

Fraunhofer IZM
Annual Report 2008 / 2009

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Fraunhofer IZM



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Preface



Prof. Herbert Reichl

Our institute is facing 2009 with some concern but also confidence.

While the financial crisis is unlikely to bypass Fraunhofer IZM completely, its impact will hopefully be less than that suggested by some news items. Thanks to its wide technological base and especially the fact that modern system integration technologies are expanding into ever more applications and industry branches, the cutbacks expected in some areas will be at least partially compensated.

We also firmly believe that developing new products and processes is key to overcoming economic crises and this is an area in which Fraunhofer IZM can provide its customers and partners with some solutions. Our technologies pave the way for the integration of electronics into more and more new branches and applications. We build highly miniaturized systems from a wide range of components (heterogeneous integration) and integrate sensors and interfaces for data processing (More than Moore). We work to ensure that electronics function reliably and safely in high-temperature and high-mechanical stress environments.

To better meet the associated challenges, we have further honed our emphasis on the technological approaches "3D wafer level integration" and "multifunctional substrate level integration". These research spheres are supported by the interdisciplinary areas "materials, reliability and sustainable development" and "system design". This research configuration allows us to provide our partners with one-stop, comprehensive technological system solutions.

For organizational reasons, our research focus has led us to merge the two departments "Chip Interconnection Technologies" and "Module Integration and Board Interconnection Technologies". We were able to find a young scientist from our own ranks, Martin Schneider-Ramelow, to jointly lead the department with Rolf Aschenbrenner. Our thanks for his work go again to the long-standing head of the department Professor Scheel, who is retiring.

As an additional feather in our cap, another Fraunhofer IZM department is being established as an independent Fraunhofer institute. Research on MEMS technology in Chemnitz led by Professor Geßner has evolved so successfully, that its ongoing success is to be ensured with its own organizational infrastructure.

Outstanding research and development requires fast and collaborative access to the basic research conducted at universities. With the appointment of Professor Bock, Department Head of "Polytronic Systems", to a corresponding professorship at the Technische Universität Berlin will see this cooperation intensify further. A cooperation was initiated with the Universität der Bundeswehr Munich to jointly establish the development center "Multi-Functional On-Top Technologies".

The viability of such close ties to university basic research combined with targeted translation of the latter into applications has again been confirmed by the many Best Paper Awards and prizes awarded to our staff at international conferences.

Such achievements again attracted the semiconductor industry, as well as material, equipment and system manufacturers, to Fraunhofer IZM in 2008. We were able to support small and large companies, niche providers and global market leaders alike with design, technology development and reliability assessment. I would like to take this opportunity to thank the federal and Länder ministries and project management organizations for their continued trust in our performance.

Of course, successful research and development is not possible without the dedication of our institute's staff, to whom I also extend my particular thanks.

The following pages showcase selected Fraunhofer IZM research and project results.

Happy reading!

Herbert Reichl

Umbrella Organization: Fraunhofer-Gesellschaft

Fraunhofer IZM is one of 57 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 57 Fraunhofer Institutes. The majority of the 15,000 staff are qualified scientists and engineers, who work with an annual research budget of €1.4 billion. Of this sum, more than €1.2 billion is generated through contract research. Two thirds of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Only one third is contributed by the German federal and Länder governments in the form of 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. As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop

the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

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.



Sister Institutes: Fraunhofer Group Microelectronics

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

The activities of the group concentrate largely on establishing joint focal research groups and projects. In this way, we are able to provide innovative small and medium-sized enterprises, in particular, with future-oriented research and application-oriented developments that will help them to gain a decisive competitive edge.

The group pools the core competences of its member institutes in the areas of:

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

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

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

Members are the Fraunhofer Institutes for

- Applied Solid State Physics IAF
- Communication Systems ESK

- Digital Media Technology IDMT (guest)
- Electronic Nano Systems ENAS
- Integrated Circuits IIS
- Integrated Systems and Device Technology IISB
- Microelectronic Circuits and Systems IMS
- Nanoelectronic Technologies CNT
- Open Communication Systems FOKUS (guest)
- Photonic Microsystems IPMS
- Reliability and Microintegration IZM
- Silicon Technology ISIT
- Telecommunications, Heinrich-Hertz-Institut HHI

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You Can Count on Us: Fraunhofer IZM

:: History

Established in 1993 from research groups within the key research area Microperipheral Technologies at the TU Berlin, Humboldt-Universität and the previous Institute for Mechanics at the Academy of the Sciences in Chemnitz, Fraunhofer IZM has enjoyed a successful track record. Over time, further sites were added to the institute, with two of these developing so successfully that they have themselves been established as independent Fraunhofer institutes.

Today, Fraunhofer IZM is represented in Berlin, with institute branches in Munich, Oberpfaffenhofen and Berlin's technology park Adlershof. 173 permanent staff and 120 students and interns now conduct research at the four sites.

:: Technological focus

Our technology areas form the basis for the transfer of our research results into industrial manufacturing processes, including for automotive and mechanical engineering and information and communication technology:

• Wafer Level Integration

This technology achieves the highest integration densities possible in heterogeneous assemblies. All processing steps are carried out at wafer level once the actual semiconductor processes have been completed. The starting point of this approach is the manufacture of packages, whose lateral package size is almost identical to the chip dimensions. As a second step, additional active and passive components are included on the wafer in an intermediate layer. Thanks to silicon throughplating, wafer level packaging today also offers very promising approaches to 3D integration.

• Substrate Integration

Due to increased demand for high-performance but cost-effective solutions, extended functionalities are also integrated on package or module level using established technologies. Two methods are possible here. In the first option, several components can be integrated into one package (system in package, SiP) and in the second, several packages can be stacked three-dimensionally. Hybrids of the two forms are also manufactured. Using such technologies on circuit board level is a rising trend. For example, in embedding technology, digital, as well as non-digital functions are integrated as uncased components into the substrate.

• Materials, Reliability & Sustainable Development

As miniaturization increases, the selection of employed material combinations becomes increasingly important. Using models for material behavior in the micro-range and the mechanical reliability of components, reliability analyses are carried out on all levels, from materials right through to the system as a whole. Apart from new simulation processes, laser-optical, X-ray and material tests are employed individually or in combination. As with reliability, environmental and sustainability factors should also be addressed at the design stage and material and energy requirements and the toxicity potential of the employed materials need to be clarified in a timely fashion.

• System Design

In highly integrated systems, design can no longer be carried out independently of technology and technology development cannot take place without considering electrical behavior. Codesign describes the cooperation between technology and design. Modeling, simulation and analysis technologies in relation to new electrical measurement methods take center stage here. This research focuses on EMC and RF aspects (parasitic effects).

Our Strength: Cooperation with Industry

:: Cost-effective packaging for radar sensors

Radar sensors are already employed in production model vehicles (e.g. ACC). Further development of driver assistance systems has also led to the use of radar sensors in active safety features (brake assistance, collision warning, etc).

However, the costs of manufacturing such radar-based systems, capable of gathering information from surroundings, for vehicles across the market spectrum or for compact executive cars are still too high.

Thus, despite the improved reliability characteristics, detection properties and security required of these sensors, the aim is to manufacture such systems more cost-effectively.

The "KRAFAS (Cost-optimized Radar Sensor for Active Driver Assistance Systems)" project is aiming at integrating 77 GHz components (esp. SiGe MMICs) into a printed circuit board, combining driver and RF circuitry and integrating antenna elements. This will significantly reduce current costs by 20-30 percent.

The higher requirements active safety systems place on sensor detection capabilities is to be met by new front-end concepts, e.g. electronic digital beamforming (DBF).

:: Packaging concept

A new manufacturing process is currently under development for the high-frequency module, whereby a cost-effective system-in-package is produced by combining two innovative embedding techniques.

The active and passive components are first packaged via molding flush to the surface into a polymer casing (chip-in-duomer). In this process, the components can be placed rapidly and with high precision. The subsequent molding process ensures the lasting, precise alignment of the components to each other.

These modules are then embedded by means of a standard mounting process, similar to that for BGA components, into a circuit board and rendered suitable for high-frequency operation via bonding (chip-in-polymer). A second layer of RF-compatible circuit board materials is then laminated onto this package and the respective antenna structures are formed. The two layers are electrically connected using μ -vias. Thanks to low thermal mismatch, such embedding promises high reliability with improved RF-characteristics as a result of shorter, impedance-adjusted electrical connections.

This project is funded by the Federal Ministry of Education and Research as part of the Microsystems framework program. The project is supervised by VDI/VDE Innovation + Technik GmbH and coordinated by Robert Bosch GmbH. Apart from Fraunhofer IZM, the project partners are: W+G GmbH, CWM GmbH, Würth Elektronik KG, Universität Erlangen-Nürnberg, Universität Stuttgart.

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Fig. left: Mold module embedded into a PCB with chip-in-polymer technology

Our Competence: From Assembly Concept to Manufacture

The particle accelerator in Geneva has now been put through its first paces, thanks in no small part to the Berlin Fraunhofer Institute for Reliability and Microintegration IZM. In a circular, underground tunnel, proton packets are accelerated in opposite directions to extremely high speeds and brought to collide. Detectors have been installed at several collision points to identify particles generated by the impact. Researchers hope this machine will prove the existence of the hypothetical Higgs particle.

To be able to confirm the existence of the particles, the Fraunhofer researchers have assembled special detector modules, in which 80 million pixels illuminate almost 2 m² of the collision site's inner wall. These sensor modules detect the trajectories of the electrically charged particles produced by the collision.

Because the particle packages collide in the detector every 25 nanoseconds, all pixels have to be read at a frequency of 40 MHz, which requires corresponding shorter signal paths. To reduce the volume of these sufficiently and at the same time increase reliability, Fraunhofer IZM employed so-called flip-chip technology for the connection between the sensor module and the evaluation electronics. Here, the researchers had to push to the limits of what is technologically possible. 16 analysis ICs only slightly thicker than a sheet of paper (150 µm) were soldered onto a 6*2 cm² sensor module. Each IC holds just over 3,000 bumps with a pitch of only 50 µm – less than a strand of hair.

Prior to the start of the manufacturing phase, the sensor units underwent many different reliability tests to ensure they continue to function throughout the many years of experiments planned for the accelerator. For example, for three months, the sensor modules were subjected to temperatures between 80 and 150 °C and over 1,000-fold extreme climate change (-55 to 125 °C) – with no damage to the individual bonds. Fraunhofer IZM experts not only developed this extremely reliable assembly and connection technology, but also manufactured and delivered the pixel detectors with a yield of more than 98 percent. At the completion of the manufacturing phase, over 18,000 individual chips and thus over 1,100 pixel modules had been produced, an achievement for which the researchers were awarded the ATLAS supplier award.

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Fig. left: Looking into the detector area of the ATLAS particle accelerator at CERN in Geneva during the build-up stage. This is where Fraunhofer IZM's detector modules are being used

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 assembly line
- Die and wire bonding center
- Reel-to-reel application center
- Micromechatronics center
- Process development and qualification for the electronics encapsulation
- Qualification and testing 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.

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:: Electronics Condition Monitoring Laboratory (ECM)

ECM specializes in function tests on electronic systems under environmental stress beyond purely thermo-mechanical 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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Fig. left: Test set-up at EMC measuring station in absorber chamber

Cooperation with Universities



:: 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 Microperipheral Technologies). 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 Professor Reichl has headed both research institutes, allowing him to foster intensive scientific exchange between the two. In heterogeneous integration, also known as smart system integration, the partners pursue the same goal of integrating components that may have been manufactured using very different technologies on or in a single carrier substrate. The advantages are higher flexibility and yield and lower costs along with high integration densities.

In the pursuit of this mutual goal the Forschungsschwerpunkt is increasingly taking on basic research into assembly and interconnection technology for sensors, microelectronics and microsystem technology. Key areas of research are:

- Materials and processes for integration technologies on wafer, chip and substrate level
- Polytronic microsystems

- Thermo-mechanical reliability and material characterization
- Sustainable technologies
- System design and modeling

For its part, Fraunhofer IZM supports teaching at Technische Universität Berlin by offering students additional seminars and the option of participating in national and international research projects.

:: H-C3: Human Centric Communication Center
 Joint use of equipment, laboratories and infrastructure means valuable synergetic effects for both sides in terms of research. By jointly participating in research projects, the partners are able to cover more scope and investigate research topics more deeply. An example of this is the "Human Centric Communication Center", "H-C3" for short, which opened its doors in February 2009. With this initiative, in which more than 50 TU Berlin departments and 11 other research institutes participate, the TU Berlin aims to provide intuitive access to and handling of growing amounts of information through suitable hardware and software technologies.

Fraunhofer IZM and the Forschungsschwerpunkt work within five research areas dealing with technological, economic and sociological aspects of human communication. Individual key areas include design and integration technologies for the assembly of the required hardware and energy management in networks of sensors with self-sufficient power supplies.



Prof. Karlheinz Bock

:: Appointment of Fraunhofer IZM's Karlheinz Bock to Professor for Polytronic Microsystems at TU Berlin

Professor Dr. Eng. Karlheinz Bock's appointment to Professor of Polytronic Microsystems means Fraunhofer IZM will cooperate with TU Berlin even more closely, both in terms of content and staff. Research in this emerging field 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. Further key areas include micro- and nano-structuring of polymer composites and multilayer technologies for multifunctional integration.

:: Cooperation with Universität der Bundeswehr
 Fraunhofer IZM researchers in Munich will be running a center for Multifunctional On-Top Technologies (MOTT) with Universität der Bundeswehr (UniBwM) over the next three years.

Led by Prof. Dr. Ignaz Eisele, the center will combine sophisticated silicon technologies with cost-effective system heterointegration. Using this type of modular system approach means systems can be developed 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.

Thanks to Universität der Bundeswehr's experience in standard CMOS technologies and Fraunhofer IZM's know-how in packaging for system integration, syner-



Prof. Zöllner, Prof. Kutzler and Prof. Wolisz at the occasion of the H-C3 opening

getic effects will result that will make new, technologically innovative products possible.

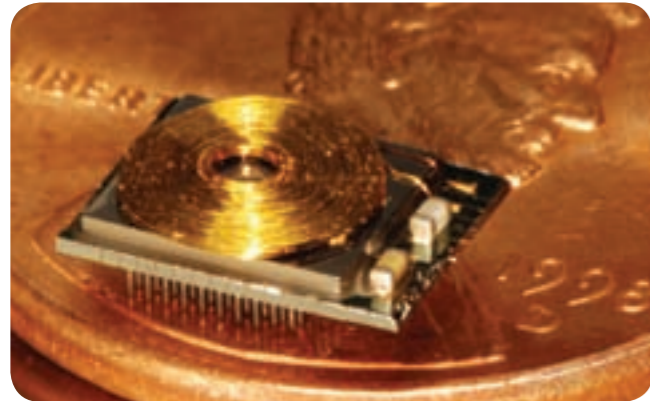
:: Cooperation with Universität Rostock
 Fraunhofer IZM and Universität Rostock collaborate in the area of soldering technologies on printed circuit boards.

The focus is on studying the correlation of wetting behavior, void formation and the quality of solder joints as well as the development of alternative manufacturing processes of printed circuit assemblies utilizing the microwave technologies.

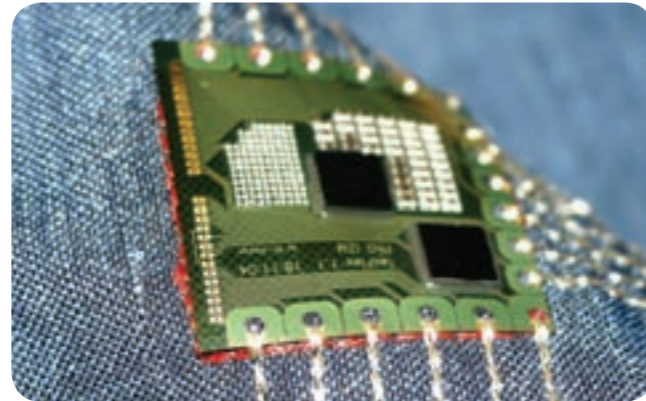
Some of Fraunhofer IZM's other university partners:

Tongji University Shanghai
Industrial Technology Research Institute Taiwan (ITRI)
Standard and Industrial Research Institute of Malaysia (SIRIM)
University of Tokyo
Korea Advanced Institute of Science and Technology (KAIST)
Georgia Institute of Technology
CEA Leti
Humboldt Universität zu Berlin
Technische Universität Dresden
Technische Universität Chemnitz
Technische Universität Bergakademie Freiberg
Universität Bonn
Universität Heidelberg
BTU Cottbus

International Research Cooperations



Neural interface – developed jointly by Fraunhofer IZM and the University of Utah



In the framework of the Heterogeneous Technology Alliance HTA Fraunhofer IZM is working on wearable electronics

:: The 3DASSM Consortium: An industry/academia collaboration

The Fraunhofer IZM (Berlin, Germany), in partnership 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) has launched a global industry consortium titled 3D All Silicon System Module (3DASSM).

This consortium will explore and develop the fundamental building block technologies to enable such Si-based systems, especially in the areas of:

- Si interposer technology with ultra-low-cost TSVs
- Fine pitch wiring
- High density systems with low temperature and low stand-off assembly of components
- Passive components made in thin film technology and
- Highly reliable connections between interposer and PWB

:: Cooperation with the University of Utah

In 2005, Fraunhofer IZM and the University of Utah started their cooperation on the basis of two projects on neuronal prostheses. Fraunhofer IZM provided the technology for a wireless integration of the system into a miniaturized device.

As part of this collaboration, two senior researchers were sent in succession to the University of Utah. In 2008, the

cooperation was strengthened by Fraunhofer IZM sponsoring a researcher position in the field of biocompatible encapsulation technologies. Aside from the already running projects, the contacts and project involvements with US industry have been intensified. Fraunhofer IZM's expertise is now applied to e.g. intelligent catheters or electronic modules for behavioural research.

Focus of the IZM cooperation with the University of Utah is clearly in the field of medical device technology, however, other areas also benefit from the know-how of IZM scientists. R&D projects in the field of miniature camera systems as well as opto-electronic components have been initiated.

Also, Fraunhofer IZM supports the Surface Mount Technology Association (SMTA) during their annual technology show and conference.

:: 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 will be 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 name "4-Labs" for joint research projects in order to provide customers with a one-stop solution for innovative products.

Independent Research and Development for the New Fraunhofer ENAS



Good ideas need room to breathe. Fraunhofer IZM's Chemnitz branch has generated many good ideas in its research and work on MEMS and BEOL and has also demonstrated commercial stability. For this reason the branch was declared an independent Fraunhofer institute on July 1st 2008.

On the day, Prof. Herbert Reichl, Fraunhofer IZM Director, thanked the Chemnitz colleagues for their many years of successful research and congratulated them on their new independence as the Fraunhofer Institute for Electronic Nanosystems ENAS. Branch head Prof. Thomas Geßner will continue as Director of new institute.

