Forschungsfabrik
Mikroelektronik
Deutschland

RESEARCH FAB MICROELECTRONICS GERMANY

FRAUNHOFER GROUP FOR MICROELECTRONICS IN COOPERATION WITH LEIBNIZ INSTITUTES FBH AND IHP

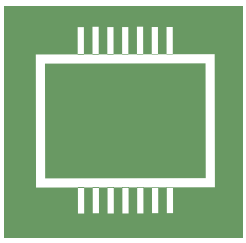
Sensor Systems

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.

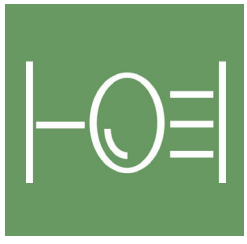
Our Technology Portfolio



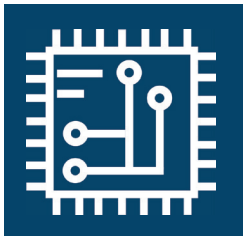
Microwave and Terahertz
Cutting-edge devices and circuits for frequencies up to and including the THz range.

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

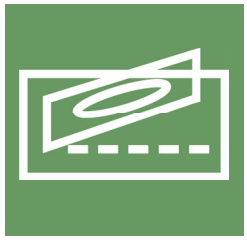
Power Electronics
Design and fabrication of power electronic devices, including integration in modules and systems.



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



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



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

Technology Platform: Sensor Systems

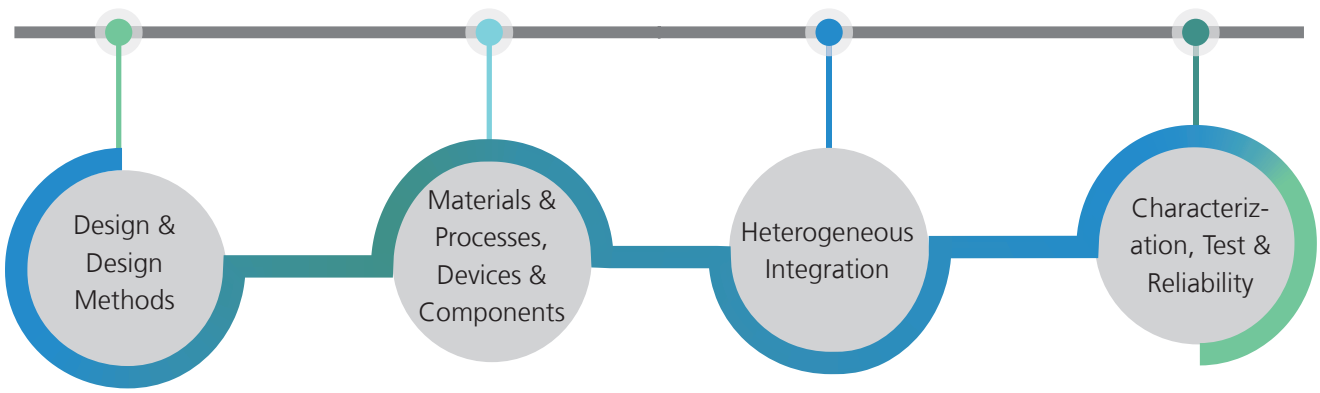
The technology platform Sensor Systems brings together the know-how of Research Fab Microelectronics Germany (FMD) along the entire value chain in system architecture, design, materials and processes, hardware and software-system integration, as well as sensors and sensor-system characterization and testing.

