

Fraunhofer Group for Microelectronics in Cooperation with the Leibniz Institutes FBH und IHP

Power Electronics

Research Fab Microelectronics Germany: Benefit from Europe's Largest R&D Cooperation for Micro- and Nanoelectronics

The Research Fab Microelectronics Germany (FMD) is a multisite cooperation advancing micro- and nanoelectronics research and development and comprises eleven institutes of the Fraunhofer Group for Microelectronics, as well as the two Leibniz institutes FBH and IHP. We are a One-Stop-Shop for cutting-edge R&D services, application solutions and new technologies for a wide range of industrial customers.

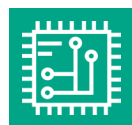
By joining forces, we are able to provide tailor made technology and system solutions from a single source. Drawing on FMD's broad technology portfolio, we have established six technology

platforms: Microwave and Terahertz, Power Electronics, Extended CMOS, Optoelectronic Systems, Sensor Systems, and MEMS Actuators. Together these bundle the necessary individual expertise – from system design to testing and reliability assessment – to meet customer needs. Apart from leveraging synergies between technological know-how and the development of technological innovation, the platforms prioritize close cooperation with customers throughout the development process and the bundling of technological competencies along the entire value chain.

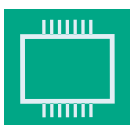
Our Technology Portfolio



Extended CMOS
Design, fabrication and system integration of CMOS circuits.



Sensor Systems
Sensor design, fabrication, integration, characterization, and testing within systems.



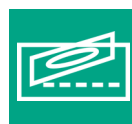
Microwave and Terahertz
Cutting-edge devices and circuit for frequencies up to and including the THz range.



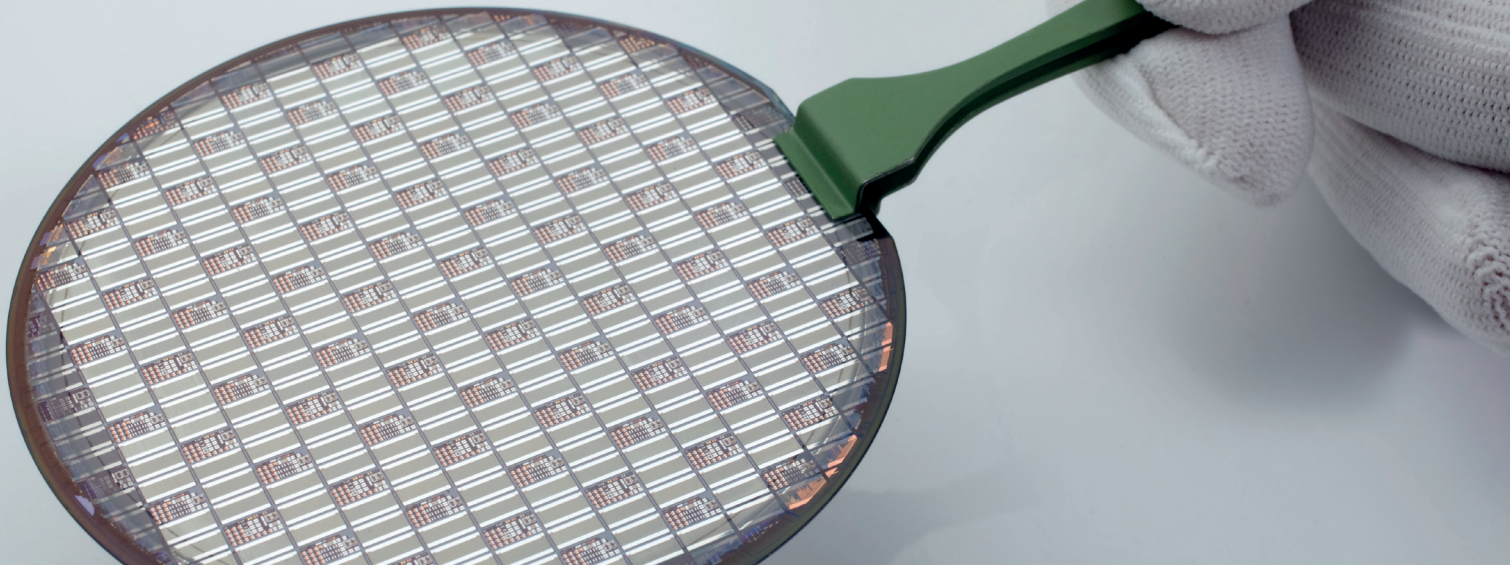
Optoelectronic Systems
Fully integrated optoelectronic systems for image acquisition and processing, and communication up to Tbit/s speed.



