September 2025

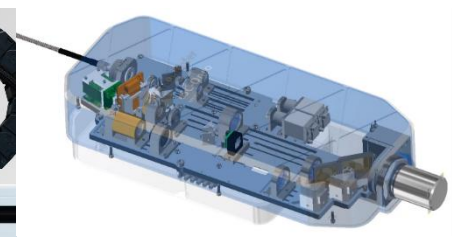
TECHFLASH

We are pleased to introduce you to Fraunhofer TechFlash - Fraunhofer's Flash News on latest and exciting technologies.
This week's TechFlash is about **Medical Imaging Technologies for Bio and Health Applications.**

The **Fraunhofer Institute for Photonic Microsystems (IPMS)** is a worldwide leader in research and development services for electronic and photonic microsystems in the fields of Smart Industrial Solutions, Medical & Health applications and Mobility.

Confocal Microscope for Rapid Detection of Tumor Boundaries during Surgery

Demonstrator of the microscope



CAD draft of the LSC-Onco demonstrator

Every year, nearly 20 million people are diagnosed with cancer. While medical diagnostics and treatments continue to advance, surgeons still face a critical challenge determining in real time whether a tumour has been entirely removed during surgery or not. Today's standard practice, sending tissue samples from the resection margin to pathology, can take up to 20 minutes, delaying crucial decisions in the operating room.

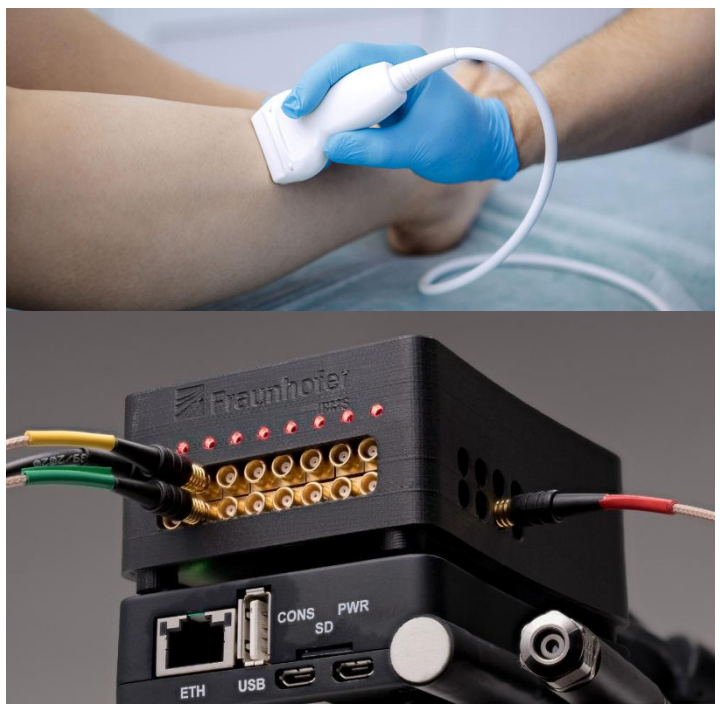
Addressing this critical need, researchers at Fraunhofer IPMS have unveiled a confocal laser scanning microscope designed for rapid, reliable, on-site tumour diagnostics during surgery. This innovation brings precision directly into the operating room, paving the way for faster decisions and better outcomes for patients.

This technology represents a significant step toward real-time, image-guided tumour surgery, improving patient outcomes and reducing surgical risk.

We look forward to hearing of your interest.

Yes, I am interested

Next-Generation Ultrasound Technology for Medical and Industrial Imaging



CMUT evaluation kit of Fraunhofer IPMS with a ready-to-use version for testing CMUTs for health application.

Ultrasound imaging (sonography) is a cornerstone of medical diagnostics and industrial measurement. Traditionally, systems rely on piezoelectric ceramic arrays, mostly lead zirconate titanate (PZT) to generate and receive acoustic signals. While effective, these arrays face challenges: High manufacturing costs for high-frequency or air-coupled arrays, complex fabrication processes, and the use of toxic materials that are non-RoHS-compliant.