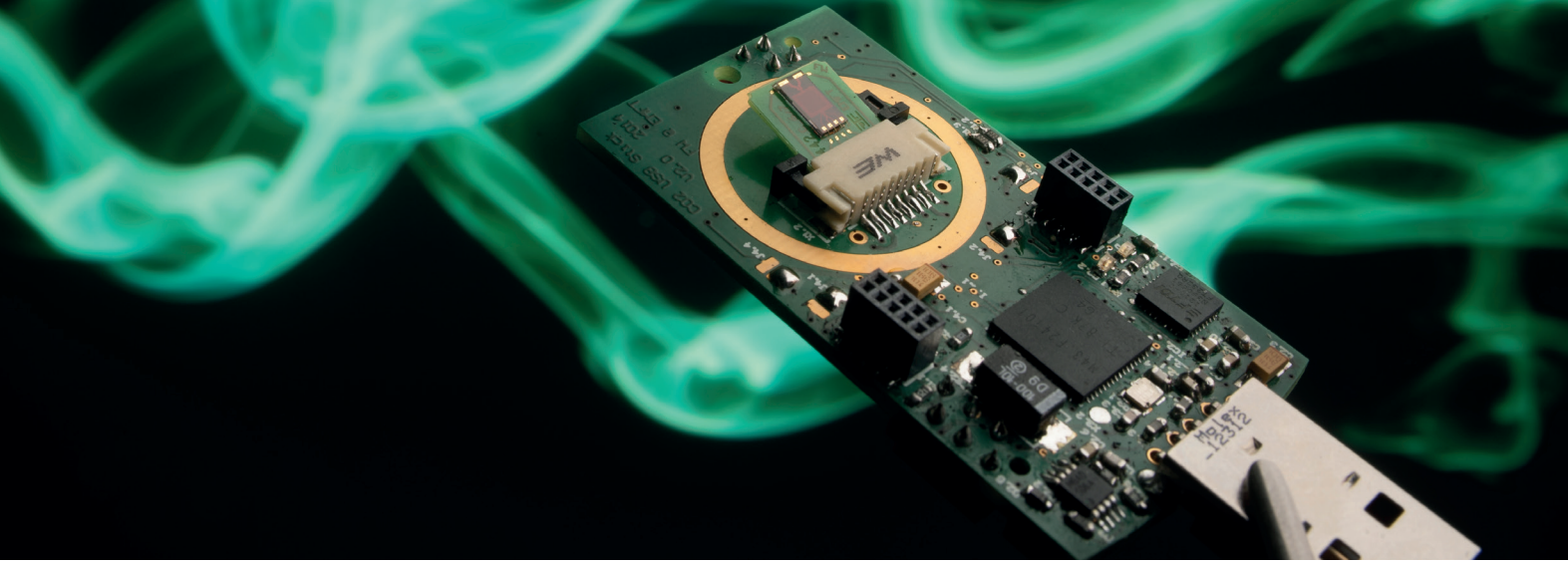
FMD has unparalleled expertise in the manufacturing of sensors and the integration of sensors in complex systems for all kinds of applications. Sensor systems may also contain modules for smart connections and for sensor-integrated signal processing used in IoT, Industry 4.0 and similar applications. The technologies even support high-density interconnection, such as for the realization of backside-illuminated (BSI) detectors.

Our platform combines a wide range of competencies, covering all phases of development, including the design of sensor systems, design for reliability and testing of sensor systems even under harsh environments. We factor in application-specific requirements, such as very low power consumption, high performance and high reliability.

For prototyping, we provide the expertise in CMOS- and MEMS-based processes and materials integration needed for customized sensors and sensor systems-in-package or system-on-chip. Fully integrated sensor solutions (MEMS on CMOS), as well as hybrid integrated sensor systems, are also available to our customers. Sensor packaging is crucial to ensure highly reliable systems. Our technological portfolio is complemented by expertise in characterization (optical, acoustical, electrical, mechanical and vibration, magnetic) and sensor/sensor-system testing, including reliability assessments under multiple stress scenarios.

In summary, the technology platform Sensor Systems offers tailored solutions along the entire microelectronic value chain for your specific application.





Our Competencies in Sensor Systems along the Value Chain

Design & Design Methods

Component Design

- MEMS/NEMS sensors, CMOS-, GaAs- and SiGe-BiCMOS-, polymer-, SiN- and InP-based sensors
- CMOS-integrated 3D Hall sensors, multi-spectral and polarization filters, color and image sensors, radar sensors
- High temperature SOI-CMOS sensors and sensor electronics up to 300 °C
- SiC sensors and amplification circuits beyond 300 °C
- Integrated signal conditioning and computing as well as generic data interfaces

Package & System Design

- Chip scale vacuum packages, MEMS packages
- Hierarchical multi-sensor systems, energy autarkic sensor systems, universal sensor platforms, sensor networks
- Sensor signal processing, calibration and self-test

Materials & Processes, Devices & Components

Material Development

- Si, SOI-CMOS, SiGe-BiCMOS, CMOS and CMOS compatible sensor materials such as SiN, polymer, AlN, CNT, and AlScN, InP, InGaAsP, InGaAlAs, graphene, BFO, polymer nanocomposite, 2D transition metal dichalcogenide monolayers