Power Electronics
Design and fabrication of power electronic devices, including integration in modules and systems.



MEMS Actuators
Design and fabrication, as well as characterization, testing and system integration of MEMS actuators.



Technology Platform: Power Electronics

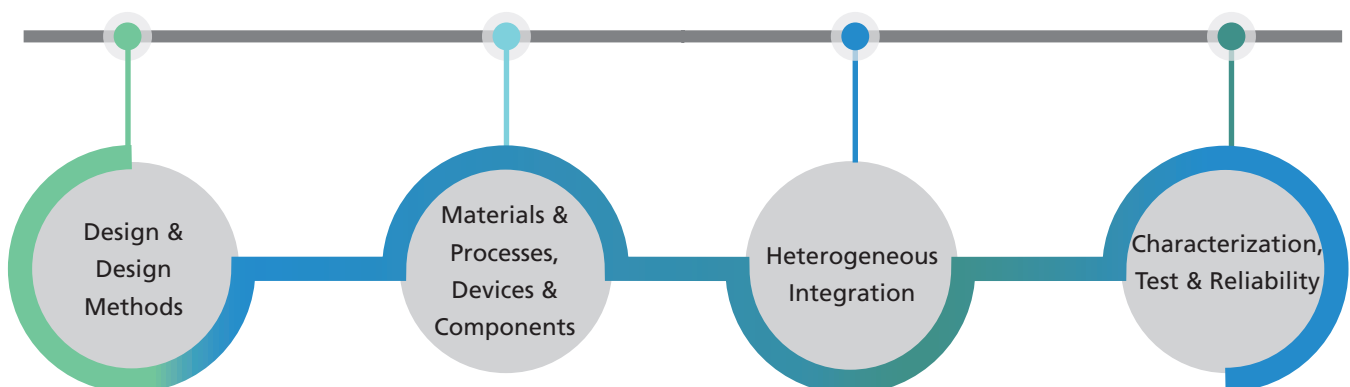
The technology platform Power Electronics brings together the know-how of Research Fab Microelectronics Germany (FMD) along the entire value chain for power electronics devices, including the integration of devices into modules and system-level development. FMD has unparalleled expertise in design, prototyping and materials of wide bandgap (WBG) semiconductors such as silicon carbide (SiC) and gallium nitride (GaN). WBG semiconductors are key devices in more power-efficient and leaner modules and systems, even at higher operating temperatures than those of conventional Si-based power electronics. In our cleanroom facilities, we are able to build devices using Si-based, SiC-based or GaN-based technologies.

