



**Forschungsfabrik
Mikroelektronik**
Deutschland

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

Extended CMOS

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

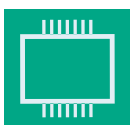
platforms: Microwave and Terahertz, Power Electronics, Extended CMOS, Optoelectronic Systems, Sensor Systems, and MEMS Actuators. Together these bundle the necessary individual expertise – from system design to testing and reliability assessment – to meet customer needs. Apart from leveraging synergies 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.



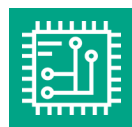
Microwave and Terahertz

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



Power Electronics

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



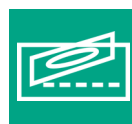
Sensor Systems

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



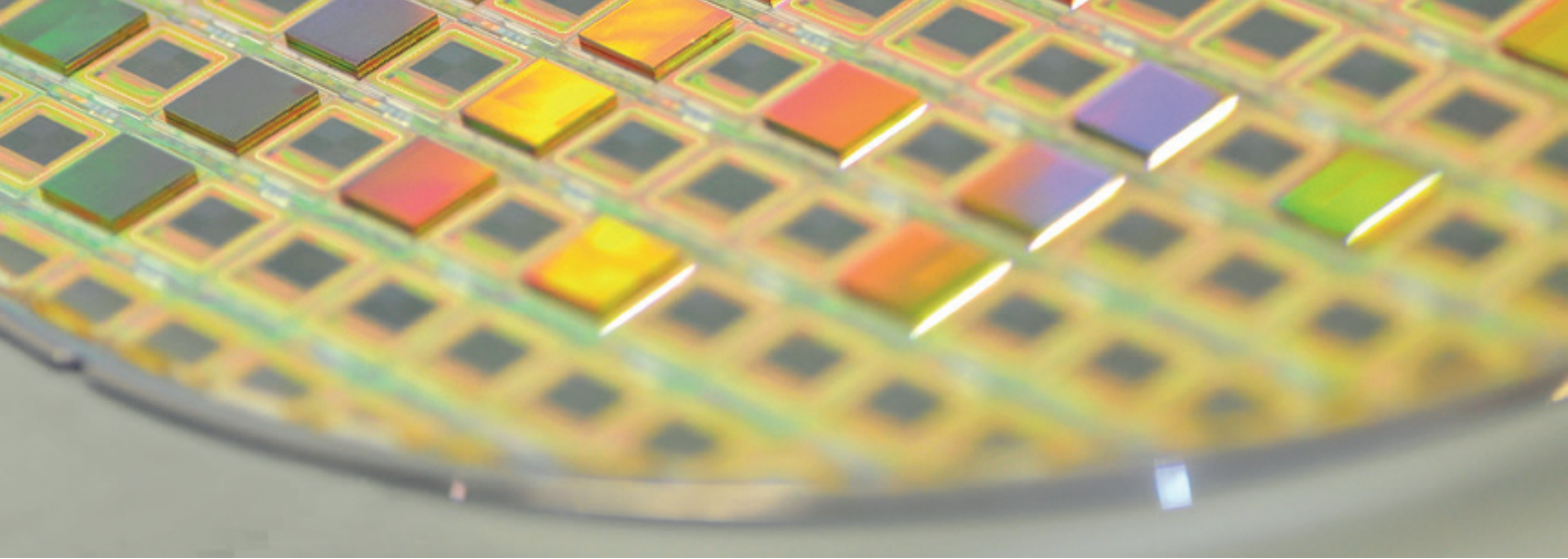
Optoelectronic Systems

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



MEMS Actuators

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



Technology Platform: Extended CMOS

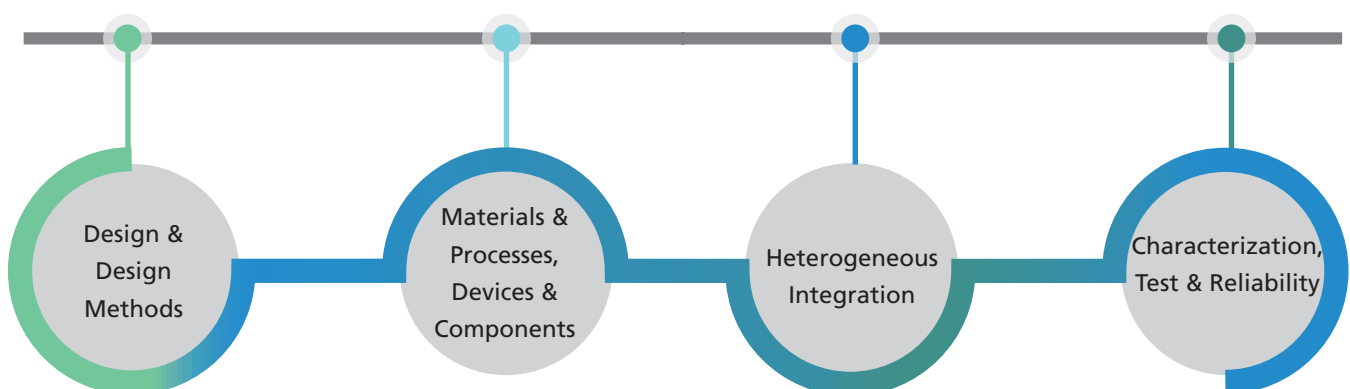
