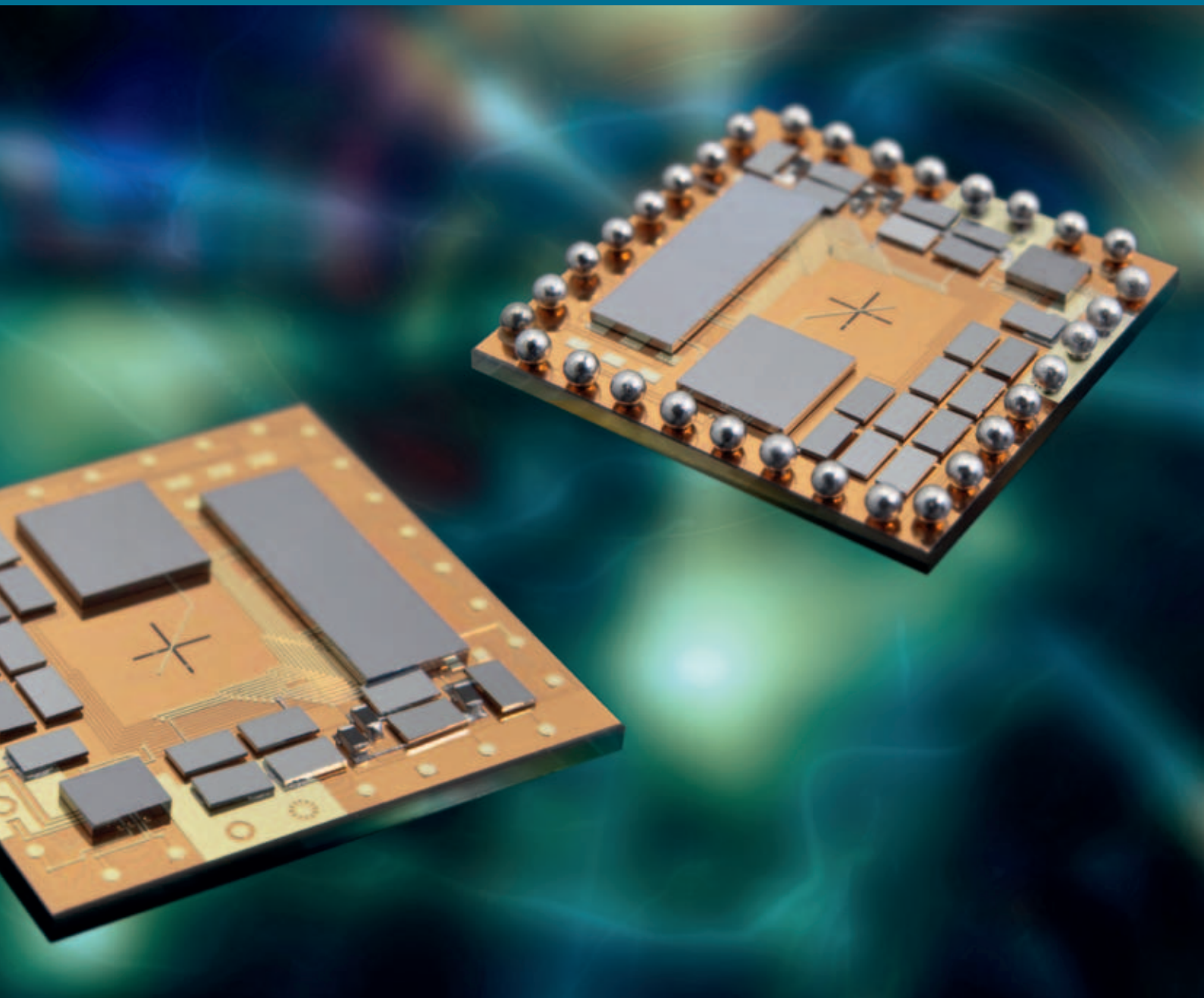
Fraunhofer
IZM

FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM

ELECTRONIC PACKAGING & SYSTEM INTEGRATION



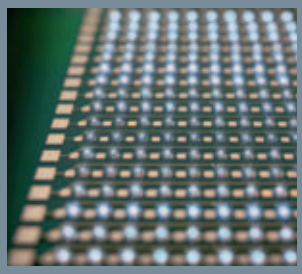
INVISIBLE – BUT INDISPENSIBLE

Fraunhofer IZM develops assembly and interconnection technology, also known as electronic packaging. Almost invisible and undervalued by many, electronic packaging is at the heart of every electronic application. Our technologies connect the individual components, protect the components and devices from vibration and moisture, and reliably dissipate heat. Fraunhofer IZM thus ensures that electronic devices continue to function reliably in even the harshest conditions – we even integrate electronics into golf balls.

