<table>
<thead>
<tr>
<th>CONTENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preface</strong></td>
</tr>
<tr>
<td><strong>FRAUNHOFER IZM</strong></td>
</tr>
<tr>
<td>Core Competencies</td>
</tr>
<tr>
<td>Heterointegration: Cutting through Old Paradigms</td>
</tr>
<tr>
<td>10 years of Fraunhofer IZM-ASSID</td>
</tr>
<tr>
<td>Department System Integration &amp; Interconnection Technologies</td>
</tr>
<tr>
<td>Department Wafer Level System Integration</td>
</tr>
<tr>
<td>Department Environmental &amp; Reliability Engineering</td>
</tr>
<tr>
<td>Department RF &amp; Smart Sensor Systems</td>
</tr>
<tr>
<td>Fraunhofer – a strong Network</td>
</tr>
<tr>
<td>Automotive and Transportation</td>
</tr>
<tr>
<td>Medical Engineering</td>
</tr>
<tr>
<td>Semiconductors</td>
</tr>
<tr>
<td>Industrial Electronics</td>
</tr>
<tr>
<td>Information and Communication</td>
</tr>
<tr>
<td>Labs &amp; Services</td>
</tr>
<tr>
<td><strong>EVENTS</strong></td>
</tr>
<tr>
<td>Events and Workshops</td>
</tr>
<tr>
<td><strong>FACTS &amp; FIGURES</strong></td>
</tr>
<tr>
<td>Fraunhofer IZM in Facts and Figures</td>
</tr>
<tr>
<td>Awards, Editorial, Dissertations</td>
</tr>
<tr>
<td>Lectures</td>
</tr>
<tr>
<td>Cooperation with Universities</td>
</tr>
<tr>
<td>Cooperation with Industry</td>
</tr>
<tr>
<td>Memberships</td>
</tr>
<tr>
<td>Publications</td>
</tr>
<tr>
<td>Patents and Inventions</td>
</tr>
<tr>
<td>Advisory Board</td>
</tr>
<tr>
<td>Contacts</td>
</tr>
<tr>
<td>Imprint</td>
</tr>
</tbody>
</table>
Dear readers,

Deserted corridors instead of hustle and bustle, a cleanroom in emergency mode, the faces of colleagues hidden away: an extraordinary year, one we’re unlikely to forget in a hurry, has come to an end. Implementing the many changes needed, continually adjusting to new circumstances, was the order of the day, both at home and in the workplace. Looking back, we met most of these challenges amply, but »normal« remains a long way off.

Although we dearly will not bid farewell to the Corona pandemic in 2021, other societal issues also demand our attention. Issues like continuing to ensure the possibilities of microelectronics are harnessed, or developing eco-friendly technologies and efficient resource usage.

Microelectronics can make a tremendous contribution. Be it in quantum technologies, next-generation computing, 5G / 6G technologies, artificial intelligence or bioelectronics – new principles and technologies have to be developed and optimized.

A multitude of outstanding project results again testify to the capabilities and collective expertise of the Fraunhofer IZM team. We are also researching microelectronics solutions for combatting the Corona virus, including with 2-megapixel sensors, UV rapid sterilization of FFP3 face masks and a platform for the development of innovative treatment strategies. Just some of our results include:

- An innovative, miniaturized LiDAR system was developed for robotics, representing a significant step forwards in deploying extreme miniaturization to advance system integration technologies.
- PCB embedding was applied in 5G / mm-wave technology.
- Photonic sensor systems, as technology solutions highly complex and energy-efficient in equal measure, were implemented for monitoring of manufacturing processes used for composite materials.
- The system integration value-added chain was extended to include innovative »system-on-a-chip« and »system-in-package« solutions on wafer and substrate levels. An example of this is the high-sensitivity medical diagnosis platform based on 3D graphics.
- Fraunhofer IZM’s system integration strategy was extended to include the Chiplet approach.
- Biomedical applications, such as biocompatible embedding of thin ASICs in flexible substrates, were developed.
- Using the investments from the »Research Fab Microelectronics Germany«, technologically optimized, resource efficient and industry compatible process lines and support services for product manufacturing were achieved.

In parallel to the considerable changes to the institute’s operations, for example, with online meetings becoming the rule, rather than the exception, Fraunhofer IZM also saw a number of structural highlights in 2020, a few of which we’d like to present here:

- Electronics Goes Green 2020+ went hybrid with more than 250 participants last year, setting new benchmarks for the conference.
- We celebrated 10 years of Fraunhofer IZM ASSID as an online event.
- The establishment of »Research Fab Microelectronics Germany«, in which Fraunhofer IZM is included as partner, led to a number of overarching cooperations and successful projects.
- The International Panel Level Packaging Consortium 2.0 entered its second round.
- The high performance centers »Functional Integration in Micro- and Nanoelectronics« in Dresden and the Berlin Center for Digital Transformation were extended into Phase II.
- The Fraunhofer IZM satellite in Cottbus began its extended research and development program: first projects as part of the iCampus initiative, including a medical 60-GHz radar for contactless monitoring of vital parameters, have already been carried out.
- Fraunhofer IZM also took center-stage again in terms of public outreach, with its hugely boosted profile across all relevant social media channels particularly striking.
- The blog REALIZM gained a sustainable, loyal following in all relevant social media channels.
- The international Panel Level Packaging Consortium 2.0 went hybrid with more than 250 participants last year, setting new benchmarks for the conference.

We would also like to extend our sincere thanks to our partners from industry and research, funding bodies and funding administrators at federal and Länder levels, as well as to our supporters in associations and committees.

Above all, however, we’d like to take this opportunity to personally express our appreciation for all our team members, who bravely faced the year’s challenges with squared shoulders, and without whom the excellent development of the institute would not be possible. Particularly in light of the exceptionality of the year 2020, we want to extend our heartfelt gratitude to you all for your steadfast support, continual efforts and loyal collegiality!

We hope you all find inspiration, new ideas and enjoyment in reading this edition of our annual report and look forward to our future cooperation.

Stay healthy, stay safe – kindest regards,

Prof. Dr.-Ing. Dr. sc. techn. Klaus-Dieter Lang
Head of Fraunhofer IZM (managing)

Prof. Dr.-Ing. Martin Schneider-Ramelow
Head of Fraunhofer IZM (acting)

All this led to our being able to end 2020 on a successful note, despite the pandemic. Particularly in uncertain times, creating new ideas, maintaining a robust customer portfolio and having stable cooperations available is paramount to ensure downtimes can be compensated and that a perspective for moderate growth in the future is possible. Our thanks here go also to the other research institutes like the Research Center for Microperipheric Technologies at the TU Berlin, but also the TU Dresden, the Brandenburg University of Technology (BTU) Cottbus-Senftenberg and the HTW Berlin – all essential partners in aspects of basic science and early career support.

Above all, however, we’d like to take this opportunity to personally express our appreciation for all our team members, who bravely faced the year’s challenges with squared shoulders, and without whom the excellent development of the institute would not be possible. Particularly in light of the exceptionality of the year 2020, we want to extend our heartfelt gratitude to you all for your steadfast support, continual efforts and loyal collegiality!

We hope you all find inspiration, new ideas and enjoyment in reading this edition of our annual report and look forward to our future cooperation.

Stay healthy, stay safe – kindest regards,

Prof. Dr.-Ing. Dr. sc. techn. Klaus-Dieter Lang
Head of Fraunhofer IZM (managing)

Prof. Dr.-Ing. Martin Schneider-Ramelow
Head of Fraunhofer IZM (acting)
CORE COMPETENCIES

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

With more than 440 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 start-ups can choose the approach that best suits their needs – from easily accessible standard technologies through to high-end disruptive innovation. As partners, our customers profit from the advantages of contract research, by selecting between exclusive release of a product innovation, improving a workflow or qualifying and certifying a process.

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

Project funding
Some development challenges require pre-competitive research. In these cases, teaming up with companies and research institutes and public funding support is more effective than operating solo. The Institute cooperates closely with numerous universities, including the Technical Universities of Berlin and Dresden and the BTU Cottbus-Senftenberg, to ensure that the preparation for future cooperation with industry is optimal.

