototypes of silicon micropumps is built up at Fraunhofer IZM. Applications in the field of lab technology and fuel cells will be addressed. For our industrial partners these micro pumps are key components for successful products, which will be realized.

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

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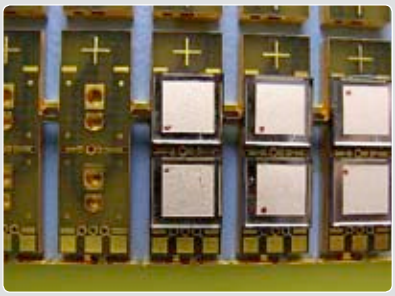
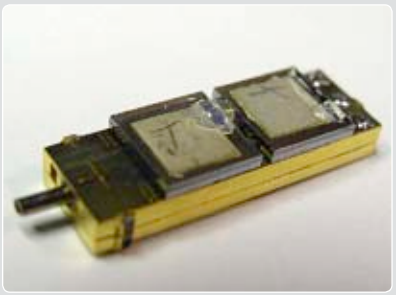
HIGHLIGHTS

- Ultra compact micropump fluid module
- Pipetting volumes from 0,1 µl to 1 ml
- System-on-package board-fluidics



Two silicon micropumps (each 7x7x1 mm³) mounted on a board



Ultra compact fluidic module: micropump with board with integrated fluid ports and fluid channels

›› RESEARCH RESULTS

Micropump fluid module for lab technology

Introduction |
Lab technology's day-to-day work demands increasingly small volumes, down to the sub-µl range, as well as parallel pipetting. Silicon micro-pumps are key components in perfectly fulfilling these demands. Miniaturization improves the size and mass of hand held pipettes and optimizes the flexibility of dosing tasks for microtiter plates. The single channels' volume and pipetting velocity can be individually assigned.

Fluidic module with silicon micropumps |
The IZM micropump technology was developed for the use in lab technology together with the company Hirschmann Laborgeräte GmbH & Co KG. The air cushion pipette requires a bidirectional working fluidic module, to which two micro diaphragm pumps with op-posing pump directions are attached. The micropump chips are diced after the full-wafer mounting of the piezo actuators. Quality control (stroke volume, flow rate, leakage) is applied to every chip. A good yield and reproducibility can be demonstrated.

System-on-package board fluidics |
Both micropump chips with the size 7 x 7 x 1 mm³ are mounted to the board. Fluid ports and fluid channels are integrated into the board. Thereby, an ultra-compact fluid module is available as a key component of innovative lab technology applications. Special attention was paid to the chemical resistance of the materials and the interfacing layers. The fluid only comes into contact with silicon within the silicon micropumps; thus the fluid module is also resistant against aggressive chemicals.

Control electronics |
Initially, a flexible control unit was developed, in conjunction with the company Jörg Volk Informationssysteme JVI, that could adjust the signal shape, voltage amplitude and time correlation of the single channels. From a series of tests with different signals, the necessary control circuit for a miniaturized electronics, including the on-board charging technology for a battery-driven device, was determined. At the same time, a second miniaturization step produced the small geometry necessary for a novel generation of an air cushion pipette.

Future prospects |
With the developed prototype the prerequisites for successfully transferring a microfluidic MEMS component into a product are established. Currently, the fluidic modules are being tested at end-user level and industrial fabrication is scheduled.

» EVENTS

Workshops

International symposium in Tokyo, Dr. L. Stobbe

Participants at the „Fraunhofer meets Continental" lectures

›› Internationales Symposium „Progress in Hetero System Integration" in Tokyo, Japan |

On April 7th, 2005 the Fraunhofer IZM was host of the symposium „Progress by Hetero System Integration" in Tokyo, Japan. Hetero System Integration is an answer to the growing demand in terms of functionality, performance and miniaturization of future micro-electronic products. It is a concept that combines various enabling technologies at the chip, board and system level.

The event at the National Museum of Emerging Science and Innovation (MeSci) attracted over 180 participants from the Japanese electronics industry, academia and non-governmental organizations. This strong Japanese interest in advanced microelectronics packaging technologies shows, how necessary and commercially successful an international collaboration in high technology can be. The global competition in the microelectronics sector demands continuous adjustments, but also mid- and long term strategies for technology development.

