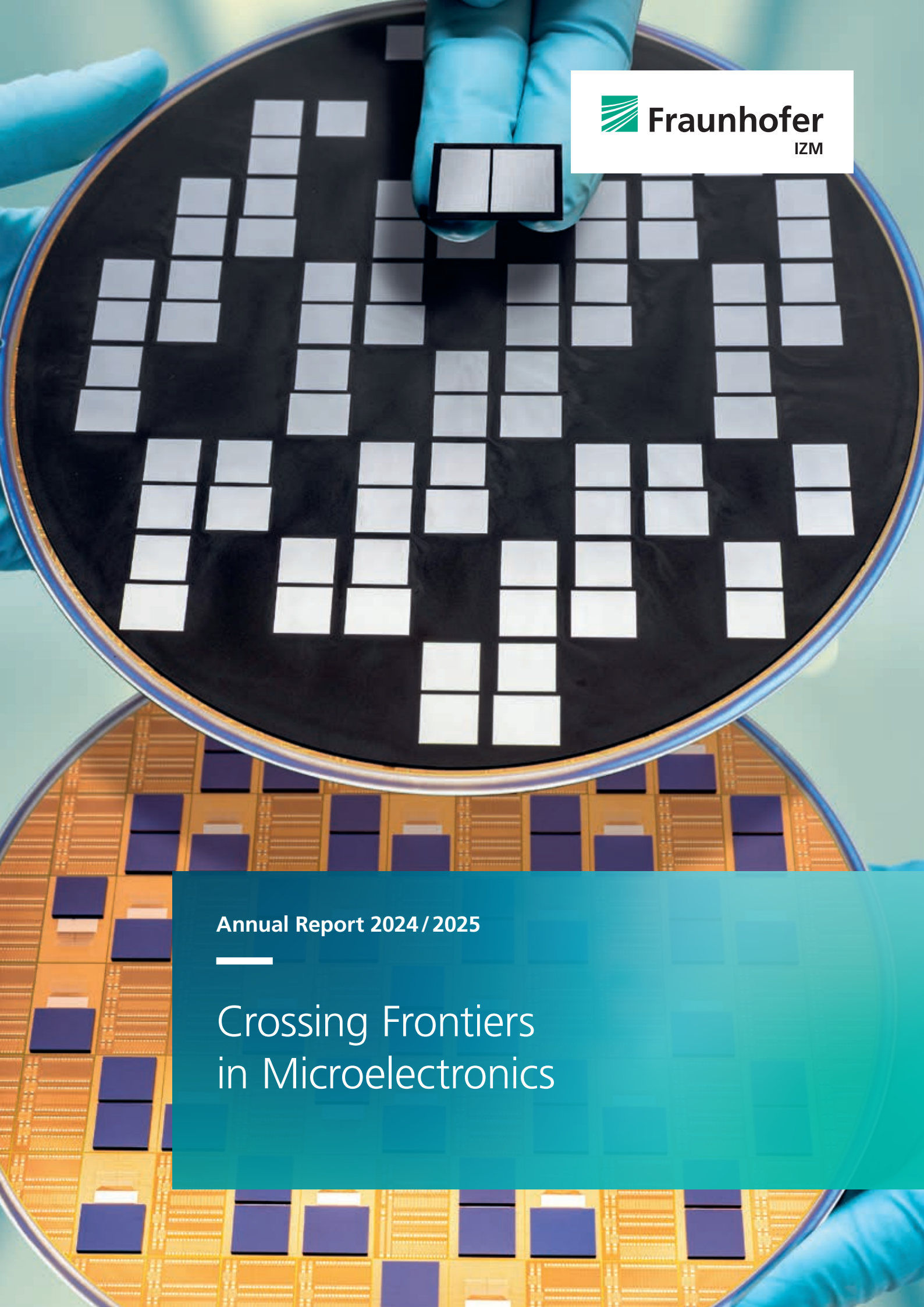


Fraunhofer IZM

Annual Report 2024 / 2025

Crossing Frontiers in Microelectronics

Annual Report 2024/2025

Crossing Frontiers in Microelectronics

»Fraunhofer IZM is taking chiplet technologies from research to actual applications – with industry-driven R&D along the entire process chain.«

Prof. Dr. Ulrike Ganesh
Director of Fraunhofer IZM

Content

Preface

Dear Friends of Fraunhofer IZM,

the last twelve months have been a time jam-packed with innovative, creative achievements, and structural transformation. Cooperation has been and remains one of the foundational principles of our research work. Our many close partnerships with our friends and partners in industry, at universities, and at other research institutes are essential for the innovative work being carried out at Fraunhofer IZM. We are proud to report that we have reinforced these ties with the academic world in the last year: in addition to our long-standing cooperation with the Research Center for Microperipheric Technologies at the Technical University of Berlin, we need to mention our active cooperation with the TU Dresden, the BTU Cottbus-Senftenberg, and the TU Delft in the Netherlands.

Starting in August 2024, the strategic focus and innovative capacities at Fraunhofer IZM are in the safe hands of not one, but two capable leaders. Ulrike Ganesh, a renowned expert in the characterization and failure analysis for highly advanced semiconductor technology took over the chair for the »Design and Hetero-integration of Microelectronic Systems« at the Technical University of Berlin. She also joined Martin Schneider-Ramelow at the helm of Fraunhofer IZM, where they are responsible for the Institute's strategic direction.

Let us survey the year 2024: The number of people working at the Institute has grown to around 460 colleagues. Together, we surpassed the 18-million-Euro mark in commercial results and increased our operating budget to €45 million.

Last year, an important part of the EU Chips Act came into force: the »Advanced Packaging and Heterogeneous Integration for Electronic Components and Systems« pilot line, or APECS for short. As part of that APECS pilot line, Fraunhofer IZM is contributing actively to Europe's aspiration towards greater competitiveness in the semiconductor industry. With its clear commitment and its one-stop-shop approach, Europe is strengthening its competitive edge for the future. The EU, the German Federal Ministry of Education and Research, and the states of Berlin and Saxony are investing substantial resources and offering more access to state-of-the-art infrastructure for wafer- or substrate-based high-integration solutions. For Fraunhofer IZM, this means exceptionally promising prospects for our future work.

The demand for reliable, powerful, and long-lasting microelectronics remains very high. This is why Fraunhofer IZM has continued to innovate in the field of packaging, including chiplets, RF packaging for 5G and 6G applications, high-performance computing, or cryo-packaging for quantum computing. Bioelectronics with the growing interest in active implants represents another important driving force for innovation.

Environmental concerns, like lifecycle assessments, ecodesign, or eco-reliability are gaining in relevance in the electronics industry. The ambitious climate goals espoused by many companies show the importance of assessing the products we all use in terms of their carbon footprint.

As part of the »Green ICT @ FMD« project, Fraunhofer IZM and our partners managed to engage with around 200 participants on site and an online audience of 800 as part of the second »Green ICT Connect« session in Berlin – a great success all around.

Other highlights of the year include:

- The major »QSolid« project with its 160 partners on the consortium managed to launch the first prototype for a German quantum computer with optimized qubit quality last November. One key aspect of this was a silicon flex interposer, developed at Fraunhofer IZM-ASSID, which is perfectly suited to operating at low temperatures and represents a leap forward in terms of its construction.
- On the European »Moore4Medical« project, the research team developed a neuromodulation implant driven by ultrasound that can stimulate or inhibit neural activity. Fraunhofer IZM made this possible through its contributions to the integration, assembly, and encapsulation of the ultrasound neurostimulator and the stimulator cuffs.
- Working with industry partners, Fraunhofer IZM developed a powerful automotive converter in the »Dauerpower« project. What is special about it? Its design, construction, and testing was made possible with cutting-edge technologies like PCB embedding, PML capacitors, and metal 3D printing.

At our Dresden site Fraunhofer IZM-ASSID, we celebrated the expansion of the »Center for Advanced CMOS and Heterointegration Saxony« (or CEASAX). Working closely with Fraunhofer IPMS, this expansion holds great potential for future innovations in 300 mm wafer technology.

We also celebrated one particular highlight: In November 2024, the talented team led by Dr. Hermann Oppermann and ams-OSRAM received the »Deutscher Zukunftspreis« (German Future Prize) from the Federal President for their groundbreaking work on LED matrix technology. We have to thank the entire team - and, of course, Hermann Oppermann - for this astonishing achievement.

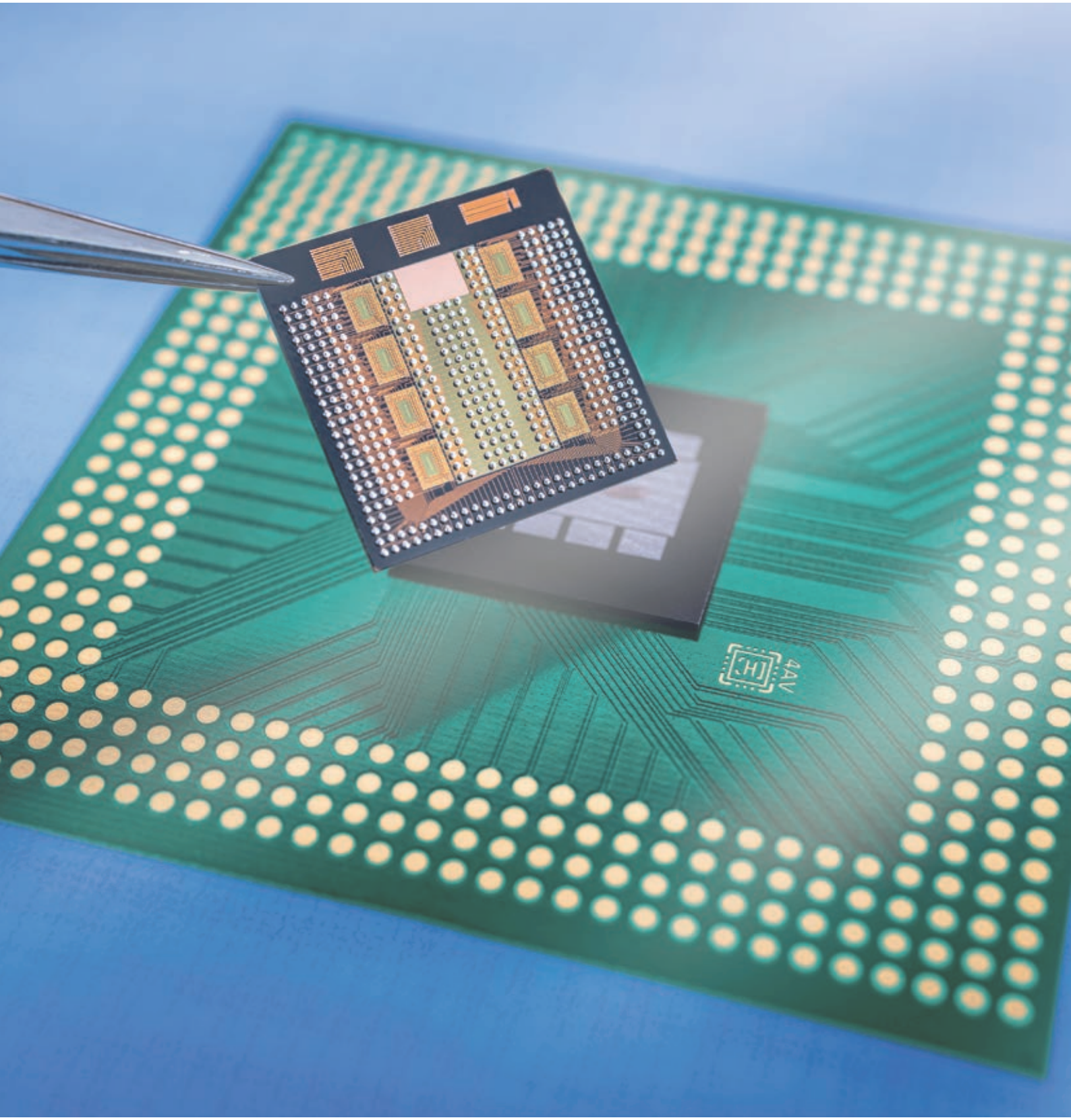
All of these great stories are due, first and foremost, to the highly motivated people of Fraunhofer IZM. They have earned our particular gratitude and respect. Without your great work and tireless pursuit of innovation, none of this would have been possible.

We also owe particular thanks to all of our partners in science and industry, the people supporting us in regional and national politics, and our project clients for their tremendous support.

This was only a whistle-stop tour of some of the highlights of the year. We hope that you enjoy discovering more in our annual report, and that you will join us in staying optimistic about the bright future ahead, despite all the crises and challenges!

Yours,

Prof. Dr.-Ing. Ulrike Ganesh and
Prof. Dr.-Ing. Martin Schneider-Ramelow



In the »PUNCH« project newly developed photonic integrated circuits (PICs) are being integrated into an electrical system in such a way that network transmissions will in future be able to operate without losses or delays

Core Competencies

High-end Performance Packaging from Wafer to System

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, and have outstanding lifetime. The Fraunhofer 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.

With 460 employees, the institute develops adapted system integration technologies on wafer, chip and board level. Research at Fraunhofer IZM means designing more reliable electronics and making reliable lifetime predictions.

Working together with Fraunhofer IZM

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.

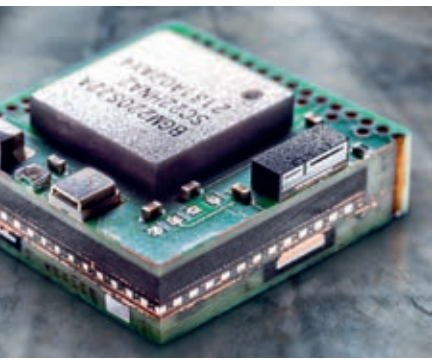
Heterogeneous integration

High-performance systems at lower costs – that is the promise of heterogeneous integration solutions and technologies such as chiplet architectures. Fraunhofer IZM sees itself as a link between manufacturers of materials, machines, and components and specialists in assembly and interconnection technology. The institute is involved in the preparations for the European Chips Act (EuCA) as a partner for integration innovations.

Driving trends

Chiplet assembly, hybrid bonding, silicon interposer technologies, fan-out wafer level packaging, cryo-packaging, the integration of high-bandwidth memories (HBMs), RF characterization, and packaging for 5G/6G applications are just a few of the technologies and examples in this catalog of services designed to meet the trend topics of the future.

System Integration & Interconnection Technologies



Highly miniaturized edge-IOT-module

The »System Integration and Interconnection Technologies« (SIIT) department with its staff of approx. 170 offers a range of services from process development to complete system solutions.We are committed to developing processes and materials for new interconnection approaches on the board, module, and package level and to the integration of electrical, optical, and power electronics components and systems.

We assist enterprises in applied, pre-commercial research as well as prototype and small series production. Our work includes application consulting, technology transfer, and practice-oriented training for our partners' staff. Our focus is on interconnection and encapsulation technology for electronic and photonic packaging, including:

- SMD, CSP, BGA, POP and Bare-Die-precision assembly
- Flip-chip technology (soldering, sintering, gluing, thermocompression and thermosonic bonding)
- Die attachment (soldering, sintering, gluing)
- Wire and ribbon bonding (ball/wedge, wedge/wedge, thick wire and ribbon bonding)
- Flip-chip underfilling and COB glob topping
- Transfer and compression molding
- Chip and component embedding
- Power electronics: Electrical / electromagnetic/thermal/thermomechanical designs, module selection, prototyping
- Thin glass and silicon photonics packaging
- Fiber coupling and optical connections to planar waveguides, fiber lenses, and laser bonding

Optoelectronics and power electronics and their challenges are part of our focus, as are the specific needs of high-temperature or high-frequency applications and the use of advanced integration technology in e.g. medical technology applications. We work in cutting-edge cleanroom, technology, and reliability laboratories, designed to be ideally suited to process and analytics development for a range of technologies.

- Processing line for substrate and panel production up to 24"x18"
- Laser direct imaging system (up to 4 µm L/S) for large-format lithography processes
- High-precision assembly line for fully automated SMD, COB, FC, and large-format chip assembly in embedding processes
- Equipment for selective, plasma, vapor-phase, and convection soldering
- Wafer and panel-level encapsulation
- Transfer molding for SiPs and high-volume power electronics packages
- Electronics textile lab
- Development of glass substrates: Laser structuring, etching and smoothing, metallization, integrated optical waveguides, microlenses, lattices, resonators
- Joining technology: Design, optical fiber coupling, fiber lenses, automated optical microassembly
- Electrical characterization lab for power electronics commissioning tests
- Power electronics design tools: electrical, electromagnetic, constructional, thermal, mechanical
- SSXPS, X-ray CT, ultrasound microscopy, FIB, and REM
- Detailed surface topography analysis with tactile, confocal scanning and optical large-area technology as well as package warpage
- Material analysis: DSC, TMA, DMA, TGA, rheometrics, dielectric analysis, sorption analysis
- Reliability tests including TCT, HT, HAST, drop, vibration, …

Contact

Dr.-Ing. Tanja Braun
tanja.braun@
izm.fraunhofer.de

Dr.-Ing. Andreas Ostmann
andreas.ostmann@
izm.fraunhofer.de

Wafer Level System Integration

The department »Wafer Level System Integration« (WLSI) focuses its research activities on the development of advanced packaging and system integration technologies and offers customer-specific solutions for microelectronic products used in smart systems. Around 80 scientists at two sites – Fraunhofer IZM in Berlin and the institute branch ASSID – All Silicon System Integration Dresden (IZM-ASSID) – conduct research in the following key areas:

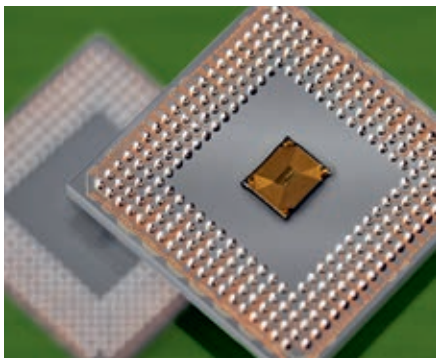
- 3D integration including Cu-TSV and wafer tacking
- Thin wafer processing and integrationtechnology
- Heterogeneous Integration
- Wafer-level packaging, fine-pitch bumping and interconnect technologies
- Hermetic MEMS and sensor packaging
- High density flip-chip assembly
- Sensor development and integration
- Hybrid photonic integration
- Photonic and plasmonic system development

At both sites, the department operates leading-edge process lines that permit a high degree of processing flexibility, particularly for 200 – 300 mm wafers. The lines are characterized by a high adaptability and compatibility between the individual sub-processes and are particularly equipped for production-related and industry-compatible development and processing. Both sites have a completely ISO 9001:2015-certified management system to guarantee highest quality standards in project and process work. The department's already outstanding technological expertise is continuously extended within numerous research projects and the gained know-how can be transferred at development stage to SME partners. WLSI has established a broad cooperation network with manufacturers and users of microelectronic products, as well as tool suppliers and material developers in the chemical industry.

The department's technological know-how is focused on the following areas:

- Heterogeneous wafer-level system integration
- 3D wafer-level system in package (WL-SiP, CSP, WSI)
- Application-specific Cu-TSV integration: via middle, via last, backside TSV
- Cu-TSV interposer with multi-layer RDL and micro cavities
- Glass interposer with TGV
- High-density interconnect formation: micro / nano interconnect and pillar bumps with solder cap (Cu, SnAg, CuSn, Au, AuSn, In, InSn, nano-porous Au)
- Pre-assembly (thinning, thin wafer handling, laser grooving, laser dicing, plate dicing)
- 3D assembly (D2D, D2W, W2W)
- 3D wafer-level stacking
- Wafer bonding, direct bond interconnects (DBI) - W2W (12"), (adhesive, soldering)
- Micro sensor development and integration
- MEMS packaging (hermetic)
- Simulation and characterization of photonic and plasmonic components & systems
- Photonic system integration (incl. e. g. polymer waveguides)

The service portfolio for industrial partners comprises process development, material evaluation and qualification, prototyping, low- and middle-volume manufacturing and process transfer. Newly developed technologies can be adapted to customer-specific requirements.



Embedded micro RFID tag in the rewiring of a chip for component identification and ensuring trustworthy supply chains

Contact

Dr.-Ing. Michael Schiffer
michael.schiffer@
izm.fraunhofer.de

Dr.-Ing. Manuela Junghähnel
manuela.junghaehnel@
assid.izm.fraunhofer.de

Environmental & Reliability Engineering

Standardized charging ports and modular device design facilitate the circular economy

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, the department can offer services in the areas:

- Environmental assessments and eco-design
- Resource efficiency, circular economy, and obsolescence research
- Reliability standards and testing and state monitoring procedures
- Failure mechanisms, lifetime models, and materials data
- Simulations for reliability analyses and optimization

Our interdisciplinary team develops processes and models and supports our partners in integrating environmental and reliability criteria in the design and development process. We can help identify weak points and untapped potential at an early stage in the introduction of new technologies, materials, processes, components, and applications and find suitable solutions for our partners.

