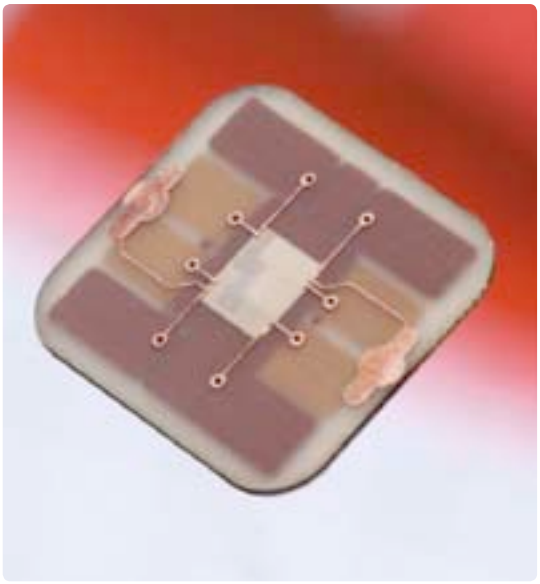
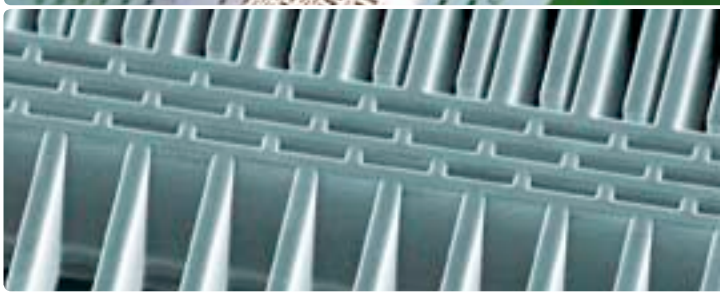
Annual Report 2006 / 2007





IZM

Fraunhofer Institut
Zuverlässigkeit und
Mikrointegration

Packaging | Quality | Reliability | Sustainability

Fraunhofer-Institute for Reliability and Microintegration IZM

Annual Report 2006 / 2007

Content
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Preface

Head of the Institute Prof. Herbert Reichl

Dr. K. Bock, Prof. T. Geßner, Prof. H. Reichl and Dr. K.-D. Lang (from left to right)

›› Facing the global challenge of merging markets, the German industry increasingly focuses on sophisticated technical products. To succeed in this market and to be able to offer surplus benefits to the customer, the integration of microelectronics into products is of growing importance, even in branches that are not directly related to electronics. Today we are able to create products with functionalities that would have been inconceivable only a few years ago. Examples for this development are camera cell phones, multifunctional navigation systems or the integration of sensor technology and radio communication interfaces into a golf ball.

Due to the consequent use of state-of-the-art assembly and integration technology future products will become smaller, lighter and, most importantly, autonomous, making them indispensable as assistants in our professional and private life. Furthermore, integrating a variety of functions into ever cheaper products has emerged as one of the main challenges of system integration, as can be seen in various areas of application, such as information and communication technologies as well as medicine and security technologies.

The term low-cost-electronics is currently undergoing a considerable image-change from simple applications to highly functional system integration for exceedingly innovative products, optimized with regard to technology, manufacturing and ecological aspects.

With its works in the field of smart system integration Fraunhofer IZM is one of the driving forces of this development. In 2006, the Institute continued to reinforce its excellent position in the area of assembly and packaging technologies in Europe. Another focus was the ongoing cross-sectoral support for small and medium-sized businesses in the field of microelectronics, microsystem integration and nano technologies.

Technology-wise, Fraunhofer IZM focuses on the related areas of smart miniaturized systems (integrating a system into a package or a board), multi device integration (development and manufacture of key components for microsystems) as well as bio system integration (the combination of electronics with bio analytics and sensors). Of course, reliability tests and lifetime estimations accompany these strategic topics.

With the appointment of Dr. Klaus-Dieter Lang (Berlin) and Prof. Dr. Thomas Geßner (Chemnitz) as deputy directors, Fraunhofer IZM also focuses its strategic adjustments on the emerging technical trends and economic markets.

Together with Dr. Bock, who is the deputy director of our Munich branch, they are now responsible for the three technology lines within Fraunhofer IZM: "Smart Miniaturized Systems" in Berlin, "Multi Device Integration" in Chemnitz and "Bio-Systemintegration" in Munich.

Excellent scientific ideas should be transformed into new product applications more quickly. To more effectively meet this goal, the federal ministry for education and research has set up six application centers to promote the use of microsystem technologies especially in small and medium-sized businesses. One of the carefully chosen sites for these centers is the Fraunhofer IZM. The Institute has a long history of successfully and competently supporting small and medium-sized companies, e.g. manufacturers of hearing aids or catheters. With the application center, however, the suppliers and users of microsystem technologies have an even better scientific-technological service offer at their disposal. For the first time ever, Fraunhofer IZM is able to offer the whole palette of tools for developing successful innovations to its partners in industry - from technology consultancy to product development, through to use of laboratories.

Last but not least due to the extension of our research, development and service offers mentioned above, we are confident to carry the momentum of last year's positive trend regarding our economic and human resources development into 2007.

In this context I would like to thank our partners in industry and research, the various government agencies and the project agencies for their confidence and the successful collaboration throughout the last year. I would also like to thank all our organization's employees for their unfailing commitment and their never-ending supply of new ideas.

This annual report again presents a selection of our most interesting research outcomes, resulting from a variety of different projects.

Happy reading!

Herbert Reichl

The Fraunhofer-Gesellschaft

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

Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. They do so by promoting innovation, accelerating technological progress, improving the acceptance of new technologies, and not least by disseminating their knowledge and helping to train the urgently needed future generation of scientists and engineers.

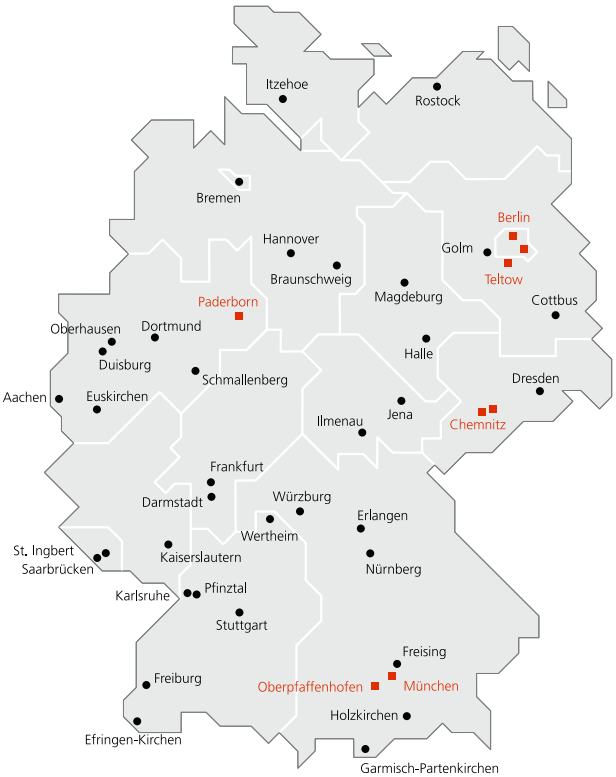
As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, in other scientific domains, in industry and in society. Students working at the Fraunhofer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

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units, including 56 Fraunhofer Institutes, at 40 different locations in Germany. The majority of the 12,500 staff are qualified scientists and engineers, who work with an annual research budget of €1.2 billion. Of this sum, more than €1 billion is generated through contract research. Two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects.

Only one third is contributed by the German federal and Länder governments in the form of institutional funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

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

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



Fraunhofer Microelectronics Alliance

›› The Fraunhofer Microelectronics Alliance VµE has been coordinating the activities of Fraunhofer Institutes working in the fields of microelectronics and microintegration since 1996. Its membership consists of ten institutes as full members and two as associated members, with a total workforce of around 2,340 and a combined budget of roughly €219 million. The purpose of the Fraunhofer VµE is to scout for new trends in microelectronics technologies and applications and to integrate them in the strategic planning of the member institutes. It also engages in joint marketing and public relations work.

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

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

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

Further information
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Fraunhofer IZM

›› Profile |

Internet-enabled PDAs, mobile medical diagnosis devices or fuel-efficient vehicles - nowadays everything requires highly integrated microelectronics and microsystem technology to function. The trend is towards increasingly small, higher performance and more economical high-tech products. The foundation of this ongoing product development is the availability of miniaturized components and reliable and cost-effective assembly technology.

Fraunhofer IZM's R&D is rooted in the methods, processes and technologies from the areas of system integration and electronic packaging on wafer-, chip- and board-level. Our core topics reflect the entire spectrum of integration processes in microelectronics and microsystem technology.

›› History |

Fraunhofer IZM has seen a great deal of success since its founding in 1993 from research groups of the Research Center for Microperipheric Technologies at the TU Berlin, the Humboldt-Universität Berlin and what used to be the Institute for Mechanics at the Aka-demie der Wissenschaften in Chemnitz. Initially, the institute saw the addition of groups in Teltow and Paderborn; later branches were also established in Munich and Chemitz. Today, 266 scientists and technicians, as well as 121 interns and undergraduate students conduct research at seven different institute locations.

›› Technological focus |

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

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

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

Cooperation with Universities

›› Cooperation with the Technische Universität Berlin |

The Berlin Center of Advanced Packaging (BeCAP) is a co-operation between the Research Center for Microperipheric Technologies of the TU Berlin and the Fraunhofer Institute for Reliability and Micro-integration IZM.

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

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

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

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

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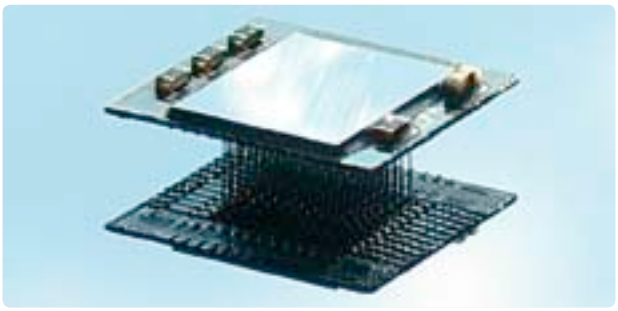
Cooperation with the Technical University Chemnitz |

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

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

Cooperation with BTU Cottbus |

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



Neuronal interface

R&D team at the University of Utah with Prof. Florian Solzbacher (4th from the left) and Prof. Michael Töpper (6th from the left)

Fraunhofer IZM and University of Utah are working on a neuronal interface |

Heterosystem integration with a focus on biomedical applications is the basis of a cooperation between Fraunhofer IZM and the University of Utah (Salt Lake City). A platform for an implantable wireless interface is the goal of this research to help disabled persons. This peripheral nerve interface to an external computer can be used to control for example an artificial arm with much more functions than for those already in use. The wireless structure will minimize any infection risk.

The micro system will be based on a biocompatible and highly reliable packaging concept using a wafer level approach. It is based on a stacked hybrid assembly of Silicon, polymer foils, ceramic and SMD components. Miniaturization and long lifetime are the main drivers for this development. The work is supported by US public research programs.

The cooperation of the two research institutions is also supported by an exchange of scientists. Prof. Michael Töpper from the Fraunhofer IZM worked in Salt Lake City as a Research Assistant Professor at the University of Utah. He started this development together with Prof. Florian Solzbacher who is the director of the MEMS lab at the University of Utah. Matthias Klein coordinates the project in Berlin. His expertise is the micro-assembly of the different components, which is a key technology for this neural interface.

The microelectronic module is based on the neuro interface (Si array) which has been developed at the University of Utah. The modular structure has the advantage of being a platform for different biomedical applications.

Power Modules – Conventional Assembly, Interconnection Technology and Reliability

›› Power electronics is a key technology for flexible and intelligent power supply and control units for a large variety of applications. Typical power electronic applications encompass e.g. electrical drives, switch-mode power supplies, regenerative energy sources or automation technology.

In order to meet the demands for reduced cost and optimum reliability, there is an increasing need to consider technological aspects at all design stages. Fraunhofer IZM has all the expertise and experience required at every stage of the entire development chain, from power electronic system design, assembly and interconnection technology to thermal management and electromagnetic compatibility (EMC), up to reliability and failure analysis.

Currently, one focus is the further development of lifetime models, designed to accurately describe the failure mechanisms by which power modules fail. The most prominent of these are fatigue damage of the solder layer and of the bond-wire wedges and are to be described as a function of time, material and loading.

Assembly and interconnection of conventional power modules |

High switching currents, voltages and frequencies, increasing operation temperatures, and reliability demands as well as strict guidelines for electromagnetic compatibility - the requirements for modern power electronic systems are becoming more and more stringent.

Assembly and interconnection technologies play a significant part in power electronics, particularly in terms of optimizing reliability and improving thermal management issues. Here, the following processes are successfully employed:

- Die bond soldering using solder preforms or pastes
- Al-US heavy-wire bonding (100 – 500µm)
- Interconnection of power electronics to logic and casing
- X-ray and scanning acoustic microscopy, visual inspection and mechanical tests

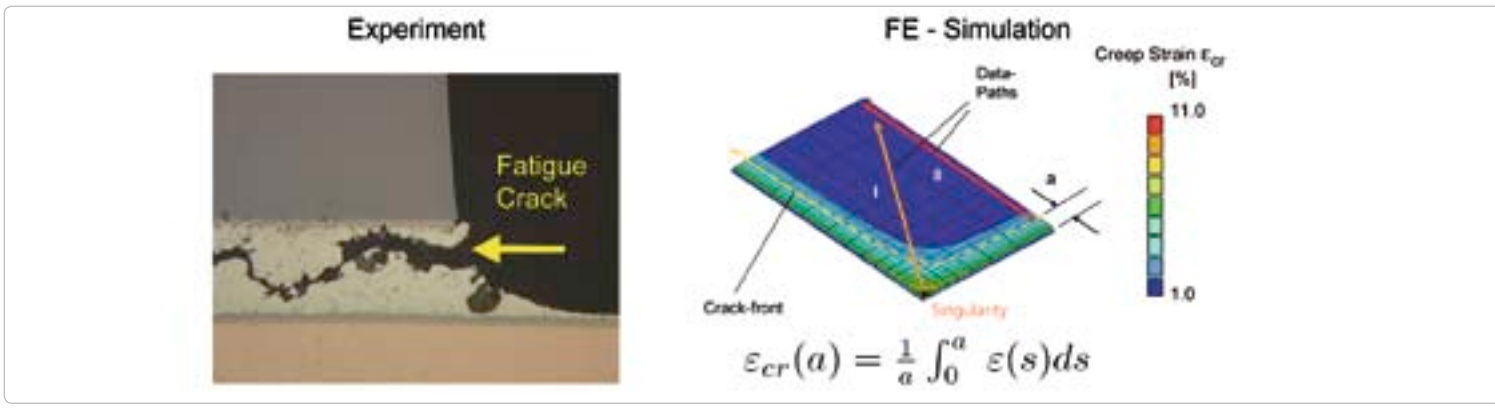
The individual process steps are systematically analyzed and continuously improved at Fraunhofer IZM in order to prepare these technologies for industrial use. An important aspect in this context is the reduction of the weight and size of the module as well as the complexity of the used technologies and costs.

Reliability and lifetime models of conventional power modules |

The processing quality of power modules, such as for example IGBTs, is determined by the employment of component and substrate, optimized assembly techniques (e.g. soldering and wire bonding) and quality checks as well as functional tests.

During both operation and reliability tests, failures mostly affect wire bond connections due to periodic thermal and/or electrical (high current) loading (e.g. power cycling), or die attach through solder creep/ fatigue.

Fig. 1: Lifetime model for solder fatigue cracks by experiment and simulation



Schneider-Ramelow, M.
Wunderle, B.

To account for these failures already during the design phase, there is high need for lifetime models which are able to describe the reliability physically as a function of system parameters and loading conditions. This requires system competence, which means consideration of technology, material, simulation and experiment as one and at the same time.

Solder fatigue |

Due to the different thermal expansion coefficients of chip and substrate, the solder as interface layer is subjected to low cycle fatigue, so that with time a crack propagates from the edge of the chip to its center. This increasingly prevents heat dissipation into the substrate thus limiting the lifetime of the chip. The maximum length of the crack can be estimated a priori by thermal simulations.

Finite element simulations (FE) are used to calculate the lifetime as a "mean time to failure" (MTTF). Using the implemented material data of the characterized materials the FE simulation calculates the mechanical stress and strain within the solder. With this information we are now able to evaluate a failure criterion by integration along a virtual damage path (Fig. 1).

In a next step this value is correlated with the MTTF value, which is experimentally obtained. The simulation is now ready to test the reliability of several loading conditions, material combinations and geometry variations, thus fulfilling the objective of a lifetime estimation.

Cracks in wire bonds |

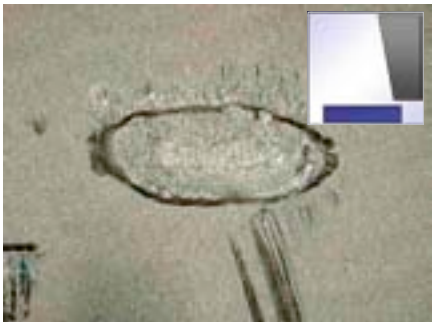
Due to the extreme thermal mismatch between Al-wire and Si-chips alternating thermo-mechanical loading occurs in the wedge area. This in return can lead to wedge lift-off and consequentially to fatal failure of the component. For this reason, special attention is currently being given to the bond-quality before stress exposure. The quality of the bond contact, i.e. the bond formation between the wires and substrate metallization after optimizing bonding parameters, can only be checked by shear-testing at the wedges (Fig. 2). As a basis for lifetime prognosis, passive and/or active temperature cycling is used for reliability analysis. In this context the temperature difference is of significant influence.

In establishing an advanced lifetime model for heavy wire bonds, this should also consider physics of materials, geometrical and processing variables, such as the Al-wedge-structure and geometry as well as interface strength between wedge and chip metallization.

For lifetime estimation, the bonding process is now FE-modelled. The strains resulting from the bond process and the subsequent thermal loading of the power cycling test can be used as a measure for reliability. Prerequisite is again the proper knowledge of the material properties which can be determined from tensile and nano-indentation measurements.

The authors are the Fraunhofer IZM Research Award laureates 2006.

Fig. 2: Different shear codes



Wedge lift-off

Partial wedge lift-off

Shearing through wedge

Future System Integration - Enabler for Innovative Products

›› Experts predict that the progress in silicon technologies will follow the well known “Moore’s law” in the next decade, too. This trend can be characterized by “More Moore”. However, for future multifunctional systems in most cases the cost efficient nano-electronic standard technologies cannot be applied.

Non-electronic and often radiofrequency functions require alternative materials and special processes. These additional process steps often reduce the yield or require special process developments which result in a tremendous cost increase. Therefore the future will be a combination of “More Moore”- or system-on-chip - and advanced system integration solutions such as “More than Moore”, “heterogeneous integration” or “smart system integration”.

More than Moore |

“More than Moore” focuses on the integration on a single chip. Unlike system on chip solutions additional functions are added on a processed wafer (back-end of line) with “not baseline” CMOS processes.

Typical examples of “More than Moore” today are an integration of RF (radio-frequency) active and passive components in wireless transceivers for mobile phones or high-voltage solid-state switches for use in transportation electronics.

Technologies for multifunctional one-chip-systems differ from silicon-IC-technology in a way that on a completed and tested IC-chip further functions can be generated on the chip compatible with CMOS-technology through layer separation and structure, wafer stacking and alternative semiconductor materials, polymer layers and MEMS-silicon-technologies.

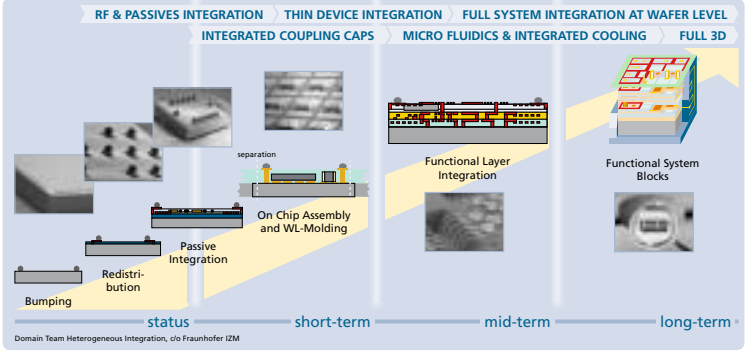
Heterogeneous Integration |

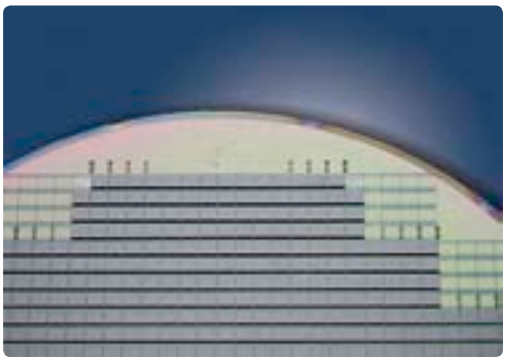
Heterogeneous integration combines several components or functionalities with a very high degree of miniaturization and flexibility at reasonable costs in one package (system in package or SiP), that is specifically adapted to the application environments.

The present technology status will not be sufficient to meet the future integration requirements of advanced SiP solutions. The very high level of miniaturization, additional non-microelectronic functionalities and extreme reliability required in future SiPs will mean that issues such as thermal and mechanical stress management will need to take into account everything between the point at which heat is generated and the outside of the package.

In addition the application environment in which the SiP will ultimately be used will also need to be taken into account.

Roadmap and example of system integration on wafer level





Herbert Reichl
Rolf Aschenbrenner
Klaus-Dieter Lang
Harald Pötter
Jürgen Wolf

To meet these challenges, new architectures will have to be developed. To reach the required level of miniaturization, it will also be necessary to develop advanced assembly and handling technologies e.g. for thin wafers and chips.

The integration of nano-ICs, sensor chips, actuator components, passives and displays into 3D architectures will require the development of new design methodologies as well as reliable ultra-thin metallic interconnect technologies. New low-cost solutions for heat dissipation and thermal and RF shielding will have to be investigated. In addition, improvements in design and simulation methodologies, test strategies and reliability modelling are required.