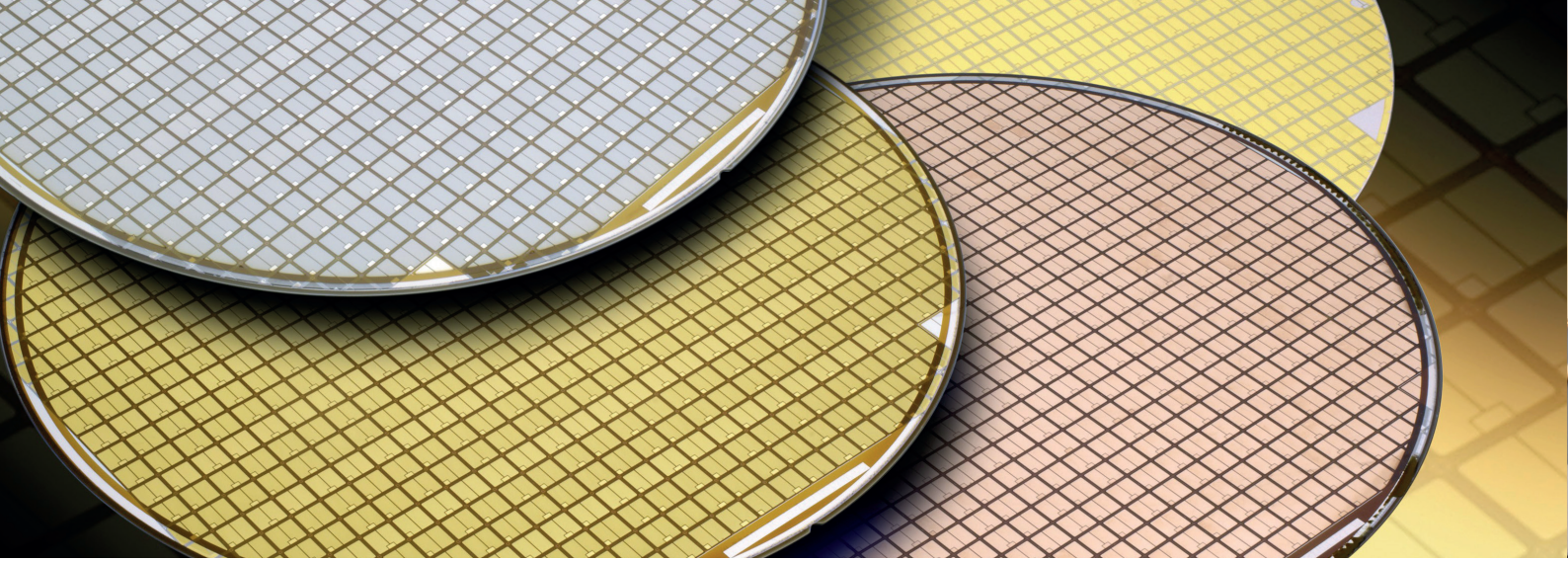
We have a fully integrated 150 mm line to manufacture state-of-the-art SiC devices. For GaN-based devices, we can also provide integration on cost-efficient 200 mm Si substrates. Moreover, we have the equipment to explore R&D approaches to new technology concepts, such as vertical GaN-transistors, Al-GaN-/GaN-based devices for fast switching, and emerging WBG semiconductors like aluminum nitride (AlN) and gallium oxide (Ga_2O_3). The integration of single devices, the first step

in building modules, plays a crucial role in the design of power electronic systems. We have the necessary expertise, not only in heterogeneous system integration, but also in the characterization of single devices, integrated modules or complete systems.