The possibilities for microsystem technology through the application of MEMS components and innovative BEOL technologies, as well as convincing economic prospects, led to the establishment of the department Micro Devices and Equipment at Fraunhofer IZM in Chemnitz in 1998. Since then, the knowledge and expertise in this area have continued to progress in a variety of directions such as towards smart system integration.

Another significant factor in their outstanding performance is the new institute's close cooperation with the Technische Universität Chemnitz, in particular with the Center for Microtechnologies (ZfM), which is also headed by Prof. Geßner. Together with ZfM, basic and applied research is conducted on micro- and nanoelectronics, as well as micro- and nanotechnologies.

"We plan to continue work on our existing research areas, namely, micro- and nano-systems, smart systems integration, reliability of MEMS/NEMS and back-end-of-line for micro- and nanoelectronics. However, as the name suggests, we intend to focus in particular on aspects of the nano-world. Furthermore, we will continue existing cooperations, as well as take on new ones," says Prof. Geßner about the plans for the institute.

Close cooperation with Fraunhofer IZM Berlin will continue on the ongoing development of micro- and nano-systems, in particular in the area of nano-assembly and interconnection technology. The cooperation will range from future-oriented development, such as carbon nano tubes, nano-bonding and system reliability, through to technological collaboration in areas such as MEMS packaging and system assembly. Furthermore, a cooperation exists with Fraunhofer IZM in the area of 3D integration.

Fraunhofer IZM wishes its colleagues in Chemnitz continued success.

Herbert Reichl, Klaus-Dieter Lang, Harald Pötter, Maik Hampicke

Modern Packaging Technologies – Indispensable for High-quality System Integration

As electronic packaging development is pushed further in the direction of system integration, it is steadily becoming a key technology for the assembly and implementation of multifunctional systems. At Fraunhofer IZM, system integration comprises two interdependent areas. (1) More and more products are being fitted with non-digital functions (such as sensors or wireless interfaces). This means that very different components, usually manufactured using different technologies, have to be combined into a sub-system in a single package. These subsystems are also ever more frequently merged into the overall system and consequently have to be adapted to the latter in terms of dimension, form, environmental parameters and cost.

This trend is almost invisible to the user and was initially spearheaded by the automotive industry in Europe. But medical and communication technologies are also using this strategy successfully. In rapidly growing product areas, such as life sciences, health and security, the employment of so-called smart systems is expected to increase strongly and thus, so will advanced integration technologies.

Despite very different requirements, four basic trends can be observed across the application fields influencing the ongoing development of integration technologies.

:: Trend 1 – Higher reliability

Three trends are leading to significantly higher reliability requirements for electronic components and systems. (1) As more tasks that determine function are integrated into electronics, customers become more aware of a failure in the latter. (2) The rising number of electronic and microsystem technology components in a product increases the possibilities of failure per component, even with a constant rate of failure. (3) The system experiences more strain because the electronics are subjected to increasingly rough environmental conditions (motor, transport crates, mobile phones dropped on pavements, etc.). Consequently industry is demanding maximum failure rates as low as in the ppb range. Furthermore, in addition to classical lifetime tests, new methods have to be employed, such as the drop test or combined lifetime tests (vibration, temperature and humidity).

:: Trend 2 – Multifunctionality

The integration of sensors and actuators is the basis of many innovations. A clear example is modern farm equipment. (1) Here, sensor technology has to improve

cost-efficiency by recording harvest-related data such as crop quantity and moisture content. GPS receivers pinpoint the machine's position on the field with an accuracy of +/- 2 cm. (2) The actuators transmit this information back into the process. In this way, GPS data help to steer tractors with the necessary accuracy during insecticide and fertilizer spraying. Because this system is often initiated electronically, the integration of power electronics and the combination of power electronics and signal processing becomes an important issue.

:: Trend 3 – Conformance with a pre-defined form / 3D integration

To integrate electronics into a given application's environment, they have to be adapted to pre-defined shapes and spaces. Here, the existing installed space has to suffice. (1) Solutions include miniaturization technologies and extremely thinned components. (2) Three-dimensional systems (3D integration) use additional degrees of freedom and increase the possibilities for an optimal combination of different technologies, as well as cost-efficiency.

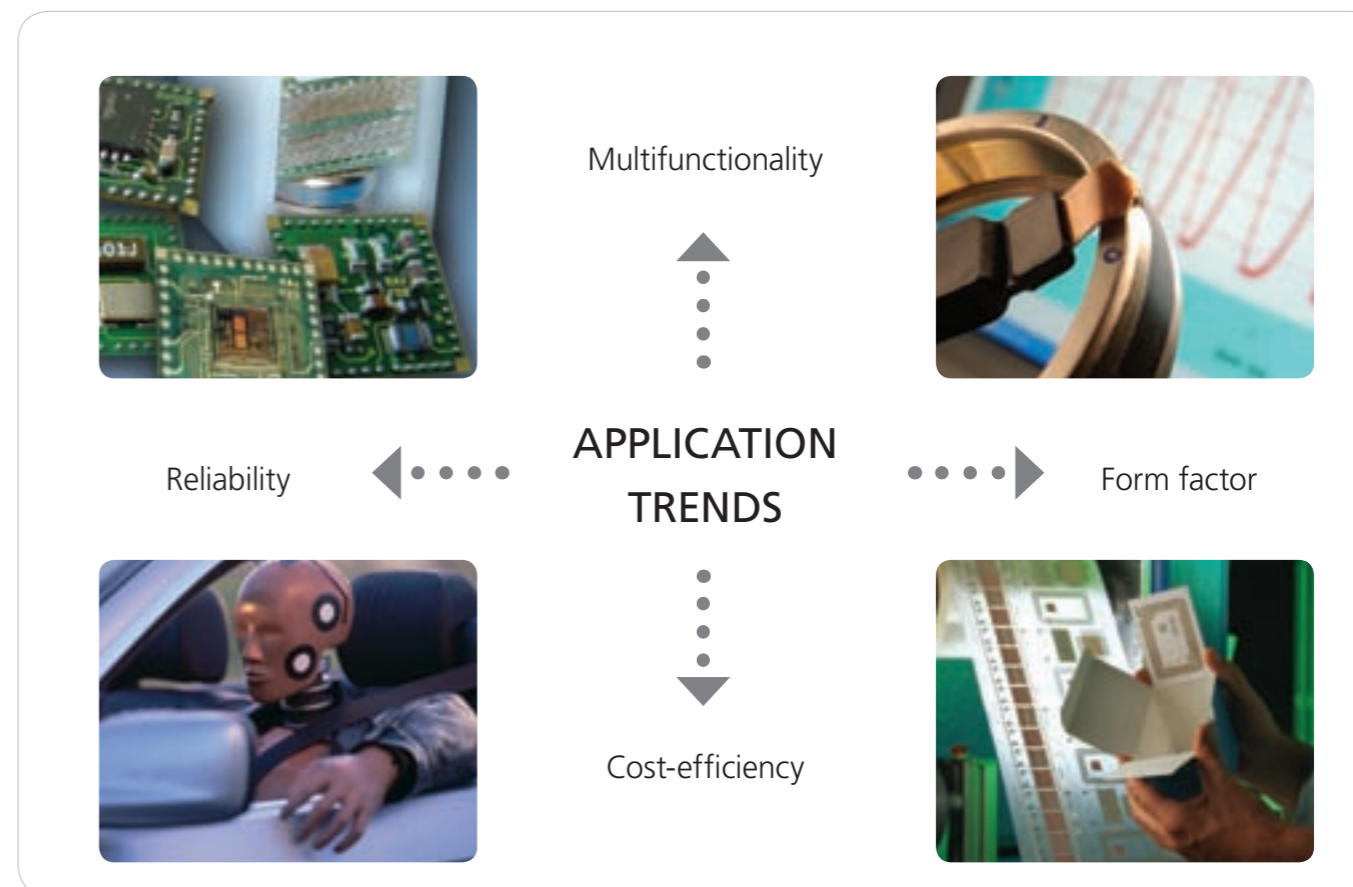
The technologies span from package and chip stacking, to embedding components in intermediate layers in the PCB or substrate, through to silicon 3D integration. (3) Foldable and/or flexible electronics and customized packages make assembly using not only an optimized manufacturing process but that also meets individual requirements possible.

:: Trend 4 – Lowering manufacturing costs

The image of low-cost electronics is set to transform from simple applications to system integration optimized in terms of technology, manufacture and environmental footprint for highly innovative and exciting products. This is clear from the rapidly increasing intelligent consumer products market. Such products require complex but cost-efficient electronics and microsystem technology to meet the demands of consumers.

:: Integration technologies: Two approaches are determining the trend

To meet the requirements of product development and the market, wafer level packaging and integration on module level have two high-performance technologies of differing complexity and integration density at their disposal. The intelligent interplay between these technology strands, also known as heterogeneous system integration, will shape future system integration.



Trends in system integration

:: Wafer level packaging

Here, all processing is carried out on wafer level, however, almost always after the actual front-end technologies have been completed. The starting point of this approach was the manufacture of chip-sized packages (CSP), the lateral package size of which is almost identical to the chip dimensions. The necessary rewiring level means additional active and passive components can be included.

Currently, intensive research is being conducted into 3D integration technologies, the embedding of thin components and wafer level molding solutions. In the future, additional functional layers will play a greater role. For example, pre-configured components will be integrated in cavities or polymer layers to create subsystems.

:: Integration technologies on module level

Due to increased demand for high-performance but cost-effective solutions, extended functionalities based on established technologies are also integrated on package or module level (heterointegration).

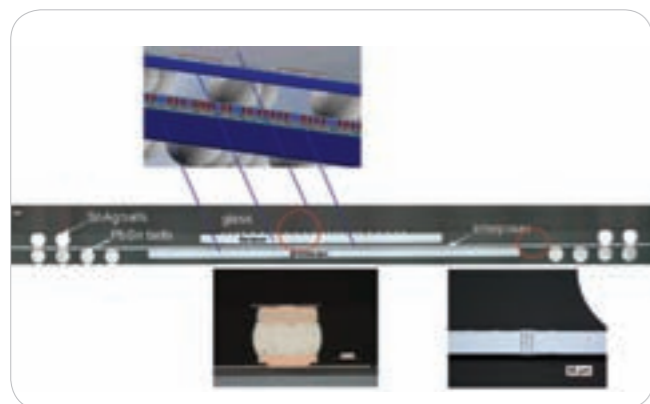
Here, several components can be integrated into a single standard package or function-oriented packages

designed specifically for a given application. In this approach, known as system-in-package (SiP), one or more ICs or sensors and additional active and passive components are integrated into one package. SiP technologies offer application-specific advantages in particular for sensor and micro-systems with primarily non-digital parameters (for example, electrical-optical or electrical-mechanical) and with special reliability, space or environmental requirements.

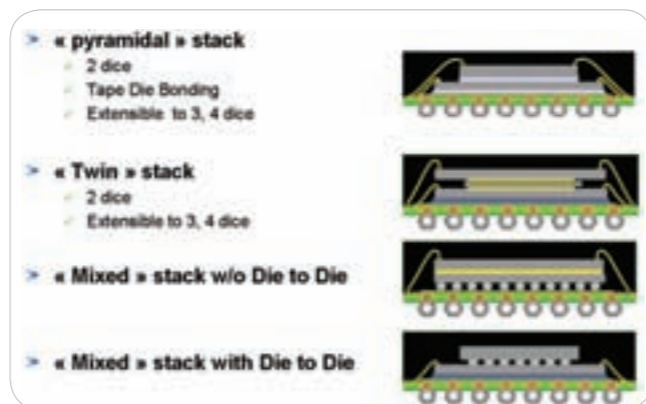
Additionally, digital and non-digital functions can be integrated as uncased components into the substrate using embedding technology. The casing is also being assigned more and more functions in addition to stability and protection. Apart from higher integration densities, this approach promises in particular cost-efficient manufacturing costs at all lot sizes. Ultimately, only heterogeneous system integration on wafer, package and board level (3D-WLP, SiP, SoB) can reliably meet the performance, functionality and miniaturization requirements of tomorrow's electronic systems. With heterogeneous system integration, the advantages of semiconductor technology can be combined with the high flexibility of modern assembly and packaging processes to manufacture multifunctional systems.

M. Jürgen Wolf, Herbert Reichl

System-in-Package Goes 3D



3D image sensor BMBF-project KASS (Source: Infineon/Fraunhofer IZM)



Examples of 3D architectures with wire bond and flip chip technology (Source: ITRS)

3D system integration is a key strategic technology in microelectronic packaging. Only heterogeneous 3D system integration can meet the performance, functionality and miniaturization requirements of future microelectronic systems.

3D silicon system integration combines high flexibility with the advantages of silicon technology to create complex micro systems. Transport and mobility, safety, energy and environment, information and communication as well as health monitoring are all key areas for future applications of this type. Possible products include image sensors, fingerprint sensors, wireless sensor nodes, memory stacks, health monitoring devices and microprocessor modules.

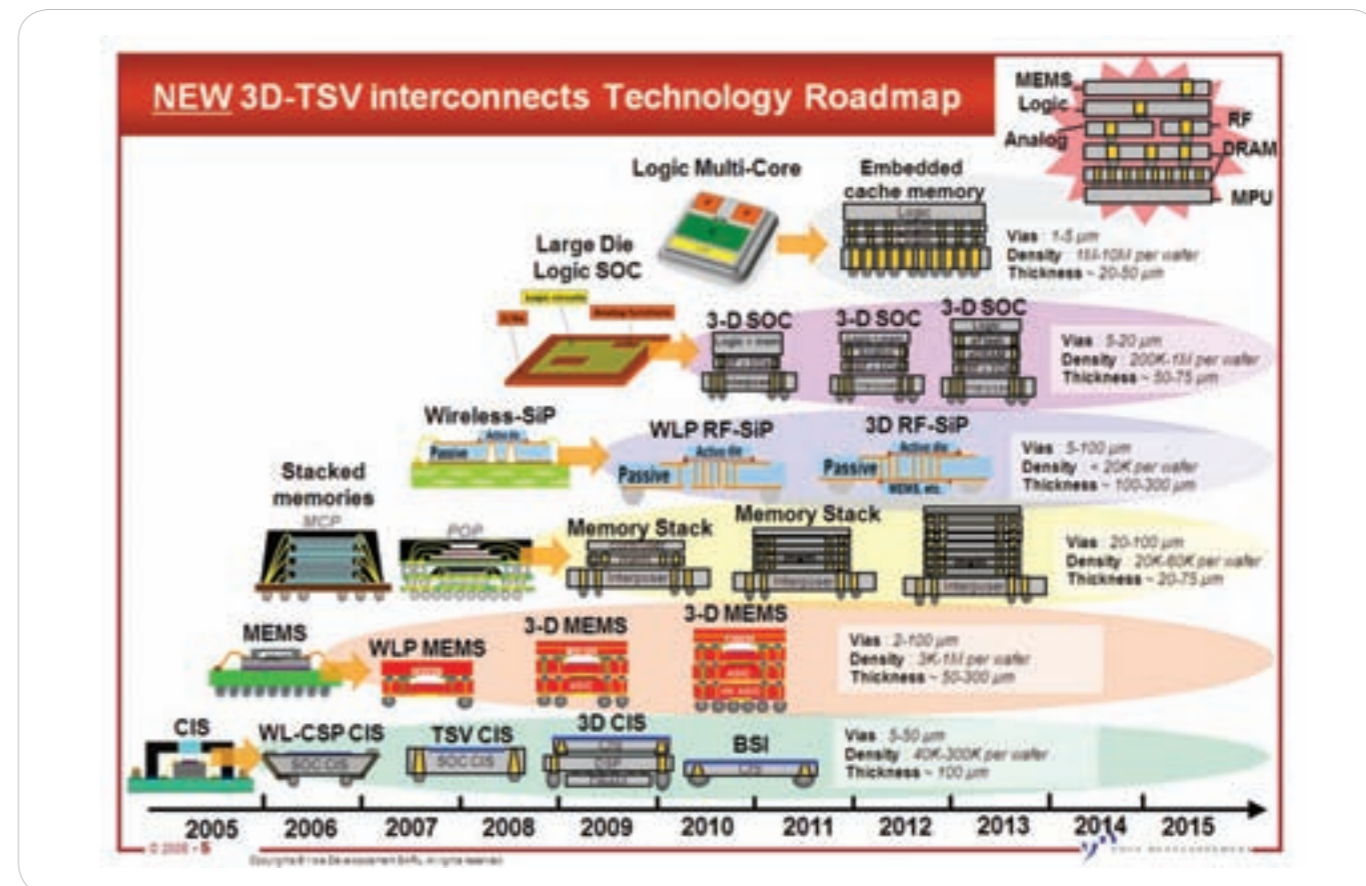
A survey by the business research and consulting firm Frost & Sullivan underlines the importance of 3D packaging as one of the most important approaches in the electronic and semiconductor industry. "A close look into the latest packaging solutions such as 3D packaging will show that packaging technologies have advanced to such an extent that they share a dominant role in maintaining advances in the semiconductor industry along the Moore curve" (Research Analyst K. Srinivasan, Frost & Sullivan).

Advances in wafer thinning and wire bonding technologies mean that 3D assembly is now a viable option for high-yield products based on wire bonding technology. This concept is already used in countless products. With 3D silicon system integration based on wafer-level technologies, state-of-the-art devices can be integrated

into heterogeneous systems, while making full use of form factor and electrical performance advantages thanks to shorter signal propagation times and lower power consumption. The approach is also suited to high I/O counts for 3D structures, which is central for image sensors with integrated signal processing, as well for manufacturing 3D multi processor- and memory modules with improved performance. The latter is an important milestone towards the coming "tera-scale computing". Together these factors account for the keen interest in 3D integration in scientific and industrial R&D activities worldwide.

Internationally, the following institutions are actively involved in R&D in this area: Fraunhofer Gesellschaft (Germany), IMEC (Belgium) and Leti (France), as well as ASET and Tohoku University (Japan), KAIST (Republic Korea), ITRI (Taiwan), IME (Singapore), RPI and GeorgiaTech (USA). Fraunhofer IZM is taking a leading role in this work and is developing an overall system approach in cooperation with equipment, material and system suppliers.

Research is primarily focusing on through-silicon via (TSV) technology with high density and aspect ratio, generic process flows for overall integration, including the handling of thinned devices and components, as well as assembly. A particular area of research is the technology's design and system environment. Here, the overall goal is establishing a technology portfolio with which 3D TSV technology can be optimized according to given product requirements while at the same time meeting cost and efficiency prerequisites.



3D TSV Roadmap (Source: Yole)

Several criteria have to be fulfilled to realize future 3D systems:

- An efficient design methodology, which takes into account system partitioning und standardized interfaces,
- An integrated process flow, including handling of thinned, large wafers,
- Availability of cost-efficient TSV technology,
- Die-to-wafer and wafer-to-wafer-assembly technologies,
- Integrated test interfaces,
- Reliability and lifecycle prognosis based on thermo-mechanical simulation models

3D integration can only be realized efficiently and make an important contribution to the development of future microsystems if all these criteria are met.