Heterogeneous System Integration

Process Development

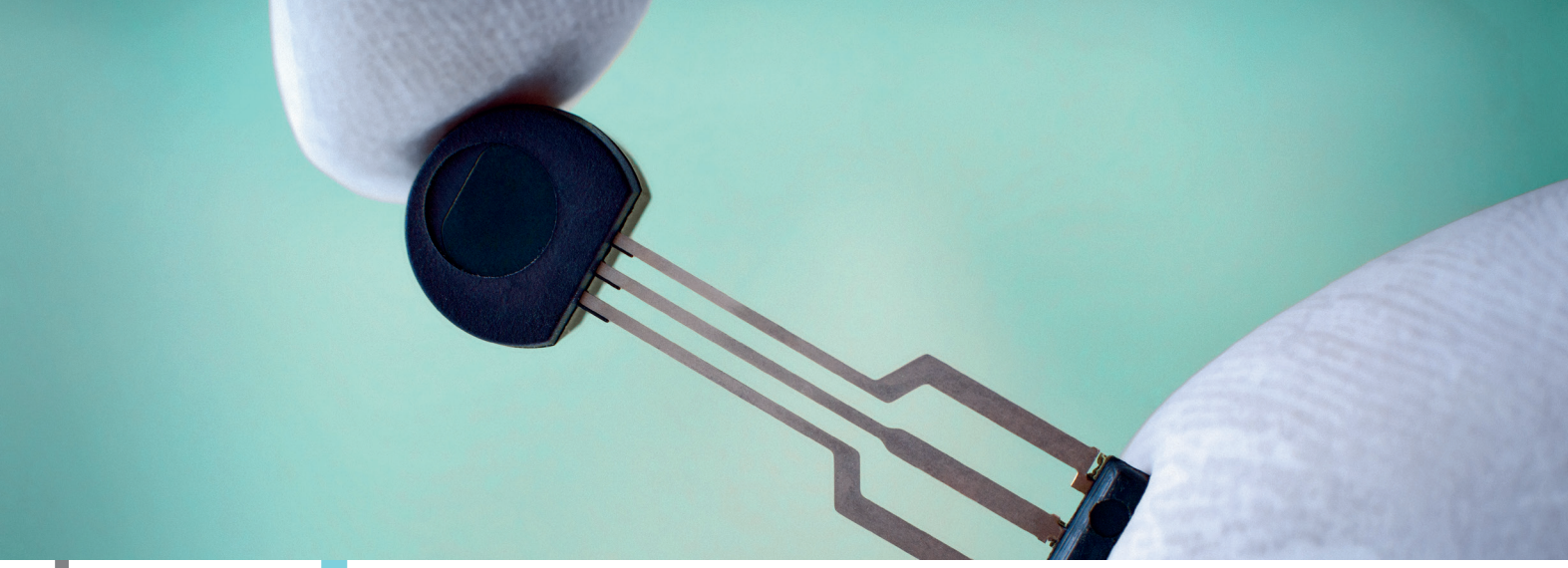
- Planarization, surface micromachining, bulk micromachining, high aspect ratio micro-machining, advanced silicon etching, low temperature backend processes, 3D-ALD structures

Devices & Components Realization

- MEMS/NEMS sensor devices for pressure, vibration, acceleration, inclinometer, gyroscope
- Bio sensors for inter-cell contact, optical devices like SPAD, LDPD, PIN-diodes, micro-fluidic feedings
- SiGe-BiCMOS sensor for viscosity
- Polymer-based optical interrogators
- Optical sensors and sensor systems (NIR spectrometers, microspectrometers)
- SiC UV sensors and high temperature electronics
- SiC- or SiN-based and RF gas sensors for H_2, NH_3, hydrocarbons, ozone, humidity, NOx, CO, CO_2CH_4
- Micro machined ultrasound transducers (CMUT, PMUT)
- Magnetic field and magnetic position sensor systems
- Radar and TWR (Two Way Ranging) back- and front-ends

Assembly & Packaging

- Chip-level integration: chip-scale vacuum package, chip-to-wafer bonding
- Wafer level integration: waferbumping/ redistribution, Si interposers, TSV imple-mentation, assembly of MEMS components on wafer level, hermetic wafer bonding of a cap wafer, housing, 3D stacking, backside illuminated sensors (BSI), chip-to-wafer and wafer-to-wafer bonding



Characterization, Test & Reliability

Devices & Components Characterization & Test

- Panel-level integration: embedding into organic substrates, optical inter-connection
- Prototype manufacturing and possibility of process transfer for high volume production