FROM WAFER TO SYSTEM
HETEROINTEGRATION: CUTTING THROUGH OLD PARADIGMS

Heterogeneous integration increases not only the degree of miniaturization, but also the functional density of microelectronics. This approach is regarded a potential solution for companies in a vast range of industries, vying for competitive advantages in their market and trying hard to stay cost-effective. Heterogeneous integration is addressing this challenge from another paradigm – instead of pushing for smaller and smaller structures (»More Moore«), here system functionalities from different manufacturing approaches other than, but also including, CMOS, are in its focus (»More than Moore«). In contrast to a monolithic system-on-chip, this approach puts as many functionalities as possible into one single device, which may either be a 3D-integrated silicon device (3D chip) or a system-in-package (SiP), which typically is not limited to silicon as a core material. While – clearly – SoC offers highest scalability for large volumes, the concept is inherently limited in its functional complexity to functions that can be built together in the same or highly compatible manufacturing processes. If, for example, functions from different manufacturing environments (III-V semiconductors, MEMS- or integrated passive components) are combined into a systemic function, this approach is bound to fail.

for the heterogeneous integration of 3D chips individual functional components are mounted on a thin silicon substrate, before their backside contacts are interconnected on a high-density interposer by means of so-called through-silicon vias (TSVs). Ultra-fine-pitch flip chip bonding is the pacesetter for this kind of small form factor integration.

This kind of side-by-side integration can use e.g. sensor chips, communication chips, or control and number crunching chips for doing some upfront calculations of the sensor parameters (»embedded AI«), prior to sending the data to cloud storage. Besides silicon interposer technology, the fan-out packaging (FO) concept is emerging as a platform technology, eventually replacing a large percentage of the > 1000 package types on the market. Technological questions, however, persist – e.g. how to deal with different functionalities which all require a different set of design guidelines, or how to interconnect and how to interface with the other elements in a heterogeneous concept. And not least among them: How to test these sizes with the high functional densities, also across domains beyond just electrical signals, e.g. photonic or even biochemical signals.

As Fraunhofer IZM positions itself at the forefront of technology for heterointegration, the Institute has been involved in one of the biggest efforts of the IEEE-ECSC community in the past 10 years, answering the roadmapting needs of this dynamically evolving field.

With players from R&D and industry, 22 technology working groups were formed and assigned their respective tasks in the matrix, covering possible areas of application from medical, safety, and security to automotive, power, and so on. Fraunhofer IZM has taken over a leading role for the SiP integration activities of the roadmap, with a list of prospective technologies that the industry can use as a toolbox for the near future.

In May 2020, Fraunhofer IZM-ASSID in Dresden celebrated its tenth anniversary. This decade has seen IZM-ASSID transcend the borders of Germany with its achievements in the field of wafer level system integration, especially 3D integration, and become a globally renowned R&D partner.

Thanks to the support it has received from the Federal Ministry of Education and Research and the Free State of Saxony, a research and development pilot line for wafer level packaging and 3D integration (8”/12”) was implemented in Dresden in 2010, and ever since then it has benefited from ongoing further development. Through its global collaboration with system users and plant and material manufacturers, IZM-ASSID has become one of the leading providers in the field of heterogeneous wafer level system integration, the scope of which extends from the development phase through to qualified low volume manufacturing.

3D Integration for tomorrow’s products
The IZM-ASSID has developed and prototyped wafer-level packaging and system integration technologies to enable 3D integration with through-silicon vias (TSVs). The modular approach of the systems is needed wherever small, energy-efficient and highly functional electronics are important. The focus is on technologies and materials for systems that combine several electronic components in miniaturized form, i.e. medical devices or applications in safety and automation technology and the automotive industry.

Research at industry level – With ISO certification
In April 2020, the International Certification Group (ICG) certified the IZM-ASSID’s management system for «research, development, and services in electronics packaging». This certification marks another important milestone for the IZM-ASSID’s provision of professional client-specific process development services.

IZM-ASSID will continue along this route as part of Fraunhofer IZM in future in order to develop and implement outstandingly successful scientific and technical solutions for the challenges of a digitalized society in the spheres of IoT, AI and HPC. IZM-ASSID would like to thank all its partners in industry, science and politics for the confidence they have shown and for the successful collaboration.
The »System Integration and Interconnection Technologies« (SIT) department is the largest in the institute. Its work focuses on heterogeneous system integration. The combination of various materials, devices, and technologies opens up a wide range of application areas such as medical engineering, automobile production, aviation, industrial electronics, or communication technology. Highly integrated electronic and photonic systems, modules, and packages are developed and manufactured for specific individual requirements. The complete value creation chain of the individual products from conception, design, and technology development to industrializable production is covered. The department focuses on the design, implementation and analysis of power electronic and photonic systems.

Our scope of services includes, for example:

- Electronic and photonic circuit carriers: multilayer conventional, rigid, and flexible printed circuit boards, partly with integrated components; mold packages with rewiring; integration of optical waveguides in printed circuit boards
- Conformables: stretchable, thermoplastic, and textile assemblies
- Assembly: high-precision chip placement, automated SMD assembly, flip-chip technology, automated optical fiber coupling, and micro-optics assembly
- Interconnection technologies: soldering, sintering; transient liquid phase bonding (TLPB) and bonding of components; micro-optics and chips; wire and ribbon bonding; galvanic metal deposition and sputtering; screen printing, stencil printing, and contactless material dosing by jets; application of polymer lenses; integrated optical waveguides in thin glass; development of new interconnection technologies
- Encapsulation: embedding in printed circuit boards; transfer and compression molding; potting and protective lacquering; underfilling and glob-top
- Processed materials and techniques: fiber composites; encapsulation compounds; soft solders, sintered materials; glass structuring; mechanical and chemical metalworking

Our employees' many years of experience in combination with state-of-the-art equipment for processing large-format manufacturing in the entire production process (610 x 457 mm²; 18" x 24") is unique worldwide. Approximately 2,500 m² of laboratory space are available, 600 m² of which are cleanrooms of ISO classes 5-7. Here, the production of complex electrical or photonic circuit carriers, the assembly of components on and embedding in circuit carriers or housings, as well as the bonding and encapsulation of the components, is carried out.

The finished systems are electrically and mechanically tested and evaluated. For documentation and analysis purposes, we use imaging techniques for structure resolution down to the nm range, optical function measurement techniques, and chemical analysis down to the sub-ppm range.

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 60 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 stacking
- Wafer-level packaging and fine-pitch bumping
- 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 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 technological know-how is focused on the following areas:

- Heterogeneous wafer-level system integration
- 3D wafer-level system in package (WLSIP, 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 bump or pillar (Cu, SnAg, CuSn, Au, AuSn)
- Pre-assembly (thinning, thin wafer handling, laser grooving, laser dicing, plate dicing)
- 3D assembly (22D, 2D, W2W)
- 3D wafer-level stacking
- Wafer bonding (adhesive, soldering, direct)
- Direct bond interconnects (DBI) – W2W (12")
- 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.
ENVIRONMENTAL & RELIABILITY ENGINEERING

New microelectronics systems have to cope with more demanding functional requirements and working conditions. At the same time, they are expected to be cost-efficient and environmentally friendly in production and in active use. The «Environmental and Reliability Engineering» department supports new technical developments on their way to the market with environmental performance and reliability checks ranging from nano-characterization to system-level evaluation and optimization.

The department offers services in the areas:

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

With an interdisciplinary team processes and models are developed and applied that enable our partners to integrate environmental and reliability relevant criteria in the design and development process. We thus help to identify weak points and potentials at an early stage during the introduction of new technologies, materials, processes, components, and applications and to react appropriately.

Stemming the tide of electrical and electronics waste and reducing our carbon footprint. More and more companies are committing themselves to finding innovative and sustainable solutions, for which they turn to the professional advice and services of Fraunhofer IZM.

The environmental footprint of actual products and of the fundamental technologies that make them possible has gained considerable salience in the industry, where improvements are being pursued on a much broader front. Increasingly stringent standards and environmental specifications have gained new relevance even for smaller-scale enterprises and suppliers who might not yet have set themselves any particular climate or 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, in some cases tailored specifically to the given use case, offer new pointers for optimization to achieve the new reliability standards expected in the supply chain and in actual use.

RF & SMART SENSOR SYSTEMS

What do so seemingly unrelated applications like radar sensing, 5G, 60 GHz communication systems, or autonomous sensors have in common? With regard to research and development they share a common technological background: large bandwidths, robustness, and a commitment to maximum energy efficiency are the defining criteria. 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 co-design) 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, and components (up to 220 GHz)
• RF system integration and module design, with due consideration for signal and power integrity
• Development of micro batteries, power supply, and power management systems
• Design and implementation of self-sufficient wireless sensor systems for industrial use
• Tools for the optimized design of microsystems and server-client software architectures

The work of the department is characterized by its effective combination of the practical insights won from our many successful projects, our extensive range of state-of-the-art equipment, our wealth of experience with modelling tools, and our unfailing dedication to a systematic approach.
The Fraunhofer-Gesellschaft is headquartered in Germany, is the world’s leading applied research organization. With its focus on developing key technologies that are vital for the future and enabling the commercial exploitation of this work by business and industry, Fraunhofer plays a central role in the innovation process. As a pioneer and catalyst for groundbreaking developments and scientific excellence, Fraunhofer helps shape society now and in the future. Founded in 1949, the Fraunhofer-Gesellschaft currently operates 75 institutes and research institutions throughout Germany. The majority of the organization’s 29,000 employees are qualified scientists and engineers, who work with an annual research budget of 2.8 billion euros. Of this sum, 2.4 billion euros is generated through contract research.