Modern packaging technologies make developing smaller and smaller products possible. We process ICs thinner than a sheet of paper. This means that all of the electronics constituting a

World's smallest micro camera for endoscopes: 1 × 1 × 1 mm³

MEDICAL



High brightness LEDs for intelligent, energy-efficient lighting

PHOTONICS

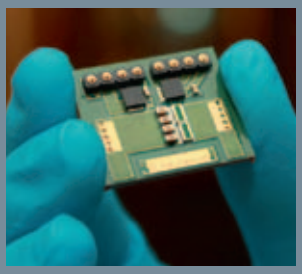
Wireless charging devices for mobile phones in cars

AUTOMOTIVE

Life without electronics is unimaginable these days. More and more products not only include electronics, but also sensors that record signals from the environment just like human senses. The data is displayed to the user on a screen or sent on to technical processing devices, such as a thermostat.

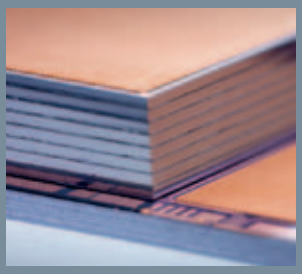
The more a product's electronics become indistinguishable from the product itself, the more important scaling and durability become. As reflected by its name, the main focus of Fraunhofer Institute for Reliability and Microintegration IZM is on these two singular properties.

hearing aid can fit discretely and invisibly in the ear.
We also work to reduce the manufacturing costs of complex electronics. One example is our project with partners from industry to assemble the next generation of radar sensors for driver assistance systems so cost-effectively that even compact executive cars will benefit. But what use would electronics be if it didn't function reliably? Our research continues to improve reliability and helps customers confidently predict the durability of a product's electronics. We test electronic components and systems on our equipment under realistic operating conditions. **We get electronic components and systems into shape for the application.**