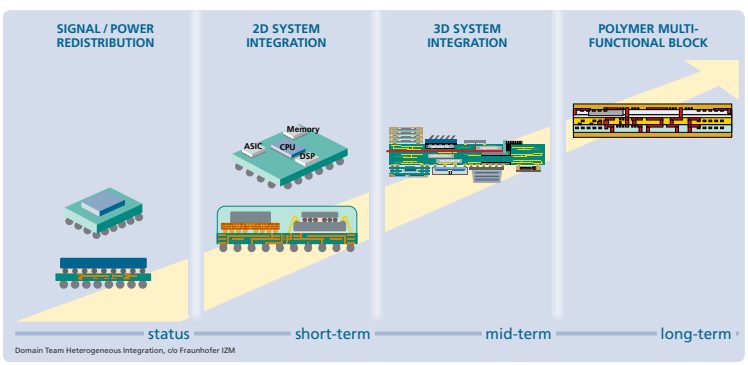
Smart System Integration |

Smart system integration is driven by functionalities and covers technologies for physical integration of subsystems and systems in various applications. From a technology point of view smart system integration uses “More than Moore” as well as heterogeneous integration solutions and integrates these solutions into the application system.

Because smart system integration is not restricted to a certain scale these components may be integrated in large-area substrate materials, generally using organic materials.

With these so called 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. Using this approach, complex, but cost-efficient plastic systems can be manufactured, leading to large-area, cost-efficient production processes for e.g. bio-analysis and therapy.

Roadmap and example of system integration on module level




*IZM PROGRAMS

›› Philosophy of IZM Programs

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

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

» IZM PROGRAMS

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›› Wafer Level 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.

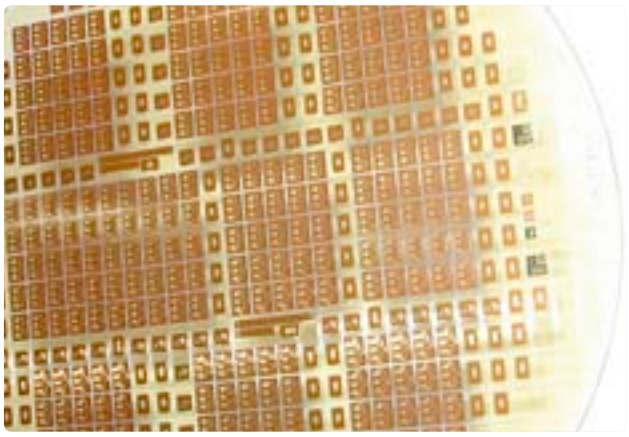
COMPETENCIES AND ACTIVITIES

Services available |

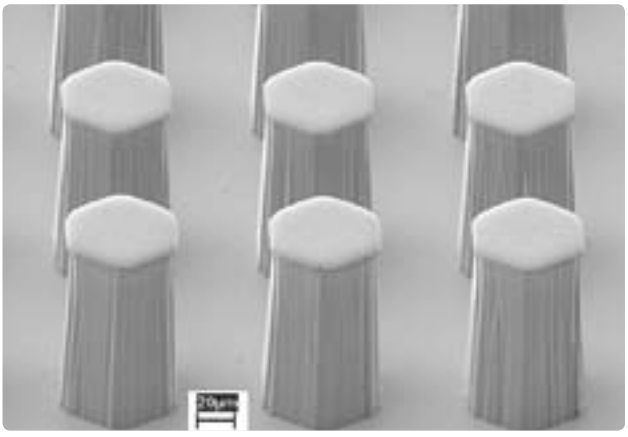
- Wafer bumping by
  - electroplating
  - electroless deposition
  - stencil printing
  - placement of premanufactured solder balls
- Redistribution technologies
  - processes using photo-definable dielectrics (BCB, Polyimide) and electroplated metallization (Cu, Ni, Au)
  - alternative processes using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



Passive device integration on wafer level



Copper pillar bumps (height 80µm)

Photonic Packaging

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

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

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

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

COMPETENCIES AND ACTIVITIES

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

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

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

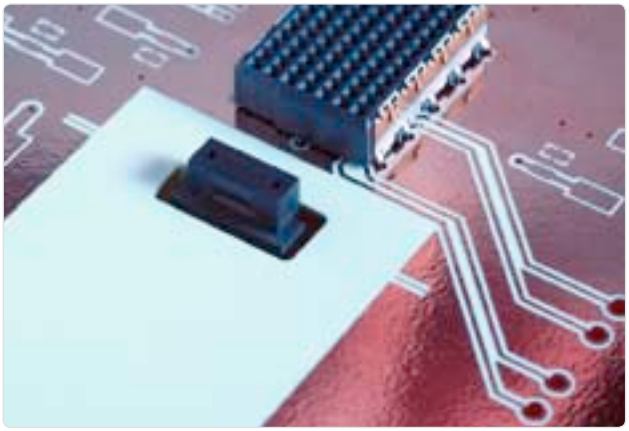
Optical backplane & EOCB |
Hot embossing or UV-direct writing, 90° beam coupling

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

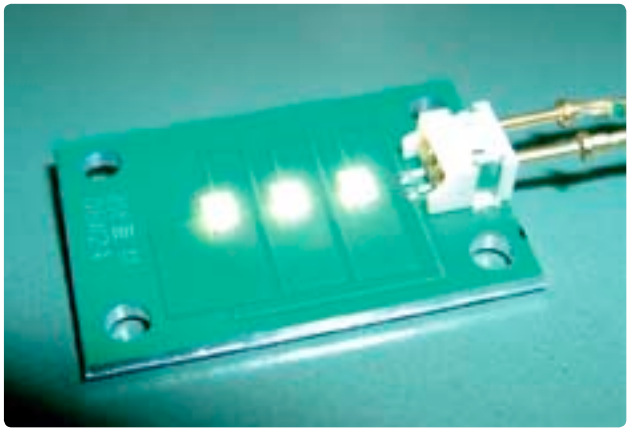
Image sensors |
Pixel detectors IR, X-ray, wafer level OPTO-CSP for CCD and CMOS cameras

Micro devices |
Micro spectrometer, laser projection devices

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



Electrical-optical interface on PCB with integrated optical waveguides



White UHB-LED packages on metal core board with blue LED and converter foil for automotive head lamps

MEMS Packaging

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

COMPETENCIES AND ACTIVITIES

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

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

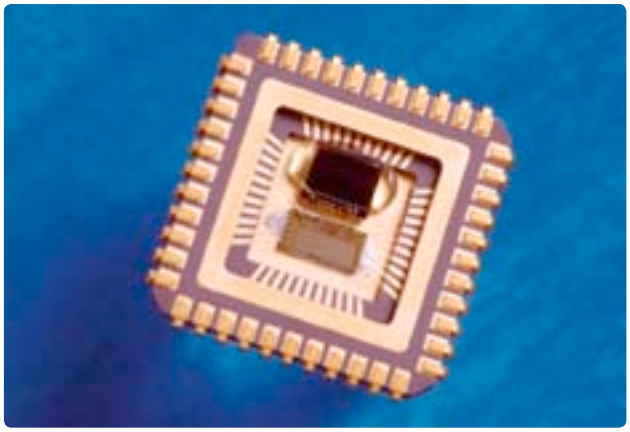
We strive to be your prime source for MEMS and sensor packaging issues.

Services available |

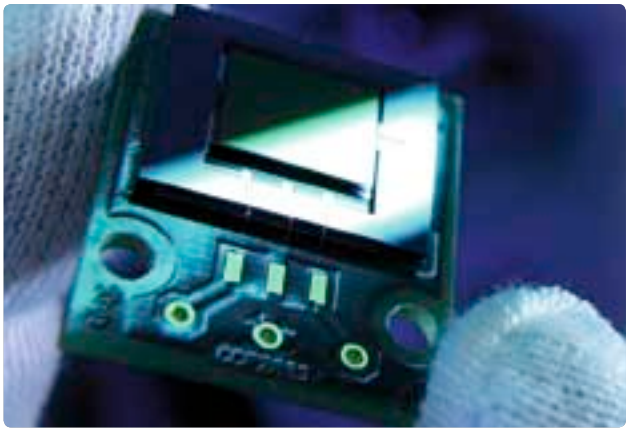
- Consultant service for emerging and existing MEMS/ sensor packaging concepts
- R&D for MEMS packages and MEMS-based SiP solutions
- Realization of packaged MEMS components

Current research activities |

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



Low g high precision acceleration sensor



Pressure sensor, capacitive top cap mounted in die-to-wafer assembly

3D System Integration

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

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

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

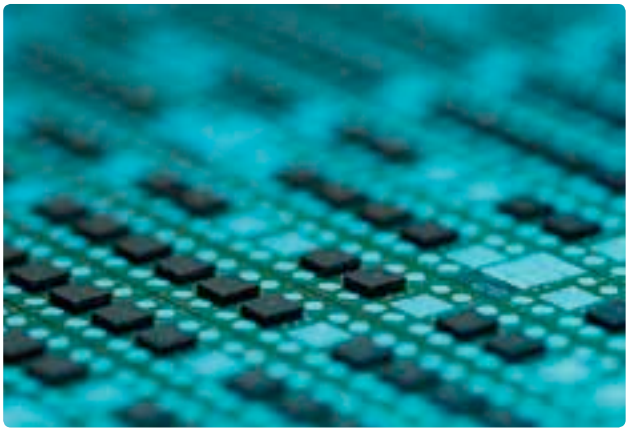
In addition, Fraunhofer IZM provides competencies in enabling 3D technologies such as 3D system design and backend-of-line technologies (BEOL).

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

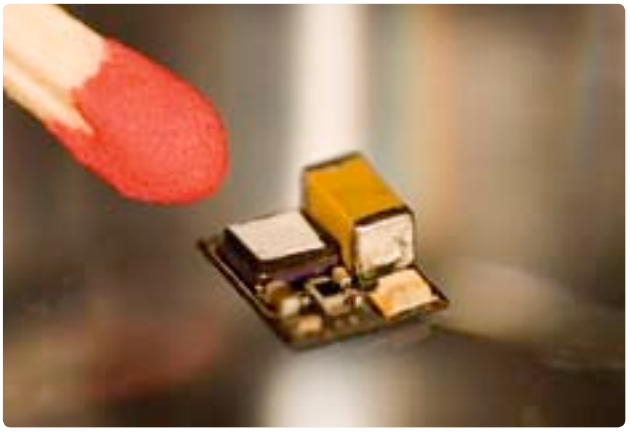
A smart substrate stacking technology based on top-bottom ball grid array is available at IZM for 3D-integration of various functions. The interfaces of the modules are standardized with IZM´s know-how by the Match-X association. State-of-the-art for stacking of dice at the IZM is mainly chip-on-chip 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.



3D integration in chip-to-wafer technology



Wireless sensor system

RF Systems

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

COMPETENCIES AND ACTIVITIES

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

Support of the industry incorporates the areas:

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

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

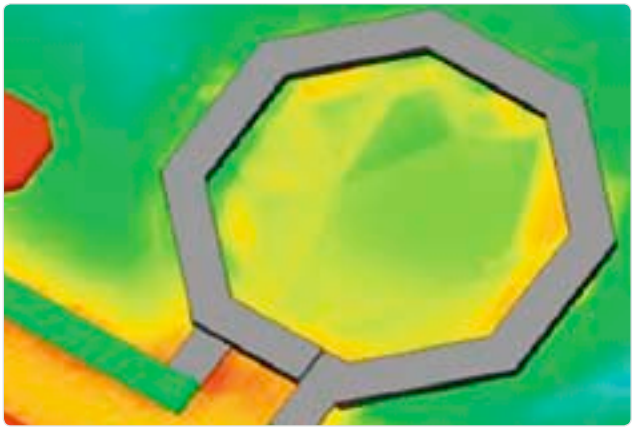
Supporting industry could consist of single process steps, ranging from consulting to developing applications tailored to industry's needs, demonstrators or prototypes with a final production qualification, or know-how transfer to the industrial partner, based on our substantial equipment and expertise.

Services |

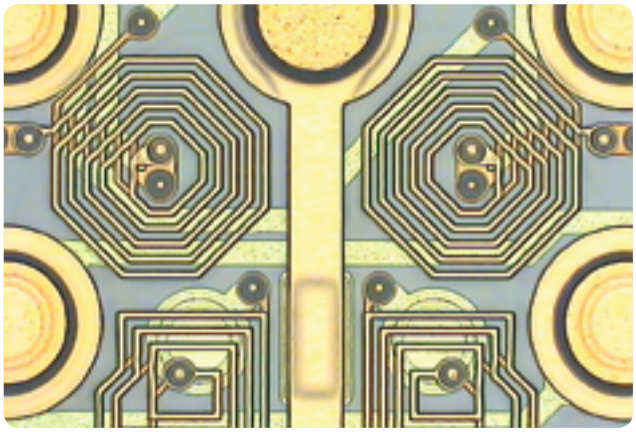
- Technology development and evaluation
- Technology-oriented RF-characterization up to 110 GHz
- Antenna development and characterization
- Technology-oriented feasibility studies for RF systems
- High-resolution high-current characterization in the time domain

Current research activities |

- Development of extremely miniaturized antennas
- Electrical modeling of Carbon-Nano-Tube-Interconnects
- Controlled impedance test solutions for RF-systems



Field distribution of an embedded inductor



RF filter structure in thin film technology

Large Area Electronics

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

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

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

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

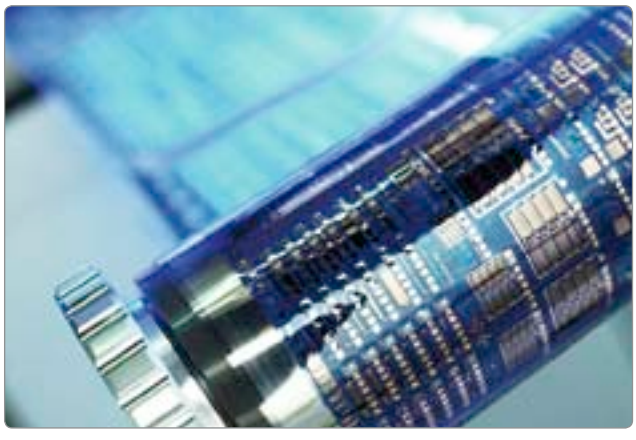
COMPETENCIES AND ACTIVITIES

Services available |

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

Current research activities |

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



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

BioChip diagnosis system for human antibodies

Micro Reliability and Lifetime Estimation

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

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

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

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

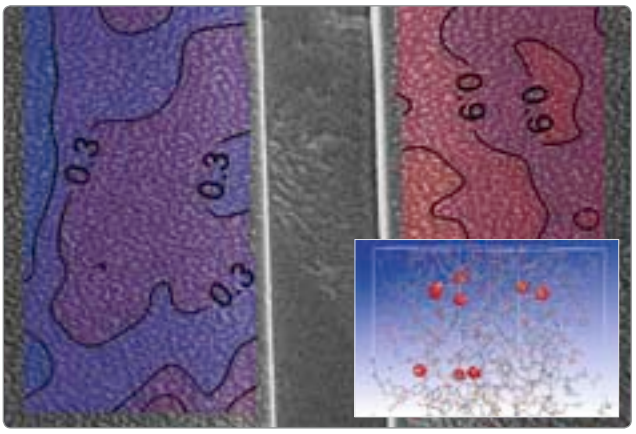
COMPETENCIES AND ACTIVITIES

The lifetime prognosis requires dealing with the following tasks:

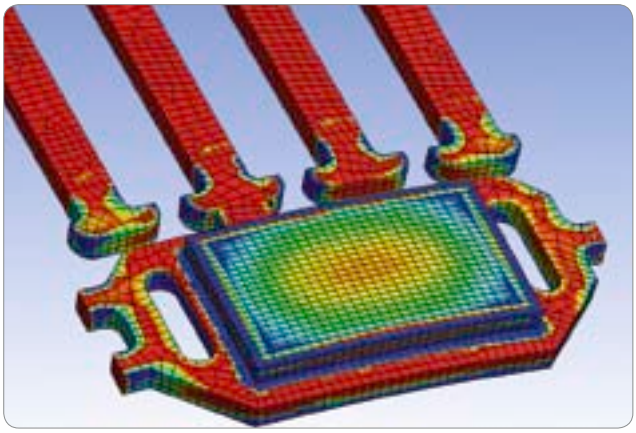
- Modeling in-situ determination of reliability parameters
- New NDE testing methods
- Identifying and verifying lifetime expectation

Activities and projects:

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



Molecular dynamics simulation of the diffusion of water in polymer



Finite element simulation of thermo-mechanical stress for sensor package

Thermal Management

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

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

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

COMPETENCIES AND ACTIVITIES

The 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”

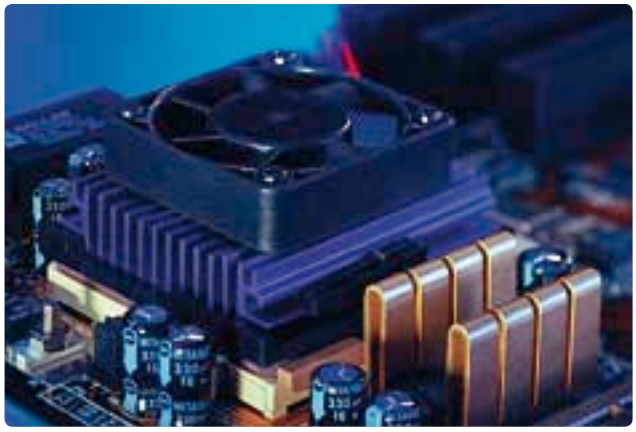
This consistent combination enables reliability-optimized thermal and thermo-mechanical design for advanced system integration and tailor-made thermal management solutions. It thus combines the key competencies of the institute’s individual departments for an efficient and customer-orientated knowledge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

Services available |

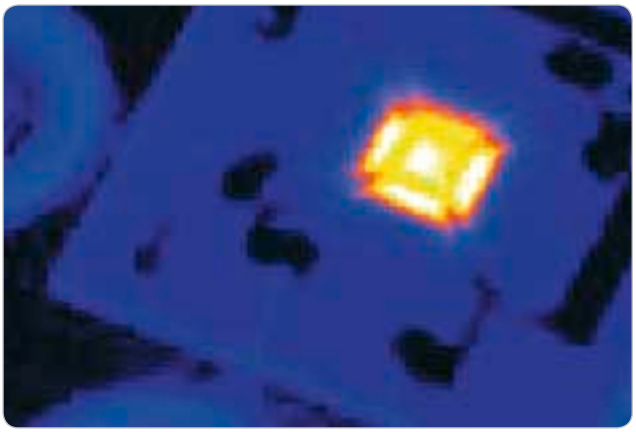
- Lifetime prediction
- Material characterization
- IR-thermography
- Rth-measurements
- Passive & active thermal cycling
- Test-station for air- and water-cooled systems
- Deformation measurements for micro- and nano-structures

Current research activities |

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



Enforced air cooling for CPU



High resolution IR thermography

Sustainable Technical Development

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›› 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.

COMPETENCIES AND ACTIVITIES

While the miniaturized domain of microsystems and integration technologies constitutes the core competence of the institute, this program by definition has to take a much broader view. This involves investigating products and their applications, with a life cycle perspective from production to recycling and even social and global effects, which are one pillar of the sustainability concept.

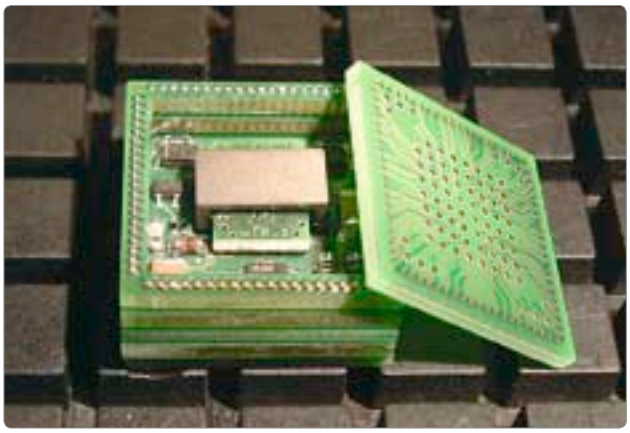
Services available:

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

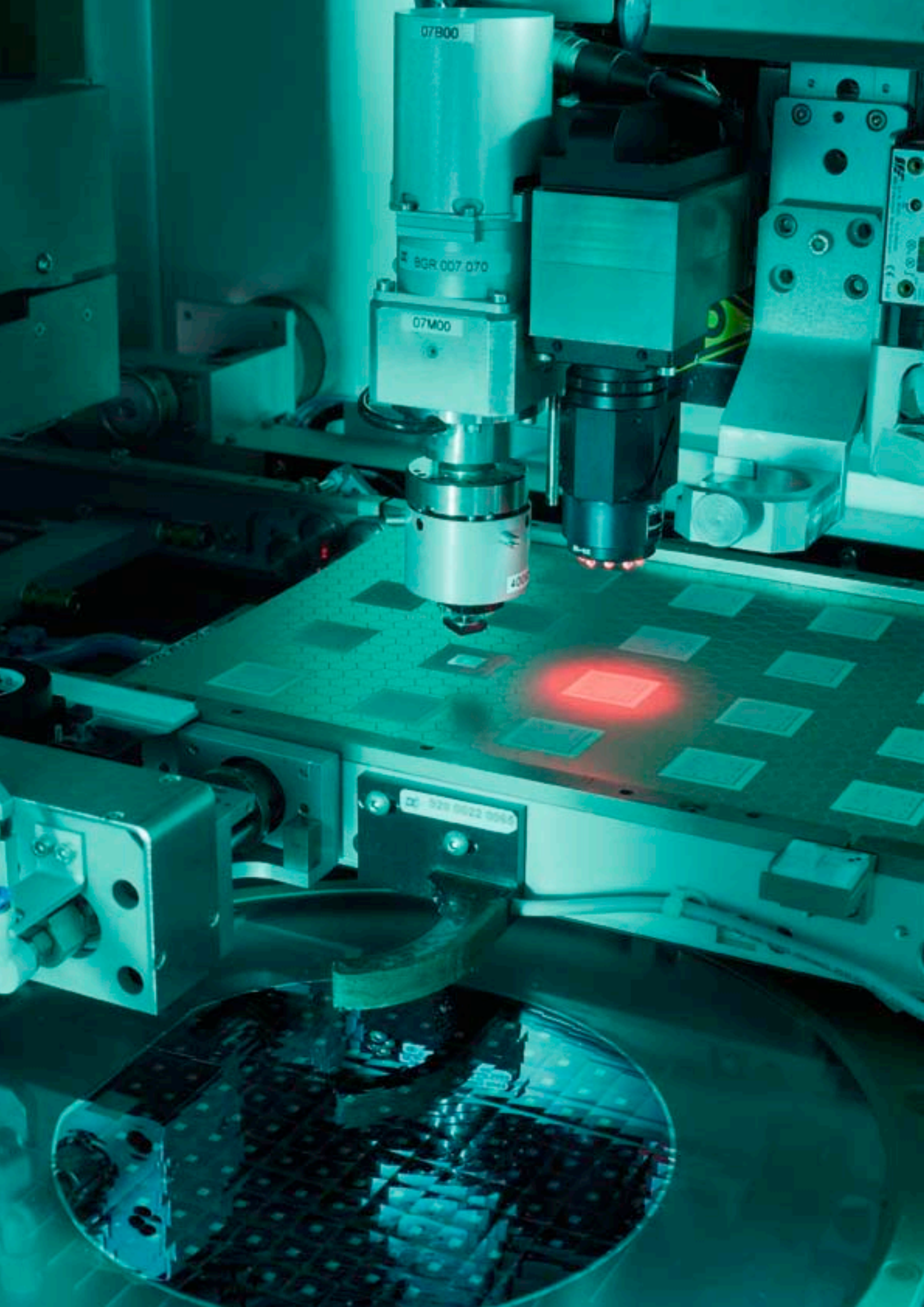
Current research activities |

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

Printed circuit board for a remote control – based on lignin from wood or straw



Novel transformer concept for miniaturized power supplies resulting from an adapted MST design process (cooperation with Elbau, Berlin)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*COOPERATION

» COOPERATION

Your Gateway to Advanced System Integration Technologies

Training success (almost) guaranteed – golf ball with integrated electronics

Miniaturized hearing aid – more comfort for the user

›› You've carved out a niche in the field of electronic packaging and are interested in sustainable success for your company? Then the Fraunhofer IZM's Marketing Team can help you.