Research Fab Microelectronics Germany
Fraunhofer IZM and its 12 partners have been operating the nationwide distributed Research Fab Microelectronics Germany since April 2017. More than 2,000 scientists from the Fraunhofer Group for Microelectronics and the Leibniz Institutes FBH and IHP make the FMD the largest world-leading R&D alliance for micro and nanoelectronics. Established to promote active research and development at its sites across Germany, the FMD began its final ramp-up in 2020. Most of its approx. 350 million euros in financial support from the German Federal Ministry of Education and Research (BMBF) went into modernizing the equipment and facilities of the 13 constituent institutes. Another common thread in the FMD’s strategic development over the course of 2020 was the production and adoption of a concept to ensure the ongoing operation of the research fab beyond the end of the original project period.

In addition to its range of services for its clients in industry, the FMD also offers a wide variety of cooperation opportunities for its partners in science and academia, including joint work in collaborative projects or joint labs operations. The services extend to the opportunity to test concepts from fundamental research for their applicability in real-world use cases. Past cooperation projects between the FMD and academic partners include the ASCENT+ project, the »iCampus« research collaboration, and the Joint Smart Beam-Lab in Duisburg.

Centers of Excellence
The goal of the »Functional Integration for Micro- / Nanoelectronics« Center of Excellence is above all to support SMEs in Saxony with sensor and actuator technology, measurement technology, and mechanical engineering and construction by rapidly transferring research results into innovative products. The Fraunhofer institutes ENAS, IIS, IPMS, and IZM, as well as the TU Dresden and Chemnitz and the HTW Dresden are also members. The Berlin Center for Digital Transformation is a cooperation between the four Berlin Fraunhofer institutes FOKUS, HHI, IPK and IZM. Its work focuses on technologies and solutions that advance increasing digitalization and networking in all areas of life.

Business Units & Industry Sectors
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.
Assembly of highly miniaturized electronic modules by embedding components in PCB substrates

The increasing functional density of electronic modules enables the development of new and increasingly complex applications. To meet these challenges, advanced PCB technologies are being investigated to allow the flexible manufacturing of highly integrated multi-components, packages, and modules. The best miniaturization potential can be achieved by embedding unpackaged or passive ICs. One alternative would be the embedding of SMD components, which allows a large number of commercially available components to be used and opens up the technology for a wide range of applications.

Wafer-level packaging for hermetic vacuum capping of infrared sensors

In the European project APPLAUSE, Fraunhofer IZM is investigating technologies and processes for the wafer-level packaging of micro bolometers on 200 mm wafers. The process development involves the creation of silicon cap wafers for the hermetic vacuum encapsulation of the large MEMS pixel array structures (FPA) created by the project partners. Two package topologies are being compared for this purpose: a single wafer cap over the bolometer wafer, and a compound lid consisting of a silicon frame and flat lid.

The technological evaluation of the overall packaging process involves the combination of different technologies, including silicon etching, electrodeposition of gold-based bonding rings (also on the bolometer side), wafer bonding with AuSn transient liquid phase bonding for permanent hermetic vacuum encapsulation, and the integration of an anti-reflective coating for improved optical performance.

Structure of power electronics – planar connections

In addition to die-attach – the planar connection of power semiconductors – two-dimensional connections to cooling units on the next level are also decisive for the performance and reliability of power electronic modules. There are essentially two technologies available for these two-dimensional connections, which can be up to a few square centimeters in size: soldering or silver sintering. These come with challenges, one relating to bulges occurring in the large-area interconnect partners and others relating to the three-dimensional design of the cooler structures. The latter must be taken into account in particular when setting the temperature profiles during soldering. In silver sintering, ensuring uniform contact pressure is particularly crucial.

3D radar sensors for autonomous cars without blind spots

For automated driving to become truly secure, Fraunhofer IZM researchers teamed up with their project partners on the KoR-Rund project to develop 3D radar modules that can be positioned relatively freely on the vehicle and integrated into a sensor network to enable a 360° all-round view. The vehicle’s surroundings can be analyzed in real time and simultaneously from all perspectives. To enable this seamless mapping of the vehicle surroundings, the scientists developed packaging methods for reliable radar sensors with revolutionary free-form surfaces that allow any antenna shape and mount on the vehicle to be realized in the future. The IZM researchers were instrumental in simulating, building, and testing the mold technologies for the 3D radar sensor technology.

The project is co-funded by the Federal Ministry of Education and Research BMBF.

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 vs. Corona campaign
The COVID-19 pandemic of 2020 figured prominently not only in all of our lives, but also in research. Fraunhofer scientists were involved in numerous projects to combat the pandemic, with the following activities a brief selection of IZM’s contributions to Corona research.

Corona rapid test in less than 2.5 hours
After a development time of only six weeks, Bosch launched a new rapid test in March 2020 that produced results at the test site in under 2.5 hours, instead of the two days needed beforehand. The technical solution was based on a PoC analysis platform developed with Fraunhofer IZM as part of the EU project CAJAL4EU. The main goal of the project was to develop miniaturized biosensor technology platforms that enable fast, robust, user-friendly, and cost-effective multi-parameter in-vitro testing applications.

High-resolution x-ray cameras for SARS-CoV-2 research
Free electron lasers, as installed at institutes like DESY in Hamburg or SLAC in the U.S., are used to investigate the structures of chemical bonds or molecules. For this study, a special high resolution x-ray camera allowed an international team of researchers to successfully investigate the protease structure of the SARS pathogen in liquid water. In contrast to cryogenically cooled samples, the method makes it possible to investigate chemical bonds at near body temperature. Fraunhofer IZM contributes silicon pixel chip modules, which are assembled into a complete x-ray detector. Four electronic readout chips are flip-chip-bonded onto a silicon sensor chip at a size of 13.5 cm². The complete epix10k2M detector consists of 16 such modules with 2 million x-ray sensitive pixels in total.

BEAT-COVID – new therapies against the pandemic
On the BEAT-COVID project, Fraunhofer researchers from several institutes are developing independent and novel therapy strategies on the basis of platform technologies that can power the rapid and targeted development of new drugs against the as yet unknown pathogens that may emerge in the future. Fraunhofer IZM is helping Fraunhofer ITEM improve its professional in-vitro technologies (P.R.I.T.), a system in which cell cultures can be directly exposed to aerosols, such as COVID-19, or other antiviral drugs, in a defined environment to monitor their reaction. The IZM researchers are working on ways to enable the evaluation of cell viability in-situ – i.e. while the cells are still exposed to the aerosols in the P.R.I.T. box.

Graphene-based rapid infection diagnostics
Fraunhofer IZM researchers are working with project partners from industry and healthcare to develop a convenient graphene oxide sensor platform that makes it possible to detect acute infections, such as sepsis, or antibodies to the coronavirus in just a few minutes. The special feature of the sensor platform is its choice of materials: Graphene oxide is unique in that it is an electrically conductive and biocompatible material that allows particularly reliable sensor performance. Its use in microelectronics has so far been restricted to its original 2D form. However, Fraunhofer IZM researchers are now applying it in 3D flake structures. This three-dimensional shape increases the measurement area and improves the accuracy of the measurements.

The project is co-funded by the Federal Ministry of Education and Research BMBF.
Hermetic wafer level capping for MEMS packaging
Fraunhofer IZM has established a new wafer level capping technology for hermetic or quasi-hermetic first-level device sealing. The technology is based on cap structures with bond frames and optional recesses on temporary carrier wafers, subsequently transfer-bonded to the device wafer. The bond frames and cap outlines can be defined with near-complete freedom by mask aligner lithography and related patterning processes. This means that arbitrary cap structures with irregular forms, sizes, and pitches are possible. The bond frames can be made of adhesives, metals, or solders to provide purely mechanical or air-tight device sealing on the target wafer.

Glass interposer concepts for the cost-efficient realization of custom applications
Fraunhofer IZM has developed a generic glass interposer concept for different via diameters and wafer designs based on fixed TGV positions and geometries. These technologies allow the fast and cost-efficient realization of customer-specific applications. Compared to silicon interposers, glass interposers have numerous advantages: the dielectric materials promise very high signal integrity, a low dielectric loss in the high-frequency range as well as less impact of cross-talk. The concept can serve the entire process chain: 100 GHz concept, design, simulation, realization, and characterization.

