

## Fraunhofer Group for Microelectronics in Cooperation with the 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.

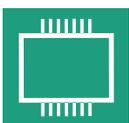
### Our Technology Portfolio



**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.



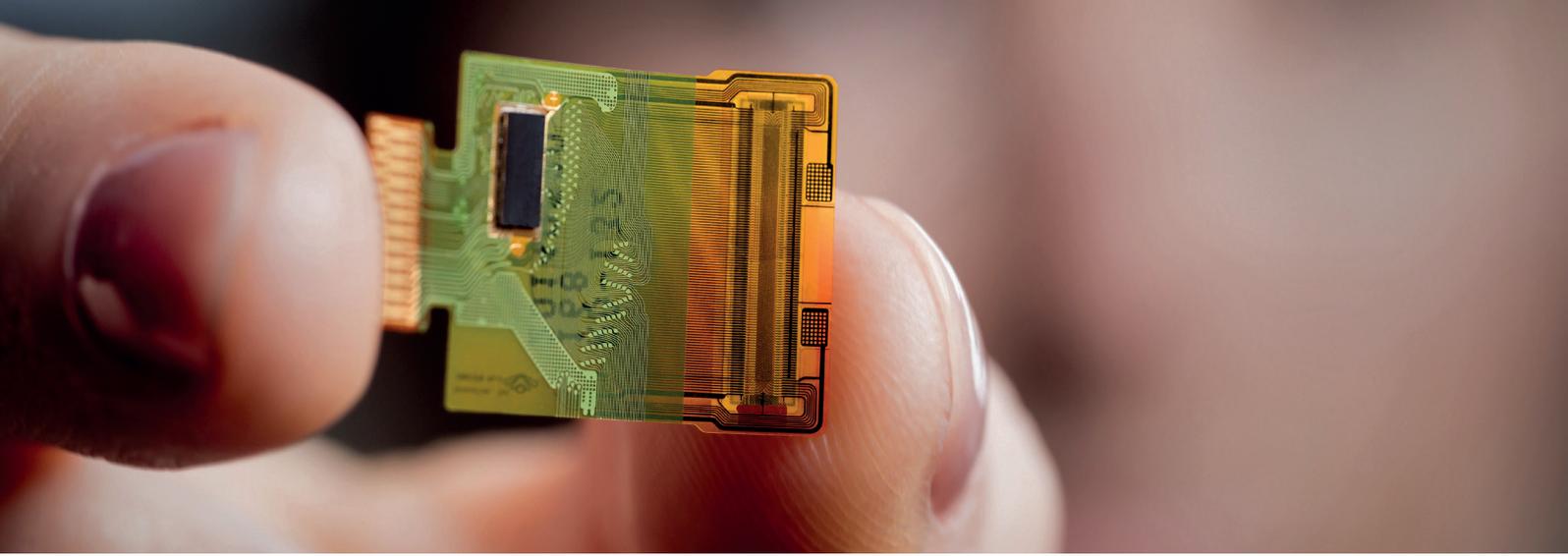
**Optoelectronic Systems**  
Fully integrated optoelectronic systems for image acquisition and processing, and communication up to Tbit/s speed.



**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: 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 in sensors and sensor-system characterization and testing.