The global concept of sustainable development has to be considered a necessity in the technology driven electronics industry. As part of the event the German Academic Exchange Service (DAAD) in co-operation with the Fraunhofer IZM awarded the „Sustainability Award 2005" to Kayoko Tsunezawa, a young Japanese scientist. In his short laudation Prof. Max Huber, Vice President of the DAAD, emphasized that we have to support the new generation of researchers and engineers to develop not only technological competence, but an understanding of the main social, environmental and economical problems in order to create sustainable technical solutions.

IZM Reliability Workshop was a great success |

Reliability being the institute's middle name, IZM researchers feel a certain obligation to keep their customers from industry and science up-to-date with the latest developments in this field. And so in September 2005 Fraunhofer IZM scientists, together with the Research Center for Microperipheric Technologies organized a one-day workshop, entitled "Reliability of Microelectronic Systems".

Almost 100 participants, predominantly from the automotive sector, came to Berlin to learn about requirements and solution concepts for reliability models and to critically discuss the different approaches.

In the first part of the workshop Fraunhofer IZM scientists presented current trends in the reliability qualification of electronic systems. In the second part they discussed the reliability effects of manufacturing processes and test environments by means of practical examples, e.g. substrates, wire bonding and encapsulation with polymers.

Using a technology example from the realm of power electronics (chip on board technology), Dr. Bernhard Wunderle of Fraunhofer IZM summarized the methods and proposed solutions for the determination of complex microelectronic systems' reliability.

Participants at the workshop „Forum 2005 – be flexible - Thin Semiconductor Devices" in Munich

Participants at the workshop „Microdosing Systems"

›› Workshop "Forum 2005 – be flexible" |

This international workshop, addressing manufacturing and applications for thin semiconductor devices and technology and production processes for flexible electronic systems, took again place in November 2005 at the hotel "Le Meridien" in Munich. More than 160 visitors from 12 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 2006. | www.be-flexible.de

Workshop „Low-Cost RFID IC Packaging and Assembly" |

This international workshop for cost-efficient technologies for the production of RFID labels was hosted by IZM Munich in cooperation with TechSearch International, USA. More than 100 attendees from Europe, USA and Far East took the opportunity to get information about the production of smart labels, from chip manufacturing and assembly to finished labels. There was a lively discussion of the pros and cons of different approaches.

Workshop "Microdosing Systems" |

Microfluidic actuators for microdosing are a key technology in many branches of industry. That's why the Fraunhofer IZM's Munich division has over the past five years regularly hosted a microdosing seminar. In 2005, it was for the first time designed as an international workshop, under the title "Microdosing Systems, Drug delivery applications" and thus attracted an international audience to the Isar.

More than 50 participants from five countries, primarily from medical and bio-technology enterprises intensively focused on the particularities and challenges of drug microdosing within the framework of the workshop.

Topics included questions of conventional infusion technology, trans- and intradermal injections, as well as the particularities of using microneedles in drug dosing. The latest trends in the area of pressure-monitored drug dosing or the use of intraoral dosing systems were also discussed.

The participants' positive feedback has ensured that the international workshop will be held again in 2006.

Workshops

Industry Day at IZM Teltow

Prof. Monika Bauer at the IZM Teltow Industry Day

›› Industry Day: Light Weight Construction with Polymers |

On September 9, 2005 the IZM branch lab in Teltow opened its doors to visitors from the aviation, automotive and supplier industries. Participants attended workshops on current developments and future challenges in light weight construction with polymers. Topic included questions of how polymers can serve to make the car body of the future flame resistant, how to equip prepregs so that they can absorb energy and provide protection in the event of a crash, or how to optimize smart labels for particular applications.

- Composites and components with polymers
- Flame resistance of duromers and composites
- Integration of smart labels

A Tribute to Einstein |

In 2005 Germany celebrated Einstein Year in a joint initiative launched by the Federal Government, science, industry and culture. The occasion was the 100th anniversary of the Theory of Relativity and the 50th anniversary of the death of the world-famous scientist.

In this context Fraunhofer IZM together with other research institutions organized a scientific colloquium under the motto "Tribute to Einstein", chaired by Prof. Bernd Michel, head of the Micro Materials Center Berlin and Chemnitz. 75 participants from science and industry took the opportunity to discuss Einstein's work and and its impact on the current and future development of science and the society as a whole.

