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FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM

ANNUAL REPORT 09/10

// FRAUNHOFER IZM

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PREFACE

Fraunhofer IZM is entering a new era in 2010. Professor Herbert Reichl, one of the institute's founding fathers, is retiring. Leadership of the institute will be transferred to the capable and experienced hands of Dr. Lang and Professor Bock, who will jointly head the institute as Acting Directors. Harald Pötter, head of marketing at Fraunhofer IZM, spoke with them about the future of microsystems technology.

Prof. Reichl, you were first appointed Professor at the TU Berlin 22 years ago and founded Fraunhofer IZM 16 years ago. How have your research areas changed over this period?

Prof. Reichl When I first began my work in Berlin, packaging technology for sensors and integrated circuits was very poorly developed internationally. The rapid development in microelectronics led to circuits with over 500 connections. Structures for 20 GHz and above had to be optimized for telecommunications. Power loss rose to over 40 W per chip. Packaging technology wasn't ready for these developments. That's why my first projects in Berlin concentrated on developing software programs for the electrical and thermal characterization of packaging elements. We also developed advanced bonding technologies (e. g. TAB, flip-chip) for multichip modules from the very beginning. Another early research area was solutions for embedding active and passive components in ceramic substrates.

Synergies with the Fracture Mechanics research group at the then Academy of the Sciences in Chemnitz and the Interconnection Technologies group at Humboldt Universität led to Fraunhofer IZM's establishment in 1993. The institute's key focus was building on the research conducted at the TU Berlin by developing and implementing new methods for electrical, mechanical and thermal reliability, as well as interconnection technologies on PCB level and environmental engineering.

Heterointegration has brought us to the point where we are now redefining our understanding of system integration. In joint projects with industry we have to develop application-oriented and manufacturable solutions more quickly than before. This changes our approach. If before everything revolved around technology, which gave the impetus for new development, and the application was the final destination, today the application determines what the technology has to look like.

1 *Prof. Herbert Reichl, Director of Fraunhofer IZM*

This trend is particularly obvious in the integration of electronics in textiles, where traces and interconnection elements are now being manufactured using textile manufacturing technologies.

What do you think the future of microelectronics in Europe holds and which topics will become more important for the international microelectronics sector over the next 10 years? In which areas do you expect ground-breaking changes?

Dr. Lang Microelectronics will continue down the road from »More Moore« to »More than Moore« successfully and resolutely. Research will focus on multifunctional systems (smart systems), even more than on VLSI digital components. Heterointegration will play a decisive role. Relevance to applications will become even more important in this. Semiconductor companies and users will have to cooperate more closely in the future from the very beginning of the product development process. This trend is a chance for European semiconductor manufacturers to move ahead of international competition by means of customized solutions developed in cooperation with customers. Whereas previously the most successful semiconductor manufacturers were those that excelled in developing standard processes, in the future manufacturers with system competency, who can translate the customer's wishes into complex products flexibly, competently and above all quickly, will lead the pack. Thanks to the strong user industry in Germany and Europe as a whole, local and regional semiconductor manufacturers will enjoy excellent conditions for development.

Prof. Bock A lot of research and development will go into multifunctional microsystems. Heterointegrated plastic microsystems, innovative functional-layer and additive processing will also become more important, because they help reduce the cost of manufacturing and system integration. One example is multifunctional-on-top technology (MOTT). Adding additional functional layers on standard silicon or MEMS components increases the value of industrial system solutions. Such systems can also be flexibly developed and manufactured on standard wafer sizes for many different application areas. Primarily heterointegrated hybrid organic systems will be commercially released in the area of polytronics and in the medium term products will contain almost completely organic integrated systems in applications such as driver electronics and electronic controls for flexible displays. In the long term we're also going to see large-area systems and plastic MEMS.

1

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1 *Dr. Klaus-Dieter Lang*

2 *Prof. Karlheinz Bock*

Which challenges and research areas will become more important at Fraunhofer IZM in the future?

Dr. Lang As already mentioned, we'll be putting more focus on relevancy to systems and applications. Increasing reliability, integrating sensors and actuators, as well as the miniaturization for and adaptation to defined build spaces, will continue to be central research foci. Key technology areas will be 3D integration on wafer-level, system-in-package solutions for module integration and embedding technologies. In 2009 we began operating a continuous processing line for multifunctional boards that can be easily translated to industrial manufacturing. With the establishment of the All Silicon Systems Integration Dresden (ASSID) research group, we also have a continuous processing line for 3D silicon system integration on wafer level that can be easily transferred to industrial manufacturing. The federal government, the government of the land Saxony and the European Union are providing substantial funds for equipment infrastructure, without which this expansion of IZM's skills and services wouldn't be possible.

Prof. Bock Our MOTT research in Munich rounds off this work in 3D integration. The combination of our research into polytronics and biosystem integration with silicon and MEMS technologies is going to create notable synergies for multifunctional 3D system development in the near future. Several of the European Commission's and Bavaria's integrated projects will make significant contributions to this in the coming years. We'll be fostering networked local cooperation between companies and research institutes (open innovation) to support this research. We are going to want to expand our technology center in Munich and intensify our cooperation with partner institutes. We had a lot of success in this area too in 2009. We were able to extend our cooperation with the Universität der Bundeswehr in Munich beyond MOTT to polytronic systems. Thanks to funding by the Free State of Bavaria, we also expanded our cooperation with Universität Regensburg on chemical sensor materials.

How has the economic crisis affected your institute and what chances and risks does it represent in the future?

Prof. Reichl As research partner of the capital goods sector we've of course also been affected by the downturn this year. Our returns from contracts with industry declined markedly. As the world economy and tendency to invest improves, our customers can expect a return to growth in 2010. As a consequence, we also expect demand to normalize.

The reduced demand was cushioned by an increased interest in new technology and innovative system solutions. Even during the economic crisis, new and innovative product development seems to be a means of remaining competitive internationally. Here we also have to thank our staff, who found creative ways to compensate for the situation with a lot of commitment and innovation. This drive was supported in particular by the federal government's research programs, as well as the Länder Berlin, Brandenburg, Saxony and Bavaria.

We'd like to sincerely thank our customers and funding bodies for this faith in our abilities even at an economically difficult time, and hope that our report will inspire you to embark on new, exciting collaborative projects.

Your

THE FRAUNHOFER-GESELLSCHAFT

Fraunhofer IZM is one of 58 Fraunhofer Institutes conducting applied research predominantly in the realm of science and engineering, because research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. 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.

Facts and Figures
At present, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 59 Fraunhofer Institutes. The majority of the 17,000 staff are qualified scientists and engineers, who work with an annual research budget of 1.6 billion euros. Of this sum, more than 1.3 billion euros is generated through contract research. Two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Only one third is contributed by the German federal and Länder governments in the form of base 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.

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

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787–1826), the illustrious Munich researcher, inventor and entrepreneur. To foster a joint presence on the R&D market Fraunhofer has pooled the competences of institutes working in related subject areas in the Fraunhofer Groups Defence and Security, Information and Communication Technology, Life Sciences, Materials and Components, Microelectronics, Production, Surface Technology and Photonics. Fraunhofer IZM is part of the Fraunhofer Group Microelectronics and closes the gap between wafer and application.

FRAUNHOFER GROUP FOR MICROELECTRONICS

The Fraunhofer Group for Microelectronics VμE has been coordinating the activities of Fraunhofer Institutes working in the fields of microelectronics and microintegration since 1996. Its membership consists of twelve institutes as full members and three as associated members, with a total workforce of around 2,700 and a combined budget of roughly 255 million euro. 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.

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

- Semiconductor technology
- Communication technologies

and application-orientated business areas:

- Ambient Assisted Living
- Energy Efficient Systems and eMobility
- Entertainment
- Light
- Security

Within the Fraunhofer Group for Microelectronics Fraunhofer IZM is your partner for packaging and smart system integration.

The central office of the Fraunhofer Group for Microelectronics coordinates all activities, working closely with the member institutes to forge durable contacts between science, industry and politics. Members are the Fraunhofer Institutes IAF, IDMT (guest), FHR, IIS, IISB, IMS, HHI, FOKUS (guest), IPMS, ISIT, IZFP (guest), IZM, ESK, ENAS and the Fraunhofer Center CNT.

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YOU CAN COUNT ON US: FRAUNHOFER IZM

System integration
Life without electronics is unimaginable. More and more products have sensors, which receive signals from the environment, electronically process these and then display the processed information graphically on navigation devices or send it on to other technical processes, such as thermostatic control units. Users hardly even notice the sophisticated electronics involved as technology is rapidly becoming indistinguishable from the product. However, to continue this trend, electronic designs have to be extremely miniaturized, robust and durable – all part of the work carried out by the Fraunhofer Institute for Reliability and Microintegration IZM under the heading »electronic packaging«.

Electronic packaging:
smaller – more cost-effective – more reliable
We develop electronic packaging, technology that is often invisible to users and often underestimated. Electronic packaging is at the heart of every electronic application; it interconnects the individual components, protects the electronic systems against vibration and moisture and dissipates heat reliably. In short, it ensures that electronics continue to function reliably in even the harshest conditions.

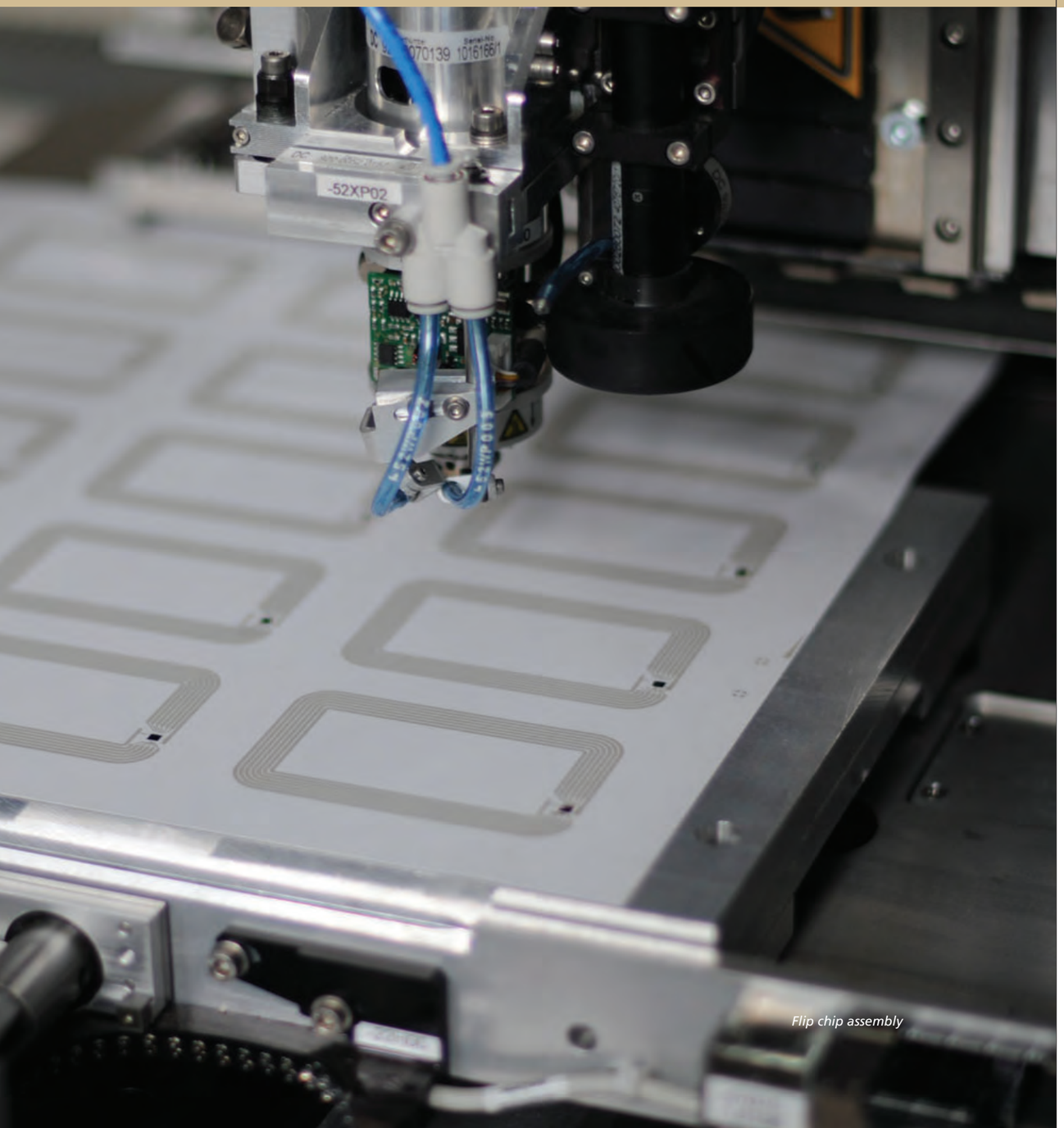
Thanks to modern packaging technologies ICs thinner than a sheet of paper can be processed. This means that the entire electronics comprising a hearing aid are so small that they can be simply hidden in the ear itself.

Clever packaging also reduces the manufacturing costs for complex electronic systems. Together with partners in industry, we are assembling the next generation of radar sensors so cost-effectively that even compact executive cars will benefit.

But what would be the point of all this if these systems do not function reliably?

Our research ensures electronic systems are designed to be more reliable, so that we can accurately predict life-cycle. We test electronic systems under conditions that are as close as possible to real-life operation and get them ready for integration into applications – from wafer to system level, irrespective of the operating environment.

Cutting-edge research with tradition
Fraunhofer IZM has enjoyed an extremely successful track record since its establishment in 1993 from the research groups of the TU Berlin's key research area Technologies of Microperipherics, Humboldt-Universität and the previous Institute for Mechanics at the Academy of the Sciences in Chemnitz. It currently has four branches in Berlin, Munich and Oberpfaffenhofen, with 251 full-time employees and 150 PhD candidates, apprentices and Diplom students.



Flip chip assembly

OUR STRENGTH:
COOPERATION WITH INDUSTRY

Secure integration technologies for ID documents of the future

In the future, just one document, such as an identity card, will be used in both the physical and digital world to uniquely identify an individual. But a prerequisite for this is equipping such documents with new security technologies at a number of different levels, such that an electronic ID itself is able to verify the identity of a user. Such a card must have all information and components required for comprehensive verification and authentification. It also has to be able to confirm not just itself and the operational reliability of the integrated components, but also the identity of the respective document holder in parallel. Since this would make transmitting biometric data redundant, identification processes would not just be faster, but also more secure.

To achieve this vision, more complex, high-functionality systems have to be integrated into chip cards that include not just the chip but also displays (e. g. OLED, e-ink), switches, passive components and biometric sensor technology. Each of these electronic, mechanical and biochemical components represents an innovative security characteristic. Despite the clearly higher complexity and functional density, researchers hope to maintain the conventional chip card's dimensions and mechanical stability. However, this is not longer possible using conventional technologies and materials. Ultra-thin components and functional layers have to be produced and optimized. Bundesdruckerei and Fraunhofer IZM have been collaborating in a number of projects since 2005 to develop and qualify the necessary three-dimensional integration processes and material combinations.

Two joint projects have already been completed, in which new high-security packaging technology to integrate ultra-thin, flexible silicon chips in chip cards was developed and analyzed. As part of the projects, the first functional prototypes of eID documents with integrated crypto-controllers were manufactured and tested.

In July 2007, the jointly operated Security Lab was established at Fraunhofer IZM's Smart System Integration Application Center. The lab is used for all aspects of this research, from analysis and ongoing development of these technologies, right through to manufacturing.

Visionary developments, which will lead to 3D-integrated microsystem components for the chip cards of the next two generations, are underway together with other Fraunhofer institutes as part of Fraunhofer's »Secure Identity Berlin-Brandenburg« Innovation Cluster, which was established in 2009. One topic being investigated is the integration of flexible OLED displays and biometric sensors. Other innovative security materials and assembles for the preventing unauthorized manipulation of circuits are also being researched and developed. The end result will be a world-first – a »system-on-card«, tamper-proof eID.

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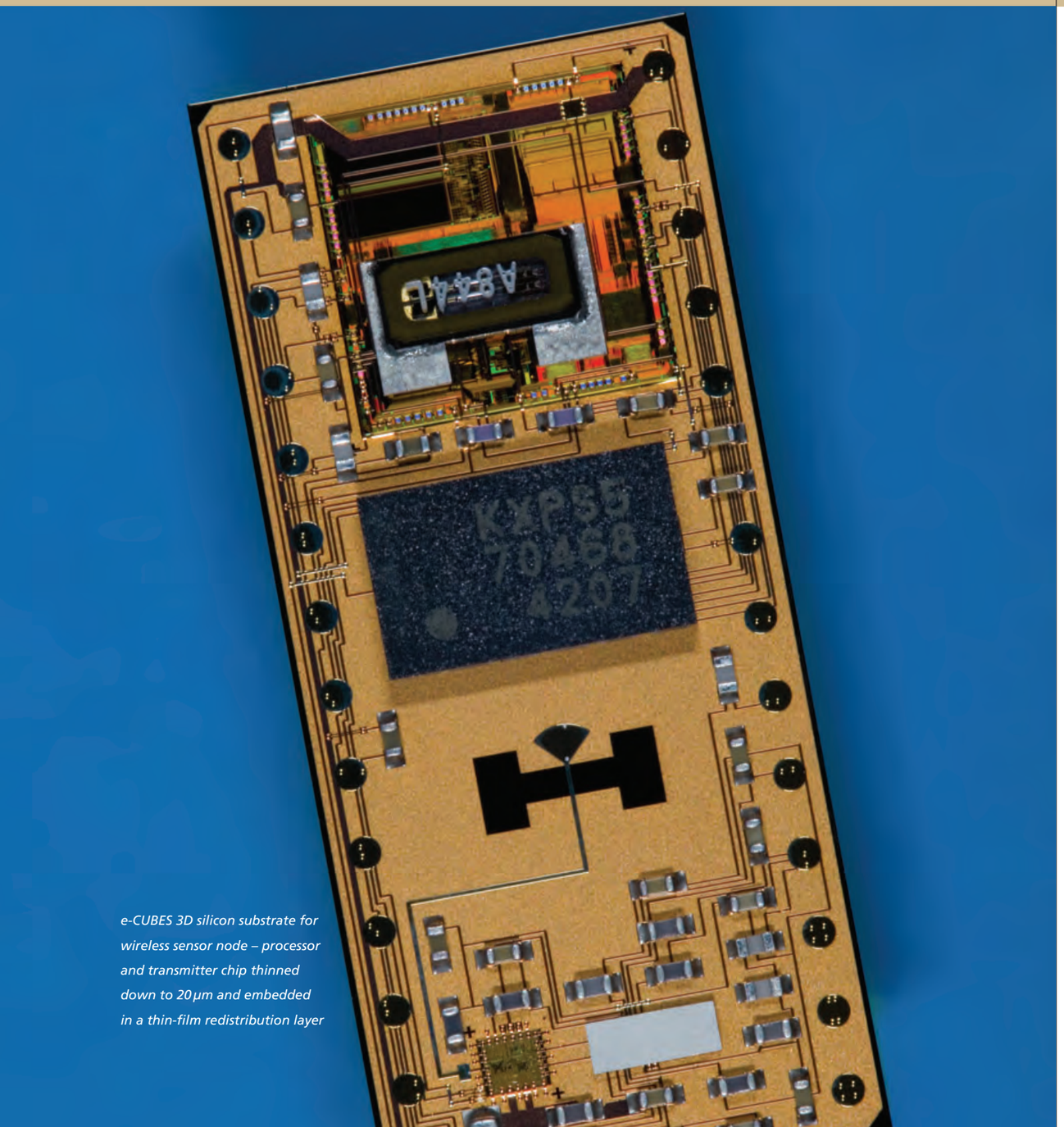

e-CUBES 3D silicon substrate for wireless sensor node – processor and transmitter chip thinned down to 20 µm and embedded in a thin-film redistribution layer

OUR COMPETENCE:
FROM ASSEMBLY CONCEPT TO MANUFACTURE

e-CUBES – 3D thin chip integration technology for wireless sensor nodes

3D technologies open up many possibilities for integrating chips in microelectronic systems and miniaturized wireless sensor nodes. One contribution to this area was recently made by the European collaborative project e-CUBES (IST-026461), which developed microsystem technologies for cost-effective realization of highly miniaturized, truly autonomous systems for ambient intelligence. In the project heterogeneous integration technologies were used to combine wireless communication interfaces, antennae, sensors, microprocessors and power provision into a sensor node, which was in turn developed into a demonstrator for wireless activity monitoring.

The thin chip integration technology (TCI) developed at Fraunhofer IZM was used as a starting point for the development. Ultra-thin chips were embedded into a multi-layer thin-film routing on a large substrate chip at wafer level in the e-CUBES project. Two variations were developed - either integrating an ASIC chip into a redistribution layer on a sensor wafer or integrating various thinned chips into an interposer substrate wafer. The advantage of the new technology is that the 3D chip stacks can be manufactured using well-established process steps and standard back-end equipment already in place for conventional redistribution and other wafer-level packaging technologies.