Stemming the tide of electrical and electronics waste and reining in the resource hunger of the industry is one of the key challenges faced by all of society. Modern life has become unthinkable without electronics. A boon and a bane alike, electronics contribute to making climate change worse, but they can also be the key to saving resources and reducing our carbon footprint.

The environmental footprint of actual products and of the fundamental technologies that make them possible has gained considerable salience in the industry. We are also assisting suppliers and smaller enterprises in defining and meeting specific climate and resource efficiency targets.

Legislators and consumers alike are increasing pressure on manufacturers in the form of toughened standards and specifications for products that are easier to tear down, to repair, and to keep in working order for a longer overall product lifespan. Methods for application-specific reliability checks are playing an important role in these efforts to extend the lives of particularly resource-intensive electronic components.

The reliability of technologies is benefitting from constant progress and refinement in testing methods and simulation models. A lot of attention is currently aimed at warpage and corrosion, but depending on their use case, the reliability of electronic components is understood and analyzed in terms of all important fatigue mechanisms or other forces affecting the components, including mechanical vibration, heat, humidity, changes in temperature, or voltage and power loads. These tests and simulations, tailored specifically to the given use case, offer new pointers for optimization for the relevant parameters (such as the materials, geometries, and process design) to achieve the new reliability standards expected in the supply chain and in actual use.

Contact

Dr.-Ing. Nils F. Nissen
nils.nissen@
izm.fraunhofer.de

RF & Smart Sensor Systems

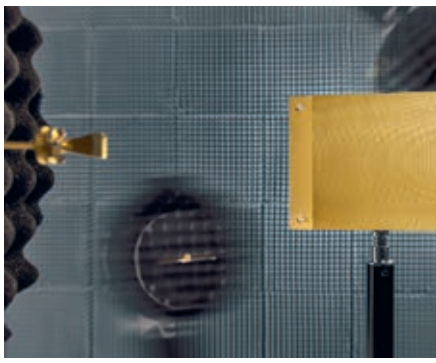
The department »RF & Smart Sensor Systems« is concerned with the research, development and industrial application of wireless sensor and communication systems. The focus of our work is on 5G and 6G communication systems, radar sensor technology and as well as wireless sensor nodes. The greatest challenge in terms of research and development and the defining criteria are large bandwidths high robustness and a commitment to maximum energy efficiency. Other features such as controllable antennas, beamforming, and protections against signal deterioration are also attracting increasing attention.

Meeting these exacting standards needs the tight integration of circuit design and technology development (hardware/package codesign) just as much as genuine cooperation

between software and hardware developers (hardware/software co-design). With this in mind, the department RF & Smart Sensor Systems combines the intensive technological know-how of Fraunhofer IZM with our in-depth expertise in firmware and hardware development.

Our activities focus on:

- RF design and characterization of materials, packages, antennas, and components (up to 220 GHz)
- RF system integration and module design- with particular attention to signal and power integrity
- Development of highly integrated radar sensor systems
- Design and construction of autonomous wireless sensor systems for industrial use
- Development of microbatteries and power supply and power management systems for autonomous devices
- Tools for the optimized design of microsystems and server-client software architectures for IOT applications



Surveying of intelligent reflective surfaces (IRS) for 6G applications

Contact

Prof. Dr.-Ing. habil.
Ivan Ndip
ivan.ndip@
izm.fraunhofer.de

Harald Pötter
harald.poetter@
izm.fraunhofer.de

Highlight
Advanced Packaging and Design Solutions for Energy-efficient HPC and AI Systems

Michael Schiffer, Ivan Ndip and Karl-Friedrich Becker

High-performance computing (HPC) and artificial intelligence applications depend on high-precision high-end performance packaging. Without this physical and electrical connection between different chiplet components, the required high data rates would simply be impossible. An optimum system design is needed to not only dissipate the heat during operation efficiently, but also maintain high signal and power integrity (SI/PI), another essential factor for high-speed data transmission and processing. Novel packaging technologies and design methods help improve energy efficiency, reduce latency, and increase computing performance, making the packaging a decisive factor for the successful realization of high-end HPC and AI systems made in Europe.

The Fraunhofer-funded STXmod project afforded the researchers the unique opportunity to prepare and try out a holistic process, using a 2.5D integration design with a silicon interposer. The project gave impressive proof of the potential of the design method and the process chain from the original silicon via the integration of HBM and stencil and tensor accelerator chips (STX) to the finished PCB.

Alongside Fraunhofer IZM (in charge of interposer design and the technological realization of the HPC module, the institutes Fraunhofer IIS and ITWM were involved, taking charge of the frontend and chip design and of the co-design, system and software development, and overall project coordination, respectively.

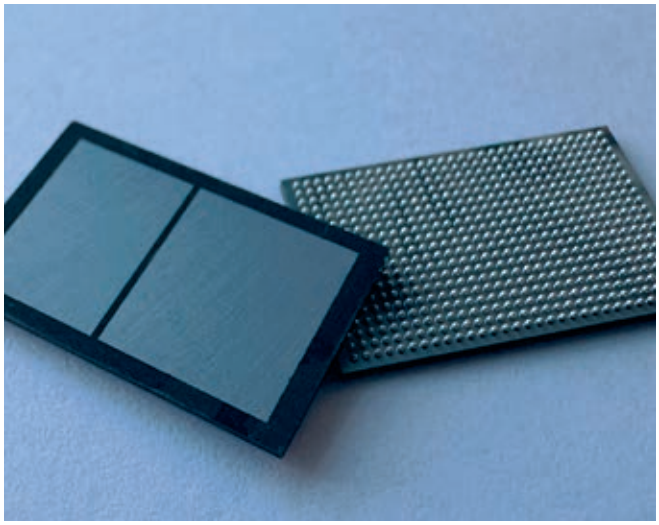
System-level design started with the definition of all SI/PI requirements for the intra-chip connections. This turned out to be a major undertaking, handling twelve different voltage levels, D2M data connections to PCIe Gen 5 standards, and the approx. 3,500 individual signal and power conductors running between the chiplets in high-precision parallel alignment for up to 3 Tb/s, and all of this on a silicon interposer with Through Silicon Vias (TSVs).

Contact

Karl-Friedrich Becker
karl-friedrich.becker@
izm.fraunhofer.de

Prof. Dr.-Ing. habil.
Ivan Ndip
ivan.ndip@
izm.fraunhofer.de

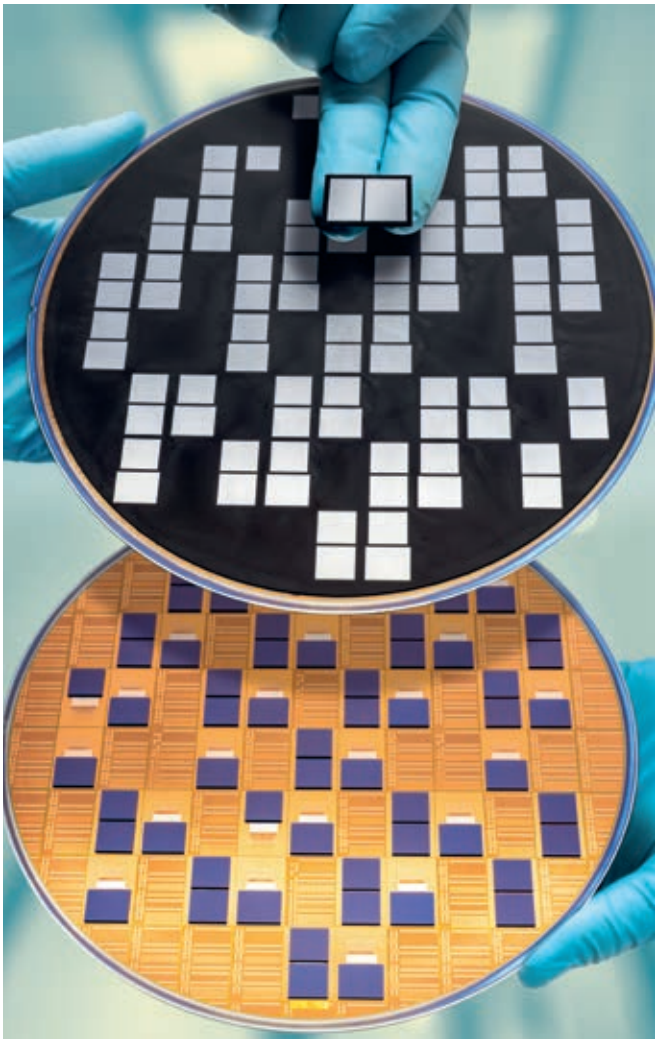
Dr.-Ing. Michael Schiffer
michael.schiffer@
izm.fraunhofer.de



Finished HPC module after wafer molding, balling, and singulation

Different topologies and assembly concepts were assessed for the optimum balance of design complexity and electrical performance, using 3D HF modeling and a combination of commercial and proprietary field solvers. The optimum layout solution was found with due consideration for the unique specifications for the chosen technology (LS track widths, number of layers, BGA pitch etc.) for the construction of the HPC modules. Suitable test concepts were developed to evaluate the electrical modeling for the signal conductors, with functioning models and test reticle layouts for a metrological verification in two and four-port measurements.

After a first assessment of warpage risks via technology short loop, a »mold last« process was used to process the 200 mm silicon interposer wafers with TSVs and multi-layer redistribution layers. This allowed the L/S to be miniaturized to 4/4 µm at 6 µm polyimide thickness and 8 µm via gauges, all at four layers plus the assembly pad layer. The reverse side was then thinned to 100 µm to expose the TSVs and apply the balling pads, made possible by several courses of rebonding the wafers temporarily during process. The final steps were chip assembly on the glass-backed wafer and encapsulation by wafer compression molding.



TSV-wafer with HD multi-layer redistribution layers and test-ICs before and after molding, as well as a finished module (STXmod project)

The measurements made in the project for a multitude of critical coupling tracks showed the very good HF performance and equally good match with the initial modeling. Time domain analyses made on this bases support the design's suitability for highly parallel signal transmission at bandwidths of up to 3.6Tb/s. The insights gleaned from the STXmod project are paving the way for more HPC projects, especially for supporting the transition from prototyping to ramp-up.

Highlight
15 Years of Fraunhofer IZM-ASSID

Manuela Junghähnel, Kathrin Reinhardt

Flip-chip chips with micro-bumps on a demonstration wafer used to evaluate high-density wiring in a 2.5D silicon interposer, ready for TSVs and 3D chip stacking

Pioneers in 3D system integration

2010 saw the birth of what would become one of today's world-leading research centers for 3D integration and advanced wafer-level packaging: the Fraunhofer IZM All Silicon System Integration Dresden (ASSID). The story of the ASSID is the brainchild of Professor Herbert Reichl. The Director of Fraunhofer IZM at the time was ahead of the curve in realizing the importance that 3D technologies could have for the future of microelectronics.

With the support of the Free State of Saxony, the Federal Ministry of Education and Research BMBF, the European Commission, and the Fraunhofer Society, Fraunhofer IZM-ASSID found its place in the heart of Silicon Saxony – built around industry-grade 200/300 mm cleanroom facilities. Its home in Dresden offered the new site ideal conditions: World-renowned semiconductors businesses, an excellent research landscape, and a local microelectronics industry experiencing dynamic growth right around the corner.

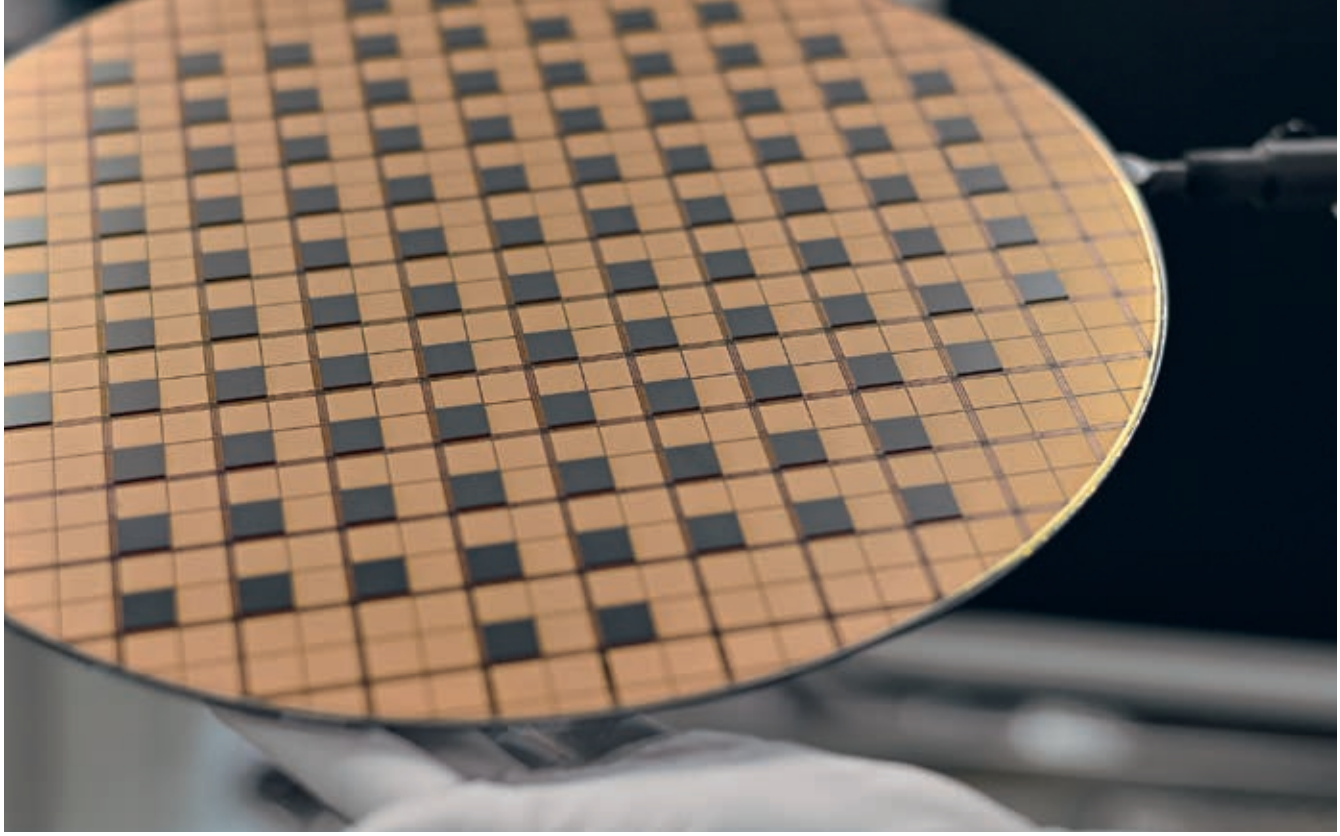
Technological milestones

Das Fraunhofer IZM-ASSID was one of the first sites in Germany offering access to 300 mm R&D infrastructure, dedicated completely to 3D integration. Already in its early years, the team headed by M. Jürgen Wolf worked on the evolution of the technological building blocks for 2.5D and 3D integration. Operating in close partnership with local foundries, key technologies like through-silicon vias (TSV), wafer-level redistribution layer (RDLs), chip stacking, and micropillar interconnects evolved here to full production readiness.

Contact

Dr. Manuela Junghähnel
manuela.junghaehnel@
assid.izm.fraunhofer.de

Dr. Kathrin Reinhardt
kathrin.reinhardt@
assid.izm.fraunhofer.de



The many exceptional technological achievements of the last 15 years include

- Establishment of a complete process flow for 3D wafer-level integration from wafer bonding and thinning to multiplex RDL structures and assembly and in-line metrology
- Completion of the CarrlCool EU project on actively cooled silicon interposers with fluid channels for high-performance computers
- Development of hybrid wafer bonding for 300 mm wafers and their successful validation with a custom test chip design that achieved output of more than 95 % with high-density 3D interconnects in the sub-10 µm range
- Construction of ISO-9001-certified pilot operations for industrial small and medium-volume production in 2014
- Development of RDL-first fan-out packaging and universal sensor platforms for miniaturized system-in-package (SiP) solutions

Headed by Dr. Manuela Junghähnel since 2022, IZM-ASSID is now working on the next generation of packaging technologies: chiplet integration, quantum computing packaging with superconducting materials and trusted electronics for critical applications.

Strong networks and partnerships

Over the years, Fraunhofer IZM-ASSID has created a strong network of cooperations and strategic partnerships, working in joint projects with high-profile enterprises like GlobalFoundries, Infineon Technologies, and NXP and maintaining joint development agreements with leading tool developers.

As an active member of the network Silicon Saxony e.V., IZM-ASSID is part of one of Europe's premier clusters for semiconductor and ICT development. Its constituent membership in the Research Fab Microelectronics Germany also gives its people access to high-tech facilities and close cooperation with more Fraunhofer Institutes and other international research institutions. One shining example of this is the European PREVAIL project - an EU-funded initiative bringing together CEA-Leti, imec, VTT, and Fraunhofer for the creation of a shared testing and development platform for 3D edge-AI hardware. Discover more about the contributions of Fraunhofer IZM-ASSID to the PREVAIL project on page 27 in this report.

The Technical University of Dresden is a particularly close partner, as ASSID Group Lead Professor Juliana Panchenko also holds the chair on »Nanomaterials for Electronics Packaging« at the university – another example of the close links that exist between applied research and academic teaching.

One more recent milestone was the foundation of the Center for Advanced CMOS & Heterointegration Saxony (CEASAX) in 2024 in cooperation with Fraunhofer IPMS and supported by the Free State of Saxony and the Federal Ministry of Education and Research. The Center brings together the entire 300 mm microelectronics value chain in one place, specifically in 4000 square meters of cleanroom facilities with the very latest infrastructure. It offers the best conditions for investigating emerging technologies like neuromorphic or quantum computing. With this new pillar solidly in place, IZM-ASSID is set up perfectly for the next 15 years.

Highlight
Chiplet Innovations for Europe

Rolf Aschenbrenner and Erik Jung

Fraunhofer IZM at the heart of the APECS pilot line promoting heterogeneous integration

The launch of the APECS (»Advanced Packaging and Heterogeneous Integration for Electronic Components and Systems«) pilot line is giving Europe a crucial platform for the development of innovative chiplet technologies, and Fraunhofer IZM has taken over a key role as an R&D partner and system integrator in this effort.

The pilot line is one of the essential building blocks of the EU Chips Act. It is meant to power new chiplet innovations and redouble Europe's semiconductor research and production capacities. Fraunhofer IZM is bringing the Institute's extensive expertise in system heterointegration in this effort – a field that is rapidly gaining in relevance as modern semiconductor systems move towards more modular designs.

Key technologies for heterogeneous integration

As part of the APECS pilot line effort, Fraunhofer IZM has taken charge of developing and implementing high-precision processes for chiplet integration, covering the entire manufacturing process from the provision of individual chiplet components and packaging technologies to the test environments required at the end of the process.