Conferences and Workshops organized or co-organized by Fraunhofer IZM		
April 2005	Berlin	Tribute to Einstein at Fraunhofer IZM | Chairman: B. Michel
	Tokyo	International Symposium „Progress in Hetero System Integration" | Chairman: L. Stobbe
June 2005	Munich	Innovative SiGe-Technologies for Multifunctional Systems | Chairman: P. Ramm
	Teltow	Scientific Colloquium: 50 Years Polymer Physics at Teltow Seehof | Chair: M. Bauer
September 2005	Berlin	Workshop: Reliability of Microelectronic Systems | Chairman: H. Reichl
	Colorado Springs	Advanced Metallization Conference 2005 (AMC 2005) | Chairman: P. Ramm
	Teltow	Industry Day: Light Weight Construction with Polymers | Chair: M. Bauer
November 2005	Munich	Workshop „Low-Cost RFID IC Packaging and Assembly" | Chairman: K. Bock
		Workshop " Forum 2005 – be flexible" | Chairman: K. Bock
		Microdosing Systems | Chairman: M. Richter

Girls‘ Day

Disassembly of a mobile phone

Visiting the clean room

Girls‘Day in Berlin |

For the second time Fraunhofer IZM Berlin participated in the nationwide Girls‘ Day. 12 girls between the ages of 12 and 15 came to the institute to learn about the basics and applications of micro-electronics.

The first practical part of the day was met with great enthusiasm – under the guidance of IZM-scientist Tanja Braun the girls used a soldering gun to build their very own version of a small lie detector. The finished device was afterwards checked for possible weak spots under the x-ray microscope. A visit to the clean room in appropriate clothing completed the morning activities.

The afternoon started off at the institute’s environmental laboratory, where in groups of three the girls disassembled old mobile phones, discussing the correct path for reuse or recycling of the individual parts.

At the end of their day at Fraunhofer IZM the girls worked in small groups to develop new ideas for the integration of electronics into textiles, so-called wearable electronics. A diaper that sends off an alarm in the case of an emergency, an intelligent outfit for a fire fighter – the young researchers‘ fantasy knew no limits.

Girls´Day Munich |

The established IZM internship in Munich - ‘The Clever Milk Carton’ - took place again in 2005. Ten girls, aged 13, took the opportunity to be introduced to the topic of non-contact identification systems (RFID).

Another 15 girls, took the opportunity of the nationwide Girls‘ Day to be introduced to ”the world of microelectronics”.

Mentoring |

The Munich branch of IZM participated in “Cybermentor”, a mentor program of the University Ulm for girls.

Gender Mainstreaming |

The guidelines of gender mainstreaming provide the basis for further medium-term activities to interest female students in a career in science and technology. IZM will continue to encourage especially the promotion of female students.

Fraunhofer IZM's Fair Activities 2005

›› More than a dozen times Fraunhofer IZM presented its manifold activities at trade shows in Germany and abroad this year. At the Surface Mount Technology (SMT) trade fair in Nürnberg the focus was on application-specific electronics developments for different high tech sectors. Using the example of different components for cars (airbag sensor, 3D acceleration sensor) the institute's development services were illustrated.

At the Sensor in Nuremberg the Fraunhofer IZM presented novel technologies for sensor development – e.g. the integration of active and passive components in a circuit board (chip in polymer) as well as optoelectronic and micro fluidic components. A special feature at the Fraunhofer IZM booth was a micro sensor system the size of a sugar cube. This tiny system is part of a radio network, which can interconnect a multitude of micro sensors and actuators and thus represents the first serious harbinger of the often cited "electronic dust".

One of the highlights 2005 was the Consumer Electronics Trade Fair IFA in Berlin. For the first time Fraunhofer IZM presented its "intelligent golf ball". Into this particular golf ball Fraunhofer IZM scientists have integrated an autarkic microsystem, consisting of power supply, a microprocessor and data storage capacities as well as wireless communication. This so-called eGrain measures the tee-off force of the golf ball and sends this information directly to a PDA. It was an occasion even Miss IFA couldn't resist – under the eyes of curious onlookers and television cameras the IFA-figurehead hit a golf ball at the Fraunhofer IZM stand.

