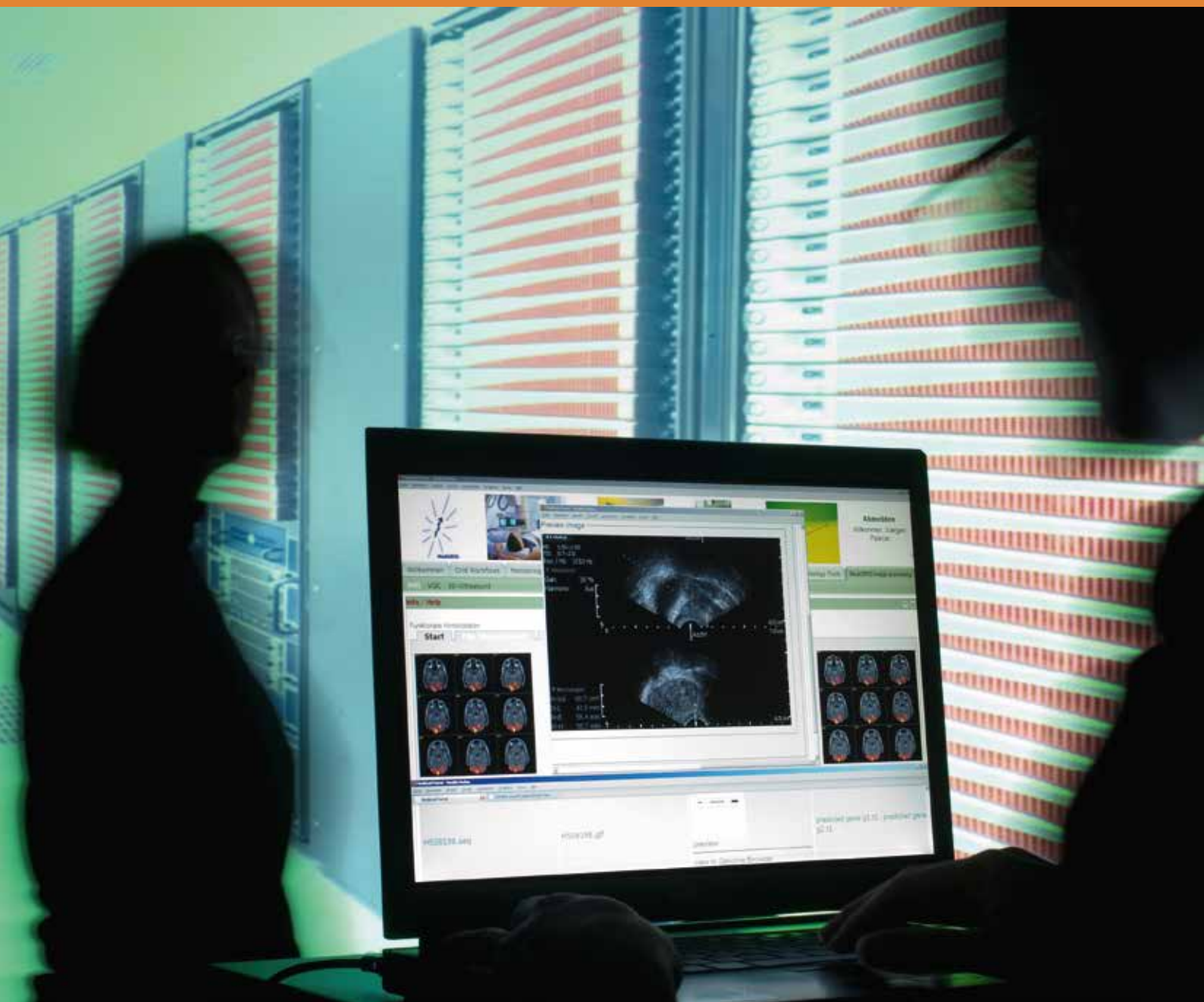
Fraunhofer
IPMS

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS

Application Area

Medical & Health



The endo-microscope is only 8 mm in diameter and small enough to be applied in minimally invasive medicine.