As part of Research Fab Microelectronics Germany (FMD), the technology platform Extended CMOS makes microelectronic development accessible by providing consulting services, development, and access to infrastructure. We cover the complete value chain, from design, materials selection, processing, system integration, materials characterization, device testing and reliability assessment.

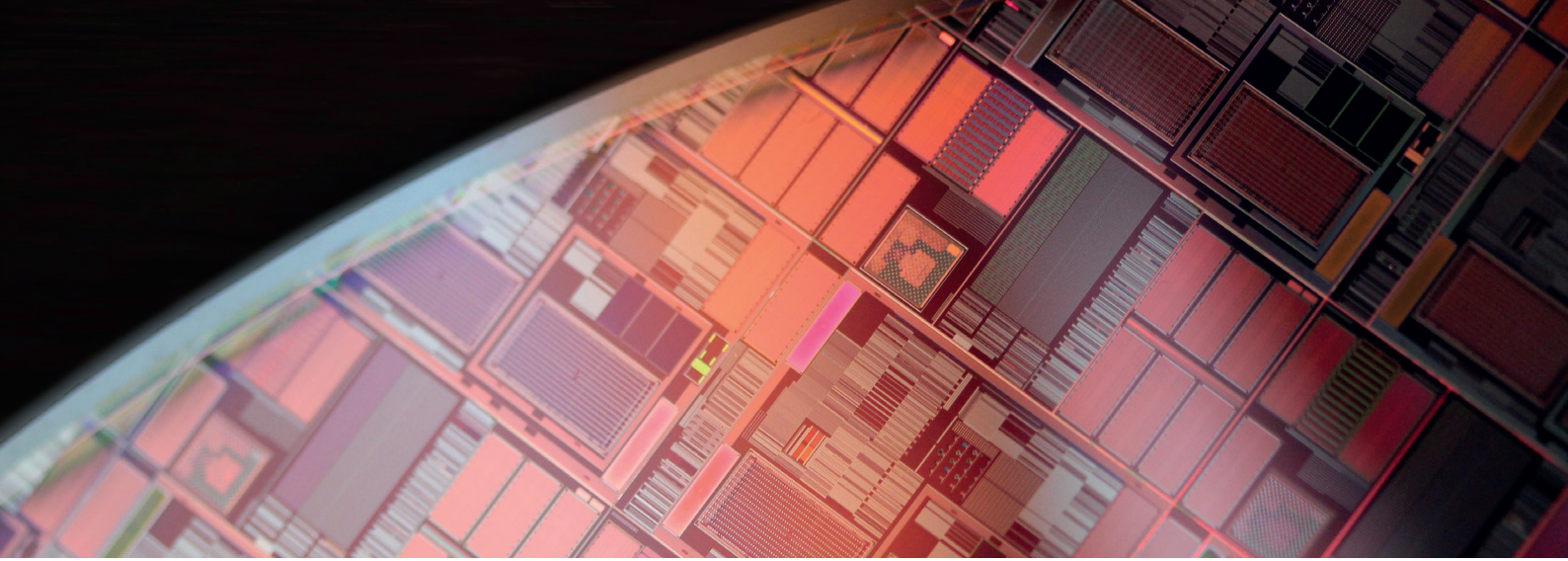
We have bundled the extensive experience and know-how of FMD in the development and manufacture of CMOS based components and systems into our technology platform. Our range of equipment is also impressive. Fully equipped, state-of-the-art 200 mm BiCMOS and CMOS lines are available for a wide range of R&D activities and can even be individually adapted to specific customer needs. Moreover, we also offer front-end and back-end processing. Our front-end equipment includes process modules for frontend-of-line (FEOL), mid-of-line (MOL), and backend-of-line (BEOL). We also have the entire range of processing technologies on hand, including deposition, patterning, implanting, planarization and metallization. Last but not least, we advance new materials, processes and technologies, including new memory concepts and neuromorphic computing technologies, on our 300 mm wafer line.