Just like at the IFA two years ago the so-called Wearable Electronics generated a lot of interest among visitors and the media alike. At the IZM-booth a so-called communication jacket was presented, developed by IZM-scientists in cooperation with the fashion designer Hugo Boss.

March 2005	Berlin	µSys Berlin
	Chongqing	China Chongqing - High Tech Fair
	Shanghai	Productronica 2005
April 2005	Munich	SEMICON 2005
	Hamburg	Aircraft Interiors Show 2005
	Paris	JEC Composites Show 2005
	Nürnberg	SMT 2005
May 2004	Nürnberg	Sensor 2005
September 2005	Berlin	IFA 2005
October 2005	Munich	MST 2005
November 2005	Munich	Productronica 2005
	Frankfurt/M.	Continental Teves
	Düsseldorf	Medica

Since 1990 the Fraunhofer IZM and Messago Messe Frankfurt GmbH host the Conference Micro System Technology (MST) in Munich. The MST serves as a meeting point for international experts from science and industry to catch up with new developments in the areas of development, realization and application of microsystems, MEMS, MOEMS, micro- and nano integration, nano-interconnects and microfluidics. The main feature at the Fraunhofer IZM booth was again the intelligent golf ball, but the response to the other IZM exhibits was very positive, too – many visitors seized the opportunity to hear more about developments like ultrasonic transducers, wafer bumping and a brain sensor.

In November the Fraunhofer IZM presented its full range of services at the Productronica trade fair in Munich. A special highlight at the institute's exhibition stand was a rebuilt logistic scenario which demonstrates the functionality of autarkic distributed microsystems. These eGrains, which also form the basis of the intelligent golf ball, were placed in toy containers onto little trucks. The integrated sensors raised an alarm as soon as the trucks were overloaded.

„Research for Life" was the motto under which the Fraunhofer IZM's Munich branch lab presented its innovations at the MEDICA 2005 in Düsseldorf. Visitors were for example invited to test the functionality of low-cost plastic micropumps for drug dosing and to learn about optical protein biochip systems for infectious disease serology that allow a rapid and comprehensive diagnosis directly at the doctor' practice. Various micro valves and nanojet components completed the Fraunhofer IZM presentation.

The final appearance at this year's trade fair circuit was a presentation at the head office of the Continental Teves AG in Frankfurt/Main organized by the Fraunhofer-Gesellschaft. Under the motto "Fraunhofer meets Continental" Fraunhofer IZM together with several other Fraunhofer institutes exhibited developments from the realms of material sciences, information and communication, manufacturing technology and quality assurance.

*FACTS & FIGURES

» FACTS & FIGURES

The IZM in facts and figures

›› Financial situation |

The IZM's turnover remained stable in 2005, with a total of 27.3 million euro. 43% of this amount was income from direct contracts from German and international industrial enterprises and business associations.

This corresponds to a total of 11.7 million euro. In total, external proceeds amounted to 21.0 million euro.

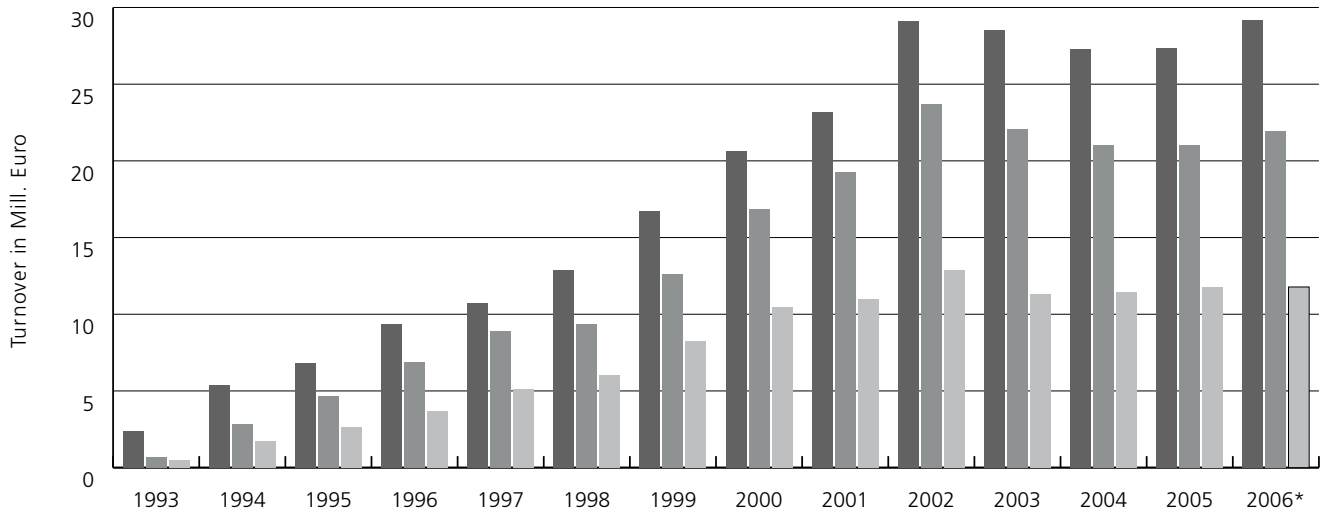
The basic funding provided by the German federal government and the Länder was primarily used for inhouse research, used to improve the IZM's spectrum of services.