Medical & Health

With extensive experience in the development of photonic microsystems and related technologies including nano-electronics and wireless microsystems, Fraunhofer IPMS has released a variety of applications benefiting both industrial customers as well as society as a whole. Innovative products developed at the institute can be found in all markets relevant to the information and communication technology, consumer electronics, automotive, semiconductor and medical industries. We are proud to present some selected examples here.

Systems for improved medical diagnostics and therapy are the subject of ongoing research and development. Fraunhofer IPMS makes many contributions to this field with the development of numerous important innovations. Fraunhofer optical MEMS devices are essential components for increased resolution in critical visual imaging. Other micromechanical devices developed at Fraunhofer IPMS facilities allow for new forms of therapy during treatment or exact dosages of medication. In addition to industry profits from innovative products and treatments, the global society draws important health benefits from new and improved medical technology.

Key Topics

- Endoscopy
- Microscopy
- Medical Imaging
- Microfluidics

Endoscopy

In recent decades, endoscopes allowing for minimally invasive medical treatment or internal surgical intervention have been developed to reduce the burden put on patients. These tools are, however, usually not capable of providing visualizations of the tissues being examined at a magnification level in which cell structures become visible.

In response to this problem, Fraunhofer IPMS has developed an endo-microscope with a diameter of just 8 mm, small enough for application in minimally-invasive medicine. This provides the ability to conduct microscopic inspection of suspicious tissue in vivo, to speed up the examination process and to carry out accurate, target-oriented biopsies.

The endo-microscope uses a MEMS scanning mirror developed and manufactured at the Fraunhofer IPMS. This mirror projects a focused beam of light over the object under examination in a defined pixel raster from which reflected light is detected and electronically reconstructed to form an image. The tip of the microscope consists mainly of the MEMS element on a ceramic bearing for electrical contact, a tilted mirror and a lens systems capable of focusing the beam of light according to the distance of the object. The light is coupled in and out over an optical fiber that is combined with electric wires to form a thin connection bundle. The microscope head yields a spatial resolution of 15 to 20 µm with a field of view of about 3 × 3 mm. The endo-microscope can be applied in the areas of biology, biotechnology and engineering for microscopic inspection of very small objects in hard to reach locations such as the interior of hollow spaces with narrow access channels.

Micro scanners and spatial light modulators developed at Fraunhofer IPMS are used in microscopy.