Novel technology for motor inverters with record power density
Two ECPE Lighthouse projects have revealed how the power density of industrial converters with an output of 63 kW can be increased by a factor of 4 by using semiconductors based on silicon carbide. The volume of the systems could be reduced with a new ultra-low-inductance power module that gets the most out of the semiconductors’ properties to achieve a high switching frequency of 140 kHz and allow the passive components to be shrunk down. Furthermore, a novel EMC filter topology and improvements to the semiconductors controls lowered the loss potential of the components with high ripple currents, which again helped shrink the size of the heat sink in particular.

Low-inductance SiC power module with conventional packaging and interconnection technology
In the Speeddrive project, a semiconductor module was developed for use in the turbine converters of biogas plants with three-phase alternating current, modelled on an Infineon IGBT module in terms of its housing, the arrangement of electrical pin contacts, and the overall size of the module. Replacing the IGBT chips with SiC chips allows for faster and thus lower-loss switching, resulting in increased switching frequency at the system level. To increase the nominal power of modules without compromises on their size, insulation ceramics with particularly good thermal performance were chosen to improve heat dissipation away from the chips.
Glass interposer technology for high-frequency applications

As part of the publicly funded (BMBF) joint project GlaRA, radar sensors were developed to be especially suitable for smart industry and process measuring applications due to their excellent distance resolution, accuracy, beam focusing capabilities, and overall tiny dimensions. This feat was made possible with a robust glass interposer technology for broadband mm-wave modules for frequencies above 100 GHz, which was used to construct and characterize system-in-package (SiP) designs. Fraunhofer IZM has developed an industry-ready process for glass via metallization with high aspect ratios. A wafer bonding process (for wafers with max. 300 mm diameter) hermetically packages the assembled components by connecting two glass wafers, fitted with the required vias and cavities.

Hybrid integrated glass benches for photonics

Optical systems can be built with combined electro-optical components and electronic controls using laser-structured and thin-film metallized glass benches. Thin glass is also used in custom-shaped fittings to enable their automated assembly with industrial alignment systems on six axes, with less than one-micrometer accuracy. This allows high-quality optical beams to be shaped and coupled to perform optical measuring tasks. With the concept capable of working with large-format panels, it can scale perfectly in terms of the size and number of systems and individual thin-glass packages produced.

ZeroPower construction kit for sensor applications

The Fraunhofer flagship project ZEPOWEL is making progress towards a more resource-efficient Internet of Things, courtesy of extremely energy-efficient and modular hardware. The project works on IoT nodes that consume significantly less energy themselves, while also pursuing energy savings in how these nodes network with each other. An IoT core developed for the project at Fraunhofer IZM enables the connection of a wide variety of IoT modules. Intelligent algorithms optimize the available resources through dynamic power management during runtime. A consistent hardware-software co-architecture has been shown to reduce energy consumption by a factor of 5 compared to the current state of the art.

High-performance modular system for sensor applications

The Berlin Center of Excellence has given birth to SWARM, an IoT device developed for tough industrial use with a focus on versatile applicability and fast and simple configuration. Its modular architecture allows the features and functions of the system to be leveled up with standard market sensors and helps make the IoT device operational in record time. The SWARM devices can also be connected to a distributed network for synchronized measurements at different locations, and actuators can be controlled with the integrated interfaces. The IoT device is readily accessed via Bluetooth using an Android app or Python application; its data can be stored and processed locally or in the cloud.

In recent years Fraunhofer IZM’s industrial electronics specialists have concentrated on the visionary concept of Industrie 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. Industrie 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.
Drop tests with high-speed cameras for mobile systems
The lifespan of electronic devices such as smartphones can be significantly shortened by accidental drops. As consumers demand more sustainable products, tests need to be developed to assess how robust products are in practice. Fraunhofer IZM offers a comprehensive range of reliability tests, including methods for testing robustness against mechanical shocks. The tumble test now adds simulated random drops to its range; the tester allows repeated random drops from two heights (50 cm and 1 m). A high-speed camera and lighting equipment enable an accurate analysis of the fall dynamics and the moment of impact and help pinpoint potential design improvements.

Beyond 5G
Setting up a European value chain for the production of radio frequency modules for next-generation mobile communications is the stated goal of the European Beyond5 project. Based on SOI technology, the project intends to create a European technology platform for communication and sensor modules to support applications like mobile broadband (5G), the Internet of Things (IoT), or connectivity for autonomous vehicles. Fraunhofer IZM is collaborating with its partners on the development of a 5G communication and a 77 GHz radar module. Building on the proposed assembly concept, the work includes the specification, design, and construction of the antennas and packages, supplemented by work on material characterization and the testing and reliability characterization of the finished modules.

Tests for robust and durable electronic end devices
The fundamental technical prerequisites for electronics to enjoy long service lives are robustness, durability, and repairability, properties that consumers need to be able to understand and compare. Test approaches are being developed to enable this as part of the EU PROMPT project. PROMPT stands for »Premature Obsolescence Multi-Stakeholder Product Testing Programme; the project is planned for a duration of four years and is coordinated by Fraunhofer IZM. Its aim is to develop an independent testing program that helps estimate the life expectancy of products as they come to market. The focus for Fraunhofer IZM lies on rechargeable batteries, general electronics, and mobile devices.

Modular bodies as a case study of ecodesign
Modular product design enables longer product lives, facilitates repair and reuse, and can thus contribute to more sustainable product concepts. Several lifecycle assessments of individual technologies, such as embedding components, connectors, or smartphones, have revealed the considerable environmental potential of manufacturing modular devices. However, only if usage habits change towards longer use will the added expense of modular design pay off. Under certain conditions, embedding technology can help improve the environmental footprint of smart devices.

Long-length monomodal waveguides in thin glass
Fraunhofer IZM has succeeded at taking an important step for process development of electrical optical circuit boards (EOCBB) in optical data transmission at the level of circuit boards. The fabrication process for single-mode optical waveguides in large-format thin glasses has improved transmission characteristics and process homogeneity to reduce propagation losses to $(0.059 \pm 0.001)$ dB/cm. These results published at ECTC 2020 are promising for several current trends, including functionalized glass as an attractive substrate candidate for co-packaging, which should enable more efficient data processing in data centres.

Drop tests with high-speed cameras for mobile systems
The lifespan of electronic devices such as smartphones can be significantly shortened by accidental drops. As consumers demand more sustainable products, tests need to be developed to assess how robust products are in practice. Fraunhofer IZM offers a comprehensive range of reliability tests, including methods for testing robustness against mechanical shocks. The tumble test now adds simulated random drops to its range; the tester allows repeated random drops from two heights (50 cm and 1 m). A high-speed camera and lighting equipment enable an accurate analysis of the fall dynamics and the moment of impact and help pinpoint potential design improvements.
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 300 mm):
- Cu-TSV integration (via-middle and via-last-processes)
- Silicon and SiC plasma etching – DRIE (TSV, cavities)
- Thin-film deposition (sputter, CVD, photolithography (resolution up to 0.5 µm), 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)
- Wafer-level bonding (Cu-Pillar, SnAg, Ni, Au, In, AuSn)
- 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 measurement system (200/300 mm) for layer thickness, topographies, roughness as well as TTV/warpage/bow
- Fully automated electric wafer measurent system

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 layers can be applied and developed after exposure. Track geometries with down to 2 µm width are under development.

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. 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.
- Molded encapsulation process
- Ultrasonic bonding of SiPs
- Process simulation and analysis of material models
- Transfer to industrial production is guaranteed due to use of production equipment.

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/AISi1 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

Photonic Lab
- Laser structuring of glass layers with optical waveguides for electro-optical boards (EOCB)
- Shack-Hartmann-characterization of micro lenses and micro lens 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

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
- Molecular-dynamic simulation

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

Power Lab
- Testing of hetero highly integrated of 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-Perot 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/BER to 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 (Q2Z)
- Thermo-mechanical Reliability Lab
- Thermal & Environmental Analysis Lab
2020 was a year lost to the COVID-19 pandemic. To contain the spread of the virus, people were prevented from gathering in groups, a decision taken in the interest of public health that brought massive repercussions for the event sector in its wake. After many events were postponed or cancelled outright after the initial shock, the industry soon realized that novel solutions had to be found and new paths had to be taken. Fraunhofer IZM was very quick out of the starting gates with its choice to move conferences and workshops into the virtual realm, and the decision was rewarded with some extremely positive experiences in return. The picture was less positive for tradefairs and exhibitions, which are harder to transition to online formats. The search for a truly satisfactory solution for our clients, partners, and other interested parties is still very much active.