›› Investments and laboratories |

In 2005, 3.8 million euro was injected into IZM investments. Of these, the following should be highlighted.

A flip chip bonder for 0.4 million euro, as well as a power COB production line for 0.5 million euro, were purchased for the Berlin branch, with support from the Fraunhofer Gesellschaft's strategic funds.

The 0.7 million euro project "Distributed model-based system design", devised to promote scientific cooperation between the various branches, was commenced.



* 2006 projected

›› Human resources development |

The IZM's level of staffing could, on the whole, be continued; only the Munich institute was reduced by 10 people. Furthermore, the reduction was achieved by winding up fixed-term contracts.

In 2005, the IZM provided a total of 213 full-time positions. The Institute continues to support students with the opportunity of combining their studies with practical scientific work in the Institute's laboratories and offices. The level of, on average, 110 interns, undergraduates and research assistants could be maintained.

The IZM, in cooperation with the TU Berlin also offers nine apprenticeships in Microtechnology, IT, and Business Administration for Office Communication.

›› Contact |

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- Turnover
- Contracts from industrial and public sectors
- Contracts from industrial sectors

Awards

Recipients of the Fraunhofer Award 2005 Dr. Vogel (center), Dr. Keller (right)

Christine Kallmayer receiving the IZM Research Award from Prof. Herbert Reichl

›› Joseph-von-Fraunhofer Prize 2005 goes to Prof. B. Michel, Dr. D.Vogel and Dr. J. Keller |
Prof. Bernd Michel from Chemnitz, Dr. Dietmar Vogel from Berlin and Dr. Jürgen Keller from Berlin have received the third Joesph-von-Fraunhofer Prize 2005. The award honors their research into product reliability in micro and nano technology through nano deformation analysis, carried out at the Fraunhofer IZM.

The Fraunhofer scientist have overcome the limits of conventional measuring systems with a new methodological approach. The nanoDAC/fibDAC process allows studies to measure residual stress, as well as material deformation and damage, information that could not be collected previously. Numerous companies are already utilizing the patented process.

Sustainability Award 2005 for K. Tsunezawa |
The German Academic Exchange Service (DAAD) in cooperation with the Fraunhofer Gesellschaft awarded the "Sustainability Award 2005" to Kayoko Tsunezawa, a young Japanese scientist. The award came with a doctorate scholarship. The award giving ceremony was part of a symposium on advanced microsystem packaging with the title "Progress by Hetero System Integration" on April 7th, 2005 in Tokyo.

f-cell Award 2005 bronze goes to Dr. R. Hahn |
Mobile devices, such as cell phones, laptops or cameras need power - regardless of where or for how long. Mini fuel cells improve power supply. Dr. Robert Hahn's research team from the Fraunhofer IZM has developed a micro fuel cell system that is only a few cubic centimeters large and has a significantly higher energy density than batteries. The research received bronze in the f-cell award 2005.

IZM Research Award 2005 goes to Christine Kallmayer |
In December the Fraunhofer-Institute for Reliability and Microintegration IZM presented the Research Award for outstanding achievements in the realm of packaging and interconnection technology for the sixth time in a row. The winner this year is Christine Kallmayer, who was honored for her work on flip chip assembly on flexible substrates. Ms. Kallmayer received her award from Fraunhofer IZM's director, Professor Herbert Reichl, during a ceremony in Berlin on December 21, 2005.