Using advanced grinding and etching technologies IZM researchers in Munich have designed a process with which CMOS chips can be thinned down to a thickness of 20 to 40 microns at high yield. Based on this process thin chip integration was used in collaboration with Philips Applied Technologies in Eindhoven to realize a technology demonstrator that wirelessly measures activity for health and fitness applications. The demonstrator can continuously measure body parameters such as temperature, heart rate and kinesics and can be worn in close proximity to the body. In addition to the sensor node, a silicon substrate with integrated thinned µ-processor, 17-GHz transmitter chip, antenna, flip-chip and SMD components measuring just 8x18mm² were developed. In detail, the main features of the integrated 3D stack include:

- MSP430 µ-processor and 17-GHz transmitter chip (each 20-µm thick) embedded into the thin film redistribution layer
- 7-GHz oscillator bare-die flip-chip component
- SMD crystal on top of an embedded µ-processor
- Integrated passives:
- NiCr thin-film resistors
- Cu-BCB-Cu capacitors
- Balun coils in a demonstrator version for external oscillator signal input
- Aperture-coupled microstrip antenna
- 0201 SMDs and 3D accelerometer SMDs assembled on the integrated Si substrate

Apart from Philips Applied Technologies, Philips Applied Research and Fraunhofer IZM's contributions, the project partners IMEC in Leuven Belgium and the University of Uppsala Sweden designed the substrate layout and antenna, respectively.

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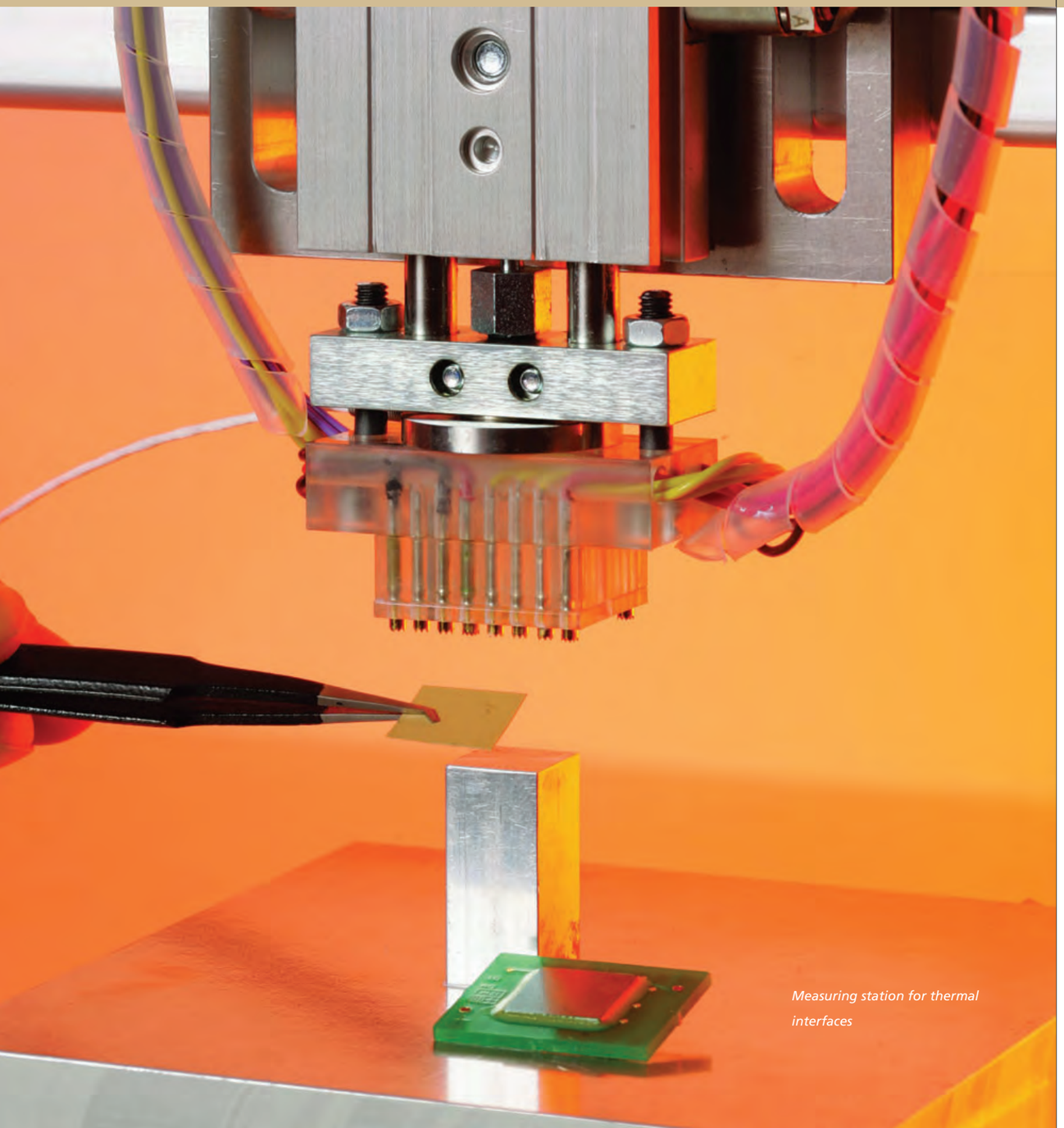

Measuring station for thermal interfaces

OUR SERVICE:
FROM MATERIAL CHARACTERIZATION TO RELIABILITY ANALYSIS

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

Our laboratories include:

- Training center for interconnection technologies (ZVE)
- Flip chip line
- Die and wire bonding center
- Reel-to-reel application center
- Micromechatronics center
- Process development and qualification for the electronics encapsulation
- Qualification and test center for electronic components (QPZ)
- Electronics condition monitoring laboratory
- Laboratory for thermomechanical reliability

We cover a broad spectrum of technologies, from material characterization, to support in manufacturing questions, through to assistance with quality and reliability problems throughout the value chain – and thus deal with all possible problems that can arise in the manufacture of electronics.

Our outstanding laboratories for reliability testing and optimization include:

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

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Qualification and Test Center (QPZ) for Electronic Components
The Qualification and Test Center focuses on application-specific qualification of new solder alloys and packaging solutions for electronic components on a wide variety of substrates. All tests are carried out according to DIN EM, IEC, IPC and MIL standards. Component inspections and failure analyses after testing include the investigation of structural alteration, intermetallic phase growth, crack propagation using metallography, SEM/EDX analysis or focused ion beam (FIB) preparation.

Troubleshoot component failure with online assistance from Fraunhofer IZM
QPZ is now offering online, optical failure analysis based on the IPC-A-610 standard. The new service provides companies that experience component failure during manufacturing or shortly after deployment in the field with fast, sound advice on the component problem and its possible cause.

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

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300 mm through silicon via (TSV) processing at Fraunhofer IZM ASSID

LABORATORY-HIGHLIGHT 1

FRAUNHOFER IZM ALL SILICON SYSTEM INTEGRATION CENTER DRESDEN ASSID

3D system integration is one of the most important strategic key technologies for microsystem integration and microelectronics in general. 3D wafer-level system integration technologies can be used to combine very different components such as sensors (MEMS), processors, memory and transceivers in highly miniaturized 3D microsystems. Apart from the high degree of miniaturization this kind of system integration provides, it also has tremendous advantages in terms of functionality and electrical system efficiency as evidenced by extremely fast signal processing and reduced dissipation loss.

Scientific research and development around the world is currently striving to develop 3D technologies and adapt them for industrial applications and product implementation. One major area in 3D systems is through silicon vias (TSVs) for active and passive devices, and various TSV integration schemes with copper metallization are currently in development. TSV technology, in combination with multilayer RDL and adjusted interconnect technologies, allows the shortest electrical connections between vertically designed, functional layers or devices.

A special focus is the qualification of this technology as an integrated process flow for 8" and 12" wafers.

The Fraunhofer IZM All Silicon System Integration Dresden (ASSID) Center in Dresden is equipped with a 200/300 mm TSV RDL wafer process line that meets the requirements of wafer-level 3D system integration, including copper TSV technology, high-density multilayer thin-film technology (RDL), wafer thinning and handling technologies (temporary bonding/debonding), wafer-level bumping (ECD), wafer-level assembly and chip stacking. Using this 300 mm TSV process line in combination with defined and qualified technologies 3D product demonstrators and prototypes can be quickly designed and fabricated. Fraunhofer IZM-ASSID is also involved in all Fraunhofer IZM's 3D integration activities and provides the entire breadth of support required to develop 3D wafer-level systems, as well as specific process developments for material and equipment suppliers and end users.

In overview, Fraunhofer IZM-ASSID provides the following services:

- Cu-TSV interposer technology,
- High-density Cu-TSVs for active and passive device integration,
- Wafer-level multilayer redistribution technology (CSP),
- Wafer-thinning and thin-wafer processing,
- Wafer-level bumping, assembly and stacking.

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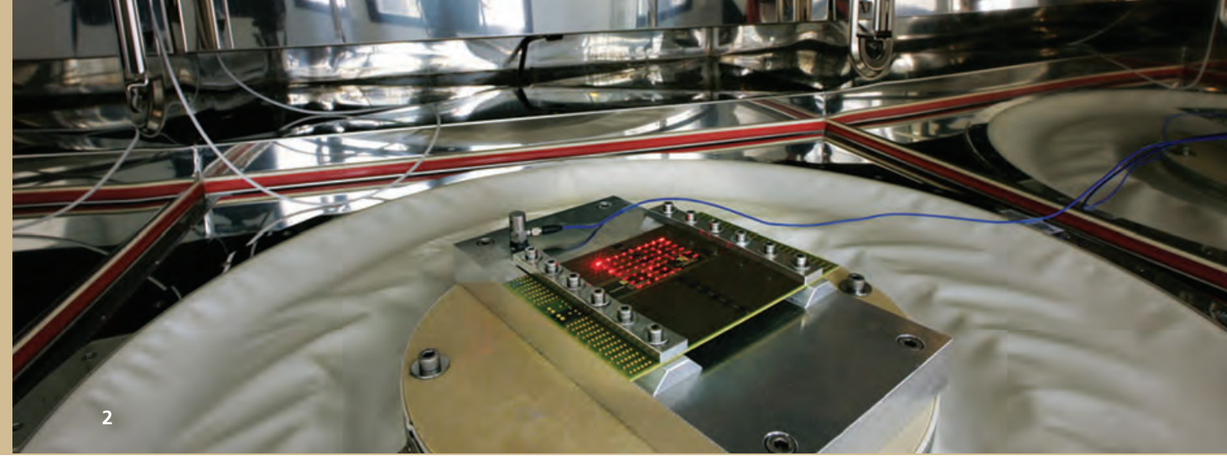

LABORATORY-HIGHLIGHT 2
PCB PROTOTYPING PROCESS LINE

Fraunhofer IZM works hard to develop innovative processes for embedding electronic components and realizing ultra-fine line structures, as well as new technologies for substrate manufacturing such as stretchable and flexible circuits.

The department System Integration and Interconnection Technologies has recently designed and installed a new prototyping and process line for these technologies. Using the new equipment, substrates with a maximum size of 610 mm x 456 mm can be continuously processed.

The process line features the following:

- High-precision component placement
- Vacuum lamination press for multilayer fabrication and component embedding
- UV laser drilling and structuring
- Mechanical drilling and milling
- Photolithographic patterning using laser direct imaging and dry-film photo resist
- Horizontal spray development of ultra-fine line structures
- Horizontal spray etching and photoresist stripping
- Automatic and manually operated galvanic equipment

As the equipment forms a continuous processing line the technology can be easily transferred to conventional industrial manufacturing environments. Moreover, it is also flexible enough to be adapted and varied for the development of new technologies. The department now plans to cooperate with a wide range of suppliers on the further development and qualification of process materials and chemicals that can be used with the equipment.

New analysis and quality assurance technologies are also now available. These include optical microscopy with digital imaging, an electrical »flying probe« tester with 6 needles for electrical testing and a high-precision optical measurement system for measuring structure size and component position.

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1 *Process line for substrate manufacturing*

2 *Fraunhofer IZM's test stand for combined loading, including temperature (cycling), moisture and vibration*

LABORATORY-HIGHLIGHT 3
ELECTRONICS CONDITION MONITORING

High availability and low failure rates are increasingly important prerequisites for durable electronic products and a benchmark for green IT. As miniaturization and the integration of more and more functions continues, electronic systems are becoming more complex, and thermal and mechanical stresses rise due to the increasing proximity of electronics to mechatronic systems.

Electronic condition monitoring methods can be divided into three categories:

- Condition measurement by means of parameter variation
- Condition calculation using physical failure models
- Condition indicators

Measuring changes in cross-sections of electrical connections
Improved online measurement techniques are being developed for the early detection of cracks and constrictions in electrical connections. The goal is determining even the smallest changes in the contact cross-section.

By identifying the so-called S-parameter correlation factor (in GHz) or by passive intermodulation distortion measurement (PIM, in MHz), changes in contact cross-sections of just 20 % can be detected.

Such online crack detection can be used to identify failures early in the field or in lifetime tests, as well as in manufacturing as part of quality assurance processes.

Simulation and testing of failure behavior under field conditions
Stresses like moisture, temperature (cycling) and vibration occur simultaneously in the field. By understanding material behavior under combined loading, failure models that describe the interdependent effects of temperature cycling and vibration can be developed.

Development of monitoring structures
Monitoring structures are a main component of condition indicators and are tuned using technological processes to react to one or several stresses more sensitively than the monitoring system and thus fail at an earlier timepoint (canary principle). Together with suitable failure sensors and analysis, they then form the condition indicator.

Condition monitoring is indispensable for ensuring the reliability and safety of electronic systems. Fraunhofer IZM is participating in the innovation cluster »Maintenance, Repair and Overhaul in Energy and Traffic« (www.innovationscluster-mro.de), as part of its focus on condition-based maintenance.

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COOPERATION WITH UNIVERSITIES

To effectively realize its research targets Fraunhofer IZM has formed strategic networks with universities in Germany and abroad. The following pages provide an overview of our most important cooperation projects.

Cooperation with Technische Universität Berlin
Fraunhofer IZM's cooperation with Technische Universität Berlin has been close and productive since the institute's establishment. The collaboration originated with TU Berlin's Forschungsschwerpunkt Technologien der Mikroperipherik (key research area Technologies of the Microperipheries). The latter was founded by the university in 1987, with support from the then German federal ministry for research and technology and the Berlin senate. Headed by Professor Herbert Reichl, it became one of the world's first research institutes for assembly and interconnection technology.

Since the founding of Fraunhofer IZM in 1993, Professor Reichl has headed both research institutes, allowing him to foster intensive scientific exchange between the two. In the area of smart system integration, the two partners pursue the same aim, namely, to integrate components that may have been manufactured using very different technologies on or in a single carrier substrate. The advantages are higher flexibility and yield at lower costs along with high integration densities.

In 2008, Professor Dr. Karlheinz Bock from Fraunhofer IZM's Munich branch was appointed as Professor of Polytronic Microsystems. This allowed Fraunhofer IZM to intensify its cooperation with the TU Berlin, both in terms of research content and staff. Research in the emerging field of polytronic microsystems focuses on the manufacturing and characterization of technological surfaces and boundary layers for polymer components, in particular, bonding processes for different types of metal, organic conductors and semiconductors.

In pursuit of these joint goals, the Forschungsschwerpunkt, in cooperation with Fraunhofer IZM, is focusing on basic research into assembly and interconnection technology for sensors, microelectronics and microsystem technology.

1 *TU Berlin's university library*

Key areas of research include:
- Materials and processes for integration technologies on wafer, chip and substrate level
- Polytronic microsystems
- Thermomechanical reliability and material characterization
- Sustainable technologies
- System design and modeling

Fraunhofer IZM also supports teaching at Technische Universität Berlin by offering students additional seminars and the opportunity to participate in national and international research projects.

H-C3: Human Centric Communication
The Human Centric Communication Center, H-C3 for short, opened its doors in February 2009. Goal of this TU Berlin initiative, in which more than 50 TU Berlin departments and 11 other research institutes are participating, is to facilitate the general public's intuitive access to and handling of growing amounts of information by developing suitable hardware and software technologies. Five PhD candidates from Fraunhofer IZM and the Forschungsschwerpunkt are working on five different research areas dealing with technological, economic and sociological aspects of human communication. Specifically, the researchers are developing design and integration technologies for the assembly of the required hardware, as well as energy management technologies for autarkic sensor networks.

New technology center with Universität der Bundeswehr
Fraunhofer IZM researchers in Munich have been running a center for multifunctional on-top technologies (MOTT) with Universität der Bundeswehr (UniBwM) since 2009. Led by Prof. Dr. Ignaz Eisele, the center is combining sophisticated silicon technologies with cost-effective system heterointegration. This type of modular system approach will lead to a system based on standard silicon wafers, on which non-CMOS-compatible functionalities such as very high frequency components, optical components or sensors and actuators can be mounted in a modular fashion.

The synergies resulting from Universität der Bundeswehr's experience in standard CMOS technologies and Fraunhofer IZM's packaging know-how for system integration will make new, technologically innovative products possible.

INTERNATIONAL RESEARCH COOPERATIONS

Heterogeneous Technology Alliance (HTA)
Together with other Fraunhofer institutes and leading European microelectronics research bodies (France's CEA-Leti, Switzerland's CSEM and Finland's VTT), Fraunhofer IZM is participating in the Heterogeneous Technology Alliance (HTA). The research partners are working on joint research topics and responding to European tenders to extend their edge over international competitors. The alliance is combining its know-how under the title »4-Labs« for joint research projects that provide customers one-stop solutions for innovative products. The first cooperation projects with industry were initiated in 2009.

Further information: www.hta-online.eu

German-French research cooperation fort the development of a miniaturized, reusable analysis system
One example of the many international cooperation initiatives is the 3µP Project (3µP – multi-reaction, multi-sample microfluidic platform). The Fraunhofer IZM scientists intend to develop a cost-effective microanalysis system for health care together with colleagues from the Fraunhofer Institute for Cell Therapy and Immunology IZI in Leipzig and France's FEMTO-Innovation Carnot Institute. The lab-on-a-chip technology means that fast and cost-effective blood analysis will be possible right in the GP's practice, avoiding the delay of having to send the samples to a specialist laboratory. The process combines conventional microfluidics with so-called electro-wetting, in which a drop of fluid can be precisely moved and placed by manipulating its surface tension. The 3µP project is only one of 11 German-French research initiatives just off the starting block in Paris. Their goal over the next three years is to develop technologies that can be translated into industrial products., a strategy that is expected to increase Germany and France's international competitiveness.

The cooperation is being co-funded to the tune of 10 million euros annually by the German federal ministry of education and research (BMBF) and France's Agence Nationale de la Recherche. The program will initially run for three years.

3DASSM – a collaboration between industry and science
Together with the Korea Advanced Institute of Science and Technology (KAIST, Daejeon, South Korea) and the Packaging Research Center (PRC) at the Georgia Institute of Technology (Atlanta, GA), Fraunhofer IZM (Berlin) has established the global R&D industry consortium »3D All Silicon System Module« (3D-ASSM). The consortium aims to develop and research basic technologies for silicon-based 3D systems. Particular research foci include:

- Application-specific through-silicon via technologies for highly reliable and optimized silicon systems
- Silicon-based high-density wiring systems with integrated passive components
- Stacking and mounting of thinned high pin-count circuits on wafer level for maximum integration densities
- Reliability-optimized interconnection systems designed for material-specific parameters and application prerequisites
- Design of 3D systems and optimization of electrical parameters

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

Two IZM researchers were seconded to Salt Lake City from 2006-2008 to provide their expertise on-site. Since 2008 Fraunhofer IZM has also been funding a research position at the University of Utah for the analysis of biocompatible packaging technologies and is developing new universal interface models for the implants together with the university. Along with the research projects initiated since 2005 with funding from the National Institutes of Health (NIH), cooperation with industry has also been intensified. Here, IZM is providing its integration technologies in projects developing intelligent catheters and electronic assemblies for behavioral research. Apart from medical technology, the institute is also involved in new projects researching miniaturized camera optics and opto-electronic components.

EMC-3D-Consortium
Fraunhofer IZM is a technology partner in the international Equipment Materials Consortium 3D (EMC-3D). The group consists of 10 companies and 5 research institutions whose mission is to rapidly develop a cost-effective and manufacturable TSV (thru-silicon-via) for 3D chip stacking and MEMS integration. Within the EMC-3D-Consortium Fraunhofer IZM is responsible for the process integration.

Some of Fraunhofer IZM's other university partners:
University of Tokyo
Humboldt Universität zu Berlin
Technische Universität Dresden
Technische Universität Chemnitz
Technische Universität Bergakademie Freiberg
University of Bonn
Mittweida University of Applied Sciences
Zwickau University of Applied Sciences
Brandenburg University of Technology
Lausitz University of Applied Sciences
University of Rostock

COOPERATION WITH FRAUNHOFER IZM

YOUR BRIDGE TO FRAUNHOFER IZM TECHNOLOGIES

Regardless of whether you are already using electronic packaging technologies or are planning to invest in it; Fraunhofer IZM Marketing and the Application Center Smart System Integration offer the support and collaboration you require to reach your development aims.

Fraunhofer IZM Marketing – employing advanced technology is the key to investing in the future
You already know what kind of technology you want to employ and would like to make sure you will be harnessing the latest trends? You are familiar with the technology but need assistance in development, failure analysis or with optimizing your products? We can provide consultancy from the Fraunhofer IZM research department by organizing workshops and technical discussions.

