

Fraunhofer Institute for Reliability and Microintegration IZM

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## Electronic Packaging & System Integration

# Electronics at the Limit

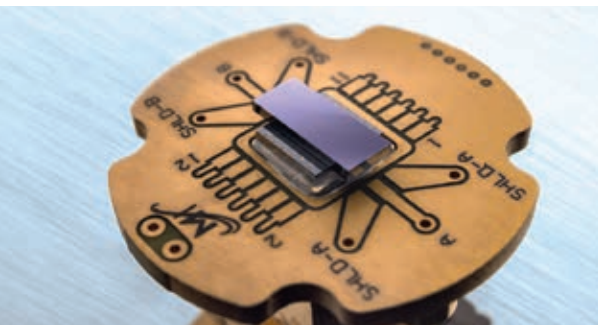
A global R&D leader for robust and reliable electronics and system integration

## Medical Engineering



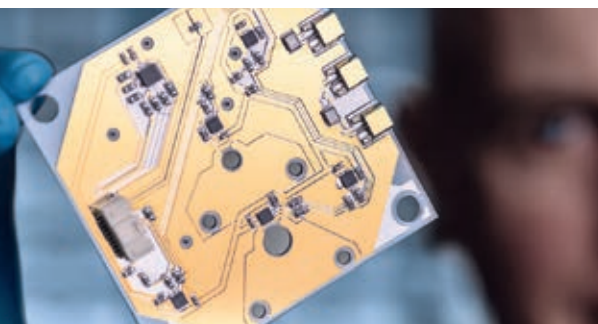
*Flexible assembly for plug & play ECG*

## Semiconductors



*Cryo packaging for quantum technologies*

## Industrial Electronics



*Optical and electrical functionalization of glass for LiDAR applications*



## Fraunhofer IZM Business Units

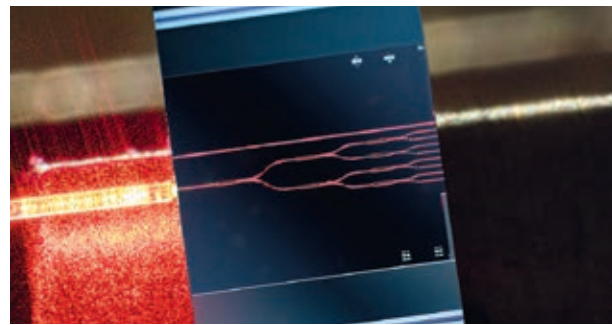
Intelligent electronic systems – available everywhere and to everyone! In order to make this possible, components need to have exceptional properties. Depending on the application, they need to function reliably at high temperatures, be extremely miniaturized and moldable to individual build spaces or even flexible. The Fraunhofer Institute for Reliability and

Microintegration IZM helps companies around the world develop and assemble robust and reliable electronics to the very cutting edge and then integrate them into the required application.

To this end Fraunhofer IZM develops adapted system integration technologies on wafer-, chip- and board level. Our research continues to improve reliability and helps customers confidently predict a product's lifetime.

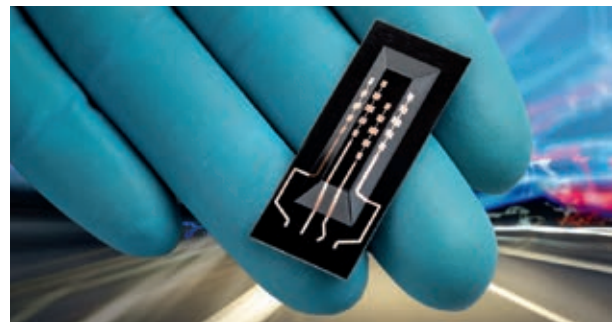


### ICT



*Photonic test kit for tap-proof communication*

### Automotive



*Cost-effective 360° radars for autonomous driving*

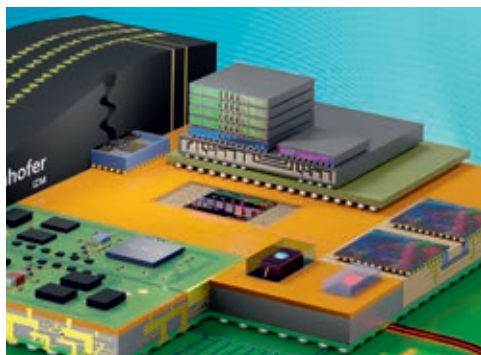
# High-end Performance Packaging from Wafer to System