ENERGY

Very fast switching module for solar inverters



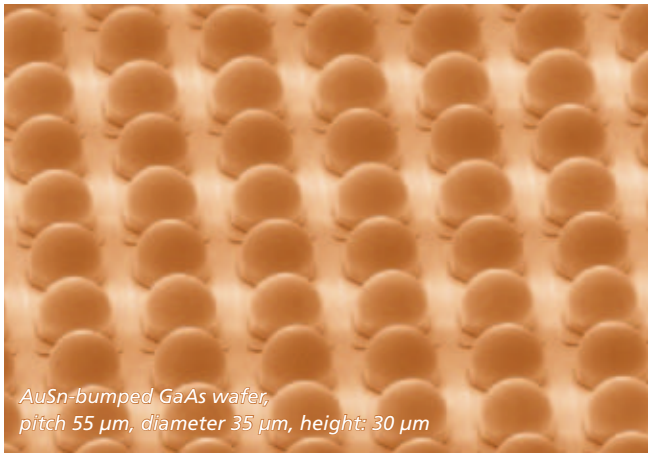
SEMICONDUCTOR & SENSORS

Chip stacking via flip chip bonding

INDUSTRIAL

Integrating ultra-thin chips in security documents

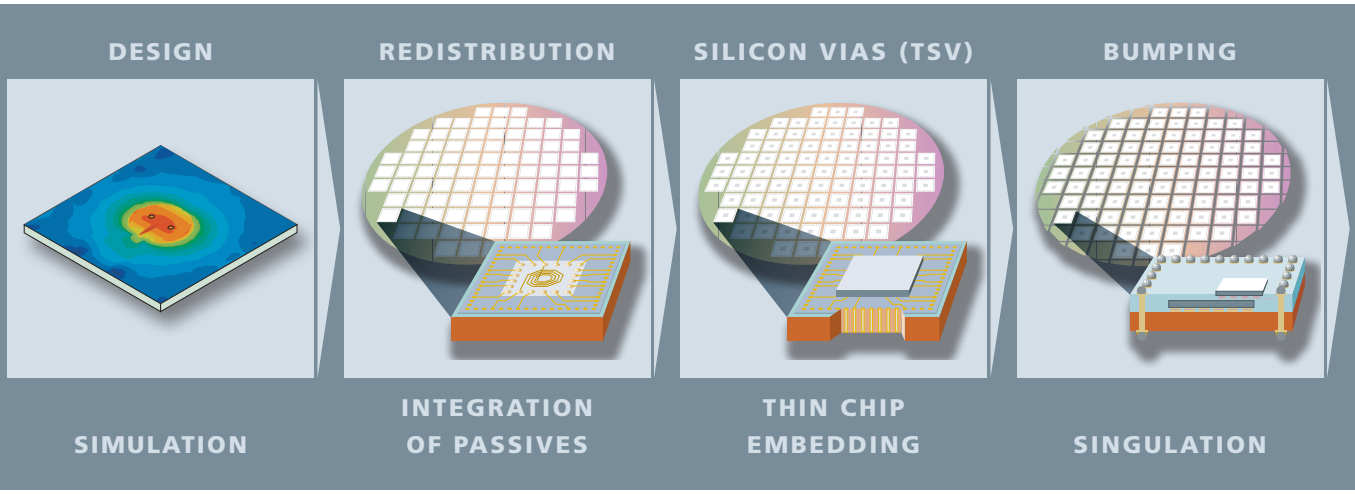
WAFER, SYSTEM AND EVERYTHING IN BETWEEN

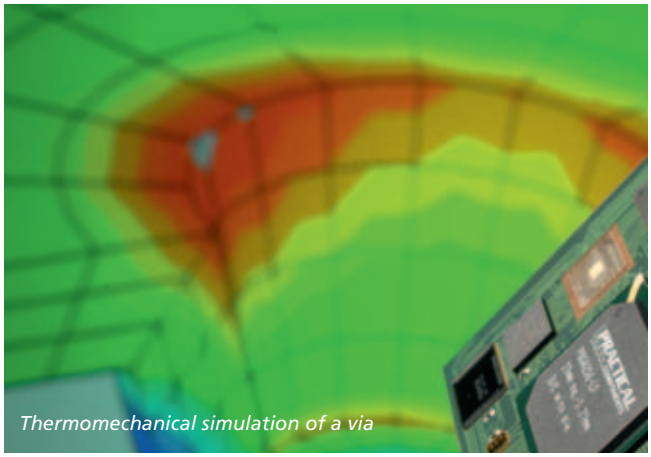


AuSn-bumped GaAs wafer, pitch 55 µm, diameter 35 µm, height: 30 µm

Integration at wafer level

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





Thermomechanical simulation of a via

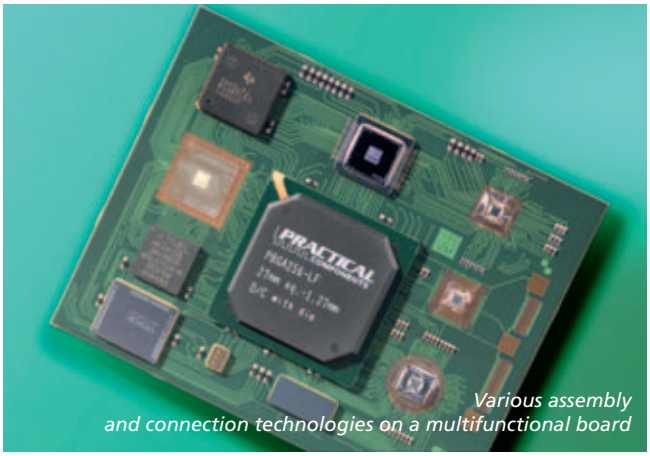
System design

In highly integrated systems, design can no longer be carried out independently of technology and technology development cannot take place without considering electrical behavior. The term "codesign" is used to denote this synergetic approach to technology and design. Modeling, simulation and analysis technologies combined with innovative electrical measurement methods take center stage here. Research and development in this area focuses on EMC and RF issues (parasitic effects). Subsequent connection to the incorporating system is also integrated into the design at this stage.

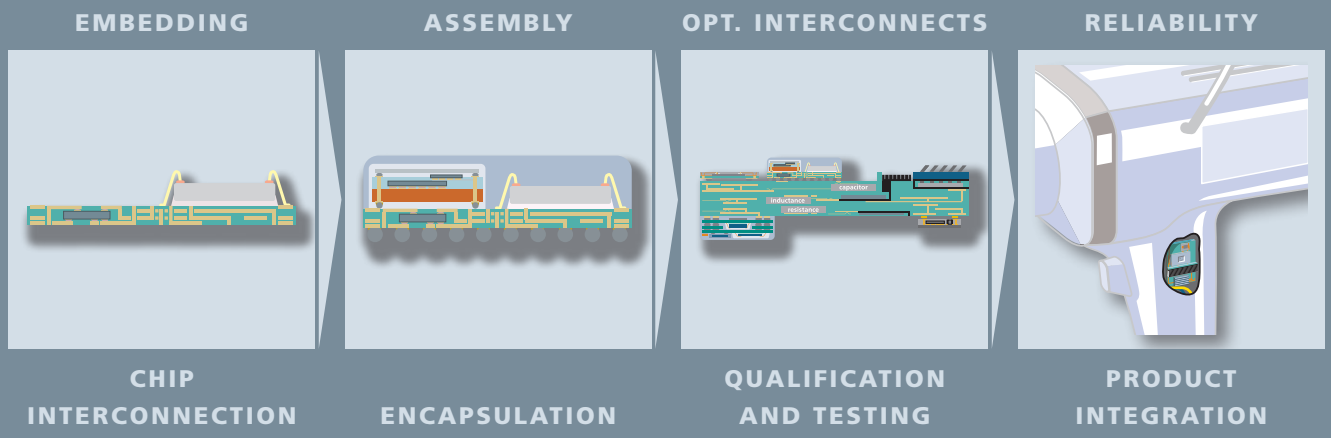
The technologies we use close the gap between microelectronics/microsystem technology and their application. Our research and development begins with the wafer and ends with ensuring that the technology functions reliably in any given environment.