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

Application Center (APZ) Smart System Integration – Remain one step ahead by employing cutting-edge technology
You want to upgrade your products but have not yet invested in microsystem technology or only use it to a limited extent? Despite this, you would like to make use of our know-how and technology in system-in-package and system integration? The APZ Smart System Integration links industry with Fraunhofer IZM's wider activities, including active support by the German Ministry for Education and Science.

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

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

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

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

FRAUNHOFER IZM MARKETING

You face problems in developing your product and need advice but lack contact with research facilities? You would like to expand your know-how with the help of a special technology workshop or directly benefit from our technological expertise?

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

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

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

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

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

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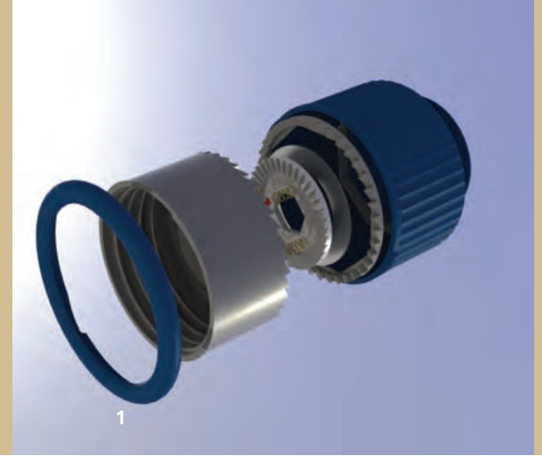

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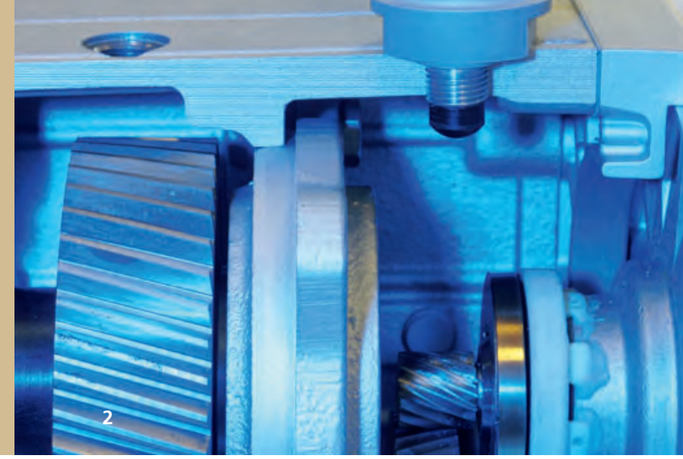

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APPLICATION CENTER SMART SYSTEM INTEGRATION

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

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

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

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

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

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

Safety in the great outdoors: the Kid-Finder
The Smart System Integration Application Center turns great ideas into great applications. Together with Potsdam's Schmidt engineering firm, the center has developed the Kid-Finder, a device for localizing persons using the wide coverage of the GSM network combined with the precision of GPS localization. Concerned parents will be able to check where exactly their child is by simply sending an SMS. The software program developed by the Schmidt engineering firm for the graphical mapping can used on both PCs and mobile devices.

But the Kid-Finder has even more tricks up its sleeve. Parents can also define a specific geographic zone and are automatically alerted if the child leaves the area. This is particularly useful for parents that work. as they are only informed if their child deviates from his or her normal school route. The device can be attached to a gaming console, which motivates children to carry it with them, and has a battery that lasts up to two days.

The battery can also be recharged using the console. The localization functions can be deployed from the gaming console itself, which opens up the opportunity for designing a range of new games.

Safety in the lab
Together with the company Angewandte System-Technik GmbH in Bavaria's Wolnzach and colleagues from IZM Oberpfaffenhofen's Micro-Mechatronic Center (MMZ), the Smart System Application Center has developed a mechatronic locking system that prevents unauthorized access to bottles and other containers. The locking system comprises an intelligent seal that can only be opened using a special opening system and a chip card for identifying the user.

As a first step, the feasibility, quality and functional requirements and target costs were determined and evaluated. Here, all special requirements were considered, including that the caps be replaceable, cost-efficient and seal tightly. Other prerequisites were also integrated into the design, such as accurate logging of when the containers are opened and assigning authorization to specific groups. In the subsequent development phase, a customer sample was manufactured. Already at this stage, the device was able to log all data necessary to monitor access and identify the users and containers by means of RFID. To ensure the systems can be manufactured cost-efficiently, the seal mechanics were designed without the need for a separate energy supply. Instead the energy required to operate the system is induced by the opening system.

The result is an electronic screw cap that increases process safety thanks to a smart integration of electronics into existing processing chains.

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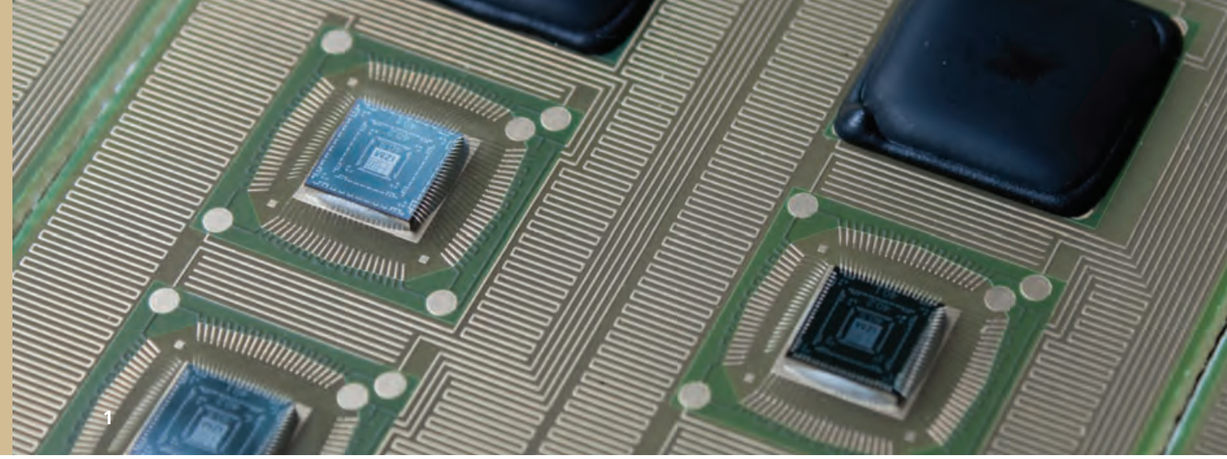
1 *Intelligent bottle cap*

2 *Integration of energy-autarkic sensors into a gear shaft*



WORKSHOPS 2010

Regular workshops at the Application Center Smart System Integration
We are holding several workshops again this year, focusing on transferring know-how from our experts to you.

You have a choice of three different kinds of workshops.
- Workshops on latest international technological trends focus on current technological developments with regard to designing future technology.
- Workshops on trends for medium-sized businesses present fully-developed technologies already in application.
- Hands-on-workshops combine market-relevant knowledge transfer with practical work in the laboratories or at machines.

Depending on demand we offer workshops in the different categories.

Please contact us if you are interested, we will tell you the dates for coming workshops and we will also be happy to organize individual events for your company.

For more information, go to
www.apz.izm.fraunhofer.de/bau/index.php?events

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[1] Workshop immersion silver
The workshop gives an overview of current trends in system integration. Immersion silver as finish with the strongest rates of growth will be introduced. The second part gives an in-depth insight into relevant technologies, starting with soldering and adhesive bonding on immersion silver up to Au-TS wire bonding and encapsulation.

What will you learn?
- Trends und requirements in printed circuit board technology
- Technological basics and results of practical tests
- Reliability and practical examples

Potential participants: Technicians, managers and designers.

[2] 3D integration for medium-sized companies
Current developments and trends in 3D integration technologies are presented. Special attention is being paid to the needs of medium-sized companies.

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

Potential participants: international packaging experts from all industry sectors.

[3] Concepts and technologies for power electronics
From design through assembly and interconnection to reliability analyses this workshop provides a comprehensive overview of power electronics.

What will you learn?
- Design and electromagnetic compatibility
- Assembly and interconnection technology
- Encapsulation
- Analytics
- Thermal management and reliability

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

[4] System-in-package
This workshop is designed to discuss international research and development trends in the area of system integration.

What will you learn?
- SIP-design, wafer-level integration
- Substrate-level integration
- Interconnects, assembly and packaging
- Reliability

Potential participants: international packaging experts from all industry sectors.

[5] Flip chip assembly – a high-volume technology reaches SMEs
Different flip chip assembly processes will be presented. In the practical part participants can gain hands-on experience with industry-scale equipment in small groups.

What will you learn?
- Technological basics
- Equipment and process chain
- Manual assembly with fine placer, reflow soldering, underfilling
- Quality assurance and reliability testing

Potential participants: technology-oriented small and medium-sized companies.

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

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

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

1 *COB assembly on PCB with immersion Ag surface finish*

RESEARCH ACTIVITIES AND OBJECTIVES

INTEGRATION ON SUBSTRATE LEVEL

System Integration & Interconnection Technologies

- New solders, adhesives, wires and bumps
- Electroless redistribution, wafer level assembly, wafer level molding
- Bumping technologies (electroless Ni/(Pd)Au, stencil printing, mechanical stud or ball bumping)
- Deposition and specification of functional layers (galvanic, electroless)
- Flip-chip technologies (soldering, adhesive joining, thermo-compression and thermosonic welding)
- Die attachement (soldering and adhesive joining)
- Wire and ribbon bonding (ball/wedge, wedge/wedge, heavy wire and ribbon)
- Flip-chip underfilling and COB glob topping
- Transfer molding of flip chip, COB and component on lead-frame devices
- Potting and conformal coating, hotmelt encapsulation
- SMD, CSP and BGA assembly
- Integration of passive (printing technique) and active devices (chip in polymer, chip in textile)
- Optical fiber and planar waveguide coupling, fiber lenses and laser welding
- Electro/optical board and fiber-optic sensor systems
- Thin glass and silicon photonics packaging
- Materials and technologies for chip-on-board, power electronics and high temperature applications
- Low temperature assembly and interconnection technology
- Reliability investigation of interconnection technologies, e. g. electro-migration, interdiffusion and fatigue
- Qualification of PCB packages, analysis of manufacturing failures and failed joints
- Training Center Packaging and Wire Bonding (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 Centre (Reel to Reel)
- Heterointegration of multifunctional sensor systems for »ambient assisted living« (AAL)
- Sensor systems for life science applications
- Analysis and test of integrated systems

PCB Soldering Training / Qualification and Micro Mechatronics

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

INTERGRATION ON WAFER LEVEL

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

High Density Interconnect & Wafer Level Packaging

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

MATERIALS, RELIABILITY AND SUSTAINABLE DEVELOPMENT

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)

Environmental Engineering

- EcoDesign integrated into product development
- Material evaluation
- Innovation and technical analyses
- Energy harvesting and MST
- Condition Monitoring for electronics
- Reliability tests using combined loading
- Design of condition indicators

SYSTEM DESIGN

System Design & Integration

- Technology oriented product design for autarkic systems and sensor networks
- Efficient design methodologies for systems based on advanced packaging technologies (SiP, MCM…)
- Design & implementation of highly miniaturized advanced systems (advanced RFID, wireless sensor networks, energy harvesting systems…)
- Design and manufacturing of power electronic systems with a strong relation to packaging design & characterization
- Physical and mechanical co-design of packages and heterogeneous micro- & power electronic products including 3D-visualisation
- Field theory-based methods for modelling & analysis of electromagnetic reliability (EMR) issues (signal/power integrity, EMI/EMC…) in electronic packaging
- Methods for antenna design & integration
- Modelling methods for mesoscopic & nano structures
- Design & characterization of filters and passive RF front-end components
- Electromagnetic compatibility (EMC) of power electronic systems
- Application and Optimization of piezoelectrical components and systems (piezoelectrical transformers, actuators, energy harvesting)

Micromechanics, Actuator and Fluidics

- Simulation of microfluidic actuators
- Design and development of microfluidic components and systems
- Micro dosage technology for liquids and gases
- Assembly and text of components and systems
- Application specific development in lab technology, lubrication dosing, drug delivery, fuel cells and many more
- Microfluidic actuators for tissue engineering

RESEARCH CLUSTER INTEGRATION ON SUBSTRATE LEVEL

Spray etching of PCB structures

System Integration & Interconnection Technologies **Page 40**

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PCB Soldering Training / Qualification and Micro Mechatronics **Page 46**

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INTEGRATION ON SUBSTRATE LEVEL


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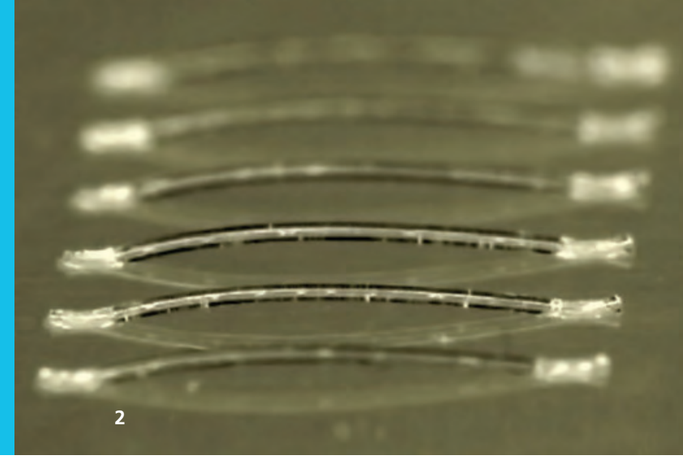
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Due to increased demand for high-performance but cost-efficient solutions, extended functionalities are also integrated at package or module level using established technologies. This allows our developers to integrate several components into one package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

HIGHLIGHT 2009

Cost-effective optical bonding technology for lasers, LEDs and detectors

Fraunhofer IZM is researching a new optical interconnection technology that promises to be extremely cost-effective and feature a high level of automation. The new process involves fiber-based coupling on module- and board-level for multimodal applications in communications and sensor technology.

Bonding thin optical fibers to the optical interface ensures the process is as cost-effective as possible. The bonding processes are based on those used in wire bonding and are being developed for the optical polymer fibers on modified, automatic wire bonders.

A thick-wire bonder with a 60 kHz sonotrode is used for the wedge-wedge bonding. A friction-induced melting process is employed to weld the fibers and/or the coating. The joining process benefits from the fact that the substrate's temperature does not increase very much, because bonding at too high a temperature causes the bonding site to cool too slowly, which in turn leads to the bonder's movement creating instable loops. By adapting the loop geometries and the thick-wire bonding and cutting parameters, a fully automatic process is possible for various loop geometries.

A thin-wire bonder is used for the ball-wedge bonding. The fiber feedthrough was modified and the bonding tools were adapted for the ball formation. Mechanically applying the fiber tips to a hot plate proved to be the best way to form the ball among the various other options, including laser or gas flame.

As is the case in wedge-wedge bonding, ultrasonic power is used to create the ball bond. Similarly to wire bonding, the joint quality can be measured using shear testing, however, the failure mode is also recorded.

To optically characterize the coupling geometry, a measuring assembly was developed in which the positions and angles of the transmission and receiver fibers could be varied. In the case of vertical coupling (e. g. VCSEL, LEDs) extremely good values of 1 to 2 dB were only obtained for ball bonding; wedge bonding proved more suitable for horizontal coupling, such as for edge emitters and particular types of LEDs.

Ray-tracing simulations confirmed the determined coupling efficiencies for both ball and wedge bonding. The best coupling efficiency was achieved using the ball geometry. Wedge bonds were demonstrated as unsuitable for coupling light, but perform very well as output coupling elements. Wedge bonds modified introducing reflecting surfaces showed excellent optical characteristics depending on the fiber assembly and the type of modification. For example, using a 45° edge achieved excellent in-coupling efficiency.

Future projects will prepare the process for commercial release and demonstrate it in sensor and data communication applications.

The scientific pilot project, KOBOLD (grant number 13N9943), is being funded by the Federal Ministry of Education and Research (BMBF).

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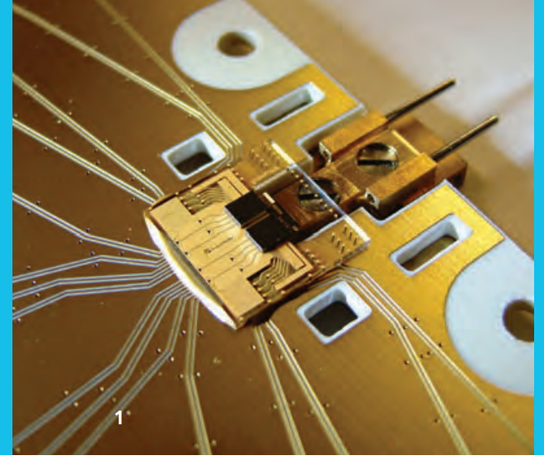
1 *Ball bond*

2 *Polymer fiber bonds fabricated using fully automatic thick-wire wedge/wedge bonding*

// INTEGRATION ON SUBSTRATE LEVEL

SYSTEM INTEGRATION & INTERCONNECTION TECHNOLOGIES



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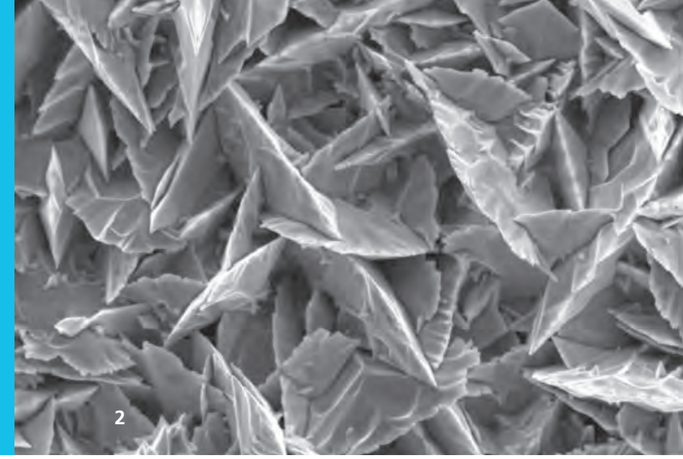

2

DEPARTMENT

The System Integration and Interconnection Technologies (SIIT) department with its 100 scientists and technical staff offers services ranging from consulting to process development and systematic technological solutions.

The department develops processes and materials for interconnection technologies on board, module and package levels, as well as for integrating electrical, optical and power-electronic components and systems.

Our main focus is interconnection and encapsulation technology for electronic packaging, such as:

- New solders, adhesives, wires and bumps
- SMD, CSP and BGA and flip chip assembly
- Die attachment (soldering and adhesive joining)
- Wire and ribbon bonding (US, TS, heavy wire and ribbon)
- Flip chip underfilling and COB glob topping
- Transfer molding of flip chip, COB and component-on-lead-frame devices
- Potting and conformal coating, hot melt encapsulation
- Chip embedding
- Optical fiber and planar waveguide coupling, fiber lenses and laser welding
- Thin glass and silicon photonics packaging

TRENDS

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

Our work on trends in future applications extends to:

- Design of multifunctional boards and interconnection technologies
- Heterogeneous packaging of system in packages (SIPs), such as MEMS, ICs, opto, RF and passive packages, and 3D-SIPs with embedded components and power ICs
- Evaluation of new surface materials for low-cost assembly technologies
- High and low temperature interconnection technologies
- Miniaturized electronics for modern medical diagnostic and therapeutic technologies
- Integration of ultra-thin chips in foldable flex modules, multilayer and security cards
- Alternative solder and sinter technologies for power module assembly
- Multifunctional packages and substrates based on thin glass layers
- Technologies for optical chip-to-chip interconnects
- LED modules and white light conversion

RESEARCH HIGHLIGHTS

Nanoporous metal contacts
Our department is applying new interconnect technologies for high-temperature and power electronics based on sintering and transient liquid phase bonding. We are also using a compressible interconnect method based on nanoporous gold for low-temperature and low-pressure sintered flip chip bonds.

Crystalline surfaces
We have developed a new galvanic method for the generation of 3D, elevated crystalline gold structures. The structures have nano-tip profiles and a stable, widened basis and are suitable for integration in a wide range of applications, particularly microsystems and microcomponents. One example is so-called Au-shark teeth structures, which can be joined using compression at room temperature. These flip chip bonds are ultra-flat (< 10 µm) and highly reliable. Furthermore, these surfaces perform excellently as interfaces in cell biology and chemical sensor technology.

High-temperature soldering
We are developing new solder materials and metallizations that can be used at higher operating temperatures. Experiments using electroplated Fe have shown that intermetallic phase growth between Fe- and the Sn-based solders is much less than that with Ni and Cu. Furthermore, Fe is an effective diffusion barrier for transiently liquid solder. This is especially useful at very high operating temperatures, for which no known Sn-based solder alloy is suitable. We are also researching new alloys that solidify isothermally during soldering, such that the bond is only formed during the process itself, and has a higher remelting temperature.

Wire bonding technologies
In a world first, we have been able to prepare and visualize fatigue cracks and the grain structure in the interface of heavy wire bonds on power semiconductors after active power cycling tests. This research is being carried out as part of a doctoral dissertation and is providing fundamental insight into and mathematical models of this interconnection technology's reliability. The technology is currently state-of-the-art for power-module assemblies, and is used for applications such as power converters or drivers.