Our design services include digital design, analog and mixed signal design, as well as design for reliability. We offer expert support for 1D and 2D materials, technologies and processes as well as 2.5D / 3D integration technologies. We also provide R&D support for TSV, wafer bumping, redistribution layers and solder balls.

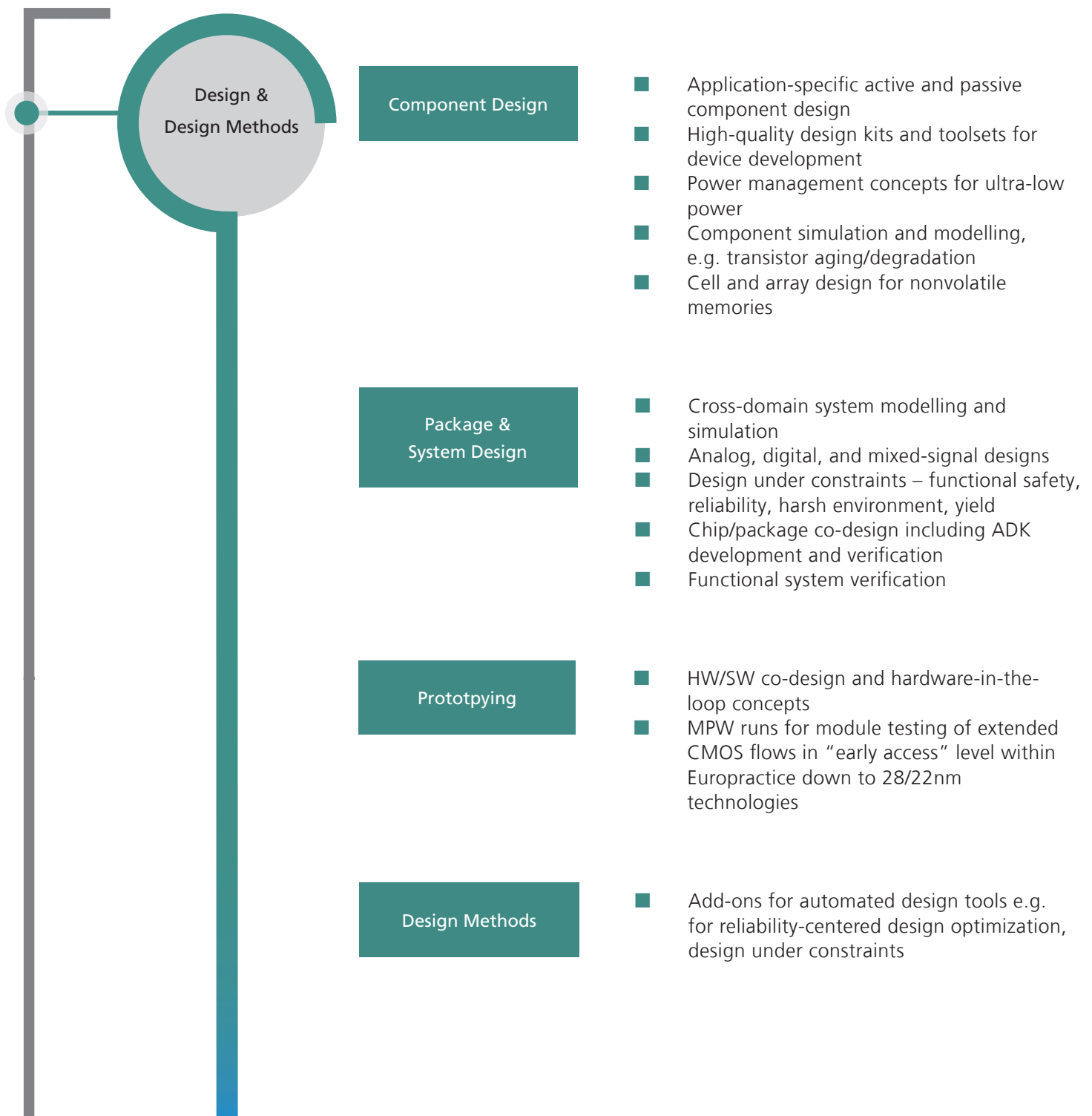
Furthermore, fabrication of high density silicon, glass and polymer interposers, wafer thinning, dicing, wafer-to-wafer bonding, high precision multi-die assembly, die stacking, and molding all feature in our technology portfolio. Testing and characterization of materials and devices, including in harsh environments, electrical tests on digital and analog devices are further services we provide, along with reliability assessment, lifetime prediction and lifetime optimization.