Integration at substrate level

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

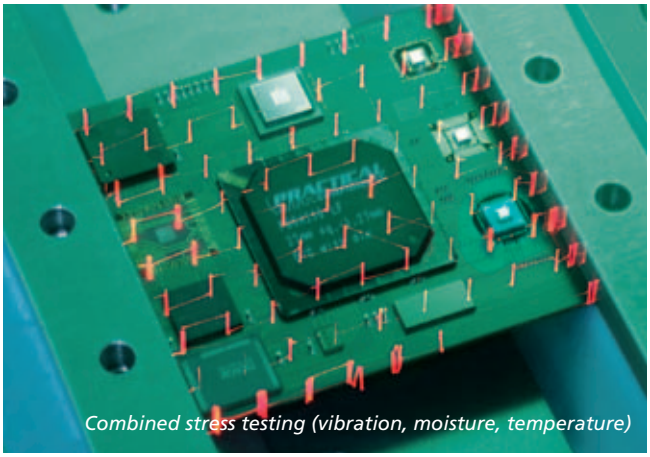


Various assembly and connection technologies on a multifunctional board



Materials, reliability and sustainable development

Throughout the design and development process Fraunhofer IZM conducts reliability analyses on the materials right through to the system as a whole using material behavior and mechanical reliability models. Apart from simulation processes, we employ laser-optical, X-ray and material tests individually or in combination. We also address environmental and sustainability questions as early as during the design process and clarify material and energy requirements as well as the toxicity potential of the employed materials in a timely fashion.



Combined stress testing (vibration, moisture, temperature)

CORE COMPETENCIES

WAFER LEVEL SYSTEM INTEGRATION

WAFER LEVEL SYSTEM INTEGRATION

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According to the technical requirements of future microelectronic products specific 3D system integration becomes one of the main drivers and the most promising technologies for heterogeneous system integration.

The department focuses on the development and application of wafer level system integration technologies which includes wafer level packaging (WLP), chip size packaging (CSP), thin film technology and as well 3D integration using through silicon vias (TSVs). The department is embedded in Fraunhofer IZM's overall strategy of heterogeneous system integration and is a well established partner in the worldwide network for advanced wafer level system integration technologies.

The department operates two clean room facilities in Berlin and Dresden (Fraunhofer IZM-ASSID) with latest state of the art equipment from 100 to 300 mm wafer sizes. It cooperates with equipment manufacturers, material suppliers and end users of microelectronic products, from all over the world to realize world class wafer level packaging solutions. The well-established technology branches offer development, prototyping and small-volume production as a service within the realms of MCM-D, wafer-level CSP with redistribution layer (RDL), 3D integration and wafer-level bumping for flip chip assembly to industrial partners and customers.

Services

- Thin-film redistribution (CU-RDL) on IC wafers
- Through-silicon-vias (Cu-TSV)
- TSV silicon interposer with Cu-multi layer high-density redistribution layer
- Passive device integration (R, L, C)
- BEOL metallization
- UBM deposition for flip chip interconnects
- Wafer bumping (ECD: Cu, Ni, Au, AuSn, CuSn, SnAG, In)
- Wafer balling with solder preforms
- Pre-assembly and wafer thinning
- Temporary wafer bonding and de-bonding
- Die-to-wafer and wafer-to-wafer-bonding
- 3D stack formation
- Dicing by grinding (DBG)
- Integrated power supply on wafer level
- Application-specific 3D WL-SiP, CSP, TCI prototyping and small batch production
- Thin-film technology workshops