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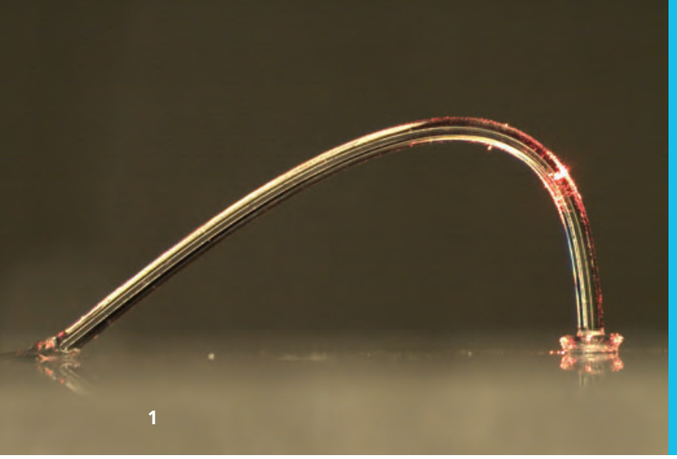
1 *4 x 10 Gbit/s transceiver with 1cm² footprint assembled on evaluation board with standard MT-ferrule for optical fiber ribbon connector*

2 *Crystalline Au-shark teeth structures*



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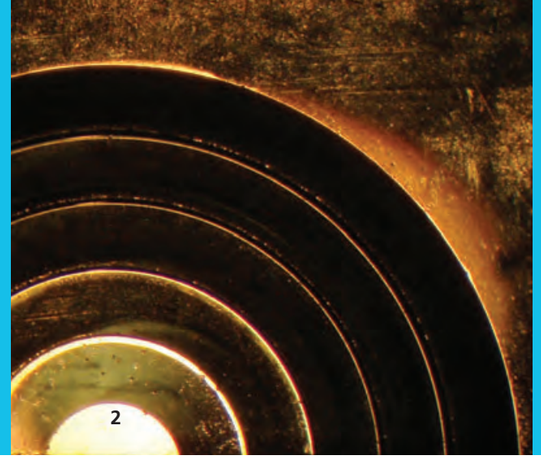

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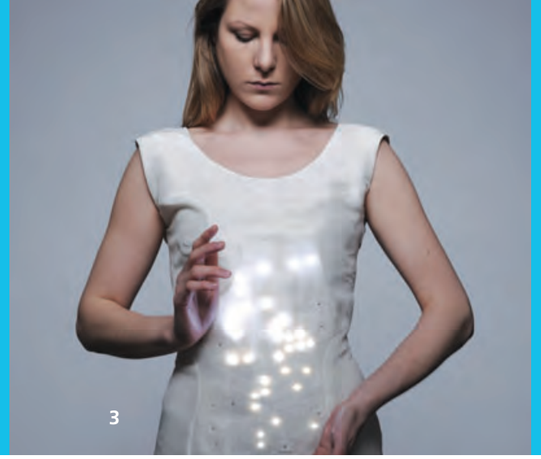

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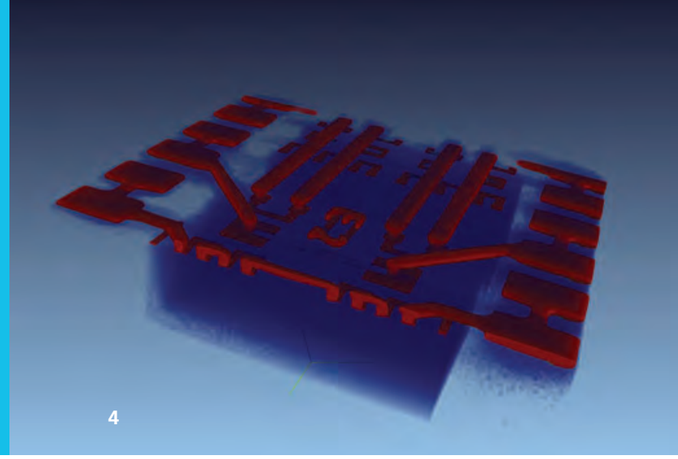


4

In the area of interconnecting alternative materials, we were able to demonstrate successful bonding of polymer optical fibers (POF) and polymer surfaces using customized wedge/wedge- and ball/wedge-bonding processes.

The optical characteristics of a ball contact bonded using the technique were comparable to those of commercially available optical plug systems. The potential of an optical interconnection technology based on wire bonding is being investigated as part of the program Optical Technologies, funded by the Federal Ministry of Education and Research (BMBF) (grant number 1N9943).

Assembly and encapsulation technologies

Our research into encapsulation tech-nologies has focused on highly accurate, contactless material deposition using jetting pro-cesses and nano- and micro-functionalized materials. Here, high-viscosity materials (1 Pas to > 300 Pas) have been successfully employed.

Advances in analysis techniques with regard to reaction kinetics, rheological and diffusion-related material characterization have allowed us to gain a better understanding of polymeric material processing and device reliability.

A 3D multisensor module (e. g. pressure, acceleration, magnetic field, gear rate) for consumer electronics as well as industrial and transport applications was realized by advancing embedding processes like chip-in-polymer/chip-in-duromer. Topics such as wafer-level encapsulation and through mold vias (TMV) were investigated as part of this research.

3D wafer-level assembly

Three chip-to-wafer (C2W) technologies were established:

- Flip chip assembly on interposer wafers
- Permanent die bonding for thin-film embedding
- Chip-to-wafer reconfiguration for wafer-to-wafer bonding

The technologies were demonstrated using pitches down to 40 µm and more than 3000 chips per wafer for ICs, MEMS and optoelectronic components.

Glass-based electro-optical interposer for high-speed SiP

An active interposer for high-speed communication modules with optical interconnects on glass substrate was recently developed at Fraunhofer IZM. The new technology is a milestone in the institute's glass packaging research and development strategy (glassPack), which is harnessing the excellent optical, electric, chemical and mechanical properties of glass for new packaging. The interposer comprises glass wafers with through glass vias (TGV) and optical interconnects. Compatible technologies, such as ion-exchange, laser drilling, electroplating, fusion bonding and direct optical butt coupling, are combined for this optoelectronic SiP. The high-speed components (VCSEL array and driver circuit, PIN diode array and TIA) are flip chip mounted to support high frequency design.

The goal of our ongoing development is to make glass-based packaging competitive with polymer- (e. g. chip-in-polymer) or silicon-based packaging (e. g. through silicon vias, stacked dies using wire bonding). The new 4 x 10 Gbit/s transceiver has been designed to allow scalability. The optical waveguides on transceiver side are integrated by means of ion exchange and interconnected using standard MT ferrules to couple fiber ribbon cables.

LED modules and white light conversion

UHB LEDs for general lighting or headlamps are limited by their thermal performance. We have developed technologies with thin interconnects and low thermal resistance using AuSn solder and sintered Ag. Wavelength converter tapes with homogenous white light were integrated in LED packages.

Medical microsystems

Medical microsystems promise to improve the lives of many patients with chronic diseases or disabilities. However, microsystems in the medical field have special requirements. They have to perform reliably over long time periods, be comfortable for the patient and allow the addition of extra functionality at a later time.

Microtechnology can now meet all these requirements, and modern assembly and packaging techniques are used to keep the features of the integrated system as small as possible. The techniques used include bare-die assembly processes, embedded component processes, as well as protective, biocompatible encapsulation processes.

As part of Fraunhofer IZM´s participation in the Fraunhofer Ambient Assisted Living (AAL) Alliance, MMS is spearheading research into the innovative integration of monitors and sensors into everyday materials and applications.

Systems-on-flex

We have developed new processes for integrating stretchable printed circuit boards in fabric. Within the project Klight various intelligent garments were created in cooperation with students from the Berlin University of Arts (UdK Berlin). The system comprises sensors (acceleration, light and strain), controller modules and an LED array. The project won Techtextil 2009's Avantex-Innovation-Award.

A passive RFID module with display was developed as part of Pariflex, a project funded by the Federal Ministry of Education and Research (BMBF). The 50 µm-thick ICs were assembled on flexible interposers to ensure the module is as thin as possible, and then integrated in printed circuit boards as 6-IC chipsets.

1 Coupling of red laser light into a ball/wedge bonded optical interconnect (POF)

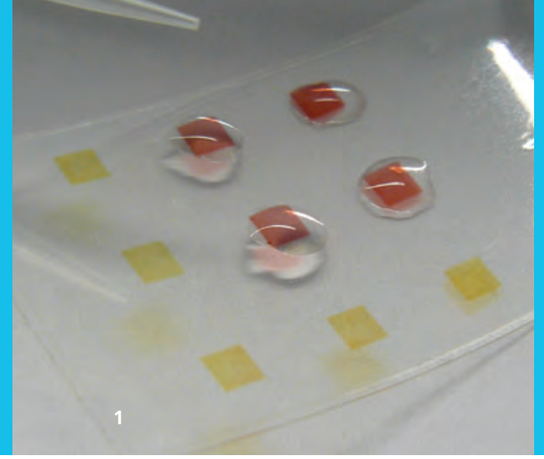
2 Design on replicated lens for twilight optical sensor

3 Pneuma dress: The wearer's breathing pattern gives the lighting impulse for the electronics integrated into the dress

4 Mold wafer-level 2-chip package with laminated redistribution layer

// INTEGRATION ON SUBSTRATE LEVEL

POLYTRONIC SYSTEMS



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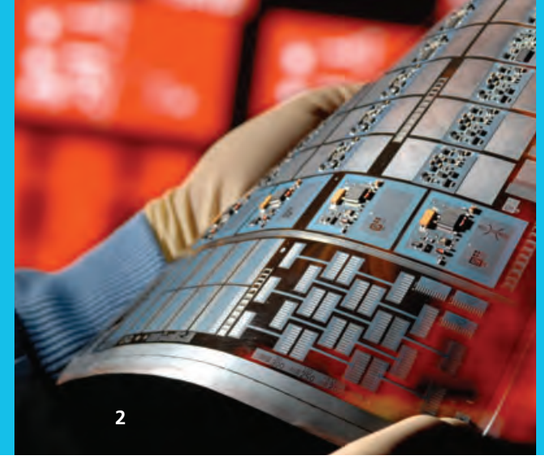

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DEPARTMENT

The department Polytronic Systems develops components and heterointegration technologies for large area electronics, particularly ubiquitous systems. We combine electronics with sensors, batteries and microfluidic systems and are expert in the fabrication of electronics and sensors based on organic semiconductors (polymer electronics). We have established low-cost reel-to-reel processes on flexible substrate materials such as plastic films or paper as key manufacturing technologies in our facilities.

Our department's application center provides unique opportunities for developing and producing flexible systems using industrial equipment. A key aspect of our approach to heterointegration system design is advanced manufacturing processes for thin silicon substrates. These substrates cover the full range of thicknesses, from commercial dimensions through to flexible silicon of less than 10 - 30 µm. We have combined the related fabrication processes into a closed thinning, handling and separation technique.

Our department also researches nanotechnologies, such as nanocontacts (nanolawn), surface programming and self-organization for chip assembly.

TRENDS

Ubiquitous systems in human-based ambient assisted living (AAL) environments require cost-effective multi-functional distributed systems. The electronics have to be manufactured cost-efficiently in large volumes on large area substrates. By combining autarkic sensor networks with RFID technology we have already been able to supply new applications for logistics, processing and medical technology.

Today's flexible systems usually consist of a single wiring layer with moderate functionality, but in the future they will comprise complex multilayer systems with increased functionality. Heterointegration of functional layers such as sensor films or polymer electronic circuits on foils will also improve sensor functionality and lower production costs. Even thinned, flexible high-performance silicon chips will be able to be integrated in such multilayer systems.

Our department is conducting extensive research in the technologies required to achieve such complex systems, including coating, patterning and microfabrication. These results can then be translated to customer-specific, tailored industrial manufacturing solutions in the reel-to-reel application center.

RESEARCH HIGHLIGHTS

To extend our department's skills and know-how in new materials and sensor layers the Fraunhofer research group »Sensor materials«, funded by the Land Bavaria, began working at the University of Regensburg in September. The group focuses on R&D of multifunctional sensor dyes, sensor paints and nanoparticles for analytical applications. Fluorescent nanosensors can be used to measure Na+, Cl-, pH and O_2 in living cells and microorganisms. By immobilising sensitive indicator dyes in polymer films, we can monitor sugars, alcohols and amines continuously. Our current aim is to obtain a stable and flexible optical array-type sensor foil for pH measurements, which we are pursuing by researching the lamination and patterning of cellulose films. We will then be able to produce smart sensor systems in foil by adapting these materials to reel-to-reel processing technology and polymer electronics.

We are also working towards new technologies for assembling different functional foils and components while ensuring good electrical and mechanical interconnections for the manufacture of autarkic and flexible electronic systems, such as smart labels. The required heterointegration techniques on plastic film have already been developed and demonstrated in the Fraunhofer Smart Plastic project. Here, an autarkic signage system was presented, which integrated organic photovoltaics, flexible batteries, electronics for energy management, plastic film display elements and a sensor interface on a foil substrate.

Our research and development in nanotechnology has resulted in a new type of low-temperature interconnection technique for contacting silicon chips electrically. Nano-scale lithography and through-mask electroplating on bond pads produce nanostructures that can be fused at low temperatures by pressure, ensuring good electrical interconnections. Substantially higher integration densities were achieved compared to the use of other techniques, such as flip chip.

The department has also developed novel bipolar mobile electrostatic carriers based on silicon wafers. For the first time, electrical charging and activation were carried out via contact pads on the reverse side of the wafer. This is a crucial milestone for the development of handling techniques compatible with industrial production for very thin silicon wafers. The new E-carrier has successfully demonstrated that the electrostatics work reliably at up to 300 °C for wafer handling.

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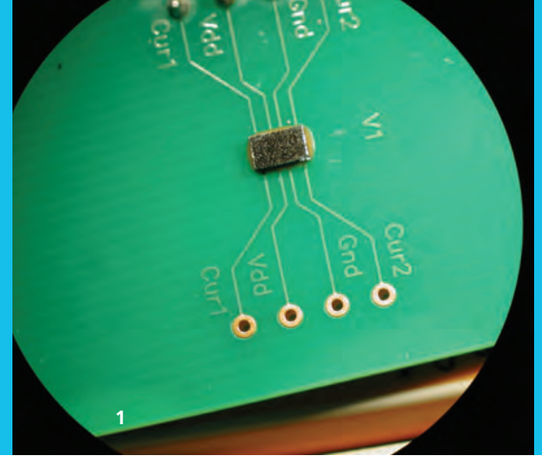
1 *pH-sensitive foil array*

2 *Heterointegration of electronic components on flexible foils*

// INTEGRATION ON SUBSTRATE LEVEL

PCB SOLDERING TRAINING / QUALIFICATION AND MICRO MECHATRONICS



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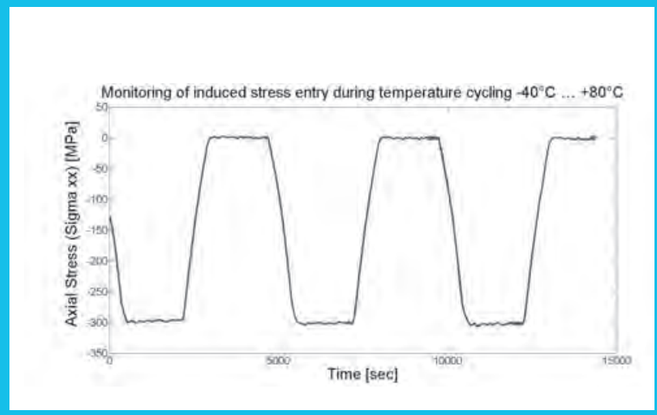

DEPARTMENT

The Micro-Mechatronics Center (MMZ) and the Center for Electronics Interconnect Technology (ZVE) are both located at the Fraunhofer IZM site Oberpfaffenhofen.

The competencies of MMZ cover design, development and rapid prototyping of electronic systems on novel substrates. New concepts for adaptability of package structures to various applications are evaluated. This includes a comprehensive design-flow for setup and packaging of chips, combining both electrical and mechanical properties of systems with structure simulations.

ZVE evaluates interconnect technologies for electronic components with enhanced reliability requirements under demanding environmental conditions. This ranges from customer-specific system qualifications through to structural and electrical reliability tests and failure analysis of single electronic components. Additionally, practical training courses for standard and novel soldering techniques are provided, as are courses on solder-free interconnect technologies.

In 2009, the Oberpfaffenhofen site was accredited as an IPC-training center.

TRENDS

Integrating electronic systems also affects applications fundamentally – form and function begin to merge. Industry sectors such as the aerospace, medical, and automotive branches prefer lightweight, integrated, low-cost, but nevertheless highly reliable alternatives to the conventional functional modules, which may comprise several individual components, screwed, glued, or pinned together.

Our goals include:

- Product qualification innovations for electronic systems that bridge various technologies
- Setup of non-planar electronic and mechatronic systems
- Development of novel substrate materials for system packaging
- Integration of electronics into heterogeneous synthetic-metal-composites
- New approaches to time- and cost-efficient in-situ monitoring of critical parameters in product qualification
- Development of novel reliability and quality criteria for heterogeneous composites of materials and functional blocks
- Adaptation of training courses to future needs

RESEARCH HIGHLIGHTS

Innovative LED-fabrication technology: the map type cavity molding concept
LED technology is undergoing an exciting transition from technology-driven development towards being a fully-fledged option in the lighting market. Although improving electrooptical conversion efficiency was the main development goal for a long time, nowadays cost reduction in fabrication technology has the highest priority. A map type molding concept was developed in the project ForPhoton, which provides 100 sites for grid-like assembly of high-precision LEDs on a square FR4-substrate (40 mm x 40 mm). The setup is realized using a 500 µm mold cap with cavities for integrating 100 LED beam conditioners. In a subsequent fabrication step, the mounted LEDs are diced into single components. The map type cavity molding concept reduces fabrication costs for high-precision micro LEDs. For STM Sensor Technologie München GmbH in Neubiberg, this innovation is a further step towards high-reliability, low-cost mass fabrication of high-precision LEDs.

Smart safety: microelectronic seals
The microelectronic seal is a sophisticated interlock system that only grants access to authorized individuals. Led by the Smart System Integration Application Center in Berlin, researchers in Oberpfaffenhofen have been developing this technology with Angewandte System-Technik GmbH, a medium-size company in Wolnzach, Bavaria. The intelligent seal was developed using a micro-mechatronic approach, and the system is based on mechanical and electrical components interacting with data processing algorithms. In principle, the development is suited to all sorts of containers equipped with seals. The system would simply have to be fine-tuned for the specific application requirements. Furthermore, the micro-electronic seal does not require external power and has been designed for cost-efficient mass fabrication.

In-situ monitoring for product qualification: the stress measuring chip
Initially developed in the BMBF project iForceSens, the CMOS stress measuring chip has become central to many potential application fields. The test chip comprises piezo-resistive structures, with which principal and shear stresses can be quantified during mechanical/thermal loading on electronic systems. Time is money, and product development cycles are continuously accelerated in the electronics industry. Applying the stress measuring chip, in-situ parameter monitoring speeds up product qualification, as the time-consuming analysis of the causes and effects of failures can be carried out more quickly. Interruptions to the fabrication flow (involvement of external analysis labs, several optimization loops, locking out of product failures) can be avoided. Currently, the CMOS stress measuring chip is being adapted for stress-monitoring of microchip and MEMS component temperature cycling and packaging processes.