The work includes:

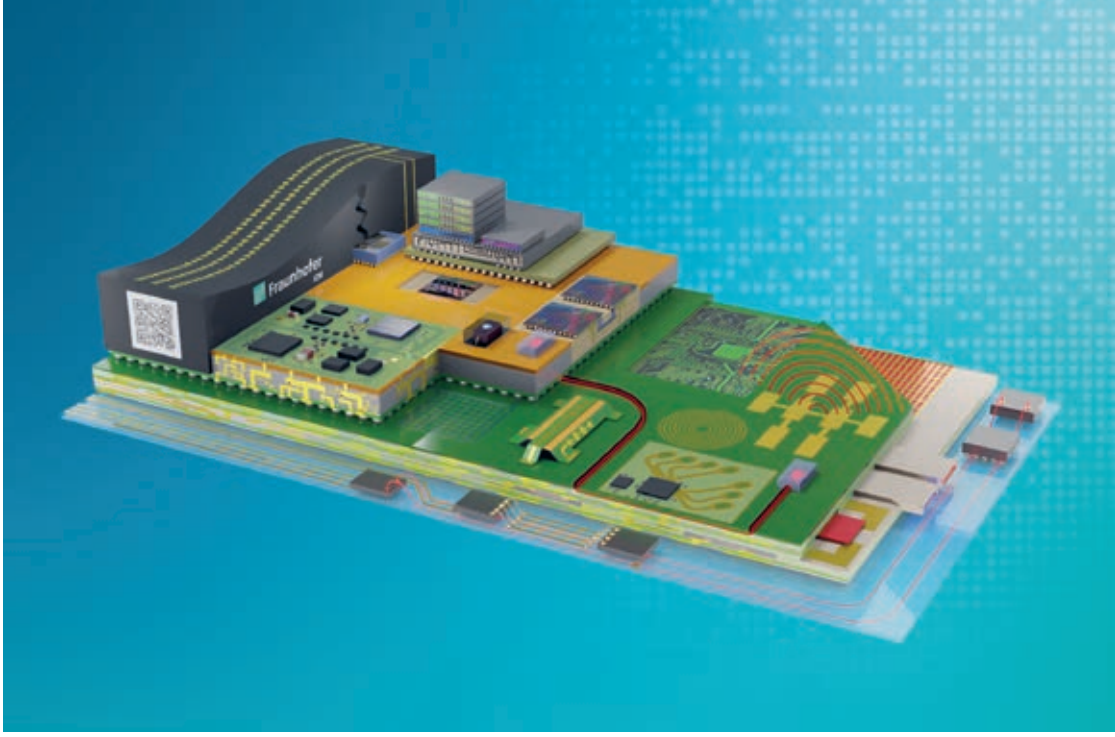
- 300 mm silicon interposer technologies with extremely fine pitches of below 1 µm
- Organic interposers with structures measuring 5 µm and ICs embedded on large-format (up to 600 mm) panels
- Technological solutions for the 2.5D integration of chiplets on interposers
- Assembly processes for 2D, 2.5D, and 3D integration with a focus on speed at extremely high-density wiring

Contact

Rolf Aschenbrenner
rolf.aschenbrenner@
izm.fraunhofer.de

Erik Jung
erik.jung@
izm.fraunhofer.de

More information:
www.apecs.eu



No hetero-integration, no chiplets: High-end performance packaging from wafers to systems is one of the crucial steps in hardware development on the APECS pilot line

Fraunhofer IZM is also preparing full-service test and qualification environments that can be used to ascertain the correct functioning of the integrated chiplets - a must for industrial applications.

Substrate prototyping for research and industry

One key avenue for innovation pursued the development and production of substrates with tiny structures at a micrometer scale. This technology allows the creation of complex prototypes for the Institute's industry and research partners, in particular in fast-moving areas like artificial intelligence and high-performance computing. Alongside organic substrates, novel materials like glass are increasingly moving into the focus of the Institute's researchers.

Modularity, reusability, and sustainability

Integrating several specialized chiplets on a single substrate makes systems not just more compact, but also more versatile and cost-efficient. Fraunhofer IZM is supporting the evolution of these systems with a toolkit of different integration processes, which is constantly updated and expanded as part of the work on APECS. The ability to adapt and reuse existing designs is speeding up the pace of innovation and supporting more sustainable product development at the same time.

APECS is adding a crucial contribution to what is called »System Technology Co-Optimization« (STCO), as integration technologies and system architectures can be perfected together. Even small-scale production can become economically viable as a result – which can be a dealbreaker for SMEs and smaller startups.

A European one-stop shop for microelectronics

The APECS pilot line is set to establish itself as Europe's central hub for advanced packaging and heterogeneous integration. Its one-stop-shop concept is bringing together cutting-edge design and pilot production capacities in one coherent platform – ranging from lab to fully scalable production facilities. This gives industrial enterprises, SMEs, and startups equal and easy access to top-flight technology.

The pilot line is being set up in close cooperation with the Research Fab Microelectronics in Germany (FMD) and other European partners. It is supported financially by the Chips Joint Undertaking and national funding initiatives from Austria, Belgium, Finland, France, Germany, Greece, Portugal and Spain as part of the »Chips for Europe Initiative«. With a total budget of 730 million Euros over four and a half years, APECS is the Fraunhofer Society's largest European initiative to date in this important area of technology.

Opportunities for climate protection and resilience

APECS is not only pursuing technological excellence, but also sustainability: The pilot line will be an engine for eco-design and greener production processes in the field. This helps Europe's transformation towards a more climate-neutral and cyclical economy.

As a cooperative platform bringing together industry, science, and higher education, APECS is fueling the evolution of a dynamic ecosystem – a joint continent-wide effort for more technological resilience and global competitiveness.

World Leader in Applied Research

A Strong Network

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft based in Germany is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research units throughout Germany. Almost 32,000 employees, predominantly scientists and engineers, work with an annual research budget of approx. 3.6 billion euros. Fraunhofer generates about 3.1 billion euros of this from contract research.

Research Fab Microelectronics Germany

Since 2017, Fraunhofer IZM has been part of the Research Fab Microelectronics Germany (FMD), which combines the expertise and technological infrastructure of 15 Fraunhofer and Leibniz institutes. Together, they develop application-oriented technologies and system solutions for sustainable microelectronics, thereby making a decisive contribution to the technological resilience of Germany and Europe.

As part of the EU Chips Act, the FMD is currently setting up the APECS pilot line together with European partners. The aim is to advance chiplet innovations and strengthen semiconductor manufacturing in Europe in the long term. The line is intended to provide companies of all sizes with low-threshold access to cutting-edge technologies.

With regular events as part of large-scale inter-institutional projects such as »Green ICT@FMD« or »FMD-QNC«, FMD brings together key stakeholders to jointly address future challenges in electronics research and provide impetus for the technologies of tomorrow.

In addition to technological development, the FMD focuses on securing skilled workers and promoting young talent. This includes programs such as the Green ICT Award, the Green ICT Camp for students, and the »Green ICT Space« and »QNC Space« accelerators, which support start-ups, research groups, and SMEs. The »Chipdesign Germany« network, which the FMD is establishing with partners, also pools expertise, develops training measures, and promotes pre-competitive exchange in chip design - with the aim of securing Germany's position as a business location in the long term.

High-performance Centers

The High-performance Center »Functional Integration of Micro- / Nanoelectronics« is embedded in Saxony's microelectronics cluster and supports SMEs in Saxony with the know-how and combined expertise of the four Fraunhofer Institutes/branches IPMS, ENAS, IIS-EAS, and IZM-ASSID, as well as the universities TU Dresden, TU Chemnitz, and HTW Dresden, arranged along the value chain for microelectronics and microsystems technology products.

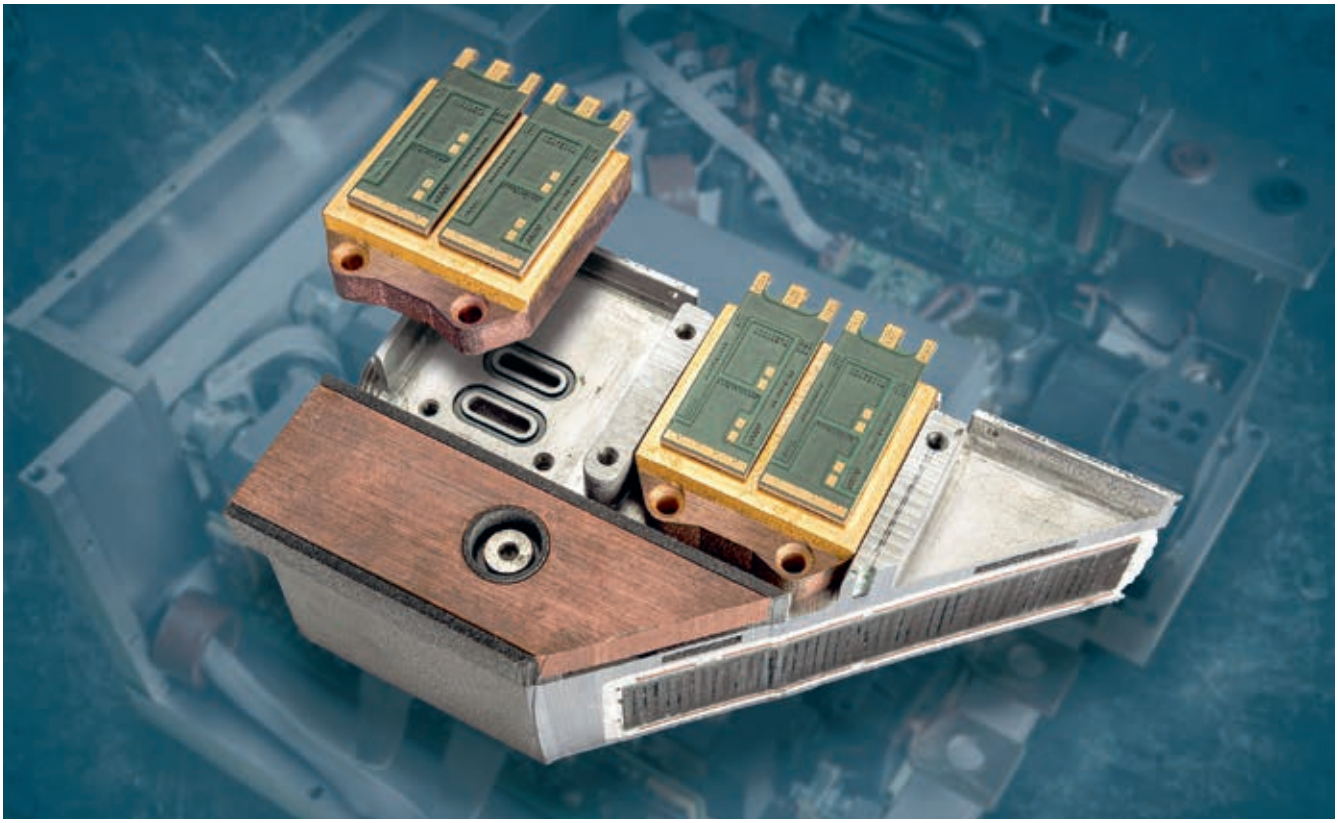
The »Digital Networking« high-performance center is a collaboration between the four Berlin-based Fraunhofer Institutes FOKUS, HHI, IPK, and IZM. Its work focuses on technologies and solutions that focus on the increasing digitalization and networking of all areas of life.

Complex project initiatives move across the boundaries of disciplines and competencies. They benefit from the business expertise of Fraunhofer IZM's dedicated Business Development Team that represents the industry's specific needs in all functional areas of the institute and coordinates the work on innovative solutions.

We are here to assist you in the strategic development of innovative areas with complex and ground-breaking technologies.

Business Units & Industry Sectors

Automotive and Transportation



Cross-section of one of the three phase modules of a 600 kW inverter

Modern traffic systems have to be safe, environmentally friendly and cost-efficient. High-performance, reliable and, in some cases, highly miniaturized systems are key goals for developers creating innovative forms of transport and traffic systems for road, rail, sea and air. Transportation has been a key priority and competence area across Fraunhofer IZM departments since the institute's very beginning. The institute helps OEMs, Tier1 companies and particularly their suppliers integrate the latest electronics into vehicles quickly and efficiently. We develop future-proof, reliable solutions, including prototypes, which improve the safety and comfort of conventional, hybrid and electric engines and systems.

Fraunhofer IZM revolutionizes charging systems with new OBC

Fraunhofer IZM has developed a new on-board charger (OBC) for electric vehicles that delivers twice the charging power (22 kW) at half the volume. The use of gallium nitride semiconductors and high-frequency switching has replaced bulky components with compact, machine-manufactured components, making production more cost-effective. The OBC is bidirectional, allowing energy to be fed not only into the battery but also back into the grid. It is compatible with 400- and 800-volt batteries and achieves an efficiency of over 97%. It also uses an innovative PCB-based PFC choke that saves space and reduces costs. These advances improve the charging infrastructure, make electric cars more efficient, and support the energy transition by enabling the vehicle battery to be used as a power storage device.

New materials for the highest frequencies

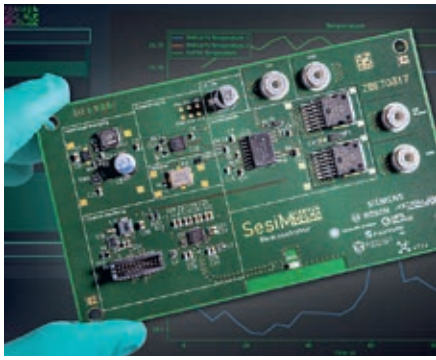
The ever-increasing frequencies in communications and radar applications pose challenges not only for system developers but also for materials manufacturers. In addition to process suitability and, where applicable, mechanical and thermal requirements, materials must now also be suitable for use in high-frequency technology. On behalf of material manufacturers, Fraunhofer IZM tests whether materials used in interconnection technology meet the requirements for use in applications such as radar systems in the automotive environment. The investigations are based on specially developed planar microstrip fork resonators and broadband single-element and 1×4-element patch antenna arrays. The tests examine whether the impedance bandwidths and antenna gain meet the requirements.

Digital twin for condition monitoring

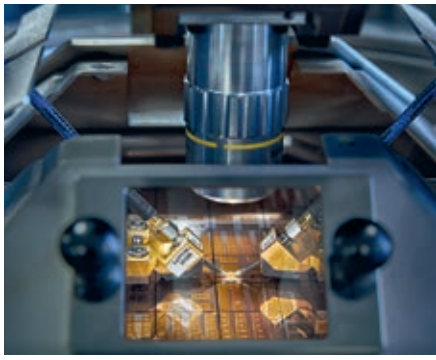
A digital twin is a virtual representation of real objects with specific goals such as condition monitoring. Grey-box modeling, combining physical and data-driven approaches, evaluates the reliability and remaining useful lifetime of mechatronic systems during operation. Trustworthy data and models enable the analysis of theoretical behavior and its comparison with reality. Challenges include data quality and availability, the need for IP-protected models, and digital thread with standardized interfaces. These aspects are being researched for automotive, railway, and aviation technology in the »SesiM« and »DIREKT« projects supported by the Federal Ministry for Economic Affairs and Energy. In the future, the findings will be expanded to circular economy issues like reuse.

Virtual release of electronic assemblies

Reliable microelectronic systems must be qualified in a lengthy and costly manner before their product release. By virtualizing these tests, they can be implemented significantly faster, more flexibly, and more cost-effectively. Together with partners from industry, universities, and research institutions, Fraunhofer IZM is working to structure the associated research field and develop new simulation approaches. Currently, validation approaches for trustworthy simulations and the use of reduced-order modeling methods for the protection of intellectual property are being investigated in the »MikroVAL« project, which is supported by the Federal Ministry for Education and Research and started in 2024.

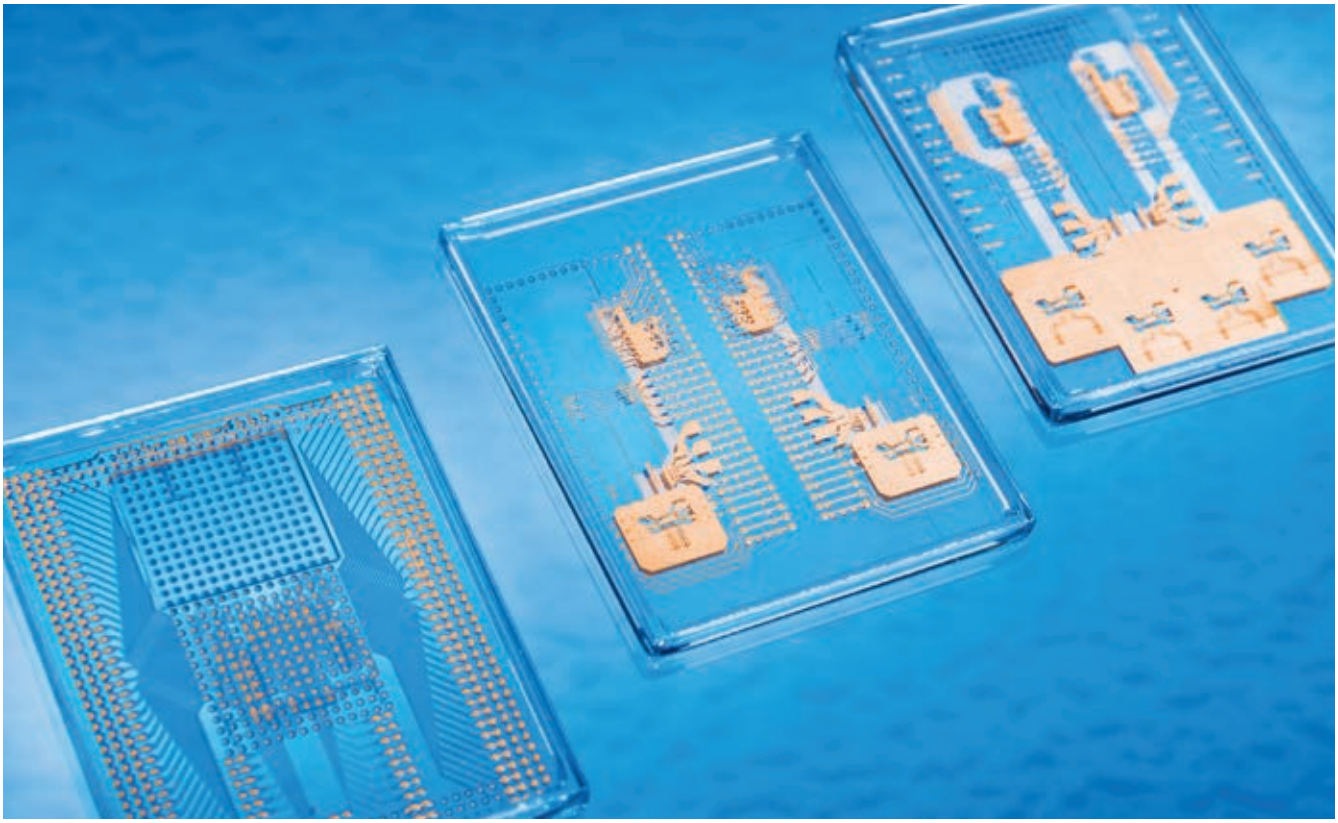


AI-supported real-time prediction of the system status based on functional parameters



Semi-automatic measurement of test structures

Medical Engineering



Thin glass interposer with structured metallization created using wafer-level processes – before assembly with photonic components (and package closure)

Over the past years, the innovation potential of microelectronics has led to considerable progress in medical technology. Fraunhofer IZM has been front and center in this development process for 20 years. Our know-how in microtechnology and innovative integration processes helps manufacturers realize innovative new medical engineering products that meet all legal requirements. Of course, Fraunhofer IZM also performs customized reliability analyses, bio-compatibility assessments, as well as the risk assessment according to ISO 14971 standards, which is required for the development of new products.

Glass interposer for photonic integrated circuits

The PhotonicLEAP project is pursuing novel approaches in photonic packaging. In the project, Fraunhofer IZM has developed and manufactured thin glass interposers that can be functionalized with thermal TGVs and electrical RDLs. This novel glass substrate accommodates photonic ICs, optics, lasers, and drivers and provides all the necessary optical, electronic, and thermal connections. Laser welding of thin glass windows creates hermetically sealed, flat glass packages (typically 18 x 21 mm) that can be easily integrated into systems as SMT components. This approach represents a cost-effective alternative to Si interposers, is easily scalable thanks to production on 200 mm (in future 300 mm) wafers, and enables new applications in the fields of biomedicine and telecommunications.