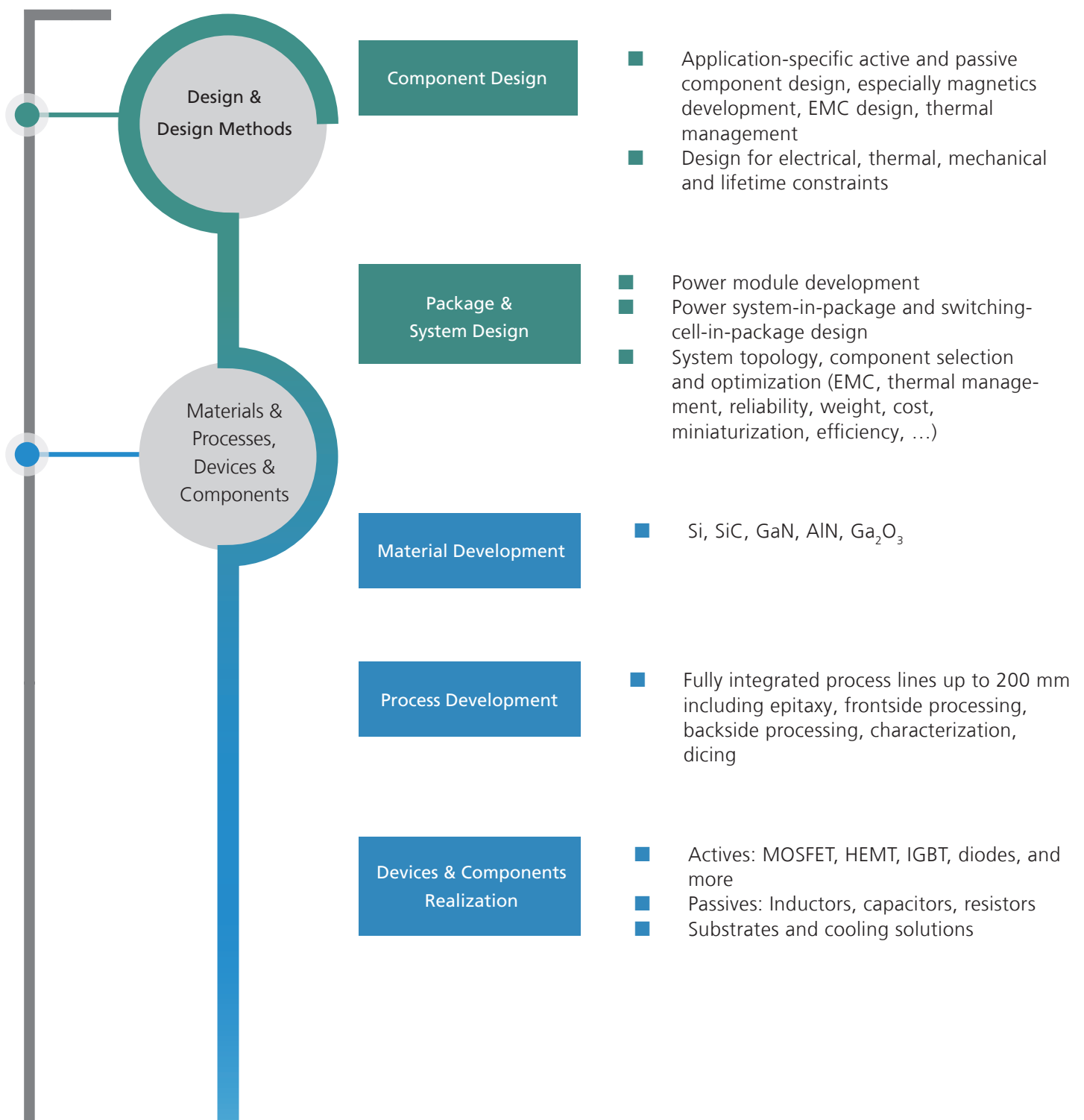
For module manufacturing, single-device packaging as well as integration on large areas up to $610 \times 457 \text{ mm}^2$ is possible. Additionally, we conduct test and reliability assessment of power modules and power electronic systems.