Even with online services and formats allowing us to stay in contact even in these difficult times, we are sincerely looking forward to the next opportunity – very soon – to meet you all in person again.

Consortium Meeting PLP 2.0

After the international Panel Level Consortium 1.0 achieved its ambitious goals for the project in 2019 with significant technical progress in the field of large-area fan-out panel level packaging, a new consortium has been formed to continue on that trajectory. The PLC 2.0 consortium is dedicated to exploring new opportunities for higher wiring density, made possible with more granular wiring geometries at a 2 μm scale. This includes new research into copper migration, the displacement of embedded components, and warpage on large-area panels.

While the kick-off meeting in early 2020 could still be held in person at Fraunhofer IZM in Berlin, later meetings and interactions had to move to the digital realm. This did not, however, stop the individual sites from making progress towards their ambitious goals.

Electronics Goes Green 2020+: Recycling management and CO₂ neutrality in production chains

For the sixth time, Fraunhofer IZM organized the world’s largest conference on sustainability in electronics in September, which had to be held online for the first time due to the COVID-19 pandemic.

250 participants had the opportunity to watch pre-recorded presentations on an online platform created especially for the conference and to participate in a virtual live event on September 1. Eelco Smit, Senior Director Sustainability at Philips, opened the live event with his keynote speech on “Best Practices in Sustainability – What Can We Learn?”. In his presentation he introduced the Philips Sustainability Program, which is developed every five years. In the afternoon Sarah Chandler, Senior Director of Operations Product Development and Environmental Initiatives, presented Apple’s roadmap up to 2030 and explained that the company wants to achieve zero CO₂ emissions in the manufacture of its products in ten years at the latest. In addition to the two keynotes, the live day featured six interactive sessions and an exciting panel discussion on the topic of “Recycling as Circular Economy?”. Even the exchange and networking with like-minded participants was possible thanks to numerous options on the online platform.
Online series «IZM Photonics: In Glass We Trust»
2020 was also a year of ad-hoc meetings and digital get-togethers to keep in touch with clients and partners. The first series of these meetings, organized specifically with this in mind, was all about photonics packaging. In the 45-minute sessions, we show what is possible with glass in this area and how participants can use the findings for their industry or in joint projects. The first session was attended by more than 50 outside guests, a figure that rose to almost 100 bookings for the second session. There is already great interest in revising the format in 2021.

No more excuses: EU Commissioner Frans Timmermans underlines that effective recycling of high-tech plastics is possible

More than 200 international participants joined the virtual workshop «Circular Product Development – The Secrets to Design for and from Recycling» on April 15, 2021, which took place within the framework of the EU project PolyCE. The experts from the PolyCE consortium presented their experiences and findings on the holistic circular economy for high-tech plastics as well as best-practice strategies developed in line with the motto «Design for Recycling». An additional highlight was the appearance of Frans Timmermans, Commissioner for Climate Action and Vice President of the EU Commission, who is responsible for the Green Deal. He was given the opportunity to present the European Union’s programme for improving data communication.

Fraunhofer IZM was in force at two of these sessions. Dr. Henning Schröder joined Wojciech Gaziewicz of Corning Optical Communications GmbH & Co. KG to introduce the first set of seminars on «Innovative Fibre-Optics – Part II», welcoming speakers from Spain, Poland, Israel, and – of course – Berlin. With around 250 attendees from around the world, the session covered new requirements for optical fibres, optical mode adjustment, spectral losses, mechanical robustness and performance reliability, connector designs, and production and packaging technologies.

On day 2, the team of the European Horizon 2020 2020 project MASSTART hosted a special webinar to introduce all project partners and their current progress with their project. Fraunhofer IZM heads the consortium under the careful management of Tolga Tekin, pursuing the ambitious goal of reducing costs for mass-produced photonic high-speed transceivers to €1Gbit/s or even lower. Again, almost 250 viewers were logged in, and all presentations were recorded and are available for viewing on the project’s website https://masstart.eu/.

IMAPS Workshop for System Integration with over 200 participants

Extremely small and powerful components can be created through system integration. But how can the great challenges of different technologies, sizes and materials, as well as electrical and mechanical connections and reliability, be mastered? Fraunhofer IZM answered these questions together with its colleagues from Fraunhofer USA at IMAPS 2020. More than 200 participants watched the presentations of the internationally renowned Fraunhofer experts and exchanged ideas in live Q&A. This workshop was part of this year’s IMAPS 2020, 53rd Symposium on Microelectronics: www.imaps2020.org.

Seminar «Reliability of Electronic Systems»
As innovation cycles keep accelerating and introducing even more complex and demanding requirements for electronic components and systems, reliability assessments are becoming more and more important. The two-day «Reliability of Electronic Systems» seminar is hosted annually and was again organized by our Environmental and Reliability Engineering team. Even with the limitations of an online format, the Fraunhofer IZM researchers made clever use of interactive opportunities, such as shared whiteboards or small-group discussions, to introduce the audience to relevant methods and tools that can be integrated in the regular electronics product development process. The audience was particularly excited about the potential of condition monitoring as part of a circular economy concept.

Selection of events organized by Fraunhofer IZM

<table>
<thead>
<tr>
<th>Event Title</th>
<th>Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panel Level Packaging 2.0</td>
<td>February, Berlin</td>
<td></td>
</tr>
<tr>
<td>Workshop: Ecodesign Learning Factory</td>
<td>March, Berlin</td>
<td></td>
</tr>
<tr>
<td>Lab Course: EMC Optimized Design</td>
<td>March, Berlin</td>
<td></td>
</tr>
<tr>
<td>Workshop: Wide-Bandgap User Training</td>
<td>September, hybrid</td>
<td></td>
</tr>
<tr>
<td>Electronics Goes Green 2020+</td>
<td>September, online</td>
<td></td>
</tr>
<tr>
<td>Session: Data Center Interconnects</td>
<td>October, online</td>
<td></td>
</tr>
<tr>
<td>Workshop: Parasitic Effects in Power Electronics</td>
<td>October, online</td>
<td></td>
</tr>
<tr>
<td>Online Course: From Wafer to Panel Level Packaging</td>
<td>October, online</td>
<td></td>
</tr>
<tr>
<td>Webinar: In Glass We Trust</td>
<td>November, online</td>
<td></td>
</tr>
<tr>
<td>Compliance and Environmental Management in the Electronics Industry</td>
<td>November, online</td>
<td></td>
</tr>
<tr>
<td>Workshop: Reliability of Electronic Systems</td>
<td>November, online</td>
<td></td>
</tr>
</tbody>
</table>

1. EU commissioner Frans Timmermans and the PolyCE consortium’s recommendations
2. Always at your (virtual) service – IZM’s professionals at the Fraunhofer Solution Days
3. One of 2020’s last in-person conferences – the 3D Systems Summit
Financial situation
2020 saw a continuation of the positive performance of the previous year, with revenue increasing by a further 5.4 percent to a sum of 37.6 million euros over the course of the year. The Institute covered 75.8 percent of its operating budget from outside revenue. External projects accounted for 28.5 million, representing a two-percent increase over 2019.

The share of publically funded projects increased by a full eight percent to 14.1 million euros. Beyond this, direct industry commissions represented 38.4 percent of the Institute’s budget, with the total amount of 14.4 million euros unchanged from the previous year.

Hardware and equipment
In 2020, a sum of 1.6 million euros was invested for regular equipment replacement and refurbishment. These investments were made in a number of targeted individual interventions to upgrade the technical facilities and improve the efficiency of existing equipment. Another 1.4 million euros was dedicated to a range of smaller construction projects, mostly for the modernization and expansion of the Institute’s physical infrastructure. Data communication and media, coolant, and pressurized air services for the research labs and cleanrooms were also improved.

These investments improved the Institute’s ability to integrate its facilities for the growing Research Fab Microelectronics Germany (FMD). A further million euros was invested into new equipment for the FMD.

HR development
The continued commercial success of Fraunhofer IZM allowed the Institute to create new jobs in 2020, increasing its headcount from 285 to 303 colleagues at its three sites in Berlin, Dresden/Montizburg, and Cottbus.

The Institute also gives students a chance to combine their academic studies with applied scientific work in the offices and labs of Fraunhofer IZM. By the end of 2020, no fewer than 133 interns, bachelor and master students, and student assistants had benefited from these opportunities at Fraunhofer IZM. The Institute is also proud to offer young people qualified apprenticeships, training eight aspiring microtechnologists and office management assistants in 2020.
AWARDS, EDITORIALS, DISSERTATIONS

Awards

Young Engineer Award of PCIM Europe 2020
Kirill Klein has won the Young Engineer Award of PCIM Europe 2020 for his paper on »Low Inductive Full Ceramic SiC Power Module for High-Temperature Automotive Applications«. In the prize paper, Kirill Klein and his co-authors introduce a fully ceramic power module designed to extend the range of electric vehicles at lower system costs by optimally utilizing silicon carbide semiconductors.