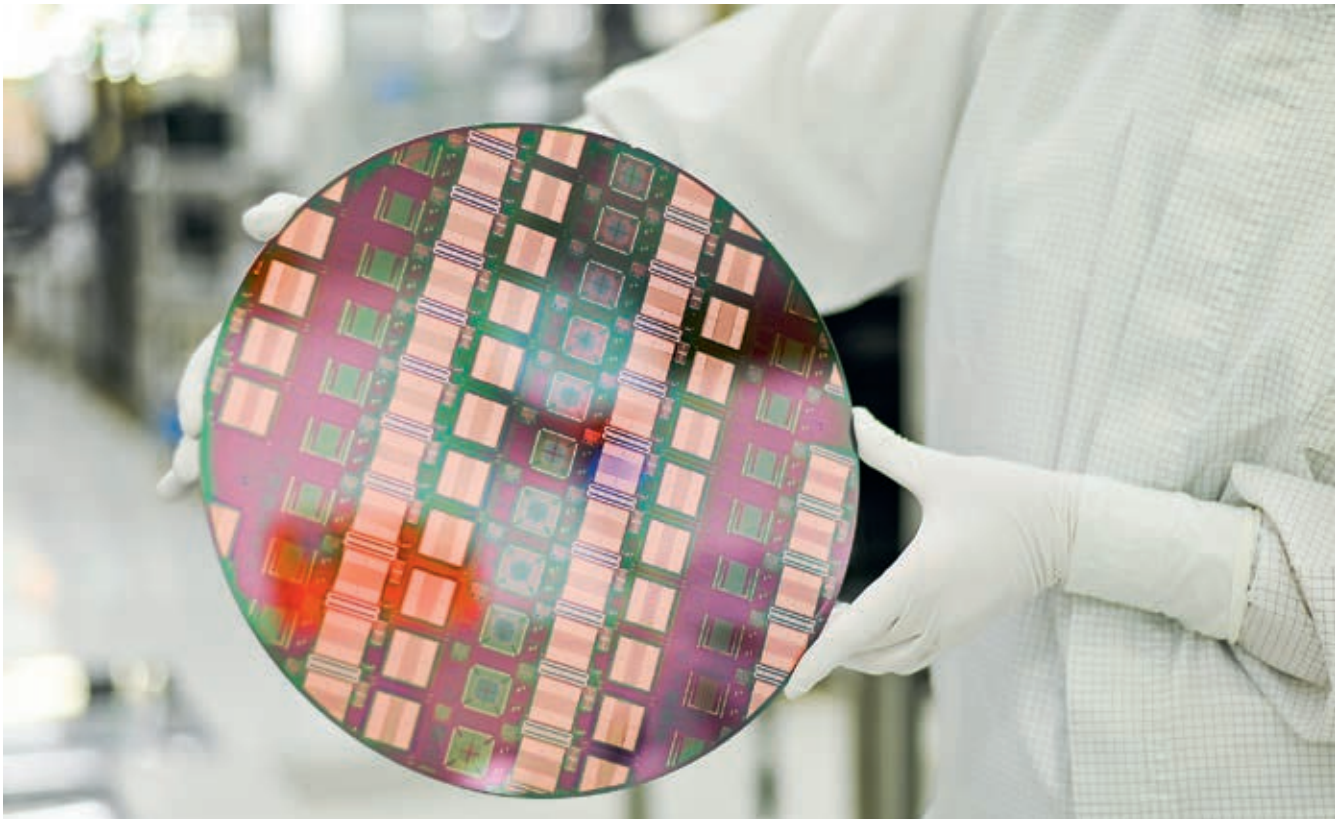
Innovative AI-based diagnostic systems: Next-level cadiovascular monitoring

The »System-on-Flex« group group at Fraunhofer IZM has made significant progress in developing innovative technologies for cardiovascular monitoring. A key focus has been the integration of artificial intelligence into bioimpedance spectroscopy (BIS) to enable new non-invasive diagnostic methods. Within the »Maia« project, a miniaturized diagnostic system was developed, combining BIS with additional sensors. A wearable system allows real-time monitoring of more than 110 cardiac parameters. Key achievements include the development of multisensor data fusion, hybrid AI diagnostics, and innovative textile electrodes. This research advances the use of wearable diagnostic systems and contributes to the early detection of heart failure.

Long-term stable neural implants: Fraunhofer IZM and TU Delft publish groundbreaking research findings

The »Technologies for Bioelectronics« group at Fraunhofer IZM, in collaboration with Delft University of Technology and other partners, has made key advances in the long-term stability of neural implants.The joint research focused on improving the durability of silicon-based integrated circuits (ICs) in the corrosive environment of the human body. Our work in »Nature« Communications demonstrated that bare-die silicon ICs maintain stable electrical performance in physiological conditions, while PDMS encapsulation significantly extends their longevity. In »Small«, we evaluated ALD and hybrid multilayer coatings for miniaturized implants, showing that ultra-thin ALD coatings provide excellent biostability. These insights contribute to the development of reliable, long-lasting neural implantants, that play a central role in the treatment of neurological diseases such as Parkinson's or depression.

Semiconductors



Higher computing power through effective cooling of the processor's underside with integrated microchannels in the silicon interposer

This business unit specializes in the integration of semiconductor elements and the production of sensors for the assembly of complex heterogeneous system-in-package (SiP) solutions. Fraunhofer IZM offers its clients holistic services – from developing the original concepts and designing the processes to characterizing and testing the reliability of the finished systems. The institute's facilities cover all relevant processes for manufacturing sensors and wafer-level packages, allowing the production of hermetically sealed sensor packages and even entire 3D systems.

Chiplet bonding technologies for split manufacturing

For the »T4T« project, a split manufacturing system is being developed for semiconductor production on 300 mm wafers. Electronic components manufactured separately are combined into a single trustworthy system in Germany using fine-pitch interconnection technologies. Fraunhofer IZM-ASSID is working on robust and stable D2W bonding processes for small interconnects based on hybrid bonding, nanowires, and microbumps. The aim is to create 5 µm contacts on a 10 µm pitch for all technologies with an application in high-performance computing. A demonstrator will show the combination of at least two different bonding technologies on Si interposers. Fraunhofer IZM ASSID also works on refining the split approach for the W2W hybrid bonding technology and multiple layer RDL interposer for automotive application within »T4T« project.

New process technology for glass core substrates facilitates high performance packaging

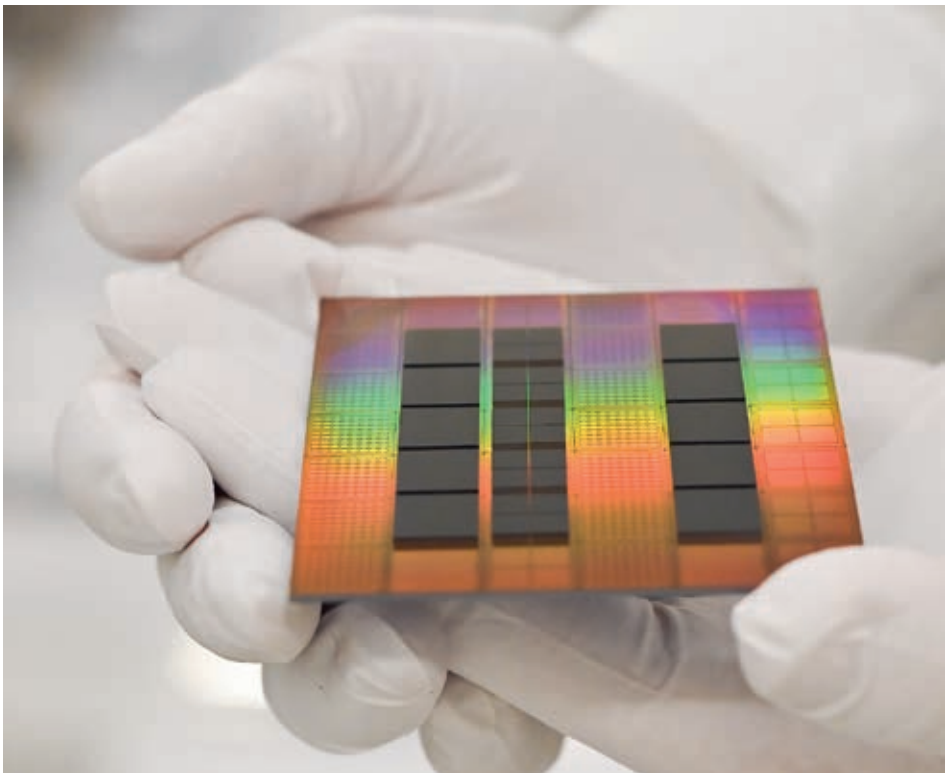
Glass core substrates represent a pioneering technology in microelectronics. They offer significant advantages over organic substrates, such as higher signal integrity and dimension stability. Glass enables circuit track widths of less than 5 µm and very high integration densities. Challenges in the processing of through-glass vias and the reliability of such GCS are the focus topics of the recently initiated Glass Panel Technology Group. Under the leadership of Fraunhofer IZM, leading industrial partners are working intensively on the further development of these technologies, including the possibility of integrating optical waveguides into glass.

Prototype of a glass core substrate, 510 mm x 515 mm, manufactured in preliminary tests at Fraunhofer IZM

A multi-hub test and experimentation facility for edge AI hardware

The »PREVAIL« project, funded by the Digital European Program, was set up to create a multi-hub platform for trusted infrastructure in Europe that enables EU stakeholders to produce innovative chip prototypes and test them in real edge AI applications. The consortium partners will provide technologies for embedded non-volatile memory, 3D integration, silicon photonics, and RF connectivity that meet all the specifications required for edge AI chips. Fraunhofer IZM-ASSID is developing new combined 3D approaches at the 300 mm wafer level, such as Si interposers with RDL on the front/back side, mixed-pitch interconnect formation, die-to-wafer assembly, TSV formation, and/or singulation. Together with the other 3D 300 mm Si wafer technologies offered with the platform, the customer is equipped with an optimum integration of dedicated building blocks into edge AI systems, significantly improving system performance and integration density.

Assembled chiplets with ultra-fine copper hybrid bond contacts on a pitch of 10 µm



Industrial Electronics

Wireless, self-sufficient, miniaturized sensor-actuator platform for industrial applications

In recent years Fraunhofer IZM's industrial electronics specialists have concentrated on the visionary concept of Industry 4.0. Particular emphasis was placed on the work on cyber physical systems (CPS) and autonomous, specifically high-reliability radio sensors that record and process the relevant monitoring and/or video data on site and distribute it via standard interfaces when and where the user needs it. Industry 4.0 means much more than CPS integration: Flexible access to monitoring data is particularly vital both for location-bound controlling and management processes and ERP systems and for on-demand access via mobile devices in inspection, maintenance, or repair scenarios.

Life cycle assesments as a basis for sustainable product decisions

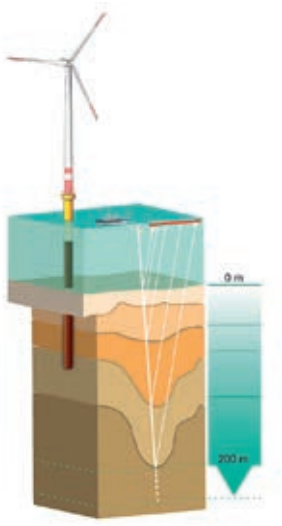
In the »ZirkuPro« project, comprehensive life cycle assessments of partner products such as electronic components of ATMs, e-charging stations and touch panels were drawn up. The aim is to identify focal points for environmentally optimized product design and to come up with improvement options along the entire life cycle. A comprehensive catalog of measures was created that shows the partner companies the path to a closed circular economy and provides recommendations for action in the areas of recyclate use, circuit board design and responsible procurement with the help of quantifiable KPIs. Workshops were held to enable the companies to carry out their own life cycle assessments in future.

MEMS support offshore wind farm construction

Seismic surveys are essential for determining the location of offshore wind farm foundations. Sound waves are transmitted into the seabed to analyze their reflections. However, conventional systems are weather-dependent and offer only limited resolution.
In the »Streamer« project, the Fraunhofer Institutes IWES, HHI, and IZM are developing an innovative solution: a chain of cascaded sensor units, each with up to eight acoustic sensors and an IMU. This approach allows the directional detection of high-resolution wave fields and deeper towed measurements. Improved signal-to-noise separation increases robustness against weather influences. Fraunhofer IZM is responsible for the architecture of the sensor nodes, the power supply, and miniaturization - with time-sensitive sensor readout as a highlight.

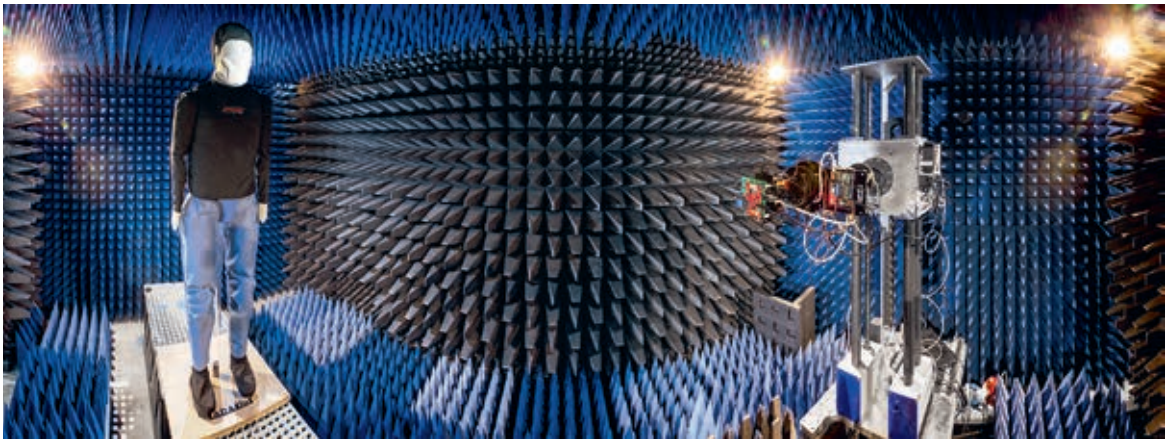
Dynamic measurement of compact radar modules

Based on innovative packaging technologies, Fraunhofer IZM develops highly integrated, powerful radar modules. Radar sensor technology is currently of great interest in both industrial and domestic environments. To verify the required functionality – such as angular resolution, detection range (FoV), speed measurement, and spatial localization – the institute has set up a laboratory for the dynamic measurement of radar modules. With the aid of a 4-axis robot and four additional linear axes, radar modules and target objects can be positioned semi-automatically and the measurement results can be recorded.
A 79 GHz dummy is available for human-centered applications. Another highlight is the measurement of the radar cross section (RCS values) of any object.

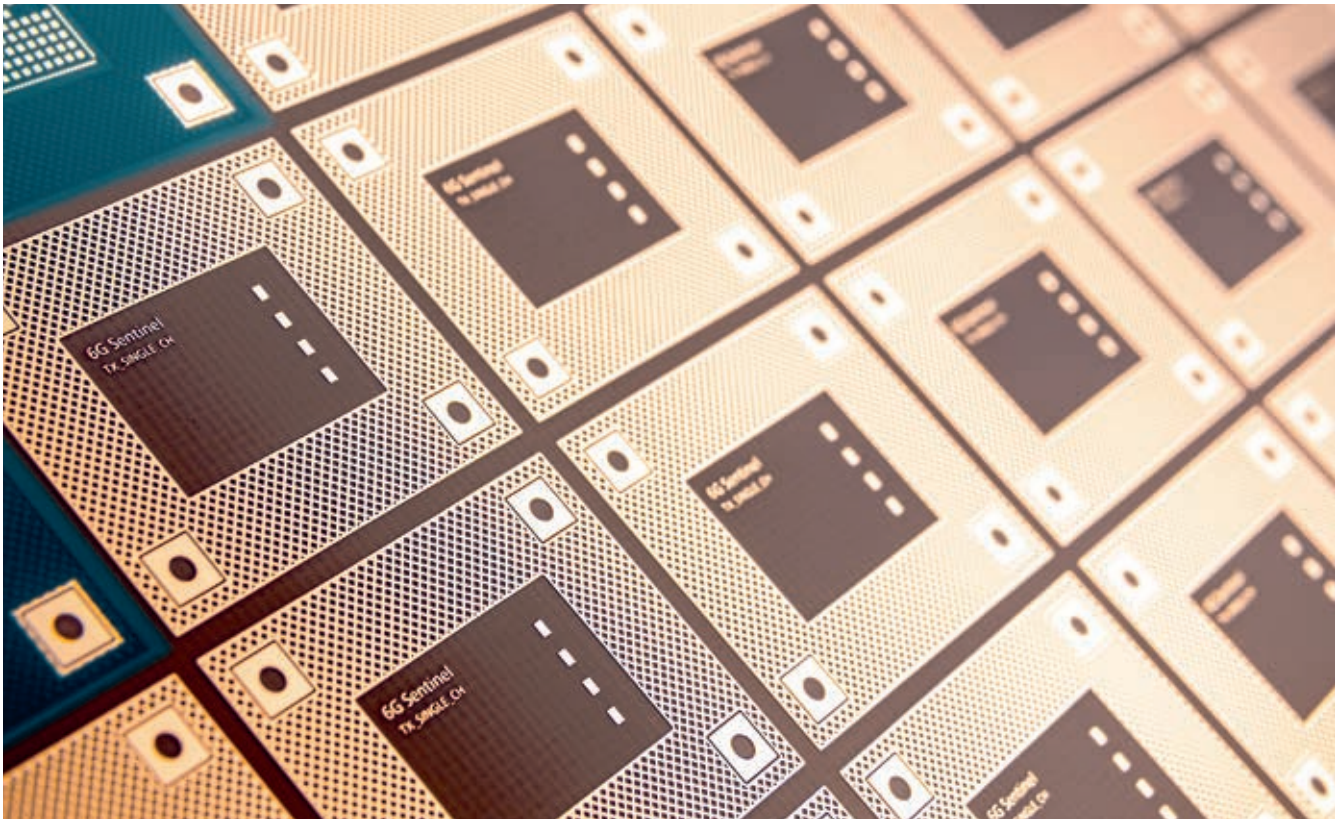


Seismic measuring cable (streamer) with real-time data acquisition

Measurement of a radar module for use in security technology with a 79 GHz dummy



Information and Communication



6G Sentinel embedding packages with integrated 140 GHz amplifier and antenna array

The new era of increasing connectivity and digitalization creates new challenges for the design and assembly of ICT systems: The efficient sharing and storing of data needs ever larger data centers and the means to transmit electric and optical signals. Digitalization itself brings its own challenges: There is increasing demand for highly dynamic networks that can transport, process, and analyze data. Fraunhofer IZM offers comprehensive solutions for these challenges with more than two decades of experience in the field of system integration.

Product category rules für laptops

The information and communication technology sector is very active in the field of product carbon footprinting. Life cycle assessments provide a comprehensive methodology for calculating the carbon footprint of a product. They are used to support purchasing decisions, implement company-wide climate policies and identify levers for improvements in product design. All these measures require a transparent approach and a clear methodology that is not yet standardized. Initiated and funded by Google, a corresponding industry-wide process was launched and moderated by Fraunhofer IZM to develop product category rules for the creation of comparable LCAs.

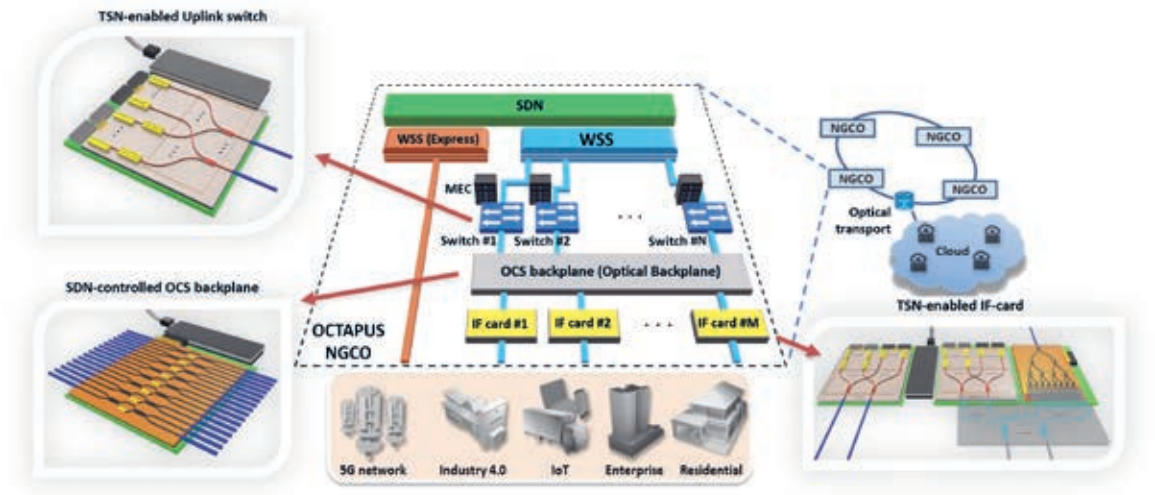
Digital Product Passport

The research landscape regarding the Digital Product Passport (DPP) has moved significantly from the concept phase to the pilot and demonstration phase in 2024. Fraunhofer IZM is supporting the »CIRPASS 2« project with an environmental assessment of the DPP's potential effects. As part of an internal Fraunhofer program, the »PACT New« project, the extent to which data from product manufacturing and remanufacturing can be used for the DPP was investigated. At the same time, a project was carried out with the industry - here there is still a desire to proactively prepare for the upcoming requirements in the delegated acts of the ESPR (Ecodesign for Sustainable Products Regulation).