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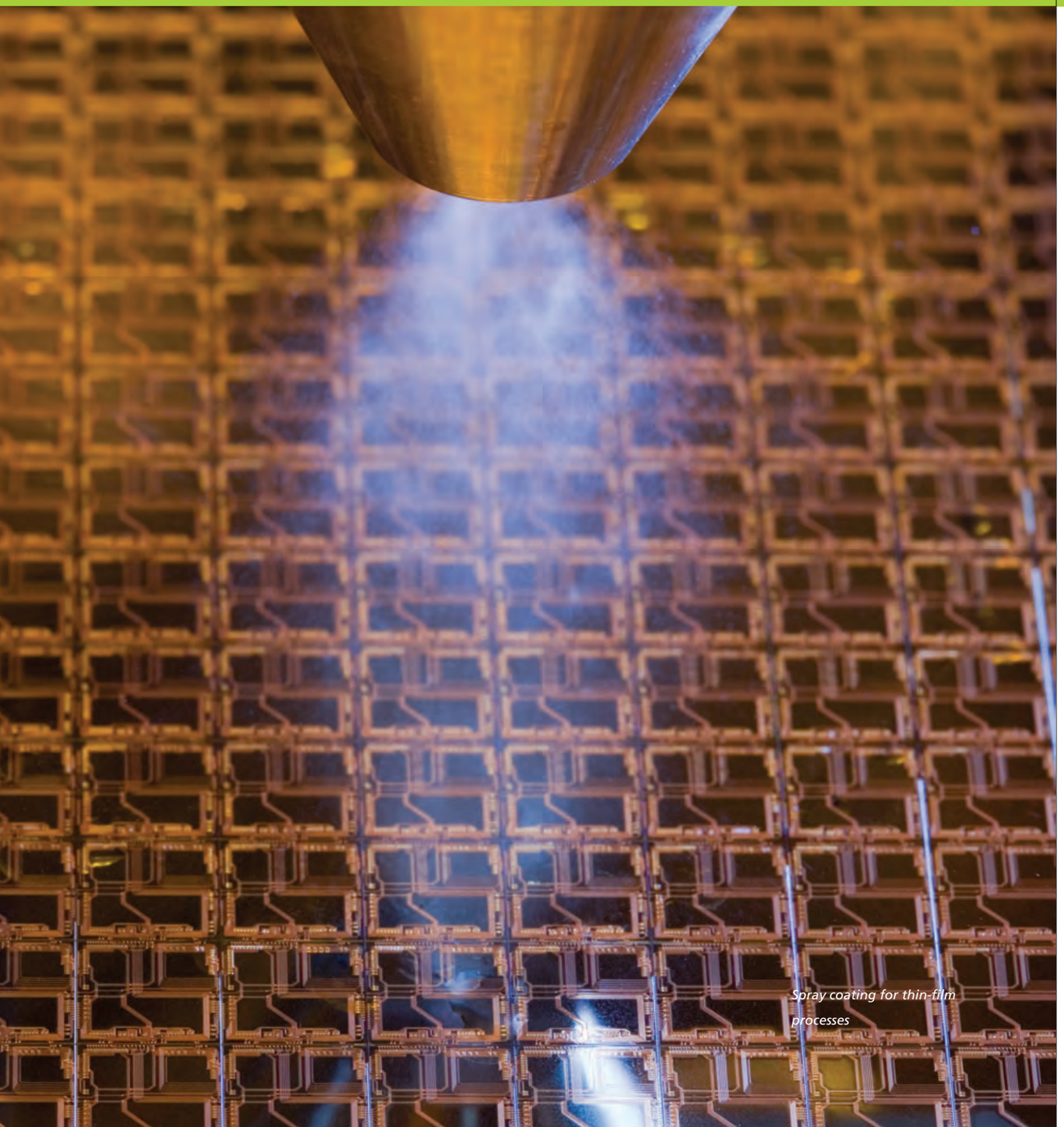
1 *Application of the CMOS stress measuring chip: investigation of a microchip package's structural integrity under temperature load*

RESEARCH CLUSTER INTEGRATION ON WAFER LEVEL



Spray coating for thin-film processes

Si Technology & Vertical System Integration **Page 52**
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High Density Interconnect and Wafer Level Packaging **Page 54**
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Nano-Materials & Devices **Page 56**
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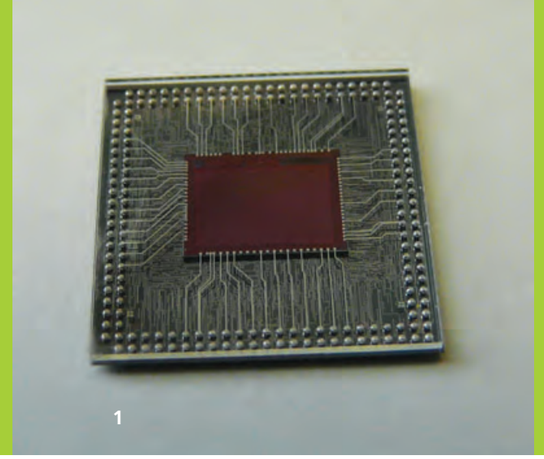
INTEGRATION ON WAFER LEVEL



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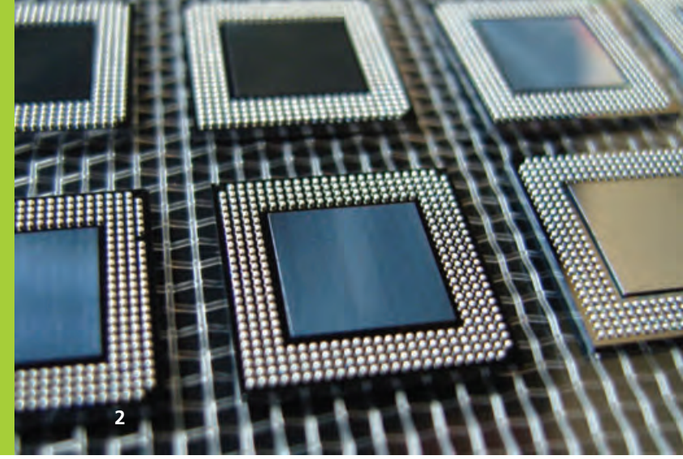

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The highest integration densities possible in heterogeneous assemblies are achieved using wafer-level integration. All processing steps are carried out at wafer level after the actual front-end processes have been completed. The packages we develop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

HIGHLIGHT 2009

3D System integration technologies in the development of an image sensor

3D system integration has opened up new means of realizing microsystems for a wide range of applications. Its most compelling advantage is the ability to combine very differently manufactured components into highly functional, highly miniaturized overall systems using heterogeneous integration, while at the same time improving electrical performance.

One example is an image sensor processing system that can evaluate image data in extreme environmental situations, such as high-contrast ratios, using a specific image sensor device and an adopted digital signal processing unit (ASIC). In a joint research project funded by the federal ministry of education and research (BMBF), Fraunhofer IZM, Infineon and Fraunhofer IIS have together developed and manufactured a functional 3D image sensor system, which is designed to be used in automotive applications such as driver assistance systems (DAS).

Infineon developed a special ASIC for the signal processing, which is combined with the sensor component into a miniaturized overall image sensor system. This was performed using silicon interposer technology comprising the silicon interposer with electrical through-silicon vias (3023 TSVs), adjusted thin-film wiring (two metal redistribution layers, RDL), and adapted micro-solder bumps (SnAg), which serve as the interconnect structures to the sensor and processor unit. The image sensor was mounted on a glass carrier with a redistribution layer using flip chip technology. To complete the overall system, both components (glass carrier with image sensor device and interposer with image processor) were interconnected using solder preforms (SnAg).

Figure 1 shows the front (sensor) of the final overall system, which has a size of 14 x 14 mm^2. Both the redistribution layer and interconnect solder balls on the interposer are visible. Figure 2 shows the backside of the complete system. The interconnection layers were designed to ensure that the system can be assembled on a suitable organic substrate carrier, as for a ball grid array (BGA). With 50 µm thickness, the TSV silicon interposer is the thinnest element in the overall system. It is held mechanically stable by the glass carrier with the flip chip-assembled image sensor.

The 3D system integration concept allows easy adjustment of the overall system construction if modified components or re-designed devices are to be incorporated. Thus, standardized components can be easily integrated in the overall system architecture. The interface to the organic substrate or package is matched to standard BGAs.

The overall system, which was realized at Fraunhofer IZM, was successfully tested at Infineon and is an excellent example of the interlocking of different system integration technologies such as Si interposers with through silicon vias, RDL technologies for processor and sensor, bumping and thinning, as well as the assembly of thinned electronic devices. Only if all these factors come together, can application-specific 3D systems be successfully realized in practice.

In 3D system integration, the synergy of system concept, design, and technologies together with test strategies and reliability assessment are the key to successful implementation. Each of these individual aspects has to be continually assessed in light of its role in the overall system. This presents a new challenge for system developer and at the same time demonstrates the enormous potential of heterogeneous integration technologies.

Fraunhofer IZM would like to thank Infineon as collaboration partner and BMBF for funding support.

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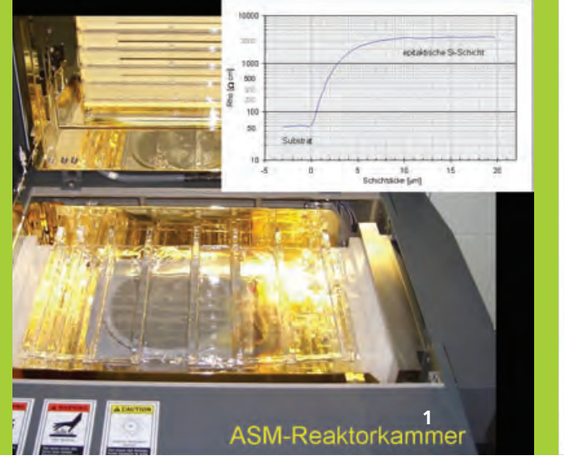
1 *3D image sensor stack (front side)*

2 *Back of the complete system*

// INTEGRATION ON WAFER LEVEL

SI TECHNOLOGY & VERTICAL SYSTEM INTEGRATION



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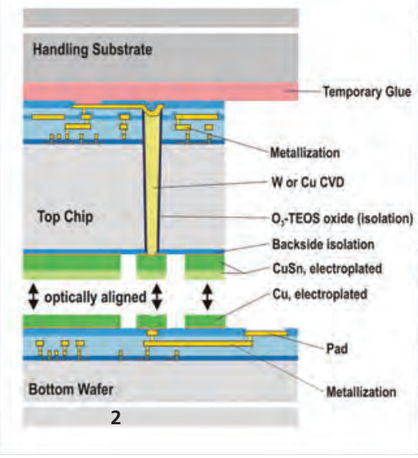

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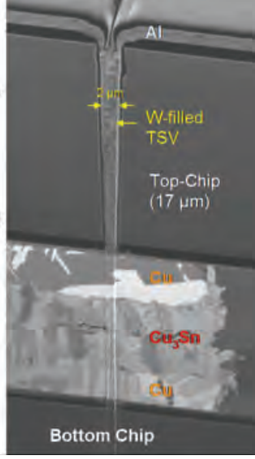

DEPARTMENT

Our department has long-term experience in developing and optimizing CMOS-compatible technologies for vertical system integration, which has led to new 3D system-on-chips (3D-SOC). We integrate fully processed device substrates using cost-effective backend-of-line processes. VSI® offers maximum flexibility for industry by means of existing mainstream technologies in combination with the highest possible density of electronic functionality. Additionally, we ensure minimal interconnection lengths and low parasitics to improve system performance.

We integrate new materials and methods in silicon-based semiconductor technologies and can fabricate test structures and small circuit units using our in-house 200 mm technology line. Our test structures are also used to assess the reliability of new integration concepts.

We have established the development and analysis of epitaxially grown Si/SiGe layers (CVD processes) for new NEMS technology applications and integration concepts for photonic systems as the department's core competency.

TRENDS

In close cooperation with our customers and project partners from industry and research organizations, we are developing new and cost-effective 3D-SOC integration approaches for ultra-miniaturized micro- and nanosystems. We will then evaluate the reliability of innovative integration technologies by realizing and characterizing suitable test structures.

Our R&D units, namely, Wafer Technology, Process and Design Integration and Functional Layers cover the topics:

- 200 mm CMOS processes
- Specific process development
- Through-silicon-via (TSV) technologies
- 3D system-on-chip integration
- Development of test structures and process flows
- Innovative Si and SiGe technologies

Thanks to the department's R&D technology line, we can develop customer-specific process units and devices (e. g. silicon-based detector units). Another of our services is small-batch fabrication.

RESEARCH HIGHLIGHTS

3D System-on-chip integration using ICV-SLID technology
Miniaturized sensor nodes for wireless communication were realized within the EU-funded e-CUBES project using optimized 3D-integration technologies. We then further optimized the through-silicon-via (TSV)-based 3D-system-on-chip technology, known as ICV-SLID (Fig. 2). The ICV-SLID technology is part of the EU e-CUBES technology platform (http://www.ecubes.org).

We also developed and fabricated components essential in the heterogeneous systemintegration of an IC/MEMS stack for the automotive demonstrator of the e-CUBES project – a tire-pressure-monitoring-system (TPMS). W-filled TSV-structures (3 µm x 10 µm, etch depth: 60 µm) were placed into pre-defined areas of a fully processed CMOS top-ASIC. A specific RIE-etch sequence was developed to etch the complete intermetallic dielectrics (thickness 8 µm). The silicon was etched using an optimized (Bosch process-based) DRIE-process. Redistribution layers using an AlSiCu-metal system were also processed on the front- and the backside of the top ASICs and on the frontside of the bottom ASIC. Signal and supply paths, as well as additional pads on the top ASIC for further assembly, were defined using the redistribution metal. Thermo-mechanical simulation was carried out and the results incorporated during the processing. The top ASICs were assembled onto the bottom-ASIC wafer using chip-to-wafer-placement. Here, SnAg microbump techno-logy combined with application of an underfiller was used for the electrical and mechanical connection of the two ASICs.

The functionality of the TSVs was demonstrated during and after the building of the stack by means of process-control modules (PCM) integrated into the ASIC stack. Appropriate system tests showed the stack was fully functional. The MEMS components were assembled onto the mechanically stable 3D-integrated IC stack by applying gold-stud-bump technology.

Quality assessment of very pure process gases
Quality assessment of very pure process gases for semiconductor fabrication was performed in close cooperation with the company Evonik. Highly intrinsic layers were grown epitaxially from the investigated gases using the department's ASM Epsilon 2000 reactor. The specific electrical resistance of the layers, measured by SRP (spreading resistance probe), correlates with the impurity of the gasses. As an example, for the layer epitaxially grown using monosilan, the measured resistance corresponded to a doping value of less than 3.8 exp 12/cm³ (Fig. 1).

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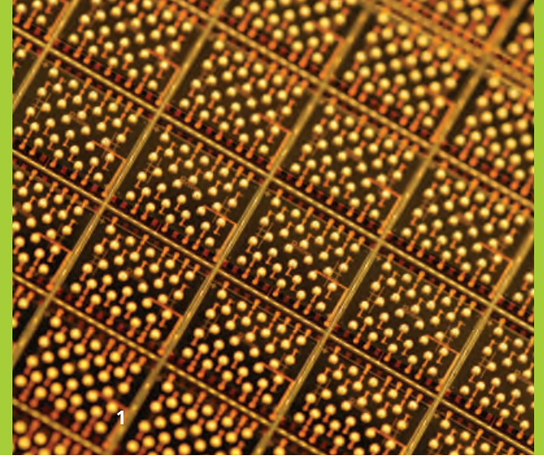
1 *Highly intrinsic, epitaxially grown Si-layers*

2 *3D-SoC integration using ICV-SLID technology (part of the e-CUBES technology platform)*

// INTEGRATION ON WAFER LEVEL

HIGH DENSITY INTERCONNECT AND WAFER LEVEL PACKAGING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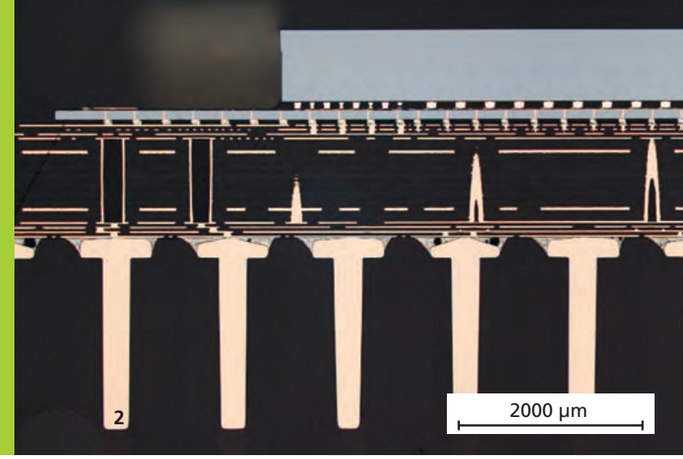

2

DEPARTMENT

Our department develops and researches the application of thin-film processes in microelectronic packaging.

Our infrastructure includes an 800-m² cleanroom and production-compatible equipment. We cooperate with manufacturers and users of microelectronic products, as well as with cleanroom-equipment manufacturers and material developers in the chemical industry around the world. Our well-established technology branches provide partners in industry and customers with prototyping and small-volume manufacturing for MCM-D, wafer-level CSP with redistribution routing, 3D integration and wafer-level bumping for flip chip mounting.

The wafer sizes processed range between 100 mm to 200 mm, but processing of 300 mm wafers is also possible in cooperation with our Dresden branch. Our service even includes technology transfer to customer-specific tools.

We are developing skills and know-how in numerous R&D projects, which can then be passed on to SME partners at development stage.

Competencies

- 3D Integration (interposers, through silicon vias (TSV), thin-chip integration, thin wafer handling)
- Wafer-level CSP (Cu redistribution, polymer dielectrics, package singulation, reliability investigation)
- Wafer bumping (electroplating of structures in photoresist masks, copper pillars, bumping materials (Cu, Ni, Au), solders (SnAg, AuSn, SnPb, Sn), optical inspection)
- Thin-film multilayer (customer-specific layout, multilayer routing, integrated passives, chip-first, flip chip)
- Micro-energy systems (wafer-level batteries, microfuel cells, hermetic sealing)

TRENDS

- Redistribution to the backside of the wafer
- Copper-filled through silicon vias
- Silicon interposers
- Assembly of ultra fine-pitch pixel detectors
- 3D packaging of image sensors
- Chip-on-chip devices
- Thin-chip integration
- Thin-wafer handling with temporary bonding on support wafers
- Fine-pitch redistribution and coils
- Development of integrated passive devices (IPDs)
- Micro-electroplated magnetic layers for coils and transformers
- Electroplating of indium solder
- Nano-porous gold bumps
- Polymer layers for RF applications
- Autonomous power supplies for microsystems
- Integration of micro-batteries on wafer and foils
- Consultation and application development for industry

RESEARCH HIGHLIGHTS

Silicon interposer with through silicon vias (TSV)
Silicon interposers with TSVs are a new means of merging advanced devices, such as high pin-count ASICs, memory types and MEMS to form 3D SiPs. We have developed a process for manufacturing silicon interposers including TSV formation using electroplated copper filling, high-density multi-layer redistribution, thin-wafer handling, thin-wafer backside processing and wafer-level component assembly.

Thin-wafer handling
Fraunhofer IZM has established various processes for thin wafer handling. The thin wafers are mechanically stiffened using a temporary carrier, which is easily released once the thin wafer processing has been completed. Thanks to this process, the developed thin-wafer handling solutions are not only highly flexible but also robust, and are optimal for all associated thin wafer processing and handling tasks.

3D packaging of image sensors
We have also developed a new technology for micro-cameras at wafer-level. Image sensor CMOS wafers bonded onto glass wafers are thinned. The I/Os are then connected from the backside of the wafer using TSVs, which is followed by redistribution and bumping. The optical lenses are wafer-level bonded and the camera stack is then diced. This technology enables the manufacture of micro-cameras with a pitch of well below 1mm.

Thin-chip integration
As part of the Project Restles (Reliable System Level Integration of Stacked Chips on MEMS), integration of thinned Si chips in a redistribution layer (RDL) attached to a functional base wafer was investigated. Two different built-up options were evaluated: in one variation, the functional base is either an accelerometer or a gyrometer wafer and the integrated chips used are signal-conditioning ASICs. In the second variation, thinned AMR sensor chips integrated into the RDL are attached to an ASIC base wafer.

Microreactor for generating hydrogen
A microsystem technology-based fabrication concept for a catalytic microreactor generating hydrogen for microfuel cells has recently been developed. With this system, hydrogen is generated via the catalytic hydrolysis of a sodium borohydride fuel solution, which is continuously fed to the microreactor by a micropump. A fully functional demonstrator was built using our specially developed process, which involves the vertical integration of three structured borosilicate glass substrates over two low-temperature polymer bonding steps.

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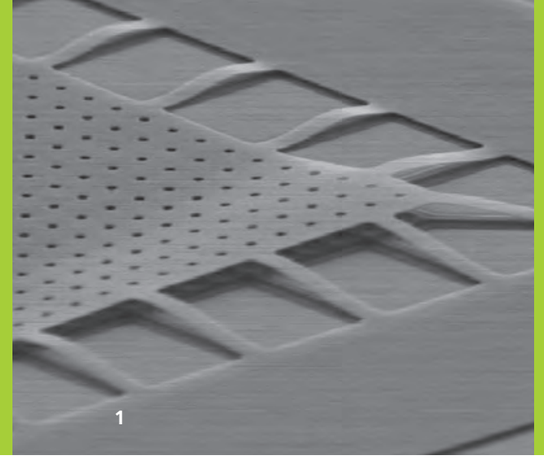
1 *Thin chip integration: thin chips (20 µm) embedded in the substrate wafer's redistribution layer*

2 *Cross-section: Device circuits flip chip assembled on TSV interposer into package*

// INTEGRATION ON WAFER LEVEL

NANO-MATERIALS & DEVICES



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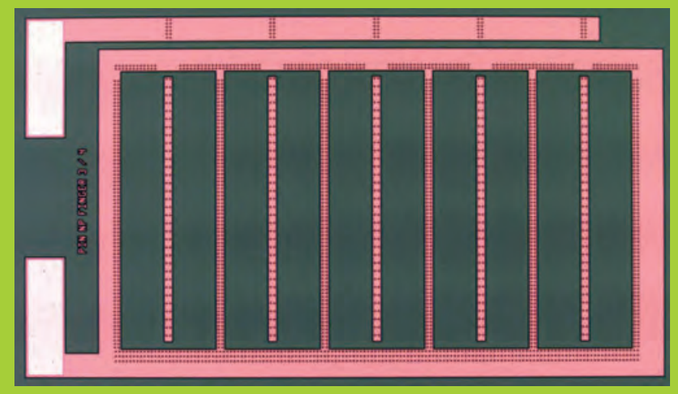

2

DEPARTMENT

Newly established in 2009, our department will design and develop innovative components using the MOTT (multi-functional on-top technologies for standard Si and CMOS) approach in cooperation with partners from industry and other research institutes. We will be focusing on a number of different application fields and plan to specialize in R&D partnerships with customers from industry.