Four technology clusters offering applied research across the entire value chain and every sector of industry

## 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

*Stacking and fabrication of glass interposers and chiplets*

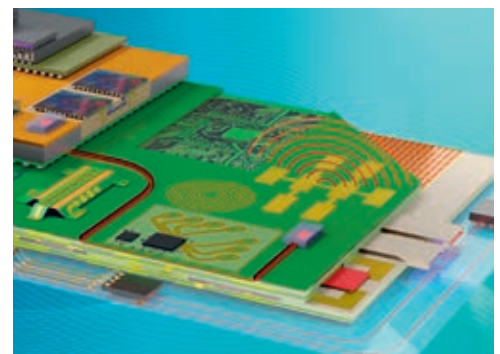


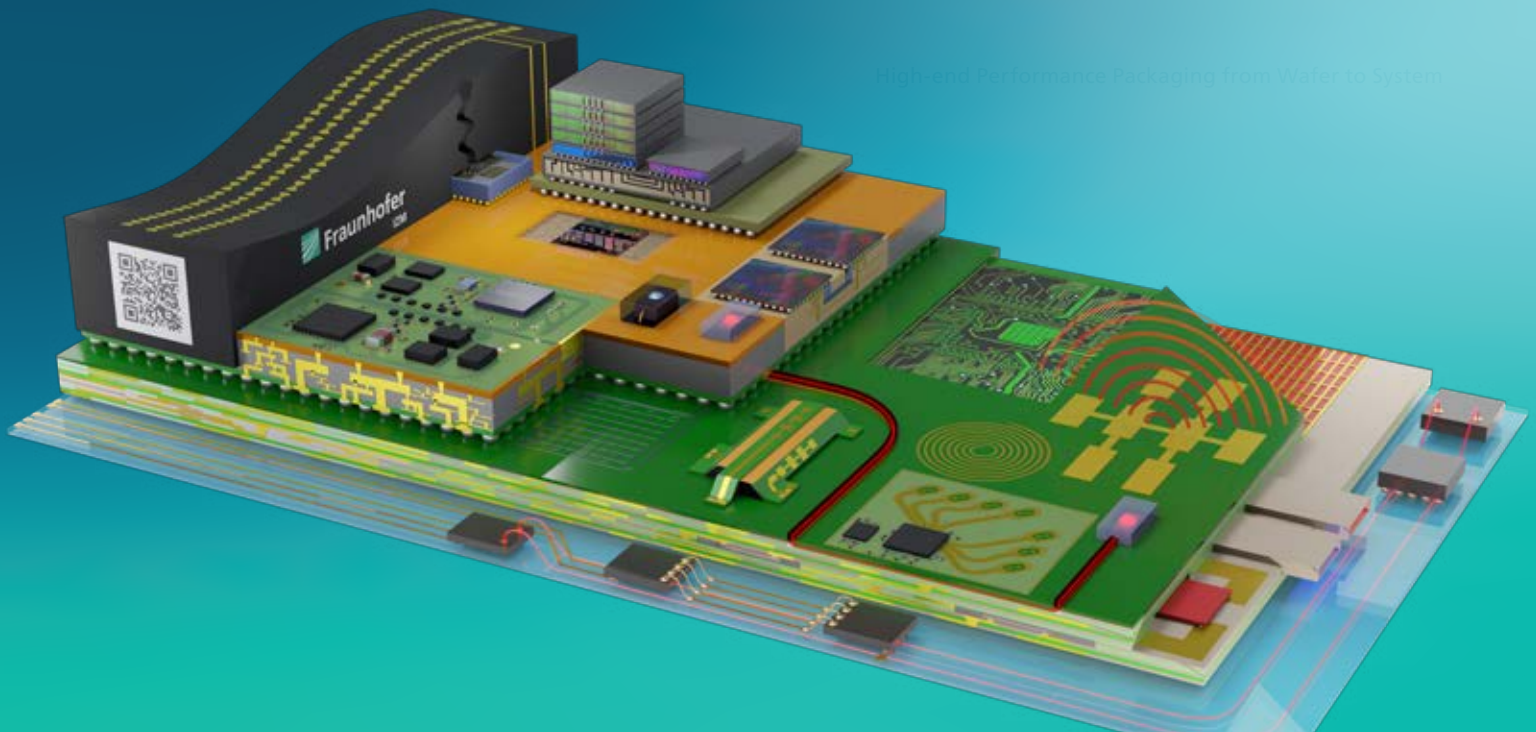
*High frequency optimized design for frequencies up to 220 GHz*

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).