Christine Kallmayer started working at Fraunhofer IZM in 1994 and has since established an international reputation as the group manager responsible for system integration on flex. Two years ago Kallmayer's team developed new interconnection technologies for the integration of flexible circuits into textiles. These were successfully applied in a bicycle courier's outfit, a development that generated lively interest both from the scientific community and the public. One of Kallmayer's most outstanding characteristics is her versatility. She is also a specialist for the assembly of ultra thin chips, conductive adhesives and the printing of polymer pastes.

iNEMI-Ehrung für Hansjörg Griese |
In recognition of his contributions to the international electronics industry, to sustainability in electronics and on the occasion of his 65th birthday, Hansjörg Griese was given the iNEMI (International Electronics Manufacturing Initiative) International Recognition Award. The award giving ceremony was part of the international symposium "Perspectives on Electronics and Sustainable Development" in February 2006.

Training & Education

Apprentices at Fraunhofer IZM

Guided tour through the clean room

How to write an application

›› Professional Training |

Micro technical assemblies and components are produced with technically challenging and complex production techniques. This requires highly qualified and responsible employees. Micro technologists are the link between engineers and the semi-skilled production crew. As a qualified employee, a micro technologist needs sophisticated technological knowledge and skills to succeed.

Since 1998, Fraunhofer IZM has been training 2-3 micro technologists every year, focussing on microsystems as well as assembly and interconnection technologies. The professional training is conducted in a cooperation of Fraunhofer IZM, the Technische Universität Berlin, other research institutions and Berlin enterprises.

Additionally, Fraunhofer IZM's administration has been training a young office manager since 2005.

›› Local Education Networks |

Within the project "Microsystem Technologies Education in Northeastern Germany" (MANO) funded by the BMBF, Fraunhofer IZM and TU Berlin work on improving advanced training concepts for microsystems technology. Reorganization of the professional training curriculum is another major task. Environmental topics have become an integrated part for all kinds of educational activities.

Our institute started a co-operation with the Diesterweg secondary school, which is situated close to Fraunhofer IZM, in 2004. In this context we provide a study group Electronics, application training, as well as consultation for technical professional orientation. Students were also our guests at the "Berlin Long Night of the Sciences" and can participate in guided tours of the institute. Fraunhofer IZM also presented its activities at the annual school fete.

Lectures, Editorials

›› Lectures (Selection) |

Prof. Reichl, Technical University Berlin
- Technologien der Mikrosysteme II
- Grundzüge der Elektronik
- Halbleiterbauelemente

Prof. Reichl, Dr. Schneider-Ramelow
- Werkstoffe der Mikrosystemtechnik II

Prof. Reichl, Dr. Dieckerhoff, Dr. Wunderle
- Entwurf und Simulation von Mikrosystemen

Prof. Reichl, Dr. Töpper
- Physikalisch-Chemische Grundlagen der Mikrosystemtechnik

Prof. Geßner, Technische Universität Chemnitz
- Semiconductor Device Technology
- Microtechnologies

Prof. Bauer, BTU Cottbus
- Organic Chemistry
- Polymeric Materials

Dr. Kurth, TU Chemnitz
- Prüftechnik (Hauptstudium)
- Elektronische Messtechnik (Hauptstudium)

Dr. Mehner, TU Chemnitz
- Computer Aided Design CAD, Mikrosystemtechnik

Dr. Streiter, TU Chemnitz
- Prozesssimulation / Equipmentmodellierung

Dr. Strohhöfer, Fachhochschule München
- Biosensors (for bioengineers)

›› Cooperation with BTU Cottbus |

Since 1997, there is a co-operation of IZM's Branch Lab Polymeric Materials Teltow and the Faculty of Mathematics, Natural and Computer Sciences of 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 are performed.