Fraunhofer IZM has successfully developed and demonstrated through-silicon via technology and 3D component stacking in projects funded by the BMBF and EU (such as KASS, eCubes). In the future, Fraunhofer IZM will build on these results and strengthen its focus on the applied development of 3D system integration technologies.

Thomas Schreier-Alt

Numerical Simulation and Innovative Sensors Shine Light onto Polymer Encapsulation

Polymer encapsulation can exert much more strain on electronic components than product and process engineers expect. Even packaging materials commonly regarded as low-stress polymers are harmful if the incorrect processing conditions are chosen.

To prevent such unpleasant surprises, Fraunhofer IZM's Oberpfaffenhofen site is optimizing encapsulation processes numerically from the very beginning of product development. Polymer-flow simulations facilitate the choice of material and determining optimum process parameters, which means highest reliability at lowest manufacturing costs.

:: Fiber Bragg gratings

- **minimally invasive, optical strain gauges**

Innovative sensors can be used to reduce strain not only for products in development, but also existing processes. A glass fiber with several optical strain sensors, called fiber Bragg gratings, can be embedded into the polymer. Like a fiber optic nervous system they are affected by all strains within the polymer, just in the same way as the embedded electronic components are:

- Material shrinkage due to polymerization
- Detection of gelation during cure, at which point a friction-locked coupling between electronic parts and polymer begins
- Strains due to different thermal expansion rates
- Strains due to delamination from the polymer

Correlation with laboratory tests such as DSC, rheology and TMA has proven excellent.

:: The CMOS stress measurement chip – a trip recorder for microelectronics

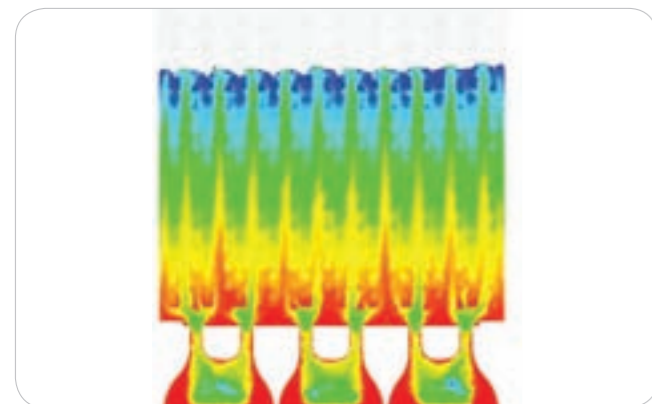
The capabilities of another measurement technology was elegantly demonstrated in the BMBF-funded project iForceSens. The technique records stresses due to process- and field-determined conditions within electronic components. The test component is replaced by the stress measurement chip, which is run through all processing and qualification steps the component undergoes, functioning as a kind of trip recorder.

Based on the well-established CMOS technology, several piezo-resistive structures detect the stress distribution on the chip surface, including shear stress, temperature and the two principal stresses on the chip's surface plane.

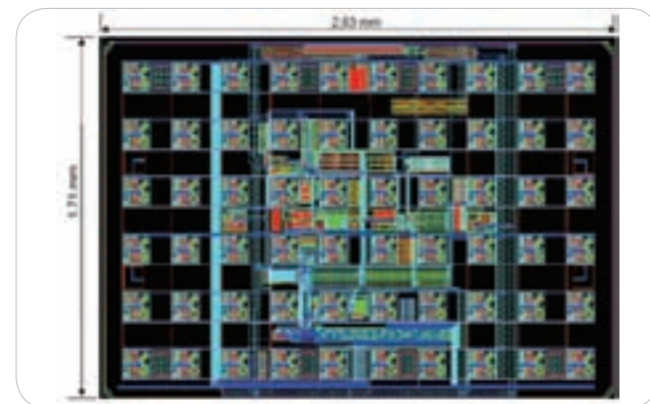
One unique advantage of the system is its high temporal and spatial resolution, which enables new insight into packaging and assembly technologies within microelectronics, including:

- Stress generation during wafer thinning and e.g. after embedding into PCBs
- Stress due to curing processes during die bonding, underfill or glob top materials
- Optimization of encapsulation processes regarding the minimization of frozen stresses within the polymer or substrate warpage (MAP type and wafer molding)
- Reliability investigation, such as the correlation of failure modes with stress characteristics, which makes „structural health monitoring“ of the system possible

For his work on Polymer Encapsulation Dr. Schreier-Alt was honoured with the Fraunhofer IZM Research Award 2008.



Simulation of polymerization state during overmolding of a printed circuit board fitted with QFN-components



Sensor layout of a stress measurement chip with 6 x 10 cells. Four different chip dimensions are available

Hans Walter

Determining the Parameters of Macro-micro-nano-scale Materials

A wide range of materials with innovative property profiles are used in today's microsystem technology to develop electronic components. Here, a precise understanding of material behavior is crucial for determining reliability.

Because the parameters provided by manufacturers are not exact enough for thermomechanical simulation and reliability optimization, they have to be determined under the various applicable environmental conditions.

In these tests, relevant material laws, theoretical material models, as well as other relevant material parameters and values are applied. Standard test specimens used in classical materials testing are not suitable for such small scales, because they cannot precisely mimic the strength and deformation behavior of microcomponents. They are also very material intensive and are thus often not ideal for developing new, enhanced material systems.

For these reasons, tiny test specimens and innovative test methods have to be specially developed.

Recently developed image correlation processes analyze temperature-dependent in-plane shifts on different surfaces of miniaturized test specimens. By calculating lateral and longitudinal strain using this method, we have been able to determine the lateral shrinkage of many different commercially available polymers.

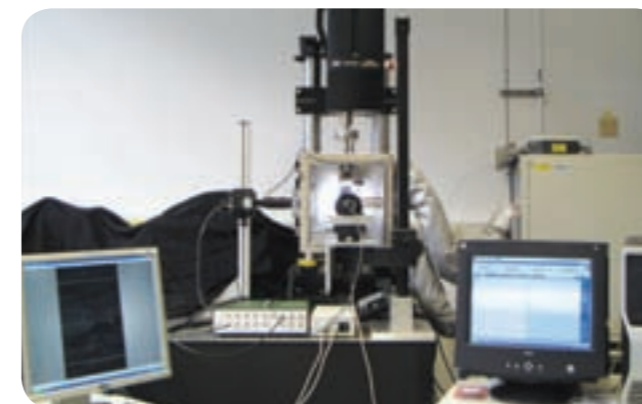
The main prerequisite for the applicability of fracture mechanics parameters to evaluate the durability of real structures is that the data obtained from miniaturized samples are valid independently of dimension. One task of the fracture criteria used here is to correlate a material characteristic that is dependent on loading, as well as crack and component geometry, with its corresponding material value.

A crucial element determining the lifetime of solder alloys using FE-simulation tests is the materials' time- and temperature-dependent behavior. Testing and measuring both primary and secondary creep of solders under cyclic loading conditions is possible using modified mini-lap shear samples.

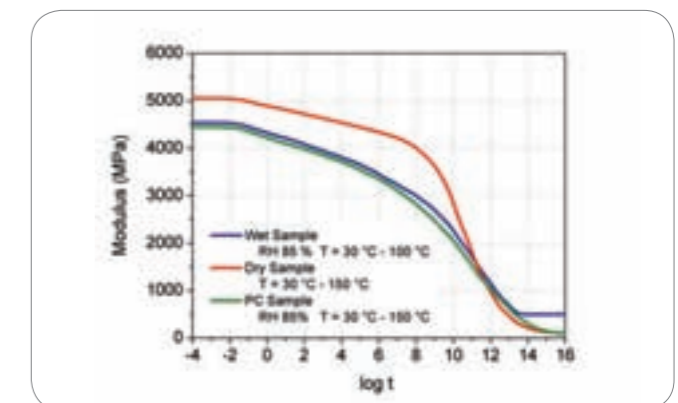
The behavior of many polymers is extremely time- and temperature- dependent and determining their viscoelastic parameters is the current state-of-the-art in mechanical engineering. Here, methods were also developed to characterize the humidity sensitivity of materials.

The influence of humidity on material behavior shows that humidity diffusion not only causes the glass transition temperature to shift and modulus values to decrease, but also significantly influences viscoelastic properties.

For his work on Parameters of Macro-micro-nano-scale Materials Dr. Hans Walter was honoured with the Fraunhofer IZM Research Award 2008.



Tensile test set-up with image correlation tool uniDAC-EDTI-USB 2.0



Influence of moisture on viscoelastic properties (master curve)



COOPERATION

YOUR BRIDGE TO

028 :: FRAUNHOFER IZM TECHNOLOGIES

029 :: FRAUNHOFER IZM MARKETING

030 - 031 :: APPLICATION CENTER SMART SYSTEM INTEGRATION

032 - 033 :: RESEARCH ACTIVITIES AND OBJECTIVES

Your Bridge to Fraunhofer IZM Technologies



Wireless sensor network

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

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

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

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

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



Yet another crowd pleaser - eScrabble

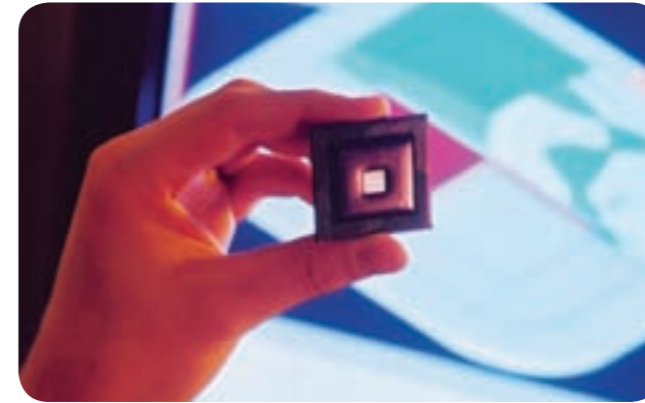
:: Application Center (APZ) Smart System Integration – Remain one step ahead by employing cutting-edge technology

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

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

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

Fraunhofer IZM Marketing



Thermo-mechanical simulation of microelectronic components

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

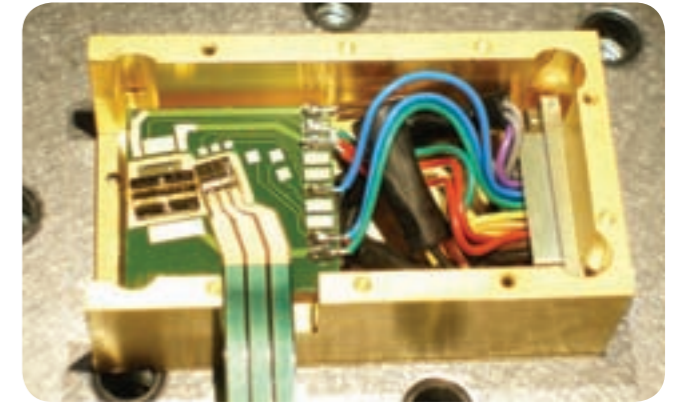
You would like to expand your know-how with the help of a special technology workshop or directly benefit from our technological expertise? We offer specialty workshops on a regular basis in all our fields of expertise.

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

:: Company-specific workshops

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

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



Green laser with 20 mW

:: Special technology workshops

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

:: Consultancy for specific technological problems

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

:: Contact



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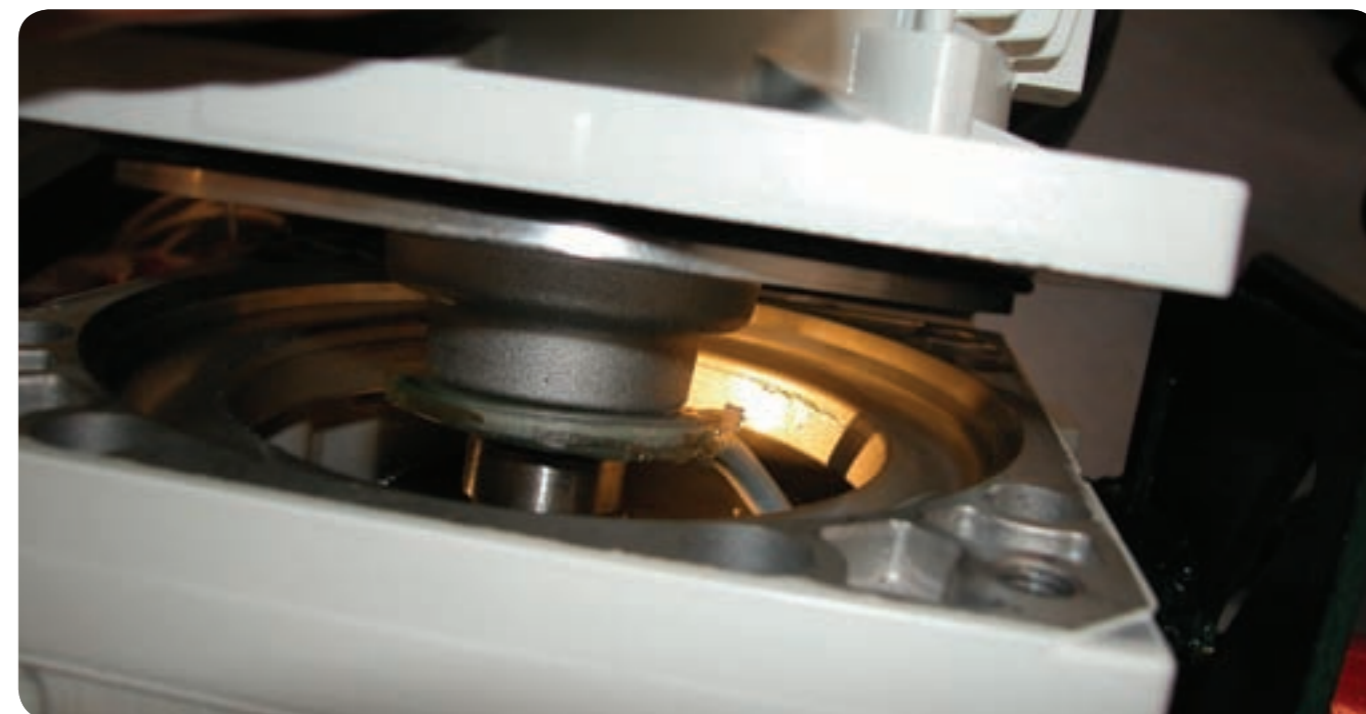
Application Center Smart System Integration Fraunhofer IZM's Focus on Applied Technology



Extremely thin transponder for secure ID documents



RF board during reliability test



RF board mounted on radial seal of a gear shaft

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

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

:: Newcomers to microsystem technology

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

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

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

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

:: Established MST companies

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

Our technology workshops and laboratory facilities are in high demand.

:: Innovation scout

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

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

:: How do we support your product development?

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

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

- First, we compile a basic study on the general feasibility of your idea and list some initial ideas for implementation. Depending on your wishes, we provide

patent searches, extensive market research and trade leads, as well as some groundwork regarding expenditure. We provide you with a customized requirements specification as outcome.

- Second, all feasible solutions will be processed by conducting evaluations, calculations, tests and simulations to collect the data required for further development and delimit the possible from the impossible. The information is compiled in a functional specifications sheet.
- As a third step, we can produce a demonstration model as a proof of concept.
- If requested, we can develop a prototype (hardware, software and technology) and take the next step toward a market solution in close collaboration with your company.
- As an additional service, we can assist you in locating the manufacturing capacities for the final product

The APZ service is a hit with our customers. We obtained excellent results in several feasibility studies carried out by our application center, including on the use of microsystem technologies in medical and mechanical engineering.

We also helped our customers realize their product ideas. These included a wireless connection between an external network and a sensor located in a vehicle gearbox.

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

:: Contact

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Research Activities and Objectives

:: SUBSTRATE INTEGRATION TECHNOLOGIES

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, thermocompression and thermosonic welding)
- Die attachment (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 leadframe 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

Micro-mechatronic Systems

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

:: WAFER LEVEL INTEGRATION TECHNOLOGIES

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

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

:: SYSTEM DESIGN

System Design & Integration

- 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...)
- 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
- Power electronic packaging design, integration & characterization
- Electromagnetic compatibility (EMC) of power electronic systems
- Application and optimization of piezoelectrical components and systems (piezoelectrical transformers, actuators, energy harvesting)

Microfluidic Systems

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



SUBSTRATE INTEGRATION TECHNOLOGIES

036 - 039 :: SYSTEM INTEGRATION & INTERCONNECTION TECHNOLOGIES

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040 - 041 :: POLYTRONIC SYSTEMS

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042 - 043 :: PCB SOLDERING TRAINING/QUALIFICATION AND MICRO MECHATRONICS

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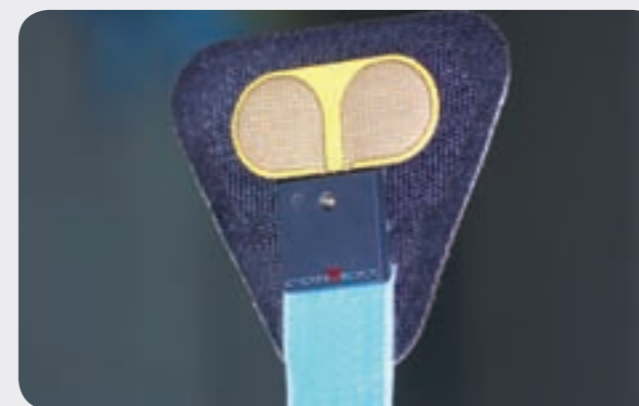
CONTACT

COMPETENCIES

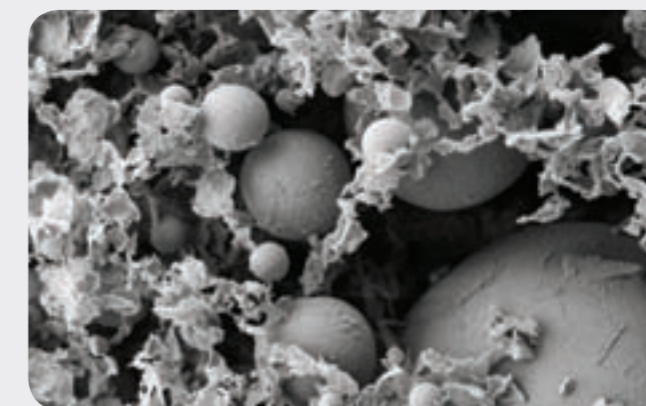
- Material and process development
- Assembly and encapsulation solutions
- Technology service and transfer
- Quality assurance and troubleshooting
- Prototype and small series assembly
- Industry-oriented seminars
- Training courses for wire bonding and PCB packaging (ESA, IPC)
- Development of jetting processes for highly viscous materials, e.g. die attach or glob top materials
- Optical coupling of nanophotonic circuits based on Sol with arrayed optical fibers

HIGHLIGHTS

- Polyurethane substrates for stretchable electronic systems
- Dual-chip SIP with embedded components
- Realization of a functional 77 GHz radar module using embedding technologies
- Advanced process control by means of in-situ dielectric measurements
- Installation of a wafer-level encapsulation lab
- Technology development for single-cell handling and analytics using PCB processes
- Increased in-situ measuring channels during reliability testing up to 571



Textile electrodes and analysis electronics for an EMG vest



SiO₂ and bentonite filler for improving the moisture barrier properties of encapsulants

SHORT PORTRAIT

In 2008 the departments Module Integration and Board Interconnection Technologies and Chip Interconnection Technologies merged, combining their research and development of substrate interconnection technologies in the department System Integration and Interconnection Technologies (SIIT).