## System design

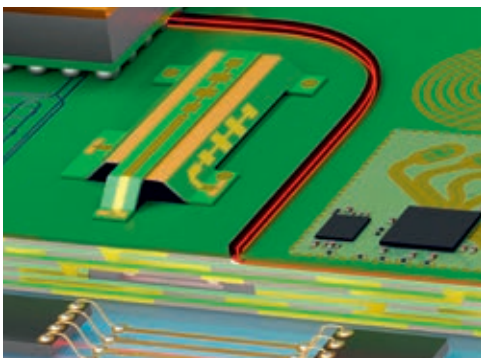
Due to the use in harsh environments, the application of new sensor principles and increasing frequencies and data rates, packaging technologies need to evolve and be more specifically characterized and optimized with regard to their electrical, thermal and thermo-mechanical properties. Fraunhofer IZM's strength lies in the combination of excellent technology development, sophisticated electrical design and electrical, thermal and thermo-mechanical modeling, simulation and analysis methods.





### Integration at substrate level

Fraunhofer IZM's substrate integration line combines state-of-the-art assembly equipment with a complete large-format PCB production and is one of a kind worldwide. Besides precision assembly, embedding technologies and highly reliable encapsulation processes we develop cutting-edge panel-level

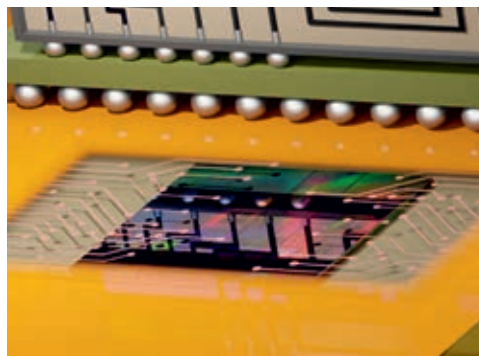


packaging technologies, which in turn provide a start-to-finish manufacturing opportunity for system-in-packages, modules and miniaturized systems on large formats. Fraunhofer IZM also offers the manufacturing of prototypes, small series and the process transfer into industry.

### Materials, reliability and sustainable development

Reliability and environmental compatibility are an increasingly important factor in the development of electronic assemblies and systems. Fraunhofer IZM combines reliability analyses of electronic assemblies and their environmental impact with the development of new technologies. We conduct analyses of 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.

*Multilayer substrates and embedding of electronic and optical components*

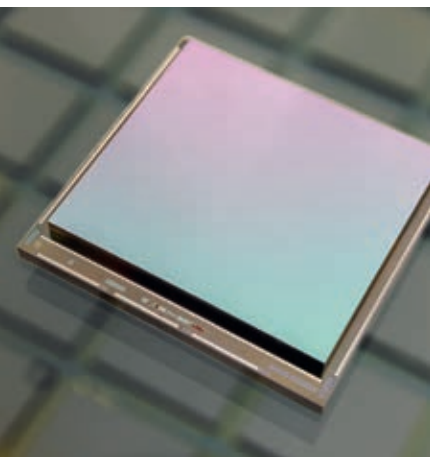


*Material characterization, thermal simulation and ecodesign*

# Core Competencies

Applied research in four departments with industry-grade facilities – and more than 30 years of experience

## Wafer Level System Integration



*IR sensor chip after hermetic wafer-level vacuum capping with AuSn bonding technology*

The Wafer Level System Integration department focuses on the development of advanced packaging, system integration technology and client-specific solutions for microelectronic products. The department's technological emphasis includes 2.5D/3D integration, wafer-level packaging, fine-pitch bumping, high-density assembly, sensor development and integration, (quasi) hermetic MEMS packaging, solid-state detector integration, and hybrid photonic integration.

The services available to industrial customers include process development, prototyping, low- and medium-volume pilot manufacturing as well as materials evaluation and qualification and process transfer. The ISO 9001 2015 certified production lines in Berlin and Dresden are set up for production- and industry-compatible development and processing (100mm to 300mm wafer size).