Are you new to the field of microsystems or looking for support in developing your new product ideas? Then – thanks to an initiative of the German Ministry for Education and Research – the Application Center Smart System Integration should be your first port of call.

Two approaches, one goal! We can deliver technology solutions customized to your particular requirements and product ideas!

Fraunhofer IZM Marketing – New technologies for your company

Facing the challenge of expanding global markets and shrinking product and lifetime cycles, precisely timing the introduction of new technologies is crucial for a competitive company. But when is the right time to invest in new technologies? Which technologies have the potential to optimize your company's technology-portfolio?

Fraunhofer IZM is one of the world's leading R&D institutions in the field of system integration for microelectronics and microsystems. Our expertise encompasses the development of new materials and the packaging design of integrated circuits, as well as solutions for quality, reliability and environmental issues.

Our strength is bridging theoretical and applied research, transforming research conducted into applications used in industry's day-to-day business. The following pages introduce our technological expertise and the services we provide. Our experts are happy to provide advice on selecting the technology that best matches your company's requirements, and in assisting you with its implementation.

Fraunhofer IZM Marketing and the Application Center Smart System Integration

Intelligent catheter - more safety for nursing staff and patients

Future electronics – integrated in clothes

›› Please feel free to contact us. Our Marketing Team is also happy to introduce you to the world of Fraunhofer IZM. We can provide you with personalized support for the following main topics:

Technology workshops that suit your company |
Would you like to put the technology you use to the test or just find out which new technologies might be relevant for your company? We offer workshops tailored to your needs. Our experts will present the whole scope of current technical developments in the field of electronic packaging. Together we can determine which technologies would be of most benefit to you and your products.

Workshops that suit your technology |
You already know in which technological fields you would like to invest and just need support in deciding which specific technology is right for your company? Our experts will discuss the pros and cons of the recommended technologies with your specialists.

Consultancy on technological questions |
You require a solution to current technical challenges within your company? Please don't hesitate to contact our staff. We look forward to putting you in touch with people who can help.

Contact |

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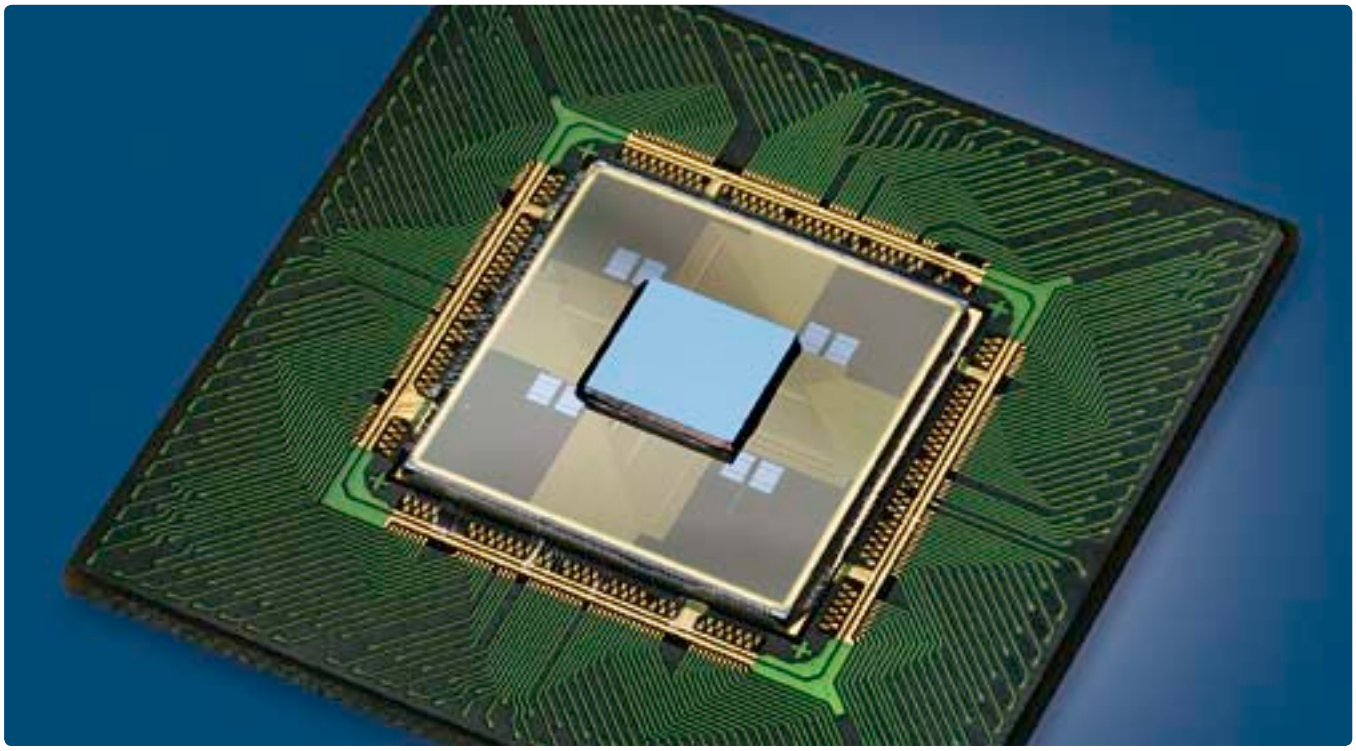
Application Center Smart System Integration – Fraunhofer IZM Deepens Focus on Applied Research



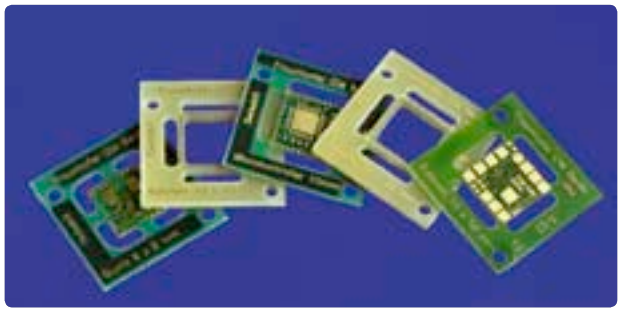
Provision of technologies and equipment

›› Excellent new product ideas should be transformed into applications more quickly. To more effectively meet this goal, the BMBF supports the Application Center Smart System Integration at Fraunhofer IZM.

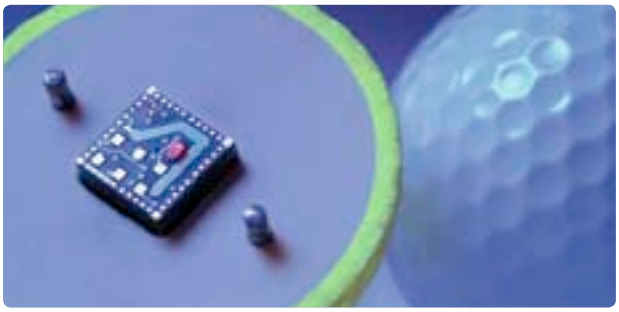
For the first time ever, Fraunhofer is able to offer the whole palette of tools for developing successful innovations to its partners in industry – from technology consultancy, to product development, through to use of laboratories.

Companies that have as yet never included microsystems in their products may benefit from the center, too, because this integrative approach to service provision is particularly suited to developing product ideas new to the area of microsystem technology. These are the services we offer:

- Consultancy and training courses on technical issues
- Realization of your product ideas
- Laboratory and manufacturing capacity



Technology consultancy



Support by realization of functional models and prototypes

›› Consultancy and training courses on technical issues |

The Application Center Smart System Integration is your first partner for all technical- and application-specific questions. We organize your courses and workshops, and provide advice on questions of quality and methodology.

To maximize your access to the right consultancy, we have built up a network of application-orientated research organizations, which augment our in-house technical capacities.

Realization of your product ideas |

By choosing Fraunhofer, you will have access to a personal Innovation-Scout, who guides you through the whole development process. Depending on the phase of your idea, we put you in touch with the appropriate Fraunhofer division, offer you advice on your product concept and organize special workshops with internal and external experts that exactly match the requirements of your company and product concept.

We then analyze the technical challenges of your developing product vision and collaborate with you in writing a roadmap. If you wish, this can also comprise developing prototypes (hardware, software, other technology). Even small cooperations succeed in finding out whether an idea really works, thanks to the special support these types of projects are provided.

Laboratory and manufacturing capacity |

You've chosen a specific technology and you know what your product should look like, but you don't feel like investing in new laboratories before you're sure that your idea really works? Or you'd like to minimize development risks and costs for laboratories and equipment? We can provide you access to laboratories, human resources and office space for your project.

Building prototypes |

You have chosen the right technology and the perfect design? All that's left is convincing your customers with a prototype? We can assemble your electrical circuits into small microsystems. Using our "Rapid Prototyping" system, which can produce small mechanical parts made of plastic, we can realize the complete product. You want more? No problem, we can also provide you with the option of small series manufacturing.

If you'd like to know more, please contact us.

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“The flexibility we encountered was amazing” – Field Report from Cooperating with Fraunhofer IZM

›› Up to now the packaging of sensor chips has been extremely complex. Thousands of these tiny chips need to be diced from large silicon wafers and then packaged individually. In a three-year-project, Schott Electronic Packaging and Fraunhofer IZM have therefore developed a more efficient way of producing optical sensors for camera cell phones.

The silicon wafer is covered with a protective layer of glass and is interconnected from the backside by means of through silicon vias (TSV) before cutting it into separate chips. The components are then less fragile, production is faster and the yield more reliable.

Harald Pötter, head of Marketing at Fraunhofer IZM, spoke with Dr. Thomas Gambke, Managing Director of Schott Electronic Packaging, about the cooperation project.

›› IZM: Herr Dr. Gambke, we’d like to start by talking about the early stages of the project on optical sensors for camera cell phones: What motivated the company Schott to initiate a collaboration with Fraunhofer IZM?

Gambke: We had already been working relatively closely with IZM. At that point, we at Schott were in the middle of an extremely critical phase. Wafer-level packaging was a completely new technology for us. To build an entire pilot line with this technology on top of that would have required significant investment, not just in devices and machines, but also in infrastructure. This would have resulted in significant cost and time factors, and would therefore have also been a risk.

I’d noticed your excellent equipment and infrastructure here during several previous visits, in particular the clean-room facilities. So I went to Prof. Reichl and asked if there was a way of letting our people also use your labs. He agreed immediately and so in a very short space of time we were able to make the idea a reality and start work here. That impressed me enormously. The flexibility we encountered was amazing.

IZM: It’s unusual to have sent Schott employees here and built up a collaborative research group. What have been your experiences of the collaborative process?

Gambke: Our collaborative relationship was and still is good. The new colleagues were people fresh from university or who had come from another research project, in other words, people who were used to working in a research institute. In this respect, the commonalities were numerous and assimilation problems few.

We worked particularly closely with Dr. Töpper, who, together with his group, is most intensively engaged with our project topic. We still have a lot of interesting discussions with him.

IZM: Were your expectations of the collaboration met from a technological point of view?

Gambke: The project was successful to the extent that we were able to catch up with the competition's technological head start very quickly. Today we can be described as being extremely competitive, even as leading technologically.

Thanks to the technological development from this project we were able to enter the mobile phone manufacturing industry and, in my opinion, that's a remarkable achievement. In the future we want to address longer-term issues, to develop these further together with the IZM and take them in other directions, for example, semiconductor lasers for HD-DVD. We'll then quite possibly be able to again launch a new, innovative consumer product on the market in a short space of time. That shows just how successful this research collaboration is.

IZM: Often research is pegged as being somewhat removed from the actual requirements of industrial manufacturing. What's your experience of this with IZM?

Gambke: What fascinated me the most was IZM's focus on applicability. Many of my entrepreneur colleagues said the Fraunhofer-Gesellschaft's developments were too expensive and too removed from actual applications. Of course, it is true that IZM doesn't develop finished product processes, which you can simply implement in a "painting-by-numbers" way. But there is a strong focus on applicability. And also the researchers understand very well how important high yield is and that this needs to already be planned for during the design and technology-development stages.

IZM: You mentioned the unbureaucratic and fast working methods, but also the comparatively high costs. How would you evaluate IZM's cost/performance ratio?

Gambke: We did sometimes have to catch our breath; the sums of money that we made available for the Fraunhofer-Institute weren't insignificant. But in the final instance, when you look at the costs soberly, there's two significant advantages. Firstly: The competency that IZM provides didn't come out of nowhere, and we haven't had to pay for that development. The scientist, engineer and technician hours do cost a lot, but we pay nothing at all for the total qualification that's inherent in the whole. And secondly - and this will sound a little brutal - when we no longer need the know-how, we won't have to pay anymore. In my opinion, both these aspects really put into perspective the total, possibly high, cost of the service.

IZM: What do you consider to be the greatest problems in the collaboration?

Gambke: In my eyes, the sore point is IP (intellectual property) issues. It took us a long time to find a solution for this with the colleagues from the Fraunhofer Headquarters in Munich. IP is the oil of the 21st Century. It's our strength. I do think that the company should hold the intellectual rights for the product. On the other hand, the Fraunhofer-Gesellschaft says: "Just because we've worked once with a company, it doesn't mean we can say we'll never work on this topic again." That's also understandable.

Unfortunately, this sees two legal departments go at it with each other and no solution found. For the operational leadership this kind of situation is a big challenge. Prof. Reichl and I saw eye-to-eye and wanted to work together. But getting this across to the two legal departments wasn't so easy.

IZM: Dr. Gambke, thank you for your time!

Research Activities and Objectives


System Integration

Chip Interconnection Technologies

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

Module Integration and Board Interconnection Technologies

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

Polytronic Systems

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

Micro-mechatronic Systems

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


Wafer Level Integration

Si Technology and Vertical System Integration

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

Multi Device Integration

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

High Density Interconnect & Wafer Level Packaging

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

Polymeric Materials and Composites

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

Micro Materials Center

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

Analysis & 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

Environmental Engineering

- Environmentally compatible product design
- Analysis and ecological assessment
- Lifetime estimation and reuse
- Ecological and economic analysis of technologies
- Sustainable development of ICT

System Design & Integration

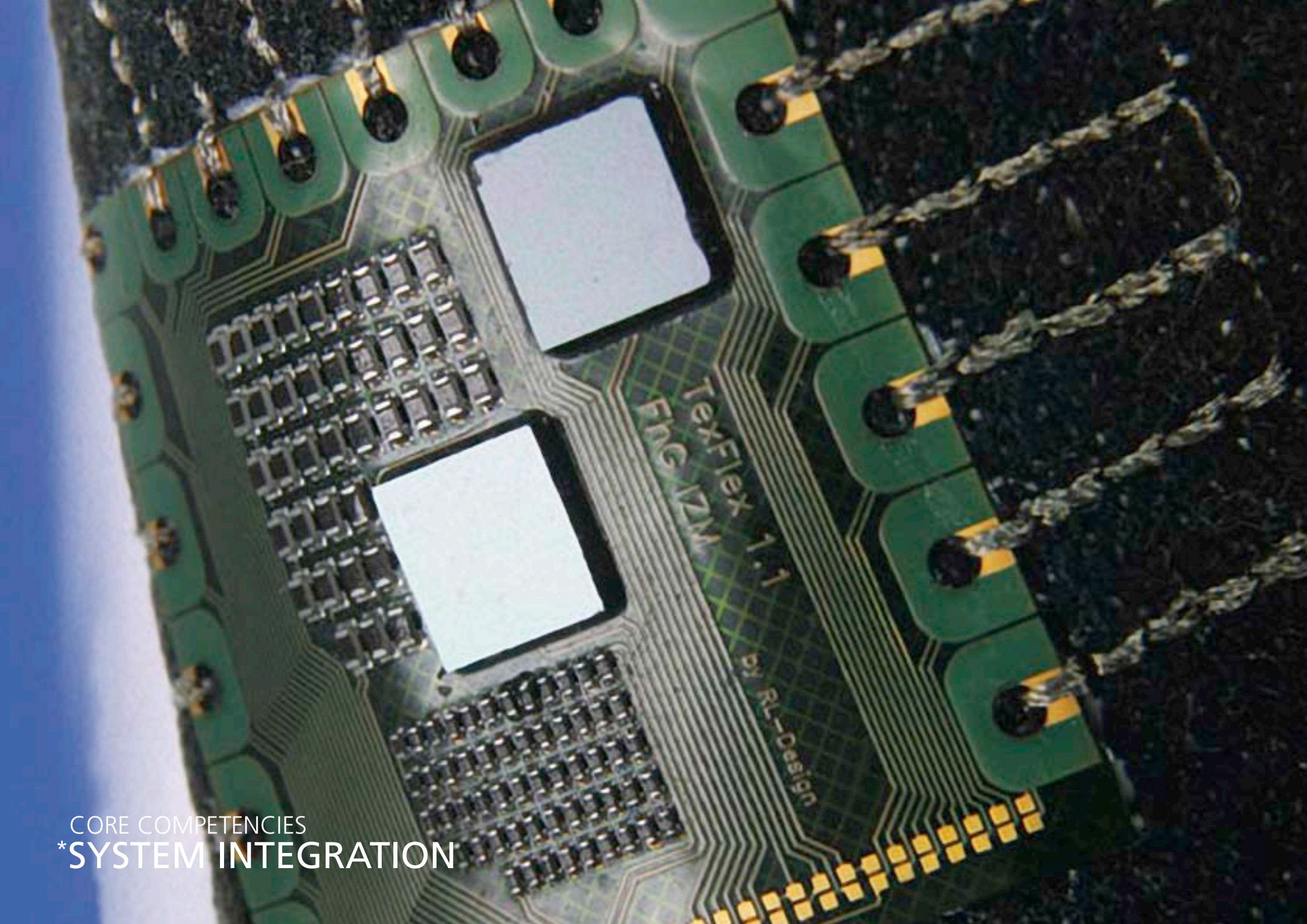
- Efficient design methodologies for advanced system packages (SiP, MCM…)
- Design & implementation of highly miniaturized advanced systems (advanced RFID, wireless sensor networks, energy harvesting systems…)
- Mechanical design of packages and micro-product design including 3D-visualization
- RF, signal/power integrity design & analysis of system packages and PCBs
- Power electronic packaging design, integration & characterization
- EMC of power electronic systems

Advanced System Engineering

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

Microfluidics Systems

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



CORE COMPETENCIES

*SYSTEM INTEGRATION


R. Aschenbrenner

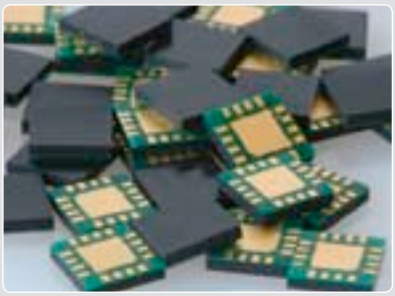

Prof. Dr. W. Scheel


Dr. K. Bock


Dr. F. Ansorge

» SYSTEM INTEGRATION

Chip Interconnection Technologies



Transfer molded QFNs after singulation, ready for testing

Embedding of thinned chips by vacuum lamination

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.

›› TRENDS

System in package |

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

Thin chip assembly and micro bonding |

- Ultra thin interconnects (< 5 µm) for thin chips (< 10µm) with solder and adhesives
- Low temperature joining (Carbon Nanotube interconnects and low melting solder)
- Low-cost bumping by stencil printing (60µm pitch)

Wearable electronics |

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

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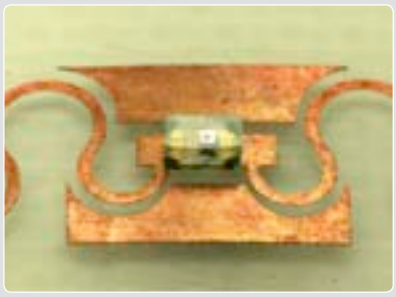
HIGHLIGHTS

- Planar embedding of RF components for RADAR
- Flexible sensor foils in multilayer-screen printing technology
- Highly accurate chip-to-chip assembly for capacitive contacts



LED mounted to a stretchable substrate equipped with meandering Cu-tracks. The Cu structures surrounding the LED stiffen the substrate locally

Detection of repetitive strain injury (RSI) with contact-less capacitive EMG sensors (Courtesy of TNO)

›› RESEARCH RESULTS

The recently developed innovation stretchable electronic systems will have manifold novel uses within electronics. 'Stretchables' have made 'wearable' health monitoring systems possible and can also be used as subsystems in textile electronics. Suitable for use in 3D surfaces thanks to their plasticity, they are massively beneficial, increasing both aesthetic and functional freedom in the design of electronic appliances. In the near future, stretchables will be fabricated on industrial scale in a process involving large-area fabrication by press lamination of copper sheets to produce stretchable, rubber-like substrate materials, onto which the conductive layer will be structured, components assembled and the package encapsulated. Initial results were achieved using 35µm copper on a 100µm polyurethane substrate.