A breakthrough alternative is Capacitive Micromachined Ultrasound Transducers (CMUTs). Built using MEMS fabrication techniques, CMUTs enable cost-effective production and open doors to miniaturized, invasive applications such as intravascular ultrasound (IVUS).

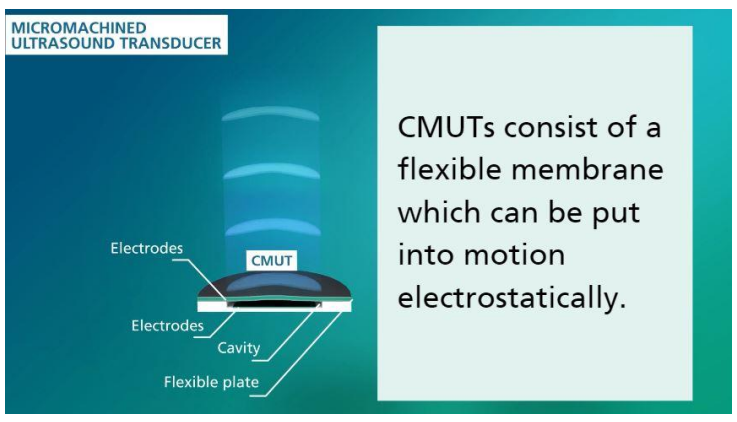
Key Advantages of CMUT Technology:
- Very high acoustic bandwidth
- Extremely low mechanical coupling between elements
- Adaptability for operation in water and air
- Integration with electronic components (e.g., ASICs) on a single chip
- Non-toxic materials, ensuring full RoHS compliance

With these advantages, CMUTs promise to redefine the future of high-frequency, high-resolution ultrasound imaging, delivering safer, smarter and more versatile diagnostic solutions.

We look forward to hearing of your interest.

Yes, I am interested

Innovative CMUT Sensors for Photoacoustic Imaging



Working principle of CMUT

Application example

Photoacoustic imaging is one of the most promising technologies in modern medical diagnostics. By combining optical excitation with acoustic detection, it enables high-resolution, functional imaging of biological tissues, for example, to visualize inflammation, tumours or metabolic processes. To apply this technique in hard-to-reach areas such as the prostate or intestines, miniaturized and integrable ultrasound detectors are essential. This is where capacitive micromachined ultrasonic transducers (CMUTs) come into play.

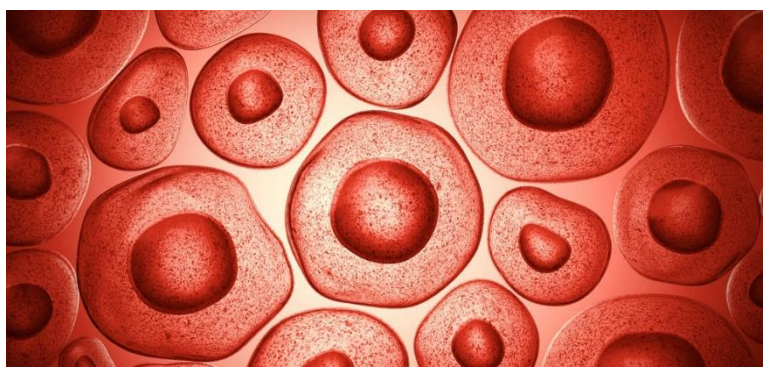
CMUTs: Key Technology for Compact and Highly Sensitive Sensor Platforms. The benefits at a glance:
- CMOS-compatible: Enables direct integration with readout electronics
- Miniaturizable: Ideal for catheter-based and portable medical devices
- Highly sensitive: Accurate detection of weak acoustic signals
- Scalable for mass production: Suitable for industrial-scale manufacturing

Outlook: CMUTs as a Standard Technology for Photoacoustic Systems: The CMUTs developed by Fraunhofer IPMS form the foundation for the next generation of photoacoustic detectors. With their high degree of integration, sensitivity, and compact design, they are ideally suited for:
- Portable ultrasound systems
- Invasive medical technologies (e.g. catheter solutions)
- Mass-produced diagnostic systems in healthcare

We look forward to hearing of your interest.