- Cu- and Al-based multilayer rewiring (RDL) on active IC wafers with inorganic/organic dielectrics
- Silicon/glass vias (TSV/TGV)
- Pre-assembly and wafer thinning
- Temporary wafer bonding and de-bonding
- Application-specific WL-SiP, CSP, TCI, 2.5D/3D integration, FanIn and FanOut wafer-level packaging, solid state detector integration, MEMS packaging ((quasi-) hermetic wafer-level capping)
- Photonic system integration and optical co-design packaging (OPC)
- Sensor development and integration (pressure, acceleration, gas), also for harsh environments

### Services

- Bumping (by ECD): Cu (pillars), Ni, Au, Sn, SnAg, AuSn, In, InSn, nanoporous Au (NPG)
- Assembly: D2D, D2W, W2W, reflow soldering, thermocompression/thermosonic/diffusion bonding



*Wafer process line up to 300mm*

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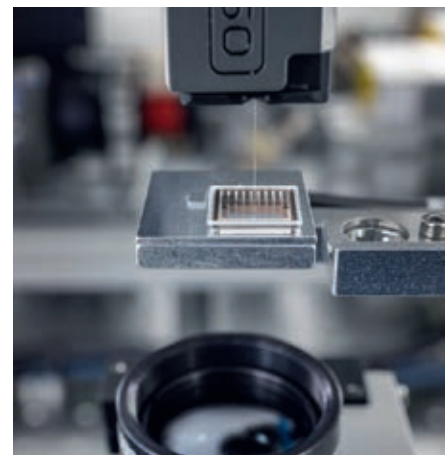
## System Integration & Interconnection Technologies

The range of services provided by the System Integration and Interconnection Technologies (SIIT) department, with its roughly 170 employees, spans from consultation and 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 the department's 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

- SMD, CSP, BGA, POP and bare die assembly
- Flip-chip techniques (soldering, sintering, adhesive joining, thermo-compression and thermosonic welding)
- Die attach (soldering, sintering and adhesive joining)
- Wire and ribbon bonding (ball/wedge, wedge/wedge, heavy wire and ribbon)
- Optical: fiber optics and sensors, electro-optical circuit boards, photonic assembly, plasmonics
- Conformable electronics
- Power electronics: Electrical/electromagnetic/thermal/thermomechanical design and assembly of module prototypes
- Power cycling of power modules



*Laser welding of optical fibers to photonic chips for quantum applications*



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## RF & Smart Sensor Systems

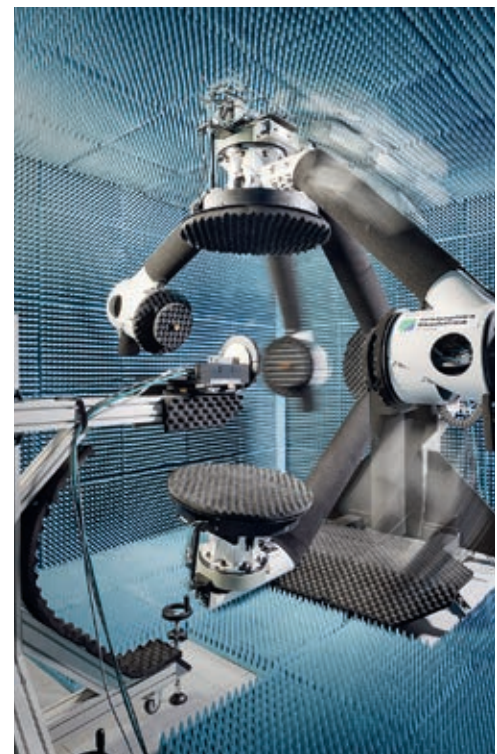
*Measurement of intelligent reflecting surfaces (IRS) for 6G applications*

Creating advanced systems for communication, radar and sensor applications, founded on Fraunhofer IZM's technology know-how. Development and optimization of methods and tools for the design of technologically sophisticated miniaturized electronic systems. Providing power supply solutions through energy harvesting, energy conversion concepts, energy management for autonomous systems and energy-optimized programming. Extensive range of equipment for measurement and characterization of RF materials, assemblies and components (up to 220 GHz), as well as for assembly and measurement of autonomous sensor nodes and for manufacturing of micro batteries..