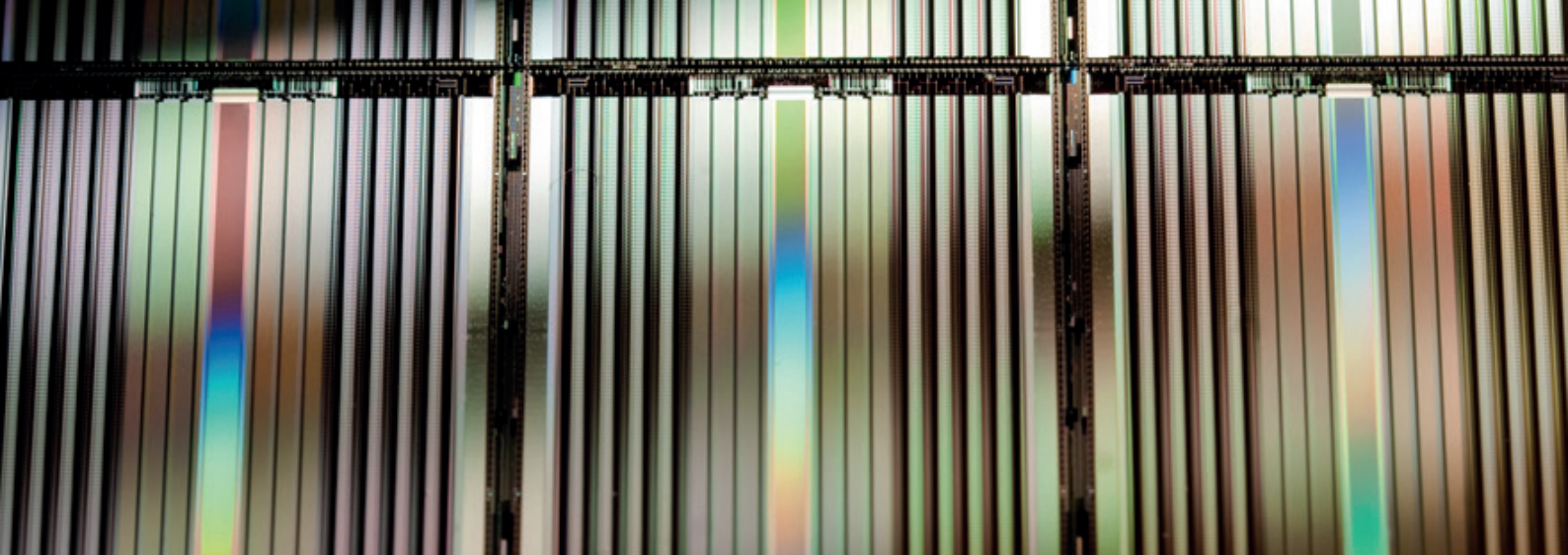
As part of the FMD One-Stop-Shop for microelectronic research and development, our aim is to help you realize your development goals. We are also open to tailoring our solutions to your individual application needs.