INTEGRATION AT SUBSTRATE LEVEL

SYSTEM INTEGRATION & INTERCONNECTION TECHNOLOGIES

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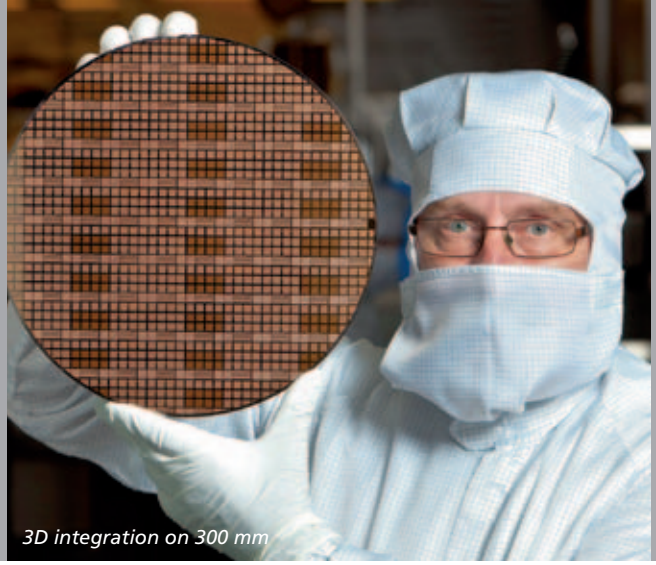
The range of services provided by the department System Integration and Interconnection Technologies (SIIT) with its roughly 150 employees spans consultation, to process development, right through to technical system solutions. Developing processes and materials for interconnection technologies on board, module and package levels and the integration of electrical, optical and power-electronic components and systems are at the forefront of our research.

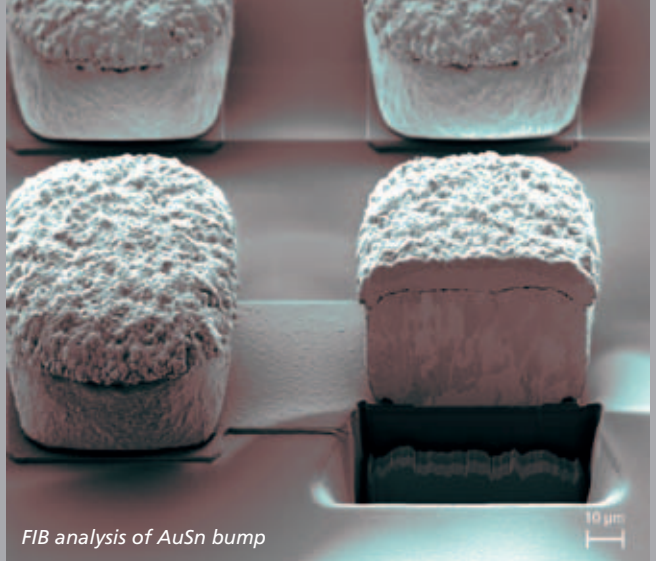
We assist companies with application-oriented pre-competitive research, as well as the development of prototypes and small volume production. Our services include application advice, technology transfer and further qualification of personnel through practical training.

Services

- New packaging materials: solder, wires, bumps, adhesives and encapsulants
- Bumping techniques (electroless Ni/(Pd)/Au, stencil printing, mechanical stud or ball bumping)
- SMD, CSP, BGA, POP and bare die precision assembly
- Flip-chip techniques (soldering, sintering, adhesive joining, thermo-compression and thermosonic welding)
- Die attachment (soldering, sintering 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 sensor packages and power modules on lead frame devices
- Wafer level & panel level molding up to 600 × 450 mm²
- Potting and conformal coating
- Embedding of chips and components
- Fiber coupling and optical interconnection to planar wave guides, fiber lenses and laser joining
- Thin-glass and silicon photonic packaging
- Power electronics: Electrical/electromagnetic/thermal/thermomechanical design, component selection, prototype manufacturing



3D integration on 300 mm



FIB analysis of AuSn bump

SYSTEM DESIGN

RF & SMART SENSOR SYSTEMS

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Development and optimization of methods and tools for the design of technologically sophisticated, miniaturized electronic systems, with a particular focus on wireless sensor networks. Function-, volume- and cost-analysis for the design process. Power supply solutions based on energy harvesting, efficient energy conversion and management, and energy-optimized programming

Services

- Miniaturized system development, covering the entire process, from technology viability studies to technology transfer
- RF and high-speed system design
- Development of sensor node technology, particularly for condition monitoring and servicing
- Power supply solutions for miniaturized and autarkic systems