Exceptional Technical Achievement Award
On March 19, 2021 the IEEE Electronics Packaging Society (EPS) has announced the winners of the 2021 Society Major Awards, and our group leader Dr. Tanja Braun, together with Intel’s Beth Keser, was honored with their »Exceptional Technical Achievement Award«. Dr. Braun receives the award for her pioneering contributions as well as her leadership in fan-out wafer level packaging and the transition to panel level packaging.

Other awards

Nomination for Falling Walls Award
Prof. Melanie Jaeger-Erben was nominated for the Falling Walls Award for her contribution »Breaking the Wall to Inclusive and Socially Sustainable Technology«.

EBL 2020: Best Paper Award for David Schütze
»Constructing Highly Miniaturized and Robust Wireless Sensor Nodes with PCB Embedded Components«

Prize of the German Research Foundation
Fraunhofer IVM’s blog was awarded first prize in the ideas competition for international research marketing.

Editorials

Bioelectronic Medicine: Engineering Advances, Physiological Insights, and Translational Applications
Giagka, V. (Guest Editor)

Bioelectronic Medicine Journal
Giagka, V. (Associate Editor)

Electronics Goes Green 2020+ Proceedings
Nissen, N. F., Schneider-Ramelow, M. (Editors)

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

PLUS Journal (Eugen G. Leuze Verlag)
Lang, K.-D. (Member of the Editorial Board)

Dissertations

Hu, Xiaodong
»Influence of Bonding Temperature and Material on Anodic Bonding for Stress Sensitive MEMS«

Kaupmann, Philip
»A Novel Indirect Actuation Concept for MEMS Micromirrors«

Otto, Alexander
»Lebensdauermodellierung diskreter Leistungselektronikbauelemente unter Berücksichtigung überlagerter Lastwechseltests«

Schmidt, Michael
»Numerische Modellierung der lokalen mechanischen Beanspruchbarkeit eines epoxyharzbasierten Schaltungsträgersubstrats«

Steinbach, Axel Friedrich
»Anforderungen für den Einsatz modularer Messsysteme bei kognitiven und funktionellen Einschränkungen von Demenz- und Rheumapatienten«

German University in Cairo
Dr. T. Tekin
• Sensor Technology

University of Applied Sciences for Engineering and Economics in Berlin
Dr. R. Hahn
• Microenergy Systems

Prof. Dr. H.-D. Ngo
• Microsensors
• Micro System Technologies II
• Characterization of Semiconductor Sensors
• Microactuators
• Advanced Microsystem Technologies
• Cleanroom Technologies

Dr. H. Walter
• Materials in Microsystem Technology

Berlin School of Economics and Law
Dr. J. Winzer
• Integrated Product Design

Technical University of Berlin
Prof. Dr. M. Jaeger-Erben
• Sociology of Engineers I and II

Dr. J. Köszegi
• Design, Simulation and Reliability of Microsystems
• High-frequency Measurement Techniques in Microelectronic Packaging

Prof. Dr. K.-D. Lang
• Assembly Technologies for Microelectronics and MST

P. Mackowiak
• Assembly Technologies for Microelectronics and MST

Prof. Dr. H.-D. Ngo
• Manufacturing Technologies for Semiconductor Sensors

Dr. N. F. Nissen, Dr. A. Middendorf
• Environmentally Conscious Design of Electronic Systems

Prof. Dr. M. Schneider-Ramelow
• System Integration Technologies
• Basic Materials of System Integration

Dr. O. Wittler, Dr. J. Jaeschke
• Reliability of Integrated Microsystems

Delft University of Technology
Prof. Dr. V. Giagka
• Bioelectricity
• Active Implantable Biomedical Microsystems
• Neurostimulation

Dresden University of Technology
Jun.-Prof. Dr. I. Panchenko
• Micro-/Nanomaterials and Reliability Aspects
• 3D System Integration and 3D Technologies

Aalborg University
Prof. Dr. E. Hoene
• Design of Modern Power Semiconductors Components
• EMI/EMC in Power Electronics
**COOPERATION WITH UNIVERSITIES** (SELECTION)

Some of Fraunhofer IZM’s university partners:
- Auburn University, Denmark
- Aalto University, Finland
- AGH University of Science and Technology, Poland
- Baptamton University, USA
- Delft University of Technology, The Netherlands
- Eindhoven University of Technology, The Netherlands
- Imperial College London, Great Britain
- KU Leuven, Belgium
- San Diego State University, USA
- Tohoku University, Japan
- University College London, Great Britain
- University of Cape, Spain
- University of New South Wales, Australia
- University of Tokyo, Japan
- University of Twente, The Netherlands
- University of Utah, USA
- University of Vienna, Austria
- Uppsala University, Sweden
- Albert Ludwig University of Freiburg, Germany
- Berlin University of the Arts, Germany
- Chemnitz University of Technology
- Friedrich-Alexander University Erlangen-Nürnberg, Germany
- Heidelberg University, Germany
- Humboldt University of Berlin, Germany
- Paderborn University, Germany
- Rostock University, Germany
- University of Born, Germany
- University of Potsdam, Germany

To effectively implement its research goals, Fraunhofer IZM has established strategic networks with universities in Germany and abroad. Close cooperation with universities is an important pillar of Fraunhofer’s success model. While the universities contribute their innovative ability and competence in basic research to the cooperation, Fraunhofer contributes excellence in applied research, outstanding technical infrastructure, continuity in human resources and long-standing experience in international projects.

**Cooperation with Technische Universität Berlin**

Since its foundation in 1993, Fraunhofer IZM has benefited from the successful cooperation with the Research Center for Microtechnologies of the Technische Universität Berlin. In the 1990s, one of the world’s first scientific institutions in the field of packaging and interconnection technology was established here. Since 2011, the traditional double appointment of Fraunhofer IZM director and Head of the Research Center has been held by Professor Klaus-Dieter Lang.

Fraunhofer IZM-ASSID cooperates with TU Dresden

Within the joint junior professorship »Nanomaterials for Electronic Packaging« of Fraunhofer IZM-ASSID and TU Dresden, junior 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. 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)

MENNEKES Elektrotechnik GmbH & Co. KG  
Kirchhundem

Merck KGaA  
Darmstadt

Multi Channel Systems MCS GmbH  
Reutlingen

Nagase Chemtex Corporation  
Osaka (JP)

OSYPKA AG  
Rhenfelden

PAAnalytical B.V.  
Almele (NL)

Philips N.V.  
Eindhoven (NL)

Picosun Oy  
Masala (FI)

POSIC S.A.  
Colombia (CH)

Reden B.V.  
Hengelo (NL)

Rena Technologies GmbH  
Gütenbach

Salvia Bioelectronics B.V.  
Eindhoven (NL)

Schmoll Maschinen GmbH  
Rödermark

Sensysca GmbH  
Salzburg (AT)

Shibata Denki K.K  
Tokyo (JP)

Siemens AG, Siemens Healthcare  
DE

SKW Associates, Inc.  
Santa Clara, California (USA)

SLAC National Accelerator Laboratory  
Menlo Park, California (USA)

STMMicroelectronics N.V.  
Amsterdam (NL)

Süss MicroTec SE  
Garching near Munich
MEMBERSHIPS (SELECTION)