Microscopy

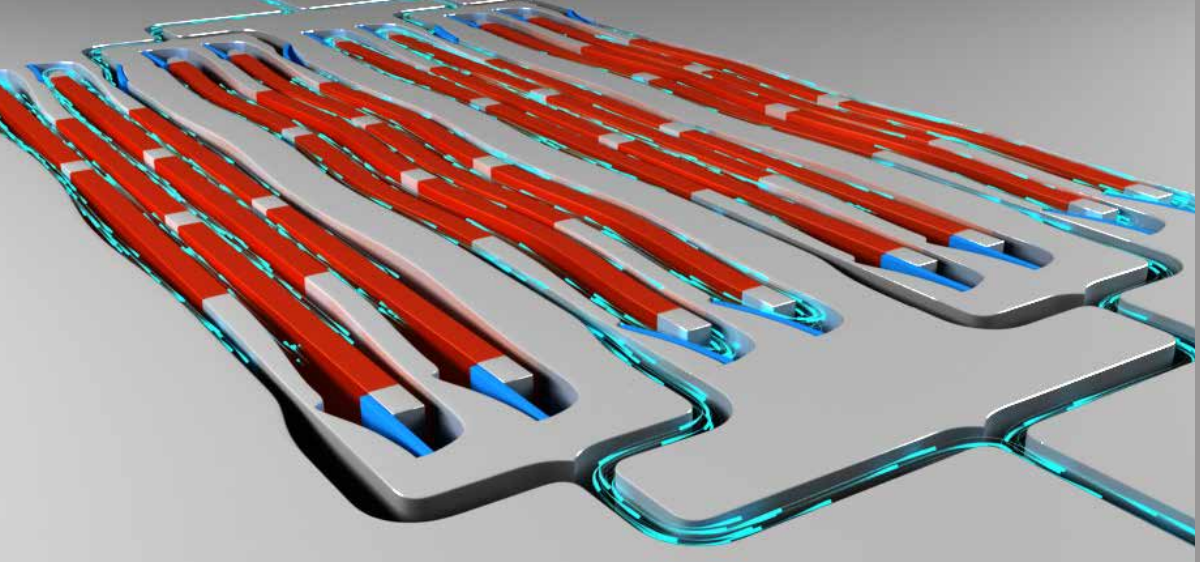
With the help of microscopy, objects and structures sized below the spatial resolution of the human eye can be viewed or visualized at a magnified scale. However, because object lighting often presents problems, Fraunhofer IPMS provides clients in-house developed solutions. In the areas of both micro scanners and spatial light modulators, Fraunhofer IPMS is an internationally leading service provider for research and development with many years of experience.

Micro scanners developed by Fraunhofer IPMS have been successfully applied in the area of light sheet fluorescence microscopy. In the microscope Lightsheet Z.1 from ZEISS, these scanners enable long-term three-dimensional and non-destructive examination of biological samples. MEMS scanners perfect image quality and eliminate undesired effects such as shadows caused by opaque parts of the sample in the light sheet.

Fraunhofer IPMS offers both the technological competence for component and system development as well as the application know-how acquired over more than ten years of development.

The institute currently offers over 50 different resonant MEMS scanners that can be used as one- or two-dimensional reflective elements and customized according to specific application demands. Scan frequencies range from ca. 0,1 kHz up to 50 kHz.

In classical optical microscopes, spatial light modulators are used in very compact systems to reflect light of diverse wavelengths with micrometer precision in an ultra-fast manner and, therefore, project arbitrary spatial patterns. The Fraunhofer IPMS micro mirror array can provide parallel lighting of several regions of which each may be smaller than a single cell, thereby collectively stimulating specific, light-sensitive molecules. Both the regions and the illumination angles can be precisely selected by using a second chip. This also accurately illuminates occluded objects that would otherwise appear as diffuse structures and considerably reduces numerous undesired environmental effects. By controlling the mirrors' reflection angles, it is possible to change both angle and intensity of the incident light up to 1000 times per second. This collaboration with the Institut Pasteur in Paris opens up a spectrum of new possibilities in the field of optogenetics.



Operating principle of MEMS-based micropumps, valves and dosage systems for liquids and gases in silicon-based microfluidics.

Medical Imaging

Sonography is a well-established method of analysis, especially in medical technology. In the form of ultrasonic arrays, the use of ultrasonic transducers is crucial for imaging techniques. The majority of ultrasonic arrays produced in medical technology today use the piezoelectric ceramic-lead-zirconate-titanate (PZT) according to the utilization of the reverse piezoelectric effect to generate sound.

High-frequency, high-resolution arrays based on PZT are, however, difficult to produce and therefore expensive. Micromachined ultrasonic transducers (MUTs), especially capacitive micromachined ultrasonic transducers (CMUTs), are providing new opportunities. The micromachining manufacturing process now allows for the economical production of high-frequency, high-resolution ultrasonic arrays. In addition, the capability for high miniaturization makes it possible to use MUTs in invasive applications such as intravascular ultrasound (IVUS).