MATERIALS, RELIABILITY AND SUSTAINABLE DEVELOPMENT

ENVIRONMENTAL AND RELIABILITY ENGINEERING

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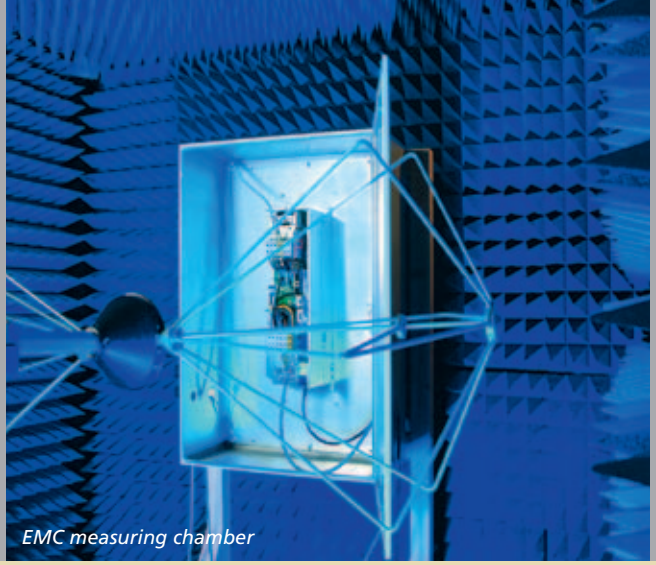
Identification and minimization of environmental impacts based on thorough technology knowledge and combined with reliability and lifetime considerations. Ecodesign of electronic products and the development of green electronic technologies. Analysis, characterization and simulation of materials down to micro- and nano-level. Accelerated lifetime testing using complex loading and specialized testing methods for early fatigue monitoring. Development of lifetime models for materials, components and electronic systems. Thermal management and optimization. Condition monitoring of electronics. Reliability management and business processes.

Services

- Reliability optimization using multi-physics simulation (thermal, mechanical, fluidic)
- Materials characterization
- Structure and failure analysis
- Combined load testing (humidity, vibration, temperature, mechanical, electrical, etc.)
- Strategies for sustainable electronic development
- Ecodesign of products and assistance with the applicable legal regulations
- Lifetime-oriented design, recycling and condition monitoring of electronic systems



EMC measuring chamber

Process line for substrate integration

EQUIPMENT AND LABORATORIES

INTEGRATION AT WAFER LEVEL

300 mm Process Line

- DRIE
- CVD, PVD, ECD, Wet Etch and Clean
- Temporary wafer bonding/debonding
- Thinning, dicing
- Flip chip wafer level assembly

Wafer Level Packaging Line

800 m² clean room (classes 10 to 1000), 4", 6" and 8", prototyping equipment for some applications also on 300 mm

- Thin-film deposition (sputter and evaporation)
- Photolithography (photo varnishes, polymers, spray coating)
- Galvanic bumping, circuit tracks and through-via filling (Cu, Ni, Au, AuSn, SnAg, PbSn)
- Wet-chemical processes (etching, cleaning)
- Wafer bonding (support wafer, thin-wafer handling)
- Silicon plasma etching (through vias, cavities)
- Precision mounting lab (clean room, including chip-to-wafer bonder to 300 mm, thermocompression/-sonic)

INTEGRATION AT SUBSTRATE LEVEL

Substrate Integration Line

- CoB lab (die, ribbon, wire bonding down to 35 µm pitch)
- Embedding lab (high-precision pick and place machine, circuit board processing line, laser drill/direct imaging)
- Photonics lab (optical packaging processes with an accuracy of up to 0.5 µm, laser structuring of glass layers with optical waveguides for electro-optical boards, Characterization of micro lenses and micro lense arrays as well as LEDs
- Encapsulations (conformal coating, potting, flip-chip and CoB molding, needle and jet dispensing, transfer and liquid molding, wafer and panel level molding)
- Textile lab (integration of electronics in textiles)
- SMD & flip-chip line (Datacon EVO, Siplace X-Placer, Asymtek Axiom Jet, Dispense System)

MATERIALS, RELIABILITY AND SUSTAINABLE DEVELOPMENT

Center for Interconnection Technologies (ZVE)

- Accredited IPC-A-610, IPC-7711/7721 and IPC J-STD-001D training center, ESA-approved training center
- CT and 2D X-ray analysis, ionic contamination measurement, surface-isolation resistance

Qualification and Test Center for Electronic Assemblies

- Ultrasound microscopy, CT X-ray microscope, metallography
- Variable-pressure FE-SEM, dual-beam FIB
- TGA, DSC, DTMA, EDX, Small Spot ESCA, SEM-EDX

Reliability

- Material assessment (thermo-analysis, tensile/flexural strength test, nano-raman spectroscopy, X-ray, EBSD)
- Thermomechanical reliability (damage analysis, lifecycle prognosis, deformation analysis (microDAC)
- Thermal measuring technology (impulse and lock-in infrared thermography, thermal interface material analysis)
- Combined stress testing, including HALT/HASS, vibration combined with climate, drop tester, online failure detection
- Moisture lab (Simulation-based reliability assessment of humidity-induced phenomena