AMA Fachverband Sensorik, Wissenschaftsrat
H. Potter Member
Cluster Optik Bf, Photonik für Kommunikation und Sensorik
Dr. H. Schneider Spokesman
Deutsche Bundesstiftung Umwelt
Prof. K.-D. Lang Reviewer
Deutsche Forschungsgemeinschaft
Prof. K.-D. Lang Reviewer
Deutscher Verband für Schweißtechnik DVS
Prof. K.-D. Lang Advisory Board
Deutscher Verband für Schweißtechnik DVS Arbeitsgruppe - Bonden-
Prof. M. Schneider-Ramelow Chairman
ECPE Competence Centre
Prof. M. Schneider-Ramelow Member
EURIPIDES Scientific Advisory Board
M. J. Wolf Member
European Network High Performance Integrated Microwave Photonics
Dr. T. Tekin German Representative
European Photonics Industrial Consortium (EPIC)
Dr. H. Schneider Representative Fraunhofer IZM
European Technology Platform on Smart System Integration (EPoSS)
H. Potter Member Executive Committee
Forschungsfabrik Mikroelektronik Deutschland (FMD)
Prof. K.-D. Lang Steering Committee
Heterogeneous Integration Roadmap (HIR)
R. Achenbrenner Chair Technical Working Group SLP
IEEE Electronics Packaging Society
Photonics – Communication, Sensing, Lighting
R. Achenbrenner/Prof. K.-D. Lang Fellow
IEEE EPS TC Material & Processes
Dr. T. Tekin Technical Co-Chair
IEEE EPS to Board of Governors
Dr. T. Braun Member
IMAPS – International Microelectronics and Packaging Society
Prof. K.-D. Lang Fellow
IMAPS Europe / IMAPS Deutschland
Dr. T. Braun Member
IMAPS Signal / Power Integrity Committee
Dr. D. N. J. Nett Member
IMAPS Executive Council
Dr. D. N. J. Nett Chair
IVAM Fachgruppe Wearables
E. Jung Technical Chair
Organic Electronics Saxony (OES)
K. Zischke, E. Jung Representatives of Fraunhofer IZM
Photonics 21
Dr. R. Jordan Board of Stakeholders
Photonics West Optical Interconnects Conference
Dr. H. Schneider Chair
Semiconductor Manufacturing Technology Sematech
M. J. Wolf Member
SEMI ESHMT Group
Dr. T. Braun Representative of Fraunhofer IZM
SEMI Europe Award Committee
Prof. K.-D. Lang Member
Silicon Saxony e.V.
M. J. Wolf Member
SMI/bonnet
Prof. K.-D. Lang Head of Programme Committee
Strategischer Arbeitskreis Silicon Germany
Prof. K.-D. Lang Member
Wissenschaftlich-technischer Rat der Fraunhofer-Gesellschaft
Dr. N. F. Nissen Representative of Fraunhofer IZM

PUBLICATIONS (SELECTION)

Bakhshaei Babaroud, N.; Dekker, R.; Serdijn, W. A.; Giagka, V.
PDM5 to Parylene Adhesion Improvement for Encapsulating an Implantable Device
Proceedings of EMBC 2020, online.

Silicon Photonics for Terabit/s Communication in Data Centers and Exascale Computers

Bickel, S.; Panchenko, I.; Tachikawa, T.; Wolf, M. J.
Low Temperature Solid State Bonding of Cu-in Fine Pitch Interconnects
Proceedings of ESTC 2020, online.

Fan-out Wafer and Panel Level Packaging and the Changing Packaging Landscape
Proceedings of ESTC 2020, online.

Fan-out Wafer Level Packaging of GaN Components for RF Applications
Proceedings of ECTC 2020, online.

Low Voltage Silicon Photonic Modulators and Switches for High Radix Integrated Transmitters
Proceedings of ICTON 2020, online.

Dijk, M. van; Kuttler, S.; Rost, F.; Jaeschke, J.; Walter, H.; Wittler, G.; Braun, T.; Schneider-Ramelow, M.
Simulation Challenges of Warpage for Wafer and Panel Level Packaging
Proceedings of EuroSimE 2020, online.

Dils, C.; Kallmayer, C.; Genhold, L.; Schneider-Ramelow, M.
Untersuchungen zum Ultraschall-Kunststoffschweißen als innovative Kontaktierungstechnologie für die Integration von Elektronik in Textilien

Dimirova, G.; Berwald, A.; Feenstra T.; Hoeggerl, G.; Nissen, N. F.; Schneider-Ramelow, M.
Design for and Design from Recycling: The Key Pillars of Circular Product Design
Electronics Goes Green 2020+, online.

Dual-rotor Electromagnetic Based Energy Harvesting System for Smart Home Applications

Guo, R.; Zufiria, P. G.; Giagka, V.; Serdijn, W. A.
Circuit Design Considerations for Power-efficient and Safe Implantable Electrical Neural Stimulators

Hahn, D.; Sehe, F.; Straube, S.; Dobs, T.; Berwald, A.; Wittler, G.; Schneider-Ramelow, M.
Current State of Durability Assessment for Four Consumer Product Groups
Electronics Goes Green 2020+, online.
Hoffmann, S.; Hoene, E.; Schroeder, B.; Stube, B.; Alraai, A.; Maritz, Q.; Müller, O.

PCB Layout Tool Integrated Loss and Inductance Estimation
Proceedings of CIPS 2020, online, pp. 355-359.

Hoffmann F.; Jaeger-Erben M.

Organizational Transition Management of Circular Business Model Innovations

Klein, K.; Hoene, E.; Lang, K.-D.

Double Pulse vs. Indirect Measurement: Characterizing Switching Losses of Integrated Power Modules with Wide Bandgap Semiconductors
Proceedings of CIPS 2020, online, pp. 414-421.

Kuśma, H.; Caradossi, A.; Braun, T.

Fan-out Wafer-level Packaging as Packaging Technology for MEMS

Le, T.; Kanitkar, A.; Rossi, M.; Nólpa, I.; Braun, T.; Müller, F.; Lang, K.-D.; Wieland, M.; Goetzte, C.; Bin Halm, S.; Trewethella, J.

Dual-band 5G Antenna Array in Fan-out Wafer-level Packaging (FOWLP) Technology
Proceedings of MIKON 2020, Warsaw, Poland.

Klein, K.; Hoene, E.; Lang, K.-D.

Electromagnetic Switching Cell Design and Characterization for WBG Power Semiconductors
Proceedings of CIPS 2020, online, pp. 552-558.

Kallinger, E.; Kutter, S.; Wagner, S.; Schneider-Ramelow, M.


Krohnert, K.; Friedrich, G.; Starukhin, D.; Wüthmann, M.; Schiffer, M.; Schneider-Ramelow, M.

Reliability of Through Glass Vias and Hermetically Sealing for a Versatile Sensor Platform
Proceedings of ESTC 2020, online.

Kuczynski, A.; Hoffmann, S.; Hoene, E.

Preparing WEEE Plastics for Recycling – How Optimal Particle Sizes in Pre-processing Can Improve the Separation Efficiency of High Quality Plastics


SiCmodul – Modular High-temperature SiC Power Electronics for Fail-safe Power Control in Electrical Drive Engineering

Murugesan, K.; Chernobryvko, M.; Zinal, S.; Rossi, M.; Nólpa, I.; Boettcher, M.

High Quality Integrated Inductor in Fan-out Wafer-level Packaging Technology for mm-Wave Applications

Nanbaksh, K.; Ritasala, R.; Serdjin, W. A.; Giagka, V.

Long-term Encapsulation of Platinum Metallization Using a HfO2 ALD – PDMS Bilayer for Non-hermetic Active Implants
Proceedings of ECTC 2020, online.

Nanbaksh, K.; Ritasala, R.; Serdjin, W. A.; Giagka, V.

Towards CMOS Bulk Sensing for In-Situ Evaluation of ALD Coatings for Millimeter Sized Implants
Proceedings of EMBC 2020, online.


A Novel Packaging and System Integration Platform with Integrated Antennas for Scalable, Low-cost and High-performance 5G mmWave Systems
Proceedings of ECTC 2020, online.

Nissen, N. F.; Clemm, C.; Billaud, M.; Töpper, M.; Stobbe, L.; Schneider-Ramelow, M.

Chiplets – Exploring the Green Potential of Advanced Multi-chip Packages
Electronics Goes Green 2020+, online.

Oppermann, H.

Heterogeneous Photonics Integration 53rd International Symposium on Microelectronics, IMAPS 2020, Symposium »System Integration – Fraunhofer Connecting the U.S. with Germany«, online.

Panchenko, I.; Wambara, L.; Mueller, M.; Rudolph, C.; Hanisch, A.; Bartussek, I.; Wolf, M. J.

Grain Structure Analysis of Cu/SiO2 Hybrid Bond Interconnects after Reliability Testing
Proceedings of ESTC 2020, online.

Proke, M.; Poppo, E.; Jaeger-Erben, M.


Rashanghas, A.; Dreisigacker, M.; Scherf, C.; Brethauer, C.; Rauter, L.; Zikudzh, I.; Braun, T.; Becker, K.-F.; Kesz, S.; Schneider-Ramelow, M.


Rotzler, S.; Kallmayer, C.; Döb, C.; Krshiwoblozki, M. von; Bauer, U.; Schneider-Ramelow, M.