Our development approach can be divided into three main areas:

- Device: development of active devices, sensors and actuators
- Function: development of passive devices and system components in wiring layers
- Integration: post-processing of wafers, such as by means of vertical system integration

We will also work with the department Silicon Technology & Vertical System Integration to develop silicon-based sensor and actuator systems, as well as the associated circuitry.

Another key area will be the integration of new material systems in standard technologies with the lowest possible thermal budget for application on fully processed wafers.

We provide the following services:

- Consulting
- Feasibility studies
- Process and device simulation
- Process development for sensor and actuator systems
- Technology support and transfer
- System integration

TRENDS

We have been able contribute meaningfully to the field of radiation detectors in just a short amount of time. Thanks to these new developments, synergies are evolving that are beneficial for all participants.

We are building on this by extending our skills and know-how in MEMS/NEMS (micro-/nano-electro-mechanical systems). Two of our more ambitious goals are developing 200 mm wafer technology and compatibility with CMOS technology. Realizing cost-effective MEMS microphones in cooperation with partners from industry (EPCOS AG, BBM) will be the starting point for achieving these milestones.

The coming years will require large-scale effort to develop not only individual sensors and devices in the above areas, but also dedicated circuitry and amplifiers using CMOS technology. Such integrated circuits can then be combined with sensors and actuators in a monolithic approach or using vertical system integration.

Long-term strategic cooperation between Fraunhofer IZM Munich and the companies Siemens AG and KETEK GmbH on microsystem technology will significantly contribute to sustaining our ongoing development research.

RESEARCH HIGHLIGHTS

Radiation detectors
In 2009, we made significant progress in the development of radiation detectors. Together with the Helmholtz-Gesellschaft, we designed and manufactured pin diodes with scintillators for X-ray applications.

We were able to expand the detector spectrum within a short space of time. Development of X-ray detectors for chemical analysis (SDD: Silicon Drift Detectors) from KETEK GmbH was partially transferred to IZM Munich.

We now plan to design highly sensitive arrays of avalanche photo diodes together with Ketek GmbH, thanks to funding from the Bavarian Microsystem Program. The diodes will be capable of detecting visible light with high sensitivity at a level comparable to that of photomultipliers. Siemens AG will be the first company to use the diodes, which will be employed as detectors in positron emission tomography systems.

Transistors
Extremely low-noise JFET transistors for amplification of X-ray detectors (SDD) will also be developed in collaboration with Ketek GmbH with funding from the Bavarian Microsystem Program. The X-ray detectors will then be connected to the JFET transistors using vertical system integration to enhance the detector system's energy resolution and simplify the assembly process.

Nano-electro-mechanical systems (NEMS)
We also began researching sacrificial SiGe-layers for use in NEMS manufacturing. Self-adjusting integration of a MOS transistor together with a NEMS structure will result in many different innovative sensor structures in the future.

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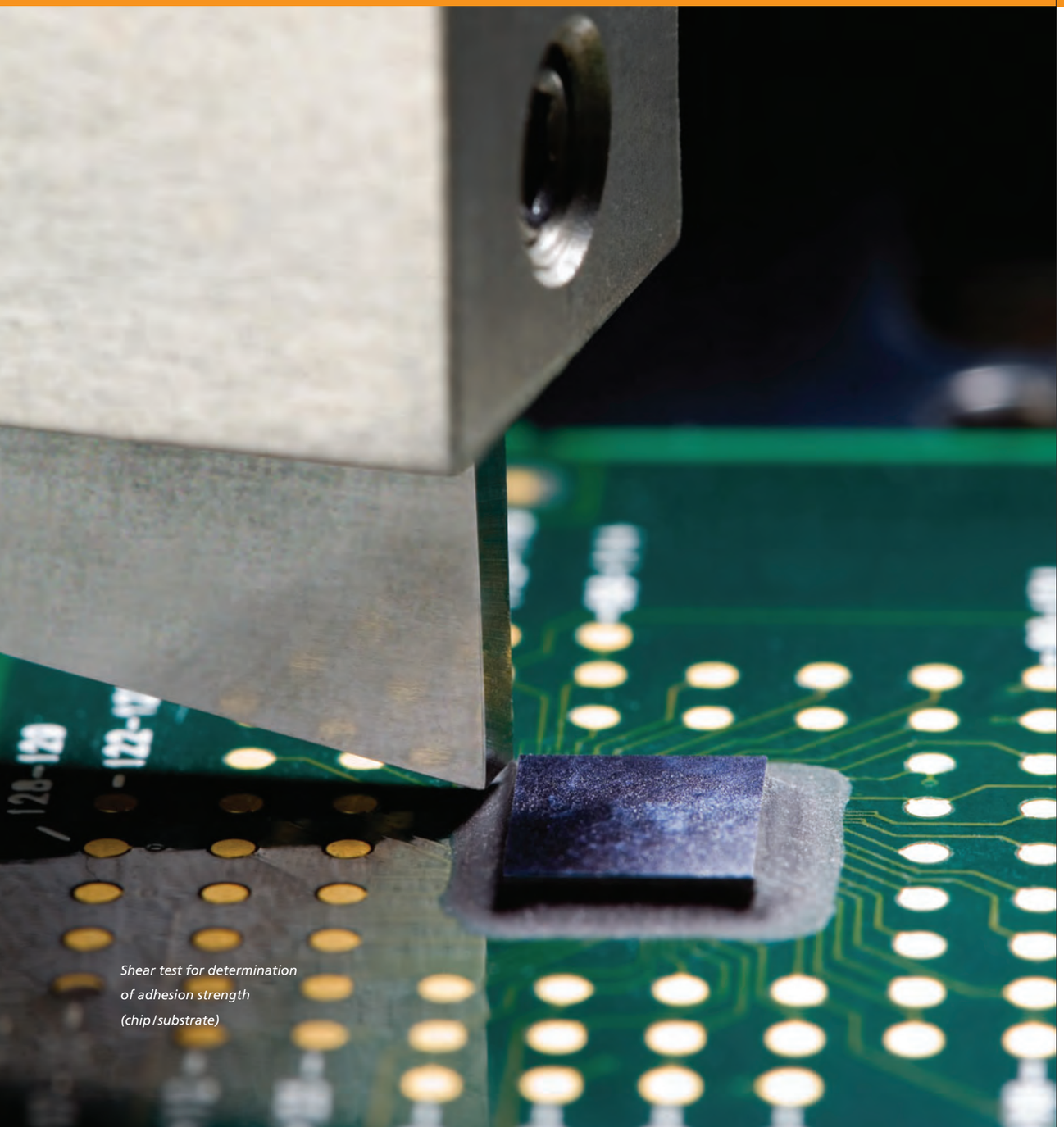
1 *Released membrane after etching of SiGe sacrificial layer*

2 *Microscopic image of a pin diode for X-ray detectors*

RESEARCH CLUSTER MATERIALS, RELIABILITY AND SUSTAINABLE DEVELOPMENT



Shear test for determination of adhesion strength (chip / substrate)

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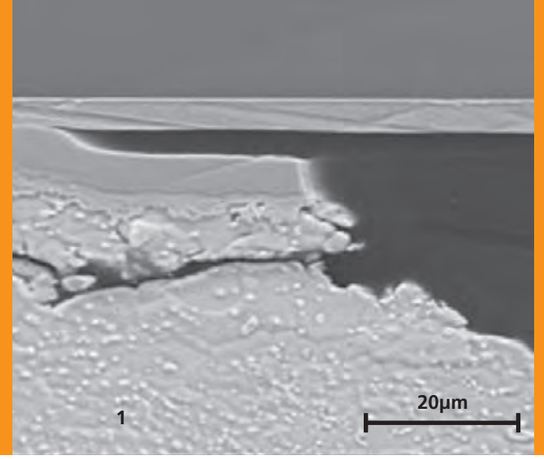
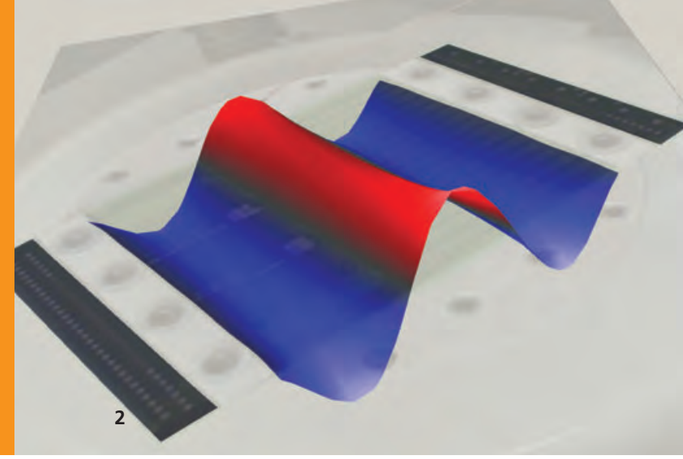
MATERIALS, RELIABILITY AND SUSTAINABLE DEVELOPMENT





Reliability and environmental compatibility have become more important in the development of electronic components and systems in recent years. Fraunhofer IZM has been combining research into the reliability of electronic components and their environmental characteristics with the development of new technologies since it was first established. Fraunhofer IZM conducts reliability analyses on the materials right through to the system as a whole using material behavior and mechanical reliability models. Apart from simulation processes, we employ laser-optical, X-ray and material tests individually or in combination.

HIGHLIGHT 2009

Combined environment reliability testing of electronic systems
With increasing miniaturization and functionality, electronic systems are becoming more and more complex. At the same time, the reliability of electronics has to be optimized to meet the low failure system rates required in the field. Particularly since electronics are increasingly integrated in engines and equipment, they are subjected to extremely high thermal and mechanical loads, which necessitate fast and accurate methods to evaluate their reliability in terms of field loads. Loads in applications are a combination of humidity, temperature(-cycles) and vibration. This is a main research focus at the Fraunhofer IZM, under the rubric Combined Reliability Tests (CERT).

Lifetime models and material properties for CERT
Testing combined loads requires groundwork in the form of a fundamental understanding of material properties, activated failure mechanisms and other determining factors. In extensive research activities the influence of humidity, temperature and vibration on polymer material properties (adhesives, encapsulation) was investigated, resulting in new material and lifetime models. We have also examined material performance under vibration and temperature cycle loads in flip chip solder joints (Figure 1). This work supports optimized material selection and development and is the basic starting point for improved component design models. Now the interaction of failure mechanisms under combined loads is the center of current and future research activities.

Test equipment for reliability and lifetime tests with combined environment loads
CERT is performed with an electrodynamic shaker, climate chamber and scanning laser vibrometer. Standard configurations for vibration tests are sinusoidal or random noise profiles. For field system performance tests, measured vibration time responses can be simulated with the shaker, determining eigenmodes stimulated by the field frequency spectrum.

A scanning vibrometer is used for high-precision vibration measurement. Distance and acceleration are measured at the test probe using a laser vibrometer. By measuring an array of points on the probe's surface, the vibration system performance can be determined and visualized (Figure 2). As the vibration performance of the probe is defined by the fixture on the shaker, preparation for testing has to include the vibration simulation and measurement of the fixture.

Vibration excitation and measurement can be conducted in a climate chamber, which allows combination of vibration, humidity and thermal loads. Due to temperature-dependent material properties, eigenfrequencies can change dramatically under field conditions and can therefore factor in field failures. A broad range of field loads can be simulated, including a temperature range from -70 °C to +180 °C and a temperature rate of up to 25 °C per minute. Monitoring of devices under testing is performed using optical (microDAC), electrical and thermal (thermal imaging) in situ methods.

Apart from reliability and lifetime experiments, our test equipment can also be employed for field failure analysis. Examples of such field failures include changes in the vibration performance causing joint failures and additional eigenmodes or altered eigenfrequencies, indicating failure sites in devices. With such capabilities, CERT with scanning laser vibrometery is a fast and effective field failure analysis method.

Identification of design flaws using HALT
Highly accelerated life tests (HALT) also employ combined vibration and thermal loads. The main advantage of HALT is its ability to quickly identify the location of weak points in the design. HALT chambers simulate temperature rates of up to 60 °C per minute and vibration of 100 grms. The most important part of the HALT procedure is failure analysis, where failures in tests are evaluated in terms of their correspondence to field failures. HALT is also generally completed in just two days, which means that the design improvement process can be initiated quickly.

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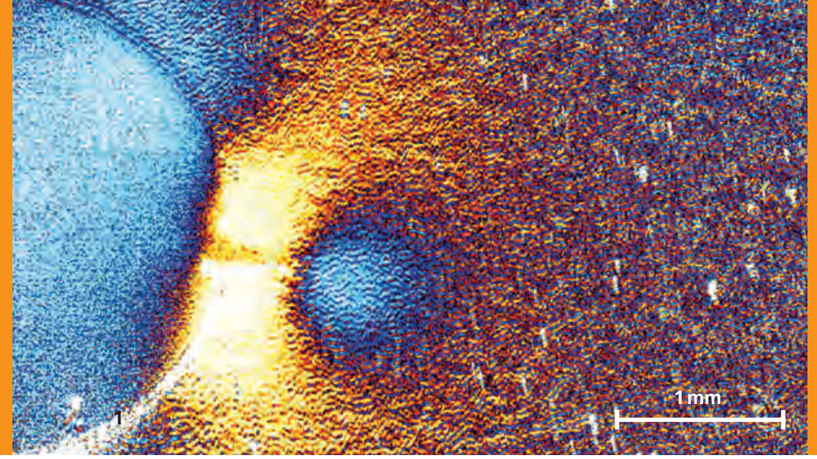
1 *Analysis of joint alterations in a solder joint after combined life-time testing with temperature cycling and vibration*

2 *Measurement of the vibration amplitude with the scanning laser vibrometer during combined testing with vibration and temperature*

// MATERIALS, RELIABILITY AND SUSTAINABLE DEVELOPMENT

MICRO MATERIALS CENTER



DEPARTMENT

We research the reliability and optimization of microsystems and microdevices at the EUCEMAN Reliability Key Lab of the European Center for Micro- and Nanoreliability at the Berlin-Adlershof Science Park.

We also focus on thermomechanical and thermal simulation combined with advanced measuring techniques and evaluation using cutting-edge reliability criteria.

Specifically, our research areas include:

- Crack analysis and crack avoidance
- Thermo-mechanical simulation
- Local deformation analysis
- microDAC, FIBDAC
- NanoRaman, EBSD
- Humidity sensitivity AFM, AFAM
- Nanoindentation
- Coupling of mechanical, thermal, vibrational, diffusion, electrical fields
- Reliability optimization of components and systems
- Materials characterization and reliability analysis
- Reliability of automotive electronics and sensors
- Safety and reliability for security

TRENDS

We use the most advanced reliability concepts, including design for reliability based on modern physics-of-failure concepts.

This comprises:

- Combined reliability, safety and security analysis
- Physics of failure analysis
- Long-life reliability analysis
- Complex loading and monitoring
- Grey-value correlation analysis (image correlation based reliability analysis) for microtechnology applications (microDAC, FIBDAC, RamanDAC, nanoDAC)
- Reliability and certification of products
- Reliability of solar modules
- Reliability of modules for medical applications
- Reliability in the micro-nano Interface region

Recently, we have also begun researching reliability for clean technologies.

RESEARCH-HIGHLIGHTS

Combined and accelerated testing

Microsystems are being exposed to increasingly harsh environments, and the stresses involved can affect systems separately or in combination. A basic understanding of failure mechanisms and the main factors that cause them is crucial for developing robust systems. Thus, research has focused on the influence of different loading factors. The junior research group, headed by Dr. Olaf Wittler, has gained vital insight into the degradation process in polymers under moisture, temperature and vibration combined.

Molecular modeling

Simulation on nanometer scale has been advanced significantly. By developing and optimizing a cross-linking algorithm, we are now able to produce atomistic models that represent 3D networks. These can be used to predict trends in the material properties of epoxy resins, which are often used as adhesives or molding compounds, as well as to investigate physical phenomena that are difficult to analyze experimentally on the scales involved. The EU project Nanointerface is continuing research into integrating these atomistic and molecular simulations with continuum-mechanical methods (FEM).

Material characterization

In collaboration with Universität Witten/Herdecke, Fraunhofer IZM has developed new experimental testing methods for evaluating the adhesive force of composite materials for endodontically treated teeth. Various root canal and fiber-reinforced composites with different surface treatments and various pre-treatment procedures were used for the characterization. Using glass-fiber composites, teeth that had undergone restorative treatment could again withstand mechanical loading. Push-out tests were performed to determine the critical adhesive force using specially prepared samples. The results show that, apart from the fiber-reinforced composites and corresponding resin cements, pre-treatment rinsing solutions contributed significantly to bond strength.

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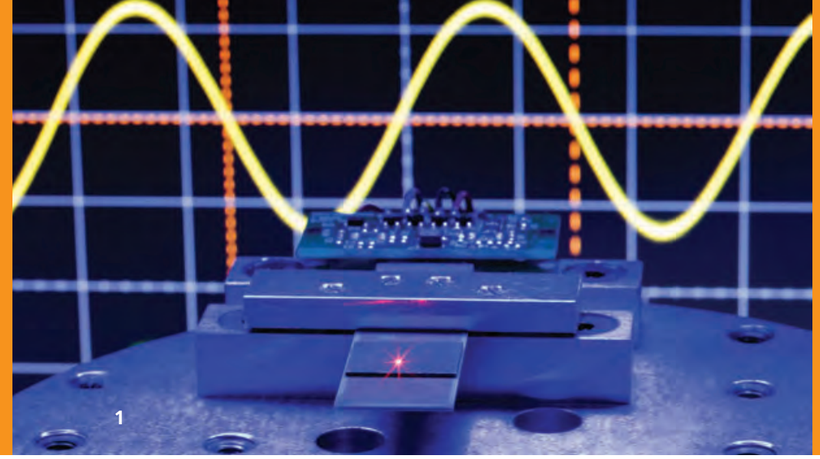
1 *Localization of crack tip by means of phase image (Δa ~ 5 µm spatial resolution)*

// MATERIALS, RELIABILITY AND SUSTAINABLE DEVELOPMENT

ENVIRONMENTAL ENGINEERING



1

DEPARTMENT

Our department rounds off Fraunhofer IZM's technological developments with competitive, ecologically sound and reliable innovations. These generally have to be implemented at early stages during the design process. The department offers screening approaches for environmental parameters and early identification of weak points for subsequent optimization. Reliability has a large influence on sustainable system performance as non-availability of electronic subsystems can have serious consequences. In some cases field failures may be countered by employing integrated monitoring approaches.

The results are more sustainable products thanks to either reduced environmental impact or optimized availability.

We focus on two main areas based on the above research threads:

- Environmental evaluation and optimization of resource efficiency, reduction of hazardous substances and recycling of electronics and
- Condition monitoring and sustainable life cycles by means of parameter degradation measurement, failure models and integrated condition indicators.

Furthermore, we coordinate the activities for vocational training and liaison with pre-university students.

TRENDS

Increasing sections of industry and politics are now seriously engaging with green topics, such as GreenIT, green eMobility or legislative regulation of electronic products.

Particularly due to the ongoing debate on climate change, consideration of energy efficiency and CO_2 emissions (or carbon footprint) has become more important in consultation and contracts.

The electronics industry still faces a great deal of work beyond reducing energy use, including further reduction of harmful substances, substitution of critical resources and increasingly the optimization of recycling, a topic that has taken on new urgency in a global context. More extensive use of products through health or condition monitoring is one additional contribution to saving resources.

Integrated microelectronics monitors are now being developed, in particular for systems that require guaranteed long-term availability, such as mobility, industrial installations or the energy sector.

Reliability, resource consumption and environmental impact minimization will continue to grow as a factor in commercial success.

RESEARCH HIGHLIGHTS

Study on ICT energy consumption
In a study for the German Federal Ministry of Economics the energy consumption of all ICT equipment in Germany has been forecast from 2007 to the year 2020. The electricity consumption of ICT in Germany already reached 55 billion kWh in 2007. This corresponds to 10.5 percent of Germany's annual electricity consumption. Despite foreseeable efficiency gains, total ICT consumption is expected to increase at least 20 percent by 2020 to 67 billion kWh. Apart from the significant increase in electricity consumption by home equipment – predominantly due to larger screen sizes – the development of data centers and communication networks are also being investigated.

Although the available published data is still incomplete, the trend is towards a further steep increase due to much higher data transfer requirements. While mainly caused by growing audio and video data transfer, the billions of small data packets transferred for the »internet of things« also play a role.

New innovation cluster initiated in Berlin
The Fraunhofer MRO (Maintenance, Repair and Overhaul in Transportation and Energy) Innovation Cluster conducts new industry and cooperation projects to bolster an already strong regional focus.