Editorials |

SMT/ES&S/Hybrid Nürnberg, Proceedings
Prof. H. Reichl (Editor)

Micro System Technologies, Journal
(Springer Verlag International Heidelberg, New York)
Prof. B. Michel (Editor),
Prof. T. Geßner, Prof. H. Reichl
(Members of Editorial Board)

PLUS Journal (Eugen G. Leuze Verlag, Saulgau)
Dr. K.-D. Lang (Head of Editorial Board)
Prof. H. Reichl, Prof. W. Scheel
(Members of Editorial Board)

Micromaterials and Nanomaterials
Prof. B. Michel (Editor)
Prof. H. Reichl, R. Aschenbrenner, Prof. M. Bauer, Prof. T. Geßner (Members of Advisory Board)

Advanced Metallization Conference 2004 (AMC 2004), Proceedings
Materials research society,
Warrendale, Pennsylvania, 2005
D. Erb, P. Ramm, K. Masu, A. Osaki (Editors)

Dissertations, Best Paper Awards

›› **Archodoulaki, V.**
Eigenschaftsänderungen von Polyoxymethylenen induziert durch Verarbeitung, Alterung und Recycling

Chenping, Jia
„Mikromechanischer Ultraschallwandler aus Silizium – Silicon Micromachined Ultrasonic Transducers“

Knechtel, Roy
„Halbleiterwaferbondverbindungen mittels strukturierter Glaszwischenschichten zur Verkapselung oberflächenmikromechanischer Sensoren auf Waferebene“

Oberender, Christof
Die Nutzungsphase und ihre Bedeutung für die Entwicklung umweltgerechter Produkte (The Use Phase and its Importance for Design for Environment)

Rau, Ingolf
Bewertung und Zuverlässigkeitsanalyse von Underfillmaterialien für die Flip-Chip-Technik

Schmitz, Andreas
System Development of Miniaturised Planer Self-breathing Proton Exchange Membrane Fuel Cell (PEMFC): Simulation, Characterisation and Construction

Schneider, Jens
Nucleation and growth during the formation of polycrystalline silicon thin films

Wolf, Heinrich
Modellierung von Prüfsystemen und Schutzelementen zur Kompaktsimulation von elektrostatischen Entladungen an integrierten Schaltungen

Best Paper Awards

„He Bong Kim“ Best Paper Award 2005 given to:
K. Bock, J. Wolf and H. Reichl
for their paper “Trends in RF and Wireless Packaging” GaAs Mantech Conference, 11 – 14 April 2005, New Orleans , Louisiana, USA

Best Poster Award, GaAs Mantech 2005
K. Bock, C. Landesberger, M. Bleier, D. Bollmann, D. Hemmetzberger
“Characterization of Electrostatic Carrier Substrates to be Used as a Support for Thin Semiconductor Wafers”

Best Paper des ESD-Forums 2005
H. Gieser, H. Wolf, F. Iberl:
„Comparing Arc-free Capacitive Coupled Transmission Line Pulsing CC-TLP with Standard CDM Testing and CDM Field Failures“

Best Paper der SMTA 2005
L. Böttcher, A. Neumann, A. Ostmann, H. Reichl:
“Integration of Active and Passive Components Using Chip in Polymer Technology“

„Philips Best Paper Award“, ICEPT 2005
Th. Löher, A. Neumann, L. Böttcher, B. Pahl, A. Ostmann, H. Reichl:
„Smart PCB‘s Manufacturing Technologies“

Best Paper Intern. Conference on Device Packaging
M. Töpper, V. Glaw, K. Zoschke, . Ehrmann, H. Reichl:
„WLCSP Technology Direction“

Best Paper des ISSE 2005
D. Polityko, S. Guttowski, W. John, H. Reichl:
„Physical Design and Technology Parameters for Vertical System-in-Package Integration“

Cooperation with Industry (Selection)

Enterprise	Location
3D-Micromac	Chemnitz
AEMtec GmbH	Berlin
AIM GmbH	Heilbronn
Airbus Deutschland GmbH	Hamburg
AMD Saxony LLC & Co. KG	Dresden
Amitronic GmbH	Seefeld
Andus Electronic GmbH	Berlin
Angewandte Mikromesstechnik GmbH	Berlin
Atmel Germany GmbH	Dresden, Heilbronn
Atotech Deutschland GmbH	Berlin
BMW	Munich
Brose GmbH	Coburg
Chemnitzer Werkstoffmechanik GmbH	Chemnitz
Colour Control Farbmessstechnik GmbH	Chemnitz
Conti TEMIC microelectronic GmbH	Nürnberg, Munich
Degussa AG Creavis Technologies & Innovation	Marl
DaimlerChrysler AG	Stuttgart, Munich
Dilas Diodenlaser GmbH	Mainz
directif GmbH	Erlangen
Dow Chemical Company	Midland, MI (USA)
Drägerwerk AG	Lübeck
EADS	Paris, Toulouse (F), Munich, Ulm
Ekra GmbH	Bönningheim
Emerson&Cuming	Westerlo (BE), Bridgewater (USA)
EMZ GmbH & CoKGaA	Nabburg
Endress & Hauser Conducta GmbH	Gerlingen
EPCOS AG	Munich
First Sensor GmbH	Berlin
Hella	Lippstadt, Bremen
Henkel KgaA	Düsseldorf
Heraeus	Hanau