SYSTEM DESIGN

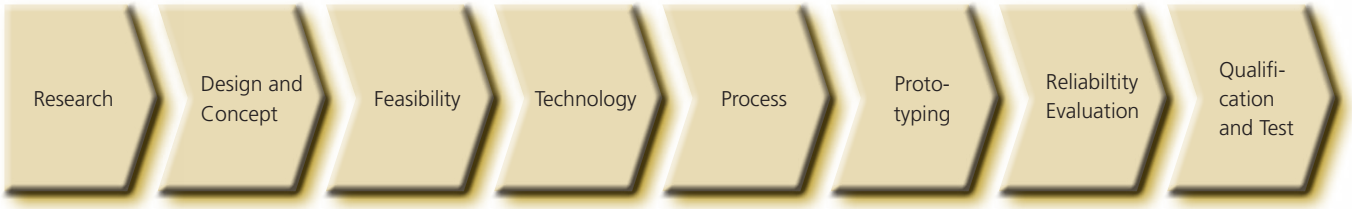
- RF lab: Dielectric material characterization 1 MHz up to 170 GHz
- Measuring electrical properties of digital data transfer systems (up to 32 Gbit/s)
- Localising EMC-hot spots with near field probe up to 6 GHz
- Multiphysics, multidimensional system simulation lab

Microenergy Laboratory

- Assembly, electrical/chemical characterization of microbatteries and micro-fuel cells

YOUR PARTNER: FRAUNHOFER IZM

WORKING TOGETHER WITH FRAUNHOFER IZM



Regardless of whether you already know your way around electronic packaging or are just beginning to consider investing in this technology, we can answer your questions and support you on your way. Our customer spectrum is as wide as our technology portfolio and ranges from the automotive industry, to mechanical engineering, through to medical, communications and security technology. We have helped companies in areas as diverse as clothing, lighting, foodstuff and logistics improve their products by integrating electronics. Don't hesitate to contact us!

Understand technology and invest in the future

You know your way around electronic packaging and want to benefit from our latest developments. We can collaborate with you to develop customized solutions for miniaturizing and integrating microelectronic systems into your products. Our development services are tailored to your requirements and our solutions range from the small details through to complete systems.

- Consultation
- Feasibility studies
- Participation in publicly-funded research projects
- Bilateral contract research right through to prototype manufacture and
- Quality, reliability and environmental solutions

The advantages of contract research

Bilateral contract research means that we develop innovative technologies and product-oriented solutions exclusively for you and your company's requirements. The benefits of direct access to a highly qualified, interdisciplinary research team include:

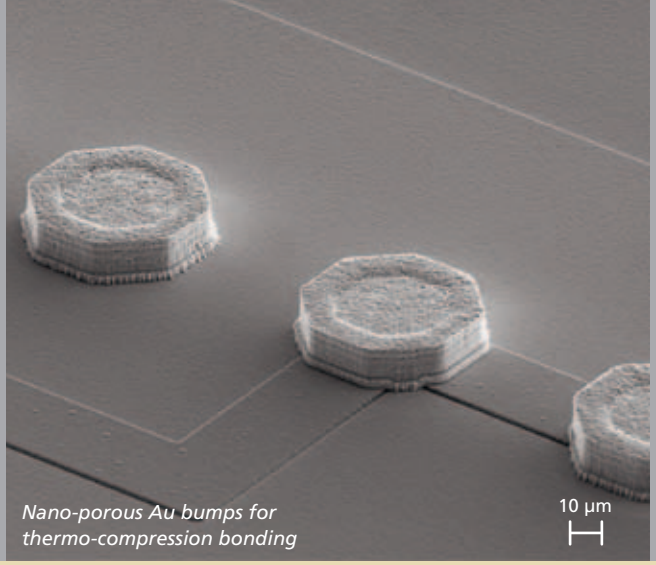
- Assured results
- Time and cost savings
- Professional project management
- High quality standards

Satisfied customers in medium-sized industry

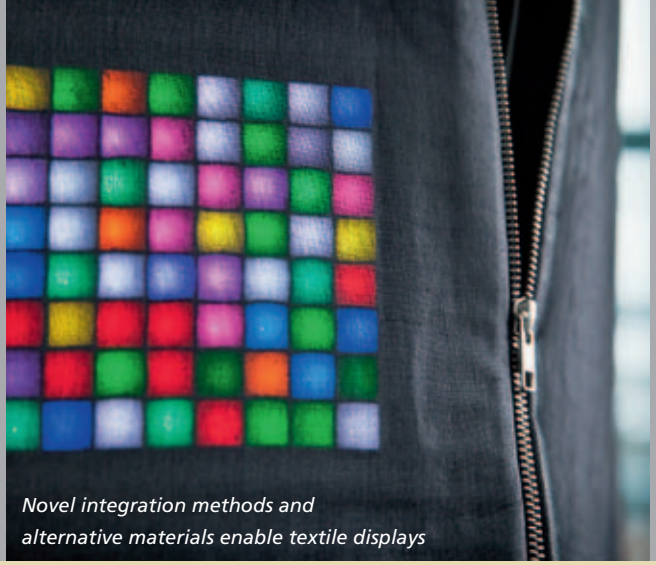
Research and high-tech development is not just for large companies. Many medium-sized companies also make use of our expert know-how. One of the best arguments for cooperating with Fraunhofer IZM are our many satisfied customers, as proven by our high rate of follow-up contracts.