Results from current development demonstrate the beneficial features of MUTs for the production of high-frequency arrays. A high bandwidth and low coupling are fundamental for the compatibility of MUT-based imaging with conventional medical imaging standards. For the first time, highly-integrated MEMS technology enables the signal of an array to locally connect with read-out electronics to achieve simple and compact contact between the elements. The implementation of this connection technique allows for highly planar surfaces to be used as a contact to the medium.

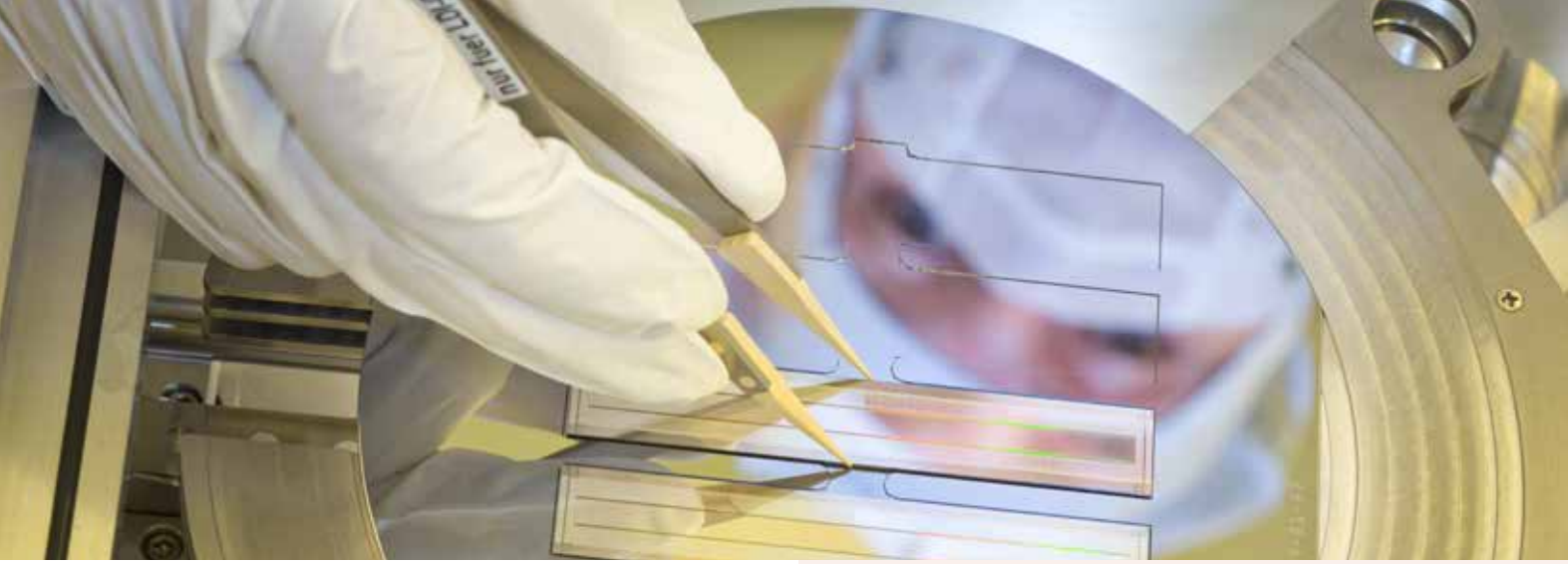
Microfluidics

Micropumps are of real importance to microfluidic research, especially in the field of health care. The capacity to handle micro volumes perfectly suits micropumps for the formulation of biopharmaceutical proteins, protein engineering and drug screening found within life science. In addition, micropumps are highly relevant in the point-of-care field.

Able to achieve sufficient flow rate and pressure at low power, embedded infusion microsystems can deliver the appropriate dosages of drugs to patients with chronic conditions to eliminate continuous daily screening tests and directly and positively impact life quality.

Designing such a micropump is a real challenge. Studies conducted on the integration of the novel MEMS-based bending actuators developed at Fraunhofer IPMS as a base element of a micropump have validated the feasibility of such a system. Therefore, Fraunhofer IPMS has already begun work on this concept in order to provide a new key element for the development of point-of-care.

