

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

# MEMS Actuators

### 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.

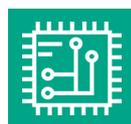
By joining forces, we are able to provide tailor made technology and system solutions from a single source. Drawing on FMD's broad technology portfolio, we have established six technology

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.

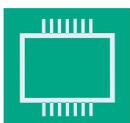
### Our Technology Portfolio



**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.



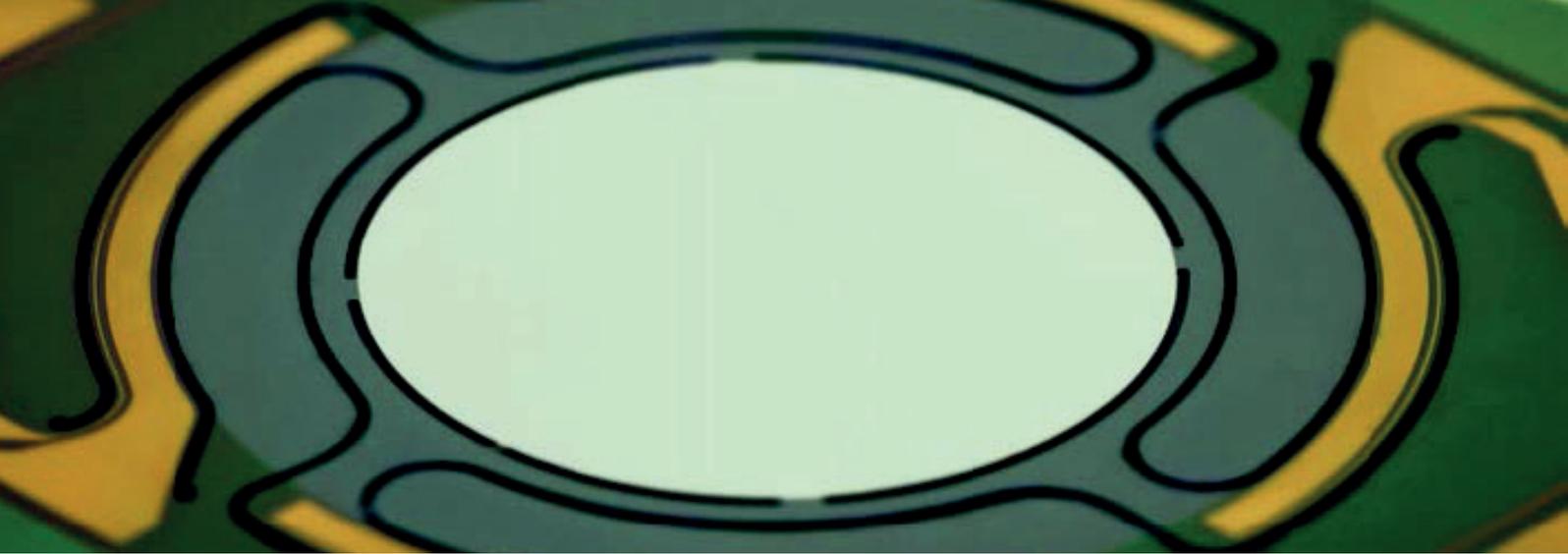
**Optoelectronic Systems**  
Fully integrated optoelectronic systems for image acquisition and processing, and communication up to Tbit/s speed.