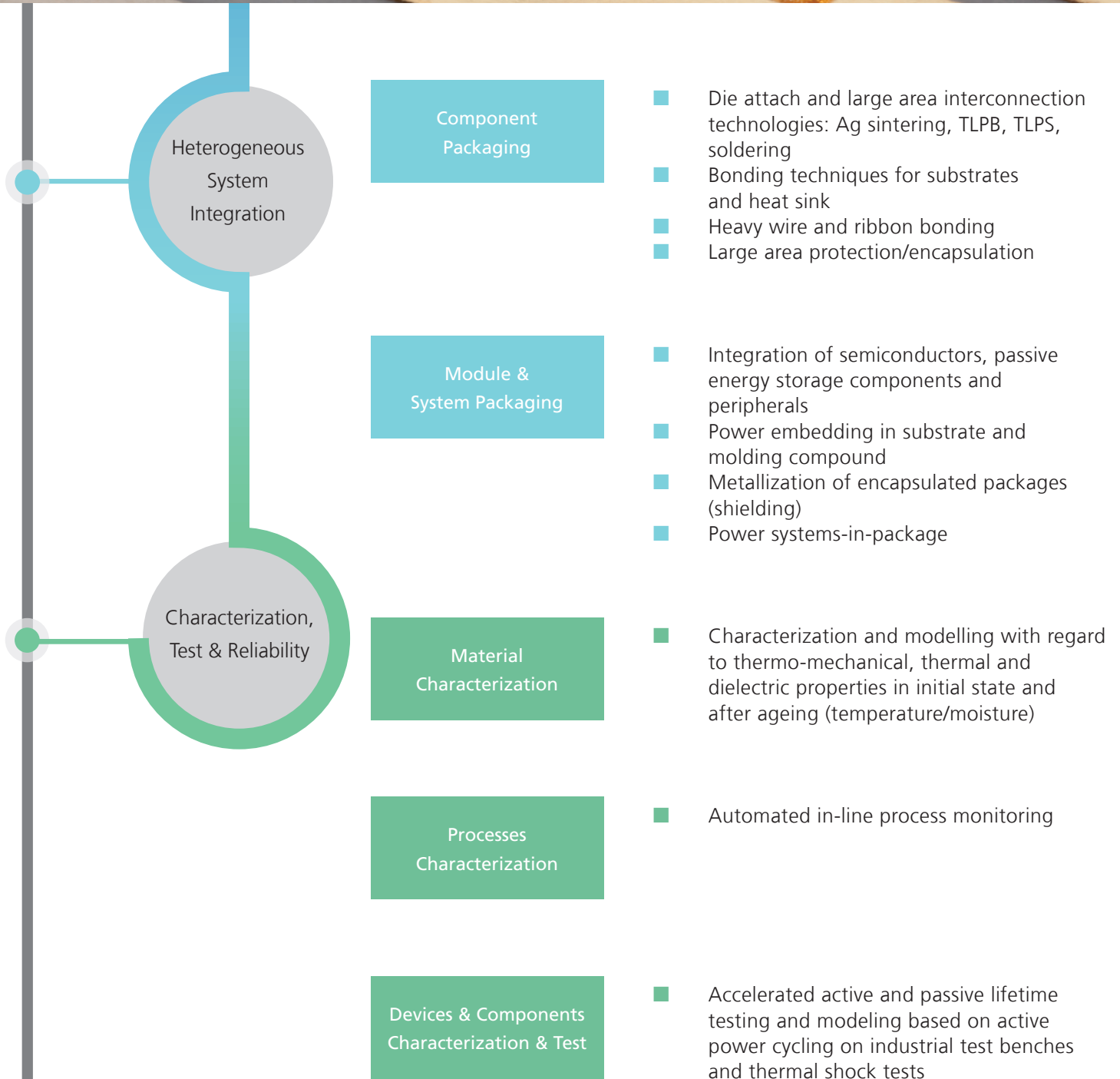
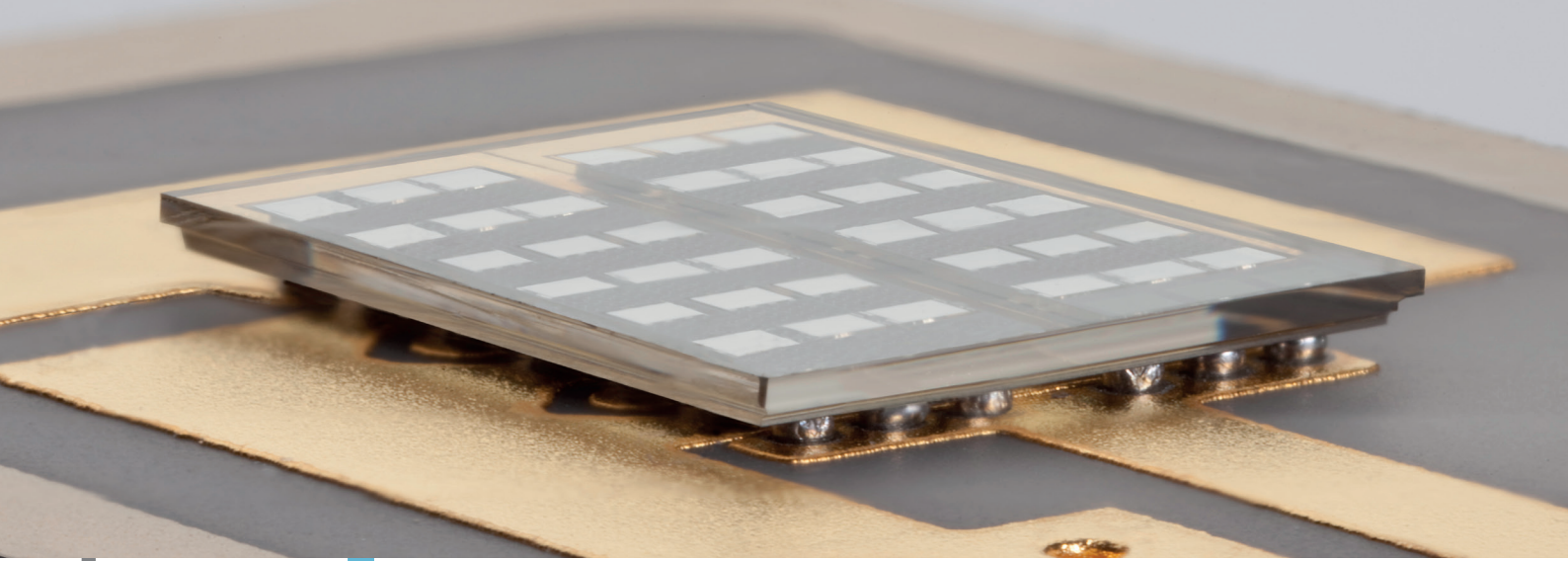
A holistic approach to designing power electronic systems, which applies both semiconductor and packaging technologies at the same time, is a prerequisite for reducing size and cost. The FMD portfolio features the development of extremely highly integrated devices like DC/DC-converters, solar inverters, drive inverters, and chargers. As part of this, our technology platform offers tailor-made solutions for power electronics along the complete microelectronic value chain, for your specific application.