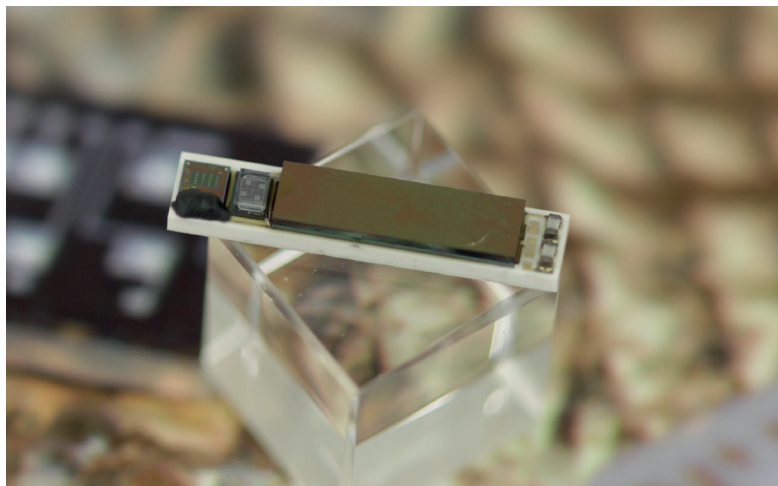
- MEMS characterization on wafer and chip level
- Optical characterization of color and image sensors
- In-circuit measurements of millimeter wave components and modules up to submillimeter wave

System Test & Reliability

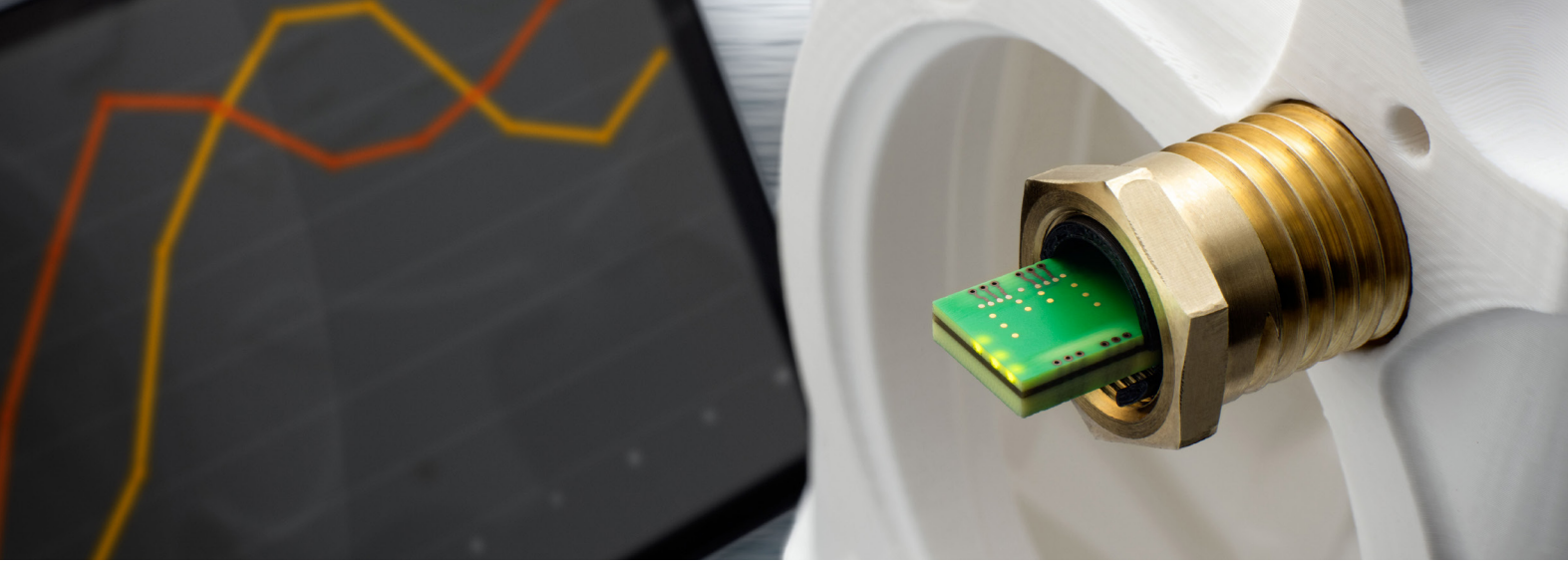
- Mono- and bistatic measurements of millimeter and submillimeter wave components, circuits and systems up to 1.1 THz
- Hermeticity characterization

Technology Example: Theranostic Implants

Theranostics is the combination of diagnostic and therapeutic features in a single device capable of measuring and functioning by means of smart technology. The emerging technology of such implants facilitate precision medicine and individualized treatment of patients.