COCHISE, an EC-funded project conducting basic research to achieve advanced cancer diagnosis and treatment, is developing a technology platform for an electronically controllable microwell array. The demonstrator will be able to simultaneously control and analyze the reaction between tumor cells and natural killer cells/antibodies to find the optimum type of cell/antibody for a given cancer type. The challenge here is adapting advanced printed circuit board technology to biocompatible materials by maintaining the precise constellation of <75µm holes, 20µm line spacing and <5µm alignment tolerance on a four-metal multilayer substrate simultaneously. Vacuum lamination, laser direct structuring and dedicated modification of the surface properties are being employed to obtain these goals.

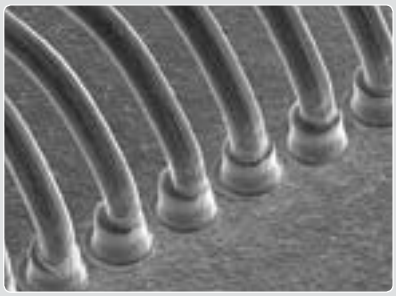
Within the project PowerSmart a rapid tooling process has been developed, using a 3D micro-machining system and aluminum alloy as tool material. This rapid tooling process was used to manufacture a system in package, developed as part of PowerSmart. The SiP integrates a flip chip and various SMD components. The package form factor was a quad, flat, non-leaded [QFN] package, therefore an area-molding process with subsequent singulation by sawing was employed.

ConText is an EU project aiming to develop contact-less capacitive EMG sensors and to integrate these in textiles. The partners are Philips, Clothing+, TU Berlin, TNO, TITV and KU Leuven. The technologies will be demonstrated in a jacket that can measure muscular activities through other layers of clothing. This unobtrusive biofeedback system can help to prevent high muscle tension, which reduces the risk of developing musculoskeletal disorders (MSD).

Apart from this new sensor, a number of different textile substrate technologies are being investigated, such as weaving conductive yarn, printing conductive ink onto fabric and laminating conductive and non conductive textile layers. We are focusing on embroidery with conductive yarn, as well as on interconnection technologies to interconnect the textile substrates with flexible electronic modules.

Module Integration & Board Interconnection Technologies

Series „Packaging in Electronics"



Au wire bond with 25 µm pitch

COMPETENCIES

- Research and development
- Technology service and transfer
- Rapid prototyping
- Qualification and reliability tests
- Failure analysis
- Technological consulting and training
- Studies and expert opinions
- Certification and training

›› SHORT PORTRAIT

The new department Module Integration & Board Interconnection Technologies combines the well-known departments Board Interconnection Technologies (BIT) and Photonic and Power System Assembly (P2SA), which merged in March 2006. Our specialists research material, process and equipment development as well as assembly technology for the packaging of microelectronic and micro-technical structures.

The department's performance spectrum comprises:

- Metallization & surface finishing
- Metallic nano-structured surfaces
- Solder materials and innovative soldering processes
- Die attach and gluing
- Fine-pitch flip chip, wire and ribbon bonding
- Assembly of optical sensors and detectors, HB-LEDs, laser modules, power modules, RF modules
- Development and simulation of optical systems and interfaces
- Electrical-optical PCBs
- Qualification/testing of microelectronic, micro-technical assemblies
- Training courses for wire bonding and PCB packaging (ESA, IPC)

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

›› TRENDS

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

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

We focus on the following:

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

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HIGHLIGHT

New low-temperature joining

The intercalation of gold nano-lawn structures at the surface of joining parts is used to produce electrical contacts by means of plastic deformation during pressure application at room temperature. Thermal treatment or loading results in contact improvement due to recrystallization.

Possibilities exist for new solderless joining techniques for HT applications.

UHB-LED-modules with and without converter

Cross section of joined Au-nanolawn @ 23°C; 100 mPa (bar: 1µm)

›› RESEARCH RESULTS

Microstructural investigations of US wedge/wedge bonding of AlSi1 wires on Cu/Ni/Flash-Au |

Microstructural processes of just a few micro- and nanometers inside the bonding wires and at the interface between wire and substrate metallization, proceeding at different phases during the wire bonding of very fine wires (< 25µm) and miniaturized pad geometries (< 50µm), are becoming more important for the formation a high-quality interconnection. By means of FIB (focused ion beam), TEM (transmission electron microscopy) and hardness measurements, it is possible to measure changes in the wire's microstructure and differences in interface formation, which depend on bonding parameters such as ultrasonic power and bonding time.

The as-received wire is characterized by the <111> and <100> fiber texture. Subsequently, the wire is cold-worked and hardened during pre-deformation by the bond tool. At the beginning of the activation phase, ultrasonic power comes to bear and changes the wire's grain structure. The fiber texture of the grains obtained at as-received and cold-worked wire recrystallizes. The level of the ultrasonic power determines the degree of softening in the wire necessary for further wedge deformation. This further deformation in turn initiates hardening processes in the bond contact. Thus, ultrasonic wire bonding is a dynamic process, in which the material alternately hardens and softens.

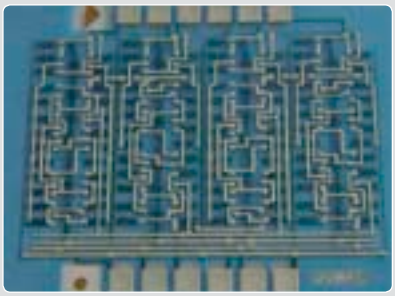
LED light sources |

UHB LEDs will play a key role in light sources in the near future and therefore a significant increase in profits is expected for all related industries. LCD-television with LED backlight, head lamps, UV-VIS- exposure units, as well as general lighting, are just the largest of the relevant application fields. Continuous development of LED chips requires that the assembly process can be adapted quickly and efficiently. As LEDs have high phonon emission, an optimally designed assembly process in terms of heat dissipation, combined with low-cost fabrication is essential. Additionally, the generation of high-quality white light by monochromatic LEDs is still a challenge. Our department delivers the following core services:

- Design und characterization of submounts and boards in terms of electrical, thermal, and optical properties
- Characterization of LED-chips
- Development of soldering processes for die- or FC-soldering with AuSn or AgSn
- Development of converter films for homogeneous wavelength conversion
- Short-loop wire bonding

We collaborate closely with other IZM-departments to optimize package design, using thermo-mechanical simulations and measurements, by the characterization of thermal interface materials and by developing transparent filling and underfill materials.

Polytronic Systems



Layout for a polymerelectronic parallel-in-serial-out register

µ-imprint of a sensor structure in PMMA

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 large-area electronics, ranging from low-cost electronic disposables to applications for the most complex communication electronics.

We work on a wide range of applications for ubiquitous systems, such as the combination of electronics with other components like sensors and batteries as well as microsystems, such as medical disposables, lab-on-chips and plastic MEMS in a system.

The development of sensors and analog and digital electronics based on organic semiconductors produced by reel-to-reel low-cost processes, enables integrating electronics on flexible plastic foils for large-area applications like sensor skins and distributed polymer-based microsystems. Advanced fabrication processes for thin silicon substrates in the full range from commercial down to flexible silicon of less than 10µm to 30µm integrated as a closed thinning, handling and separation process further support our hetero-integration system approach.

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

›› TRENDS

Ubiquitous systems in a human based ambient intelligence environment need cost-effective multi-functional distributed systems. Therefore electronics needs to be produced in large volumes, cost-efficiently on large area substrates and is applied to cover large areas with the electronic systems to build the ambient intelligence services needed.

Even today autarkic sensor networks in combination with RFID technology result in new applications in logistics, process and medical technology.

The technologies for large-area electronics are based on electronic multilayer systems into which functional layers, such as polymeric foils, organic electronics and sensors, are integrated by means of hetero integration. Thinned classical components like ultra-thin silicon chips, sensors or MEMS integrated in flexible substrates are also of interest for such applications.

The reel-to-reel application center's main foci are large-area electronics and bioanalytical systems.

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.

Fraunhofer 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

- µ-Imprint of sensor structures
- Ink-jet printed structures for functional layers
- Reel-to-reel capable laser-drilled via holes for multilayer-flexible circuits
- Immunodetector with reference channels

Self-assembled Si-Chips on copper pads

Hybridisation and electrochemical detection system

›› RESEARCH RESULTS

Novel structuring techniques for inline-capable production of integrated electronic circuits and microsystems have been developed within the BMBF-supported research project "HADPEPP". The project has focused in particular on selective additive coating and structuring processes (e.g. imprint and ink-jet printing). Such new production processes can replace existing techniques, such as conventional lithographic processes, to overcome technological and economic limitations in microstructuring on foils. The production of digital circuits in polymeric semiconductors is a crucial milestone towards polymer-electronic applications.

NAND-gates for use as basic components in more complex logic circuits have been produced and verified, designed for flip flop, counter and register circuits, respectively. Although the components still require technical optimization for reliable process integration, results indicate low-cost, polymer-integrated circuits in foils will be achieved.

A further step toward cost-efficient production of electronic systems has been taken in the BMBF-aided network project "Assemble". Here, techniques for self-assembly, including contacting of very small silicon components, have been developed.

First results show that alignment of silicon chips with several 100µm edge length on a foil is feasible. Applications for self-assembly processes include assembly lines for RFID chips, LEDs and discrete components.

The EU-funded project "Shift" is concentrating on multilayer-flexible circuits with integrated active and passive components.

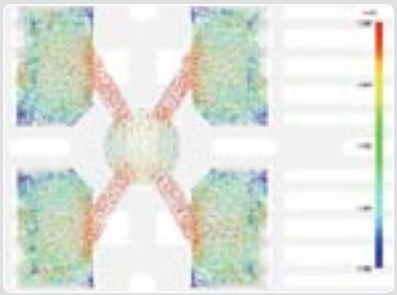
The aim is developing integral processes for reel-to-reel compatible manufacturing of a 2-layer system, such as a screen-printed dielectric intermediate layer with reel-to-reel compatible laser-drilled via holes.

In biosystem integration, a fully automated bench-top hybridization and detection system for molecular diagnostics has been developed.

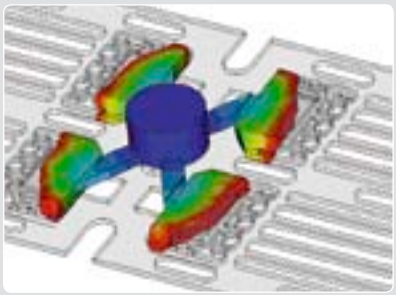
The system is designed for completely autonomous operation. All reagent and control elements have been integrated for both mobile employment and a lab setting.

An advanced version of the immunodetector has been produced. Additional measuring channels for control functions and measurements are now available.

Micro-Mechatronic Center



Simulation of Polymer Velocity during Transfer Molding



Simulation of polymer flow during transfer molding

COMPETENCIES

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

›› SHORT PORTRAIT

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

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

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

›› TRENDS

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

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

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

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

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

- Combining system simulation and process simulation
- Functional polymers for micro-mechatronic packages
- Rapid production technologies

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HIGHLIGHTS

Encapsulation process for high-reliability packaging systems

At the Micro-Mechatronic Center a housing module that protects complex electronic components from high g-forces has been developed.

- Mold design
- Use of special inlay methods in the mold cavity
- Evaluation of packaging processes
- Process simulation

6-channel datalogger for integration into crash test dummies (Source: Fa. Messring)

IZM-micro-projector: design study

›› RESEARCH RESULTS

Process simulation of electronic packaging |

The department develops advanced methods to optimize the polymer encapsulation of mechatronic and microelectronic systems.

Stresses during the entire encapsulation process are measured by use of fiber-optic Bragg-grating sensors and are employed to analyze the process using numerical simulations.

Process simulation makes answering key questions about tooling geometry and material choice possible.

To minimize stress on electronic components, we optimize typical failure sources during industrial encapsulation processes: forces acting on sensors due to polymer flow, stresses caused by polymerization and during ejection of the part.

Data logger for integration in crash-test dummies |

The objective of the project M=BUS, in cooperation with Messring GmbH, is integrating a 6-channel data-storage unit in a compact housing that allows a direct insertion of the module into the “bones” (aluminum tubes) of a crash test dummy. The unit would be used for online measurement at crash tests. The electronic components of the 6-channel data-storage unit are mounted, double-sided, on a rigid flexible printed circuit board that consists of two rigid elements which are connected by a flexible element and a flexible outlet element. The challenges for the MMZ were developing a suitable housing, selecting an applicable encapsulation material and method, and designing a mold tool. To protect the electronic components from the high g-forces (up to 1100g) at crash tests, the hotmelt encapsulation process was selected as a suitable encapsulation method.

The mold tool was designed in a way that makes it possible to insert the folded rigid flexible circuit board into the mold cavity. The seating in the mold cavity is done only by the connectors which are mounted on the rigid flexible circuit board. This allows a complete encapsulation of the electronic components. Only the flexible outlet element, for the contacting of the battery, and the connectors were routed outside of the housing. The first prototypes for functional tests were encapsulated in 2006.

CORE COMPETENCIES

*WAFER LEVEL INTEGRATION

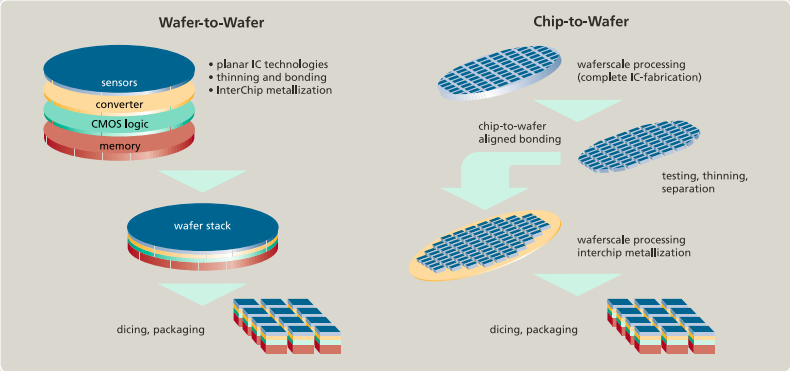

Dr. P. Ramm


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

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

R&D Technology Line
- 200mm CMOS process technology

SHORT PORTRAIT

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

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

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

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

TRENDS

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

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

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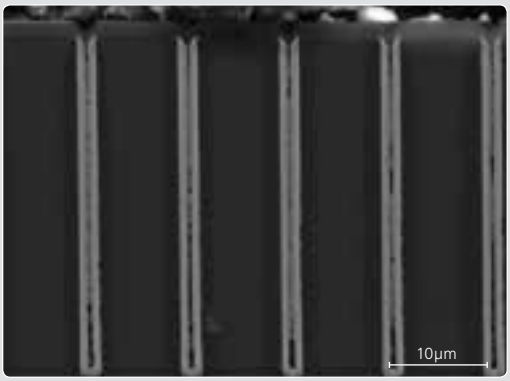
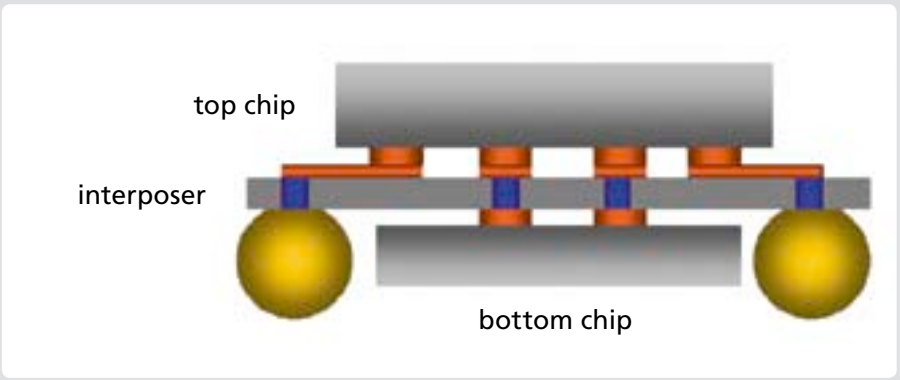


High aspect ratio TSV (50 µm depth, 3 x 10 µm² opening dimensions) covered with CVD tungsten



Interposer for communication between chips and I/O-ports

›› RESEARCH RESULTS

Vertical System Integration VSI® |

The department has been researching two types of multilevel silicon stacks, chip on top of and below an interposer (cf. figure on the right), to reduce the physical height of 3D-integrated systems and enable adaptation of different I/O-port pitches. Interposers are made of silicon to match the thermal expansion coefficient of chips. Electrical through silicon vias (TSV) are placed in the interposer. To increase mechanical stability the remaining thickness of the interposer should be as thick as possible. Maximum thickness is restricted by the maximum depth of TSV. The aspect ratio of the TSV is dependant on the limits of plasma etching and the filling of metal with chemical vapor deposition (CVD).

The figure on the left shows a high aspect ratio TSV, 50µm deep and with a 3 x 10µm² opening, covered with CVD tungsten. As can be seen, the CVD tungsten is very conformal, even at this depth, and therefore the possibilities for deeper TSV are very promising. Etching resulted in slightly undercut trenches, a typical outcome using the Bosch process. While CVD tolerates this feature, void-free closing of such trenches with CVD is not possible. Electrical measurements of daisy chains with 900 TSV elements, as well as single Kelvin elements, have shown a yield in TSV formation as high as 98%. The resistance of this 50µm-deep TSV is in the range of 380mΩ, scaling proportionally with the depth and inversely to the cross section.

Physical and electrical characterization |

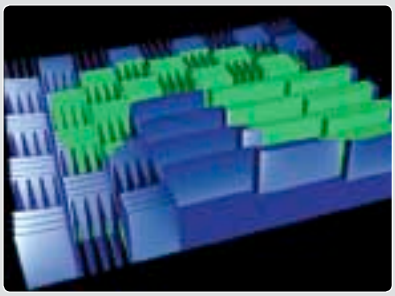
New system integration approaches are evaluated at the Fraunhofer IZM, Munich division by means of physical and electrical characterization.

As part of the European MNT project, the Ge-content, layer thickness and layer-structure of Poly-SiGe layers used at the IMEC institute for MEMS above CMOS have been analyzed in detail by using X-Ray-Reflection (XRR) .

The integration and electrical characterization of test structures built in VSI-stacked layers, Si/SiGe-layer systems or silicon layers with high specific resistance up to more than 1 kΩcm, which have been grown using the Fraunhofer IZM Munich Division's Epsilon 2000 reactor, is used for evaluating the quality of the deposited layers.

Transistor characteristics, ring-oscillator frequencies and leakage currents of PIN-diodes compared to standard silicon are used to quantify the enhancement or possible degradation of performance due to new system integration technologies. Integrated capacitor structures are used to determine concentration density and charge carrier life cycle.

Multi Device Integration



CMP simulation: pressure distribution at the beginning of the polishing process

Bonded and diced MOEMS device (in cooperation with Ricoh Ltd. Japan)

COMPETENCIES

We offer the following services:

- Mask design and fabrication
- Wafer lithography
- High-temperature processes
- Layer deposition with PVD and CVD
- Wet and dry etching
- Wafer, chip and wire bonding
- Chemical mechanical polishing (CMP)

We also provide

- Consulting, feasibility studies, research cooperation, contract research

›› SHORT PORTRAIT

During 2006 the department MDI of the Chemnitz branch was able to significantly intensify its research work.

Within the department, the work of the 'MDI systems and component design' group focuses on MEMS design and development, system integration and the prototyping of sensor and actuator devices, including electronics and software development.

Research by the group 'Technologies/Wafer Bonding' concentrates on developing and applying wafer-bonding processes for MEMS packaging on wafer-level and in 3D-patterning technologies for silicon and non-silicon materials.

The 'Back-end of Line (BEOL)' group focuses on developing materials, processes and technologies for fabricating on-chip-interconnects. In addition, the simulation and modeling of processes and equipment are special topics of interest within this group.

The group 'Reliability of Micro- and Nano-Systems' investigates the mechanical and thermal properties of electronic components, integrated systems, and MEMS, as well as packaging for reliability and lifetime evaluation.

The group, 'Printed Electronics' develops mass printing processes for electronics. Advanced micro-structuring methods for liquid materials are adapted so that, in the future, "plastic electronics" can be realized.

›› TRENDS

In the near future, microsystems will be more multifunctional. One example is the integrated combination and packaging of electronics for signal and information processing, with sensors and actuators in silicon and non-silicon technologies.

So-called multi-device integration, which produces smaller and smarter systems, is a holistic system approach, whereby sensors acquire information from the surrounding environment. Such integrated electronics can then process and transfer these data as required. These systems are already playing an active role in their various fields of operation.

To meet strategic challenges for multi-functionality, multi-materials and advanced technologies, the research of the department Multi Device Integration in Chemnitz is focusing on technologies and methods for smart systems integration that will become more important in the near future.

As part of this, the Chemnitz branch of the institute is being extended by a new building. Planning will be completed and the foundation stone laid in 2007.

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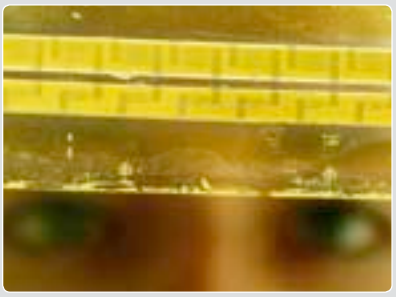
HIGHLIGHT

A package for a micro-machined silicon micro-mirror for consumer electronics applications has been developed.

The device features optical and electrical interfaces and is fabricated completely at wafer level. It comprises a stack of different silicon and glass layers bonded together and is able to maintain an internal vacuum. First quality tests have shown the compound has good bonding strength.

Schematical view of a MOEMS spectrometer for analysis in the near infrared range (NIR)



Printed ring oscillator circuit

›› RESEARCH RESULTS

MOEMS spectrometers |

Food control, medical diagnostics and gas analysis are just some of the application fields in which miniaturized and cost-efficient spectrometers for near and middle infrared (NIR/MIR) spectroscopy are becoming more important.

The project MOPAL has developed such spectrometers based on MOEMS for different spectral ranges. Thanks to further optimization of the micro-mirror and functional housing, the whole system has been made more mechanically stable and robust. Thus, the portable spectrometer is ideally suited to operate in harsh and vibrating environments, e.g. in industrial process control.

Process simulation and BEoL – process technology |

The CMP process for shallow trench isolation (STI) was investigated within the 3-year R&D project SKALAR. A new CMP model that enables consistent simulations on different scales – wafer, chip and feature scale – was developed. The results of such simulations provide predictions of the planarization behavior of patterns on each of these scales according to the exact starting topography, pad characteristics, and process conditions.

Evaluations of CMP consumables (slurry, pads) were carried out for different suppliers.

In the nanoelectronics field, the department is investigating processes for Cu/low-k interconnect systems for AMD Dresden's 45 and 32nm microprocessor technology. The goal is introducing porous ultra-low-k dielectrics and reducing feature sizes to below 100nm.