**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.

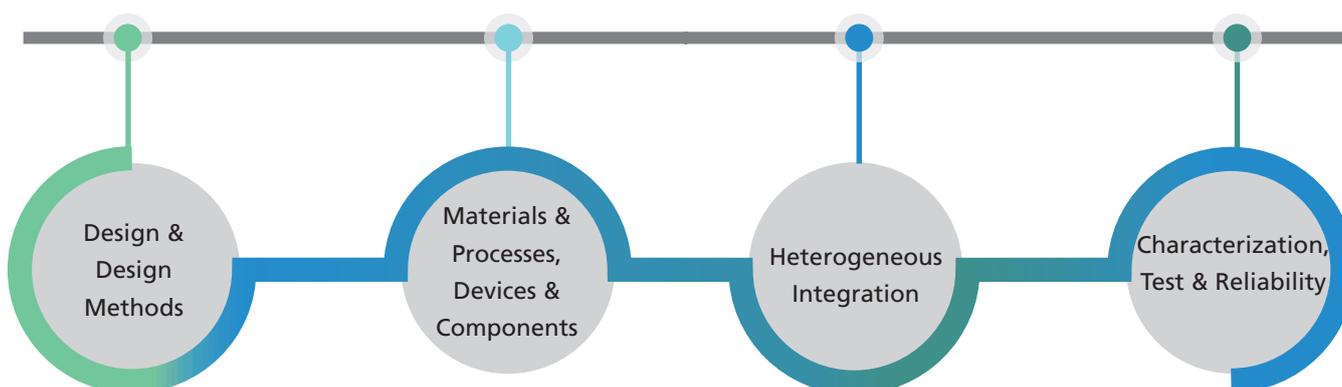


## Technology Platform: MEMS Actuators

As part of Research Fab Microelectronics Germany (FMD), the technology platform MEMS Actuators makes microelectronic development accessible to industry and research 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 to reliability assessment.

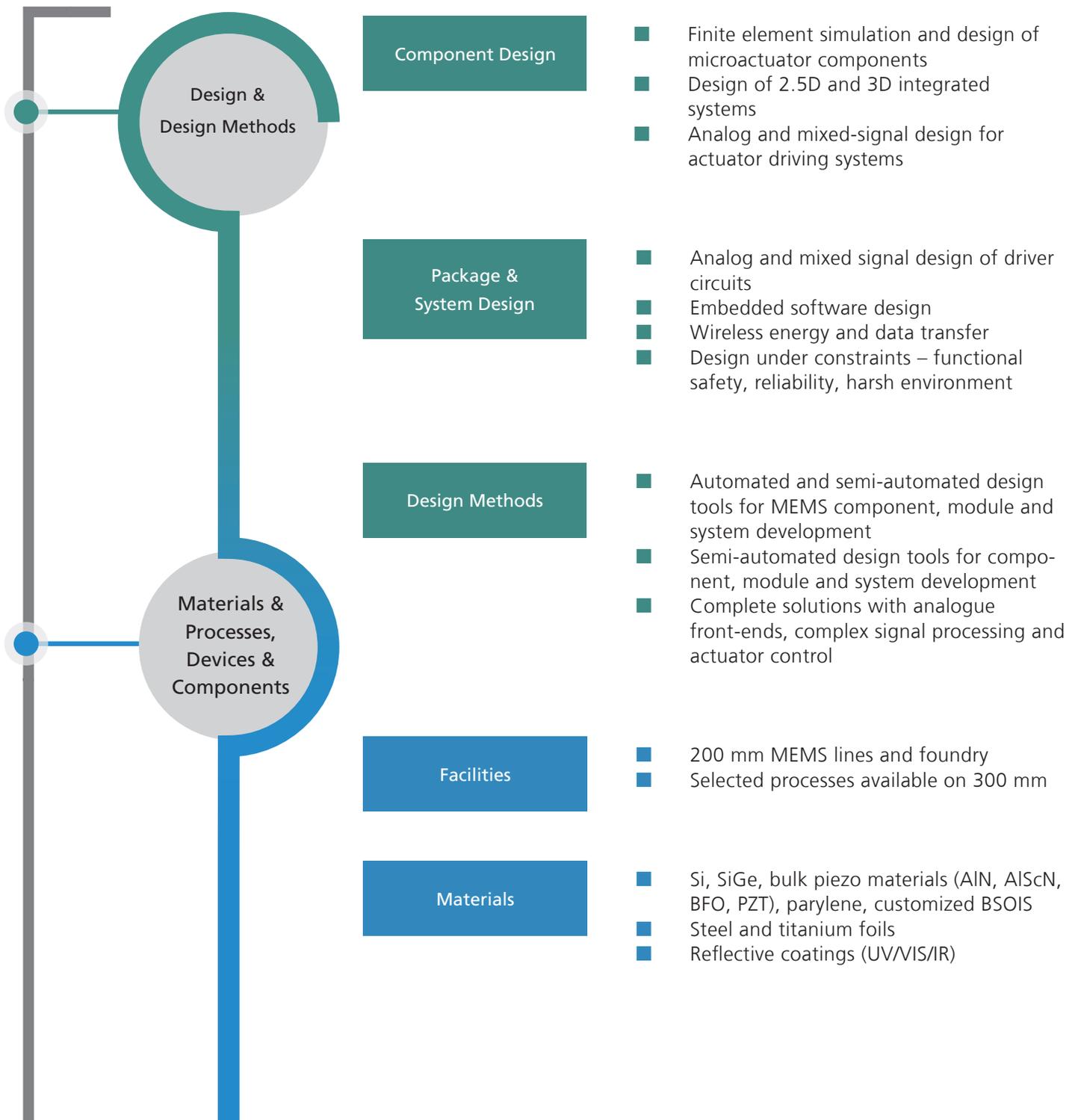
We have bundled the extensive experience and know-how of FMD in the development and manufacture of MEMS actuators into our technology platform. We specialize in design, including analog and mixed signal design for novel actuators, and design for reliability, functional safety and harsh environments. We advance materials and processes for bulk and surface micromachining, including epitaxy, advanced Si etching and piezoelectrical materials. Finally, we also develop components, including optical MEMS scanners, spatial light modulators, acoustic actuators, and microfluidic devices.