Overall system including pressure and acceleration sensor with a length of about 15 mm and a diameter of about 3 mm.



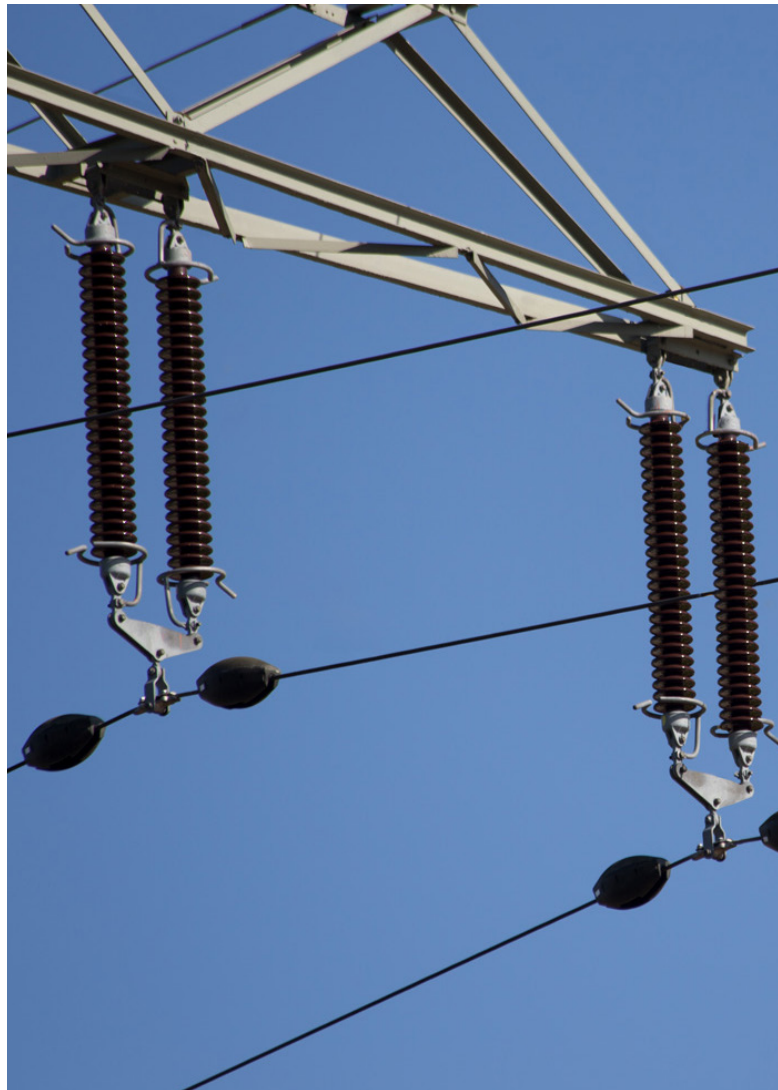
The high-end sensor technologies these devices are based on, are demonstrated as part of the "Fraunhofer Light-house-project", which saw the development of a highly miniaturized wireless and implantable multi sensor system.

The overall system consists of a pressure sensor, an ASIC for data and energy management, an accelerometer, and an LTCC-based interposer containing a coil for inductive energy supply and data transmission. The pressure sensor has an operating range from 800 hPa to 1400 hPa and a resolution of 0.2 hPa. An acceleration sensor was integrated into the system to detect external conditions like movement and shock. The two-dimensional inertial sensor has two measurement areas ±1 g (low frequency) and ± 5 g (high frequency), and a sensitivity of about 100 fF/g per dimension.

Technology Example: High-Voltage Power Grid Monitoring

ASTROSE® is a tried and tested monitoring system for high-voltage power grids. By providing a reliable stream of data, the current-carrying capacity of power lines (ampacity) can be optimized, faults and damage pinpointed immediately, and maintenance activities managed more efficiently.

ASTROSE® monitors power grids directly on the lines. The autonomous wireless sensor nodes are installed on the lines themselves and capture a range of information locally. The fully autonomous sensor nodes are located at a distance of up to 500 m, typically immediately after pylons. The monitoring data is fed wirelessly through the sensor chain to a feed point that interfaces with the grid control center. ASTROSE® uses the inclination (tilt) of the line as the integral physical measurement and the reference for calculating additional properties, such as the current temperature of the line or its catenary and surface clearance.



Monitoring system for high and maximum voltage power grids increases the capacity of overhead lines, streamlines monitoring and maintenance, and promises substantial economic and ecological benefits.

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