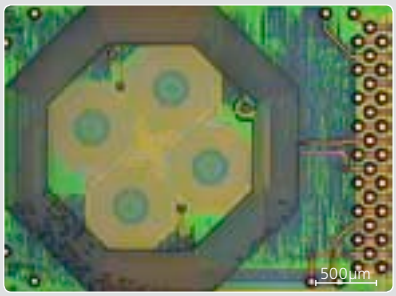
Circuit simulation for printed electronics |

Over the last year, novel approaches have been studied and developed that will lead to new circuit concepts for printed electronics devices and technologies. Printed electronics – although offering a number of advantages in comparison with conventional Si-electronics, such as low-cost mass-production, large area and flexible circuits – has several drawbacks, which make developing special approaches for circuitry necessary for effective applications.

The project emphasizes the advantages of printed electronics and finds work-arounds for the restrictions to ensure printed electronics finds broad application, by conducting research on modeling and simulation of printed devices and circuits.

High Density Interconnect & Wafer Level Packaging

Encapsulated wafer-level battery on silicon oxide substrate



Multilayer coil (Cu/BCB) on ASIC

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 micro-electronic 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 100mm to 200mm. In cooperation with some equipment manufacturers, 300mm 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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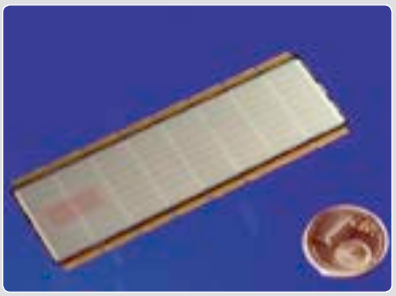
HIGHLIGHT

ATLAS pixel detector module production

In 2006 the production of ATLAS Pixel detector modules could be finished successfully. About 1,100 silicon modules for the ATLAS particle detector system have been assembled at Fraunhofer IZM with a total module yield of 98%. The ATLAS experiment will start at the Large Hadron Collider (LHC) CERN in Geneva in 2007.

To achieve a high resolution of the particle tracks every sensor tile consists of an array of 46,080 diode pixels with a pixel size of 50 x 400 µm². 16 thinned electronic readout chips are assembled in flip chip technology on one sensor tile by 30µm electroplated lead tin solder bumps. Subsequent to the flip chip assembly these modules were completed for detector assembly at the laboratories of the ATLAS Pixel Collaboration.

The outer barrel layer of the ATLAS Pixel detector (by courtesy of ATLAS Pixel Collaboration); the completed modules are mounted on staves which are assembled to the pixel detector tube



ATLAS silicon pixel detector module; 16 radiation hard readout chips are flip chip bonded by 46,080 lead-tin solder bumps to one sensor substrate

›› RESEARCH RESULTS

Wafer-level battery |

A new lithium polymer material system for secondary batteries has been investigated with regard to the compatibility to the wafer-level battery concept. The formerly used type of electrodes consists of a mixture of polyvinylidenefluoride-co-hexafluoropropylene (PVDF-HFP), acetone, active components (Li_(1-x) CoO_2, Li_xC_6) and plasticizer, e.g. di(n-butyl) phthalate (DBP). Once the acetone is evaporated, plasticized films of anode, cathode and separator are bonded together with aluminum and copper current collectors by lamination. The DBP plasticizer is then extracted from an assembled battery with an appropriate solvent.

The new type of battery components, which was investigated now, has no plasticizer within the active material mixture. Thus, no plasticizer needs to be extracted after laminating the battery. The adhesive strength of laminate made of this material is lower. To increase the adhesiveness within the interface between the active electrodes and the porous separator, a thin fragmentary PVdF-HFP layer was added to the active material before assembling the battery by lamination. Good electrical results were observed with this material system. So, a new material system could be presented for wafer-level batteries. Arbitrary footprint of the battery laminates allows the best utilization of the available space in small electronic systems.

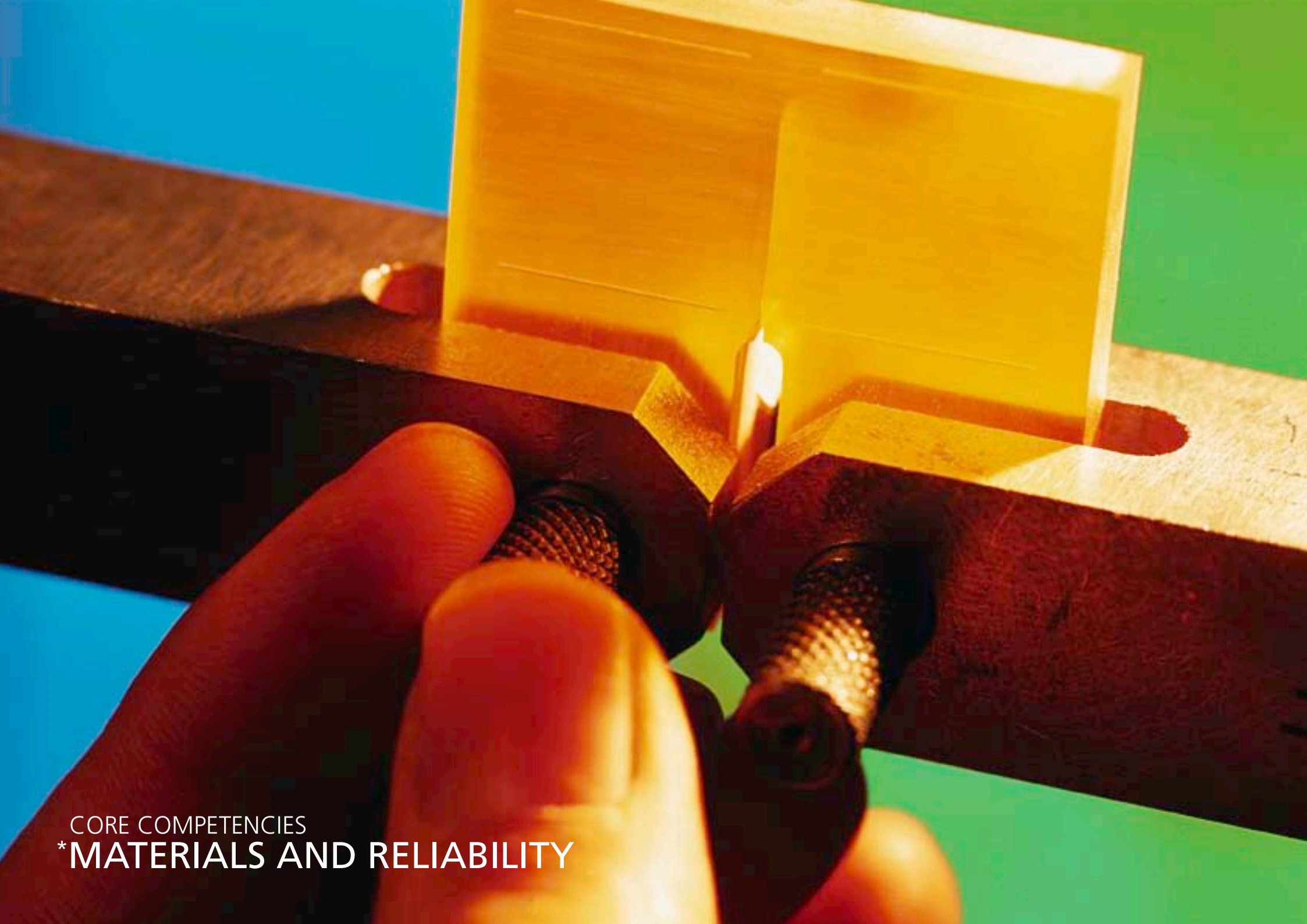
Ultra-fine pitch micro coils for position sensors |

Inductive sensors or on-chip inductors can be used for position sensors, proximity sensors, non-destructive testing, layer thickness measurement, on-chip passive components for RF circuits, DC-DC converters and miniature transformers.

The operating principle of the microcoil position sensors which was developed by the company Posic and manufactured at Fraunhofer IZM is based on an oscillator generating a carrier signal at a frequency around 500 kHz. This signal is a current that is sent through the excitation coil and thus generates an AC magnetic field.

In order to maximize the magnetic field at a given supply voltage (5V), the resistance must be minimized, which explains the use of copper as the material of choice for the excitation coil.

The technology for these microcoils is based on a high-density thin film BCB/Copper process.
A process for 3.5µm lines and space in 15µm thick photo-resist has been developed on 200 wafers.



CORE COMPETENCIES

*MATERIALS AND RELIABILITY


Prof. Dr. M. Bauer


Prof. Dr. B. Michel


Dr. H. A. Gieser

» MATERIALS AND RELIABILITY

Polymeric Materials and Composites

Thermooptic switch (polymer). Visible is the switching

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

COMPETENCIES

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

›› SHORT PORTRAIT

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

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

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

The Fraunhofer 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.

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

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

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

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

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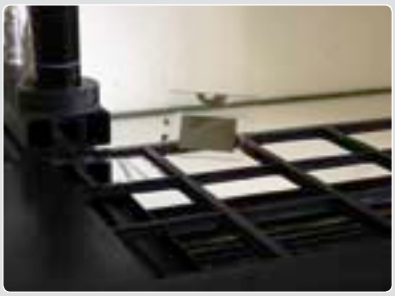
HIGHLIGHT

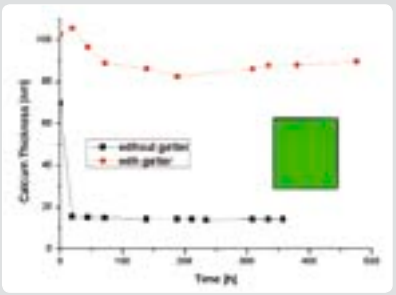
An initiative of the Fraunhofer-Gesellschaft together with the University of Braunschweig and industry (Applied Films, Optrex Europe GmbH) was devoted to the development of new OLED technologies. Our department developed encapsulation technologies for OLEDs. The cooperation focused on:

- Set-up of sensitive testing equipment of display encapsulation
- Quantitative characterization of barrier properties of a broad selection of adhesives and barrier substrates
- Proof of reliability of encapsulation at elevated temperatures and humidity as well as in temperature cycling experiments

This work was supported by the Ministry of Education and Science (No. 01BK919) and was performed in cooperation with Fraunhofer IPMS, Fraunhofer IAP and Optrex Europe GmbH.



Measurement of the optical transmission of the Calcium test cells using a Laser at a wavelength λ = 633nm and a photodiode as detector. The frame can hold up to 15 samples which are measured in parallel under the same climatic conditions



Reliability test at 60 °C, 90% humidity of encapsulated Calcium mirror with and without the integration of a getter material. The inset shows an encapsulated OLED pixel with getter after 1.000 h of storage with no visible degradation (sample provided by Fraunhofer IPMS)

›› RESEARCH RESULTS

Encapsulation of OLEDs |

The development of novel display technologies based on organic light emitting materials (OLEDs) is accompanied by the development of reliable encapsulation technologies due to the sensitivity of the active materials towards the diffusion of water and oxygen into the display cell. We conducted a broad screening of commercial and home made adhesives with respect to their barrier properties and their long time stability at high temperatures and humidity.

The characterization of barrier properties of adhesives was performed using a quantitative Calcium test in a homebuilt device. In the configuration of an OLED device the degradation of Calcium is followed by measuring the optical transmission of an initially opaque thin Calcium layer which is degrading to a transparent film of Calcium oxide or hydroxide. The time dependence of this process results in the permeation rate of the material used for the encapsulation of the display cell. The table summarizes upper limiting values of permeation rates for different display sizes which are required for a reliable encapsulation of OLEDs. These values are obtained under the assumption of a lifetime of 10,000 h and a degree of degradation of 20% of one of the active materials through the diffusion of either water vapour or oxygen.

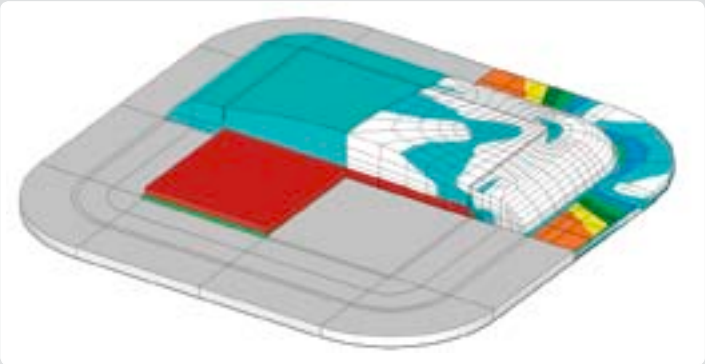
Furthermore, the seal line is assumed to be 1mm wide and 5µm high. Change in the seal line dimension, the display dimension and further protection steps like the inclusion of getter materials

Display size (active area)		WVTR [g/m²d]
Edge encapsulation	21 mm x 30 mm	0.052
	28.8 mm x 73.8 mm	0.19
	5“ diagonal	0.24
	10“ diagonal	0.49
Full encapsulation	independent of size transmission rate for the given surface	$5.5*10^{-5}$

(e.g. CaO, Zeolithes) or the application of barrier layers (SiOx, SiN etc.) increase these upper limit values and thus lead to a better long-term stability of the OLED device.

The reliability of the encapsulation as compared to the OLED has been tested at high temperatures and high humidity as well as in temperature cycling experiments. Thus the long-term stability of encapsulated Calcium mirrors has been compared to the stability of OLEDs prepared by the partners at the Fraunhofer IPMS and Fraunhofer IAP in the same manner. Reliable encapsulation could be achieved with few commercial adhesives and the implementation of getter materials to protect the active layers from the degradation after diffusion of water vapour. In a test at 60 °C, 90% rel. humidity, Calcium without the integration of getter materials already degrades after a few days, whereas after 500 h the integration of a getter leads only to a degradation of about 10%.

Micro Materials Center



Thermo-mechanical simulation of microelectronic components

COMPETENCIES

- Microdeformation analysis
- Nanodeformation analysis
- Reliability and lifetime simulation
- Determination of material data
- Packaging simulation
- Internal stresses
- Fracture and crack diagnostics

›› SHORT PORTRAIT

The department Micro Materials Center operates Labs at the main Center of Fraunhofer IZM in Berlin. It also has a research group in the field of nano electronics at the Science Center in Berlin-Adlershof, and a working group "Reliability for Micro-and Nanosystems" in Chemnitz.

The main focus of our research is on:

- Mechanical and thermal reliability of components and systems in microelectronics
- Lifetime optimization of automotive electronics and sensors
- Deformation experiments by advanced measuring techniques from macro to nano directly coupled with simulation
- Applications in the field of security (microsecurity) for aero- and space research, automotive electronics and microelectronics
- Reliability estimation for nanoelectronics and microelectronic systems

›› TRENDS

- Reliability evaluation of complex systems with several micro- and nano components
- Lifetime optimization for products (design for reliability)
- Complex influences of mechanical, thermal, electrical, magnetic, vibrational, diffusive effects on reliability
- Long term reliability estimations
- Coupling effects between creep, fatigue, crack delamination, vibration, temperature effects, diffusion etc.

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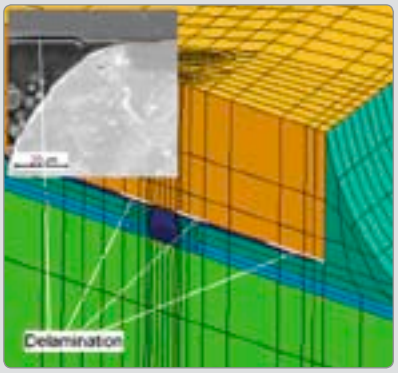
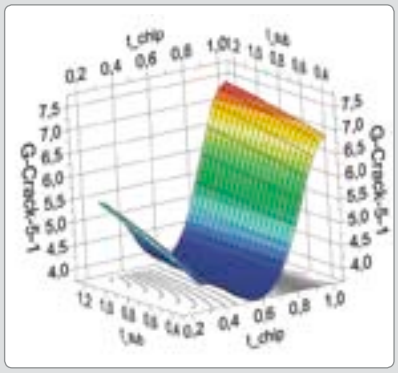
HIGHLIGHTS

- Industrial projects for reliability estimations
- Reliability of nano electronics
- Best paper award at International Conference on Electronics Packaging Technology , Shanghai
- New testing methods by means of pulse thermography
- Thermo-mechanical optimization of electronic packages



Delamination of chip/underfiller and underfiller/solder interfaces



Dependence of the energy release rate of a delamination in the chip-edge/underfiller interface on the thickness of chip and substrate

›› RESEARCH RESULTS

Incorporating bulk fracture, bimaterial interface fracture and fatigue evaluation into DOE concepts |

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

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

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

So it has to be a vital purpose of design-of-experiments-studies (DOE) to take into account failure modes that are essential to the overall thermo-mechanical reliability, a flip-chip assembly for example. For that reason several failure modes have been assumed to have an effect. Simulations performed here are to show exemplarily the possibility of utilizing different failure hypotheses in parallel (fracture mechanics approach for chip cracking or the volume weighted dissipated inelastic strain energy as a measure for solder fatigue for instance):

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

Parameterized, highly nonlinear, transient FE-simulations which consist of fracture, delamination or fatigue monitoring elements will then be handled by DOE-software in order to extract mathematical models which describe the response surfaces of all results data with regard to the variation of all input variables with a limited number of finite element runs.

This work was awarded the Philips Best Paper Award, 2006 at the 7th International Conference on Electronics Packaging Technology

Analysis and Test of Integrated Systems - ATIS

ATIS transient latch-up (TLU) module for sensitivity analysis at package and wafer Level

Damage of surface acoustic wave filter after pulsed stress

COMPETENCIES

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

›› SHORT PORTRAIT

Testing, analysis, and reliability of integrated circuits and systems are an increasing challenge for the development and manufacture of advanced electronic systems. Since 1990 ATIS has been a reliable, efficient partner for the analysis of weak spots, as well as the development and implementation of advanced solutions in a very sensitive and competitive international environment. Long-term relationships with our partners build on our sound technical and scientific experience.

ATIS investigates and improves the built-in robustness of integrated circuits used in various technologies by means of pulsed-stress methods emulating electrostatic discharges (ESD), transient latch-up, and overvoltage. Developing application-specific ESD-protection is also part of our work. Further, we support the development of semiconductor processes on substrates up to 300mm by means of our electrical and electro-optic metrology in wide ranges of temperatures (55° to 300°C) and frequencies up to 110 GHz. Probe card solutions and test concepts benefit from our experience. Weak spots and failures identified 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 bond, test, and screen bare dies on the wafer and monitor their function.

›› TRENDS

Increased functionality and system complexity in smaller forms, together with reliability requirements for harsh environments, call for new, more efficient qualification approaches. For the prognosis and avoidance of a failure, these must build on a fundamental understanding of application, design, technology, and their mutual interaction, including the physics of failure. Elaborate strategies and appropriate tools are required to test individual components of such high-requirement systems, as well as the complete system module. This includes self-testing and monitoring, even for sensors, MEMS and other actuators. In terms of ESD, the small sizes used in such systems mean sensitive, high-performance interfaces (e.g. USB2.0) in the integrated circuit are even more exposed to the uncontrolled environment. Larger SiPs will face an increasing threat from charged device model (CDM) discharges. Both trends mean new protection and qualification strategies are necessary.

Novel flexible and cost-effective probe-card solutions will be required to test RF and mixed signal components on wafer-level. They will switch from pure electrical interfacing of the test system to the DUT (device under test) to an intelligent probe card co-designed with the system to be tested and built directly into most advanced manufacturing and assembly technologies. Rapid proto-typed load boards will shorten the time required for evaluation and circuit debugging, and reduce costs.

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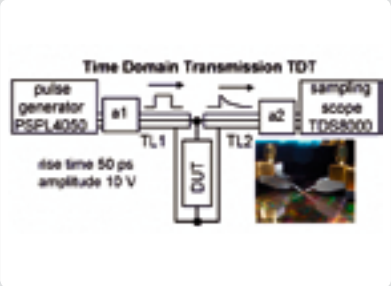
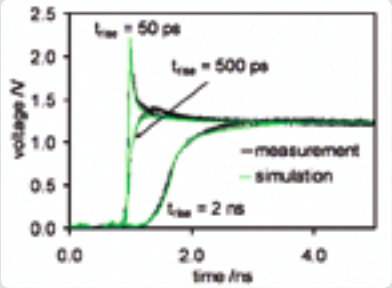
HIGHLIGHTS

- ps-resolved turn-on characterization of ESD-protection elements
- 1 ns – very-fast transmission line pulser (vf-TLP)
- Capacitive-coupled transmission line pulsing on wafer level (cc-TLP)
- Charged device model (CDM)
- System-level ESD



TDT-Setup for the turn-on characterization of ESD-protection elements in the CDM-domain



Voltage overshoot of protection diode caused by forward recovery effect

RESEARCH RESULTS

ATIS is respected internationally for its work in developing and applying most advanced techniques for the pulsed characterization and stress of integrated circuits and systems.

In the past we have successfully hardened integrated circuits against the so-called human body model discharges with moderate rise times and peak currents by means of 100 ns-wide TLP pulses. Less frequent and ESD-controlled human handling has minimized this risk. Charged device model (CDM), typical for automated handling in test and assembly lines, with discharge currents rising within a fraction of 1ns to more than 10A, have become the major concern. Developing protection elements and concepts against this threat requires characterization techniques with a ps time resolution. For this purpose ATIS has introduced the time domain transmission technique with repetitive medium level current pulses of up to 40mA. The accuracy and performance exceeds that of the time domain reflectometry (TDR) used previously. Despite the low currents in comparison with real ESD events it is successfully used to find the protection element with the fastest turn-on and best voltage-clamping characteristic on a test chip. A further application is the calibration of device simulators.

Optimizing the relay and narrowing the pulse width of the existing ATIS very-fast TLP system (vf-TLP) to 1.2ns allows an almost adiabatic characterization of active and passive devices at up to much higher current levels. The very narrow pulses of the vf-TLP are a prerequisite for studying the response of circuit interfaces to the system-level human body model described in the IEC standard.

Further progress has been made in generating CDM-like failure signatures in integrated circuits on the wafer, employing the ATIS capacitive-coupled TLP (cc-TLP) method.

New modules were developed for the characterization of the transient latch-up susceptibility of integrated circuits up to 50V and test structures on the wafer and in the package. They assist in reproducing latch-up failures triggered by a transient in operating circuits.

Beyond silicon, the pulsed stress and characterization techniques were successfully applied to non-semiconductor devices and passives that are sensitive to overvoltage and ESD and do not have a protection diode for shunting the current.