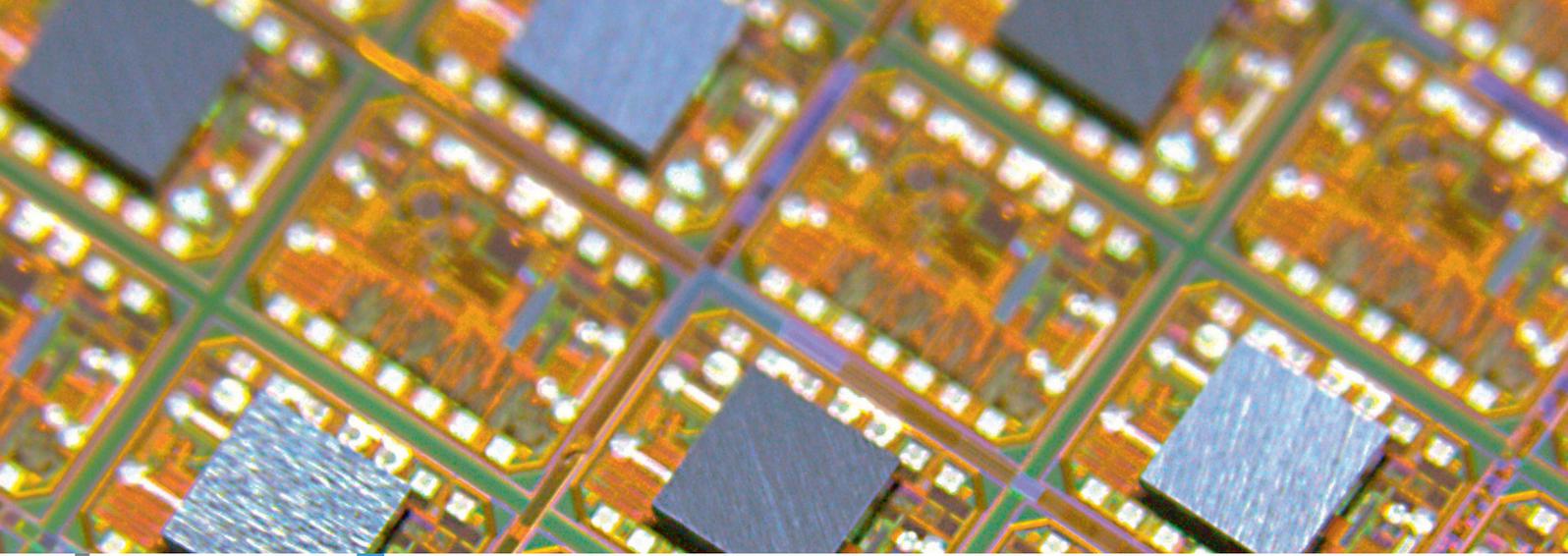
We offer a variety of MEMS/NEMS packaging services, including advanced approaches, silicon micro patterning, hermetic glass packaging, and wafer level capping are all available as mature device technologies. We also provide the widely established technology monolithic integration (MEMS-on-CMOS). Testing and characterization of materials and MEMS devices, including in various types of harsh environments, belong to our technology portfolio. Expert, nondestructive analysis of materials is widely available as well as techniques for assessment of MEMS device degradation. Characterization of heterointegrated systems, reliability testing under multiple stress scenarios and loading, lifetime measurement and prediction are all part of our service. We also perform virtual prototyping based on digital twins to estimate probable reliability prior to the fabrication of the first physical samples. The technology platform MEMS Actuators covers the entire value chain of microelectronic research and development as well as customized solutions. We aim to help you realize your development goal.