Almost 100 employees work in the new department, developing 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 assembly
- Flip chip technologies (soldering, adhesive joining, thermocompression and thermosonic welding)
- 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

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 RESULTS

:: Integration of thin chips

The integration of thin chips in various materials for different types of applications has advanced over recent years. This has meant that the height of adhesive and soldered interconnections has had to be reduced to just a few microns. Functional ICs of < 10 µm thickness have been integrated as flip chips in polycarbonate security cards.

Display driver ICs with 50 µm thickness and 50 µm pitch have been laminated in FR4 for the realization of passive RFID modules with displays. These technologies are also employed for the assembly of very small folded multi-chip packages.

:: Integration in textiles

In the realm of integrating electronics into textiles we have developed processes and materials for the fabrication of textile UHF transponders further and modules are now washable (up to 95 °C).

Moreover, our group is currently developing technologies for manufacturing luminescent textiles and integrating sensors in car seats within other funded projects.

:: Encapsulation

Over the last year, our research into encapsulation has concentrated on high accuracy contactless material deposition of nano- and micro-functionalized materials using jetting processes. Here, we were able to successfully employ high viscosity materials between 1 Pas and > 300 Pas.

Advanced analytical techniques for determining reaction kinetics and rheological and diffusion related material characterization allowed us to achieve greater insight into material processing and device reliability.

We also developed a 77 GHz Radar module for automotive use by means of embedding processes such as chip-in-polymer/chip-in-duromer.

Reliability evaluations of heterogeneous systems were supported by the development of a rapid prototyping system for PCB based SiPs. Furthermore, we investigated topics such as wafer level encapsulation and through mold vias (TMV) as part of a government-funded project.

:: Assembly

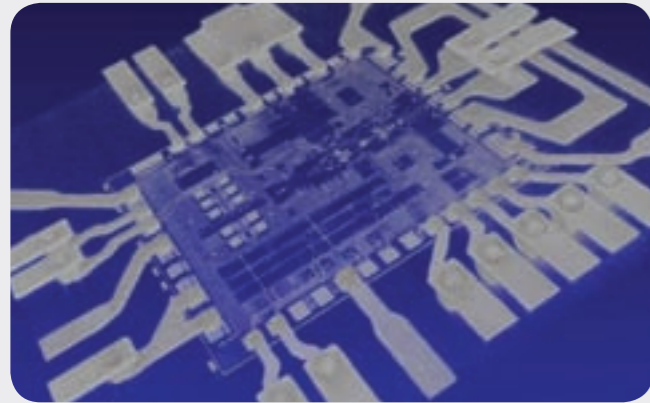
Here we focused on MEMS, sensor, IC and SMD integration. Contactless handling processes on modified standard PCB were used to evaluate the positioning of delicate components. The principles used for this were magnetic handling and electrowetting on dielectrics [EWOD].

System Integration & Interconnection Technologies

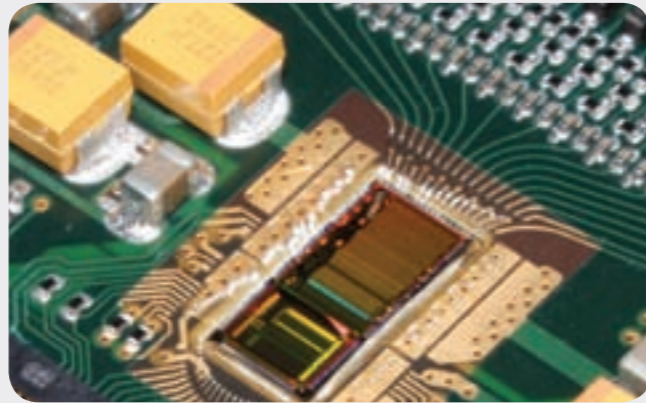
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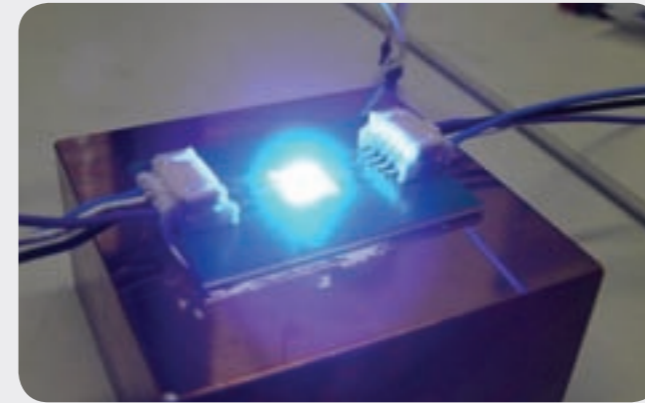
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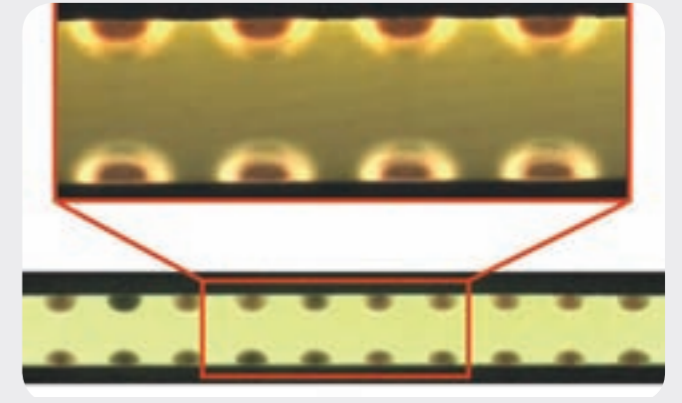
77 GHz automotive radar module manufactured using embedding technologies



Wire bonded ASIC (70 µm bond pad pitch, AlSi1 wedge/wedge)



Reliability testing of recently developed LED module



Double-sided optical thin glass with waveguides measuring approximately 53 µm x 110 µm and 250 µm horizontal and vertical spacing

RESEARCH RESULTS

:: Stretchable systems

Our department, in close cooperation with the Technische Universität Berlin, has developed manufacturing processes for electronic systems based on stretchable substrates. Conducted as part of the EU project STELLA, this research is intended for medical applications and electronics in textile.

Thermoplastic polyurethane is used as material for stretchable substrate itself. A copper film is laminated onto a polyurethane film and structured using photolithography. Long connections between components are realized in meander shapes, allowing single elongations of up to 300%. After structuring, a solder mask is applied locally and the exposed areas of the conductor covered by a second polyurethane film. Components are then soldered onto the thus created stretchable substrate using low temperature tin-bismuth alloy. As a final step, the components are encapsulated by polyurethane ensuring a robust mechanical connection to the substrate.

Systems based on this technology are easily processed further, for example by lamination onto textile carriers.

:: Interface reactions in wire bonding

The recently completed Association of Industrial Research Organisations (AiF) project "Mechanical testing methods for micro-contacts of extremely small dimensions in electronic systems" has found that quality criteria for pull tests at wedge/wedge bonded wires are also applicable to wire diameters of less than 25 µm.

However, the ball shear test showed changes in the appearance of fractures, especially in fine wire applications, in which Au-wires of higher mechanical strength are used. As the wire hardness increases, the crack becomes more likely to go through the chip's softer Al metallization, as has previously been observed when shearing Cu balls. These findings mean that the quality criteria for the ball shear test (e.g. the German Research Association on Welding and Allied Processes (DVS) Technical Bulletin 2811) has to be revised - a project presently coordinated by Fraunhofer IZM.

Reliability analyses of optimized bonded copper wires on AlSiCu metallization have shown promising results during storage of up to 1,000 h at 200 °C. We will continue our research on the interface formation of copper ball bonds in 2009.

RESEARCH RESULTS

:: 3D wafer level assembly

Chip-to-wafer assembly leads to new methods and technologies for system integration.

Three different applications have been established:

- Flip chip assembly
- Permanent die bonding for thin-film redistribution
- Reconfiguration on handling wafer for wafer-to-wafer bonding

These technologies were demonstrated in different projects with pitches as low as 40 µm and 3,000 chips per wafer, for ICs, MEMS and optoelectronic components.

:: LED modules and white light conversion

High brightness LEDs for general lighting, automotive headlamps or backlighting of displays are limited by thermal performance. To address this issue, we develop technologies for thin, high-temperature resistant interconnects with very low thermal resistance, such as AuSn soldering, sintering and TC bonding. We have also developed polymer films with a homogenous wavelength converter for the integration of white light LEDs in various packages.

:: High temperature interconnection technology

We employ new interconnect technologies for high temperature and power electronics to reduce thermal resistance and increase reliability. These technologies include

AuSn solder for GaN and SiC, sintering and transient liquid phase bonding, such as diffusion soldering and amalgamation.

:: Thin glass waveguides

This novel approach to producing waveguides uses a specially developed double-layered optical laminate comprising just one thin-glass sheet. Thanks to its dielectric loss factor of $\tan \delta \approx 6 \cdot 10^{-3}$ and a relative permittivity of $\epsilon_r \approx 7$, the material is excellently suited to high-frequency applications.

To optically functionalize the thin-glass sheets, an ion exchange process is employed between the thin glass and a salt melt. The produced graded-index multimode waveguides number 2x12 and have an attenuation of less than 0.1 dB/cm @ 850 nm. The thin-glass sheets are laminated between FR4 base laminates and diffusion simulation is used to determine the diffusion parameters. In this approach, many glass foils can also be processed at one time.

:: New optical interconnects

New arrayed optical coupling elements have been developed for electrical-optical circuit boards and sensors, in an effort to bridge the gap between the expanding field of nano-photonics and micro-photonics periphery. This photonic packaging technology uses thin glass foils and innovative features have been included to improve its versatility.

Polytronic Systems

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COMPETENCIES

- Polymer electronics and MEMS
- Ultra-thin silicon devices and their packaging
- R2R and fast sheet processes for flexible electronics
- Multifunctional biosensor systems for health, environment and process monitoring
- Analysis and test of integrated circuits

HIGHLIGHTS

- Hetero integration techniques for plastic film electronics (sensor bracelet)
- Hydrogel waveguide biosensor for the detection of calcium and glucose
- Mobile electrostatic carrier for thin wafer handling
- Gold nano lawn for cold interconnection
- Capacitive coupled transmission line pulsing



Sensor bracelet



Miniaturized climate chamber

SHORT PORTAIT

The department develops processes, components and hetero integration technologies for large-area electronics, especially for ubiquitous applications such as sensor skins and distributed polymer-based micro systems by integrating electronics onto flexible plastic films. This is only made possible through the development of a specific type of electronics – one that uses organic semiconductors and sensors on plastic films, which are produced by reel-to-reel or fast sheet processes, or on any other substrate material.

A key aspect of our approach of system design by hetero-integration is advanced fabrication processes for thin silicon substrates. These substrates cover the full range of thickness, from commercial through to flexible silicon of less than 10 to 30 μm , and the fabrication processes have been combined to a closed thinning, handling and separation technique. Nanotechnologies, such as nanocontacts (nanolawn), surface programming and self-organisation for chip assembly are investigated.

Our application center provides unique possibilities for developing and producing flexible systems using industrial equipment, which in turn enables cost-efficient manufacturing of electronics and micro systems development on conventional and large-area substrates. We work on integration of electronics with peripheral components, such as sensors, displays, batteries, fluidic elements etc., to enable fabrication of inexpensive microsystems on plastic films, like medical disposables, lab-on-chips or polymer MEMS.

TRENDS

Ubiquitous systems in a human-based ambient assisted living (AAL) environment require cost-effective multi-functional distributed systems. Here, electronics need to be produced in large volumes, cost-efficiently on large area substrates. Autarkic sensor networks in combination with RFID technology have already resulted in new applications for logistics, processing and medical technology.

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

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

For the approaches to health, environment and process monitoring the customer specific development of fully integrated, highly functional, polymer-based (bio-)sensor systems is available.

RESEARCH RESULTS

:: Smart plastics

One key to the future of flexible electronic systems is integration technologies for combining different plastic film components, such as polymer electronics, solar cells, printed batteries, displays and sensors into a flexible system.

Our Smart Plastic project has demonstrated the viability of these crucial hetero integration techniques on plastic film using a signage system with an autarkic power supply, in which organic photovoltaics, flexible batteries, energy management electronics, plastic film display elements and a sensor interface are integrated on a foil substrate. The new development provides a firm platform for the ongoing evolution of polytronic systems.

:: Thin wafer handling

Techniques for handling and processing silicon wafers of less than 100 μm thickness are a basic requirement in the manufacture of many different semiconductor products. Our patented mobile electrostatic carriers ("E-Carrier", EP 1305821B1) are a technical solution for the secure processing of very thin wafers. In recent R&D, silicon wafers with through substrate vias for electrical charging and de-charging from the backside of E-carriers were used to demonstrate the viability of the concept. Thin wafers can be reversibly attracted after initial charging at a voltage of 150 V.

:: Gold nano lawn

Gold nano lawn is a completely new interconnection technique, which promises substantially higher integration densities using techniques such as flip chip. The nano lawn is produced by means of nano-scaled lithography, through-mask electroplating on bond pads and cold welding. Daisy chains and Kelvin structures were used to characterize the interconnections electrically. The results showed that the resistance of a single 25 μm x 25 μm connection is about 1 mOhm. Daisy chains with 360 elements confirmed high reliability and excellent electrical properties.

:: Analysis and Test of Integrated Systems

Research into ESD failures using 90 nm CMOS devices and the charge device model (CDM) has shown for the first time that the department's patented capacitive coupled transmission line pulsing (CC-TLP) technique reliably and highly reproducibly generates failures and therefore helps prevent extremely expensive errors.

A miniaturized climate chamber measuring only 168 cm^3 makes transient investigations possible on small high frequency or polymer electronics set-ups.

PCB Soldering Training / Qualification and Micro Mechatronics

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COMPETENCIES

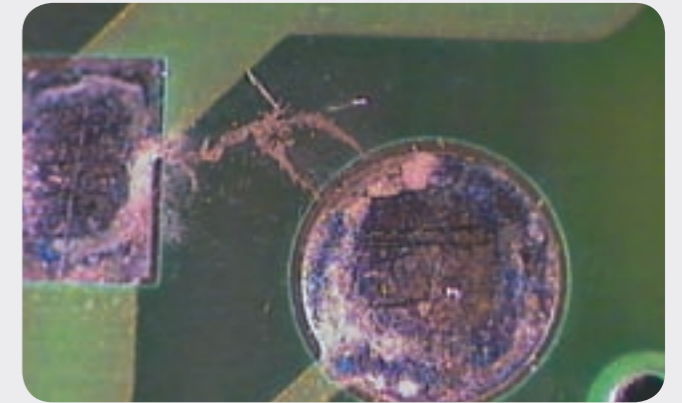
- Process simulation for assembly, connection and encapsulation technologies
- Functional rapid technologies
- Construction, assembly and evaluation of micro-mechatronic packages
- Quality analysis and reliability testing of solder joints using temperature cycling, climatic and vibration tests
- Non-destructive and destructive analysis of components and microsystems (X-ray analysis, metallography and SEM to identify causes of failures and malfunctions)
- Training according to IPC and ESA norms

HIGHLIGHTS

- Process simulation of microsystem encapsulation supported by measuring technology
- Encapsulation technology for mechatronic modules
- Additive fabrication of microelectronics
- Damage analysis of complex systems
- Evaluation of reliability under extreme conditions



Integrated electronics: Sensor package made using additive technologies



Solder resist does not prevent condensation

SHORT PORTRAIT

:: Fraunhofer IZM at the Oberpfaffenhofen site
 Through their long-term practical experience in projects with industrial partners Fraunhofer IZM's Micro-Mechatronic Center and the Training Center for Joining Technologies in Oberpfaffenhofen are able to provide particularly efficient technology and system solutions. The know-how transfer to companies takes place through workshops and seminars.

:: Micro-Mechatronic Center
 The Micro-Mechatronic Center develops technologies for mechatronic systems with mechanical, optical, electrical, power, chemical and software functions. Mechatronic assembly technology is the key to high performance mechatronic devices. We conduct advanced research, focusing in particular on process simulation, novel interconnection methods designed for mechatronic applications and a variety of different encapsulation methods.

The application of simultaneous mechanical and electrical design combined with novel rapid prototyping concepts facilitates the fast development of cutting-edge technologies. Interconnection of the modules with electrical, mechanical and optical interfaces is possible, as well as assembly on 3-dimensional substrates.

Advanced packaging solutions for electronic systems, including the use of high performance polymers, are a second focus of our department. Finally, we also perform detailed reliability investigations, measuring thermal, dynamic, mechanical and chemical stresses.

:: Training Center for Joining Technologies
 The Training Center for Joining Technologies ZVE provides industry-oriented seminars and training in processing, manufacturing and quality control. A further topic is the qualification of processes, microsystems and assemblies as well as failure analysis.

ZVE puts particular emphasis on services. Using X-ray inspection, metallography and scanning electron microscopy, the causes for failures and malfunctions in electronic assemblies are analyzed and corrective measures for preventing failures developed.

To determine the reliability of solder joints, thermal-cycling, climatic and vibration tests are carried out. Using SIR and humidity tests, it is possible to determine the probabilities of electronic assembly failure due to flux residue exposure to moisture. Testing solderability according to DIN EN and J-STD standards prevents solder failures.

RESEARCH RESULTS

:: Additive fabrication processes in microelectronics
 Investigation into mechatronic package integration at IZM's Oberpfaffenhofen site is focusing on a variety of additive processes. The research is being conducted within Fraunhofer Gesellschaft's Rapid Prototyping Alliance.

Focus of the work is the embedding of semiconductors and components into packages manufactured using additive processes and connecting these electrically. A key area is freeform fabrication of packaging for industries such as medical technology. Using an additional technology such as "integrated electronics" "intelligent" packaging with integrated sensors can be produced, while mechatronic approaches enable "integrated assembly". These techniques simplify conventional manufacturing processes for assembly, connection and encapsulation.