CORE COMPETENCIES

*SYSTEM DESIGN & SUSTAINABLE DEVELOPMENT


H. Griese


Dr. S. Guttowski


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

To achieve more sustainable development, it is necessary to assess the positive and negative impacts of technology trends. Within this context we are working on quantitative and qualitative assessment methodologies, which address economical and ecological issues. We apply these together with partners from industry for continuous improvement of products. Our research focuses, in particular, on supporting the development of SMEs.

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

We work in several different areas in the design of energy-using products (EuP), on behalf of the European Commission.

International collaboration and industry support is central to 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 producer responsibility and closed material loops are concepts that have entered the management of many enterprises in the electronics sector. This trend is driven by legislation, and to an increasing extent by market changes, that is, higher demand for environmentally benign technologies and products.

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

Reliability of electronics is an important aspect of our work, even from an environmental point of view. However, we realize the need to understand and influence the reliability of electronics on a larger system level. 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 provides that wide range of expertise and is a neutral and trusted partner of industry.

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

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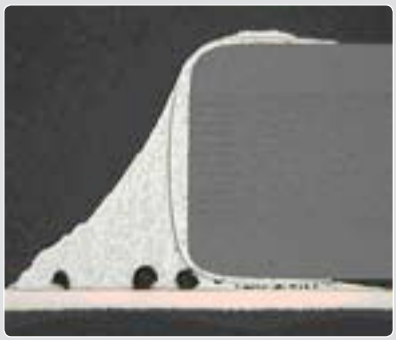
HIGHLIGHTS

- Start of the project "Sustainability by Application of Used Automotive Electronic Components – ReECar"
- Preparatory studies for the EuP on behalf of the EU Commission
- Projects concerning renewable resources for electronics application
- Symposium "Perspectives on Electronics and Sustainable Development"
- Workshop "The Chinese RoHS and its importance for the German Electronics Industry"



Potential weak point: soldered connection

›› RESEARCH RESULTS

Environmental Engineering on behalf of the EC |

The department Environmental Engineering is project leader of the EuP preparatory studies Lot 4 "Imaging equipment", Lot 5 "Television", Lot 6 "Standby and off-mode losses", and is partner in Lot 7 "Charger and external power supply". The EuP is the new EU Framework Directive for setting Eco-design requirements for energy-using products. In the preparatory studies Fraunhofer IZM, in close collaboration with industry, is assessing the environmental impact and eco-improvement potential of representative products. The EuP preparatory study will provide the necessary information to the European Commission (EC) and all stakeholders, and prepare them for the next phase of the legislative process – the consultation forum.

We have also been contracted by the European Commission to assess RoHS exemptions from a technological viewpoint.

Sustainability in spare parts supply |

The project ReECar – sustainability by using pre-used assemblies in automotive electronics aims at the development of sustainable strategies for supplying spare parts in the automotive industry. Reuse is a promising option for promoting sustainability, but questions of reliability and ageing of electronics still have to be answered. To enable the overall assessment of the sustainability of spare part strategies, environmental, economic and social criteria were defined. As part of this, we developed an application-specific catalogue focusing on social criteria.

By social criteria, we mean, for example, risk potentials in production, working conditions, the employment rate and education. In the case of social criteria, there is little reference to product characteristics and processes. Furthermore, possibilities for optimization are not clearly defined. The IZM/EE-Toolbox developed by Fraunhofer IZM enables the environmental assessment of spare part strategies. In parallel, a methodology for assessing the sustainability of spare part supply strategies is presently in development. This methodology will encompass all technical, environmental, economic and social criteria and will lead to a decision-support system.

Preparation of the electronics industry for legal requirements |

Several activities were held to assist in preparing the electronics industry for compliance with RoHS, which bans specified materials in electronic products intended for the European or Chinese market.

At an event in Guangzhou, in cooperation with the University of Tokyo and EcoPac – the International EcoDesign and Microelectronic Packaging Research Institute in Wuxi – the EU requirements were introduced for the Chinese electronics industry. A particular focus was on the effects of the lead ban on interconnection technologies.

Proposals for a harmonization of region-specific regulations were discussed at the Fraunhofer IZM workshop "The Chinese RoHS and its importance for the German electronics industry".

System Design & Integration

EMC test setup in the absorber chamber

4-port measuring equipment for RF characterization of coupled structures

COMPETENCIES

- Technology-oriented feasibility studies
- Technology development and evaluation
- Technology-oriented RF-characterization
- Antenna development and characterization
- 3D-construction of hybrid microsystems
- 3D-package design and characterization
- Design of multichip modules
- Prototype design and implementation
- Cost estimates of system solutions

›› SHORT PORTRAIT

The department System Design & Integration develops methods and tools used for customized and technology-oriented design of electronic systems. Theoretical methods form the basis for simulations of all kinds of electromagnetic as well as thermal and mechanical behavior and coupling. Using such a characterization approach makes it possible to analyze, evaluate and compare different technologies right in the design phase. This leads to an optimized design flow, considering the particular specifications of the systems to be designed.

Hence, even in the early development stage, function, volume, reliability and costs can be analyzed according to technological parameters.

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

›› TRENDS

The field of technology-oriented design methodologies will face the challenges of vertical integration of heterogeneous systems into 2.5D-SiPs.

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

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

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

In the near future, the application of new technologies to increase power density and reliability and the integration of suitable switches with sensor and logic components will be the main focus of research activities in the realm of power electronic systems.

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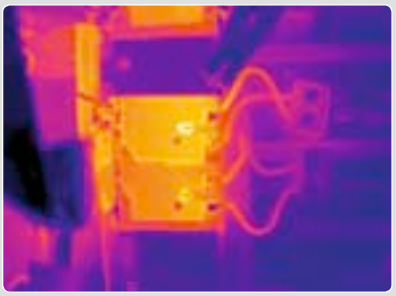
HIGHLIGHTS

- Demonstrators for advanced RFID-solutions
- New packaging solutions for power electronic systems
- Characterization of antennas for mobile applications
- Design methods for highly integrated EMC-filters
- M3-approach for optimal and cost-effective design of system packages & PCBs
- Novel method for defining the electrical boundaries of all geometrical discontinuities

Worldwide smallest Sensor-Node with ad-hoc network capability (Mica-Z-Chipset)



Temperature measurement of a power MOSFET flip-chip-on-flex assembly

›› RESEARCH RESULTS

The department System Design & Integration was established in 2006 in response to a growing need for application-oriented competency in system design and integration within Fraunhofer IZM.

As part of the R&D pre-project „AVM", the foundations were laid for integrating self-sustaining micro sensor systems into applications. An early example of application has been the autonomous networking of logistics-eGrains (volume 1cm³) for documenting temperature profiles during transport, including monitoring of the truck's total freight.

A second application of the AVM's concept has been the extension of the system by an acceleration sensor inside a golf ball.

Research has also focused on developing highly miniaturized, wireless sensor nodes. The volume of the Mica-Z node, based on ZigBee, which was realized by the University of Berkeley, has been reduced by a factor of 20.

In summary, the department has a design and technology pool at its disposal that enables it to create demonstrators and prototypes for various types of applications within the research field of distributed sensor networks.

As part of the R&D project PARIFLEX, the department designed and fabricated demonstrators for a new generation of smart RFID labels, enlarged by a bistable display showing changing information on a passive label.

To facilitate the optimized and cost-effective design of packages and PCBs for RF and high-speed applications, the department has developed the "M3" approach. First of all, innovative methods to determine accurate electrical models were developed. These models were then used to perform numerous RF, signal and power-integrity analyses. Using these results, optimal design processes that improve performance and minimize cost were developed.

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

Using this process, a new flip chip-on-flex technology for power semiconductors was developed, as part of a project involving several IZM departments. The design and both the electrical and thermal characterization of various technologies were carried out by SDI.

Due to the constricted placement of passive components, avoiding mutual coupling has become a major priority. Meeting this challenge, the department developed a design method that combines circuitry, EMC and constructive design, and which has now been successfully applied in industry, in fields as diverse as miniaturized filters based on LTCC technology, filters in SMDs on PCBs and filters in power plants processing 19 MVA.

Advanced System Engineering

Measurement for modeling of bulk current injection method

COMPETENCIES

- RFID antennas and circuits
- EMC/EMR on chip level
- EMC/EMR of microelectronic systems
- Design for multi device integration
- Knowledge management in microelectronics

›› SHORT PORTRAIT

The department Advanced System Engineering ASE is located in Paderborn and deals with technology-oriented questions of design, of the electrical simulation and the characterization of microelectronic circuits.

The particular focus of the ASE department lies on the research in the area of parasitic electromagnetic effects (electromagnetic compatibility, electromagnetic reliability, signal integrity, radio frequency) not only on the IC-level, but also with view to the coupled on-chip and off-chip aspects.

Using RF models for single IC parts in combination with an extended model of the measuring system direct power inspection (DPI) it is possible to model the EMI behavior of mixed signal ICs more accurately. The steady-state methods harmonic balance and the shooting method are used for an accelerated simulation of these circuits in combination with the DPI model. Based on the simulation results it is possible to use black box models based on neural networks to describe model behavior of individual parts of the circuits. These models can then be used for a simulation of the whole system to determine the EMI behavior.

The verification against ESD pulses is necessary in order to evaluate the efficiency of the ESD protection concepts of integrated mixed signal circuits in a very early phase of development.

In principle a manual and long time analysis of simulation results leads to increasing development times and costs. For that reason it is necessary to increase the automation level in the analysis of propagation paths of the pulses.

The main focus of the work is on the efficient modeling of the behavior of the ICs in the ESD case and the net list reduction. The conversion in commercial frameworks of the IC design includes the automatic generation of the simulation models, the integration of the tools developed in the graphic interface and efficient access to the available database.

An extensive offer of services facilitates the fast transfer of the latest research results to industry. Supporting industry in the broad application of future packaging technologies is one of ASE's main objectives.

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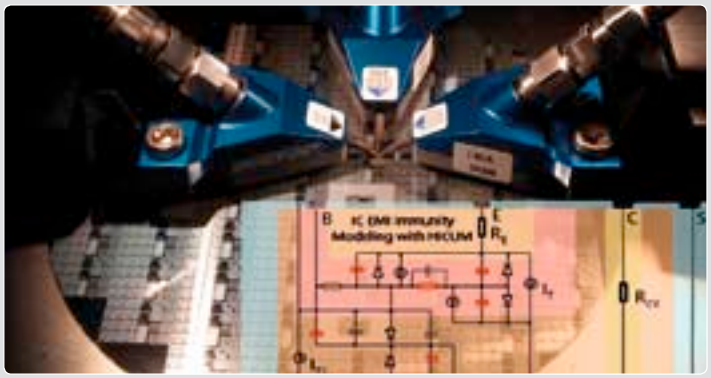
HIGHLIGHTS

- Construction of the complete measurement system applicable for testing of broad class objects radiating electromagnetic emissions
- Development of probes for vector field detection
- Reduction of scanning time
- Data post-processing for compensation of measurement errors
- Data post-processing for extraction of radiated emission models and source reconstruction
- Software development for automated measurements, data storage, visualization and post-processing of near-field data
- 3D relief model extraction of DUT



Measurement and modeling of immunity behavior of mixed-signal ICs

›› RESEARCH RESULTS

There are growing challenges in the prevention of electromagnetic interference (EMI) problems within mixed analog-digital systems used e.g. in automotive or telecommunication products. Continuously rising clock rates of digital circuits shift electromagnetic noise towards higher frequencies. The effective length of unwanted antennas becomes shorter, enlarging the potential for noise radiation from the system.

Progressive miniaturization, complexity and reductions in operating voltages of the electronic products increase the risk of malfunctions due to higher sensitivity for ambient noise as well as parasitic field couplings between closely separated "aggressive" and "sensitive" subcomponents. Consequently, there is a great demand for the detailed analysis of EMI sources which is necessary for the design of faultless system operation.

Near field scanner system |

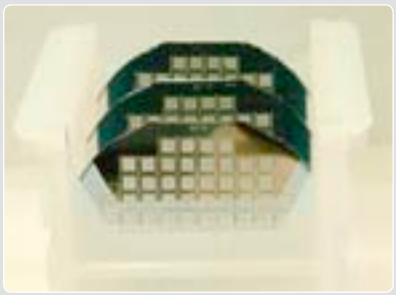
The near field scanner system is able to measure the vector electromagnetic field as a function of spatial coordinates and frequency due to arbitrary DUT radiating periodic emission.

The measured data might be used to determine field distribution outside scanning volume as well as for reconstruction of electric currents and charges inside DUT.

One exemplary application is verification of the EMC compliant design of the system where the discovery of parasitic effects and hot-spot localization provides a possibility for the quick correction of design mistakes at their origin.

Micromechanics, Actuators and Fluidics

Silicon micropump in plastic housing



Micropumps, full wafer assembly

COMPETENCIES

Devolopment of

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

›› SHORT PORTRAIT

The department Micromechanics, Actuators and Fluidics develops intelligent solutions for the active handling of small quantities of liquids and gases. Micro-devices customized for microfluidic applications are highly versatile, suitable for integration in a wide variety of industrial solutions.

The department employs seven experts who design microfluidic components, and develop simulations and prototypes of these. With more than 12 years experience in the field, the department can ensure individual applications are realized in the most cost-effecient manner and to the highest standard possible.

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

›› TRENDS

Currently the department is focusing on the following strategic areas:

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

Furthermore, a new platform for manufacturing plastic devices is currently being developed, which will allow applications to be produced more cost-efficiently. Using this new platform, micropumps and microcompressors will be developed for application in cooling systems, fuel cells and medicine.

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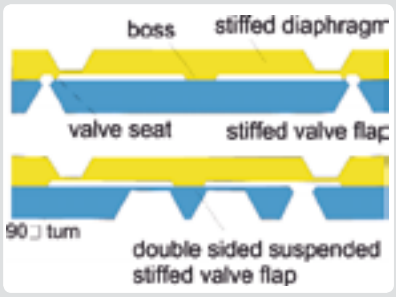
HIGHLIGHT

The 'double normally-closed' microvalve

A 'double-normally closed' (DNC) microvalve has been developed at Fraunhofer IZM (see report below).

The excellent behavior of the DNC chip will lead to its integration in many applications. As a first step, we plan to integrate the valve in a portable fuel cell system, in cooperation with our partner SFC (Smart Fuel Cell) AG. A future priority will be producing the valve for medical applications using low cost manufacturing methods, such as injection molding.



Design of the DNC valve

Top view of the DNC chip. One can see the stiffed diaphragm

›› RESEARCH RESULTS

The 'Double Normally-Closed' Microvalve

Introduction |

Current commercially-available micropumps have an unwanted behavior, known as 'free flow', whereby, if the pump is switched off, excess pressure at the inlet generates an unwanted flow through the pump. Clearly, this is a critical issue for medical drug delivery and many other applications.

The DNC valve concept |

To solve this 'free-flow' problem, we have developed a novel component, the 'double-normally closed' (DNC) microvalve. The valve is a passive chip that

- self-blocks when over pressure is applied to the inlet
- self-blocks when over pressure is applied to the outlet
- opens if under pressure is applied to the outlet

That means, if this passive valve chip is arranged in series upstream to the micropump, over pressure at the inlet leads to a self blocking function. If the pump is turned on, it generates an under pressure at the pump inlet and the valve outlet, opening the valve.

Design of the DNC |

The diaphragm of the top chip is connected by silicon fusion bond to a doubly suspended flap via the boss.

The stiffened parts of the diaphragm, the flap and the connecting boss form an I-shaped structure. For the closed valve, the force balance of the I-shaped structure, if an atmosphere pressure P0, an inlet pressure P1 and an outlet pressure P2 is acting on the valve, is:

$$P0 - P1\ \beta < P2\ (1-\beta) \qquad (1)$$

Where β is defined as the relation between the effective areas A_f of the stiffened part of the flap and A_m the stiffed part of the diaphragm:

$$\beta = A_f/A_m \qquad (2)$$

As it is very important that β is smaller than 1, we chose a value of $\beta = 0.5$.

Fluidic characterization |

The DNC valves were manufactured using silicon micromachining and were tested fluidically. The valves behaved as predicted, self blocking, and opening when under pressure was applied at the outlet. The leakage, measured using the highly sensitive capillary method and a yield of 75%, was less than 100 µl/day at 50 hPa over pressure. Additionally, extremely high device-to-device reproducibility was achieved.


*EVENTS

» EVENTS

Events

Booth of the Fraunhofer IZM at the Cluster Initiative Congress

Prof. Ab Stevels of TU Delft (left) and Dr. Volker Hauff, President of the German Council for Sustainable Development

›› "The Bavarian Cluster Initiative" |

The "Bavarian Cluster Initiative" is a new political instrument of the Bavarian government, implemented in order to establish Bavaria as a business and research location and to facilitate the competitiveness of the Bavarian economy.

The close integration of research and development facilities with the economy is meant to create a momentum, finally leading to innovation and competitive advantages concerning products and processes.

A congress in the M.O.C., the Munich exhibition center, marked the starting point of the "Bavarian Cluster Initiative". It was opened by the minister for economic affairs, Erwin Huber, and acknowledged by the Bavarian prime minister Edmund Stoiber.

More than 3000 visitors were proof of the outstanding interest of economy, science and local authorities in the strategy of the "Bavarian Economic Cores".

In the afternoon, six clusters had the opportunity to introduce first considerations to representatives from science and economy. In this context Professor Herbert Reichl presented the Fraunhofer IZM in the sensors cluster.

An exhibition with approximately 80 exhibitors accompanied the congress event. Fraunhofer IZM's Munich branch as well as the Micro-Mechatronics Center Oberpfaffenhofen presented new developments here.

›› International Symposium – Perspectives on Electronics and Sustainable Development |

On February 24, 2006 the Department Environmental Engineering hosted the International Symposium "Perspectives on Electronics and Sustainable Development" at the TU Berlin.

Prof. K. Kutzler, President of the TU Berlin, welcomed 12 international speakers and 130 guests mainly from industry to a symposium about implementation strategies for the concept of sustainable development.

The presentations focused on how to integrate societal, economic and environmental aspects into the development of new technologies and products. Dr. V. Hauff, President of the German Sustainability Council, emphasized the necessity to exploit the full potential of energy efficiency in electronics. Prof. F. Mattern, ETH Zürich, explained about opportunities and risks of ubiquitous electronics and applications in industry, medicine and homes. Prof. H. Reichl put a focus on the aspect of miniaturization and its potential for an energy and resource efficient supply of new products to our societies.

Finally, Dr. N. Nissen presented the new IZM Research Program "Sustainable Technical Development". Topics of the program are energy efficiency in microsystem technology and system reliability.

Looking through a microscope at the Long Night of the Sciences

Peter Ramm (right) discusses European cooperation possibilities with Jean- Frédéric Clerc (center) and minister for research Goulard

›› The smartest night of the year - a huge success! |

For the third time Fraunhofer IZM and TU Berlin's Research Center for Microperipheric Technologies participated in the Long Night of the Sciences. More than 500 visitors made a pilgrimage to Berlin's Wedding district in order to take a guided tour through the clean room or to catch up on the latest developments in microelectronics.

In half-hour tours between 5pm and midnight, visitors were shown how microelectronic systems are examined without destructive interferences by both ultrasonic and X-ray microscopy for possible quality or material defects, and how and within which ranges a scanning electron microscope functions. In IZM's environmental laboratories they learned which pitfalls lurk within environmentally appropriate disposal of mobile phones. Especially the younger visitors showed great aptitude for taking their parents' mobile phones apart and then analyzing the parts for toxic substances.

Many guests took the opportunity to try out the intelligent golf ball developed by IZM scientists and found out how hard it is to actually hit the ball at the tee off. Once they had successfully maneuvered it into the net, however, the microsystem inside the ball signaled whether the force of their tee-off made them a "Professional" or whether were still at the stage of "Amateur" or "Rabbit".

The program was supplemented by tours inside the dust-free world of the clean room as well as by presenting intelligently interconnected articles of clothing, e.g. a textile keyboard integrated into a smart jacket, a micro fuel cell for the energy supply of portable products as well as an intelligent BioChip analysis system for doctors' practices.

›› Visit of the French minister for research |

On June 19, 2006, the French minister for research François Goulard visited the Fraunhofer-Gesellschaft.

Set against the background of a restructuring of the French research landscape, Goulard discussed the advantages of the Fraunhofer model with Fraunhofer president Professor Hans Jörg Bullinger and Dr. Ullrich Buller, responsible for research on the Fraunhofer Executive Board.

Another interesting topic was the cooperation between CEA-Leti and Fraunhofer IZM. With Fraunhofer IZM's director Professor Herbert Reichl and the head of department Dr. Peter Ramm the minister spoke about bilateral cooperation projects on topics such as 3D integration and wafer-level packaging and corresponding European research initiatives like eCUBES.

Industry day – Aircraft research at the Fraunhofer IZM Teltow |

The research-intensive development of aircrafts needs strong networks. An important step in developing such a network was made at the industry day "aircraft research" at the Fraunhofer IZM Teltow.

In the presence of the Brandenburg Minister of Economic Affairs, Ulrich Junghanns, scientists of the Fraunhofer IZM Teltow met with representatives of the aircraft industry and its suppliers to discuss new research results and to initiate new partnerships in aircraft research.

A main topic of research is the development of new cabin systems. Here new composite materials, which are developed by the Fraunhofer IZM Teltow and its industrial partners, are a focal point.

Events

Munich school students at the Fraunhofer IZM booth

Participants at the workshop „Microdosing Systems“

›› Science Summer in the Bavarian Capital |

Despite subtropical temperatures of more than 40°C, Munich turned out en masse for the seventh Science Summer. Almost 60,000 people visited the BMBF-supported festival from July 15-21, 2006.

This year, for the first time, Fraunhofer IZM took part, represented by the Micro-Mechatronic Center and the institute's Munich branch, among others.

A special highlight was the opening of the Science Summer with guests of honor including the German federal minister of education, Dr. Annette Schavan, and Mayor Christian Ude, who toured the event for an overview of the diversity of research activities.

During the tour Fraunhofer IZM's main exhibit, a "speedy reporter" jacket, caused a stir among the attending press. A phone call from the jacket demonstrated Fraunhofer IZM's impressive achievements in developing basic technology and integrating auxiliary electronics in clothing.

Other exhibits, including the intelligent golf ball with an integrated autarkic sensor system, intelligent folding boxes and blood bags with integrated RFID tags, attracted strong interest from the broad range of visitors.

As a parallel event, international specialists met in Munich at the EuroScience Open Forum (ESOF). The visitors to the Fraunhofer IZM stand at the Science Summer were accordingly mixed, as likely to include curious retirees, families with toddlers, teenagers and students, as scientists from all over Europe.