## Our Competencies in MEMS Actuators along the Value Chain





### Processes

- Silicon bulk micromachining and surface micromachining:
  - Cavity SOI technologies, positioning and patterning of piezoelectric film, strained SiGe epitaxy, advanced silicon etching
  - Wafer bonding (direct, adhesive, metal)
- Release technologies (HF- / XeF<sub>2</sub>-GPE):  
Anti-stiction coating (FDTS)
- Pick, place and glueing of thin bulk PZTs (50 μm)
- Laser welding of steel and titanium foils
- AIM technologies

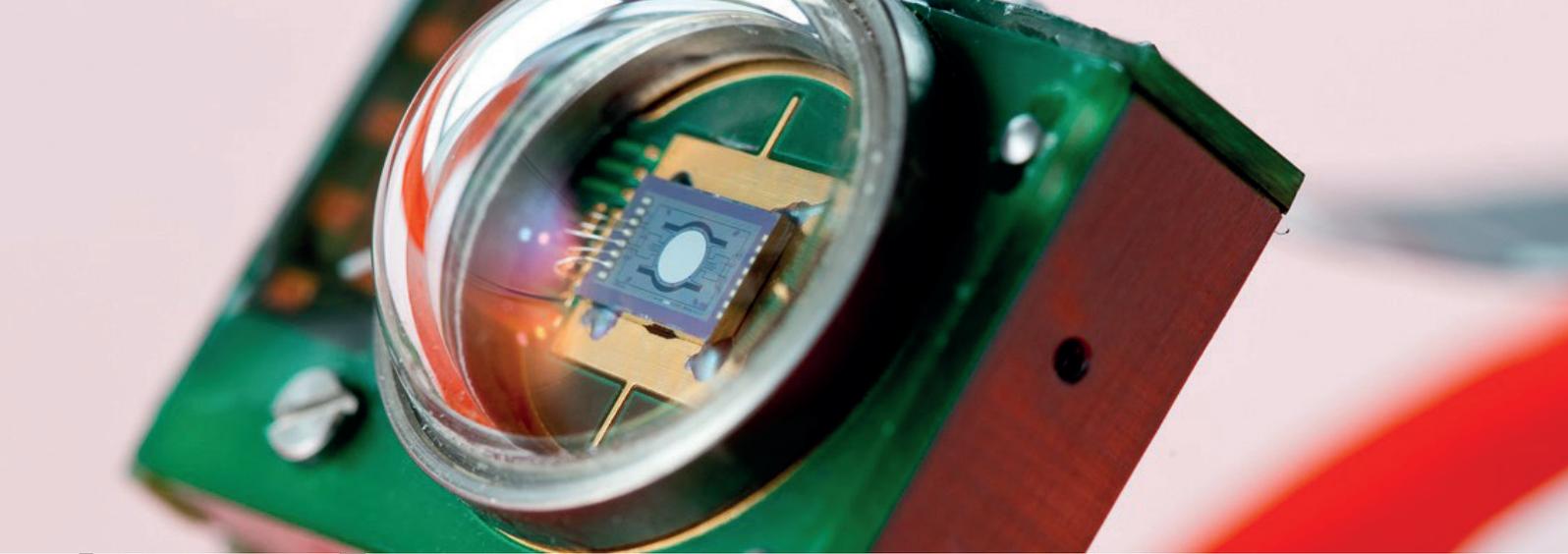
### Components

- Microfluidic (micro pumps, active/passive micro valves – normally open, normally closed)
- Spatial light modulators
- Acoustic actuators (CMUT, loudspeaker)
- Optical MEMS (MOEMS)
- Step switching mechanisms
- Ultrasonic transducers
- Microfluidic (valves, pumps)
- Optical MEMS scanners
- Fabry-pérot filters
- BAW, SAW, FBAR filters
- RF-MEMS switch
- Optical (IR) chopper