Yes, I am interested

Portable MEMS-Based Confocal Fluorescence Laser Scanning Microscope for Medical Applications



High-resolution 3D imaging using Portable MEMS-Based Confocal Fluorescence Laser Scanning Microscope

Confocal fluorescence laser scanning microscopy is a leading imaging technique that scans samples point-by-point, capturing high-resolution sectional images and generating 3D models of structured surfaces and fluorescent samples. It is vital in biological research, medical diagnostics, and industrial quality assurance. Conventional systems, however, are often large, complex, and costly, restricting use to specialized labs. To overcome these barriers, Fraunhofer IPMS has introduced a compact, robust, and portable MEMS-based fluorescence laser scanning microscope.

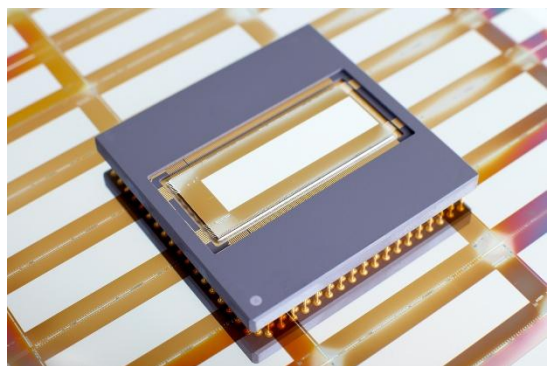
At its core is a high-precision 2D MEMS microscanning mirror, developed in-house at Fraunhofer IPMS, which ensures fast, accurate laser beam steering. This innovation delivers excellent imaging performance in a small form factor, making it ideal for field research, point-of-care diagnostics, and industrial inspection.

Key benefits of Portable MEMS-Based Confocal Fluorescence Laser Scanning Microscope:
- High-resolution 3D fluorescence imaging
- Compact and portable design for mobile use
- Cost-effective alternative to traditional stationary systems
- Versatility for applications in medical, biological, and industrial sectors

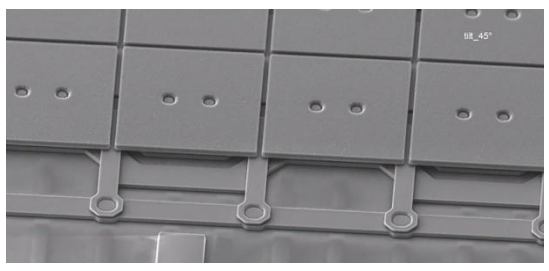
We look forward to hearing of your interest.

Yes, I am interested

Selective Illumination with Micromirror Arrays for Advanced Light Microscopy



Spatial light modulator with one million micromirrors



SEM image of 16 × 16 µm micromirrors

A major limitation in modern light microscopy is that continuous, high-brightness illumination can cause phototoxic damage to sensitive living tissues. Preventing this requires precise, selective illumination restricted to regions of interest.

To tackle this, Fraunhofer IPMS has developed an innovative micromirror array technology. Comprising millions of tiny mirrors on a semiconductor chip, the arrays enable dynamic modulation and directional light control. Using a dual-array optical setup, Fraunhofer IPMS enables can enables control over both the illumination pattern and the incident light angle, ensuring selective illumination, minimizing light exposure and reducing phototoxic effects.

This technology paves the way for advanced biological and medical research by enabling gentle, selective imaging methods. It also opens opportunities in medical diagnostics and material science where precise light control is critical.