Our Competencies in Extended CMOS along the Value Chain





Materials &
Processes,
Devices &
Components

Facilities

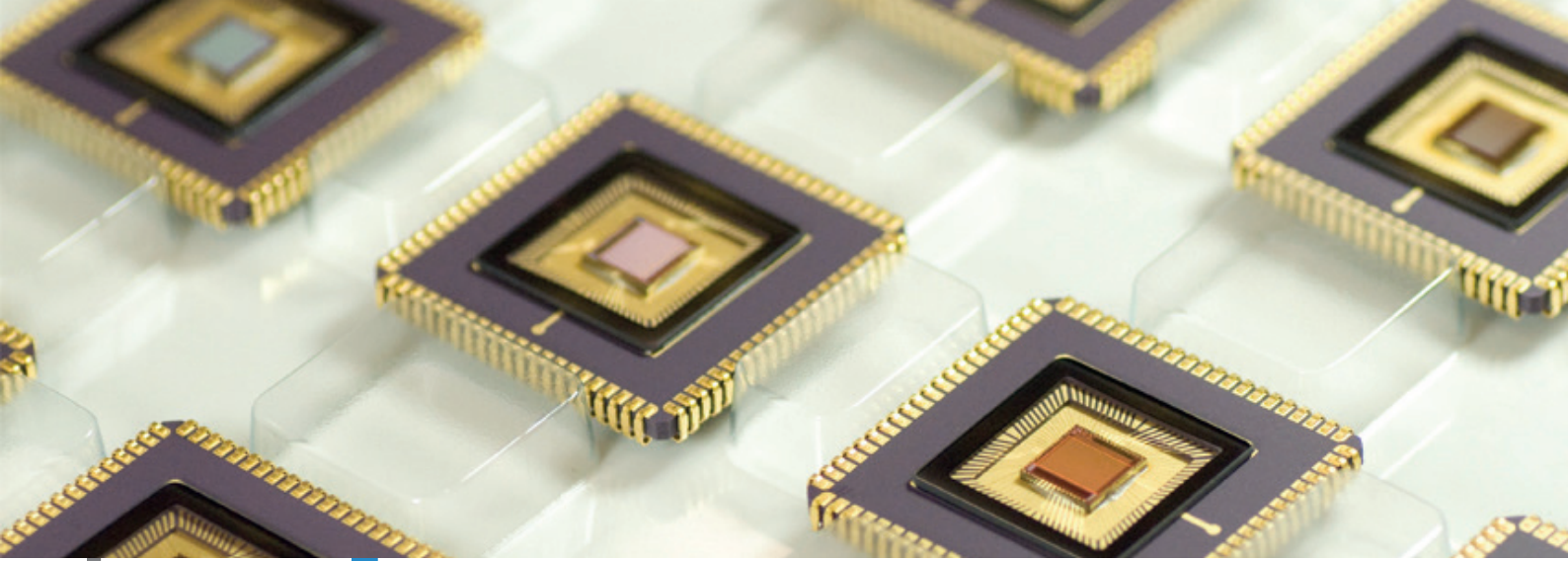
- 7 cleanrooms, ISO9001 and partially automotive certified
- 200 mm complete BiCMOS/CMOS, high temperature CMOS, HV CMOS lines and foundry, incl. FEOL and BEOL modules
- Interface to other foundries, wafer exchange to 200 mm/300 mm foundries and IDMs
- 300 mm material, process and equipment screening line
- 200 mm / 300 mm packaging lines
- Automated in-line process monitoring
- front-end and back-end contamination procedure and control