Our department is pursuing MRO research on the following topics:

- Reliability of repair methods and refurbishment of electronic modules
- Failure prediction models for electronics
- Long-term availability planning for electronics
- Energy supply from energy harvesting for autonomous condition-monitoring systems
- Integrated health-monitoring microsystems for electronic assemblies

Maintenance, repair and overhaul research and development into (power) electronics is gaining in significance, because the amount and value of electronics in long-lived products is steadily increasing. Integration of electronics gives rise to new functionality, improved efficiency and novel business cases, which, in turn, compensates the cyclical nature of new business and steadily increases returns from technical service contracts. Remote maintenance, condition-based failure prediction and generally lower maintenance risk between scheduled maintenance cycles are examples of new features that can only be realized with additional electronics. In the future, electronic circuits themselves will also need to be monitored.

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1 *Characterization of energy harvesters: besides technical parameters the long-time reliability and environmental issues are increasingly important*

RESEARCH CLUSTER
SYSTEM DESIGN

Highly integrated control circuit for generating +- 150 V supplied to a piezo ceramic pump

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System Design & Integration **Page 70**
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Micromechanics, Actuators & Fluidics **Page 72**
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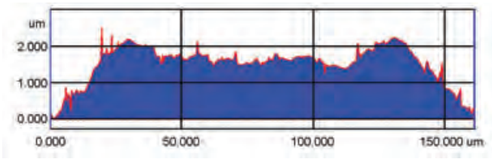
SYSTEM DESIGN



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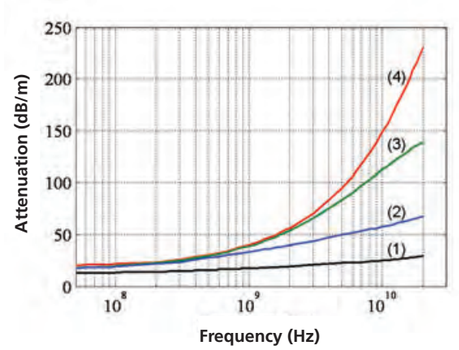

2

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

HIGHLIGHT 2009

M3-Approach for optimal system design considering the impact of packaging and integration technologies

To meet the continuous demands for miniaturized and multi-functional microelectronic systems, the integration density is steadily increased. This is achieved by numerous techniques, including the following: compact placement of heterogeneous devices (e. g., RF, digital, sensors…) on system packages and PCBs; using transmission lines with smaller cross-sections and pitches; and applying advanced 3D integration and chip stacking methods. These high-density integration techniques, combined with the continuous trend for multi-GHz signal transmission, may cause electromagnetic reliability (EMR)/electromagnetic compatibility (EMC) problems such as poor signal/power integrity and electromagnetic interference. Hence, reliable design rules/measures which account for the impact of packaging and integration technologies at high frequencies are needed at the beginning of the design cycle (pre-layout stage), so as to prevent degradation of the system performance or even failure. To meet these needs, we developed a comprehensive design approach, the M3-approach (methodology, model, and measure).

The goal of the M3-approach is to overcome the limitations of conventional trial and error design methods by enabling an efficient, accurate, reliable and cost-effective system design considering the impact of various packaging and integration technologies. To reach this goal, we proceed as follows:

1. Electromagnetic, microwave and circuit theories are applied to develop methodologies for efficient and accurate modeling of the packaging structures under consideration. These methodologies enable technology parameters and integration techniques to be taken into account at the pre-layout stage during the electrical modeling process. Depending on the geometrical complexity of the system to be designed, the parasitic effects to be captured as well as the frequency range (or bandwidth) of interest, static, quasi-static or full-wave electromagnetic modeling techniques are used. Based on the field computation results, equivalent circuit/parameterized models, which provide a direct relationship between technology and electrical parameters, are extracted.

2. Experimental validation of the extracted models. This involves fabrication and measurement of test samples as well as correlating the measurement and simulation results. The experimentally validated models are then used to study the impact of the packaging technology, process tolerances, integration technique and the packaging environment at the required frequency range on system performance and EMR/EMC.

3. Based on the results of these studies, reliable design measures/rules are extracted. Applying these measures/rules/guidelines at the pre-layout stage leads to the elimination trial and error designs, re-design efforts and place/route iterations. Consequently, time-to-market is reduced while performance is optimized.

The M3-approach has been successfully applied in a wide range of research projects for the design of system components, especially components of the signal and power distribution network (i. e., transmission lines, vias, TSVs, wire bonds, FC interconnects, power-ground planes), noise isolation structures (i. e., electromagnetic band gap and interconnected patch-ring structures), integrated antennas, filters and complete signal paths (chip-to-board). In the following paragraph, the M3-approach will be briefly illustrated using a coplanar transmission line with significant surface roughness and non-ideal cross-section (Figure 1). The coplanar line is printed using the maskless deposition technique. The surface roughness of the conductor is considerable when put in relation to the thickness of the conductor. At high frequencies, as the skin-depth decreases to a similar height as the surface roughness, the current meanders through the peaks and valleys of the roughness, increasing the resistance. The edges of the conductors are very narrow angles, and are referred to as »edge effects« in this work. This is further complicated by a strong proximity effect, as a result of adjacent conductors, that draws the current into the edge of the conductor. As the frequency increases, the surface roughness effect increases due to skin, proximity and edge-effects. Furthermore, the surface roughness on the return-current paths must also be taken into consideration because the proximity and edge effects cause current crowding on the reference conductors.

To account for these effects at the pre-layout phase, we developed an accurate electrical model. The cross-section of the trapezoidal signal conductor is discretized and resistances, inductances, and mutual inductances are calculated for each filament. The same is done for the reference conductors, in this case the two coplanar flanks. Three different ladder circuits are constructed for the three different conductors. Then, a mutual inductance matrix between each reference conductor and the signal conductor is created containing the mutual inductances between every filament in each conductor. The self and mutual inductances as well as the resistances are computed using conventional formulas. To account for the surface roughness of the conductor, the resistances of the outside filaments were increased. A systematic approach for selecting the resistance of the filaments has been implemented in the model. This leaves us with signal and reference conductors with inhomogeneous conductivities over their cross-sections. The model is then solved with a computer. To experimentally validate the proposed model, a comparison was made between simulation and measurement results. A very good correlation was obtained. Using the proposed filament model, the sources of the different losses were determined and design measures to minimize these losses were developed.

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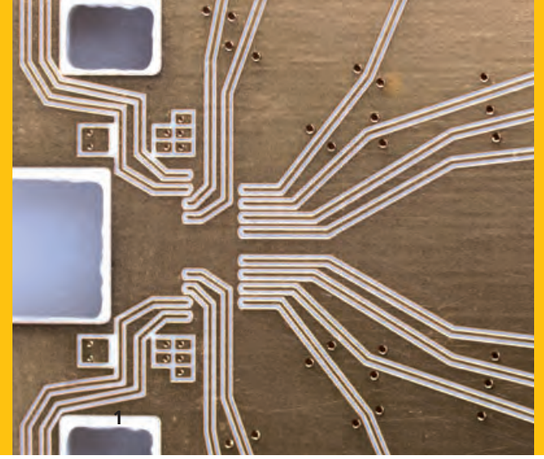
1 *Profile of the signal trace of a printed coplanar transmission line*

2 *Breakdown of losses in a coplanar line (1) Skin-effect in ideal copper slab, (2) Skin-effect and proximity effect in an ideal coplanar line, (3) Skin-effect and proximity effect in a coplanar line with angled edges, (4) A trapezoidal coplanar line with surface roughness.*

SYSTEM DESIGN & INTEGRATION



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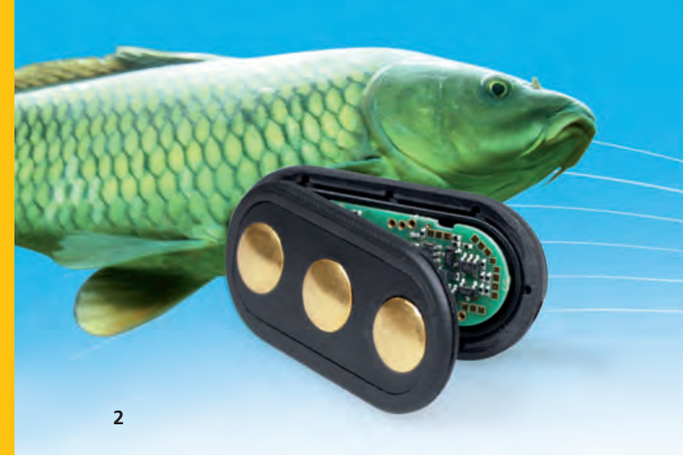

2

DEPARTMENT

Our department bundles Fraunhofer IZM's technology-oriented system competencies. We research and develop methods and tools for designing microelectronic systems, microsystems technology and power electronics.

Our main aim is defining scientific fundamentals to facilitate the simulation of various phenomena, such as electrical, magnetic, electromagnetic, and thermal and mechanical coupling, during every phase of the design process. Analyzing systems using such a multi-phenomena approach enables an integrated design process, in which not only the coupling effects are considered, but all technological parameter-based functions, volumes, reliability, and cost analyses are included.

Our research focus is microelectronic and microsystem development with an application-oriented emphasis on wireless sensor systems, package design and characterization, HF and high-speed system design, as well as the EMC and packaging of power electronic systems.

TRENDS

Converging system and technology approaches, which have until now been separate areas, is increasingly necessary to develop the prerequisites for reliable and highly miniaturized products.

Guaranteeing the reliability of energy storage is an extremely important goal in the design of autonomous microsystems. Optimizing the use of available energy and the exploitation of energy in the environment is a very important future research topic.

In the field of design automation, tools for 3D-SIP layouts were realized. The next step will be to integrate newly developed technologies into these tools.

Systems with very high frequencies pose special challenges for reliability design. We are currently developing a new approach in this area, known as the M3 approach. One proposal here are waveguide structures with integrated transmission lines that transmit both the TEM and TE modes.

In power electronics, aspects of assembly and interconnection technologies will increasingly determine the framework for the realization of new systems.

RESEARCH HIGHLIGHTS

Microelectronic systems und microsystems
We completed our basic research into bistable displays in autarkic systems and have begun developing application-specific features. In terms of hardware/software co-design, our focus has been on minimizing energy consumption. In technology-oriented product design, we concentrated on increasing the multi-functionality and robustness of miniaturized multi-sensors. System-in-package (SiP) integration is becoming more and more important, but automation tools for designing 3D-SiP are still lacking. Component placement remains a time-consuming task for such systems. In cooperation with Fraunhofer ITWM, we successfully developed a placement tool based on a multi-criteria optimization engine.

RF and high-speed systems
Our department has developed new methods for the electrical modeling of packaging structures to optimize electromagnetic reliability. An adapted filament model was applied to accurately model transmission lines with significant surface roughness and non-rectangular cross-sections.

New TSV configurations, based on the coaxial transmission line configuration, were designed to overcome the limitations of conventional TSVs due to silicon's lossiness. We also designed new techniques to reduce parasitic interaction with other integrated components, based on the results of our preliminary investigation into electromagnetic field distribution in the immediate vicinity of antennas.

Power electronic systems
The department has been very active in power electronics. One example is our new inverter for actuators in avionics with highest redundancy. For motorized bicycles (pedelecs), we developed programming controls and characterized electrical motors. Work also began on piezoelectric energy conversion and harvesting, which includes high-voltage generators for electro-rheological applications in sports, industry and car dampers, as well as off-line power supplies for LED lighting and mobile phones.

We also established techniques for the ASIC design of power control ICs with a universal driving IC for resonant converters. Additionally, we realized low-power conversion electronics for autonomous sensors.

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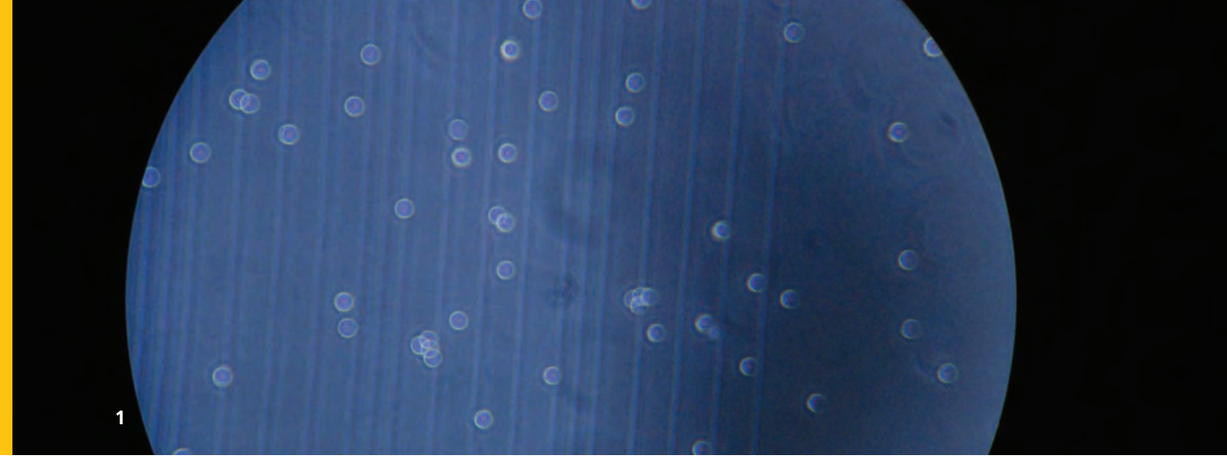
1 *RF-PCB with differential interconnects for testing 40GBit/s optical transceiver modules*

2 *Autarkic multi-channel wireless sensor for implantation in animals*

// SYSTEM DESIGN

MICROMECHANICS, ACTUATOR AND FLUIDICS



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DEPARTMENT

The Micromechanics, Actuators and Fluidics Department provides intelligent solutions for the active handling of small quantities of liquids and gases. Micro-devices designed especially for microfluidic applications can be used in a wide variety of industrial solutions.

We have eleven experts and twenty students working on the design, simulation and prototyping of microfluidic components. With more than 15 years experience in the field, we can guarantee optimal solutions for realizing individual applications.

Our key competencies include the development of micropumps, microdosing systems, micromixers, microvalves, microreactors and flow sensors and combination of these for deployment in biotechnology, chemistry and medicine.

TRENDS

Currently we are focusing on a number of strategic areas: Together with Tronics Microsystems in Grenoble, we are working towards manufacturing silicon micropump prototypes. Application areas for these micropumps include lab technology and fuel cells.

We are also researching novel, cost-efficient manufacturing platforms (micro-injection molding, metal structuring) in cooperation with industry.

In terms of micropump components, we are improving reliability, dosing accuracy and user safety by integrating free-flow protection, bubble point-free filters.

Another focus is on developing complete systems, including electronics, sensors and system control.

A new working group has been established to address the use of microfluidic actuators for tissue engineering. The group's first project is a cell release application that uses megasonic sound to disrupt cells and bacteria.

RESEARCH HIGHLIGHT

Pump Cube

Piezoelectrically driven microfluidic actuators such as micropumps need miniaturized and energy-efficient driver electronics. Fraunhofer IZM has set new standards by developing exactly this type of technology, paving the way for completely new applications with integrated autarkic microfluidic actuators.

Description

The Pump Cube illustrates that a new level of packaging has been reached – a complete autarkic micropump and electronic system measuring less than 1.5 cm^2. It comprises Fraunhofer IZM's silicon micropump of 7x7x1 mm^3, recently developed driving electronics of 7x7x4 mm^3 and a lithium-polymer battery. Without the battery, the system size is just 0.6 cm^3. To achieve such tiny dimensions, the electronics is mounted directly on top of the micropump. Electrical connection is possible using tiny contact springs, without the need for bonding technologies.

The Pump Cube features energy recovery circuits, which makes autarkic use possible. All this ensures the Pump Cube's power consumption is only 30mW.

Technical data

Pump Cube	0.6 cm^3 without battery
Material	PCB or PEEK
Electronic	7 x 7 x 4 mm^3
V_{in}	3.7 Volts DC
I_{in}	10 mA (typ.) @ 80 Hz
V_{out}	+100 V / -40 V @ 80 Hz
Power Consumption	min. 30 mW

Development status

The assembly is designed to allow several different output waveforms. We are currently adapting the module for use with the Fraunhofer IZM's high-performance micropump at higher voltage levels of max. ±500 V.

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1 *Disruption of cells with megasonic sound*

EVENTS

EVENTS & WORKSHOPS

Trends in system integration – Reliability tests using combined loading
In September 2009 Fraunhofer IZM held a two-day event on trends in system integration in Berlin. Customized solutions and the integration of non-digital functional elements, such as sensors and power electronics, are the future of microelectronics/MST in Europe. This means that electronic packaging will become a key focus in the industry. What range of technologies is available? What developments can be expected? And lastly, which is the right technology for my project? The first day of the event dealt with these pressing questions. In the morning, IZM scientists presented the current state of technology in system integration on substrate and wafer level. After lunch, parallel workshops examined the topics in more detail. Additional workshops on system design and reliability analysis were also held.

What precisely are the current reliability demands on electronic systems? How are such systems tested and qualified? The second day of the event was dedicated to these questions, which fall under the rubric of this year's key topic: »Reliability tests using combined loading«.

The afternoon featured a particular program highlight, namely the opening of Fraunhofer IZM's new Electronics Condition Monitoring Laboratory. Thanks to the new laboratory, we are finally able to simulate combined loading, including temperature (cycling), moisture and vibration, and feed these results into our research on reliability analysis.

Portugal's president visits Fraunhofer IZM in Munich
Portugal and Fraunhofer are planning to cooperate closely in the future. A new Fraunhofer Center in Porto will be at the heart of this cooperation. In this context the Portuguese State President Anbal Cavaco Silva visited Fraunhofer on March 5, Europes largest organisation for applied research. Integrated into this visit was a short tour of the reel-to-reel laboratories at Fraunhofer IZMs Munich branch. Here Prof. Karlheinz Bock showed examples of flexible electronics (sensors on foil) and 3D system integration at wafer level as possible application to the president.

Buenos días, señor Castro! Fraunhofer IZM and Cuba discuss collaboration
During a visit of several hours in Berlin, scientific advisor to the State Council of Cuba, Prof. Fidel Castro Diaz-Balart and the heads of Fraunhofer IZM met to discuss potential European cooperation on microsystem technology and system integration. The nuclear physicist and his four-person delegation were particularly interested in Fraunhofer's know-how in micro- and nanotechnology. A main topic of discussion during the meeting in June was packaging technologies for biomedical applications.

The Long Night of the Sciences
The Long Night of the Sciences is always a great opportunity for the whole family to learn more about the work carried out in research projects. At this year's event in June, over 500 visitors found out everything they ever wanted to know about RFID. Once the basics of the theory had been explained, with questions answered such as whether RFID works under water, the visitors had the chance to try out real applications that use the technology. These included a Scrabble set in which all the game components are interconnected and a scanner that can optically read and determine how fresh meat is in just a few seconds. At the Fraunhofer IZM Wedding branch, visitors also played a game using GPS and GSM in which they had to find »Mr. X«, who explained the institute's technical refinements at different locations in the building. The visitors were also treated to the Fraunhofer Truck's amazing road show.

First Electronic Ecodesign Congress
Round about a hundred delegates, many of them developers, attended the 1st Electronic Ecodesign Congress on October 13 and 14, 2009 in Munich. The congress and accompanying exhibition on »green« electronics and electronic product ecodesign were organized by Fraunhofer IZM in cooperation with the German trade journal Electronik. Up-to-date information about European guidelines, regulations and standards, new materials, developing and constructing environmentally friendly electronic products, recycling and reuse were presented at the event. Another main topic was energy efficiency, because the electricity required during use of the product is responsible for the vast majority of the environmental damage. Thus, designing energy efficiency into products is an important step in saving the environment. High-profile presenters and exhibitors were on-site to offer solutions and valuable assistance for current development challenges.

Seminar on autarkic wireless sensors
Fraunhofer IZM, TU Berlin and the AMA Association for Sensor Technology organized a seminar on the essentials of autarkic wireless sensors, held in Potsdam-Babelsberg on October 29, 2009. Fraunhofer IZM's Dr. Stephan Guttowski was responsible for organizing the seminar content. The main focus of the seminar was on the design of autarkic wireless sensors (system design, assemblies and components, operating and user software, cost-effective design) and the technologies for manufacturing them (packaging, manufacture using wire-bonding technology, reliability and lifecycle). Due to the overwhelmingly positive response, the event will be held again in April 2010.

Chemical silver – cost-effective and reliable finishes for the next generation of circuit boards
35 experts from science and industry gathered at Fraunhofer IZM in Berlin in November 2009 to learn about the possibilities of chemical silver as surface metallization. Mixed mounting of COB, flip chip and SMD is steadily increasing, however hardly any metallization systems are available that can be used for all these technologies. The workshop showcased chemical silver (immersion Ag) as a robust and cost-effective alternative for COB applications. The use of chemical silver as a surface finish, as well as the associated technologies (soldering and gluing on chemical silver, Au-TS wire bonding, and encapsulation) met with particular interest from the participants and was discussed at great length.

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Open day at the Federal Ministry of Education and Research
The German federal government held its 11th Open Day on August 22 and 23. This year, for the first time, Fraunhofer IZM scientists also took part.

At the Federal Ministry of Education and Research (BMBF) visitors had the opportunity to learn about Fraunhofer IZM's latest developments, produced as part of the »E-motion« project. An interdisciplinary initiative by the Berlin University of the Arts (UdK)'s Institute of Fashion and Textile Design, Fraunhofer IZM's researchers have been contributing their know-how in assembly and interconnection technology. On display were electronics and microsystems integrated into textiles and fashion, which make visible the body's biometric data and a spectrum of emotions – interactive fashion as a means of communication, as a »second skin«. Although the functionality of the clothing is often the main focus of so-called »intelligent textiles«, in this case the UdK research group has been more concerned with designing aesthetically pleasing fashion that is suited to everyday wear.