Optical circuits for the next generation of ultra-dynamic /reconfigurable central office environments

The »OCTAPUS« project works to advance communication networks with lower latency and time-sensitive networking (TSN). It emphasizes reconfigurability through software-defined networking (SDN) and the use of both O- and C-band telecom wavelengths.

Innovative devices including lasers, optical switches, and diplexers are being developed as part of the project. Our role is to provide packaging concepts for these devices, which will culminate in demonstrators that showcase the components developed within the project. We are optimizing optical coupling and developing an alignment setup with glue dispensing capabilities to enhance device performance and integration.



Communication network OCTAPUS Next Generation Central Office: Time-sensitive networking components are used for switching, routing, and external interfaces. Software-defined network agents orchestrate the system and resource sharing with other NGCOs

Labs & Services

System Integration

Wafer-Level Packaging Line

Fraunhofer IZM operates two process lines (cleanroom class 10 – 1000) in Berlin (975 m²) and Dresden (ASSID, 1000 m²), that offer our customers various wafer-level packaging services from development stage to prototyping and small volume production. Different substrate materials (e.g. silicon, III/V, ceramic and glass) and wafer sizes (4"–12") can be processed. Project and process work on both lines is executed in compliance with ISO 9001:2015 management standards.

Process Modules (up to 12")

- Cu-TSV integration (via-middle and via-last-processes)
- Silicon and SiC plasma etching – DRIE (TSV, cavities)
- Multilayer thin-film deposition (PVD, CVD, ECD, lithography (resolution up to 0.5 µm), mask aligner, reactive ion beam etcher)
- PECVD process chamber (200/300 mm) for the deposition of TEOS oxide, Silane oxide and Silane nitride
- High-density thin-film multilayer (Cu/polymer RDL, Cu-Demascene)
- Wafer-level bumping (Cu-Pillar, SnAg, Ni, Au, In, UnSn, AuSn, Cu-nano interconnects, nanoporous Au)
- Wafer thinning and thin wafer dicing (blade, laser grooving and stealth dicing)
- Wafer bonding – permanent and temporary
- Wafer-level assembly up to 300 mm (D2W)
- Automatic inline wafer metrology for layer thickness, topographies, roughness as well as TTV / warpage / bow
- Fully automated electric wafer measurement system (8" / 12")

Substrate Line

In the substrate area panel-size substrates (460 x 610 mm²) can be prepared for resist and PCB lamination, solder resist and cover lays can be applied and developed after exposure.

In our bonding lab high-precision module assembly is carried out under inert gas. New equipment in the 480 m² cleanroom allows surface preparation for assembly at reduced bonding temperatures. Track geometries with down to 2 µm width are under development.

Our services include:

- Embedding of passive and active components
- Multilayer lamination of PCB substrates
- Realization of smallest vias, mechanically as well as with a laser
- Quality assessment and x-ray microscopical analysis

Mold Encapsulation Lab

The lab offers various encapsulation processes, related material and package analysis and reliability characterization tools as a one-stop-shop. The focus is on FO-WLP / PLP, on sensor packages with freely accessible surface and on power SiPs. Production-ready machines facilitate the transition into industrial production.

- Precision assembly and compression molding on wafer- and panel-level (610 x 460 mm²)
- Redistribution in 2D (PCB-based and thin film) and 3D (TMV)
- Transfer molding of SiPs for sensors and power
- Process simulation and analysis of material models

Wire Bonding Lab

- Processing of Au-, Al- and Cu-based bonding wire materials for thin and heavy wire bonding
- Assembly of power modules using Al / Cu- and Cu-heavy wires for quality and reliability analyses
- Assembly of sensor packages using Cu-ball / wedge bonding for lead frames and Au / AlSi1 wires for COB processes

Soldering Lab

- Vapor phase soldering with vacuum enables manufacturing of voidless large-area solder joints for power electronics
- Hermeticity test
- Fluxless soldering of printed circuit assemblies using active gas in oxygen free nitrogen or vapor phase atmosphere
- Leak testing including helium bombing up to a pressure of 10 bar

Photonics Lab

- Laser structuring of glass layers with optical waveguides for electro-optical boards (EOCB)
- Shack-Hartmann-characterization of micro lenses and microlense arrays
- Optical and thermal characterization of LEDs and LDs
- Research and development of optical packaging processes with an accuracy of up to 0.5 µm
- Fs writing processes and thermal ion exchange for integrated optics in glass

Quantum Lab

- 3D glass structuring with selective fs laser etching
- 2PP printing of microoptical interconnects / lenses
- Laser sealing for hermetic cavities (vacuum / gas)
- Automated coupling for quantum chips / PICs
- Characterization of optical fields (SNOM)

Material Analysis

Moisture Lab

- Comprehensive simulation-based reliability assessment of humidity-induced phenomena in microelectronic components and systems
- Surface analysis through atomic force microscopy
- Analysis methods for sorption, permeation and diffusion of water in materials

Long-term Testing and Reliability Lab

- Fast temperature cycling tests in the range from -65 °C to 300 °C
- Temperature storage up to 350 °C
- Component and assembly qualification in acc. with AEC, IPC, JEDEC

Power Lab

- Testing of hetero highly integrated power modules
- Active cycling of power modules for lifetime assessment
- Calorimetric measurement of the effectiveness of highly efficient devices

Design

High Frequency Lab

- Free-space measuring station up to 170 GHz, Fabry-Pérot resonators up to 140 GHz and THz system for HF material characterization
- Semi-automatic sample station with thermal chamber (-60 °C to 300 °C)
- EMC and test environment for wireless communication systems in the multi-gigabit and terabit-range
- Antenna measuring system for up to 330 GHz
- Test lab for mm wave modules for radar and communication, signal source (AWG) and spectrum analyzer up to 325 GHz
- Time range measuring station (sample oscilloscope up to 70 GHz / BERT up to 64 Gbit/s)

Microelectronics Lab

- Development and qualification of mechatronics systems and energy-efficient wireless sensor systems
- PXA for range calculation, conformity checks, and failure analyses; allows the recording of very fast signals (from 162 µs)

Further laboratories include:

- Micro Battery Lab with 10-meter battery development and assembly line
- Laboratory for Textile-integrated Electronics (TexLab)
- Photoelectron spectroscopy and electron spectroscopy for chemical analysis (ESCA)
- Corrosion Lab
- Electronics Condition Monitoring Lab (ECM) for functional tests of electronic systems under environmental stress, salt spray, shaker
- Qualification and Test Center for Electronic Components (QPZ)
- Thermo-mechanical Reliability Lab
- Thermal & Environmental Analysis Lab

Taking notes is so yesterday. Nowadays, cell phones and cameras are a sure sign of interest in scientific lectures, as seen here at Electronics Goes Green in Berlin in June.

Events & Promoting Young Talents

Creating and communicating knowledge together – The event year 2024

The year 2024 was marked by international encounters and new scientific impetus at Fraunhofer IZM. From high-profile conferences like IEEE ESTC and Electronics Goes Green, to trade fairs such as PCIM Europe, and interactive formats including Lab Week and GreenICT Camp – IZM showcased its research, explored emerging technological developments, and strengthened international collaborations.

IIn online series such as »Powering the Future« or »Advanced Substrates beyond PCB«, Fraunhofer IZM explored forward-looking topics including power electronics based on ultra-fast-switching semiconductors and innovative substrate technologies. These formats were designed to make complex developments accessible to a broad community of experts. Throughout the year, sustainability remained a recurring theme, reflected in initiatives such as the Green ICT Courses and Fraunhofer IZM's involvement in the STADTRADELN cycling campaign.

A series of high-level visits further emphasized the institute's strong commitment to international collaboration. Notable guests included the President of the Fraunhofer-Gesellschaft, the French Minister of Research, and the Chairman of the Taiwanese research organization ITRI.

On the following pages, you will find an overview of the many events and encounters that shaped 2024 at Fraunhofer IZM.

Events

After his visit to Fraunhofer IZM-ASSID, Fraunhofer President Prof. Dr. Holger Hanselka is even more certain that Fraunhofer will play an important role in the EU Chips Act

Fraunhofer President explores semiconductor research in Dresden

In January 2024, Prof. Dr. Holger Hanselka, president of the Fraunhofer Society, visited the Fraunhofer IZM-ASSID in Dresden as part of his inaugural trip. In the clean room, site manager Dr. Manuela Junghähnel and IZM institute director Prof. Dr. Martin Schneider-Ramelow provided insight into producing pilot-scale detectors based on wafer technologies for the latest generation of computer tomographs. Discussions also focused on the site's strategic objectives, particularly the planned expansion of the »Center for Advanced CMOS & Hetero Integration Saxony« (CEASAX), in close collaboration with Fraunhofer IPMS-CNT. Prof. Hanselka high-lighted the Dresden site´s importance for the implementation of the European Chips Act and acknowledged the strong commitment of its researchers.

Fraunhofer IZM presents ASTROSE at CIGRE 2024 in Paris

In late August 2024, Fraunhofer IZM showcased its cutting-edge power line monitoring system, ASTROSE, at the CIGRE, the world's premier congress for high-voltage technology, in Paris. At booth 146 of the accompanying technical exhibition, the IZM team presented the system's latest functions. The focus was on two key factors for safe and efficient grid operation: ice detection and increasing the current-carrying capacity of electrical lines. CIGRE provided Fraunhofer IZM with an ideal platform to showcase technological advances in intelligent grid monitoring and network with international experts from research, industry, and energy supply.

The expert online series »Powering the Future – Innovative Technologies for Power Electronics Modules with SiC and GaN Semiconductors«

From January to March 2024, Fraunhofer IZM held expert sessions that focused on the potential of wide-bandgap (WBG) semiconductors based on silicon carbide (SiC) and gallium nitride (GaN) for power electronics. These materials enable significant miniaturization and increased system efficiency through higher switching speeds, as well as higher voltage and temperature resistance. This is particularly important for applications in electromobility and renewable energies.

During the five online sessions, Fraunhofer IZM experts provided practical insights into current developments and challenges in power electronics. They also highlighted the latest approaches and technologies, and discussed application scenarios, as well as the opportunities and challenges in customizing power electronics modules.

French Ambassador François Delattre visits Fraunhofer IZM

On April 29, 2024, French Ambassador François Delattre visited Fraunhofer IZM in Berlin to see for himself the successful cooperation between Germany and France in research. Close cooperation has existed for many years and is now being further expanded, particularly in the fields of microelectronics for electromobility, integrated sensor technology, and the protection of critical infrastructures. In a discussion with Institute Director Prof. Dr. Martin Schneider-Ramelow, the ambassador gained a deep insight into Franco-German and pan-European projects for innovation transfer and technological sovereignty.

Delattre was particularly interested in the model of the "Microelectronics Research Factory Germany," as it enables small and medium-sized enterprises to become less dependent on the conditions of high-volume production.

Michael Schiffer shows Fraunhofer IZM's Start-A-Factory and the cleanroom to the French delegation

Events organized by Fraunhofer IZM (selection)

Expert Session Series »Powering the Future - Innovative Technologies for Power Electronics Modules with SiC and GaN Semiconductors«	January – March 2024, online
Green ICT Courses	Feb. – Nov. 2024, online
Electronics Goes Green 2024+	June 2024, Berlin
Expert Session Series »Advanced Substrates beyond PCB«	Oct. – Dec. 2024, online
E-Textiles Conference 2024	November 2024, Berlin

Ulf Oestermann presents the »Future Packaging« production line and is available to answer visitors' questions during the line tours

Goodbye, SMTconnect – Good Morning, Future Packaging!

Last June, the final edition of SMTconnect took place. Since then, the »Future Packaging« production line has continued to evolve and is now taking off in a new setting.

What began in the late 1990s has grown continuously, most recently bringing together 19 line-participants and co-exhibitors in an area spanning 1,200 m². The 52-meter-long »Future Packaging« line demonstrated how machines from various manufacturers work together seamlessly in electronics production to assemble circuit boards. The line attracted numerous trade visitors and became one of the trade fair's biggest attractions. At its last edition, the »Future Packaging« stand attracted an impressive 2,700 visitors over the three days of the trade fair. However, »Future Packaging« was more than just a technical exhibition; it represented innovation and collaboration in electronics production. Thanks to its continuous development and presentation of cutting-edge production technologies, it became an indispensable highlight of the trade fair. SMTconnect may be over, but the Future Packaging concept lives on. A further development is planned for Productronica in Munich.

iCampus Cottbus Conference 2024

The iCampus Cottbus Conference (iCCC2024) took place in Cottbus, Germany from May 15-16, 2024. The conference focused on the importance of sensor technology, MEMS, and artificial intelligence for Industry 4.0, the environment, and energy. The event brought together experts from research and industry to present current trends and developments in microsensor technology for industrial applications and to promote knowledge exchange. Fraunhofer IZM was actively involved as both a co-organizer and exhibitor, presenting its latest research results. The IZM branch »High-Frequency Sensors & High-Speed Systems«, directed by Prof. Dr. Dr. Ivan Ndip, was especially highlighted. This branch conducts research on innovative radar and proximity sensor systems, as well as high-speed modules, packages, and boards.

Events with IZM participation (selection)

embedded world 2024	April 2024, Nuremberg
techtextil 2024	April 2024, Frankfurt am Main
connecticum 2024	April 2024, Berlin
iCCC2024	May 2024, Cottbus
ECTC 2024	May 2024, Denver (USA)
PCIM Europe 2024	June 2024, Nuremberg
Sensor+Test 2024	June 2024, Nuremberg
SMTconnect 2024	June 2024, Nuremberg
3D & Systems Summit	June 2024, Dresden
SEMICON WEST 2024	July 2024, San Francisco (USA)
CIGRE 2024	August 2024, Paris (FR)
Green ICT Camp 2024	September 2024, Berlin
IEEE ESTC 2024	September 2024, Berlin
IMAPS International Symposium	October 2024, Boston (USA)
Green ICT Connect 2024	October 2024, Berlin
COMPAMED 2024	November 2024, Düsseldorf
MEDICA 2024	November 2024, Düsseldorf
Electronica 2024	November 2024, Munich
SEMICON Europa 2024	November 2024, Munich

Climate-friendly travel – Fraunhofer IZM at STADTRADELN

In June 2024, Fraunhofer IZM participated in the Germany-wide STADTRADELN competition once again. The campaign aimed to encourage participants to make as many everyday journeys as possible by bike for 21 days, including commuting, shopping, and leisure activities. With great motivation and sporting ambition, 60 IZM employees from various departments took part and pedaled hard together. The results are impressive: The team rode a total of 15,000 kilometers. This joint effort positively impacted not only fitness and team spirit but also the climate. Over 2.5 tons of CO_2 were prevented from being emitted by avoiding car journeys.

Electronics Goes Green 2024+: From Silicon to Sustainability

In mid-June 2024, Fraunhofer IZM hosted the seventh Electronics Goes Green conference, one of the largest international conferences on sustainability in electronics. Over 360 participants from the fields of science, industry, and politics gathered in Berlin to discuss innovative technologies, sustainable processes, and political measures aimed at reducing the environmental impact of electronic devices. During the keynote speeches, Todd Brady (Intel) discussed the challenges and potential of more sustainable semiconductor production. Meanwhile Mads Kogsgaard Hansen (Bang & Olufsen) presented circular approaches that promote sustainable innovation in consumer electronics.

The diverse conference program included over 160 technical presentations by 151 speakers. The event featured interactive workshops, company visits, and ample opportunities for professional and personal networking. Electronics Goes Green 2024+ thus sent a strong signal once again for the urgent transformation of the electronics industry toward greater sustainability.

ITRI Chairman Prof. Tsung-Tsong Wu visits Fraunhofer IZM

On August 27, 2024, Prof. Dr. Tsung-Tsong Wu, chairman of the Industrial Technology Research Institute (ITRI) in Taiwan, visited Fraunhofer IZM. The meeting strengthened the long-standing partnership between ITRI and Fraunhofer IZM, which began in 1998. During a strategic exchange with Institute Director Prof. Dr. Ulrike Ganesh and Research Fab Microelectronics Germany (FMD) representatives, future cooperation opportunities in semiconductor technologies, generative AI, and green ICT were discussed. The meeting aimed to expand existing collaborations and strengthen both institutes' innovative capabilities to secure a leading role in global microelectronics and sustainability research.

Technical Chairs Alexandra Morozov (far right) and Dr. Nils F. Nissen (second from left) with the winners of the Best Paper and Best Poster Awards at EGG 2024+

French Minister of Research Patrick Hetzel together with Institute Director Prof. Ulrike Ganesh, Deputy Institute Director Rolf Aschenbrenner, Dr. Charles-Alix Manier, Dr. Tekfouy Lim, and representatives from the French Embassy

Visit by French Minister of Research Patrick Hetzel

On November 8, 2024, Fraunhofer IZM welcomed the French Minister of Higher Education and Research, Patrick Hetzel. In addition to Institute Director Prof. Dr. Ulrike Ganesh and Deputy Director Rolf Aschenbrenner, several Fraunhofer researchers with French backgrounds also took part in the exchange. The meeting centered on key technologies, including high-performance computing, quantum electronics, hardware security, and sustainability, as well as Europe's technological sovereignty in the semiconductor sector. The discussions emphasized the need to reduce dependence on global supply chains and intensify cooperation between industry and research to secure Europe's competitiveness. This visit follows an exchange with French Ambassador François Delattre in April and highlights the importance of Franco-German cooperation for Europe's future.

The IEEE ESTC Conference 2024 in Berlin

The 10th IEEE Electronics System Integration Technology Conference (ESTC) took place from September 11 to 13, 2024, at the MOA Hotel in Berlin and was a resounding success. Led by Dr. Tanja Braun, department head at Fraunhofer IZM and general chair of the conference, the event significantly contributed to the exchange of information on the latest electronic system integration developments. With around 430 participants from 27 countries, the extensive program included four keynotes, 117 presentations, and 46 poster presentations. Topics included advanced packaging, wafer-level packaging, and the reliability of electronic devices and power electronics. A special highlight of the conference was the accompanying trade fair, where over 40 companies and research institutions from around the world presented their services. Many conference attendees took advantage of the breaks to learn about current trends, make new contacts, and reconnect with old acquaintances.

The online expert series »Advanced Substrates beyond PCB«

In 2024, Fraunhofer IZM organized the online expert series »Advanced Substrates beyond PCB« which dealt with innovative substrate technologies beyond conventional printed circuit boards. The four-part series aimed to provide in-depth insights into advanced solutions for next-generation electronics to experts from industry, science, and politics. The focus was on technologies that meet the increasing demands for miniaturization, performance, and sustainability.

Topics ranged from fan-out wafer and panel-level packaging as a platform for 2D and 2.5D system integration to the integration of III-V RFICs in antenna-in-package modules for 5G/6G applications to high-density organic substrates and glass core substrates. Taking place from late October to early December 2024, the series provided a valuable opportunity to exchange ideas on current developments and future trends in substrate technology. This contributed significantly to the further development of this key area of electronics.

Lab Week 2024 – Insights into research

As part of Lab Week 2024, numerous Fraunhofer IZM laboratories opened their doors for five days. Employees had the opportunity to gain direct insight into the ongoing research of all four departments across 18 laboratories. During 33 tours, nine of which were

in English, 23 enthusiastic lab guides and co-organizers provided clear explanations of the research, development, and testing work conducted at the institute. A total of 208 colleagues participated in the tours, which is significantly more than the 172 people who participated last year. Lab Week offers a valuable opportunity to look beyond one's own field of expertise and learn about the diversity of research at one's institute.

Green ICT Courses

In 2024, Fraunhofer IZM organized a series of online seminars as part of the »Green ICT @ FMD« competence center, dealing with the ecological transformation of the ICT industry. Between February and November 2024, the five Green ICT Courses covered various topics in sustainable ICT technologies. Topics included the presentation of a wireless, self-sufficient, miniaturized sensor-actuator platform and challenges and solutions for reducing the ecological footprint of electronic assembly manufacturing. The seminars also focused on life cycle assessments, climate neutrality, and the development of practical tools for environmental assessments. Additionally, the ecological challenges of semiconductor production and resource consumption throughout the entire process chain were discussed. The seminar concluded with a presentation that highlighted the often invisible ecological impacts of the digital world. The seminar series offered industry and research experts comprehensive insights and solutions for a more sustainable ICT industry.

E-Textiles Conference 2024

From November 19 to 21, 2024, Fraunhofer IZM hosted the sixth E-Textiles Conference at the Fraunhofer Forum in Berlin. Sponsored by IEEE and IEEE-EPS, the event provided an important platform for international exchange on the latest electronic textile technology developments.