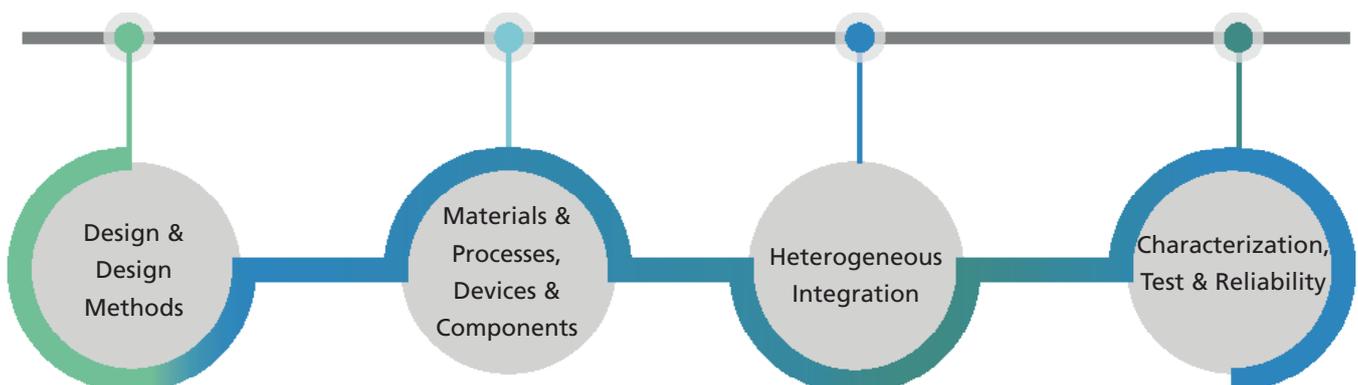
FMD has unparalleled expertise in the manufacturing of sensors and the integration of sensors in complex systems for all kinds of applications. Sensor systems may also contain modules for smart connections and for sensor-integrated signal processing used in IoT, Industry 4.0 and similar applications.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

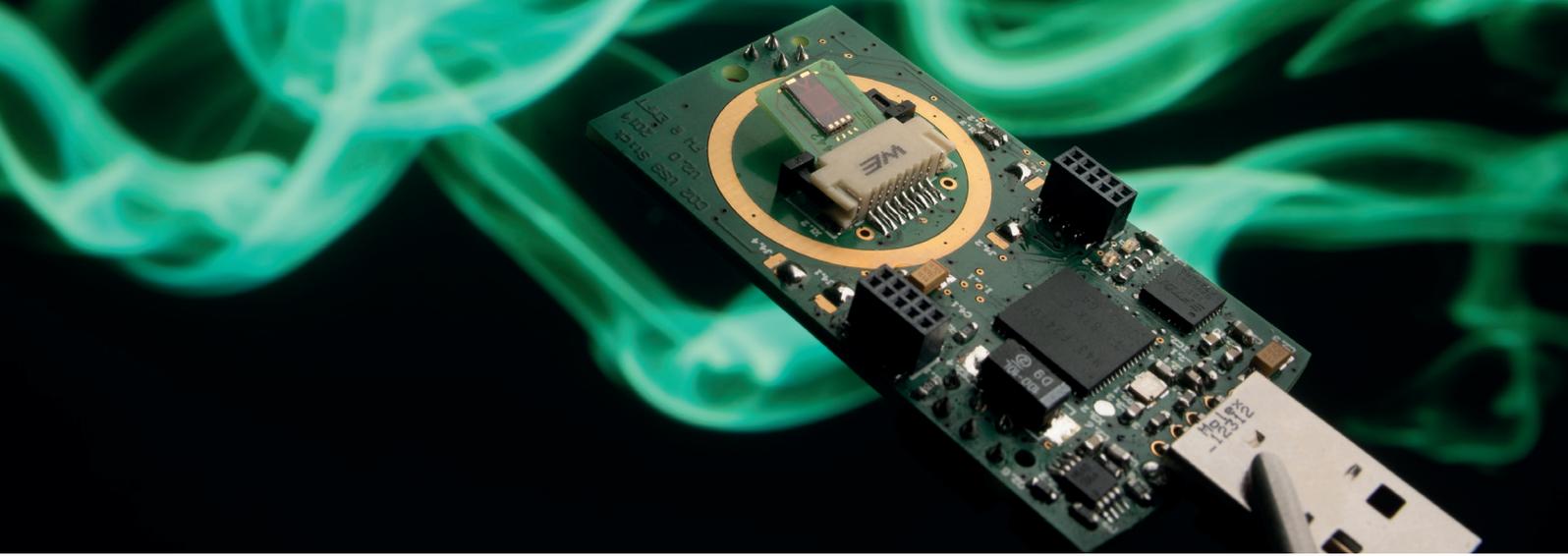
Our platform combines a wide range of competencies, covering all phases of development, including the design of sensor systems, design for reliability and testing of sensor systems even under harsh environments. We factor in application-specific

requirements, such as very low power consumption, high performance and high reliability.