:: Reliability of components under extreme conditions
 A particular focus here is the qualification of components exposed to thermal, mechanical or climatic strain. Apart from determining specific damage mechanisms, the prerequisites for protecting the components are also identified. The effect of protective coatings, casting compounds and encapsulations can also be analyzed in experiments and simulations. Investigating how fluxing agents affect the quality of solder joints completes the work spectrum.

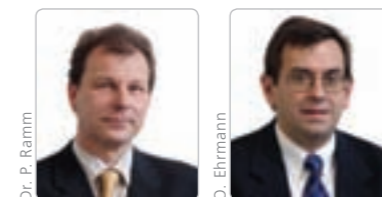
:: Project: ForPhoton
 The collaborative project ForPhoton has developed a beam deflection unit along with the first functional experimental models. The packaging, manufactured using additive processes, is suited in principle to integrated bonding and assembly. A micromirror was integrated at high precision into the carrier structure in the work package "Assembly of hybrid optical microsystems using a flexible assembly system". A specially developed casting technology protects the unit from environmental influences.

The project is funded by the Bayerische Forschungstiftung (Bavarian Research Foundation) and is being carried out in cooperation with iwB, the company Amitronics and STM.

:: Project: A new test method for classifying fluxes
 Increasingly, electronic components bonded using a selective soldering process are exhibiting failures, caused by flux residues interacting with humidity even though the fluxes used had passed the SIR test during classification.

This project is developing new/modified test methods that can make reproducible prognoses about the behavior of flux residues when affected by moisture. Once the process has been demonstrated as suitable for use, it will replace the standardized SIR test. The project is funded by AIF/DVS.

CORE COMPETENCIES
* WAFER LEVEL INTEGRATION TECHNOLOGIES



Dr. P. Ramm

O. Ehrmann

WAFER LEVEL INTEGRATION TECHNOLOGIES

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Si Technology and Vertical System Integration

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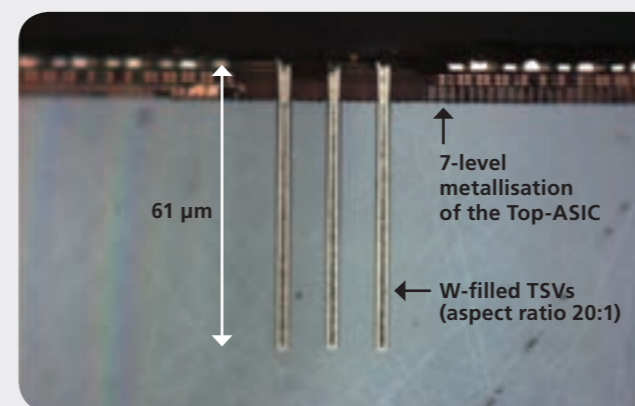
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COMPETENCIES

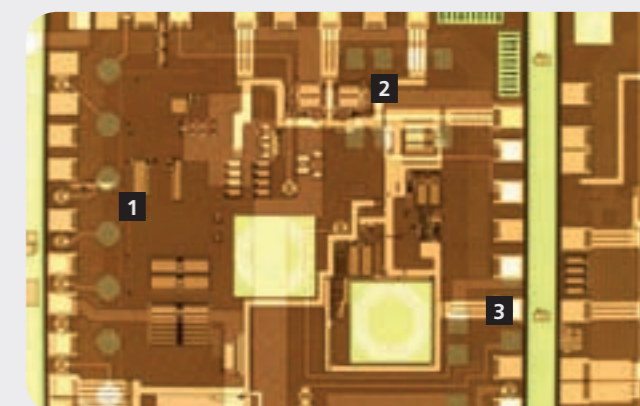
- Wafer technology
- Functional layers
- Process & design integration
- Innovative Si and SiGe technologies
- Vertical system integration
- Customer-specific solutions
- Development of test structures and process integration
- 200mm CMOS process technology

HIGHLIGHTS

- 3D integration of heterogeneous systems (3D-IC/MEMS stacks) based on post BeoL TSV technologies
- Fabrication of CMOS-compatible electro-static carriers (200 mm) for chip-to-wafer handling: e-Chuck
- Fabrication of 3D integrated product chips by through silicon via technology
- Wiley's "Handbook of 3D Integration" (August 2008), edited by Phil Garrou, Chris Bower and Peter Ramm



Cross section of an ASIC device with W-filled TSVs, for assembly of a 3D integrated ASIC/MEMS stack



Plan view on Top-ASIC of a 3D-IC stack prepared for the assembly of further components: Pads for sensor (1), BAR (2) und wire-bonds (3).

SHORT PORTAIT

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

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

Second main competence of the department is development and analytics of Silicon-Germanium epitaxial layers (CVD process) for innovative CMOS applications and new integration methods for photonic systems. The charge carrier mobilities of CMOS transistors are substantially improved by using strained silicon (sSi) as semiconductor substrate resulting in significant improvement of speed rates.

TRENDS

The potential for low-cost fabrication will be the key for future applications of 3D integration. Today fabrication of systems-on-a-chip (SoC) is based on embedding multiple technologies by monolithic integration, but there are serious disadvantages.

The chip partition with the highest complexity drives the process technology, leading to a cost explosion of the overall system. In contrast, suitable 3D integration technologies enable the combination of different optimized base technologies with the potential of low-cost fabrication through high yield and smaller IC footprints: Device stacks (e. g. controller and memory layers) fabricated with optimized 3D integration technologies will show reduced production costs compared to monolithically integrated SoCs.

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

RESEARCH RESULTS

The department's know-how in 3D integration of fully fabricated ICs, established over more than two decades, was completed by 3D integration of heterogeneous systems composed of sensor-devices und ASIC-chips fabricated with state-of-the-art technologies. Within this work both, through-silicon via (TSV) and solid-liquid-interdiffusion (SLID) technologies have been optimized with respect to process stability and reliability.

A „post backend-of-line via first“ approach for the 3D integration of an ASIC-MEMS stack which was composed of two ASICs, a pressure sensor and a bulk-acoustic-resonator (BAR) has been successfully realized in close cooperation with Infineon, SINTEF and others within the e-CUBES® project, funded by the European Commission. W-filled TSV-structures with an aspect ratio of 20:1 have been placed with high accuracy within predefined open areas of the Top-ASIC. Etching of the intermetal-dielectrics of a 7-level metallisation (thickness approx. 8 µm) was performed by applying a specific RIE-etch-sequence.

An optimized DRIE process was used for etching the silicon (etch-depth approx. 50 µm) of the Top-ASIC. Isolation of the side-walls and metallisation of the TSVs have been carried out by applying highly conformal CVD-processes. The electrical connection of the TSVs to the front-side pads and the new pads used for the subsequent assembly of the sensor and BAR components were realized by sputtering and structuring an AlSiCu-metallisation.

For thinning and processing on the bottom-side of the wafer the ASIC-Wafer was temporarily bonded to a handling substrate by polymer gluing. After thinning to a silicon thickness of 50 µm and deposition of a low temperature oxide, the W-filled TSVs were opened and the electrical connection to the pads on the bottom-side was realized by an AlSiCu metallisation. A further isolation oxide was deposited and the chips were prepared for the stacking process by etching the vias to the pads on the bottom-side and applying a Cu-UBM by electro-chemical deposition (ECD). Electrical functionality of the TSVs was demonstrated by DC-resistance measurements on integrated process-control-modules. The typical resistance value of a single TSV (3 x 10 µm², depth 60 µm) amounts to 0.45 Ohm. The thinned and processed Top-ASIC dies were placed onto a correspondingly prepared Bottom-ASIC by a chip-to-wafer placement. The electrical and mechanical connection was realized by a SnAg micro-bump technology. Thus, a stable 3D-IC stack suitable for the assembly of further MEMS and passive components was built.

To optimize the chip-to-wafer placement, further development on 200 mm CMOS-compatible mobile electrostatic carriers *) ("mobile e-Chuck") was carried out. Designs for precise chip-to-wafer handling were transferred into correspondingly structured e-Chuck wafers. First mobile e-Chucks for the temporary fixing of product dies were successfully tested within industrial projects.

*) R. Wieland, D. Bollmann, "Bipolarer Trägerwafer ...", DE 10 2005 056 364

High Density Interconnect & Wafer Level Packaging

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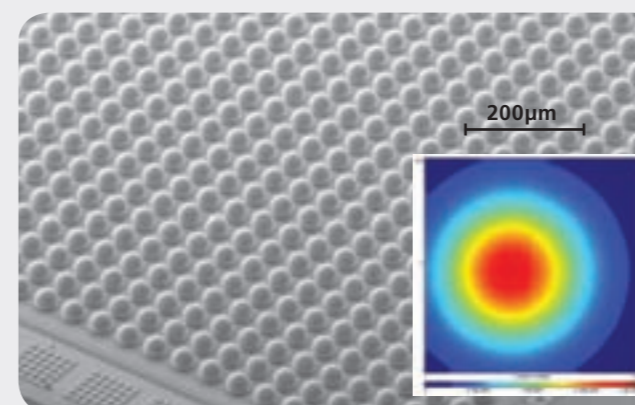
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COMPETENCIES

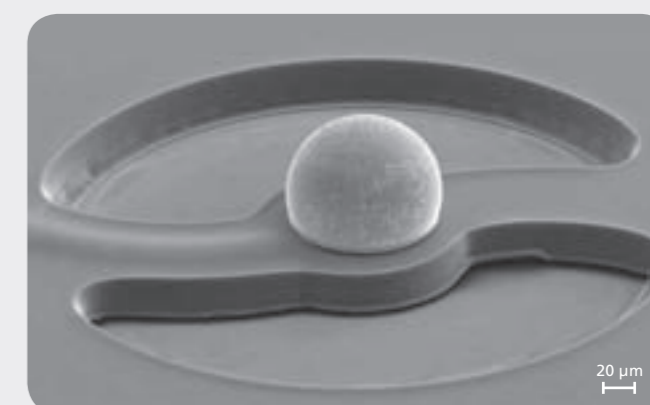
- **Wafer level CSP**
Cu redistribution, polymer dielectrics, reliability investigation
- **Wafer bumping**
Electroplating of structures in photoresist masks, bumping materials Cu, Ni, Au; PbSn, AuSn solder; lead-free solder, optical inspection
- **Thin film multilayer**
Customer-specific layout, multilayer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

HIGHLIGHTS

- Thin wafer handling and processing using various support systems
- Development of silicon interposers with copper filled vias
- New polymers for multilayer wiring
- Wafer level packaging of sensors



Readout chip with 25 µm interconnection bumps. Inset: test image from a radio active source (Courtesy of ACSR Prague)



Bump on flexible lead

SHORT PORTRAIT

The department High Density Interconnect & Wafer Level Packaging focuses on the development and application of thin-film processes in microelectronic packaging. Production-compatible equipment for thin-film processing in an 800 m² clean room determines the technological possibilities. The department cooperates with manufacturers and users of microelectronic products, as well as with clean room equipment producers and material developers from the chemical industry from all over the world.

The well-established technology branches offer prototyping and small-volume production as a regular service within the realms of MCM-D, wafer-level CSP with redistribution routing and wafer level bumping for flip chip mounting to both industrial partners and customers. Processible wafer size is limited from 100 mm to 200 mm. In cooperation with some equipment manufacturers, 300 mm tools are being introduced step by step. The service in the above areas can also include a technology transfer, even to customer-specific tools.

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

TRENDS

- Redistribution to the backside of the wafer
- Copper filled through silicon vias
- Silicon Interposers
- Fine pitch redistribution
- Chip-on-chip devices
- Thin chip integration
- Thin wafer handling with temporary bond on support wafers
- Integration of R, L, C in wafer level redistribution
- Process integration of high-K-materials
- Development of integrated passive devices (IPDs)
- Polymer layer for RF applications
- Autonomous power supply for Microsystems
- Micro fuel cells (1 cm²)
- Integrating micro batteries on wafer and foils
- DC/DC converter based on integrated magnetic materials
- Assembly of ultra fine pitch pixel detectors
- Technology for compliant bumps
- Consulting and application centre for industry

RESEARCH RESULTS

:: Ultrafine pitch bumping for X-ray detectors

Hybrid multi-channel pixel detectors are widely used for particle and radiation detection. They comprise a semiconductor sensor substrate and one or several electronic readout chips. Both parts are bonded using flip chip technology to minimize the signal track length between the sensor pixel and the electronic chip. Every pixel of the sensor substrate is connected to a single readout cell in the electronic chip. Thanks to this short signal path, the readout is extremely fast. The detector's high spectral and spatial resolution requires small solder joints on tight pitch component areas.

The X-ray detector modules manufactured at Fraunhofer IZM work with a pixel size of only 55x55 µm². SnAg solder bumps with a size of only 25 µm are deposited by electroplating on the electronic readout chip. Every chip consists of a matrix of 256x256 solder bumps, which equals exactly 65,536 bumps per chip and more than 6 million bumps on an 8" readout chip wafer. A solderable pad metallization is deposited by electroplating on the sensor side in the same tight pitch. Furthermore the flip chip assembly requires the readout chip and pixel sensor substrate to be aligned extremely accurately.

We manufacture hybrid pixel detectors for several applications. The range of assembled modules spans from single multichip prototypes for basic physical research to small batch manufacturing for X-ray material diagnostics tools used in industry.

:: Bump on flexible lead

The current transition to 300 mm wafers favors the wafer level chip size packaging (WL-CSP), with costs decreasing as wafer size increases. After dicing, WL-CSPs can be mounted onto the printed circuit board using standard surface mount assembly techniques. Board level reliability becomes a critical issue here because no underfill exists for most WL-CSP assemblies. A frequently observed failure mode in these packages is solder fatigue due to different CTEs, which increases with chip size.

We have developed a flexible interconnect technology, so-called bump on flexible lead (BoFL). The concept of BoFL is based on the thin-film redistribution technology developed at Fraunhofer IZM/TU-Berlin. Building on this technology, BoFL requires only 3 additional processing steps.

To achieve high flexibility in x-, y- and z-direction and therefore prevent excessive solder straining, the bump is placed on a flexible lead. The latter consists of a copper redistribution layer embedded in a polymer-bridge, which is mounted over an air-gap. As the flexible lead of the BoFL-WLP absorbs most of the stress during thermal cycling, the risk of solder fatigue decreases and the reliability of the PCB assembly increases.

CORE COMPETENCIES
*MATERIALS, RELIABILITY & SUSTAINABLE DEVELOPMENT



MATERIALS, RELIABILITY & SUSTAINABLE DEVELOPMENT

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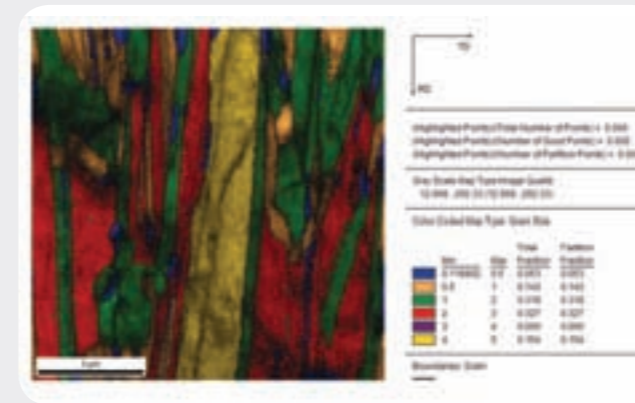
CONTACT

COMPETENCIES

- Complex reliability analysis
- Longterm reliability
- Crack avoidance strategies
- Security – Safety – Reliability
- Thermomechanical simulation
- Mechanics of packages

HIGHLIGHTS

- Establishment of a measurement system for combined reliability testing and condition monitoring
- Application of IR-thermography in failure analysis
- Analysis and mechanical characterization of thin films in the nm range
- Assessment of the thermo-mechanical reliability of polymers under the influence of moisture



Grain size distribution of an anisotropic copper foil by means of EBSD



Pre-stress analysis using focused ion beam (FIB) analysis

SHORT PORTRAIT

The department's key research area is investigations into the reliability of microelectronics components and packaging.

Competencies are:

- Deformation analysis macro – micro – nano with state-of-the-art experimental techniques
- Lifetime analysis
- Crack avoidance in components and systems
- Simulation (thermal, mechanical, electrical, diffusion, vibrations, also coupled effects)
- Combination of experiment and simulation
- Reliability of automotive electronics
- Lock-in-thermography
- Key-Lab – complex reliability analysis in micro- and nanoelectronics
- Reliability in security applications
- Acousto microscopy
- NanoRaman
- EBSD
- Materials mechanics in micro/nano regions
- Materials mechanics of packages from micro to nano
- Internal stresses in micro material compounds

TRENDS

- Dynamic material behavior in reliability analysis
- Improving the coupling of experiment and simulation
- New concepts for long-term reliability
- Inclusion of health monitoring
- Inclusion of advanced physics of failure concepts in reliability and lifetime evaluation
- Combined experiments

New kinds of applications e.g.:

- Reliability of clean technologies
- Power electronics
- Power micromechatronics
- Reliability of solar technologies
- Reliability of „low energy“ traffic
- Reliability in bio/medical fields
- Nano packaging
- Nano BioPackaging
- Combining microsecurity and nanosecurity research with reliability optimization in micro/nano regions

RESEARCH RESULTS

A new laboratory has been established for the center's junior research group TeSiMat, which is supported by the InnoProfile initiative of the German federal ministry of education and research (BMBF). The lab features internationally unique facilities for micro and nano-material and component reliability analysis.

The new measurement set up combines complex loading regimes for temperature, moisture, vibration and electrical current with advanced online and offline analysis techniques. Various online (in-situ) techniques can be selected individually or in combination as required. They include advanced electrical, thermal and optical methods quantifying load and degradation. A wide range of cutting-edge analysis techniques can be applied to the test devices before and after loading to identify the induced failure mechanism.

One analysis technique within the lab deserving special mention is tip enhanced Raman spectroscopy, with which Raman spectra can be collected at the highest lateral resolution currently possible. These spectra can be employed for a wide variety of purposes, including quantifying mechanical stress. Because such stress becomes critical at material interfaces, modified edge lift off technique (MELT) was also established in the lab. This system characterizes the fracture toughness of thin films.

The measurement system was introduced in September 2008 and crucially supports the group's ongoing research. Overall this research links process, material structure, mechanical properties, multi-physics field coupling and reliability/lifetime, focusing specifically on the following areas:

- Condition monitoring of die attach materials
- Infrared thermography used for failure detection
- Mechanical fatigue of wire bonds
- Mechanical characterization of thin films
- Influence of moisture on the mechanical properties of polymers
- Molecular modeling
- Experimental and simulative analysis of interface cracks
- Structure analysis by electron back scatter diffractometry (EBSD) and X-ray analysis

These strategies allow us to analyze the main factors influencing thermo-mechanical reliability and establish the required methods. We help develop robust products by developing novel reliability assessment methods. All research is carried out in close cooperation between Fraunhofer IZM and local companies. We also train junior staff in the industry in specialized areas. Our work thus makes a crucial contribution to maintaining the economic competitiveness of companies in the Berlin-Brandenburg region.