With 149 registered participants from academia and industry, the conference was a notable event in the field of smart textiles. The diverse program included 30 presentations spread across six thematic sessions and 38 poster presentations. Two keynotes, two panel discussions, an industry pitch session, and eleven exhibitors rounded out the event. Among the eight invited speakers were IZM scientists Dr. Max Marwede and Sigrid Rotzler. The invited talks covered topics ranging from sustainable and circular approaches to innovative applications in medical and manufacturing technologies.

The conference promoted scientific exchange and networking between research institutions and industry to advance e-textile development and application.

Participants at the E-Textiles Conference 2024 use the coffee breaks to network and visit the accompanying trade fair

GreenICT Camp – Experiencing sustainable electronics up close

From September 2 to 6, 2024, more than 40 students took part in a week-long camp in Berlin, hosted by the Green ICT@FMD competence center in collaboration with Fraunhofer IZM and the Ferdinand-Braun-Institut. Through interactive workshops with researchers, hands-on activities, company visits, and fireside chats with political representatives, participants gained valuable insights into the research landscape and infrastructure of resource-efficient information and communication technologies. This successful program will continue in 2025 in cooperation with Fraunhofer IIS. Fraunhofer IZM will contribute its expertise in life cycle assessment and eco-design once again.

At the first FMD »Green ICT Camp«, 40 students met for five days to engage intensively with environmentally sustainable microelectronics – co-organized by Fraunhofer IZM

Promoting Young Talents

For many years, promoting young talent has been a top priority at Fraunhofer IZM. The institute offers a wide range of opportunities to learn about technical professions and gain initial practical experience. In 2024, the institute's high-quality training was recognized twice by external organizations: the Berlin Chamber of Industry and Commerce (IHK) honored Fraunhofer IZM with its seal of approval for »Excellent Training Quality« and Tobias Herrmann, a trainee in surface coating, was recognized as the best in his year in Zwickau.

Fraunhofer IZM is training the skilled workers of tomorrow

In 2024, activities in the training sector further intensified. Currently, seven trainees are completing an apprenticeship in microtechnology, one is specializing in surface coating, and one is training to be an office communications clerk. Additionally, an external joint trainee is being supervised. Through practical training and close collaboration with research teams, trainees gain valuable insights into cutting-edge technologies and emerging fields.

The internship program also continued to expand in 2024. A total of 30 young people gained practical experience in 15 working groups at Fraunhofer IZM and IZM-ASSID. Each group supervised and mentored one or two interns. Additionally, the institute offered an EnterTechnik intern the opportunity to explore technical professions. Furthermore, two young individuals dedicated themselves to sustainable technologies and environmental compatibility in the electronics industry through a voluntary ecological year (FÖJ).

Close cooperation with the Gabriele-von-Bülow-Gymnasium

Fraunhofer IZM is committed not only to training but also to promoting young talent at an early stage. A particularly noteworthy partnership is with the Gabriele von Bülow Gymnasium, which was strengthened in 2024 through various activities. For instance, students participated in a social media workshop based on the IZM format »µ fragt nach« (µ asks). Additionally, Institute Director Prof. Martin Schneider-Ramelow appeared as a guest on the school podcast »DeMasked« and gave a lecture on study orientation for students. Fraunhofer IZM was also present at the high school's Career Day, where trainer Sven Schmidt and IZM trainees offered insights into the diverse career opportunities at the institute.

A special highlight last year was a joint environmental project: Thirty-two students from the partner school tested a newly developed IZM app before its release and provided valuable feedback to the developers. These types of collaborations allow young people to engage with current research topics practically and discover their interests in science and technology.

Girls' Day 2024: Hands-on technology experience!

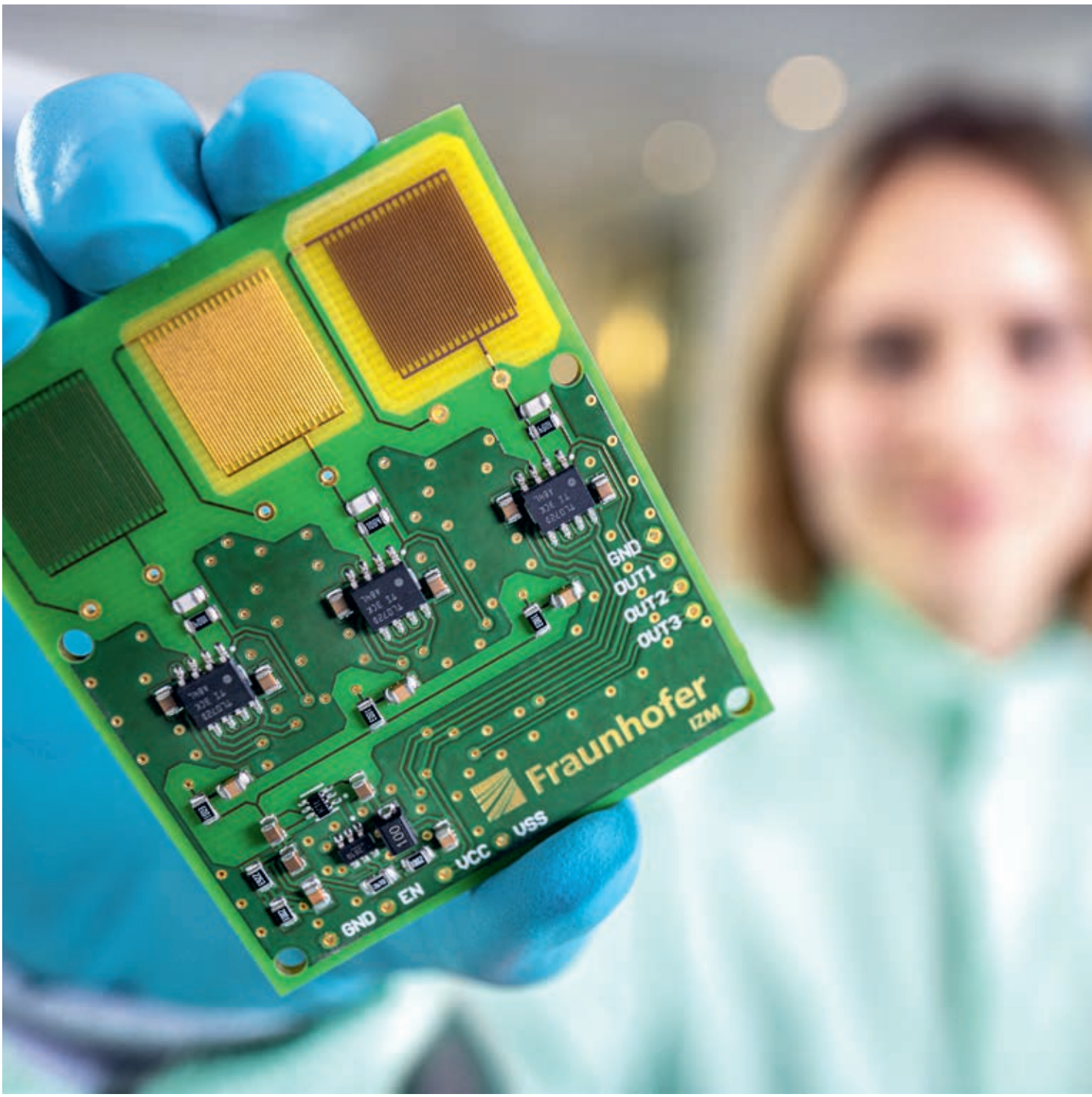
For over 20 years, Fraunhofer IZM has inspired female students to pursue technical careers on Girls' Day, and 2024 was no exception. In April, interested students from Gabriele-von-Bülow-Gymnasium visited the institute and gained exciting insights into the world of microelectronics. After an introduction to research work, the students got hands-on experience soldering electrical circuits, making batteries from fruit, and examining the components of sustainable smartphones.

In the afternoon, the participants' engineering skills were put to the test with the Marshmallow Challenge, which required creativity, intelligence, and dexterity to construct the tallest possible tower out of spaghetti and marshmallows.

Another highlight was the visit to the clean room, where the students learned about the wafer production process. The hands-on experience was very well received, and many participants expressed interest in interning at Fraunhofer IZM in the future.

How are wafers actually processed? The Girls' Day participants were able to see this live in the cleanroom

Facts & Figures



Fraunhofer IZM in Facts and Figures

Financial situation

Growth and stability were the hallmarks of 2024 for Fraunhofer IZM. Turnover increased markedly by 6.3 percent to a total of €45 million. Earnings from research commissions on behalf of German and international industry partners and associations also increased to €18 million in the same period, an increase of €2 million over the already excellent previous years' results. These earnings enabled Fraunhofer IZM to cover 40 percent of its costs from industry commissions. In total, externally funded projects again accounted for €33.9 million, meaning that the Institute could finance a full 75.4 percent of its operating budget from third party earnings.

Investments in equipment

The Institute has invested more than €1.9 million of its own assets for maintaining, updating, and replacing its facilities. This has enabled targeted investments into the equipment at Fraunhofer IZM and helped improve the efficiency of the Institute's existing facilities. A further €1.7 million were used for several smaller construction projects, which focused improvements and adjustments that will help increase performance at Fraunhofer IZM and fulfill new health and safety standards.

The work on setting up a research fab for microelectronics for quantum and neuromorphic computing (FMD-QNC), initiated in 2023, has continued in 2024. The consortium behind the plans hopes to serve the technological requirements of researchers working on QC/NC technologies in Germany and to become a vital bridge between fundamental research, industrial production, and actual applications. The research fab is set to cover services from preparatory research to tech development and pilot production. Fraunhofer IZM invested a further €2.9 million in hardware and equipment for this purpose in 2024.

The »Next Generation Computing Alliance« of CEA-Leti, Fraunhofer/FMD, and Imec plans to form a »Testing and Experimentation Facility for Hardware for Edge AI« (TEF) with VTT. As part of this, the »PREVAIL« project was introduced to develop and produce the core of what will become a connected multi-hub technology platform. The platform will offer Europe's R&D vanguard in the field – from research institutes and corporate enterprises to SMEs and smaller startups – high-tech capacities for constructing prototype chips for new AI applications. To this end, IZM-ASSID is investing a total of €12 million at its Dresden site, supported by funding from the EU and the Federal Ministry of Education and Research. In 2024, a full €9.2 million Euros were already invested for this purpose.

With financial support coming from the the Fraunhofer strategic funds, work has begun on a laboratory for the testing and metrological characterization of combined RF sensor and communication systems for the 5G and 6G THz standards at the Cottbus site of Fraunhofer IZM. €0.6 million have been earmarked for this.

HR developments

The number of professionals working at the IZM's sites in Berlin, Cottbus, and Dresden/Moritzburg has grown to 460 people at the end of 2024, including 125 interns, bachelor and master students, and student assistants, all of whom enjoy comprehensive support and supervision at Fraunhofer IZM. This is a sign of the importance placed by Fraunhofer IZM on fostering and training the talented researchers of tomorrow, today. The Institute offers students an opportunity to combine their studies with hands-on scientific work at the offices and in the labs of Fraunhofer IZM.

Fraunhofer IZM is also committed to offering opportunities for apprentices. In 2024, eight new trainees joined as microtechnology specialists, surface coating specialists, and office communications managers.

Fraunhofer IZM in 2024

Budget	45 million euros
External revenue	33.9 million euros (75.4 percent of total turnover)
Sites	Berlin, Cottbus and Dresden/Moritzburg
Laboratories	> 8.000 m²
Staff	460 (including 125 interns, bachelor's and master's students, student assistants, as well as 8 apprentices)

Awards

From left to right: Cem Özdemir (Federal Minister of Food and Agriculture and Federal Minister of Education and Research), Dr. Hermann Oppermann (Fraunhofer IZM), Dr. Norwin von Malm (ams OSRAM), Stefan Grötsch (ams OSRAM), Federal President Frank-Walter Steinmeier, and presenter Yve Fehring at the Deutscher Zukunftspreis award ceremony

Deutscher Zukunftspreis 2024 goes to a combined ams OSRAM and Fraunhofer IZM research team

At the end of November 2024, Federal President Frank-Walter Steinmeier presented the Deutscher Zukunftspreis 2024 (German Future Prize) to the team led by Dr. Norwin von Malm and Stefan Grötsch from ams OSRAM and Dr. Hermann Oppermann from Fraunhofer IZM. This honor recognizes their development of »digital light« LED technology, which is not only revolutionizing the automotive sector but also setting new standards for efficiency, safety, and interactivity.

The innovative system uses a matrix of 25,600 separately activated LEDs arranged in a 320 x 80 pixel array. Compared to conventional technology, which relies on two light sources, the new system offers much more precise and adaptive control over the emitted light. It could enable car headlights to target their beam directly onto the road ahead without blinding pedestrians or oncoming traffic. This adaptive light could substantially improve safety on the road.

Another advantage of the system lies in its very energy efficient nature. Again compared to conventional passive lights, which use shielding solutions to control how much of the light they create is actually emitted, the digital controls would activate only the number of LEDs actually required at any given moment. This reduces both the power going into the system and the heat give off by it. It makes more compact design possible by removing the need for complex cooling systems.

One captivating feature of the technology is its ability to use LEDs not just for regular lighting, but as a means to share information. The LED matrix can act as a projector and display pictograms e.g. on road surfaces. A stylized snowflake could warn drivers of sleet or ice, or a warning symbol might alert them to a driver going the wrong way ahead of them. This ability offers new options for communication in traffic and again makes the roads safer for all users.

The award of the German Future Prize 2024 by the Federal President Frank-Walter Steinmeier in Berlin underlines the exceptional place this innovation can hold in Germany's innovation landscape. The prize is awarded for excellence in technology, engineering, and the natural sciences and comes with 250,000 Euros in prize money. For Fraunhofer IZM, winning this award represents an important milestone – a first for the Institute and only the tenth overall for the Institutes of the Fraunhofer Society.

Ivan Ndip was honored with the IMAPS Outstanding Educator Award

Professor Ivan Ndip wins the IMAPS Outstanding Educator Award 2024

In early October 2024, Professor Ivan Ndip, Department Head at Fraunhofer IZM, was chosen as the newest recipient of the coveted IMAPS Outstanding Educator Award. With this honor, the International Microelectronics Assembly and Packaging Society (IMAPS) recognizes his exceptional achievements in education and training in the field of assembly and interconnection technology. Professor Ndip received his award at the 57th International Symposium on Microelectronics in Boston, USA, from the hands of former IMAPS Director Dr. Beth Keser.

For more than 15 years Ivan Ndip has dedicated a lot of his time to educating the next generation of engineering students and training engineers in the field. In his time teaching at the Technical University of Berlin between 2008 and 2019, he introduced the first courses on signal and power integrity and on the electromagnetic compatibility of interconnect technology in microelectronic systems. His courses combined the fundamental theory with practical lab time and prepared countless students for their careers in science or industry.

Professor Ndip still continues his work as an educator and researcher at BTU Cottbus-Senftenberg, where he holds the chair for antenna and RF system integration. Over his time, he has supervised more than 100 bachelor, master, and doctorate research projects and offered numerous training courses for professionals in the industry.

At Fraunhofer IZM, Ivan Ndip heads the RF & Smart Sensor Systems department in Berlin and the RF Sensor and High-Speed Systems office in Cottbus. His contributions play a major part in advancing the application-driven research of innovative technologies and supporting the growth of future talent for the field.

The award by IMAPS – the world's largest professional association for microelectronics and interconnection technology – is a sign of the respect Professor Ndip has gained around the world for his contributions to research and education. Ivan Ndips role in preparing the next generation of professionals in our field is strengthening the position of Fraunhofer IZM as a global leader in the field of microintegration.

Top left: IZM colleague Andrei Costina (center) receives an »ESTC 2024 Student Travel Award« from Program Chair Toni Mattila (right) and IEEE representative Jeff Suhling (left)

Top right: Laura Wenzel from Fraunhofer IZM-ASSID is honored with an »ESTC 2024 Student Travel Award« at the ECTC 2024 in Denver

Laura Wenzel and Andrei Costina proud winners of the »IEEE Student Travel Award«

Not one, but two junior researchers from Fraunhofer IZM are the proud recipients of a 2024 travel award by the IEEE Electronic Packaging Society (IEEE-EPS). The awards are given to up-and-coming researchers in the field at IEEE-sponsored conferences and are meant to support young talent by covering their travel expenses.

Laura Wenzel, research assistant and doctorate researcher at Fraunhofer IZM-ASSID, received her award at Denver's Electronic Components and Technology Conference (ECTC 2024) in May for her work on the »Influence of Heat Treatment on the Quality of Die-to-Wafer Hybrid Bond Interconnects«, in which she researches the effect of certain process parameters on hybrid bonding.

In September, Andrei Costina from the Wafer Level System Integration department at Fraunhofer IZM in Berlin, received a travel award at the Electronics System-Integration Technology Conference (ESTC 2024) in Berlin for his contribution on the »Manufacturing and Characterization of Thin-Film Tantalum Pentoxide Integrated Capacitors«. In his paper, Costina looks at the production and performance of thin-film tantalum pentoxide capacitors, made by standard wafer-level packaging processes on silicon wafers.

Nyake Gahein-Sama receives the Best Poster Award at IEEE ESTC 2024

From 11 to 13 September 2024, Berlin was host to the Electronics System-Integration Technology Conference (ESTC 2024) organized by IEEE Electronics Packaging Society. 430 attendees from around the world assembled in the city for new insights in interconnection technology. As part of the conference, Nyake Gahein-Sama, student assistant at Fraunhofer IZM, was proud to win the Best Poster Award.

His winning poster on the »Alignment Between Subsequent 3D Molding Layers for Optimized Performance of 3D Integrated Patch Antennas for Advanced Sensing Applications« addressed challenges for packaging in 3D molding and presented a technical solution for the highly precise alignment of pre-molded substrates in a second molding process.

»Elektronik« readers choose a Fraunhofer IZM invention as their Product of the Year

The readers of the »Elektronik« industry publication had an opportunity to choose three products from more than 2500 innovations as their Products of the Year. They chose the impedance spectroscopy capsule developed at Fraunhofer IZM alongside innovations coming from Bosch and Infineon.

As the world's tiniest capsule of its nature, the system facilitates failure analyses in industrial machinery and can even be used for medical diagnostics in the human body. The groundbreaking technology is the output of a cooperation venture between Fraunhofer IZM, the Technical University of Berlin, and the industry partners Micro Systems Technologies and Sensry GmbH. The project leader, Basel Adams from the TU Berlin, received the people's award in the medical category in March 2024.

Project manager Basel Adams (left) together with the other winners of the »Product of the Year« competition

Tobias Herrmann named best surface coating specialist in the class of 2024

Tobias Herrmann has completed his training as a surface coating specialist at the top of his class among the graduates of 2024. His achievement was recognized as part of a special event of the German Society of Electroplating and Surface Technology's Saxon region in Zwickau, praising Hermann's exceptional performance during his apprenticeship at Fraunhofer IZM. Herrmann had originally been interested in a career as a microtechnology specialist and eventually entered his current field by chance when Fraunhofer IZM recommended the apprenticeship to him in which he would eventually excel with his remarkable commitment.

Fraunhofer IZM awarded the IHK Seal for »Excellence in Vocational Training«

In January 2024, Berlin's Chamber of Industry and Commerce chose to recognize Fraunhofer IZM's educational efforts with the seal for its »Excellence in Vocational Training«. The Institute not only fulfilled all required criteria, but also won particular praise for its sustained commitment to vocational training in the award's additional voluntary and excellence criteria. The Berlin-based Institute has a track record of a quarter of a century of training future microtechnology and office communications specialists and is always looking for new trainees.

Particular praise was given to the additional educational activities of the Institute, including the Girls' Day, its participation in projects like EnterTechnik, and the focused support offered to particularly promising trainees.