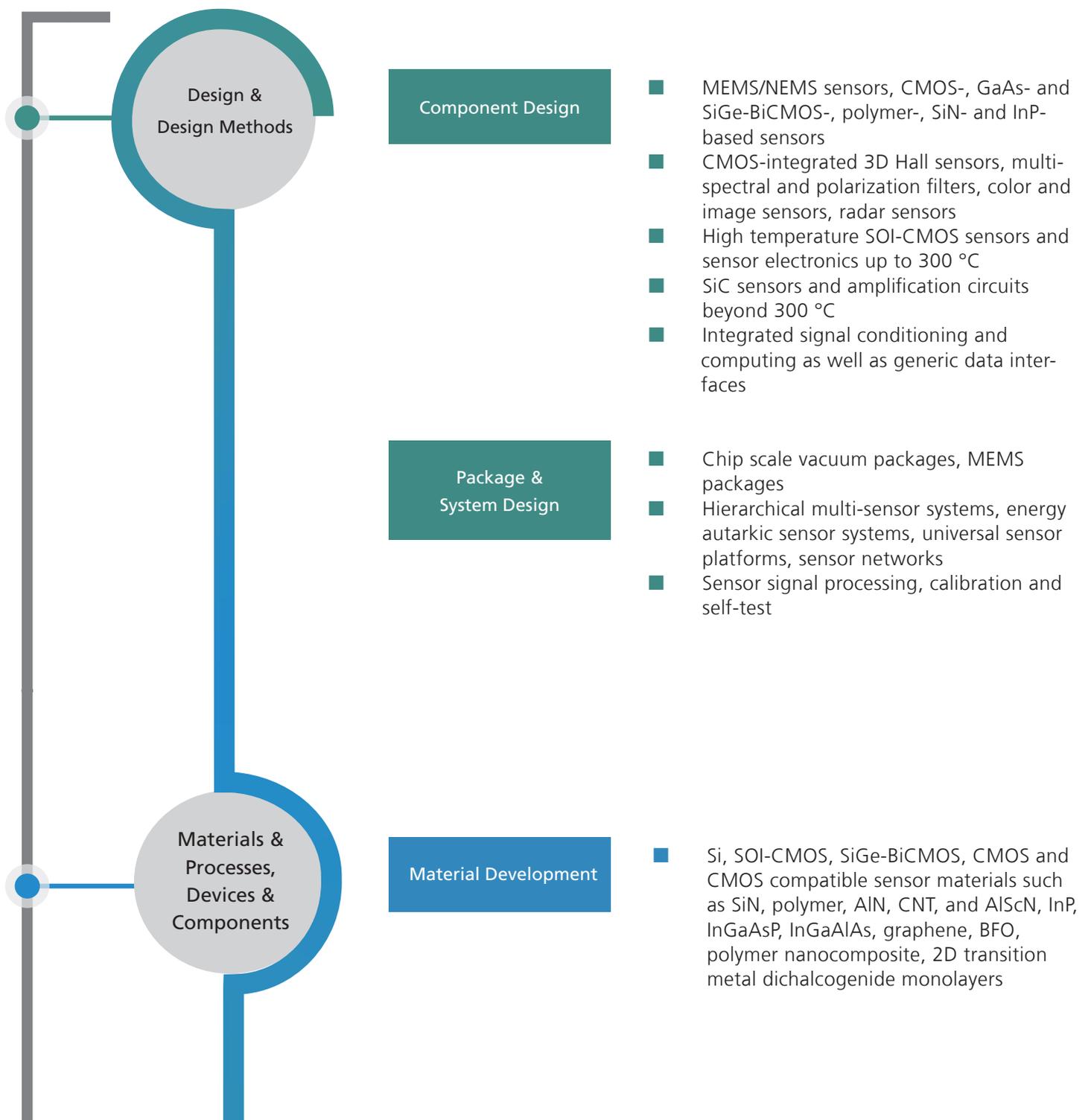
For prototyping, we provide the expertise in CMOS- and MEMS-based processes and materials integration needed for customized sensors and sensor systems-in-package or system-on-chip. Fully integrated sensor solutions (MEMS on CMOS), as well as hybrid integrated sensor systems, are also available to our 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