Environmental Engineering

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CONTACT

COMPETENCIES

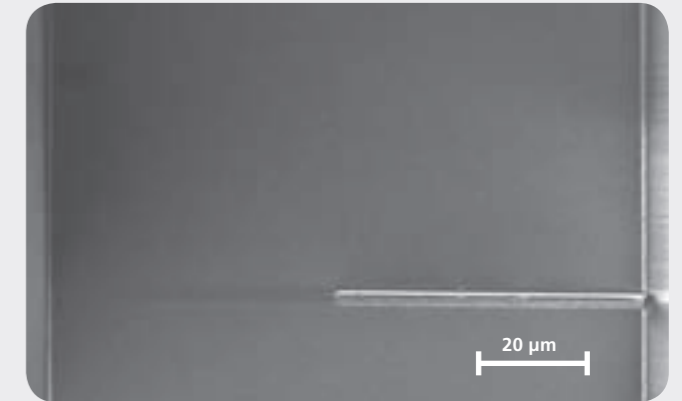
- Strategies for sustainable development of electronics
- Environmentally compatible product design – Analytics, assessments and design strategies
- Environmental and economic process optimization
- System reliability as a contribution to sustainable products
- Condition monitoring for electronic assemblies
- Industrial working groups "Reliable Lead-free Systems" and "Design for Compliance with WEEE/RoHS and EuP"
- Education and training for students and professionals

HIGHLIGHTS

- Successful international conference "Electronics Goes Green 2008+" with high industry participation
- Completion of the project "Sustainability through the application of used parts in automotive electronics – ReECar"
- Completion of the projects "BioPro" and "BioFun" for the modification and application of Biopolymers (especially PHB) in electronic products
- Completion of project "Innovation and technology analysis for autonomous distributed microsystems – ITA-AVM"
- Energy efficiency studies for the EU commission and for the German Ministry of Economy and Technology



A functional project demonstrator showing the use of renewable resources ("bioplastics") in electronic applications



A conductor line intentionally weakened via FIB (focused ion beam) to test the electrical detection of crack growth

SHORT PORTRAIT

The department focuses on the design of electronic products and technologies for sustainable development. To achieve this ecological, economic and social consequences are analyzed, evaluated and optimized in the early development phases of products and processes. The reliability of electronic systems has been identified as one technology-oriented task to increase overall resource efficiency.

New technical capabilities have been added in a laboratory covering combined stress tests and the development of microsystems for condition monitoring. From this basis we are able to test, analyze and extend the technical life span of electronic systems.

Saving resources by increasing energy efficiency, avoiding resource losses at end-of-life and the continued reduction of potentially toxic materials in electronics are other typical starting points of our investigations. We specifically support small and medium-sized companies in their activities to advance in the field of sustainability.

The application of renewable resources not just for product packaging, but for actual electronic parts is pursued to open alternatives to oil in the long-term perspective. In various studies for the EU commission main ecodesign requirements for future products are developed together with industrial partners and NGOs likewise.

TRENDS

Against the background of CO₂ reduction targets energy efficiency will remain the top target in environmental activities. This is exemplified with trend analysis studies for energy savings in ICT products and through increased use of ICT. Two such studies have been carried out for the European Commission and for the German Ministry of Economy. Environmental topics are clearly of growing importance beyond the environmental departments.

From a scientific view the concentration on energy and CO₂ emissions is a narrow selection of lead indicators from the spectrum of established ecologic assessment categories. This is indeed useful for pragmatic application, for targeted communication and for lowering the data requirements, which are still an obstacle in electronic assessments.

Nevertheless, it should be ensured that scientific research is not singularly concentrated on energy indicators. Many environmental impacts of electronics, such as toxic process chemicals or problematic materials in the products, will neither be addressed nor improved when looking at CO₂ reductions only. Modular toolsets able to do at least a screening of non-CO₂ related impacts are required. And while many people push for one simple and therefore limited indicator, at the same time movements are underway to quantify additional economic and social aspects in an evolution towards more practical sustainability assessments.

RESEARCH RESULTS

:: Sustainable spare part management

Regarding both sustainability and reliability the application of qualified re-used parts is an important area of long term spare part management. In the project "ReE-Car" long term spare part options, covering downward compatible design, periodic manufacturing, long term storage and re-use, were evaluated against sustainability criteria for the automotive sector. A decision finder now supports sustainable spare part management. Tests regarding quality and reliability of parts recovered from scrapped cars were performed and showed that used electronic parts pass the original qualification tests. As a proactive approach to determining technical risks and the expected "remaining lifetime" concepts for lifetime indicators have been improved. Integrated condition indicators will bring the ability to assess the cumulative environmental loads encountered during actual use. Product design options and requirements were established to ensure efficient spare part availability for electronics for different assumed mixes of supply paths. In reality a preferred and managed combination of re-use, long term storage, etc. has to be considered during the design stage already.

:: System reliability as a pillar of product sustainability

Achieving fewer field failures and better availability through planned maintenance increases the effective utility of systems and are important steps towards more

sustainability. Apart from optimizing existing maintenance procedures, condition based maintenance is an expanding field for long lived products.

To advance this subject more information from field use (actual load data and types of failures) and about the individual ageing state is necessary. To support research and development in this area Fraunhofer IZM has established a new Electronics Condition Monitoring Laboratory (ECMLab).

The facilities include:

- Measurement equipment for condition parameters and for online failure detection
- Test equipment for highly accelerated stress (HALT/HASS)
- Test equipment for combined stress testing (vibration, temperature and humidity)

The ECMLab is the basis for new research activities and services regarding:

- Function tests of electronic systems under extended environmental loads
- Condition diagnosis through measurement of degrading parameters
- Condition diagnosis via coupling measured environmental loads with failure models
- Design and test of monitoring microstructures and failure sensing for integrated condition monitoring



Dr. S. Guttowski

Dr. M. Richter

SYSTEM DESIGN

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CONTACT

COMPETENCIES

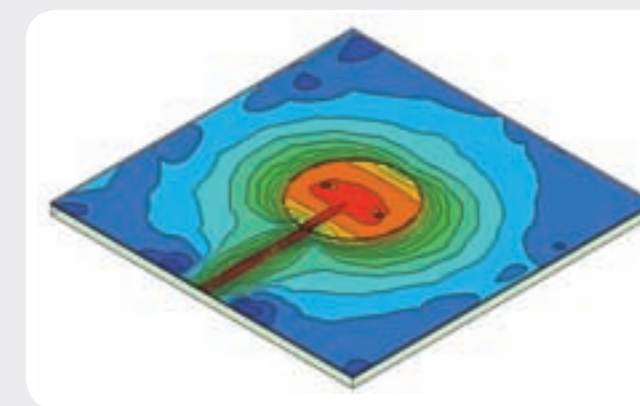
- Technology-oriented development of heterogeneous micro- and power electronic systems, from feasibility studies and cost estimates, to technology evaluation, package design and construction, right through to realization and characterization of prototypes
- RF- & EMC-aware development and characterization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

HIGHLIGHTS

- Implementation of a first prototype of SiP Expert for integrated design optimization of systems-in-package
- In-process testing of the condition of meat along the entire production chain based on microsystem technology
- Demonstrator of a mobile pulsoxymeter with integrated temperature and GPS position recording
- First-step realization and testing of hybrid components for Formula 1 vehicles
- 24-GHz-antennas in planar technology demonstrators
- Special test-IC that allows a multitude of piezo-alteration regulation and control function possibilities



Multi sensor system with RFID interface, communication via GSM



Simulation of surface current density of a 24 GHz patch antenna

SHORT PORTRAIT

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

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

Since 2008 the SDI department offers services in technology-oriented product and communication design. This way technical developments, innovations and their applications can be synchronized to each other and adjusted to the user.

TRENDS

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

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

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

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

RESEARCH RESULTS

Fraunhofer IZM's wide-ranging know-how in technology-oriented system assembly is combined in the department System Design and Integration. A particular focus is autonomous microsystems and over the last year we made important progress in this area, specifically in logistics monitoring systems, by developing the first prototypes for a system that assesses the condition of meat.

We have also developed automated layout tools that significantly accelerate the layout of 3D systems-in-package. Furthermore, a chip design user interface is now available for the design of especially sensitive circuits. In cost-driven microsystem layout, new models of system components, production processes and development resources were compiled that can be used by product developers to simplify evaluating performance measures in relation to system costs.

The M3-process was developed further for systems with very high signal frequencies. A new waveguide structure was designed with integrated transmission lines for simultaneous transmission of TEM and TE modes. We also developed a new planar functional structure for isolation from high frequency coupling on circuit transmission structures, which has several advantages over conventional methods (such as EBG structures). In addition, a substrate layer construction that secures the return current path for vertical interconnects has also been proposed.

Once developed, the idea will significantly reduce electromagnetic compatibility problems in assembly and interconnection technology.

We also intensified efforts in our department's secondary focus, namely novel packaging and interconnection technologies for high performance semiconductors. Our preliminary peripheral research on assembly technology for two-sided cooled semiconductors was taken to the next stage with a tested hybrid component for Formula 1. We also researched and successfully implemented a new circuit topology and design rule concept for piezo-actuator control. In the area of electro-magnetic compatibility in power electronics, we transferred basic research results on noise mechanisms in electrical propulsion into practice.

Our department also built on research into high reliability power electrical systems and piezoelectronic conversion performed in previous years. Here we designed a complete system concept for customer-specific development of network parts with piezoelectronic transformers.

We also developed a special test-IC that includes many of these piezo-alteration regulation and control function possibilities. In addition to the novel IC, a modernized parameter extraction software program was developed, with which exact simulation can be carried out on available piezo-transformers.

Micromechanics, Actuators and Fluidics

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CONTACT

COMPETENCIES

Development of

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

Microfluidic actuators for

- Tissue engineering

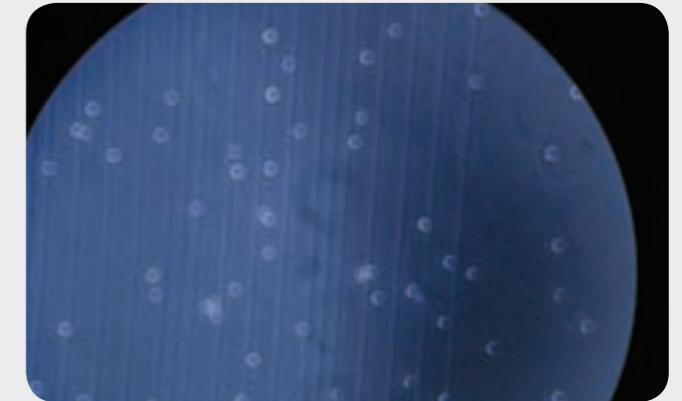
HIGHLIGHT

Micro-membrane pumps with passive seat valves exhibit "free flow" if too much pressure builds up at the inlet. We have developed a 2.7 x 3.5 mm² silicon flap valve, which only opens at a predefined threshold pressure. As example, the valve can be placed between a DEFC fuel cell's reservoir and dosing pump. The valve not only solves the "free flow" problem, but is also extremely cost-efficient thanks to its small size.

A mono-crystalline silicon flap valve, suspended on one side, is joined to a port chip and closes the latter's valve opening. Elastic springs attached to the flap valve are punched into a recess under the casing during assembly, ensuring that the flap remains closed up to a certain threshold pressure.



Silicon microvalve chip



Disruption of cells with megasonic sound

SHORT PORTRAIT

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

11 experts and 20 students of the department undertake design, simulation and prototyping of microfluidic components. The department has more than 15 years experience in that field and guarantees optimal solution for the realization of individual applications.

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

TRENDS

Currently, the department focuses to the following strategic areas:

A capability to manufacture prototypes of silicon micropumps is built up in cooperation with the company Tronics, Grenoble (silicon micropump) and Pari GmbH (high performance pump). Applications in the field of lab technology and fuel cells are currently under development. For our industrial partners these micropumps are key components for successful products, which will be realized.

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

A new working group has been setup to address the use of microfluidic actuators for tissue engineering. Here, new applications are the cell release with megasonic sound and the disruption of cells and bacteria.

RESEARCH RESULTS

:: Microvalve with threshold pressure

More efficient power supplies using micro fuel cells will soon be available for portable electronic devices. A key component of these power supplies are microfluidic actuators, in particular micropumps, which supply the cells with fuel. However, current micropumps have one major drawback, that of "free flow". Here, unwanted flow passes the micropump if too much pressure is applied in the fuel reservoir.

Our recently developed microvalve is a simple and cost-efficient solution.

:: Concept und design

The microvalve comprises a silicon flap chip that is a little thicker at the front compared to the back and is bonded to the chip with the valve opening closed by the flap. The flap is suspended with a (or, in an alternate design, two) long, elastic and meander-shaped silicon spring, manufactured together with the flap. This spring has a defined distance to the bottom chip.

After mounting the valve chip into the valve housing, the spring is pressed down at a defined position, which closes the flap. The valve opens again once a pressure exceeding a threshold value is applied.

:: Manufacturing

Several of these silicon microvalves have been designed and manufactured using a four-mask process. Two KOH etching processes are used to manufacture the wafer with the valve seat and two dry-etching steps are required for the flap wafer. The wafer stack is bonded by silicon fusion bonding. The size of the valve chip is extremely small (less than 10 mm²) and approximately 1,000 chips can be positioned on a 6" wafer stack, which optimizes cost-efficiency.

:: Fluidic characterization

The valves were mounted and tested fluidically using air. The results showed that the valves were tightly sealed once a threshold pressure of 40 hPa was applied, with a leakage rate of < 50 µl/min. Above this threshold pressure the valves opened reliably. By varying the spring geometry and the position at which the spring presses down the threshold pressure can be adjusted within a wide range.

:: Perspective

This device is a cost efficient solution to "free flow" and is also suitable for use in hydrogen fuel cells. The research was funded by the German federal ministry of education and research (BMBF) project „Pem-Gen“ (project number 16SV3312, coordinating organization VDIVDE-Innovation+Technik).



EVENTS

064 - 068 :: OVERVIEW OF EVENTS 2008

069 :: FRAUNHOFER IZM'S FAIR ACTIVITIES 2008

070 - 071 :: WORKSHOPS 2009

Events 2008



Podium event during the Electronics Goes Green 2008+ Conference

:: More than 500 participants at the Electronics Goes Green 2008+

"Electronics Goes Green" (EGG 2008+) on 8-10 September was the third time Fraunhofer IZM organized the quadrennial symposium on the environment and electronics. It is the largest expert symposium on the topic in the world.

Politicians, environment experts and engineers from around the world, including representatives from all major electronics corporations, came together at the symposium. The world's leading experts in technology development and the environment exchanged their know-how on ensuring the technological development and manufacture of products is as environmentally friendly as possible against a backdrop of ongoing economic globalization.

Especially information and communication technology (ICT) products will become more important in the world economy in the near future compared to products from other areas. Their production, use and disposal have an enormous influence on the environment and climate. However, carefully thought through innovations can also head off or at least improve ecological efficiency. The term "energy efficiency" is central to this.

More than 150 presentations by representatives from government, private enterprise and research, are proof of how significant EGG 2008+ is for the topic "The environment and electronics". Without a doubt, this international expert symposium highlighted the importance of creativity in designing solutions to promote and develop "green electronics".



Prof. Herbert Reichl gives Senator Jürgen Zöllner a guided tour of Fraunhofer IZM's Security Lab

:: Scientific excellence made in Berlin: Senator Zöllner visits Fraunhofer IZM

It's no secret: Berlin's reputation as a center for scientific excellence is primarily due to the available training programs and strong international networks. In April the Senator for Education, Science and Research Jürgen Zöllner was able to see the successful integration of science with commerce for himself in his meeting with the Heads of the various Berlin Fraunhofer institutes.

Excellence in science by international standards is more or less tradition at Fraunhofer. One topic was Fraunhofer's successful cooperation with the TU. Both parties benefit: while the university has access to the cutting-edge industry processes through Fraunhofer's application-oriented research, Fraunhofer benefits from the basic research carried out at the university.

Of the many international collaborations Fraunhofer is currently participating in, the projects with the University of Utah are particularly promising. Here, an electrode array is being developed that takes the form of a neural interface, which will be able to wirelessly transmit signals between the brain and a prosthesis. The interface will make controlling artificial limbs with the power of thought alone possible - the research project drew particular admiration from Senator Zöllner, who is himself a distinguished academic in the area of Medicine.

And what about the commercial enterprises? Fraunhofer IZM's involvement in the local research community is, on the one hand, driving up the technological standard at traditional companies and, on the other hand, providing an ideal entry point for innovative start-up companies.



Opening of the Fraunhofer innovation cluster "Secure Identity"

:: Hightech security – The Fraunhofer innovation cluster "Secure Identity"

Over 230 guests from research and industry attended the launch of Fraunhofer's innovation cluster "Secure Identity" at the Berlin-Brandenburg Academy of Sciences on November 6th 2008. The cluster and its cooperative partners will bring together research and industry know-how throughout Germany on identity theft prevention.

Five Fraunhofer institutes (FOKUS, HHI, IAP, IPK and IZM) in the Berlin-Brandenburg region are cooperating with the four regional universities (FU, HU, TU and Universität Potsdam), as well as numerous partners from industry (e.g. Bundesdruckerei GmbH, BOSCH Security Systems, Daimler AG, T-Labs, Xetos AG) and the German Federal Office for Information Security to make unambiguous identification for people, products and intellectual property a possibility.

:: 600 visitors at Fraunhofer IZM for Long Night of the Sciences

It was the fourth time that Fraunhofer IZM has taken part in the Long Night of the Sciences. The science fans were able to move through three different areas in the institute between 5 pm and 1 am, learning about the background of the term RFID (radio frequency identification), a process for wireless identification and localization of objects.

"How does it work?" and "What happens with our information?" were probably the most common questions. Florian Ohnimus and his colleagues had all the answers – through practical experiments they demonstrated on which frequencies and in which ranges data is transmit-



Christine Kallmayer presents the Security Lab at the Long Night of the Sciences

ted, how various RFID systems function and in which applications they have already been integrated.

The next area featured an eScrabble game developed by IZM scientists. Unlike a conventional Scrabble set, in the Fraunhofer version all game components – the board, the racks and all 102 alphabet tiles – are wirelessly connected. A thesaurus and an algorithm for defining the "optimal" word are stored on a laptop. eScrabble was a huge favorite with kids, who all wanted to see whether they could match the maximum point score calculated by the system.

In Security Lab, which is operated by Fraunhofer IZM together with the Bundesdruckerei, the IZM researchers demonstrated the individual manufacturing steps for producing a flexible chip card. Kids got to make their own personal chip cards.