The developments presented over the weekend included an interactive coat with flexible LED stripes and integrated sensors supplied by IZM scientists.

1 *At the BMBF open day Annette Schavan, federal minister for education, takes an interest in Fraunhofer IZM's electronics integrated in textiles*

Fraunhofer IZM Events 2009 (Selection)	
Fraunhofer Innovation Cluster »Maintenance, Repair and Overhaul (MRO) in Energy and Transport«	March 2009, Berlin
Safety and Security Conference	June 2009, Potsdam
Open Day at BMBF	August 2009, Berlin
Workshop Autarkic Wireless Sensors	October 2009, Potsdam
Workshop Microfluidics for Cells	October 2009, München
Workshop Lowering the Cost of MEMS and Sensors Fabrication and Assembly	November 2009, München
Forum be-flexible	November 2009, München
Forum Education, Science and Sustainability	November 2009, Berlin
Workshop Chemical Silver	November 2009, Berlin

FRAUNHOFER IZM AT EXHIBITIONS

Fraunhofer IZM kicked off the 2009 trade-show season in Hanover, presenting select research and development highlights at the IVAM joint booth. Sensor integration for measuring wear and tear on an industrial gearbox's gear shafts drew much attention, as did the world's smallest silicon micropump. Also demonstrated was a filter principle that reduces unwanted leakage current in high-performance engines.

The institute's booth at the SMT in Nuremburg, on the other hand, was all about reliability. Fraunhofer IZM's combined accelerated reliability tests turned out to be the hit of the day. The tests measure stress under realistic operating conditions and thus make reliable lifetime predictions possible. Fears that the critical global economic climate would lead to fewer visitors were allayed – interest rose by 20 percent compared to the previous year.

The institute also shared the Fraunhofer Group for Microelectronics' booth at SEMICON Europe, showcasing its know-how in semiconductors. The showstoppers here included copper-filled vias and electrostatic carriers for processing extremely thin flexible wafers. The researchers of the ASSID (All Silicon System Integration) project group also felt at home, as plans were announced to open a center of the same name for 3D wafer-level packaging and wafer stacking in Dresden.

No less successful was Productronica, which features the best of circuit board and component manufacturing. Together with other Fraunhofer institutes, IZM presented its entire spectrum of research and services in system integration, including technologies for multifunctional rigid and flexible circuit boards, 3D and embedding technologies, as well as the breadth of all current packaging technologies.

Fraunhofer IZM at Exhibitions 2009 (Selection)	
Hannover Messe	April 2009, Hanover
SMT	May 2009, Nuremberg
Semicon Europe	October 2009, Nuremberg
Productronica	November 2009, Munich


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PROMOTING YOUNG TALENTS

For several years Fraunhofer IZM has been trying to awaken young people's interest in technical development, as well as careers in technology and research. Fraunhofer IZM offers training programs in three recognized professions in technology and administration.

As part of the Berlin training cooperative for microtechnologists, external trainees are also regularly completing part of their internship at Fraunhofer IZM.

Furthermore, Fraunhofer IZM regularly offers a variety of events designed to interest young people in careers in technical or technology-related fields.

My type of job? Career day at Fraunhofer IZM
Ten year-nine students from Gottfried-Keller Secondary School in Charlottenburg-Wilmersdorf received a behind-the-scenes look at Fraunhofer IZM's research. After a general introduction to the institutes different working areas, the teenagers visited various laboratories, including the Security Lab, which Fraunhofer IZM operates together with Bundesdruckerei, the newly established laboratory for predicting product lifecycles and the clean room.

Focus of the tour was the mobile phone, a product with which each of the visitors was very familiar. What does a mobile phone comprise? What is needed to make more and more functions fit into such a tiny device? What does circuit and antenna design have to do with the size of the phone? And how does the scientists' research contribute to making components more energy-efficient, environmentally friendly and using fewer resources in their manufacture?

The IZM scientists answered these and other questions from the teenagers. The students also disassembled phones for a closer look at the individual components and design.

By the end of the busy day, more than a few of the visitors were contemplating a future career in technology. The IZM staff also enjoyed the visit by the enthusiastic youngsters: »I've never seen so many girls enthusiastic about technology«, said Uwe Maaß, who gave the introduction to the basics of circuit design.

9th Girls' Day: Students discover Fraunhofer IZM
As in previous years, Fraunhofer IZM Berlin and Munich played host to 11- to 14-year-old girls interested in technology as part of the 9th Girls' Day. The girls were introduced to the institute's work in the hope of enthusing them for courses and/or careers technical or technology-related fields.

The following topics were explored in Berlin:
- What does a scientist do? Fraunhofer IZM scientists report on their day-to-day
- How to bring sparkle to an evening dress? The workshop demonstrated how to integrate electronics in clothing using various examples
- How does an electronic circuit work? This was a hands-on opportunity for the visitors to build electronic tea lights

Fraunhofer IZM's Munich branch holds events just for girls all year round. At this year's Girls' Day, the visitors were able to set to work in the institute's clean room, as part of the topic »Where do microchips come from?« After inspecting the basic building blocks of microelectronic components, wafers, the girls sawed the silicon into microchips and were even able to take them home as mementos.

Talent Take-Off – young scientists visit Fraunhofer IZM
Approximately twenty year 11 to 13 students attended a preparatory course for natural science and technology degrees in Berlin at the beginning of August as part of the »Talent Take Off – First Steps in Higher Education« program. Apart from technology workshops and laboratory experiments at the Technical University, the one-week course also included visits to two Fraunhofer institutes.

»Talent Take Off« is a new network for promising high school and university students and is part of the National Joint Initiative for Women in MINT Professions, funded by the German Federal Ministry of Education and Research (BMBF). MINT stands for mathematics, informatics, natural sciences and technology.

On August 7, at the end of their stay in Berlin, the group visited Fraunhofer IZM to learn about opportunities for studying assembly and interconnection technologies. Following a general introduction by Head of Marketing Harald Pötter, the students visited a number of the institute laboratories. While some of the students were introduced to the finer points of optical interconnection technology by IZM scientists, others learned about Fraunhofer IZM's mounting technologies, using its flip chip line, and even had the opportunity to try out the equipment themselves.

Encouraging up-and-coming young researchers at Fraunhofer IZM's Munich branch
Since 2009, Fraunhofer IZM's Munich branch has been a member of the »National MINT Pact – more women in MINT professions«. As part of this BMBF initiative, the »Mätä« project is coordinating technology activities for girls in south Bavaria in the lead-up to holding the first, Bavarian Girls in Technology congress at the Kempten University of Applied Sciences, planned for September 2010. The congress, which is to be organized together with high-school and university students and apprentices, will take microsystem, optical and nano-technologies as its main theme.

High school and university students are being trained as disseminators for the congress at the Munich branch. The girls will then themselves present workshops for 10- to 16-year-old students during the event. Schools, companies and other organizations in the Allgaeu region are being encouraged to get involved in the activities in Munich. The first graduates at the Munich branch practiced their new skills at the annual Girls' Holiday Workshop »The Intelligent Milk Carton«.

1 / 2 *Young researchers experimenting with the Fraunhofer IZM flip-chip line during Talent Take-off*

FACTS & FIGURES

FRAUNHOFER IZM IN FACTS & FIGURES

In 2009 Fraunhofer IZM began establishing the infrastructure for its new branch in Dresden-Moritzburg, which will house the Fraunhofer IZM Center All Silicon System Integration Devices ASSID. Funding for the new branch is being provided by the European Union, the Federal Ministry of Education and Research (BMBF) and the Land Saxony. The establishment of this new center considerably broadens Fraunhofer IZM's service portfolio in the realm of 3D system integration. On page 19 of this report the various measures are listed in detail.

Financial situation
The global economic crisis also left its mark on Fraunhofer IZM.

Private sector contracts decreased by approximately a third to 6.6 million euros in 2009. Reliable funding by the public sector ensured that revenue from contracts remained stable at approximately 12.7 million euros.

Thanks to the concerted effort of IZM employees and austere budgeting, a balanced operating result was achieved by the year's end. Due to cost reductions of 1.1 million euros, Fraunhofer IZM's turnover fell to 27.2 million euros.

Investment and laboratories
The institute was able to begin its largest investment project in years, namely establishing the Fraunhofer IZM ASSID research group at the new Dresden/Moritzburg branch. A total sum of 49.9 million euros is being provided by the European Fund for Regional Development (EFRE), the Land Saxony and the Federal Ministry of Education and Research (BMBF). This financial support was released in 2009 and will be available throughout 2010 for the purchase of a building and equipment.

The IZM Berlin branch also received 3.3 million euros in investment funding from the federal government's Autumn 2008 stimulus package. The funding will be used for measures such as developing technologies for energy-efficient power modules and the optimization of LEDs Thanks to a new substrate processing line, substrates of a maximum of 610 mm x 456 mm will be able to be manufactured in a continuous process (see page 20 for details).

Fraunhofer Gesellschaft's strategic funding made two investment measures possible in Berlin:

An integrated testing and qualification system for highly miniaturized systems-in-packages (SiP)
This investment has allowed the EMC Laboratory to extend its service and know-how to the testing and qualification of SiPs.

A particular focus of the investment was measurement technology for high-frequency electrical signals. An oscilloscope for recording extremely fast time signals is the centerpiece of this upgrade. Tying design methodological approaches more closely to testing and qualification results for highly miniaturized SiPs is a another focus of future research. Part of the investment was therefore also dedicated to new design tools. The total investment amounted to 750,000 euros.

Assembly equipment for micro-fuel cells
Miniaturized PEM fuel cells can now be assembled and mass-produced at high yield and with high reproducibility thanks to a new assembly machine for micro-fuel cells, which was purchased for 250,000 euros. This step forward paves the way for the further development and miniaturization of fuel cells.

Various investment measures were also undertaken at the Munich IZM branch.

Bavarian Polytronic Demonstration Center
For a total of 196,000 euros laboratory equipment for chemical surface treatment of films was purchased. The new technology allows films to be treated precisely and reproducibly. Obtaining and characterizing specific surface characteristics during processing is also now possible.

A precision winding machine for assembling the film systems, as well as a cutting and joining unit for film substrates, were also established.

Sensor materials research group
A fluorescence spectrometer, a spectrometer and a Zetasizer were purchased for the material characterization of chemical sensor materials and nano-particles. This investment came to 91,000 euros.

MiMiBay
For a total of 198,000 euros a topography measurement station for fluidic systems was purchased for this project. The equipment features variable connectivity for fluidic assemblies, and includes a stereo microscope, imaging technology and a pressure control system.

Staff development
Despite the tense economic situation, Fraunhofer IZM was able to keep staffing at the Berlin, Munich and Oberpfaffenhofen branches stable. Staffing of the new Dresden branch was also begun, with an initial team of nine. This meant that the institute's number of employees rose to 251 in 2009.

The institute also continues to offer students the opportunity to combine their theoretical studies with practical scientific research. By the year's end, the institute had supervised 150 interns, master's students and student assistants.

Additionally, 10 apprentices were trained as microtechnology technicians, IT administrators, precision machinists and business administrators.

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AWARDS

Herbert Reichl receives IEEE Components, Packaging & Manufacturing Technology Award 2010
Herbert Reichl has helped shape the development of countless microelectronic applications. In recognition of his achievements, the »Institute of Electrical and Electronics Engineers (IEEE)«, which is the largest professional association in the world and is active globally, has named Professor Reichl as recipient of their »IEEE Components, Packaging & Manufacturing Technology Award 2010«.

Professor Reichl was one of the first to recognize the importance of packaging for microelectronics. His role as Head of TU Berlin's Forschungsschwerpunkt Technologien der Mikroperipherik and Director of Fraunhofer IZM has allowed him to combine first-rate basic research with applied research for industry.

EUCEMAN Award and Fraunhofer IZM Special Award 2009 for Bernd Michel
A colloquium on micro- and nano-reliability was held at the Faculty of Electrotechnology and Information Technology at the TU Chemnitz on the 17th April 2009 in honor of Prof. Dr. Bernd Michel's 60th birthday.

Prof. Michel received the EUCEMAN Award as part of the faculty colloquium for his outstanding achievements in micro and nanoreliability. Fraunhofer IZM Director Prof. Herbert Reichl acknowledged Prof. Michel's contribution to Fraunhofer IZM in establishing reliability as a main component in system development. Also on the occasion of his 60th birthday Prof. Michel received the IZM Special Award 2009 for his outstanding scientific achievement in the field of thermomechanical reliability of micro- and nanoelectronics.

Masters thesis on energy harvesting in microsystem technology awarded Elektronik Ecodesign Cup 2009
For the first time, the German trade Journal Elektronik has awarded prizes to young engineers and universities for Masters dissertations on green electronics. The TU Berlin research department Microelectronics Assembly and Interconnection Technologies, which is headed by IZM Director Prof. Herbert Reichl, won the competition, with its paper »Energy harvesting in microsystem technology – technical opportunities and limits allowing for sustainability«, written by Stephan Benecke.

Benecke's results were developed further within the TU Berlin/ Fraunhofer IZM project EcoMoS (Energy Autarkic Condition Monitoring System). EcoMoS is developing a wireless network of sensor nodes with self-sufficient power supply for machine monitoring, which is to be installed in the harsh operating conditions of a paper factory as part of a regular condition-monitoring schedule.

Peter Ramm receives the IMAPS William D. Ashman Award
Peter Ramm was the 2009 recipient of the IMAPS society's prestigious William D. Ashman Award for his »pioneering work on 3D IC stacking and integration«.

The award ceremony took place at the IMAPS International Symposium, in November 2009 in San Jose, California, and the award was presented to Peter Ramm by IMAPS-president Steve Adamson. Peter Ramm sees this honour as an appreciation of his Munich team's excellent work on 3D integration for more than two decades.

Avantex Innovation Award 2009 for interactive dress
As part of the European research project STELLA (STretchable ELectronics for Large Area Applications) by scientists at Fraunhofer IZM and TU Berlin have developed a manufacturing process for stretchable circuit boards (SCB). An interdisciplinary cooperation between design students from the HTW and the UdK Berlin and Fraunhofer IZM scientists has used these IZM and TU Berlin innovations to develop new smart clothing designs. The group received the Avantex Innovation Award 2009 for one of their creations, an interactive dress.

Fraunhofer IZM apprentice honoured for excellent exam results
Christian Dombrowski, along with other Fraunhofer-Gesellschaft apprentices, is receiving an award for outstanding results in his precision mechanics journeymans examinations. Excellent exam results have become something of a tradition among Fraunhofer IZM apprentices: After Julia Moch, who was among Berlin's top apprentices in 2006, and Janine Scholtz in 2007, Christian Dombrowski is the third IZM apprentice to finish his exams with excellent grades.

Fraunhofer IZM's Rolf Aschenbrenner is new CPMT president
IZM-scientist Rolf Aschenbrenner has been elected president of the IEEE CPMT Board of Governors. The IEEE Components, Packaging and Manufacturing Technology (CPMT) Society is the leading international forum for scientists and engineers engaged in the research, design and development of advances in microsystems packaging and manufacture. As a member of the IEEE CPMT Society Board of Governors, Rolf Aschenbrenner has worked as a European representative on the Conference Advisory Committee, and has played an active role in the globalization of IEEE CPMT in terms of membership and chapter development. He previously served as Strategic Program Director, European Activities. From 2003 until 2005 he was Vice President, Technical and from 2005 until 2009 he was the Vice President, Conferences.

Dr. Martin Schneider-Ramelow elected Chair of IMAPS Deutschland
Dr.-Ing. Martin Schneider-Ramelow took office as Chair of the German IMAPS chapter in January 2010. The International Microelectronics and Packaging Society (IMAPS) is the world's largest microelectronics association with over 10,000 members. IMAPS Deutschland e.V. was initially founded in 1973 as ISHM (International Society for Hybrid Microelectronics). It currently counts approximately 300 individuals and companies as members. Martin Schneider-Ramelow heads Fraunhofer IZM's SIIT department in Berlin (together with Rolf Aschenbrenner) and the IZM's Microsystem Engineering branch lab in Berlin Adlershof. He is a recognized expert in wire bonding quality and reliability. Apart from his work for IMAPS Deutschland, Martin Schneider-Ramelow also participates in DVS – German Welding Society, the European Center for Power Electronics e. V. ECPE and VDI – The Association of German Engineers.

1 *Rolf Aschenbrenner, Dr. Martin Schneider-Ramelow*

2 *Prof. Bernd Michel and Prof. Herbert Reichl at the occasion of the Euceman Award presentation*

LECTURES, EDITORIALS

Lectures

TU Berlin

Prof. K. Bock
- Micro- and Nano System Integration
- Technologies of Polytronic Microsystems

Prof. H. Reichl
- Technologies of Hetero System Integration
- Basics in Electronic Circuits

Prof. H. Reichl / O. Bochow-Neß
- Reliability of Microsystems

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

Dr. I. Ndip
- Elektromagnetic Reliability of Microsystems

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

Dr. M. Schneider-Ramelow
- Materials of System Integration

Dr. M. Töpper
- Physical/Chemical Foundations of MST

TU München

Dr. M. Richter
Guest Lecture: Theoretical Foundation of Microfluidic Actuators

University of Stuttgart

Dr. M. Richter
Lecture series technology assessment:
»Microfluidics – Everything flows« Application perspectives of microfluidic actuators

Editorials

Micro- and Nanosystems
(Bantam Science Publishers Ltd.)
Bock, K. (Member of Editorial Board)

Future Fab International, Mazik Media Inc., San Francisco
Ramm, P. (Member of Editorial Board)

Materials and Technologies for 3D Integration, Warrendale, Pennsylvania
Ramm, P. (Member of Editorial Board)

International Journal MicroSystem Technology
Michel, B. (Editor)

Micro- and Nanomaterials
Michel, B. (Editor)

DISSERTATIONS, BEST PAPER AWARDS

Dissertations

Gaul, H.
Berechnung der Verbindungsqualität beim Ultraschall-Wedge/Wedge-Bonden

Hutter, M.
Verbindungstechnik höchster Zuverlässigkeit für optoelektronische Komponenten

Middendorf, A.
Lebensdauerprognostik unter Berücksichtigung realer Belastungen am Beispiel von Bondverbindungen bei thermomechanischen Wechselbeanspruchungen

Best Paper Awards

Fraunhofer IZM scientists honoured with IMPACT Outstanding Paper Award
At the 4th International Microsystems, Packaging, Assembly and Circuits Technology (IMPACT) Conference in Taipei (Taiwan) Dionysios Manessis, Lars Boettcher, Andreas Ostmann, Stefan Karaszkiewicz and Herbert Reichl were honoured with the 2009 Outstanding Paper Award in October.

The IZM researchers received the award for their excellent contribution entitled, »Breakthroughs in chip embedding technologies leading to the emergence of further miniaturised system-in-packages«. The paper provides evidence for chip embedding capability at the very fine chip pad pitch of 100 µm and discusses the technology limits. The main activities in the EU-Hermes project towards the industrialisation of chip embedding technologies are described.

IMAPS 2009 Best Paper of Session Award for Fraunhofer IZM Researchers
In November, Ivan Ndip, Stephan Guttowski and Herbert Reichl received the IMAPS 2009 Best Paper of Session Award for their outstanding paper entitled, »Modeling and Analysis of a New Packaging Structure for Noise Isolation in Mixed-Signal Systems«, presented at the 42nd International Symposium on Microelectronics (IMAPS 2009) in San Jose, CA, USA.

In this paper, the «space» problem and some of the electromagnetic reliability (EMR) issues associated with conventional noise suppression structures (e. g., Electromagnetic Bandgap structures) are first quantified.

MEMBERSHIPS (SELECTION)

Academy of Sciences of New York	Prof. B. Michel	Member
Advanced Metallization Conference AMC	Dr. P. Ramm	Executive Committee
AMA Wissenschaftsrat, Fachverband Sensorik	Dr. V. Großer	Member
Arnold Sommerfeld Gesellschaft zu Leipzig	Prof. B. Michel	Scientific Committee
CATRENE - EAS Working Group on Energy Autonomous Systems	Dr. R. Hahn	Member
Deutsche Venture Capital Gesellschaft	Prof. H. Reichl	Advisory Board Member
Deutscher Verband für Schweißtechnik DVS	Dr. K.-D. Lang	Executive Board
DVS Working Group »Bonden«	Dr. M. Schneider-Ramelow	Vice Chairman
EcoDesign 2009	Dr. N. Nissen	International Co-Chair
Electronic Components and Technology Conference	Prof. K. Bock	Tec. Program Committee
Electronic Sytems Integration Technology Conference ESTC 2010	R. Aschenbrenner Dr. K.-D. Lang	General Chair Executive Chair
ENIAC - European Technology Platform	Prof. H. Reichl	Domain Team Leader
EOS European Optical Society	Dr. H. Schröder	Member
ESD Association	Dr. H. Gieser, H. Wolf	Tec. Program Committee
EUCEMAN, European Center for Micro- and Nanoreliability	Prof. B. Michel	President
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