Ceremonial presentation of the IHK seal at Fraunhofer IZM with (from left to right) Sven Schmidt, Andreas Grünschneder, and Stefan Ast (vocational trainers), Franziska Klenner (Head of Education & Career at the IHK Berlin), and Julia Günther-Sorge (supervisor of student interns)

Dissertations, Editorials

Dissertations

Bakhshaee Babaroud, Nasim
Graphene-based Microfabricated Platform Technologies for Multi-modal Neural Interfaces

Bickel, Jan
Entwicklung von Hochtemperatur-Schichtsystemen für MEMS Anwendungen mittels Atmosphärendruck-Sputtertechnologie

Dilek, Seyyid Muhammed
Performance Evaluation of an E-band Transceiver Front-end Considering Nonidealities

Forndran, Freerik
Physics-of-failure Based Lifetime Modelling of Silver Sintered Power Modules for Electric Vehicles by Experiment and Simulation

Fußwinkel, Nils
Systemansätze zur Verbesserung der Verfügbarkeit und Lebensdauer von Traktionsbatterien durch Differenzierung der Zellbelastungen im Reihenverbund

Hoffmann, Stefan
Optimization Strategies in Public Grid Connected Power Electronic Systems Applying High Pulse Frequencies

Kawasaki, Shinnosuke
Revitalizing CMUTs

Pak, Anna
Thermoplastic Polymers for Neural Implantable Interfaces

Saccher, Marta
Collapsed CMUTs for Neuromodulation and Wireless Power Transfer

Editorials

Bioelectronic Medicine Journal
Giagka, V. (Associate Editor)

International Journal of Microelectronics and Electronic Packaging
Ndip, I. (Associate Editor)

Lectures

Aalborg University

Prof. Dr. E. Hoene
- Design of Modern Power Semiconductor Devices
- EMC in Power Electronics

BTU Cottbus-Senftenberg

Prof. Dr. Dr. I. Ndip
- Fundamentals of Antennas
- Antennas I and II
- Signal/Power Integrity and Electromagnetic Compatibility

Delft University of Technology

Prof. Dr. V. Giagka
- Active Implantable Biomedical Microsystems
- Bioelectricity
- Neurostimulation

Dresden University of Technology

Jun.-Prof. Dr. J. Panchenko
- 3D System Integration and 3D Technologies
- Micro-/Nanomaterials and Reliability Aspects

German International University in Berlin

Dr. T. Tekin
- Sensor Technology
- Strength of Materials

Technical University of Berlin

B. Adams
- Fundamentals of Medical Engineering
- Signal Processing of Biological Data with Python

Dr. P. Mackowiak, Dr. M. Schiffer
- Manufacturing Technologies for Semiconductor Sensors

Dr. N. F. Nissen, Dr. A. Middendorf
- Environmentally Friendly Product Development

Prof. Dr. M. Schneider-Ramelow
- System Integration Technologies
- System Integration Materials

University of Applied Sciences for Engineering and Economics in Berlin

M. Bäuscher, M. Hubl
- BioMEMS

Dr. A. Middendorf
- Quality and Reliability of Microsystems

S. Rotzler
- Innovative Materials

Dr. H. Walter
- Materials in Microsystem Technology

Cooperation with Universities (Selection)

Some of Fraunhofer IZM's university partners

Aalborg University, Denmark
Aalto University, Finland
AGH University of Science and Technology, Poland
Binghampton University, USA
Delft University of Technology, The Netherlands
Eindhoven University of Technology, The Netherlands
ETH Zurich, Switzerland
Hanyang University, South Korea
KU Leuven, Belgium
Michigan State University, USA
Tohoku University, Japan
Université du Québec à Trois-Rivières, Canada
University College London, Great Britain
University of Tokyo, Japan
University of Utah, USA
University of Zurich, Switzerland

Berlin University of the Arts
Bielefeld University
Bundeswehr University Munich
Chemnitz University of Technology
Heidelberg University
Humboldt University of Berlin
Otto-von-Guericke University Magdeburg
Rhenish Friedrich Wilhelm University of Bonn
Technische Hochschule Ingolstadt
University of Erlangen-Nuremburg
University of Freiburg
University of Mainz
University of Münster
University of Rostock
Weißensee Academy of Art Berlin

Close cooperation with universities is an important pillar of Fraunhofer's success model. While the universities bring their innovative ability and competence in basic research to the table, Fraunhofer contributes excellence in applied research as well as outstanding technical infrastructure.

Cooperation with the Technical University of Berlin

Ever since its foundation in 1993, Fraunhofer IZM has drawn a lot from its productive cooperation with the Research Center for Microperipheric Technologies at the Technical University of Berlin, forming one of the world's first research institutions for packaging and interconnection technologies in the 1990s. Since 2021, Professor Martin Schneider-Ramelow has been heading not just Fraunhofer IZM, but also the Research Center for Microperipheric Technologies. Since August 2024 he has been sharing this resposibility with Professor Ulrike Ganesh, who has taken over the Chair of Design and Hetero-Integration of Microelectronic Systems at the TU Berlin.

Fraunhofer IZM-ASSID cooperates with TU Dresden

Within the joint junior professorship »Nanomaterials for Electronic Packaging« of Fraunhofer IZM-ASSID and TU Dresden, honorary professor Juliana Panchenko and her team are working on new materials and technologies for fine-pitch interconnects in 3D/2.5D Si structures.

Cooperation with BTU Cottbus-Senftenberg

Fraunhofer IZM intensifies its cooperation with BTU in the branch office for high-frequency sensor systems in Cottbus. Since February 2023 IZM department head Prof. Ivan Ndip has held the chair for for Antennas and Radio Frequency Systems Integration. The research activities within the Innovation Campus (iCampµs) Cottbus focus on design, test procedures and characterization of integrated antennas, on co-design of chip-package antennas as well as system integration solutions for the realization of miniaturized radio frequency sensor systems.

Cooperation with Industry (Selection)

AEMtec GmbH	Berlin (D)
Adeia Inc. / Xperi	San Jose, CA (USA)
Ajinomoto Group	JP
Allegro MicroSystems	Manchester, NH (USA)
Amkor Technology, Inc.	Tempe, AZ (USA)
ams AG	Premstätten (AT)
Amsterdam Scientific Instruments B.V.	Amsterdam (NL)
AnSem NV	Leuven (BE)
AT&S Austria Technologie & Systemtechnik AG	Leoben (AT)
AUDI AG	Ingolstadt (D)
Baker Hughes Inteq GmbH	Celle (D)
BASF SE	Ludwigshafen am Rhein (D)
Berliner Nanotest und Design GmbH	Berlin (D)
BMW AG	Munich (D)
Bosch Semiconductor Manufacturing	Dresden (D)
Brewer Science, Inc.	Rolla, Missouri (USA)
Carl Zeiss SMT GmbH	Jena (D)
CERN	Meyrin (CH)
Contag GmbH	Berlin (D)
Corning Inc.	Corning, NY (USA)
Delo GmbH	Windach (D)
DeltaHeat GmbH	Berlin (D)
Diehl Aerospace GmbH	Überlingen (D)
DISCO Corporation	JP
DResearch	Berlin (D)
DuPont Electronics & Imaging	Marlborough, MA (USA)
EV Group	St. Florian am Inn (AT)
Evatec AG	Trübbach (CH)
FACEBOOK TECHNOLOGIES, LLC	Menlo Park, CA (USA)
FIRST SENSOR	Berlin (D)
Fujifilm Electronic Materials	EU, USA
GEFRAN S.p.A.	Provaglio d'Iseo (IT)
GLOBALFOUNFRIES INC.	Dresden, USA
Heraeus	Hanau (D)
IMASENIC Advanced Imaging S.L.	Barcelona (ES)
InnoSenT GmbH	Donnersdorf (D)
Intel Corporation	Santa Clara, CA (USA)
KSG GmbH	Görnsdorf (D)
LTB GmbH	Radebeul (D)
Malvern PANalytical B.V.	Almelo (NL)
MENNEKES Elektrotechnik GmbH & Co. KG	Kirchhunden (D)
Micro Systems Engineering GmbH	Berg (D)
Mitteldeutsche Netzgesellschaft Strom mbH	Halle (D)
Multi Channel Systems MCS GmbH	Reutlingen (D)
Nagase ChemteX Corporation	Osaka (JP)
Nexperia	Nijmegen (NL)
NEXT FUEL R&D LTD	Neve Yamin (IL)
NGK	Nagoya (JP)
OSYPKA AG	D
Philips	NL
Picosun Oy	Masala (FI)
Pilz GmbH & Co. KG	Ostfildern (D)
Plath	Ostfildern (D)
Rapidus Corp.	JP
RENA Technologies GmbH	Gütenbach (D)
Resonac	Tokio (JP)
Robert Bosch GmbH	Renningen (D)
Rolls-Royce Deutschland Ltd & Co KG	Cottbus (D)
Saltec GmbH	Salzhausen (D)
Schaeffler AG	Herzogenaurach (D)
Schlumberger	Paris (FR)
Schmoll Maschinen GmbH	Rödermark (D)
Semsysco GmbH	Salzburg (AT)
sensiBel AS	Oslo (NO)
Siemens AG	Berlin, Erlangen, Munich (D)
SLAC National Accelerator Laboratory	Menlo Park, CA (USA)
Süss MicroTec SE	Garching, Munich (D)
Swissbit Germany AG	Berlin (D), Broschhofen (CH)
Texas Instruments	Munich (D), London (GB)
Thales Group	Paris (FR)
The Chemours Company	Wilmington, DE (USA)
Tokyo Electron Ltd. TEL	Albany, NY (USA), Tokio (JP)
United Monolithic Semiconductors (UMS	Villebon-sur-Yvette (FR)

Memberships (Selection)

3D & Systems Summit (SEMI)	Dr. M. Junghähnel	Member Program Committee
3DInCites	Dr. M. Junghähnel	Member Advisory Board
AMA Fachverband Sensorik, Wissenschaftsrat	H. Pötter	Member
Cluster Optik BB, Photonik für Kommunikation und Sensorik	Dr. H. Schröder	Spokesman
Deutsche Gesellschaft für Kardiologie (DGK)	B. Adams	Member
Deutscher Verband für Schweißtechnik DVS	Prof. Dr. M. Schneider-Ramelow	Representative of Fraunhofer IZM, Chairman of Arbeitsgruppe Bonden
ECPE Competence Centre	Prof. Dr. M. Schneider-Ramelow	Member
EFDS – Europäische Forschungsgesellschaft Dünne Schichten e. V.	Dr. M. Junghähnel	Member
Fachausschuss »Beschichtungstechnologien für optische und elektronische Funktionalisierung – FABF«	Dr. M. Junghähnel	Member
Wissenschaftlicher Beirat des EFDS	Dr. M. Junghähnel	Elected Member
European Photonic Industrial Consortium (EPIC)	Dr. H. Schröder	Representative of Fraunhofer IZM
European Technology Platform for the Future of Textiles	S. Rotzler	Member
European Technology Platform on Smart Systems Integration (EPoSS)	H. Pötter	Member Executive Committee, Board Member
FED Fachverband Elektronik-Design e. V.	Dr. N. F. Nissen	Member
Fraunhofer Forschungsbereich Textil	M. von Krshiwoblozki	Representative of Fraunhofer IZM
Heterogeneous Integration Roadmap (HIR)	R. Aschenbrenner	Chair Technical Working Group SiP
IEEE Electronics Packaging Society	R. Aschenbrenner	Fellow
IEEE EPS Board of Governors	Dr. T. Braun	VP of Conferences
IEEE TC RF High-Speed Components of Systems	Prof. Dr. Dr. I. Ndip	Senior Member
IMAPS International Microelectronics Assembly and Packaging Society	Prof. Dr. M. Schneider-Ramelow, Prof. Dr. I. Ndip	Fellows
IMAPS Deutschland	Prof. Dr. M. Schneider-Ramelow	President
IMAPS Europe ELC	Prof. Dr. M. Schneider-Ramelow	Member
IMAPS Signal/Power Integrity Committee	Prof. Dr. Dr. I. Ndip	Chair
Int. Conference on Coatings on Glass and Plastics (ICCG)	Dr. M. Junghähnel	Board Member
Int.Conference on Planarization/CMP Technology (ICPT)	C. Rudolph	Program Committee
Int. Electronics Manufacturing Initiative (iNEMI)	Dr. T. Braun	Member
IVAM Fachverband für Mikrotechnik, Fachgruppe »Sensors«	E. Jung	Leader
OPTICA	Dr. G. Böttger, Dr. W. Lewoczko-Adamczyk, Dr. H. Schröder	Representatives of Fraunhofer IZM
Organic Electronics Saxony (OES)	E. Jung	Chairman
Photonics 21	Dr. R. Jordan	Board of Stakeholders
Photonics West Optical Interconnects Conference	Dr. H. Schröder	Chair
PLASMA GERMANY	Dr. M. Junghähnel	Elected Expert
SEMI ESiPAT Group	Dr. T. Braun	Member
Silicon Saxony e. V.	Dr. M. Junghähnel	Member
Strategischer Arbeitskreis Silicon Germany	Prof. Dr. M. Schneider-Ramelow	Member
Wissenschaftlich-techn. Rat der Fraunhofer-Gesellschaft	Dr. M. Hampicke	Representative of Fraunhofer IZM
Verband Sichere Digitale Identität e. V.	Christine Kallmayer	Member

Publications (Selection)

Adams, B.; Dils, C.; Kühne, T.; Kretzler, L.
AI-Enhanced Smart Textile System for the Monitoring of Cardiovascular Insufficiency
Proceedings of E-Textiles 2024, Berlin, Germany, DOI: 10.23919/E-Textiles63767.2024.10914344.

Albrecht, O.; Müller, M.; Petersen, L.; Nowotnik, L.; Panchenko, J.
Reliability Analysis of Surface Mount Interconnect Technologies Suitable for Temperatures up to 200°C
Proceedings of IEEE ESTC 2024, Berlin, Germany, DOI: 10.1109/ESTC60143.2024.1071207.

Bakhshaee Babaroud, N.; Rice, S. J.; Camarena Perez, M.; Serdijn, W. A.; Vollebregt, S.; Giagka, V.
Surface Modification of Multilayer Graphene Electrodes by Local Printing of Platinum Nanoparticles Using Spark Ablation for Neural Interfacing
Nanoscale, Vol. 16, No. 7, 2024, pp. 3549-3559, DOI: 10.1039/D3NR05523J.

Becker, K.-F.; Voges, S.; Safak, G.; Nallaweg, O.; Müller, F.; Tschoban, C.; Becker, L.; Dreissigacker, M.; Younis, M. A.; Maretzki, R.; Wallrodt, M.; Braun, T.; Schneider-Ramelow, M.
Molded SiP Manufacturing with Integrated Shielding Layer for Optimized EMI Robustness
Proceedings of IMAPS 2024, Boston, USA.

Beyer, V.; Mayer, D.; Haiduk, F.; Meinig, M.; Wittemeier, S.; Geneiß, V.; Meißner, P.; Weder, A.; Werner, T.; Steller, W.; Zorn, W.
Structural Integration of Smart Sensors for the Industrial Internet of Things
Proceedings MikroSystemTechnik Kongress 2023, Dresden, Germany.

Bickel, S.; Panchenko, J.; Junghähnel, M.
Solid-state Growth Kinetics of Compound Layers in Electroplated Cu-In Layer Systems
Proceedings of IEEE ESTC 2024, Berlin, Germany, DOI: 10.1109/ESTC60143.2024.10712038.

Bickel, S.; Quednau, S.; Birlem, M.; Panchenko, J.; Junghähnel, M.
Cu Nanowire Fine-pitch Joints for Next Gen Heterogeneous Chiplet Integration
Proceedings of ECTC 2024, Denver, USA, DOI: 10.1109/ECTC51529.2024.00224.

Bickel, S.; Quednau, S.; Birlem, O.; Graff, A.; Altmann, F.; Junghähnel, M.; Panchenko, J.
Fine-pitch Copper Nanowire Interconnects for 2.5/3D System Integration
Journal of Electronic Materials, Vol. 53, 2024, pp. 4410–4420, DOI: https://doi.org/10.1007/s11664-024-11107-8.

Braun, T.; Hölck, O.; Adler, M.; Obst, M.; Voges, S.; Becker, K.-F.; Aschenbrenner, R.; Voitel, M.; Dreissigacker, M.; Schneider-Ramelow, M.
How to Manipulate Warpage in Fan-out Wafer and Panel Level Packaging
Proceedings of ECTC 2024, Denver, USA.

Chaudhuri, A.; Jaeschke, J.; Gollhardt, A.; Oppermann, H.; Schneider-Ramelow, M.
Investigating the Failure Mechanisms of Electromigration and Copper Oxide Formation in Fine-Pitch Cu RDL
Proceedings of IEEE ESTC 2024, Berlin, Germany.

Costina, A.; Wöhrmann, M.; Schiffer, M; Schneider-Ramelow, M.
Manufacturing and Characterization of Thin-film Tantalum Pentoxide Integrated Capacitors
Proceedings of IEEE ESTC 2024, Berlin, Germany, DOI: 10.1109/ESTC60143.2024.10711996.

van Damme, C.; Wardhana, G. K.; Velea, A. I.; Giagka, V.; Costa, T. L.
Feasibility Study for a High-frequency Flexible Ultrasonic Cuff for High-precision Vagus Nerve Ultrasound Neuro-modulation
Proceedings of UFFC-JS 2024, Vol. 71, No. 7, pp. 745-756, DOI: 10.1109/TUFFC.2024.3381923.

van Dijk, M.; Wittler, O.; Wagner, S.; Schneider-Ramelow, M.
Numerical Simulation Approach for Consideration of Ageing Effects in PCB Substrates by Modifying Viscoelastic Materials Properties
Microelectronics Reliability, Vol. 157, 2024, 115403, ISSN 0026-2714, https://doi.org/10.1016/j.microrel.2024.115403.

Elsotohy, M.; Dobs, T.; Jaeschke, J.; Sehr, F.
Lifetime Prediction Strategy for Electronic Systems to Enhance Environmental Sustainability
Proceedings of EGG 2024+, Berlin, Germany, DOI: 10.23919/EGG62010.2024.10631217.

Fell, J.; Bickel, S.; Fiedler, C.; Delan A.; Junghähnel, M.
Enhanced Process Control for Dry Etching of Functional TiN Structures on 300 mm Wafer Level
Proceedings of IEEE ESTC 2024, Berlin, Germany, DOI: 10.1109/ESTC60143.2024.10712050.

Gahein-Sama, N.; Dreissigacker, M.; Müller, F.; Tschoban, C.; Braun, T.; Becker, K.-F.; Schneider-Ramelow M.
Alignment Between Subsequent 3D Molding Layers for Optimized Performance of 3D Integrated Patch Antennas for Advance Sensing Applications
Proceedings of IEEE ESTC 2024, Berlin, Germany.

Gäbler, A.; Maaß, U.; Ndip, I.
Efficient Investigation of Coupled Lines in Quasi Periodical High-density Signal Routings for HPC Applications
Proceedings of SPI 2024, Lisbon, Portugal.

Gäbler, A.; Maaß, U.; Ndip, I.
Investigation of RF Characteristics of Chiplet to PCB Transitions for Advanced HPC Packaging Solutions
Proceedings of IEEE ESTC 2024, Berlin, Germany.

Gissing, J.; Brockmann, C.
Dezentrale Methode zur adaptiven Funkparameteroptimierung eines LoRa Funkmoduls
Proceedings of EBL 2024, Fellbach, Germany.

Holzapfel, L.; Giagka, V.
A Robust Backscatter Modulation Scheme for Uninterrupted Ultrasonic Powering and Back-communication of Deep Implants
Proceedings of UFFC-JS 2024, Taipeh, Taiwan, DOI: 10.1109/TUFFC.2024.3465268.

Huber, S.; Scheibe, P.; Mutlu, S.; Wittler, O.; Schneider-Ramelow, M.
Analyzing the Influence of RDL Stack-up on Wafer Warpage in FOWLP Through Experimental and Numerical Investigations
Proceedings of ECTC 2024, Denver, USA, pp. 1018-1024, DOI: 10.1109/ECTC51529.2024.00163.

Kröhnert, K.; Böttger, G.; Jürgensen, N.; Schiffer, M.; Schneider-Ramelow, M.; Kumar, D.; Lee, J. S.; O'Brien, P.; Schöning, N.; Schulz-Ruthenberg, M.
Hermetically Sealed Glass Interposer Platform for Photonic Integrated Circuits
Proceedings of MiNaPAD 2024, Grenoble, France.

Le, T. H.; Kaiser, M. P.; Koezegi, J.-M.; Murugesan, K. S.; Gerhold, L.; Hichri, H.; Oishi, R.; Nakano, R.; Ndip, I.; Schneider-Ramelow, M.
Wideband Antennas on Thin-film Packaging Substrates for 140 GHz 6G Applications
Proceedings of ECTC 2024, Denver, USA.

Le, T. H.; Ndip, I.; Schneider-Ramelow, M.
Broadband Antenna for High Performance 5G mmWave Modules
Proceedings of IEEE ESTC 2024, Berlin, Germany.

Lechowski, B.; Kutokova, K.; Grenzer, J.; Panchenko, J.; Krüger, P.; Clausner, A.; Zschech, E.
Laboratory X-ray Microscopy of 3D Nanostructures in the Hard X-ray Regime Enabled by a Combination of Multilayer X-ray Optics
Nanomaterials 2024, Vol. 14, No. 2, p. 233, DOI: https://doi.org/10.3390/nano14020233.