### Services

- RF-design and RF-characterization of materials, packages and components
- RF-system integration and module design with regard to signal and power integrity
- Design and realization of miniaturized radar systems

- Design and realization of autonomous, wireless sensor systems
- Development of micro batteries, power supply and management for autonomous systems
- Tools for optimized design of micro systems and server-client software architecture
- Analysis, consulting, and development support for energy-minimized design of electronic systems



*Automated antenna measuring station for near and far-field measurements at up to 325 GHz*

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## Environmental & Reliability Engineering

Reconciling progress in microelectronics with the needs of our environment has become a key priority in the industry. Fraunhofer IZM is a pioneer in this field. The »Environmental and Reliability Engineering« department has been supporting new technical developments and the innovation of more sustainable, durable, and greener electronics for over two decades. With its unique combination of environmental performance and reliability checks,



*Condition monitoring of electronics*

the service spectrum not only encompasses both the investigation and the minimization of environmental impact with regard to development and reliability aspects, but also the eco-design of products. In addition, we offer accelerated lifetime testing for complex load operations, special testing methods for monitoring the aging process and can support

you in the material-related analysis, characterization and simulation in the micro and nano range. We can also offer the development of lifetime modeling for materials, components and systems, thermal management, condition monitoring for electronics and reliability management.

### 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 the sustainable development of electronics
- Ecodesign of products and assistance with the applicable legal regulations
- Lifetime-oriented design, recycling and condition monitoring of electronic systems
- Circular design Lab



*Disassembly and ecodesign*

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# Cooperation

## Individual Order – Technology Transfer – Industrial Service – Strategic Partnership



**R & D for medium-sized companies, large enterprises and startups**

Fraunhofer IZM's research results are highly relevant to industries such as the automotive industry, medical engineering, industrial electronics and even lighting and textiles. Semiconductor manufacturers and suppliers of related materials, machines and equipment, but also small companies and startups can choose the approach that best suits their needs – from easily accessible standard technologies through to high-end disruptive innovation. As partners, our customers profit from

the advantages of contract research, by selecting between exclusive release of a product innovation, improving a workflow or qualifying and certifying a process.

### Contract research

Often a successful cooperation project begins with a preliminary consultation phase that is usually free-of-charge. Fraunhofer only begins billing for its research and development services once the parameters of the cooperation have been defined. Customers retain ownership of the material project outcomes developed within their contract, as well as the applicable usage rights to the produced inventions, property rights and the know-how.

### Project funding

Some development challenges require pre-competitive research. In these cases, teaming up with companies and research institutes and public funding support is more effective than operating solo. The institute cooperates closely with numerous universities, including the Technische Universität Berlin and the Berlin University of Applied Sciences (HTW), to ensure that the preparation for future cooperation with industry is optimal.

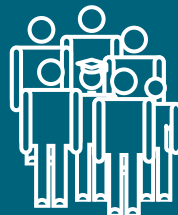
### Fraunhofer IZM in facts & figures



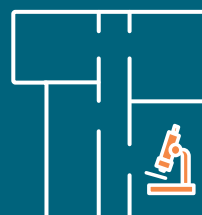
Turnover < 40 Mio €



Industry projects ≈ 35 %



≈ 450



Labs & cleanrooms > 8.000 m<sup>2</sup>



## Benefit from our Networks

### Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft is the leading organization for applied research in Europe. Its research activities are conducted by 76 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs a staff of more than 30,000, who work with an annual research budget totaling roughly 3 billion euros. Of this sum, Fraunhofer generates about 2.5 billion euros through contract research. Industry contracts and publicly funded research projects account for around two thirds of that. International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