### Process Development

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

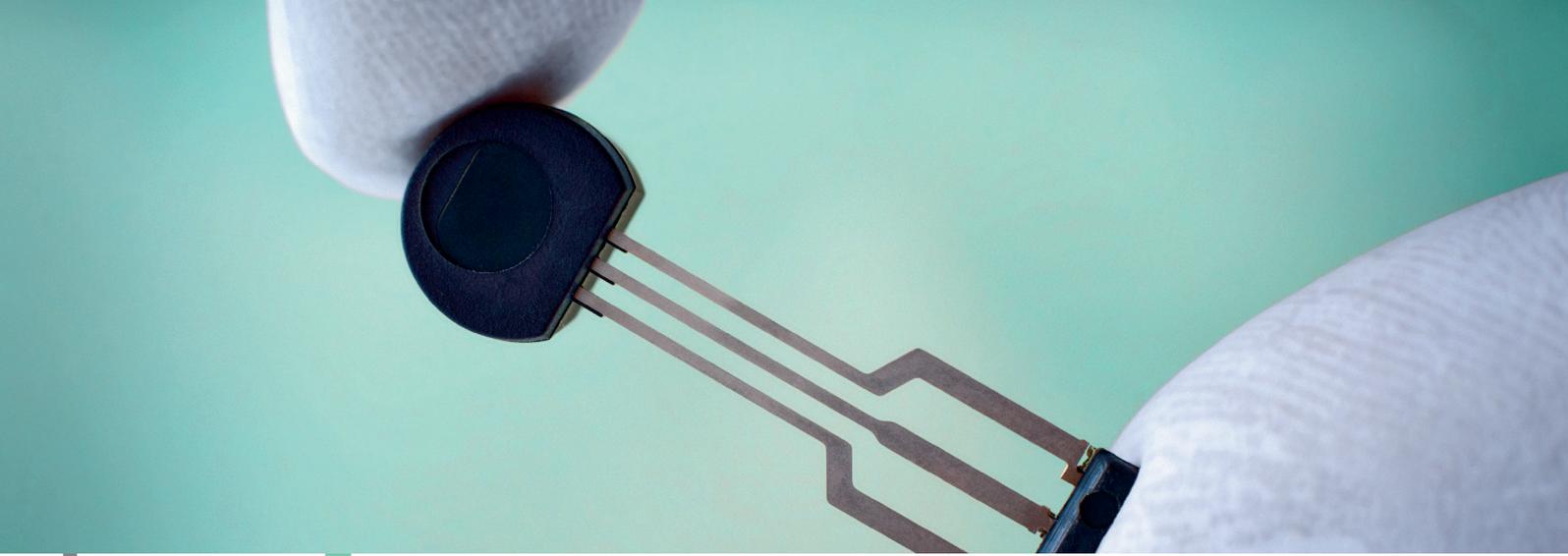
### Devices & Components Realization

- 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<sub>2</sub>, NH<sub>3</sub>, hydrocarbons, ozone, humidity, NOx, CO, CO<sub>2</sub>, CH<sub>4</sub>
- Micro machined ultrasound transducers (CMUT, PMUT)
- Magnetic field and magnetic position sensor systems
- Radar and TWR (Two Way Ranging) back-and front-ends

### Heterogeneous System Integration

### Assembly & Packaging

- Chip-level integration: chip-scale vacuum package, chip-to-wafer bonding
- Wafer level integration: waferbumping/redistribution, Si interposers, TSV implementation, 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