Using technologies for the first time

You want to increase the value of your products, but have not yet invested in electronic technologies or only to a small extent. Despite this, you would like to benefit from the advantages of modern assembly and interconnection technology and microsystem technology and utilize the know-how and the technology transfer we offer? Then the right address is Fraunhofer IZM's application center. At the center, we take your ideas and select the right solution for your product environment from Fraunhofer IZM's extensive technology portfolio. We consult with you, determine the technical viability, conceive and develop solutions customized for your products.



Nano-porous Au bumps for thermo-compression bonding



Novel integration methods and alternative materials enable textile displays

WORKING TOWARDS THE FUTURE

The products of the future are smaller, lighter, more multi-faceted and reliable, thanks in no small part to the latest integration technologies. In power electronics and LEDs, Fraunhofer IZM works on issues such as dissipating power loss safely even in highly integrated assemblies. Embedding technologies and double-sided die bonding of power ICs are promising possibilities here.

At the same time, depositing biologically active layers on ICs using nanostructured surfaces makes low temperature processing possible. Using nanotechnologies, the researchers also pursue the vision of the "self-assembly" of especially small components.

Higher integration densities can be realized cost-efficiently and flexibly using 3D assemblies. Fraunhofer IZM also researches and develops silicon through vias (TSV), as well as stacking concepts at module level.

Another trend-setting development we pursue is system design that approaches integration beyond the component level to combining the overall architecture, as well as electrical, thermal, mechanical and environmental aspects. "Design for reliability" is a key approach here, providing tools for robust design based on material models and an understanding of combined failure mechanisms.

Partners in Germany and around the world

Fraunhofer IZM is at the cutting-edge of research and maintains a tight network of cooperation projects with renowned research institutes. In Berlin, longstanding and extremely successful collaboration with the Technische Universität Berlin's Research Center for Microperipheric Technologies secures direct access to basic research results in wafer-level packaging and substrate integration.

On European level, Fraunhofer IZM cooperates with CEA-LETI (France), CSEM (Switzerland) and VTT (Finland) in the High Technology Alliance. Globally, we work together with leading research institutes in the USA, Japan and Korea.

Facts about Fraunhofer IZM

Fraunhofer IZM has enjoyed a successful track record since its establishment in 1993. Three independent Fraunhofer institutes have evolved out of Fraunhofer IZM, proving its sense for important upcoming technology developments. Over 350 researchers and developers work at the three sites in Berlin, Dresden and Oberpfaffenhofen, of which approximately 35 percent are involved in direct industry projects. Our customers are comprised equally of small- and large-sized companies.

The umbrella organization: Fraunhofer

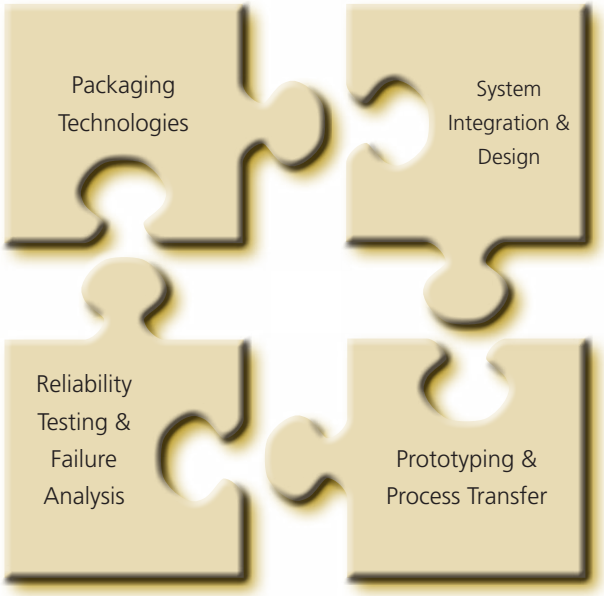
Fraunhofer IZM is one of 67 Fraunhofer-Gesellschaft institutes and is the alliance's expert in electronic packaging. With its staff of 24,000 and research volume of 2.1 billion euros, Fraunhofer Gesellschaft is one of the world's leading research centers for applied biological and mechanical engineering research and development. Research of practical utility lies at the heart of all Fraunhofer Gesellschaft activities, and this is reflected by its 1.8 billion euro turnover through contract research, that is, direct contracting from industry or together with industry in national and international funding projects.

Fraunhofer Gesellschaft's key research areas are:

- Microelectronics
- Information and communication technology
- Production
- Materials and components
- Light & Surfaces
- Life sciences
- Defence and Security

Within these areas, Fraunhofer IZM closes the gap between wafer and application and is a member of the Fraunhofer Microelectronics alliance, representing the group's competency in packaging and smart system integration.

FROM WAFER TO SYSTEM



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