:: "Transfer Molding" Workshop with practical component

What does high reliability microsystem encapsulation look like? Which thermomechanical boundary conditions and specific requirements determine quality encapsulation? In an all-day workshop, twelve participants from the medical technology and electronic development industries were not only provided with theoretical answers, but also received practical demonstrations of transfer molding on manufacturing scale. To start the day off, an overview of the components and materials used and the possibilities of process simulation and analysis was provided. An experienced mechanical engineer followed this up with an introduction to common concepts in molding technology and the machines currently em-

Events 2008



Prof. Wolfgang Scheel (right) together with his long-time secretary Brigitte Liske-Miels and his successor Dr. Martin Schneider-Ramelow

yed commercially. The practical component honed in on the basics of machine technology, process control and packaging analysis.

The workshop also showed how to put these processes into practice using the example of technology development for flip chip molding. The day closed with an overview of future trends in transfer molding and alternative processes for encapsulation.

:: Multifunctional Board Workshop

The demands on components are increasing. The average board is required to accommodate more and more and increasingly different functions. At the same time, applications require high reliability. How can companies respond to these challenges?

The workshop "The multifunctional board – technologies for the components of tomorrow", held at the beginning of 2008, gave over 30 participants from medium-sized measurement technology, semiconductor and automotive supplier companies and institutions an overview of current trends in component integration and current and future single technologies. The workshop also provided comprehensive insight into relevant component technologies, from substrate selection, to suitable metallization systems and bonding processes such as gluing, soldering and wire bonding, through to encapsulation and coating.

Finally, a number of questions were answered: Which analysis processes are available for quality assurance? Which material and stress-related failure mechanisms are relevant? At the very end the participants were given tips on how to predetermine reliability in experiments and simulations.



The Jugend Forscht 2008 medalists during their visit to Fraunhofer IZM

:: Colloquium in honor of the circuit board

Last summer the multifunctional board was again a hot topic in discussions on future technologies. For this reason, the who's who of the German circuit board industry met in Berlin for a one-day colloquium on 24th June 2008 to discuss the future of the circuit board. Apart from integration technologies for optoelectronic and high-frequency components, topics included combining optical waveguides in thin glass with organic or other glass layers, as well as new soldering processes such as reaction and reactive soldering and microwave soldering. In terms of power electronics, the over 100 experts debated aspects of die soldering and wire bonding, as well as the quality and reliability monitoring of these in terms of lifecycle prognosis. Development of nanotechnology low temperature bonding technologies, in the form of a metallic touch fastener, was also presented.

The event culminated with a special celebration to wish Prof. Dr. Wolfgang Scheel, the "father" of the electrical-optical circuit board (EOCB) and multifunctional board, all the best for his well-deserved retirement.

:: Young scientists visit Fraunhofer IZM Berlin

The 60 medalists of Jugend Forscht 2008, a German competition for young scientists, visited Fraunhofer IZM in September 2008 for a look behind the scenes of a research institute. After an introductory seminar on system integration by Fraunhofer IZM Head Prof. Reichl, the youngsters had the opportunity to study the institute's various research areas, such as wireless communication, biological interfaces and environmentally friendly electronics. In the afternoon they gained hands-on experience for example in the battery laboratory, where electrolysis is used to generate hydrogen for micro fuel cells.



Junior scientists during Technology Day

:: Fraunhofer IZM joins the "Maths Ship" tour

The exhibition ship MS Wissenschaft anchored near the Kennedy Bridge in Bonn on 6th May. Curious journalists and visitors witnessed a festive naming ceremony held by the project initiators to ready the "Maths Ship" for its journey to a total of 30 Germany cities. The expo space was approximately 600 m² and will be filled with over 30 exhibits with lots of opportunities to join in, try out or just observe. Of course, the Fraunhofer Institutes were there as well with four booths of our own, and we brought Fraunhofer IZM's eScrabble – the first ever fully electronic board game. Exhibitions help to make seemingly abstract science understandable and demonstrate its practical applications.

Regardless of age visitor took the opportunity to have a look at this and other science projects free-of-charge at the Maths Expo on board the 105-m inland vessel.

:: Technology Day - highschool students get the scoop on RFID technology

For the first time under the auspices of President Horst Köhler, Berlin enterprises opened their doors to students for Germany's annual Technology Day, which aims to get young people interested in technology and technical careers.

Fraunhofer IZM's contribution was a laboratory workshop on radio frequency identification (RFIDs) with 20 highschool students from the districts Charlottenburg and Friedrichshain-Kreuzberg. In basic experiments the 8th and 12th grade students were able to find out for themselves what this technology can do. An electronic Scrabble set also helped to demonstrate how RFID can be used to network an entire board game.



EURIPIDES-Forum: Yves Le Goff, Vicenc Aguilera, Dr. Ulrich Katenkamp, Jean-Luc Maté, Dr. Klaus-Dieter Lang (from left)

:: 2nd EURIPIDES Forum takes place in Berlin

In October almost 150 developers, manufacturers and users of microsystem technology from all over Europe met at the MARITIM Pro Arte Hotel in Berlin to exchange information on a multitude of EUREKA-EURIPIDES projects in various application fields.

EURIPIDES is the European Cluster of Electronic Packaging and Integration of Microdevices and Smart Systems. Klaus-Dieter Lang, Fraunhofer IZM's deputy head and member of the Scientific Advisory Board of EURIPIDES, acted as local conference organizer.

Various companies took the opportunity to present so-called "Expressions of Interest", introducing project proposals on topics ranging from wireless car sensors to MEMS for RF applications and micro fuel cells.

"We are very pleased with the turnout" says Yves le Goff, director of the EURIPIDES Office. "The feedback from our visitors from science and industry has been very positive, both with regard to the quality of proposals as well as to the Forum as a whole."

:: Workshop: Energy efficiency in information and communication technology

Fraunhofer IZM, together with Fraunhofer ISI, held a experts workshop on ICT energy requirements at the Federal Ministry of Economic Affairs in Berlin on 26.02.2009.

About 50 participants from industry, federal agencies and research came together to discuss a Fraunhofer trend analysis on ICT power consumption throughout Germany. The report is to be a cornerstone in the federal government's "Green IT" strategy.

Events 2008



Prof. Eisaku Ohtsuru, Prof. Hajime Tomokage, Dr. Peter Ramm and Dr. Lorenz Granrath at the signing ceremony in Fukuoka, Japan

:: Cooperation contract with Japanese partners

The Fukuoka Industry, Science & Technology Foundation and Fraunhofer have agreed to encourage and promote cooperation in the fields of 3D and MEMS integration by working together in all areas of technological development, especially pertaining to industrial technology, technology strategy, R&D management, and technical information and training. Objectives of the cooperation with Fraunhofer IZM Munich are, among others, MEMS 3D integration and joint reliability testing.

The signing ceremony of the Memorandum of Understanding contract was celebrated in Fukuoka on November 25, in the presence of Managing Director Prof. Eisaku Ohtsuru, Dr. Lorenz Granrath, Fraunhofer Japan, and representatives from associated industrial companies.

:: Fraunhofer IZM scientist present packaging solutions in Vietnam

In December 2008 IZM researchers headed by the institute's deputy director Dr. Klaus-Dieter Lang, met with Vietnamese representatives from science and industry to discuss current trends in the realm of packaging and assembly technology.

The meeting took place at the occasion of a Workshop on System Integration and Packaging Technologies at Fraunhofer IZM at the HCMC Institute of Physics in Ho Chi Minh City, jointly organized by the Vietnamese Academy of Science and Technologies and Fraunhofer IZM. The feedback both from the participants and the organizers of the workshop was very positive. Many attendants were particularly interested in the organisation of research funding in Germany in general and the Fraunhofer model in particular.



Dr. Klaus-Dieter Lang in Vietnam

:: International Symposium on Photonic Packaging

On November 13 the second International Symposium on Photonic Packaging took place in Munich, concurrent with the electronica trade fair. 50 international participants from science and industry met to discuss current trends in optical technologies.

The event was organized by Dr. Henning Schröder of Fraunhofer IZM, who also presented recent developments in the field of optical transmission technology.

Fraunhofer IZM Events 2008 (Selection)		
February 2008	München	Fraunhofer Talent School
	Berlin	Arbeitskreis Richtlinien-konformes Design für WEEE, RoHS und EuP
March 2008	München	Reel-to-Reel Forum
April 2008	Berlin	Girls' Day
May 2008	Berlin	Workshop Technology Scouting
September 2008	Berlin	Microsystems Summer School
	Berlin	Workshop Flip Chip Assembly
October 2008	München	Workshop Microdosing Systems
November 2008	München	2nd International Symposium on Photonic Packaging
	Dortmund	Workshop ReECar
	Berlin	Hochschulforum MST
December 2008	München	Forum be-flexible 2008

Fraunhofer IZM Ahead of the Pack at Trade Fairs in 2008



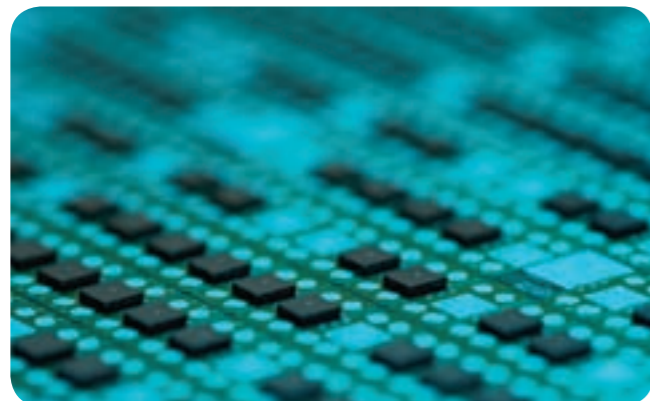
The trade fair season began with a home game for the Munich branch in April 2008, with the institute presenting its recent developments in medical technology, bio-technology and food stuff technology at Analytica. Also held in April was the Hannover Messe. Fraunhofer IZM researchers' eScrabble, the first completely electronically networked board game, drew a lot of attention here. Using sophisticated integration technologies, the entire electronics, from the power supply to the processor, through to the wireless transmission, is packaged in the board itself, which is less than 3.5 mm high.

This year's IZM booth at the SMT in Nuremberg was all about embedding technologies. The highlight was a 77 GHz radar sensor for active driver assistance systems. By combining two innovative embedding technologies, the system-in-package (SiP) will reduce costs by 30%. The new SiP was developed as part of the cooperative project KRAFAS.

The season closed with SEMICON Europe in Stuttgart. Here Fraunhofer IZM caused a stir with a 3D stack completely mounted on wafer level. The stack combines three functional layers by integrating a 20 µm IC in the substrate IC's rewiring layer and accommodating the third IC using flip chip technique.

Fraunhofer IZM at Trade Fairs 2008 (Selection)		
April 2008	München	Analytica
	Barcelona	Smart Systems Integration
	Hannover	Hannover Messe
May 2008	Berlin	Microsystems Summer School
	Nürnberg	PCIM
June 2008	Nürnberg	SMT
September 2008	Berlin	IFA
	Berlin	Electronics Goes Green
October 2008	Berlin	SEMICON Europe

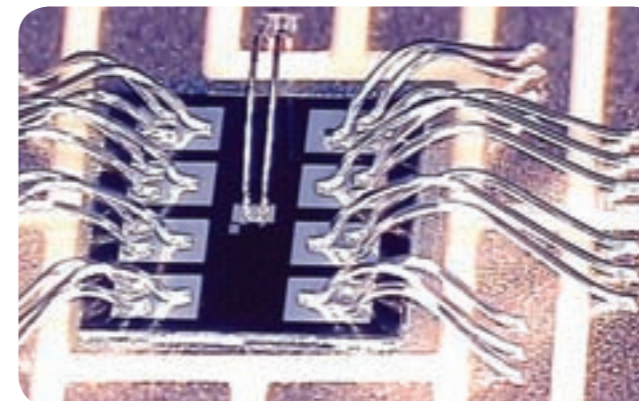
Workshops 2009



Chip-to-wafer technology



Silicon micropump



Heavy-wire bonded power semiconductor



Flip chip assembly line

:: 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 <http://apz.izm.fraunhofer.de/cms/workshops.phtml>

:: **Contact:** Harald Pötter
 Phone: +49 (0)30 / 4 64 03-7 42
 E-Mail: harald.poetter@apz.izm.fraunhofer.de

:: [1] Microdosing Seminar

The workshop aims at giving an overview of recent developments and future trends in microfluidics, as well as challenges concerning the technology transfer into industrially manufactured products.

What will you learn?

- High-performance micropump for medical applications
- Simulation and reliability testing
- Industrialization of Si-micropumps
- Key technologies for the miniaturization of the next generation fuel cells

Potential participants: Technicians, managers, designers and construction engineers.

:: [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.



FACTS & FIGURES

- 074 - 075 :: FRAUNHOFER IZM IN FACTS & FIGURES
- 076 - 077 :: AWARDS
- 078 - 079 :: TRAINING & EDUCATION
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- 081 :: DISSERTATIONS, BEST PAPER AWARDS
- 082 :: COOPERATION WITH INDUSTRY
- 083 :: MEMBERSHIPS
- 084 - 087 :: PUBLICATIONS
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Fraunhofer IZM in Facts and Figures

Fraunhofer IZM's Chemnitz branch was established as the independent Fraunhofer Institute for Electronic Nanosystems (ENAS) on July 1st 2008. The economic development described below is based on the performance of the Berlin and Munich branches in the previous year.

:: Financial situation

Fraunhofer IZM's turnover in 2008 increased by 11 percent to 28.3 million euros. External proceeds accounted for 81 percent of the operating budget. A total of 23 million euros was procured from external sources, which represents a 6 percent increase compared to the previous year.

Contracts with German and international industry and trade associations also increased by 11% to just over 10 million euros. Thus the proportion of revenue from industry remained stable at about 34 percent.

:: Investments and laboratories

Several new laboratories areas were completed in 2008. At Fraunhofer IZM-Berlin's Wedding site the Electronics Condition Monitoring Laboratory was opened, featuring measuring devices for determining the condition and online failure of electronic systems, a testing station for weak-spot analysis and one for combined lifecycle tests (vibration, thermal cycling and humidity).

The ECM lab provides concepts, methods and solutions for:

- Estimating remaining service life
- Condition-based servicing and availability
- Integrated condition indicators
- Reliability and safety assurance
- System behavior during use

The ECM lab opens up new possibilities for Fraunhofer IZM:

- Function testing of electronic systems under extended environmental stresses
- Condition assessment by means of measuring degradation-dependent parameters
- Condition assessment by means of stress recording, data analysis and failure models
- Design and testing of monitoring structures and failure sensors to develop condition indicators

The 1 million euros required for the set-up were provided by the Fraunhofer Gesellschaft's strategic investment fund and Fraunhofer IZM's own budget.

The Electronics in Textiles Laboratory
Textile electronic systems are becoming more commercially viable and interest from industry has grown strongly. Fraunhofer IZM has been researching this topic since

2000 and is now one of the world's leading research institutes in this area.

In a world-first, textiles and electronics are fused in a joint laboratory at Fraunhofer IZM's TexLab. Almost all manufacturing steps can now be carried out in the one laboratory, ensuring highly efficient research. TexLab's machine park includes a professional industrial knitting machine, a standard washing machine and an automatic thermal transfer press. All machines are also employed in industrial manufacturing, which facilitates developing solutions for industry and subsequently transferring these into production.

Wafer Level Assembly Line

Installation of a new wafer-level assembly line costing about 1 million euros also began in 2008.

Furthermore, the infrastructure of the Micro-Material Center Berlin at the Berlin-Adlershof site was significantly improved, including at the "Laboratory for Reliability Assessment of Micro- and Nanoelectronic Material Composites".

:: Human resources

In 2008 the number of Fraunhofer IZM's staff increased marginally from 238 to 242.

The institute also offers students the option of combining their studies with practical scientific research at IZM's offices and laboratories. With 11 additional contracts compared to the previous year, an average of 147 interns, Masters' students and student assistant took advantage of working and learning at Fraunhofer IZM.

IZM also continued its commitment to providing apprenticeships. In 2008, 10 apprentices were trained as microtechnology technicians, IT administrators, precision machinists and business administrators.

:: Contact

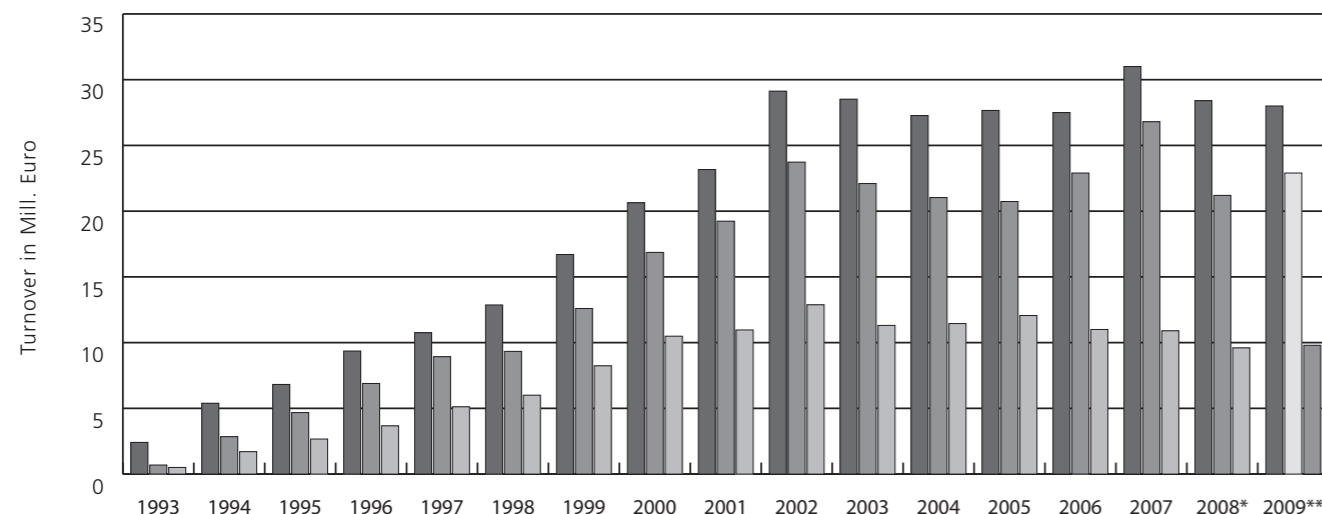


Head of Administration

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* 2008: Since the Chemnitz branch of the institute has become an independent Fraunhofer institute, the figures above are only based on the performance of the Berlin and Munich branches in the previous year

** 2009: Expected

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

Awards



Dr. Hans Walter und Dr. Thomas Schreier-Alt with Institutsleiter Prof. Herbert Reichl

:: Fraunhofer IZM Research Award 2008 for Thomas Schreier-Alt and Hans Walter

In December 2008 the Fraunhofer IZM Research Award was presented for the ninth time. This year the IZM researchers Dr. Thomas Schreier-Alt and Dr. Hans Walter were honoured for their outstanding achievements in the realm of electronic packaging.