Key benefits of Micromirror Arrays in High-Resolution Microscopy:

- Enables high-resolution imaging with minimal sample damage
- Supports dynamic and flexible illumination patterns
- Improves the viability of live-cell imaging and long-term biological studies
- Compatible with existing high-resolution microscopy systems

We look forward to hearing of your interest.

Yes, I am interested

Innovative Measurement System for Precise Assessment of Microperfusion ("MicroFlow")

Blood flow in organs and tissues

Project MicroFlow aims to develop a compact, novel measurement system for precise, independent, and practical monitoring of microperfusion - the blood flow in organs and tissues.

Core Technology: CMOS-Integrated Sensor with Optoelectronic Approach
At the heart of the system is a CMOS-integrated sensor that combines optical and mechanical measurement methods. This sensor can be integrated into wearable clothing and enables secure, energy-efficient data transmission via DECT NR+.

Applications and Benefits: The system is designed to improve the diagnosis of microcirculation disorders and the monitoring of patients with cardiovascular, metabolic, and vascular diseases, severe infections, or post-surgery recovery. Additionally, the technology offers applications in ophthalmology and ear, nose, and throat (ENT) medicine.

Proof-of-Concept and Development: Fraunhofer IPMS and TU Dresden have successfully demonstrated the detection of capillary refill time using an optoelectronic method in a proof-of-concept project. Building on this, an application-oriented sensor is now being developed to serve as the foundation for innovative medical technology products.

Future Outlook: Planned next steps include initial patient studies and expanding applications into leisure and sports to enable microperfusion monitoring beyond clinical settings in collaboration with Industry.

We look forward to hearing of your interest.

Yes, I am interested

Human health is a global priority and one of the key application areas of photonic microsystems at Fraunhofer IPMS. The medical imaging technologies of Fraunhofer IPMS enable early disease detection, advanced diagnostics and targeted therapies, addressing the growing demands of an aging population and the rise of chronic diseases.
With our modern MEMS-based solutions, we support:

- Early diagnosis using high-resolution imaging techniques
- Detection of pathogens and ingredients in food, breath and body fluids

Fraunhofer IPMS combines miniaturization, precision, and integration, thus paving the way for next-generation medical technologies.

About Capacitive micromachined ultrasonic transducers (CMUT) Evaluation Kit:

The evaluation kit "CEK CMUT" offers interested developers of ultrasonic sensors and users the possibility to build up a fully functional test setup for the evaluation of miniaturized capacitive micromechanical ultrasonic transducers (CMUT). It consists of either one or two CMUT sensor modules, customized control electronics and software as a web application that controls the CMUT via plug-and-play.

Virtual Showrooms of Fraunhofer IPMS:

(Please click on the hyperlinks)

- **Ultrasound technology in our 3D showroom**
- **MEMS scanner technology in 3D showroom**
- **Spatial light modulators in our 3D showroom**

Videos:

(Please click on the hyperlinks)

- **MEMS-based laser scanning microscopy for improved cancer cell detection**
- **Structured Illumination for Microscopy**
- **How does our CMUT evaluation kit work?**

About Fraunhofer-Gesellschaft:

Founded in 1949, the Fraunhofer-Gesellschaft based in Germany is the world's leading applied research organization. It offers contract-based R&D services for specific industry demand, application-oriented technology development from proof-of-principle up to market-readiness across the value chain and offers technical consultancy and feasibility studies to nearly all the industry sectors. The Fraunhofer-Gesellschaft currently operates 75 institutes and research units throughout Germany. Over 32000 employees, predominantly scientists and engineers, work with an annual research budget of €3.6 billion. Fraunhofer generates €3.1 billion of this from contract research. Our global footprint is very strong, with offices and research centres in the USA, Europe and Asia. Some of our renowned innovations are the MP3 software, white LED's and the smallest of cameras. Fraunhofer has been a long-time trusted innovation partner in India, collaborating with some of the major players in the fields of Material Science, Energy, Environment, Automotive, Electro-mobility, Production Technology, Microelectronics and Smart Cities, working with Industry, Government and Public Sector.

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