Material
Development

- Si, SOI, SiGe
- Materials for frontend processes – metals, high k, low k, oxides, magnetic films
- Functional materials: piezo materials (lead free materials), ferroelectrics, low dimensional – 1D/2D (e.g. metal-dichalcogenides (MoS_2 , WS_2), CNTs, graphene), spintronic stacks
- Packaging: Si, glass, polyimide

Process
Development

- Own 130 nm - 350 nm CMOS processes
- Special technologies for harsh conditions (high temperatures, radiation hardened for space applications)
- BiCMOS compatible module integration, like IR sensors and NVM
- Developments for memories, neuromorphic computing, quantum computing
- Single process development and optimization such as etch, clean, CMP, epitaxy (Si, SiGe), plating, ALD/ALE, thin film deposition
- Process and equipment simulation (e.g. lithography, PVD, CVD, ALD, ECD, CMP)
- Bonding processes for CMOS-compatible module integration



Heterogeneous System Integration

Components & Circuits Realization

- Passives (inductors, MIM capacitors, resistors)
- High-performance and high-voltage SiGe HBTs, RF-LDMOS devices and monolithically integrated Si-phonic devices
- Emerging memories (Fe-FET, FRAM, MRAM, RRAM)
- CNT-FETs, memristors, spintronic
- Digital, analog, mixed-signal, high frequency circuits

Assembly & Packaging

- Memory, CPU, FPGA – (single- and multi-chip) packaging – advanced packaging, die stacking, D2W bonding and die stacking
- Wafer level packaging, 2.5D/3D integration, TSV/TGV and RDL
- Advanced PCB substrates including chip embedding
- High density Si, glass and polymer interposer for high performance applications
- Fan-out molding (200mm / 300 mm or panel format (18" x 24"))
- MEMS on CMOS
- Full-wafer thinning down to 10 μm
- Permanent/temporary wafer bonding, hybrid bonding/low temperature wafer bonding