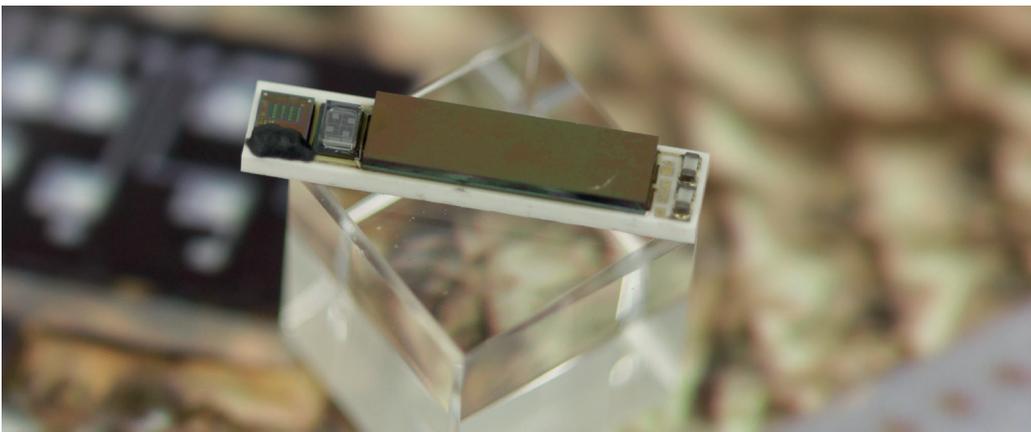
- Panel-level integration: embedding into organic substrates, optical inter-connection
- Prototype manufacturing and possibility of process transfer for high volume production

- 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



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



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.

The high-end sensor technologies these devices are based on, are demonstrated as part of the “Fraunhofer Lighthouse Projects”, 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 accelero-

meter, 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.

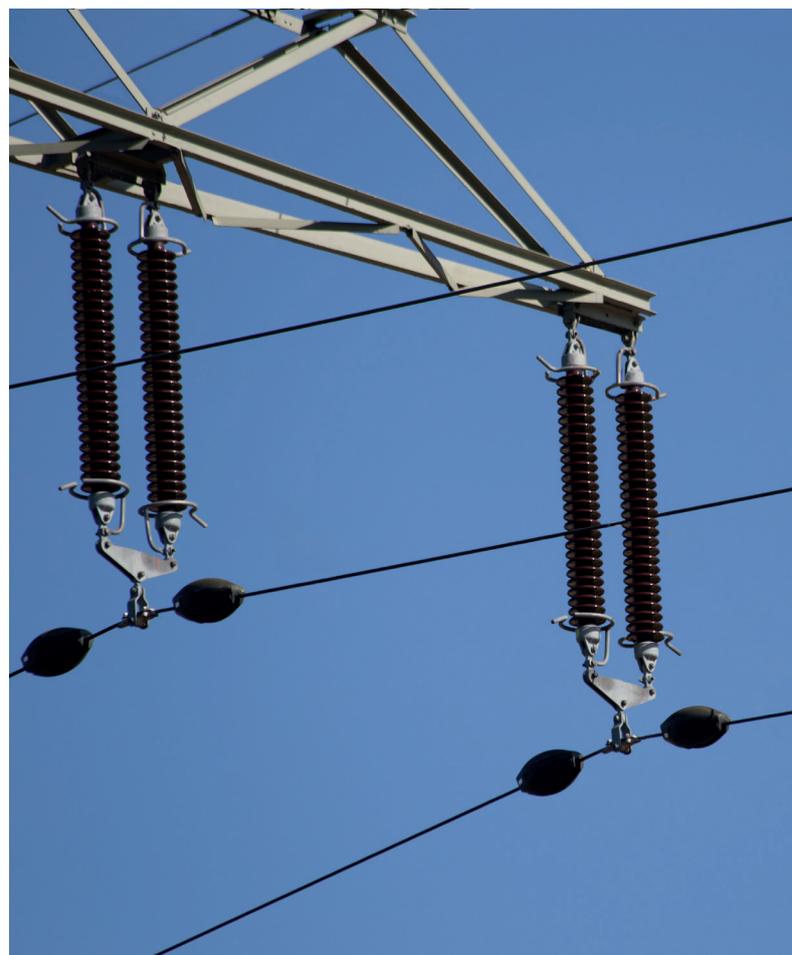
The two-dimensional inertial sensor has two measurement areas  $\pm 1$  g (low frequency) and  $\pm 5$  g (high frequency), and a sensitivity of about 100 fF/g per dimension.

## 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.*



# 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.

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Learn more about the range of products and services of the Research Fab Microelectronics Germany!

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*Examples: Fraunhofer ENAS, Fraunhofer IZM*