Thomas Schreier-Alt received the Research Award for his groundbreaking work on the simulation of encapsulation processes. The physicist applies numeric simulation to optimize packaging for microelectronic and mechatronic components in order to make sure that their design is as reliable as possible before series production begins. He has also developed a new way to investigate existing manufacturing processes using optical strain gauges inside components. Such innovative measuring techniques can be used to analyze the component stress in terms of temperature and strain in the key process steps.

Dr. Schreier-Alt shares the award with his colleague, Dr. Hans Walter, who was recognized for his experiments in thermal-mechanical material characterization and the analysis of damage in micro-nano electronics. These included developing and modifying measuring techniques and the test specimen geometries required for these. His methods are widely employed to analyze time-, temperature- and moisture-sensitive material behavior in many different projects.

Fraunhofer IZM held the awards ceremony at Berlin's Maritim Hotel, where Institute Head Prof. Herbert Reichl presented the certificates to the awardees.



Dr. Martin Richter, Tonio Haas and Martin Bucher (from left)

:: Fraunhofer IZM researchers win prize at the "Munich Business Plan Competition"

Yet again, a team headed by Dr. Martin Richter of Fraunhofer IZM's Munich branch has succeeded at the Munich Business Plan Competition. For the business plan for their "MEGACELL" project Richter and his fellow researchers Tonio Haas and Martin Bucher were awarded a first prize in the „Idea Stage“ in the category „Research Centers and other Universities“.

MEGACELL is a planned Fraunhofer bioprocess engineering spin-off and intends to manufacture and run a device that rapidly and cost-efficiently detaches a cell from its carrier substrate, while ensuring the cell is damaged as little as possible in the process. The device is to replace trypsinization as standard technique. The basic idea of the detaching process commended by the jury is to mechanically detach the cells using high-frequency ultrasound, thereby excluding the involvement of enzymes.

:: Fraunhofer IZM's Florian Ohnimus receives the Erwin Stephan Award

In October 2008, Fraunhofer IZM researcher Florian Ohnimus received the Erwin Stephan Award from the Technische Universität Berlin's "Helene and Erwin Stephan Foundation". The award is presented twice a year to TU students who have completed their studies particularly quickly and successfully. The prize money of 4000 euros contributes towards making research and study abroad possible for the recipient. His final year project was entitled „A Comparative Study of Integrated Antennas for 60 GHz Applications“. Florian Ohnimus has now begun his PhD thesis on the „electrical design of integrated antennas for communications and radar applications.“



Innovation Award for Dr. Baumann (Rostock), Dr. Schulte-Mattler (Regensburg), Dr. Fiedler und Prof. Töpfer of Fraunhofer IZM (from left)

:: Controlling prostheses with nerve impulses – Innovation Award for nerve-computer coupling

Patients who have lost significant parts of a hand, arm or leg will one day have more control over their prostheses by means of nerve signals. A nation-wide research group with the participation of IZM-researchers Prof. Michael Töpfer and Dr. Stefan Fiedler has developed an extremely promising technology to make this a reality and was honoured with the Innovation Award for Medical Technology from the German Federal Ministry for Research and Education for this project.

Patients who have lost a hand can already control their prosthesis by means of electrical signals relayed from the muscles in their forearms. But what happens if the forearm has also been lost? Around the world, high-profile research groups are attempting to design a "brain-computer interface".

Using the system, the patient thinks of a movement and electrodes attached to the head record the brain waves. A computer then attempts to interpret the information by filtering the matching signals from the noise of the brain waves and triggering the corresponding movement in the hand. The process is laborious, prone to errors and slow. Approximately 10 seconds lie between a thought and action.

In the future the remaining nerves instead of the brain will be used to trigger movement. Here, researchers are attempting to wrap the nerve ends in a special foil, which is then used to relay the electrical impulses to, and thereby control, a prosthesis. The foil contains circuit traces and a microchip, whereby the nerve endings (axons) are in electrical contact with the circuit traces and



High tech from Berlin: additive microstructuring on glass

the chip then sends the received information on to the prosthesis. Technology similar to RFID is employed for this. The chip is powered by an external inductor.

Besides Fraunhofer IZM in Berlin the research alliance led by Dr. Schulte-Mattler of the Universität Regensburg includes the Technical University Berlin (Center for Microperipheric Technologies, Dr. Thomas Löher) and the Universität Rostock, Chair for Biophysics (Institute for Biomedical Sciences, Prof. Jan Gimsa).

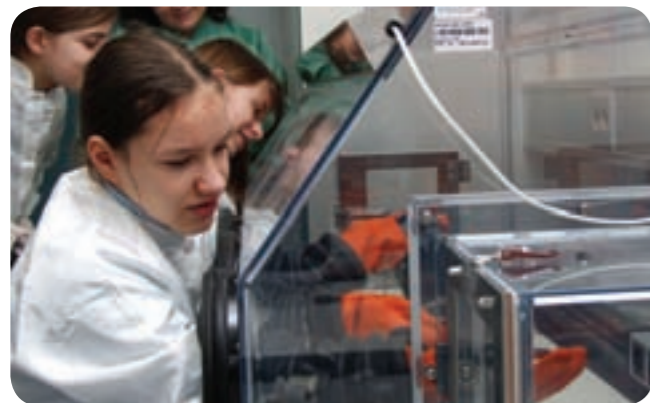
:: Berlin researchers are revolutionizing microelectronics by microstructuring glass

With a project developing thin-glass deposition onto substrates, so-called "additive microstructuring" of glass, researchers from the company MSG Lithoglas AG and Fraunhofer IZM have been shortlisted for this year's Berlin- Brandenburg Innovation Award. The micro- and even nanometer layers could revolutionize countless applications in opto- and microelectronics.

The process that the Berlin researchers have developed up to serial production makes the manufacture of image and photo sensors for applications such as high-resolution camera chips or photodiodes for BluRay drives extremely simple and cost-effective.

Applications for this technology are virtually limitless. It can be employed cost-effectively and for high-volume manufacturing wherever optical information is processed in microelectronics, including for micromirrors in scanners and displays, in acceleration and pressure sensors, as light sources such as semiconductor lasers and LEDs. Thanks to its biocompatibility it also holds great potential for medical technology.

Professional Training at Fraunhofer IZM



Experimenting with nano-materials in a glove box



Participants of this year's Girls' Day with their self-assembled electronic tea light



Investigation of fluorescent markers



Hands-on experience: wafer inspection at a Munich primary school

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

As part of a cooperation between Fraunhofer IZM, the TU Berlin, Berlin research institutions and small and medium enterprises in the training of microtechnology engineers, two external trainees are also regularly completing part of their internship at the Institute. At Fraunhofer's IZM's Environmental Engineering Department, two teenagers finished their voluntary ecological year with a device that generates power for an MP3 player or a GPS device using a bicycle. They not only developed but also built the demonstrator themselves. Furthermore, another student completed an internship in the field of optical interconnection technologies.

:: "Nano" Project Day for high school students

In mid-February Fraunhofer IZM opened its doors to year-8 students from a local high school. „Nano“ Project Day offered these youngsters a chance to find out all about Fraunhofer IZM's work in nanotechnology. After all, they even got to experiment with real nano-powder! The day's schedule comprised many different activities; from discussions on what a mobile phone has to do with microsystem technology via how do we get from

microsystem technology to nanotechnology up to how to work with nano-materials. To make nano-technology visible the so-called nano-lawns were examined under a scanning electron microscope (SEM). The project day was a huge success, not least because instead of just focusing nanotechnology and microsystem technology theory, the students were able to try their hands at nanotechnology themselves.

:: Job application training

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

:: Girls' Day at the Fraunhofer IZM laboratories

As in previous years, Fraunhofer IZM participated in the eighth national Girls' Day on the 24th April. Four students aged 11 to 14 experienced an exciting day of science. The girls had the opportunity to take apart cell phones and learn about the functions of the individual components. They also visited the high-tech processes in the absolutely dust-free cleanroom. As well as analyzing electronic circuits, the girls built their very own electronic tea lights based on microelectronics.

At the end of the day, more creativity was required – even in the science day-to-day ingenuity is a top priority. Thus, the girls brainstormed ideas for integrating electronics in clothing. For instance, what could a bicycle courier's jacket look like in the future?

:: Talent Day 2008

Talent Day 2008 celebrated the winners of publicly funded national school and apprenticeship competitions. The 300 students participate in scientific, political, media and cultural workshops held throughout Berlin and Potsdam. One of these was hosted by Fraunhofer IZM on the topic „Fuel cells for generating electricity (battery laboratory)“.

10 students had the chance to learn about different fuel cells and fuel-cell systems by using a demonstrator to electrolyze hydrogen, as well as testing the actual fuel cell function for creating the electricity. The participants recorded simple characteristics of the demonstrator and compared them with those of batteries. Additionally, the advantages and disadvantages of fuel-cell systems as compared to batteries were discussed and a Q&A held.

:: MINToring

As part of the German Federal Ministry for Education and Research's MINT Initiative, Fraunhofer IZM and TU Berlin presented a special technology workshop for enquiring young minds in December. High school students had the opportunity to take apart mobile phones and participate in an ideas workshop on the future of mobile phone technology.

As a special highlight, they also assembled mobile phones and accessories themselves to learn about why such devices continue to decrease in size and weight while at the same time increasing in performance. On the second day, each participant designed their own electrical circuit for an "electronic die" in the TU labs as an introduction to how microelectronics are designed. Of course, everyone got to take home his or her die as souvenir.

:: Luminescent molecules

Forty sixth-form high school students had the opportunity to learn about research at Fraunhofer IZM's Munich branch. Entitled "Luminescent molecules", a series of workshops specially designed for women was held as part of the ongoing EU project P. Cézanne. The students carried out bioanalytical experiments using fluorescent markers and learnt the theory behind determining blood sugar using fluorescence analysis.

New paths for encouraging young scientists were forged in a workshop, in which two trainees shared what they had learnt to date with an audience of 30 female pupils. The microtechnology trainee and a scientist in the field already employed at an IZM-partner company talked about their profession and held a Q&A with the pupils.

:: Visiting a Munich primary school

For the first time the Munich branch of Fraunhofer IZM extended their activities for junior scientists to primary school pupils. As part of the teaching unit "jobs" boys and girls from the primary school Westerheim were introduced to the occupational field of semiconductor technologies. The 27 children aged 8 to 9 were shown blank and structured silicon wafers and a Fraunhofer IZM colleague put the wafers into relation with microchips in electronic components for them.

The children were very enthusiastic about the project and took the opportunity to ask lots of questions. What kind of professional training is required? How does the assembly of microchips work? The form teacher, too, was extremely pleased with the class' curiosity and open-mindedness concerning the topic of semiconductor technologies.

Lectures, Editorials

LECTURES

:: TU Berlin

Prof. H. Reichl

- Technologies of Hetero System Integration
- Basics in Electronic Circuits

Prof. H. Reichl / O. Bochow-Neß

- Reliability of Microsystems

Prof. K. Bock

- Technologies of Polytronic Microsystems

Dr. S. Guttowski

- EMC in Power Electronic and Electric Drives

Dr. I. Ndip

- Electromagnetic Reliability of Microsystems

Dr. N. Nissen

- Design of Environmentally Compatible Products

Dr. M. Schneider-Ramelow

- Materials for System Integration

Prof. M. Töpper

- Physical/Chemical Foundations of MST

:: TU München

Dr. M. Richter

- Guest lecture: Theoretical Foundation of Microfluidic Actuators

:: BTU Cottbus

Dr. O. Deubzer (Visiting professor)

- Corporate Environmental Protection

EDITORIALS

Handbook of 3D Integration

Wiley-VCH, Weinheim, 2008

P. Ramm (Co-editor)

Future Fab International

Mazik Media Inc., San Francisco

P. Ramm (member of Editorial Board)

Materials and Technologies for 3D Integration

MRS Symposium Proceedings Vol. 1112, Materials

Research Society, Warrendale (2009)

P. Ramm (Co-editor)

Micro- and Nanosystems

(Bantam Science Publishers Ltd.)

K. Bock (member of Editorial Board)

PLUS Journal (Eugen G. Leuze Verlag Saulgau)

K.-D. Lang (Head of Editorial Board)

ZEMI Microsystems Summer School Berlin 2008:

Systemintegration am Beispiel AVM

S. Schmitz

Electronics Goes Green 2008+

(IRB Verlag Stuttgart)

H. Reichl, N. Nissen (Editors)

Dissertations, Best Paper Awards

DISSERTATIONS

Baba, M.

Efficient Design, Integration and Optimization of Highly Miniaturized Filters for RF/Wireless Applications, Technische Universität Berlin, 2008

Geißler, U.

Verbindungsbildung und Gefügeentwicklung beim Ultraschall-Wedge/Wedge-Bonden von AlSi1-Draht, Technische Universität Berlin, 2008

Nittayarumphong, S.

Vereinfachte Methoden zur optimalen Regelung resonanter Leistungskonverter, Technische Universität Dresden, 2008

Polityko, D.

Physikalischer Entwurf für die vertikale SiP Integration, Technische Universität Berlin, 2008

Schinkel, M.

Entwurf und Simulation aktiver EMV-Filter für dreiphasige drehzahlveränderbare Antriebe, Technische Universität Berlin, 2008

Wagner, S.

Entwicklung von Mikro-Polymermembran-Brennstoffzellen unter Einsatz von Mikrostrukturierungstechnologien, Technische Universität Berlin, 2008

BEST PAPER AWARDS

Böttcher, L.; Manassis, D.; Ostmann, A.;

Karaszkiwicz, S.; Reichl, H.

“Embedding of Chips for System in Package Realization – Technology and Applications”
Outstanding Paper Award of the „3rd IMPACT and 10th EMAP Joint Conference”

Brunschwiler, T.; Rothuizen, H.; Kloter, U.;

Wunderle, B.; Oppermann, H.; Reichl, H.; Michel, B.

“Forced convective interlayer cooling in vertically integrated packages”
Best Paper Award “iTherm 2008” (Emerging Technologies Track)

Wunderle, B.; Kallmayer, C.; Walter, H.; Michel, B.;

Reichl, H.

“Life time model for flip chip on flex using anisotropic conductive adhesives under moisture and temperature loading”
Best Paper Award, “iTherm 2008” (Materials Track)

Manassis, M.; Patzelt, R.; Ostmann, A.; Aschen-

brenner, R.; Reichl, H.; Axmann, A.; Laentzsch, C.;

Klemann, G.

“Evaluation of innovative nano-coated stencils in ultra-fine-pitch flip chip bumping processes”
Best Paper Award “IMAPS 2008, Rhode Island”

Rainer Dudek, E. Kaulfersch, S. Rzepka, M. Röllig, Michel, B.

“FEA Based Reliability Prediction for Different Sn-Based Solders Subjected to Fast Shear and Fatigue Loadings”
NXP Semiconductors Best Paper Award
9th International Conference on Electronic Packaging Technology & High Density Packaging (ICEPT-HDP 2008)

Cooperation with Industry (Selection)

Company	Location
AEMtec GmbH	Berlin
AIM Infrarotmodule GmbH	Heilbronn
Airbus Deutschland GmbH	Hamburg, Laupheim
Aktiv Sensor GmbH	Berlin
AMD Saxony LLC & Co. KG	Dresden
Andus Electronic GmbH	Berlin
ASEM Mühlbauer	Dresden
Atmel Germany GmbH	Dresden, Heilbronn
Atotech Deutschland GmbH	Berlin
Brose Fahrzeugteile GmbH & Co KG	Coburg
Casio Computer Co. Ltd.	Tokyo (J)
Chemnitzer Werkstoffmechanik GmbH	Chemnitz
Continental Automotive Systems	Nürnberg, München,
Daimler AG	Stuttgart, München
Dell	Frankfurt/Main
Dilas Diodenlaser GmbH	Mainz
Dow Chemical Company	Midland, MI (USA)
Drägerwerk AG	Lübeck
Dyconex AG	Bassersdorf (CH)
EADS	Paris, Toulouse (F), München, Ulm, Dresden
Emerson & Cuming	Westerlo (BE), Bridgewater (USA)
EMZ GmbH & Co KG aA	Nabburg
Endress & Hauser Conducta GmbH	Gerlingen
EPCOS AG	München, Berlin
ESYS GmbH	Berlin
Evonik Industries	Marl
First Sensor GmbH	Berlin
General Electric, Medizintechnik	USA
Genum Corporation	Burlington (CDN)
Global Light Industries GmbH	Kamp-Lintfurt
HARTING Mitronics AG	Biel (CH)
Häusermann GmbH	Gars am Kamp (A)
Hella KG aA Hueck & Co	Lippstadt
Hirschmann Laborgeräte GmbH & Co KG	Eberstadt
Hitachi PERL	Yokohama (J)
hmp Heidenhain Mikroprint GmbH	Berlin
Hymite Deutschland GmbH	Berlin
IBM Zurich Research Laboratory, Halbleiter	Zürich (CH)
IMC	Berlin
Infineon AG	München, Regensburg, Dresden
Intel	Feldkirchen, München
KSG Leiterplatten GmbH	Gornsdorf
Liebherr-International Deutschland GmbH	Lindau

Company	Location
LTI Drives GmbH	Lahnau
Magna Donnelly	Winzendorf (A)
Mignos GmbH	Deckenpfronn
Mikrogen GmbH	Neuried
MPD Microelectronic Packaging Dresden GmbH	Dresden
Nanotest und Design GmbH	Berlin
Numerik Jena GmbH	Jena
NXP Semiconductors GmbH	Hamburg
OREE, Inc.	Tel Aviv (IL)
OSRAM Opto Semiconductors GmbH	Regensburg
Panasonic	Wiesbaden
Paritec GmbH	Weilheim
PerkinElmer Elcos GmbH	Pfaffenhofen
Qimonda AG	Dresden
Raumedic AG	Helmbrechts
Ricoh Company Ltd.	Yokohama (J)
RKT GmbH	Roding (A)
Robert Bosch GmbH	Stuttgart, Berlin, Reutlingen, Hildesheim
Rohde & Schwarz GmbH	München
SCD Semi Conductor Devices	Haifa (IL)
Schefenacker Vision Systems Germany GmbH	Schwaikheim
Scherer & Trier	Michelau
Schweizer Elektronik AG	Schramberg
Sensata Technologies Holland B.V. Almelo	Almelo
Sensitech Naomi	Mainz
SFC AG	Brunthal-Nord
Siemens AG	Amberg, Regensburg, Berlin, München
Silex	Järfälla (S)
Simons Vertrieb und Druck GmbH	Nottuln
Smart Fuel Cell AG	Brunthal
Sony	Tokyo (J)
ST Microelectronics	Agrate Brianza (I); Tours (F)
Süss Microtec GmbH	München
Swissbit Germany AG	Berlin
Tanaka Denshi Kogyo Co. Ltd.	Tokyo (J)
Texas Instruments	Freising
T-Mobile	Bonn
Tokyo Ohka Kogyo	Tokyo (JP)
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