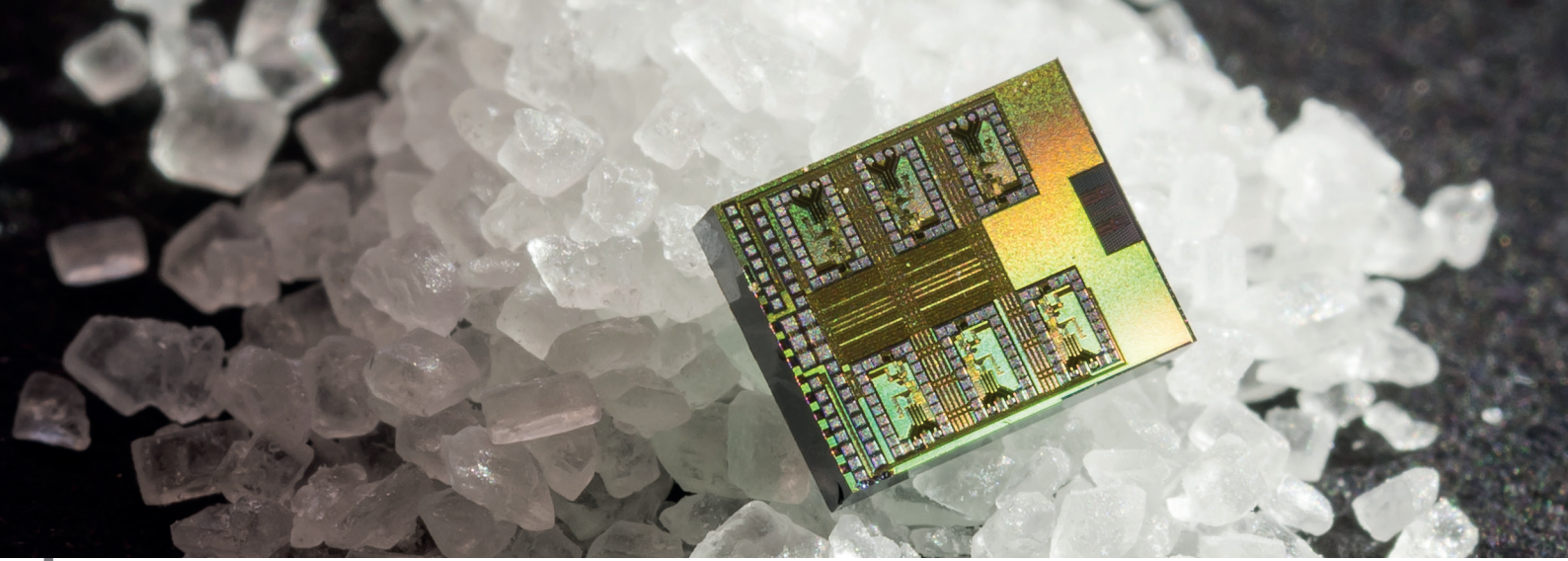
Characterization, Test & Reliability

Materials & Devices Test

- Nondestructive and in-depth analysis of materials, devices and components on micro and nano scale
- Electrical device test for wide range in DC/AC performance

Wafer level Analysis & Test

- Automated in-line monitoring for process and devices
- Test of analog-mixed signal circuits and digital circuits



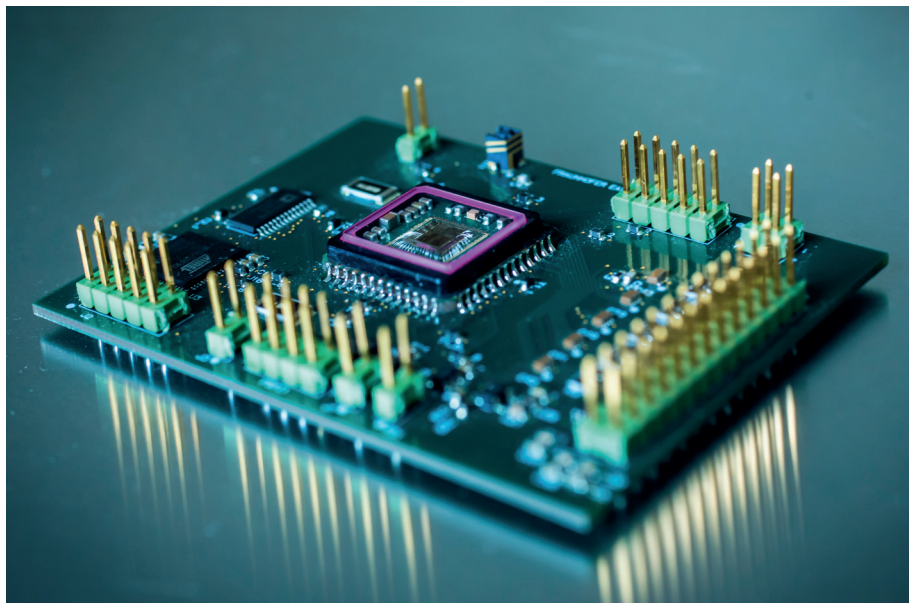
Materials & Devices Test

- Electromagnetic compatibility (EMC), signal integrity (SI)
- 200mm / 300 mm wafer level in-line metrology
- Degradation, lifetime, failure analysis and system/package test under multiple stress scenarios
- Finite element modeling (FEM) of packaging, life-time estimation and optimization
- Thermoelectrical, mechanical and electromagnetic reliability and combined load testing

Technology Example: Universal Sensor Platform – USeP

The Fraunhofer institutes ENAS, IIS/EAS, IPMS, IZM-ASSID, in cooperation with GLOBALFOUNDRIES Dresden Module One LLC & Co. KG. are together developing a Universal Sensor Platform (USeP).

GLOBALFOUNDRIES supplies a 22 nm CMOS circuit. A variety of sensors and actuators from the Fraunhofer institutes are integrated into the packaging. The project is advancing innovative packaging, system design, sensor development, data transfer, simulation and testing. The platform also features novel hardware and IT security solutions.



Example of a chip package.

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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