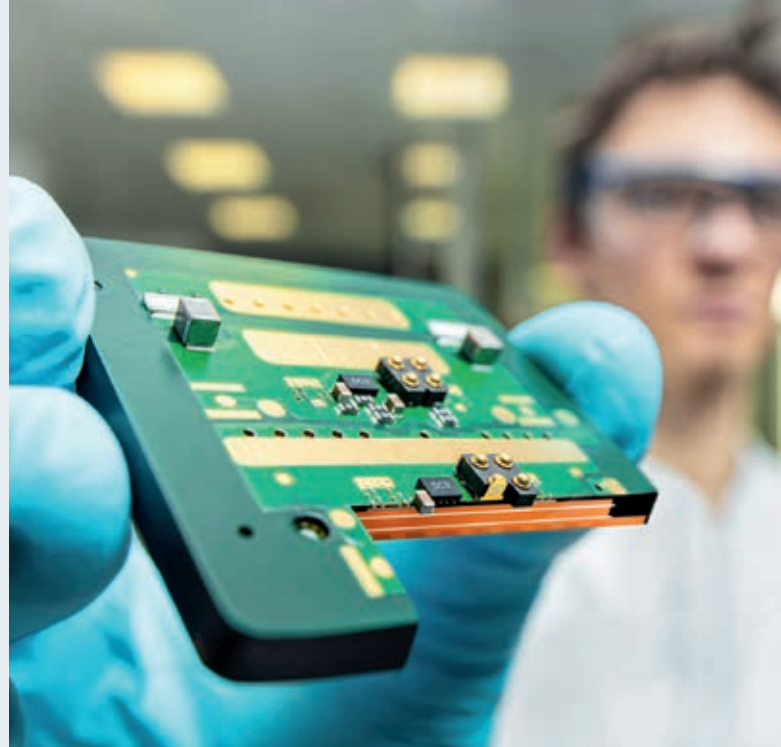
### Fraunhofer – Excellence in Microelectronics

Since 1996 the Fraunhofer Group for Microelectronics has been coordinating the research activities of the Fraunhofer institutes working in the fields of microelectronics and microintegration. The Fraunhofer Group for Microelectronics currently consists of eleven members, as well as four guest institutes from other Fraunhofer groups.

Since 2017, eleven Fraunhofer institutes of the Group for Microelectronics have been working together with two Leibniz institutes FBH and IHP as the "Research Fab Microelectronics Germany", FMD. FMD is the largest cross-location R&D alliance for microelectronics in Europe and now provides a One-Stop-Shop, combining the scientifically excellent technologies, applications and system solutions of the cooperating institutes in the field of micro- and nanoelectronics. The activities of the Fraunhofer Group for Microelectronics and the FMD are coordinated by the joint office in Berlin.

### Advancing Chiplet Technology with the APECS Pilot Line

Fraunhofer IZM is taking over a key role in powering the hardware integration of chiplet systems as part of the APECS



*SiC power module for low-inductance automotive applications*

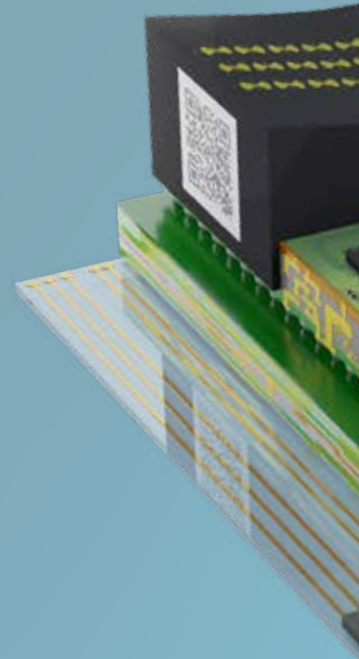
pilot line, established in preparation for the EU Chips Act. With access to chiplet components, the Institute can cover the entire process up to the realization of fully functioning systems. To this end, the Institute's researchers are working on cutting-edge interposer technologies on 300 mm high-density substrates with innovative assembly technologies. The processes developed at the Institute enable the advanced hetero-integration of highly integrated systems. The stated aim of the initiative is to take the development and integration of chiplet technologies to the next level to bolster the competitiveness of Europe's semiconductor industry.

### High-Performance Centers

The High-Performance Center »Functional Integration of Micro-/Nanoelectronics« supports SMEs in Saxony with know-how in sensor and actuator technology, measurement technology, and mechanical engineering and construction by rapidly transferring research results into innovative products. The Fraunhofer Institutes ENAS, IIS, IPMS, and IZM, as well as the Technical Universities Dresden and Chemnitz and the HTW Dresden are members of the Center. The High-Performance Center is part of the microelectronics hot spot Saxony.

### Start-A-Factory

Bringing startups and small and medium-sized companies quickly from the first idea to professional prototypes: This is what Start-A-Factory offers, with the help of state-of-the-art systems and embedded in the network of scientists at Fraunhofer IZM and partners. The development team remains fully involved and retains 100 % intellectual property.



Cover:

*Fraunhofer IZM's technology portfolio in High-End Performance Packaging (HEPP)*



**Forschungsfabrik  
Mikroelektronik  
Deutschland**

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