Enterprise	Location
Hitachi PERL	Yokohama (J)
hmp Heidenhain Mikroprint GmbH	Berlin
Hymite Deutschland GmbH	Berlin
Infineon AG	Munich, Regensburg, Dresden
InnoMat GmbH	Teltow
Infratec GmbH	Dresden
Laser Components GmbH	Garching
LG Thermo Technologies GmbH	Annaberg-Buchholz
Lust Antriebstechnik GmbH	Lahnau
Mandigo GmbH	Munich
Mikrogen GmbH	Neuried
Nanotest und Design GmbH	Berlin
Philips Semiconductors B.V.	Eindhoven (NL)
Phonak	Stäfa (Ch)
Polytec GmbH	Waldbronn
Ricoh Company Ltd.	Yokohama (J)
RKT GmbH	Roding
Robert Bosch GmbH	Stuttgart, Berlin, Reutlingen
Rohde & Schwarz GmbH	Munich
Schott Electronics GmbH	Landshut
Sentech Instruments GmbH	Berlin
Siemens AG	Munich
Smart Fuel Cell AG	Brunnthal
ST Microelectronics	Agrate Bianza (I); Tours (F)
Suss Microtec GmbH	Munich
TÜV Bayern	Munich
X-Fab GmbH	Erfurt
Texas Instruments	Freising
Hewlett Packard	Böblingen
Tanaka Denshi Kogyo Co. Ltd.	Tokyo (J)
Volkswagen AG	Wolfsburg

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)	Peter Ramm	Executive Committee
ALCATECH Council of Technical Sciences of the Union of German Academies of Sciences and Humanities	Prof. T. Gessner	Member
American Chemical Society (ACS), USA	Prof. M. Bauer	Member
Arnold Sommerfeld Gesellschaft zu Leipzig	Prof. B. Michel	Scientific Committee
Chongqing University	Prof. T. Gessner	Advisory Professor
Deutscher Verband für Schweißtechnik (DVS)	Prof. W. Scheel	Executive Board
EcoDeNet (Tokyo/Japan), EcoPac (Wuxi/China)	H. J. Griese	Member
European Technology Platform Nanoelectronics (ENIAC)	Prof. H. Reichl	Team Leader Domain "Heterogeneous Integration".
ESD Association	Dr. H. Gieser H. Wolf	Technical Program Committee
FUDAN University	Prof. T. Gessner	Advisory Professor
German Science Foundation	Prof. T. Gessner	Referee
Interessengemeinschaft Electrostatic Discharge e.V.	Dr. H. Gieser	President
International Technology Roadmap Semiconductors (ITRS) (Technical Working Group Assembly and Packaging)	M. J. Wolf	Chairman Europe
Kompetenzzentrum Kunststoffe des Landes Brandenburg	Prof. M. Bauer	Advisory Council
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
Organic Electronics Association OEA of the VDMA	Dr. K. Bock	Vice President
PIDEA+ (Packaging and Interconnection Development for European Applications)	Dr. K.-D. Lang	Chair of the PIDEA+ Technical Advisory Committee
Senatsausschuss Evaluierung der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (WGL)	Prof. T. Gessner	Member
Silicon Sensor	Prof. H. Reichl	Advisory Board
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 H. Griese E. Jung M. Töpper	Vice President Conferences Technical Chair Technical Chair Technical Chair
VDI/VDE- Gesellschaft für Mikroelektronik, Mikro– und Feinwerktechnik (Society for Microelectronics and Micro Technologies – GMM) Technical Committee Packaging and Interconnection Technologies	Dr. K.-D. Lang	Chairman
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