Fraunhofer IPMS is developing customer-specific solutions for silicon-based components to be used in microfluidics as well as the handling of gases and liquids.



Services

The Fraunhofer IPMS offers various cooperation possibilities along the entire value chain to its customers. Feasibility studies are the first step if it is unclear at the beginning of a cooperation whether – and if so by what means – a customer request can be realized. For the basic proof of the functionality of a device or system demonstrators are realized within a development project. Especially in wafer-based processes, new technologies might be required which could be then developed in parallel. In the second step, the demonstrator turns into a prototype that fulfills all customer specifications. Fraunhofer IPMS offers qualified pilot fabrication in its clean room for MEMS and other microsystem devices.

Fraunhofer IPMS participates in the high-performance center "Functional Integration for Micro-/ Nanoelectronics". Together with multiple other Saxon Fraunhofer institutes, Dresden University of Technology, Chemnitz University of Technology and the University of Applied Sciences Dresden, Fraunhofer IPMS is working on developing application-oriented products based on the results of basic research to strengthen the economy. The whole project is coordinated by the Fraunhofer IPMS. On the basis of roadmaps we jointly identify possible opportunities for cooperation in talks with industrial customers. If the need arises, the center of excellence's topics can be extended accordingly.

Research Topics

The applications realized in close cooperation with our customers make use of the following results of our R&D activities:

- **SPATIAL LIGHT MODULATORS**
  Arrays of micromirrors on semiconductor chips
- **MEMS SCANNERS**
  Resonant and quasi-static MEMS mirrors for light deflection
- **WIRELESS MICROSYSTEMS**
  Devices and systems for RFID and optical communication
- **ENVIRONMENTAL SENSING**
  Sensor devices and systems for photonic and chemical sensing
- **NANOELECTRONIC TECHNOLOGIES**
  Semiconductor device development and screening of processes and materials on 300 mm wafers
- **MESOSCOPIC ACTUATORS AND SYSTEMS**
  Electrostatic bending actuators with very large stroke
- **CAPACITIVE MICROMACHINED ULTRASOUND TRANSDUCERS**
  Ultrasonic devices manufactured with microelectronic technologies
- **SMART MICRO-OPTICS**
  Liquid crystal wave guides, tunable micro lenses and energy harvesting solutions
- **MEMS SENSORS**
  Product oriented development and pilot fabrication of diverse physical and chemical sensors

Short profile

Based in Dresden, Fraunhofer IPMS is your research and service partner in the fields of optical sensors and actuators, integrated circuits, microsystems (MEMS/MOEMS) and nanoelectronics. As one of the currently 67 independent institutes making up the Fraunhofer-Gesellschaft for the Promotion of Applied Research, the leading European organization for near-industrial research, our approximately 280 scientists work together with both private industrial and service companies as well as the public sector in projects to directly benefit business and society. To meet the high standards of our customers, Fraunhofer IPMS is certified by DEKRA in accordance with DIN EN 9001:2008 for the research, development and manufacturing of microsystems, respective semi-conductor and microsystems processes as well as integrated actuators/sensors.

Regarding micromechanical and photonic microsystems we offer complete solutions: From conception to component right up to complete systems. This includes sample and pilot production in our 1500 m² (15,000 ft²) clean room (ISO 14644-1 class 4) with qualified processes. Additionally, our business unit Center Nanoelectronic Technologies CNT provides services in the field of nano and microelectronics with functional electronic materials, processes and systems, device and integration, maskless lithography and analytics. Another 800 m² of clean room space (ISO 14644-1 class 6) is available for this purpose, along with analysis and metrology processes with atomic resolution and high sensitivity.

Smart Industrial Solutions

Quality of Life

Medical and Health

Fraunhofer IPMS

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