Manier, C.-A., Zoschke, K.; Oppermann, H.
Massive Parallel Assembly and Interconnection for Micro-LEDs – a Technical Feasibility Study
Proceedings of IEEE ESTC 2024, Berlin, Germany, DOI: 10.1109/ESTC60143.2024.10712028.

Mueller, M.; Saakyan, S.; Luniak, M.; Pietruske, H.; Schleicher, E.; Panchenko, J.
Study of the Water and Steam Resistance of Thick Film Materials for Sensor Application up to 300°C
Proceedings of IEEE ESTC 2024, Berlin, Germany, DOI: 10.1109/ESTC60143.2024.10712069.

Mukhopadhyay, P.; Wenzel, L., Rudolph, C.; Tuchman, A.; Ryan, K.; Gildea, A.; Nichols, C.; Allgair, J.; Arkalgud, S.; deVilliers, A.; Fulford, H. J.
Annealing Effects in Sub-8 µm Pitch Die-to-wafer Hybrid Bonding
Proceedings of ECTC 2024, Denver, USA, DOI: 10.1109/ECTC51529.2024.00325.

Murugesan, K. S.; Schneider, J.; Le, T. H.; Gerhold, L.; Kaiser, M. P.; Koeszegi, J.-M.; Hichri, H.; Oishi, R.; Nakano, R.; Ndip, I.; Schneider-Ramelow, M.
Temperature Dependent Dielectric Characterization of Low Loss Thin Film Polymer up to sub-THz bands
Proceedings of ECTC 2024, Denver, USA, 2024.

Murugesan, K. S.; Schneider, J.; Ndip, I.; Frankosky, J.; Amos, B.; Georgiev, G.; Fiehler, F.; Schneider-Ramelow, M.
RF Characterization and Analysis of Low-loss PCB Material and Transmission Line up to 110 GHz
Proceedings of IEEE ESTC 2024, Berlin, Germany.

Nanbakhsh, K.; van Gompel, M.; Ritasalo, R.; Gollhardt, A.; Horvath, D.; Toth, K.; Meszena, D.; Ulbert, I.; Serdijn, W.; Giagka, V.
An In Vivo Biostability Evaluation of ALD and Parylene-ALD Multilayers as Micro-packaging Solutions for Implantable ICs
Small, Vol. 21, 2025, DOI: 10.1002/smll.202410141.

Nanbakhsh, K.; Shah Idil, A.; Lamont, C.; Dusco, C.; Akgun, O. C.; Horvath, D.; Toth, K.; Meszena, D.; Ulbert, I.; Mazza, F.; Constandinou, T. G.; Serdijn, W. A.; Vanhoestenberghe, A.; Donaldson, N.; Giagka, V.
On the Longevity and Inherent Hermeticity of Silicon-ICs: Evaluation of Bare-die and PDMS-coated ICs after Accelerated Aging and Implantation Studies
Nature Communications, Vol. 16, No. 12, 2025, DOI: 10.1038/s41467-024-55298-4.

Oppermann, H.; Manier, C.-A.; Fröhlich, J.; Schneider-Ramelow, M.
Fine Pitch Flip Chip Bonding for Heterogeneous Chiplet Integration
Proceedings of NANO 2024, Gijón, Spain, DOI: 10.1109/NANO61778.2024.10628553.

Panchenko, J.; Wenzel, L.; Bickel, S.; Shehzad, A.; Rudolph, C.; Quednau, S.; Birlem, O.; Müller, M.; Junghähnel, M.
Combination of High-density Interconnect Technologies for Chiplet Integration on Si Interposer
Proceedings of 3D & Systems Summit, Dresden, Germany.

Proske, M.; Billaud, M.; Clemm, C.; Sanchez, D.; Lorf, Y.; Stobbe, L.
Investigation of Semiconductor Die Area as a Reference Variable for LCA
Proceedings of EGG 2024+, Berlin, Germany.

Rämer, O.; Hutter, M.; Schneider-Ramelow, M.
Examination of the Pore Structure of Copper Sintered Die Attach Layers by Local Thickness Analysis and Scratch Test
Proceedings of CIPS 2024, Düsseldorf, Germany.

Rotzler, S.; von Krshiwoblozki, M.; Kallmayer, C.; Schneider-Ramelow, M.
Washability of E-Textiles: Washing Behavior of Textile Integrated Circuits Depending on Textile Substrate, Circuit Material and Integration Method
Advanced Functional Materials, 2024, DOI: 10.1002/adfm.202417344.

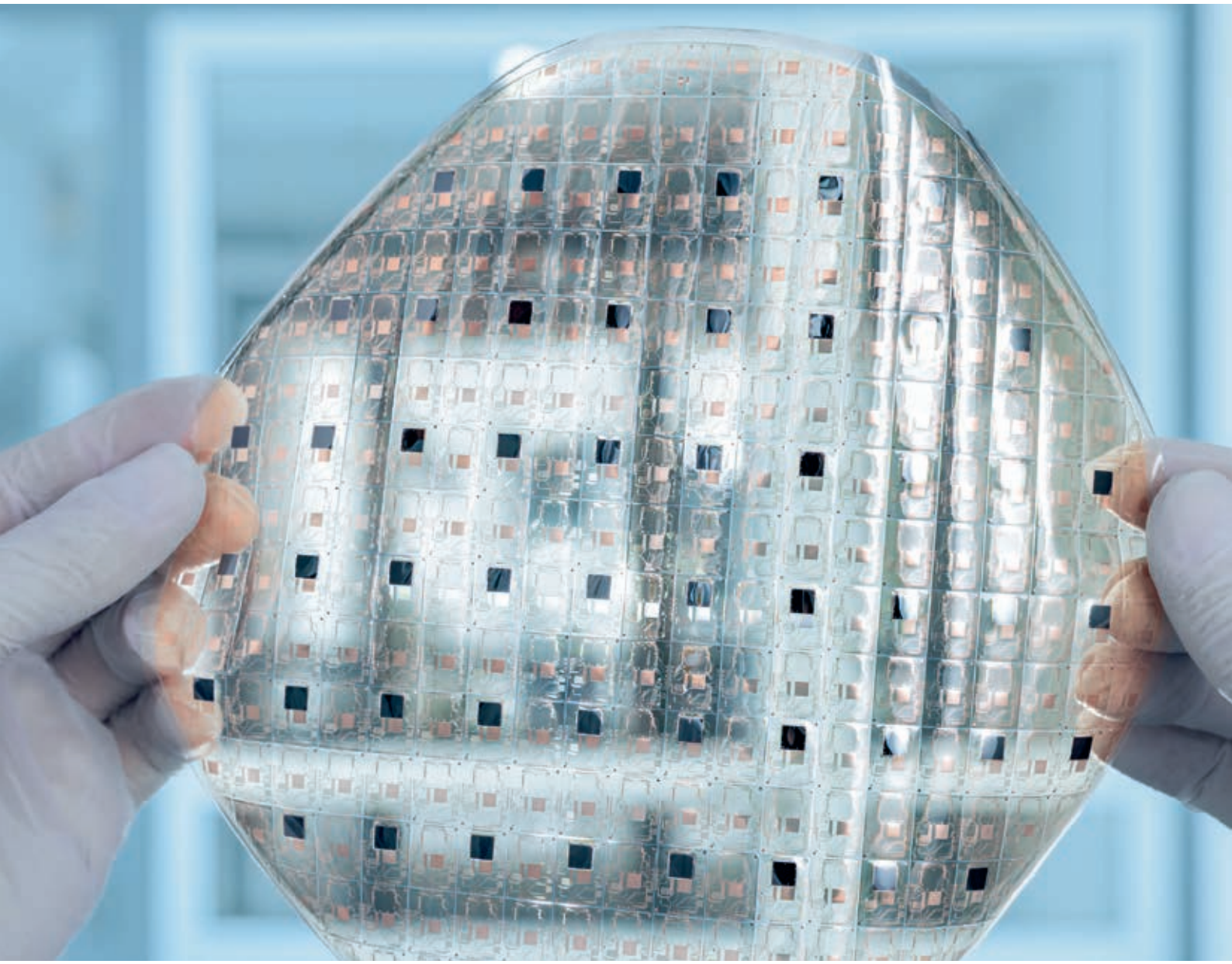
Rückschloss, J.; Sánchez, D.; Schischke, K.; Bregadze, S.; Nissen, N. F.; Schneider-Ramelow, M.
Energy Efficiency Labelling for Computers: How Can Product Groups be Covered?
Proceedings of EGG 2024+, Berlin, Germany.

Schischke, K.; Proske, M.; Sánchez, D.; Poppe, E.; Cherem Lopes, S.
Advancing the State of Life Cycle Assessments for Computers and Laptops Towards a More Sustainable IT Ecosystem
Proceedings of EGG 2024+, Berlin, Germany.

Sehr, F.; Wagner, S.; Schulz, A.; Vorwerk, A.
Condition Monitoring for Detection of Humidity-induced Failures in Control Electronics of Power Converters
Proceedings of ESREF 2024, Parma, Italy.

Shehzad, A.; Myndyk, M.; Junghähnel, M.; Panchenko, J.
Investigation of Side Wall Loss for Development of 6 µm Microbumps for 3D/2.5D Integration
Proceedings of IEEE ESTC 2024, Berlin, Germany, DOI: 10.1109/ESTC60143.2024.10712070.

Stadler, P.; Braun, T.; Geissler, C.; Scheibe, P.; Braun, T.; Hoelck, O.; Romstadt, J.; Pohl, M.
In-package Characterization of Dielectrics Using Ring Resonators and Adaptive 3D EM-Simulations Around 77 GHz
Proceedings of GeMiC 2024, Duisburg, Germany, ISBN 978-3-9820397-3-2.



Stobbe, L.; Nissen, N. F.; Proske, M.; Schulz, A.; Aslan, T.
Methodical Challenges of Prognostic Lifecycle Assessment – an Exemplary Study of ICT's Environmental Impact in Germany 2030
Proceedings of EGG 2024+ Berlin, Germany.

Tekin, T.
Towards Photonic Chiplets
Proceedings of 3D & Systems Summit, Dresden, Germany.

Tschoban, C.; Pötter, H.; Perlwitz, P.; Dreissigacker, M.; Müller, F.; Becker, K.-F; Ndip, I.; Schneider-Ramelow, M.
Packaging-codesign for the Development of a High resolution MIMO-radar-module for Automated Guided Vehicles
Proceedings of EPTC 2024, Singapore, Singapore.

Tschoban, C.; Schmied, M.; Thomas, T.; Becker, K.-F.; Braun, T.; Ndip, I.; Pötter, H.; Fiehler, R.; Schneider-Ramelow, M.
Evaluierung von 79 GHz Automotive-Radarantennen und ihre Limitierungen hinsichtlich Prozess-Abweichungen im PCB-Prozess
Proceedings of EBL 2024, Fellbach, Germany.

Wagner, E.; Kegler, S.; Gallina, V.; Aigner, T.; Koller, J.
How Industrial Data Meets Information Requirements of the Digital Product Passport – The Case of Remanufacturing Data
Proceedings of EGG 2024+, Berlin, Germany.

Wenzel, L.; Rudolph, A; Shehzad, P.; Mukhopadhyay, H.; Fulford, J; Junghähnel, M.; Panchenko, J.
Influence of Heat Treatment on the Quality of Die-to-wafer Hybrid Bond Interconnects
Proceedings of ECTC 2024, Denver, USA, DOI: 10.1109/ECTC51529.2024.00306.

Werft, L.; Kallmayer, C.; von Krshiwoblozki, M.; Schneider-Ramelow, M.
Comparison of Electrical and Mechanical Properties of Stretchable Circuit Boards
Proceedings of IEEE ESTC 2024, Berlin, Germany.

Zoschke, K.; Oppermann, H.; Schiffer, M.; Ndip, I.; Becker, K.-F.; Adler, M.; Gäbler, A.; Maaß, U.; Paulin, G.; Kocon, W.
Key Technologies and Design Aspects for Wafer Level Packaging of High Performance Computing Modules
Proceedings of ECTC 2024, Denver, USA, pp. 433-440, DOI: 10.1109/ECTC51529.2024.00340.

Patents & Inventions

Böttcher, Mathias; Windrich, Frank; Zoschke, Kai; Wolf, Jürgen
Support Assembly and Method for Producing a Support Assembly
CN 113615324 A

Dietrich, Lothar; Brink, Morten; Oppermann, Hermann
Aqueous Formulation for Creating a Layer of Gold and Silver
CN 111647919 A

Krüger, Michael; Trampert, Stefan
Method and Measuring Arrangement for Testing a Conductive Body
DE 10 2013 224 394 A1

Manier, Charles-Alix; Oppermann, Hermann; Zoschke, Kai; Tekin, Tolga
Optical System and Method of Manufacturing an Optical System
DE 10 2019 211 002 A1

Manier, Charles-Alix; Oppermann, Hermann; Zoschke, Kai; Tekin, Tolga
Optical System, Carrier Substrate and Method of Manufacturing an Optical System
CN 112240145 A

Ndip, Ivan; Braun, Tanja; Lang, Klaus-Dieter
Fan-out Panel-/Wafer-level-based System Integration Platform with Antenna Board
DE 10 2018 220 712

Oppermann, Hermann; Tekin, Tolga; Manier, Charles-Alix
Optical System, Optical Component and Method of Manufacturing an Optical System
CN 1122401046 A

Oppermann, Hermann; Tekin, Tolga; Stockmeyer, Jörg; Fröhlich, Juliane
Assembly Comprising a Substrate and Two Components Including Optical Waveguides, as well as Method for Production
CN 112241044 A

Oppermann, Hermann; Zoschke, Kai; Manier, Charles-Alix
Massive Parallel Assembly Method
2023-507362

Wöhrmann, Markus; Zoschke, Kai
Method for the Production of Modular, Embedded Components for Miniaturized Systems
DE 10 2020 201 295 A1

Advisory Board

Chairman

Dr. Markus Ulm
Robert Bosch GmbH, Reutlingen

Members

Dr. Annerose Beck
Saxon State Ministry of Science, Art and Tourism, Dresden

Paradiso Coskina
VDI/VDE Innovation + Technik GmbH, Berlin

Robert Giertz
AEMtec GmbH, Berlin

Gabi Grützner
Micro resist technology GmbH, Berlin

Dr. Michael Hosemann
Siemens Healthcare GmbH, Forchheim

Prof. Gerhard Kahmen
IHP GmbH – Innovations for High Performance Microelectronics, Frankfurt (Oder)

Dr. Christian Koitzsch
European Semiconductor Manufacturing Corporation (ESMC), Dresden

Bernd Lietzau
Senate Department for Higher Education and Research, Health and Long-Term Care, Berlin

Prof. Regine Mallwitz
TU Braunschweig

Jörg Muchametow (until December 2024)
eagleyard Photonics GmbH, Berlin

Dr. Robert Plikat
Volkswagen AG, Wolfsburg

Prof. Geraldine Rauch (until December 2024)
Technical University of Berlin

Dr. Alina Schreivogel
Würth Elektronik GmbH & Co. KG, Niedernhall

Prof. Stephan Völker
Technical University of Berlin

Marcel Wieland
Teltec International GmbH, Dresden

Christoph Zimmer-Conrad
Saxon State Ministry of Economy, Labour and Transport, Dresden

Dr. Tina Züchner (until December 2024)
Federal Ministry of Education and Research, Bonn

Guest

Dr. Ann-Kathrin Schatz
Saxon State Ministry of Science, Art and Tourism

Contact

FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM

Gustav-Meyer-Allee 25 | 13355 Berlin
Telefon +49 30 46403-100
info@izm.fraunhofer.de

Managing Director
Prof. Dr.-Ing. Ulrike Ganesh
Phone +49 30 46403-153
ulrike.ganesh@izm.fraunhofer.de

Director
Prof. Dr.-Ing. Martin Schneider-Ramelow
Phone +49 30 46403-172
martin.schneider-ramelow@izm.fraunhofer.de

Deputy Director
Dipl.-Phys. Rolf Aschenbrenner
Phone +49 30 46403-164
rolf.aschenbrenner@izm.fraunhofer.de

Director's Assistant
Dr.-Ing. Maik Hampicke
Phone +49 30 46403-683
maik.hampicke@izm.fraunhofer.de

Head of Administration
Dipl.-Ing. Carsten Wohlgemuth
Phone +49 30 46403-114
carsten.wohlgemuth@izm.fraunhofer.de

DEPARTMENTS

Wafer Level System Integration
Head: Dr. Manuela Junghähnel
Phone +49 0351 795572-0
manuela.junghaehnel@assid.izm.fraunhofer.de

Head: Dr.-Ing. Michael Schiffer
Phone +49 30 46403-234
michael.schiffer@izm.fraunhofer.de

System Integration and Interconnection Technologies
Head: Dr.-Ing. Tanja Braun
Phone +49 30 46403-244
tanja.braun@izm.fraunhofer.de

Head: Dr.-Ing. Andreas Ostmann
Phone +49 30 46403-187
andreas.ostmann@izm.fraunhofer.de

Environmental and Reliability Engineering
Head: Dr.-Ing. Nils F. Nissen
Phone +49 30 46403-132
nils.nissen@izm.fraunhofer.de

RF & Smart Sensor Systems
Head: Prof. Dr.-Ing. habil. Ivan Ndip
Phone +49 30 46403-679
ivan.ndip@izm.fraunhofer.de

Head: Dipl.-Ing. Harald Pötter
Phone +49 30 46403-742
harald.poetter@izm.fraunhofer.de

DRESDEN ASSID BRANCH OF THE INSTITUTE

All Silicon System Integration Dresden (ASSID)
Ringstraße 12, 01468 Moritzburg

Head: Dr. Manuela Junghähnel
Phone +49 0351 795572-0
manuela.junghaehnel@assid.izm.fraunhofer.de

Head: Dr.-Ing. Michael Schiffer
Phone +49 30 46403-234
michael.schiffer@izm.fraunhofer.de

COTTBUS BRANCH OF THE INSTITUTE

Branch Lab for High-Frequency Sensor Systems
Karl-Marx-Straße 69, 03044 Cottbus

RF & Smart Sensor Systems
Head: Prof. Dr.-Ing. habil. Ivan Ndip
Phone +49 30 46403-679
ivan.ndip@izm.fraunhofer.de

BUSINESS DEVELOPMENT / MARKETING & PR

Business Development Team
Head: Dipl.-Phys. Rolf Aschenbrenner
Phone +49 30 46403-164
rolf.aschenbrenner@izm.fraunhofer.de

Dipl.-Phys. Erik Jung
Phone +49 30 46403-230
bdt@izm.fraunhofer.de

Tekfouy Lim, Ph.D.
Phone +49 30 46403-8110
tekfouy.lim@izm.fraunhofer.de

Dr.-Ing. Andreas Middendorf
Phone +49 30 46403-135
andreas.middendorf@izm.fraunhofer.de

Violeta Prodanovic, Ph.D.
Phone +49 30 46403-150
violeta.prodanovic@izm.fraunhofer

PR & Marketing
Georg Weigelt
Phone +49 30 46403-279
georg.weigelt@izm.fraunhofer.de

Start-A-Factory
Alexandra Rydz
Phone +49 30 46403-203
alexandra.rydz@izm.fraunhofer.de

Imprint

Editors

Prof. Dr. Ulrike Ganesh
Prof. Dr. Martin Schneider-Ramelow
Fraunhofer IZM
www.izm.fraunhofer.de

Editorial Office

mcc Agentur für Kommunikation GmbH
Georg Weigelt, Fraunhofer IZM

Layout / Design

mcc Agentur für Kommunikation GmbH
www.mcc-events.de

Photography

Fraunhofer IWES (29); Bildschön GmbH (46); Horacio Canals | WEKA Fachmedien (49).
All image rights Fraunhofer IZM or Fraunhofer IZM together with:
Volker Mai (Cover, 6, 8, 9, 11, 13, 18, 20, 23, 24, 28, 29, 30, 44, 58);
MIKA Berlin (34, 39, 47, 48, 62, 63); Erik Müller (62), Silvia Wolf (15, 26, 27)

Cover

TSV-wafer with HD multi-layer redistribution layers and test-ICs before and after molding, as well as a finished module (STXmod project)

Member of

Forschungsfabrik Mikroelektronik Deutschland

Contact

Fraunhofer-Institute for
Reliability and Microintegration IZM

Gustav-Meyer-Allee 25, 13355 Berlin
Germany
www.izm.fraunhofer.de