›› "Microdosing Systems" Workshop in Munich |

In every area of technology – whether medical technology, bio-analytics, chemical analytics, process engineering or biotechnology – devices and systems are steadily becoming smaller and more cost-effective. This is true, too, of the micro-pump, hailed as the "beating heart" of microfluidic applications, which is employed to accurately deliver the smallest doses of fluids and gases possible.

This year's annual microdosing workshop, the sixth in the series hosted by Fraunhofer IZM's Munich branch and entitled "Micropumps – the beating heart of microfluidics", again proved extremely popular.

The workshop gave 35 participants from diverse branches of industry the opportunity to engage intensively with the particularities and challenges of microdosing. Discussion focussed on the application of micropumps in areas such as laboratory technologies, medicine and fuel cells.

A rapid-prototyping procedure for custom designed dosing systems and nanoliter dosing of high viscous liquids were debated, as were current trends in developing innovative micro-dosing systems. Apart from market-driven issues, technical aspects were also addressed, with special emphasis placed on the modelling and simulation of piezoelectronic actuation and reliability tests.

Participants at the workshops „Chinese RoHS"

CMP User meeting: IZM colleagues inspecting a polished and cleaned wafer

›› Workshop „The Chinese RoHS and its Importance for the German Electronics Industry" |

Fraunhofer IZM hosted a workshop on "The Chinese RoHS and its Importance for the German Electronics Industry" on October 25, 2006. More than 80 participants, most of them from industry, attended this meeting at the Fraunhofer IZM Berlin.

The Chinese RoHS is very important for companies which export products to PR China or even manufacture products there. Since July 1, 2006, material bans for Pb, Cd, Hg and CrVI as well as PBB and PBDE have been effective in the EU. The Chinese regulations, however, differ in several aspects from those in the European directive. Missing information and a lack of understanding resulted in uncertainties for the companies, a fact that motivated Fraunhofer IZM to host this workshop and to make German companies more familiar with the Chinese RoHS regulations.

Dr. Lustermann and Ms. Chen, from Luther Rechtsanwaltgesellschaft explained the legal aspects of the Chinese RoHS. Mr. Wenzel from ZVEI presented the activities of this industry association for a harmonisation of the EU and Chinese RoHS. Mr. Husemann from Phoenix Contact described the direct impact on the companies. Dr. Mueller from Fraunhofer IZM, who also moderated the workshop, summarized the similarities and differences between the EU and Chinese RoHS. All participants reflected on possibilities to harmonize the implementation of the different regulations.

›› Great Turnout for Fraunhofer-Symposium on Photonic Packaging |

Concurrent with this year's electronica trade fair Fraunhofer IZM organized a one-day International Symposium on Photonic Packaging in Munich on November 16, 2006. Almost 50 participants, half of them from abroad, came together to discuss the state-of-the-art in hybrid electro-optical circuit boards and future roadmaps. Research institutions and companies alike also presented hardware components and demonstrators as well as design software at the table-top exhibition, which had been organized outside the conference room.

The feedback from the participants was very positive – many not only remarked upon the high quality of presentations, but also appreciated the opportunity to discuss recent developments in photonic packaging with their colleagues from all over Europe.

17th CMP User Meeting |

On October 27, 2006, the 17th CMP User Meeting took place in Chemnitz, where users coming from the realm of chip and wafer technologies, researchers and scientists from industry and institutes met with equipment and material supplier to discuss new developments and latest results from the field of chemical-mechanical polishing.

Event location was the Chemnitz branch of the Fraunhofer IZM. With 60 participants the turnout of the event was very positive, probably due to the close vicinity to the fabs of AMD, Infineon and Qimonda in Dresden as well as the wafer manufacturers Siltronic and FCM in Freiberg.

Events

The Fraunhofer IZM booth at the Smart Biomedical Systems event

From left to right: Prof. Esahi (Tohoku University), Mr. Miyamoto (City of Sendai), Dr. Lorenz Granrath (Fraunhofer-Gesellschaft) and Mr. Homma (MEMS Core Ltd.)

›› Smart Biomedical Systems |

Regensburg was host to the cooperative forum "Smart Biomedical Systems", on November 29, 2006, held to foster close collaboration between science, technology development and clinical application in early stages of development, as well as the interlinking of potential sources of regional revenue creation.

The event was collaboratively organized and hosted by Bayern Innovativ GmbH, Fraunhofer IZM's Munich branch and Sensor Cluster – Bavaria.

The forum focused on the development of novel devices for medical technology. During the course of the workshop, it was convincingly demonstrated that the high degree of innovation in microelectronics and diverse specialist fields in medicine, such as cardiology, neurology or ophthalmology, is currently resulting in cutting-edge instruments for use in diagnosis and therapy.

The approximately 80 conference participants also attended the accompanying trade fair, taking the opportunity to become acquainted with the latest medical-technological solutions. The Fraunhofer IZM stand here featured complex intelligent implants, micropumps, as well as sensor systems for the precise detection of bacteria, viruses and/or toxins.

Overall, the symposium was a huge success, facilitating a lively exchange of ideas between science and the economic sector and resulting in numerous new cooperative initiatives.

›› Fraunhofer-Gesellschaft opens new MEMS Showroom together with Japanese partners |

From November 6-7, 2006, the International Forum on Micro-Nano Hetero System Integration took place in Sendai, Japan. The two-day event was designed to give an overview of new developments in the area of smart system integration for microelectronics and microsystem technologies.

About 250 guests attended the opening ceremony for the new Fraunhofer MEMS showroom in Sendai, a cooperative project of the Fraunhofer-Gesellschaft, the city of Sendai, Tohoku University and the MEMS Core Company. Development samples and prototypes provided by the partners involved are presented in the showroom.

There is a close cooperation between the Fraunhofer-Gesellschaft and Tohoku University. The two partners signed an agreement for the joint development of MEMS in July 2005.

Workshops on die- and wire bonding at Fraunhofer IZM - practical training

Workshops on die- and wire bonding at Fraunhofer IZM - theoretical training

›› Regular courses on die- and wire bonding in Berlin |

The Fraunhofer IZM Berlin/Adlershof presents a wide variety of support and services in the field of bonding. Consulting services for device selection and technology implementation, development and qualification of processes and products as well as staff training are offered.

In 2006 more than 50 individuals from industry and research attended the courses on die and wire bonding for operators, managers, developers and constructors.

›› Workshop "Forum 2006 - Be flexible" in Munich |

This international workshop, addressing manufacturing and applications for thin semiconductor devices and technology and production processes for flexible electronic systems, again took place in November 2006 at the hotel "Le Meridien" in Munich. More than 150 participants from 15 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 2007.

More information at www.be-flexible.de.

Fraunhofer IZM workshops 2006 (selection)		
February 2006	Munich	„The Bavarian Cluster Initiative"
	Berlin	International Symposium - Perspectives on Electronics and Sustainable Development
May 2006	Teltow	Industry Day - Aircraft research at the Fraunhofer IZM Teltow
	Munich	ESD-Design and Test Seminar
July 2006	Munich	Science Summer in the Bavarian Capital
September 2006	Berlin	Microsystems Summer School
October 2006	Munich	„Microdosing Systems" Workshop
	Berlin	The Chinese RoHS and its Importance for the German Electronics Industry
	Chemnitz	17th CMP User Meeting
November 2006	Munich	International Symposium on Photonic Packaging
	Munich	Forum 2006 - Be flexible
	Sendai	International Forum on Micro-Nano Hetero System Integration
	Regensburg	Smart Biomedical Systems

Fraunhofer IZM's Fair Activities 2006

Erik Jung of Fraunhofer IZM explains the flip chip demonstration line to visitors at the VDI-booth at the SMT in Nürnberg

›› Exhibition-wise, the year 2006 started on home territory for Fraunhofer IZM – at the Laser Optik Berlin in March. Here, the focus of the institute's presentation was on photonic packaging for optical and optoelectronic packaging technologies.

April brought three fair presentations – the Semicon Europa in Munich, the China Chongqing High Tech Fair and the Hannover Messe. In Munich Fraunhofer IZM presented its activities together with TU Berlin's Research Center for Microperipheric Technologies. Recent projects that met with a lot of interest were the integration of passive devices at wafer level as well as the so-called "smart carrier" technology.

Concurrent with the High Tech Forum "Microsystems for Health" the focus of the Fraunhofer IZM presentation at the Chongqing High Tech Fair was on advanced assembly and packaging for biomedical devices.

Exhibits included nucleic acid-based biosensors for medical diagnostics (DNA-sensor), microsystem-based cooling systems, a modular optical analysis system, the world's smallest hearing aid, a neuronal interface sensor and an intelligent sensor band aid.

At the Hannover Messe the intelligent golf ball developed at Fraunhofer IZM had its grand entrance, and even federal minister for education and research Dr. Annette Schavan could not resist the temptation of hitting it into the net. 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.

As always the SMT in Nürnberg, this year taking place in June, was the institute's most important exhibition event.

Fraunhofer IZM at the JEC Composites Show in Paris

Fraunhofer IZM at the SMT 2006

One highlight of the presentation was an illustrated process flow of the integration of active and passive components into a printed circuit board (chip in polymer). An opto-mechatronic micro projector, realized at Fraunhofer IZM within a very short timeframe by means of rapid prototyping, also pulled a lot of visitors.

Concurrent with the SMT, Fraunhofer IZM took part in this year's SENSOR + TEST in Nürnberg, along with other Fraunhofer institutes. In addition to new developments in microfluidics, the many visitors were particularly interested in current developments in sensor packaging and sensor networks.

The IZM presentation focused on autonomous, wireless sensors (so-called eGrains), which not only transfer data, but can also organize themselves into ad-hoc networks. These sensor nodes can communicate among each other, which makes them perfect for use in freight haulage and logistics. The goods are fitted out with the autonomous sensor system. It holds the goods' particulars and keeps the responsible parties continually informed with up-to-date data, such as the load's weight and temperature.

After a long summer break, Fraunhofer IZM presented current activities under the motto: "From Leadfree to Reliability - ecoDesign and Sustainable Development" at the CARE Innovation 2006 in Vienna. For the first time the new IZM research program Sustainable Technical Development was presented to the public. A lot of visitors took the opportunity to get some expert information about upcoming legislation changes concerning the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS).

Fraunhofer IZM at Fairs 2006 (selection)		
February 2006	Tokyo	Nano Tech
March 2006	Berlin	Laser-Optik Berlin 2006
	Shanghai	Productronica 2006
	Paris	JEC Composites Show
April 2006	Munich	SEMICON Europa 2006
	Chongqing	CCHTF - China Congqing Hi-Tech Fair
	Hannover	Hannover Messe 2006
May 2006	Frankfurt/M.	ACHEMA 2006
	Nürnberg	SMT 2006
June 2006	Nürnberg	Sensor + Test 2006
	Bremen	Actuator
	Dresden	Fraunhofer VµE Technology Days
September 2006	Dresden	ESTC Dresden
November 2006	Vienna	CARE 2006
	Tokyo	Micromachine 2006
	Düsseldorf	Medica
	Munich	Smart Biomedical Systems

*FACTS & FIGURES

» FACTS & FIGURES

Fraunhofer IZM in Facts and Figures

›› Financial situation |

In 2006 it was possible to integrate new areas of research, developed independently of external funding, into federally and state-supported projects. Fraunhofer IZM's turn-over consequently increased to approx. €27.5 million.

About €22.9 million of this came from non-government sources. This represents an increase of 8%, or €1.8 million.

Overall, €11 million, an estimated 40% of expenditure, was financed by contracts from German and international industrial enterprises and trade associations.

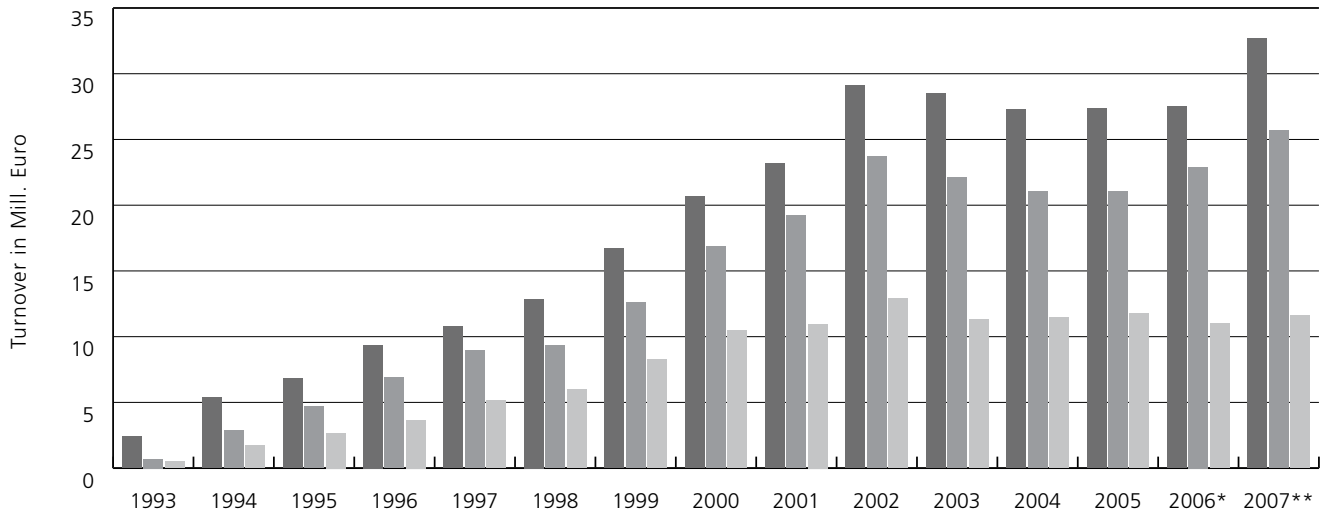
›› Investments and laboratories |

To efficiently prepare for research of the new topics, Fraunhofer IZM invested €2.5 million in new devices and equipment in 2006.

With support from the Land Berlin, construction was begun on a European laboratory for component and system reliability in micro- and nano-technology in the Micro Materials Center. The project is expected to cost €1.2 million. The Land Berlin is also contributing to the €0.3 million construction of a purpose-built measurement station for characterizing nano-materials by means of an atomic force microscope.

The Fraunhofer-Gesellschaft's strategic funds were also employed to initiate several measures.

In Munich, a deep trench etching machine for 3D integration and a finishing system for fabricating film-based polytronic systems with higher functionality were procured for a total of €1.3 million. In Berlin, work on an integration platform for system-in-package (SiP) modules at a cost of €0.7 million was begun.



* 2006 actual
** 2007 projected

›› Human resources development |

The staff cuts of recent years were able to be halted thanks to the increase in contracts. At the end of 2006, Fraunhofer IZM employed a total of 266 staff throughout the Fraunhofer IZM branches. That equals 20 more positions than were available at the end of 2005.

The Institute continues to support students with the opportunity of combining their studies with practical scientific work in the Institute's laboratories and offices. Fraunhofer IZM took on an average of 121 interns, undergraduates and research assistants in 2006.

Fraunhofer IZM also again extended its spectrum of vocational training courses. In addition to the professions of microtechnology engineer, IT specialist and business administrator, training as mechatronics technician and mechanical engineer for precision tools, instruments and machines is now provided. Consequently, Fraunhofer IZM is now able to help a total of 12 trainees achieve their vocation.

›› Contact |

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

Awards

IZM Research Award winners Dr. Martin Schneider-Ramelow and Dr. Bernhard Wunderle together with Prof. Herbert Reichl and former laureates

H. Griese (left) receives a large Japanese daruma doll from Prof. T. Suga on the occasion of his 65th birthday, Prof. H. Reichl gets a small one

›› IZM Research Award 2006 goes to Dr. Martin Schneider-Ramelow and Dr. Berhard Wunderle |

On the December 19, 2006, the Fraunhofer IZM presented the seventh IZM Research Award for outstanding achievement in assembly and interconnection technology. This year's winners were Dr. Martin Schneider-Ramelow and Dr. Bernhard Wunderle from Fraunhofer IZM Berlin.

Dr. Schneider-Ramelow was recognized for his work in the advanced development of wire-bonding technologies for the manufacture of high-reliability components. His group's research on material characterization of the junction between bond wire and pad metallization and, in particular, of bond wire during the wire-bonding process, has initiated new directions in research on wire-bonding technology internationally.

Dr. Wunderle's area of specialty is material characterization and reliability prediction, as well as thermal management of microelectronic systems by means of experiment and simulation. He received this year's Research Award for his work on the mechanical and thermal reliability of package assemblies in the micro-nano-transition area.

The award was presented by Fraunhofer IZM's Director, Professor Herbert Reichl, as part of a celebratory colloquium in the Italian Courtyards in the Spandau Citadel.

›› Prof. Herbert Reichl receives highest VDE accolade |

Prof. Herbert Reichl has been awarded the Golden Ehrenring (Eng. Golden Ring of Distinction), the highest accolade of the VDE – the Association for Electrical, Electronic and Information Technologies, for his outstanding services in the development of assembly and interconnection technology.

This international recognition honors Prof. Reichl's significant achievements in microelectronics and microsystem technology, turning Germany into a world leader in integrating electronics into the products of tomorrow.

Hansjörg Griese is honored with iNEMI Award |

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

Electronic course students of the Diesterweg Gymnasium assembling a circuit at the IZM

Tribute to the best apprentice of Fraunhofer Gesellschaft by executive board member Dr. Polter

Pupils testing a mobile Tel. integrated in a jacket

›› Professional training at Fraunhofer IZM |

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 micro technologists every year, focussing on microsystems as well as assembly and interconnection technologies. Additionally, Fraunhofer IZM offers professional training for precision mechanics since 2006. In summary eight apprentices in three professions receive a qualified education within the Fraunhofer IZM research environment since then.

The professional training is conducted in a co-operation of Fraunhofer IZM, the Technische Universität Berlin, other research institutions and Berlin enterprises. Additionally to the internal apprentices, two external trainees are therefore regularly performing their internship at the institute.

For her excellent final micro technologist exam, Julia Moch was honored for the best apprentice of her age by Dr. Schweitzer, president of the IHK Berlin. Furthermore, she received a certificate as Fraunhofer's best apprentice by Fraunhofer executive board member Dr. Polter in Munich.

›› Supporting young students at Fraunhofer IZM |

Since 2004 the Diesterweg Gymnasium and the Fraunhofer IZM have a co-operation. In this context numerous school-classes have taken the chance to participate in Fraunhofer IZM's job application training. This year, two pupils again did a practical training in the Fraunhofer IZM labs. Electronics course students of the Diesterweg Gymnasium, specialising in physics, participated in an electronics devices course at the Fraunhofer IZM and had the opportunity to develop and assemble electronic circuits themselves.

During a one-day-visit to the Fraunhofer IZM, 6th level pupils of the Siemens Gymnasium obtained information about the work of scientists and the research at the institute. Besides testing a mobile Tel., integrated in a jacket, the pupils also had the opportunity to analyse highly integrated microsystems, so-called eGrains, with an X-ray microscope. A visit to the clean room in appropriate clothing completed the morning activities.

Within the project "Microsystem Technologies Education in Northeastern Germany" 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.

Training & Education

Assembling a lie detector

Students examining prepeg materials used in light weight construction

›› Girls' Day - Ten girls visit the Fraunhofer IZM laboratories |

Fraunhofer IZM's participation in the nation-wide Girls' Day this year met great approval once again. The event was booked out only shortly after publication on the Internet. Ten female students, between the ages of 12 and 15, had the opportunity of diving into the world of microsystem technology on April 27, 2006.

Mobile teleTel. technology was used to introduce the visitors to Fraunhofer IZM's work. Various cell Tel. generations were weighed to demonstrate the miniaturization. The girls were also allowed to disassemble the cell Tel.s by themselves to look at the assembly.

With a lot of enthusiasm, the girls then applied themselves to the first practical task – under the guidance of an IZM colleague, they themselves welded together and tried out a lie detector. As a comparison, the girls were then shown the automatic assembly process at an SMD line.

As was the case last year, the tour through the cleanroom was a big hit, with the "dressing-up" in the cleanroom overalls and caps a source of much amusement.

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

"This is a place I'd like to work," was heard more than once throughout the day. Girls' Day 2006 was therefore a complete success.

›› Students get a taste of scientific work at the Fraunhofer IZM Teltow |

Fraunhofer IZM's branch lab Polymer Materials and Composites welcomed a group of primary school pupils who wanted to make an excursion into the world of science. On November 29, a fourth and a sixth form from the Ernst von Stubenrauch primary school came to Teltow to explore chemistry in the form of simple experiments: they made an elastomer from milk and vinegar, a fire extinguisher from baking soda and a ph-value indicator from red cabbage.

For quite some time now the Teltow branch lab has been cooperating with Brandenburg's Technical University Cottbus to offer some hands-on training to ninth graders, with great success. The focus is on vocational orientation: Experimental working, questioning things, looking for new solutions, – in short, getting to know a scientific work environment.

These days, the branch lab even receives enquiries from Berlin students, who travel the distance to Teltow to participate in these courses. "Such cooperations between schools and research institutions make young people enjoy scientific work and might make them want to choose a career in science," says Professor Monika Bauer, head of the Teltow branch lab.

The winners of the Focus magazine's student competition together with their mentor Sabine Scherbaum of Fraunhofer IZM (left)

Making a bacterial dilution series

›› Fraunhofer IZM protégés win main prize in FOCUS student competition |

The award ceremony of FOCUS magazine's student competition "Schule macht Zukunft" (Our Schools, Our Future) 2006 was held in Berlin on September 27, 2006.

A group of female high school students from Baden-Wurttemberg, supported by Fraunhofer IZM, the University of Jena and Metro AG, received one of the two main prizes with their project on the "Potential and Risks of RFID".

In the attendance of the German Federal Minister for Education Annette Schavan, the happy winners received a voucher for a trip to Helsinki (Finland), where they will spend a week at the invitation of the "Stiftung Industrieforschung".

The eight students, between the ages of 12 to 16, examined the development and social acceptance of non-contact identification systems (so-called RFID) in their project. Developing such systems is a main focus of the Department Polytronic Systems at Fraunhofer IZM Munich. On invitation of the Fraunhofer-Gesellschaft, the girls spent a day there gaining practical experience by working in the laboratories and learning how the RFID chips are fabricated. Fraunhofer IZM employee Sabine Scherbaum guided the girls through their visit and throughout the project.

Fraunhofer IZM's Munich branch has for several years been offering female students glimpses into the world of microelectronics, not only as part of nationwide Girls' Day. It also regularly hosts multiple-day workshops and career-orientation weeks for girls – events that are always in high demand.