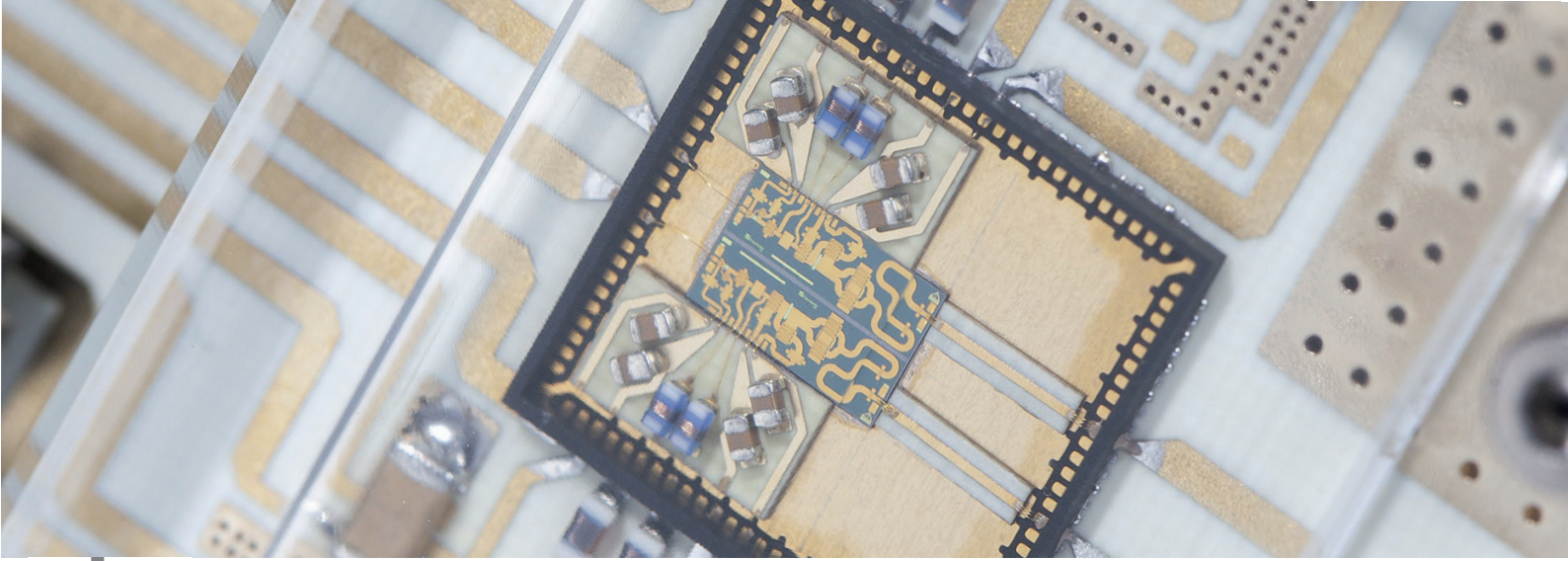




Our Competencies in Power Electronics along the Value Chain







System Test & Reliability

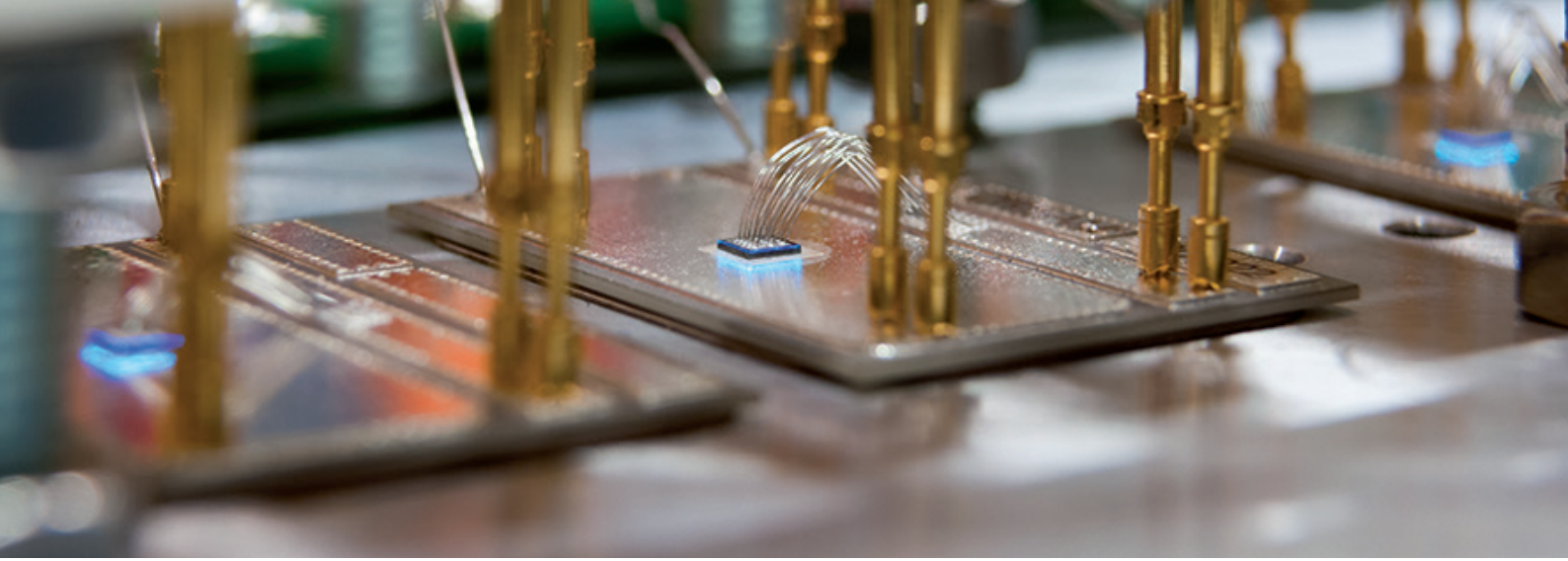
- Comprehensive physics of failure analysis (microscopy, SAM, SEM, computed tomography, thermal impedance spectroscopy)
- Device and system qualification test using extended test parameters towards high temperatures, high voltages and high currents
- Efficient system level test under multiple stress scenarios
- Systems modeling and lifetime prediction using FE simulation methods
- EMC application tests
- Thermal simulation and thermographic package & system analysis
- FMEA support

Technology Example: GaN Chip Prepackage

Much of our work places the system center-stage as basic building block of functionality in microelectronics. System integration is necessary to translate technology advances on component level into enhanced functionality – but increasingly, integration involves system-level analysis and even further development or adaptation of existing system infrastructure.