Improving the Washability of Smart Textiles: Influence of Different Washing Conditions on Textile Integrated Conductor Tracks
Schaubbeck, S.; Hutter, M.; Jaeschke, J.; Deutinger, A.; Schneider-Ramelow, M.
Sporadic Early Life Solder Ball Detachment Effects on Subsequent Microstructure Evolution and Fatigue of Solder Joints in Wafer-level Chip-scale Packages

Schiffer, M.
Heterogeneous Integration Technologies for Fan-out, Embedding and Interposer Wafer Level Packaging

Schischke, K.; Nissen, N. F.; Schneider-Ramelow, M.
Flexible, Stretchable, Conformal Electronics, and Smart Textiles: Environmental Life Cycle Considerations for Emerging Applications
MRS Communications, Vol. 10, Issue 1, 2020, pp. 69-82.

Tiwari, K. K.; Grass, E.; Thompson, J. S.
Memory-assisted Statistically-ranked RF Beam Training Algorithms for Sparse MIMO
Proceedings of VTC2020-Spring, online, pp. 1-7.

Vagionas, C.; Ruggieri, E.; Kaifas, G.; Sirbu, B.; Leiba, Y.; Kanta, K.; Giannoulis, G.
An End-to-end 5G Fiber Wireless A-RoF/IfOFOptical Link Based on a 60 GHz Beamsteering Antenna and an InP EML

Velea, A. I.; Vollebregt, S.; Warchana, G. K.; Giagka, V.
Wafer-scale Graphene-based Soft Electrode Array with Optogenetic Compatibility


Weber, C.; Hutter, M.; Schneider-Ramelow, M.
Influence of Process and Stress Conditions on Microstructure and Failure Mechanisms of Second Level Sintered Ag Joints
Proceedings of CIPS 2020, online.

Woehrmann, M.; Keller, A.; Fritzsch, T.; Schiffer, M.; Gallhardt, A.; Walter, H.; Schneider-Ramelow, M.; Lang, K.-D.
Reliability Investigation of Ultra Fine Line, Multi-layer Copper Routing for Fan-out Packaging Using a Newly Designed Micro Tensile Test Method
Proceedings of ECTC 2020, online, pp. 893-899.

Zoschke, K.; Lohrer, T.; Kallmayer, C.; Jung, E.
Flexible and Stretchable Systems for Healthcare and Mobility

Cap Fabrication and Transfer Bonding Technology for Hermetic and Quasi Hermetic Wafer Level MEMS Packaging
PATENTS & INVENTIONS

Bauer, Jörg; Becker, Karl-Friedrich; Kahle, Ruben
Method for Production of Low-temperature Contacting for Microelectronic Superstructures, Involves Applying Photo-structured Material on Connection Contacts Having Surface of Microelectronic Element
DE 10 2009 017 692 A1

Becker, Karl-Friedrich; Hüßmann, Axel; von Rosenberg, Harald
Millimeter-wave Radar
DE 10 2012 201 367 A1

Braun, Tanja; Ndip, Ivan
Wafer Level Package with Integrated Antennas and Means for Shielding
DE 10 2017 200 122 A1

Braun, Tanja; Ndip, Ivan
Wafer Level Package with at Least One Integrated Antenna Element
US 10,797,375

Brusberg, Lars; Schröder, Henning
Plug-in Fiber Coupling Unit, Fiber Coupling System and Method for Coupling Optical Fibers to Integrated Optical Waveguides
EP 3 179 285 A1

Gemhardt, Robert; Manier, Charles-Alix, Oppermann, Hermann; Tekin, Tolga; Wilke, Martin; Zaschke, Kai
Method for Manufacturing a Semiconductor Component and a Semiconductor Component
US 10,658,187

Gerritzen, Andreas; Großer, Völker; Jung, Erik
Mobile Optical Analysis Device*
DE 10 2011 100 507 A1

Hefer, Jan; Rojahn, Johannes
Sensor System for Monitoring an Object
EP 3 444 787 A1

Hempel, Martin; Höfer, Jan; Schneider-Ramelow, Martin
Bond Foil, Electronic Component and Process for Producing an Electronic Component
DE 10 2018 215 638 A1

Janzen, Sergey; Middendorf, Andreas; Nowak, Torsten
Method for Determining a Bonding Connection in a Component Arrangement and Test Apparatus
EP 3 117 452 A1

Ndip, Ivan
Antenna Apparatus Having Bond Wires
EP 3 346 546 A1

Ndip, Ivan
Ribbon Bond Antennas
US 10,566,679

* The German patent title was translated into English. In the original the name is as follows: Mobiles optisches Analysagerät.

FACTS & FIGURES

Prof. Dr. Bernd Tillack
IHP GmbH, Leibniz-Institut für innovative Mikroelektronik, Frankfurt (Oder)

Dr. Markus Ulm
Bosch Sensortec GmbH, Reutlingen

Dr. Thomas Wille
NXP Semiconductors Germany GmbH, Hamburg

Ministerialrat Christoph Zimmer-Conrad
Saxony’s State Ministry for Economics, Labor and Transportation, Department Industry, Dresden

Dr. Tina Züchner
Federal Ministry for Education and Research, Department Electronics and Autonomous Driving, Bonn

CHAIRMAN
Dr. Franz Richter
Süss MicroTec AG, Garching near Munich

MEMBERS
Paradiso Coskina
VDI/VDE Innovation + Technik GmbH, Berlin

Gabi Grützner
Micro resist technology GmbH, Berlin

Martin Hierholzer
Infineon Technologies Bipolar GmbH & Co. KG, Warstein

Dr. Stefan Hofschen
Bundesdruckerei GmbH, Berlin

Martin Herholzer
Infineon Technologies Bipolar GmbH & Co. KG, Warstein

Dr. Stefan Hofschen
Bundesdruckerei GmbH, Berlin

Ministerialrat Bernd Lietzau
The Governing Mayor of Berlin, Senate Chancellery for Science and Research

Johannes Stahr
AT&S AG, Leoben (AT)

Prof. Dr. Christian Thomsen
Technische Universität Berlin

Prof. Dr. Bernd Tillack
IHP GmbH, Leibniz-Institut für innovative Mikroelektronik, Frankfurt (Oder)

Dr. Markus Ulm
Bosch Sensortec GmbH, Reutlingen

Dr. Thomas Wille
NXP Semiconductors Germany GmbH, Hamburg

Ministerialrat Christoph Zimmer-Conrad
Saxony’s State Ministry for Economics, Labor and Transportation, Department Industry, Dresden

Dr. Tina Züchner
Federal Ministry for Education and Research, Department Electronics and Autonomous Driving, Bonn

GUESTS
Ministerialratin Dr. Annerose Beck
Saxony’s State Ministry for Higher Education, Research and the Arts, Dresden

Christian Wiebus
NXP Semiconductors Germany GmbH, Hamburg

ADVISORY BOARD
FRAUNHOFER IZM CONTACTS

FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM

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

Director (managing)
Prof. Dr.-Ing. Dr. sc. techn. Klaus-Dieter Lang
Phone +49 30 46403-179
klaus-dieter.lang@izm.fraunhofer.de

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

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

Head of Administration
Jürgen Rahn
Phone +49 30 46403-105
juergen.rahn@izm.fraunhofer.de

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

DEPARTMENTS

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

Head: M. Jürgen Wolf
Phone +49 30 46403-606
Phone +49 351 7955 72-12
juergen.wolf@izm.fraunhofer.de

System Integration and Interconnection Technologies
Head: Rolf Aschenbrenner
Phone +49 30 46403-164
rolf.aschenbrenner@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: Dr.-Ing. Dr.-Ing. habil. Ivan Ndip
Phone +49 30 46403-679
ivan.ndip@izm.fraunhofer.de

Head: 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: Prof. Dr.-Ing. Dr. sc. techn. Klaus-Dieter Lang
Phone +49 30 46403-179
klaus-dieter.lang@izm.fraunhofer.de

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

Head: M. Jürgen Wolf
Phone +49 351 7955 72-12
Phone +49 30 46403-606
juergen.wolf@izm.fraunhofer.de

COTTBUS BRANCH OF THE INSTITUTE

Branch Lab for High-Frequency Sensor Systems
Karl-Mare-Strasse 69, 03044 Cottbus

Head: Dr.-Ing. Dr.-Ing. habil. Ivan Ndip
Phone +49 30 46403-679
ivan.ndip@izm.fraunhofer.de

MARKETING & BUSINESS DEVELOPMENT

Head: Dr.-Ing. Maik Hampicke
Phone +49 30 46403-683
maik.hampicke@izm.fraunhofer.de

Business Development Team
Dr.-Ing. Mathias Blüttcher
Dipl.-Phys. Erik Jung
Andreas Middendorf
Dr. rer. nat. Michael Töpper
bdt@izm.fraunhofer.de

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
Cover:
Hermetic glass package with TGVs for a radar fill level sensor with an operating frequency of 160 GHz (the GlaRA project was sponsored by the Federal Ministry of Education and Research)