›› Workshop „Implantable Glucose Sensor" for Cyber Mentees |

The Munich branch of Fraunhofer IZM participates in the CyberMentor project – a web-based mentoring program for female student from Baden-Wurttemberg between the ages of 11 and 19. Fraunhofer IZM acts as a mentor for two girls (ninth and eleventh form).

In the context of an offline meeting of the the CyberMentor project a workshop on a current EU project was offered in cooperation with the Fraunhofer IZM Munich branch. The aim is to bring together a girls team willing to work on the topic of an implantable glucose sensor. The project work will focus on the framework conditions (15 partners from eight countries), the technical background (interdisciplinary topic at the interface of microsystem technology, medical technology, chemistry, biology) as well as ethical questions. The project results will be presented in a competition.

Two-week vocational orientation |

From July 10 – 21, 2006, three girls between the ages of 15 and 16 completed a vocational orientation internship at Fraunhofer IZM's Munich branch. They were introduced to the topic of electroluminescence and were in charge of preparing and introducing a presentation on illuminated foils at the young people's event "Microworlds" on July 18, 2006.

The three vocational trainees were also a great help in organizing a laboratory day for five girls from the Bavarian School for the Deaf on July 19, 2006.

Lectures, Editorials

›› Lectures (Selection) |

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

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

Prof. Reichl, TU Berlin
- Semiconductor Devices

Prof. Reichl, Dr. Nissen, O. Deubzer, O. Bochow-Neß
- Design of Environmentally Benign Products

Prof. Reichl, Dr. Schneider-Ramelow, Dr. Dieckerhoff
- Materials for Microsystems Technologies II

Prof. Reichl, O. Bochow-Neß
- Microsystems Technologies II

Prof. Reichl, Dr. Dieckerhoff
- Fundamentals in Electronic Circuits

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

Prof. Reichl, Dr. Töpper, Dr. Dieckerhoff
- Basic Principles of Physics and Chemistry for Microsystems

Prof. Reichl, B. Bouhlal
- Fundamentals of Electronics

Prof. Reichl, O. Bochow-Neß
- Reliability of Microsystems

Prof. Geßner
- Microelectronics and Microtechnologies

Dr. Schulz
- Interconnect Processes and Technology – Back-end of Line (BEOL) Processing

Dr. Kurth
- Testing and Electronic Measurement Technology, Microsystem Technology

Dr. Mehner
- Computer Aided Design, CAD;

Dr. Streiter
- Process Modeling of Component Technology

Editorials |

Journal Microsystem Technologies, Springer Verlag Berlin, Heidelberg, New York
Prof. B. Michel (Editor in chief)

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

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

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

Dissertations, Best Paper Awards

›› Dissertations |

Angwafo, N.
Towards Conformal Antennas for Miniaturized Autarchic Distributed Systems

Cichos, S.
Verfahren zur Modellierung von planaren Spulen für den Entwurf und die Optimierung von Antennenspulen induktiv gekoppelter RFID-Transponder

Ecke, R.
Abscheidung (CVD) und Charakterisierung W-basierter Diffusionsbarrieren für die Kupfermetallisierung

Heinz, S.
Integrierte Hochvolt-Ansteuerelektronik für Mikroaktoren mit elektrostatischem Antrieb

Lohmann, C.
Beiträge zur Entwicklung einer Technologieplattform für die Herstellung von oberflächennahen Mikrostrukturen mit hohen Aspektverhältnissen

Ndip-Agbor, I.
"Novel Methodologies for Efficient and Accurate Modelling and Optimization of System-in-Package Modules for RF/High-Speed Applications"

Schreier-Alt, T.
Polymerverkapselung mechatronischer Systeme – Charakterisierung durch eingebettete Faser Bragg Gitter Sensoren

›› Best Paper Awards |

Best Paper Award – 7th International Conference on Electronic Packaging
Auersperg, J.; Michel, B.
Capabilities of Incorporating Bulk Fracture, Bimaterial Interface Fracture and Fatigue Evaluation into RSM/DOE Concepts of Enhanced Microelectronics Applications
Shanghai, China, August 26-30, 2006

Best Paper Award – **EcoDesign 2006**
Stobbe, L.; Schischke, K.; Hayash, H.; Suga, T.; GRIESE, H.-J.
EcoDesign Strategies for Electronics Supply Chains Based on Product Material Declarations

Best Poster Paper Award – **ECTC 2005**
in Lake Buena Vista, FL, USA
Ndip, I.; John, W.; Reichl, H.
Effects of Discontinuities and Technological Fluctuations on the RF Performance of BGA Packages

Silver Leaf Certificate Award – **PRIME 2006**
in Otranto (Lecce), Italy.
Ndip, I.; Reichl, H.; Guttowski, S.
A Novel Methodology for Defining the Boundaries of Geometrical Discontinuities in Electronic Packages

Outstanding Paper Award – **Electronics Packaging Technology Conference, Singapore**
Dionysios Manessis
Failure Analysis of Sub- 50 µm Lead-Free Solder Bumps on Electroless Ni-P UBM for Flip Chip Interconnects

Cooperation with Industry (Selection)

Enterprise	Location
3D-Micromac	Chemnitz
AEMtec GmbH	Berlin
AIM GmbH	Heilbronn
Airbus Deutschland GmbH	Hamburg, Laupheim
Aktiv Sensor GmbH	Berlin
AMD Saxony LLC & Co. KG	Dresden
Andus Electronic GmbH	Berlin
Angewandte Mikromesstechnik GmbH	Berlin
Atmel Germany GmbH	Dresden, Heilbronn
Atotech Deutschland GmbH	Berlin
Berliner Nanotest und Design GmbH	Berlin
Brose Fahrzeugteile GmbH & Co KG	Coburg
Campus Micro Technologies	Bremen
Casio Computer Co. Ltd.	Tokyo (J)
Chemnitzer Werkstoffmechanik GmbH	Chemnitz
Colour Control Farbmesstechnik GmbH	Chemnitz
Conti TEMIC Microelectronics 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
Dyconex AG	Bassersdorf (CH)
EADS	Paris, Toulouse (F), Munich, Ulm, Dresden
Emerson & Cuming	Westerlo (BE), Bridgewater (USA)
EMZ GmbH & Co KG aA	Nabburg
EPCOS AG	Munich
First Sensor GmbH	Berlin
General Electric, Medizintechnik	USA
Global Light Industries GmbH, Optoelektronik	Kamp-Lintfurt
HARTING Mitronics AG	Biel (CH)
Häusermann GmbH	Gars am Kamp (A)
Hella KG aA Hueck & Co	Lippstadt
Henkel Kg aA	Düsseldorf
Hewlett Packard	Böblingen
Hirschmann Laborgeräte GmbH & Co KG	Eberstadt
hmp Heidenhain Mikroprint GmbH	Berlin
IBM Zurich Research Laboratory, Halbleiter	Zürich (CH)
Infineon AG	Munich, Regensburg, Dresden
Infratec GmbH	Dresden
KSG Leiterplatten GmbH	Gornsdorf

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

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Wissenschaftlich-technischer Rat Forschungszentrum Karlsruhe	Prof. H. Reichl	Member

Publications (Selection)

›› *Ansorge, F.; Rebholz, C.; Schreier-Alt, T.; Krumm, R.; Reichl, H.*
Thermal Management, Characterization of Materials and Packaging. Technologies for High Temperature Electronics
1st European Advanced Technology Workshop on Micropackaging and Thermal Management, La Rochelle (Frankreich), 01.-02.02.2006

Ansorge, F.
Assembly and Packaging of Sensors, MEMS-Components and Micro-Mechatronic Systems
20th Eurosensors Göteborg, Schweden, 18.-19.09.2006

Aschenbrenner, R.; Löher, T.; Ostmann, A.; Kallmayer, C.; Scheel, W.; Reichl, H.
Innovative Substrate Technologies for New Products
Key Note Speaker at the IMPACT 2006, October 18-20, 2006, Taipei, Taiwan

Auersperg, J.; Michel, B.
Capabilities of Incorporating Bulk Fracture, Bimaterial Interface Fracture and Fatigue Evaluation into RSM/DOE Concepts of Enhanced Microelectronics Applications
Proceedings 7th Int. Conf. on Electronics Packaging Technology, Shanghai, China, Aug. 26-30, 2006

Bauer, M.; Boeffel, C.; Kuschel, F.; Zaschke, H.
Evaluation of Chiral Dopants for LCD Application
Journal of the SID, 14(9), 2006, S. 805-812

Bauer, M.; Uhlig, C.
Zusammenhang zwischen Netzwerkstruktur und Bruchverhalten sowie Bruchzähmodifizierbarkeit hochvernetzter Polymere – vom Formulierungs-Know-How zum Bauteil
Polymerwerkstoffe 2006, IL-C4, S. 74

Becker, K-F.; Koch, M.; Gramckow, J.; Braun, T.; Bader, V.; Jung, E.; et al.
Rapid Tooling for High Reliability Transfer Molded Devices
Proceedings of ESTC 2006; 05.-07.09.2006, Dresden, Germany

Bock, K.
Microsystems technologies as an enabling platform for new application areas
Invited lecture at the BMBF-event „Korea und Deutschland – Partner in Forschung und Entwicklung“, 1. November 2006 in Seoul, Korea

Braun, T.; Becker, K.-F.; Koch, M.; Bader, V.; Aschenbrenner, R.; Reichl, H.
High-temperature reliability of Flip Chip assemblies
Microelectronics Reliability 46 (2006), S. 144 - 154

Dietrich, L.; Toepper, M.; Ehrmann, O.; Reichl, H.
Conformance of ECD Wafer Bumping to Future Demands on CSP, 3D Integration, and MEMS
56th Electronic Components and Technology Conference (ECTC), 2007, San Diego, USA

Ecke, R.; Rennau, M.; Zimmermann, S.; Schulz, S. E.; Geßner, T.
Influence of barrier crystallization on CV characteristics of MIS structures (poster)
Advanced Metallization Conference (AMC), San Diego (USA), 2006 Oct 17-19

Elst, G.; Schneider, P.; Ramm, P.
Modeling and Simulation of Parasitic Effects in Stacked Silicon
Invited Paper
Proceedings MRS 2006 Fall Meeting, Boston (2006)

Fiedler, S.; Zwanzig, M.; Schmidt, R.; Scheel, W.; Reichl, H.
Verbindungen der Zukunft – Metallische Nanorasenstrukturen für Anwendungen im Chip-Packaging
Elektronik Praxis, electronica-Magazin Nov. 2006

Fritzsch, T.; Jordan, R.; Glaw, V.; Töpper, M.; Dietrich, L.; Wolf, J.; Ehrmann, O.; Oppermann, H.; et al.
Packaging of Radiation and Particle Detectors
Proceedings of the 56th Electronic Components & Technology Conference, May 30 - June 2, 2006, San Diego, CA, USA

Frömel, J.; Geßner, T.
Advanced packaging is the breakthrough technology of MEMS commercialisation
The 12th International Micromachine / Nanotech Symposium, Tokyo, 08.11.2006

Geißler, U.; Schneider-Ramelow, M.; Lang, K.-D.; Reichl, H.
Investigation of Microstructural Processes during Ultrasonic Wedge/Wedge Bonding of AlSi1 Wires
Journal of ELECTRONIC MATERIALS, Vol.35, No.1, 2006

Geßner, T.; Baum, M.; Hiller, K.; Mehner, J.; Wiemer, M.; Otto, T.; Saupe,R.; Nestler, J.
Smart Systems Integration - Eine Herausforderung für zukünftige Mikro- und Nanotechnologien
VDE Kongress 2006, Aachen (Germany), 2006 Oct 23-25; Proceedings, Band 1 (2006) pp 495-500 (ISBN 3-8007-2979-2)

Griese, H.-J.; Mueller, J.; Stobbe, L.
Environmental-based regulations for electronics – From regional variety to internationally harmonized guidelines
EcoDesign2006 Asia Pacific Symposium, December 2006, Tokyo

Hahn, R.; Wagner, S.; Reichl, H.
PEM micro fuel cell system with on demand hydrogen generation
Moscow 2006 Hydrogen technologies for hydrogen production, Feb. 6-10

Herz, M.; Richter, M.; Jung, E.; Malek, C. Khan
Report on the Development of a Low Cost Micro-pump
Fraunhofer IZM-Munich Proceedings Workshop Micropumps, 24.10.2006, pp. 33-36

Hutter,M.; Oppermann, H.; Engelmann, G.; Dietrich, L.; Reichl, H.
Precise Flip Chip Assembly Using Electroplated AuSn20 and SnAg3.5 Solder
56th Electronic Components and Technology Conference, San Diego, CA, USA, May 30 - June 2 (2006)

Jordan, R.; Bauer, J.; Oppermann, H.
Optimized heat transfer and homogeneous color converting for ultrahigh-brightness LED package
Photonics Europe, Conference Proceedings of SPIE 6198: Photonics in the Automobile, Strasbourg, France, April 3-7 (2006)

Klumpp, A.; Ramm, P.; Wieland, R.; Merkel, R.
Integration Technologies for 3D Systems
Invited Paper
Proceedings MRS 2006 Fall Meeting, Boston (2006)

Landesberger, C.; Bollmann, D.; Drost, A.; Schaber, U.; Bock, K.:
Handling and processing of thin semiconductor substrates by means of mobile electrostatic carriers
Advanced Packaging Conference, in conjunction with Semicon Europa 2006, poster presentation, April 2006, Munich, Germany

Leidich, S.; Voigt, S.; Kurth, S.; Geßner, T.
Microwave Phase Shifter with Electromagnetic Signal Coupling in Silicon Bulk Technology
Int. J. Microwave and Optical Techn., 1 (2006) pp 1-9 (ISSN 1553-0396)

Michel, B.; Winkler, T.; Dost, M.; Kaulfersch, E.
Security assistance systems – Security support by integration of sensorics, Miniaturization and image processing
Proceedings "Safety and Security Systems in Europe", Potsdam, 30. 11. – 1. 12.2006

Publications (Selection)

Michel, B.; Winkler, T.
Microsecurity – Sicherheit durch Miniaturisierung mit Sensorik und Mikrosystemtechnik
Proceedings 2. BMBF-Workshop Sicherheitsforschung, Bonn, 11. - 12. 5. 2006

Müller, J.; Nissen, N.F.; Scheel, W.; Schmidt, R.
Renewable Resources for Electronics: Lignin-based Polymers for Printed Circuit Boards
CARE INNOVATION 2006 -
November 14, 2006, Vienna

Ndip, I.; Reichl, H.; Guttowski, S.
RF/Microwave Modeling of SiP Modules – A Novel Approach
39th International Symposium on Microelectronics (IMAPS 2006), San Diego, CA, U.S.A,
October 8-12, 2006

Ndip, I.; Reichl, H.; Guttowski, S.
A Novel Methodology for Defining the Boundaries of Geometrical Discontinuities in Electronic Packages
IEEE Conference on Ph.D. Research in Microelectronics and Electronics (PRIME 2006),
June 11-15, 2006, Otranto (Lecce), Italy

Nissen, N.F.
Sustainable Technical Development - New Fraunhofer IZM R&D Program
International Symposium "Perspectives on Electronics and Sustainable Development",
February 23-24, 2006, Berlin

Oberender, C.; Middendorf, A.; Bochow-Neß, O.; Griese, H.-J.; Reichl, H.
Electronic systems from the perspective of sustainability and reliability
CARE INNOVATION 2006 -
November 14, 2006, Vienna

Otto, T.; Saupe, R.; Weiss, A.; Stock, V.; Bruch, R.; Geßner, T.
Principle and Applications of a new MOEMS-Spectrometer
San Jose, 2006, Proceedings of SPIE, Volume 6114, pp. 77-86 (2006)

Polityko, D.; Guttowski, S; John, W.; Reichl, H.
Integration Technology Parameters for Physical Design of Vertical System-in-Package
Electronic Components and Technology Conference, San Diego, USA, 2006

Ramm, P.
3D System Integration: Enabling Technologies and Applications
Invited Paper
Extended Abstracts of the International Conference on Solid State Devices and Materials SSDM 2006, Yokohama (2006)

Richter, M.; Congar, Y.; Nissen, J.; Neumayer, G.; Heinrich, K.; Wackerle, M.
Development of a multi-material micropump
Proc. IMechE Vol. 220 Part C: J. Mechanical Engineering Science, pp. 1619-1624, 2006

Schinkel, M.; Weber, S.; Guttowski, S.; John, W.; Reichl, H.
HF Modeling and Model Parameterization of Induction Machines for Time and Frequency Domain Simulation
Applied Power Electronics Conference,
Dallas, USA, 2006

Schischke, K.; Müller, J.; Reichl, H.
EcoDesign in European Small and Medium Sized Enterprises of the Electrical and Electronics Sector
Record 2006 IEEE Int. Symposium on Electronics and the Environment, May 8-11, 2006, San Francisco

Schneider-Ramelow, M.; et al.
Physics-of-failure-Modelle für Ausfallmechanismen.
In: AVT in der Elektronik – Aktuelle Berichte. Band 3. Hrsg.: W. Scheel, et al. 1. Aufl. 2006

Schröder, H.; Bauer, J.; Ebling, F.; Franke, M.; Beier, A.; Demmer, P. Süllau, W. Kostelnik, J.; et al.
Invited talk „Waveguide and packaging technology for optical backplanes and hybrid electrical-optical circuit boards"
Proceedings Photonics West 2006, 21.-26.1.2006, San Jose, USA; SPIE 6115-6136

Sommer, J.-P.; Döring, R.; Dost, M.; Michel, B.
Advanced Packages with Buried Dies: Design Support by Means of FE Analysis and Deformation Measurement in Micro Scale
Proceedings 4th European Microelectronics and Packaging Symp., Terme Catez, Slovenia, May 22-24, 2006

Steffensen, M.B.; Hollink, E.; Kuschel, F.; Bauer, M.; Simanek, E.E.
Dendrimers Based on [1,3,5]-Triazines
Journal of Polymer Science, Part A: Polymer Chemistry, 44(11), 2006, S. 3411-3433

Töpper, M.; Klein, M.; Buschick, K.; Glaw, V.; Orth, K.; Ehrmann, O.; Hutter, M.; Oppermann, H.; et al.
Biocompatible hybrid flip chip microsystem integration for next generation wireless neural interfaces
Proceedings ECTC 2006, San Diego

Wackerle, M.; Bigus, H.-J.; Blumenthal, T. v.
Micro pumps for lab technology and medicine
Fraunhofer IZM-Munich Proceedings Workshop Micropumps, 24.10.2006, pp. 5-8

Wolf, H.; Gieser, H.;Stadler, W.; Wilkening, W.; Rose, P.; Qu N.
Transient Analysis of ESD Protection Elements by Time Domain Transmission Using Repetitive Pulses
Proceedings of the EOS/ESD-Symposium, Tucson, AZ, USA, pp. 303-309

Yacoub-George, E.; Hell, W.; Meixner, L.; Wenninger, F.; Bock, K.; Lindner, P.; et al.
10-Kanal-Immunosensor zum automatisierten Schnellnachweis von Bakterien, Viren und Toxinen
13. Heiligenstädter Kolloquium, Heilbad Heiligenstadt, 25.09.-27.09.2006

Zoschke, K.; Buschick, K.; Scherpinski, K.; Fischer, T.; Wolf, J.; Ehrmann, O.; Jordan, R.; Reichl, H.; et al.
Stackable Thin Film Multi Layer Substrates with Integrated Passive Components
55th Electronic Components and Technology Conference, May 30 – June 2, 2006, San Diego, Kalifornien USA, pp. 806-813

Patents and Inventions (Selection)

›› *Bauer, M.; Wurzel, R.; Uhlig, C.; Völkle, D. Müller, V.*
Flammfeste, niedrigtemperaturhärtende, cyanatbasierte Prepregharze für Honeycomb-Sandwichbauteile mit excellenten Oberflächen
DE 10 2006 022372.1-43
Gemeinschaftsanmeldung mit Airbus

Bauer, M.; Bauer, J.; Wurzel, R.; Uhlig, C.
Flammfeste, niedrigtemperaturhärtende, cyanatbasierte Harze mit verbesserten Eigenschaften
DE 10 2006 041037.8-44

Bock, K.
Verfahren und Vorrichtung zum Herstellen eines Systems mit einer an einer vorbestimmten Stelle einer Oberfläche eines Substrats aufgebrachten Komponente
United States Patent; 10/861,289

Bruch, R.; Fritzsch, U.; Gessner, T.; Otto, T.; Stock, V.
Verfahren und Vorrichtung zum spektroskopischen Nachweis und zur Bestimmung von biologischen und chemischen Mitteln im nahen und mittleren Infrarotbereich
DE 102004046983

Buchner, R.; Ramm, P.
Verdrahtungsverfahren für Halbleiter-Bauelemente zur Verhinderung von Produktpiraterie und Produktmanipulation
DE 598 10 231

Frömel, J.; Nester, J.; Otto, T.; Geßner , T.
Vorrichtung und Verfahren zur Strukturierung von Materialien, insbesondere mittels Substratbondern
DE 10 2005 041 505

Hacker, E.
Verfahren zum mechanischen und elektrischen Verbinden von Chips und Wafern auf einer Oberfläche
DE 10 2004 015 017

Hacker, E.
Verfahren und Vorrichtung zum Erzeugen elektrischer Kontaktierung zwischen zwei Halbleiterstücken und Anordnung von Halbleiterstücken
DE 103 23 394

Hahn, R.
Battery, especially a microbattery, and the production thereof using wafer-level technology
EP1673834, 2006-06-28

Jung, E.; Thomas, T.
Verfahren zum Gehäusen eines optischen Sensors
Patentnr. 10 2006 059 411.8

Landesberger, C.
Vorrichtung und Verfahren zur elektrostatischen Fixierung von Substraten mit polarisierbaren Molekülen
DE 10 2006 013517

Manke, I.; Ostmann, A.; Becker, K-F.; Reichl, H.
Verfahren zur Erzeugung von Verbindungen in der Mikroelektronik
Patentnr. 103 34 391.1

Ostmann, A.; Jung, E.; Landesberger, C.
Integration eines Chips innerhalb einer Leiterplatte und integrierte Schaltung
Patentnr. 199 54.941.9

Schröder, H.
Substratbauteil mit eingebettetem Lichtwellenleiter und Strahlumlenkung und Verfahren zu dessen Herstellung
DE 10 2004 043 001 B3

Scheel, W. et. al.:
Multilayer Printed Board
Canadian patent C 2395080

Wagner, S.; Hahn, R.; Holl, K.; Kreidler, B.; Krebs, M.; Dejan, I.
Brennstoffzellensystem mit elektrochemischer Wasserstoff-Entwicklungszelle
WO2006111335, DE102005018291 (A1) 2006-10-26

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