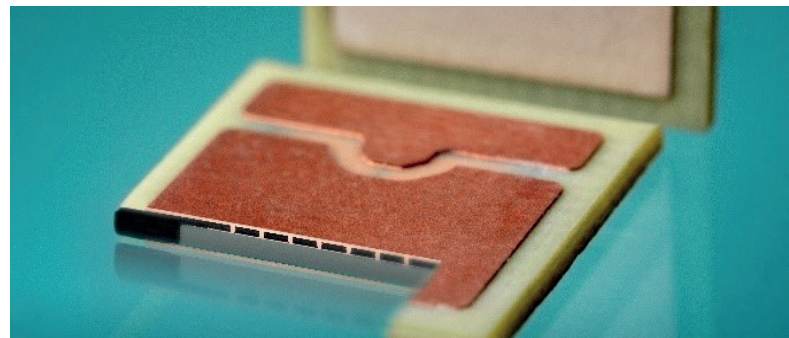
An example is the WBG semiconductor, whose superior switching performance, higher power density, and improved efficiency has caught the attention of early adopters and forward-thinking product designers loo-

king for an edge on the market. However, not only has the new technology required integration on system level, the existing on-board packaging has had to be redesigned to meet the specifications of the semiconductor. We eliminated longstanding limitations in packaging design using the Bernstein module: a two-layer ceramic substrate with a cooler structure on the bottom, that yields extremely low DC link inductance, EMI shielding, a short thermal path, good heat spreading and mechanical stiffness against cooling water pressure. We also combine an innovative metallized transfer mold encapsulation with assembly of local DC link components as SMDs on top of the module. This close



proximity of the SMD to the driver ensures fast switching and avoids parasitic switch-on. The result is a module with perfect switching at even the highest switching speed, high reliability, and lowest possible thermal resistance thanks to a low cost (plastic) cooler.

GaN chip prepackage to be integrated in metallized mold module.



Technology Example: Multi-level Converters – A Key Technology for Efficient and Cost-Effective Power Electronic Systems

The disadvantages of high-blocking voltage semiconductors can be overcome using multi-level converters. The latter are key in efficient and cost-effective power electronic systems in high- and medium-voltage applications. They also provide better EMC performance for smaller size and less cost. Specially adapted joining technologies are used to increase the lifetime of these multilevel systems.

New application-specific power module concepts allow the integration of protection mechanisms to improve the converter behavior and availability in case of system or device failure. One drawback of such multi-level topology concepts is the increased number of semiconductor switches that have to be controlled. Especially in small- and medium-power systems, the effort required to control the simultaneous switching is a significant factor in total system cost. These technology developments are just individual examples of the Fraunhofer IISB development of optimized control and communication systems as key elements in cost-efficient multi-level systems.

Modular multi-level converter.



Research Fab Microelectronics Germany (FMD)

The Research Fab Microelectronics Germany (FMD) as a cooperation of the Fraunhofer Group for Microelectronics with the Leibniz Institutes FBH and IHP is your central contact for all questions concerning micro- and nanoelectronics in Germany and Europe. As a One-Stop-Shop, FMD combines the scientifically excellent technologies, applications and system solutions of the cooperating institutes into a combined overall offer in order to actively address the current and future challenges of electronics research. Under the virtual roof of FMD, Europe's largest R&D cooperation has been created, which, with its 2,000 researchers and its unique diversity of competencies and infrastructures, provides customers and partners with easy access to new applications and high technologies at different technical levels of maturity. The FMD offers a comprehensive and Europe-wide unique range of services for companies, especially for small and medium-sized enterprises (SMEs) but also start-ups, and is an important innovation driver and strategic dialog partner.

In this way, the Research Fab Microelectronics Germany strengthens the competitiveness of Germany as a microelectronics location and ensures further technological sovereignty along the entire value chain. Together with its international partners from science and industry, FMD also actively contributes to the German and European research agenda, thereby providing important impetus for the development of elementary innovations for the world of tomorrow – to the benefit of society and the strengthening of the German and European economy.

A cooperation of



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