## Heterogeneous System Integration

### MEMS Actuator Packaging

- MEMS/NEMS integration on CMOS
- Packaging – advanced packaging
  - Chip-on-chip, chip-on-wafer
  - Hermetic glass packaging
  - Wafer level capping (Si, glass, other materials on request)
  - Integration of microfluidic channels
  - Wafer bonding: direct, anodic, SLID, reactive, TCB, seal glass
- Encapsulation (molding, potting, parylene thin film, ...)
- (Heavy) wire bonding



## Characterization, Test & Reliability

### Materials & Components

- Mechanical, thermal, electrical and electromagnetic characterization and modeling
- Nondestructive and destructive examination of materials and devices
  - White light interferometry for deflection and bending analysis
  - Dynamical/high frequency characterization of MEMS and MOEMS
- General test of MEMS/NEMS: MEMS test on wafer level (WLI)
- Device degradation testing

### Analysis & Test

- Automated in-line process monitoring
- Test of analog mixed-signal circuits and digital circuits
- Characterization of hetero-integrated systems
- Wafer level tests of actuator components
- Development of analytical and numerical models for advanced system characterization
- Wafer level optical probing

### Reliability

- Combined load testing
- Lifetime assessments and failure analysis
- Efficient system level test under multiple stress scenarios
- Environmental testing (moisture, vapor, corrosive atmospheres, vibration, shock)
- Wafer level reliability tests
- Electromagnetic compatibility tests
- Thermo-electrical and thermo-mechanical reliability



## Technology Example: MEMS Micropump – TUDOS

Once a cancer tumor begins to metastasize, the chances of recovery diminish significantly. Metastasis is particularly dangerous, if malignant tumors are present. Intensive, long-term research has failed to deliver a treatment that can halt the proliferation. Fraunhofer EMFT tackled the challenge in the industry-funded project  $\mu$ P Brain Test. The scientists approached the challenge from a new angle, developing a silicon, bubble-tolerant MEMS micropump (TUDOS – Tumor Dosing). The pump served as the core element of an autonomous implant that combats meningeal metastasis. By means of metronomic dosing in microliter range it provides the basis for cancer treatment that is highly forward-thinking, and more patient friendly.

*Device for tumor dosing: TUDOS.*

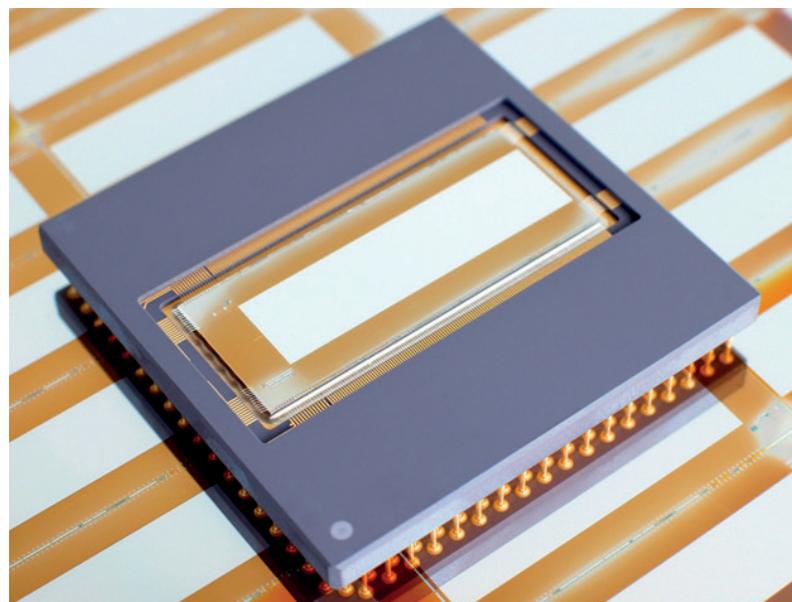


## Technology Example: MEMS/CMOS Integration

In a well-established, highly productive cooperation, the Fraunhofer institutes IMS and IPMS are developing a process for integrating actuators on CMOS backplanes. Fraunhofer IMS designs the backplane and provides 200 mm wafers to its sister institute Fraunhofer IPMS.

In Dresden, MEMS and MOEMS actuators are integrated into the underlying CMOS substrates. The cooperation has already seen spatial light modulators and micro mirror arrays produced.

*Tilt mirror array with 1 mln. individual mirrors.*



# 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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