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Adaptive optics enable faster and more precise correction of optical distortions

A Clearer View of Tissue Thanks to Smart Mirror Technology

The Fraunhofer Institute for Photonic Microsystems IPMS has developed a new technology that can significantly improve the image quality of optical microscopes. A specially designed micromechanical mirror array corrects optical distortions that occur when viewing biological tissue. This makes even fine structures appear sharper, which is an important prerequisite for biomedical research and future applications in medical diagnostics.

One of the biggest challenges in microscopy is light scattering, because biological tissue distorts light as it passes through the sample. This results in blurry images and a limited depth of field. This makes high-resolution imaging particularly difficult with living samples. To compensate for these distortions, a technique known as adaptive optics is used. It specifically modifies the wavefront shape of the light, thereby correcting image aberrations. Until now, however, this often required additional sensors or complex optical systems.

“Until now, microscopes had to first measure the image aberrations and then correct them. Our new mirror array performs both tasks simultaneously, which saves time and simplifies the entire setup,” explains Dr. Maxim Darvin, project manager at Fraunhofer IPMS.

At the heart of the development is a chip containing approximately 64,000 movable micromirrors. Each individual mirror measures just 16 micrometers, meaning that about four such mirrors can fit side by side on the thickness of a human hair. Each mirror can be adjusted with extreme precision to 256 different positions without tilting and changes its alignment up to 1,000 times per second. This allows the system to compensate for optical disturbances with virtually no delay. It is suitable for wavelengths ranging from deep ultraviolet to the near-infrared and is independent of the light's polarization. This makes it flexible and suitable for a variety of microscopy techniques.

“We have already demonstrated the performance of our development on various biological samples, including corneal cells and cellulose. In all cases, our adaptive optics delivered visibly sharper and higher-contrast images. We have also succeeded in precisely focusing the laser light through highly scattering materials. This allows

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structures in deeper tissue layers to be examined with higher image quality,” says Darwin.

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Due to the algorithm, the system currently still takes a few minutes to fully identify and correct image distortions. The goal of further development is to perform these processes in near real time in the future. In the long term, this technology can help make high-resolution microscopy faster, simpler, and more powerful, both in basic biological research and in future diagnostic applications in medicine.

About Fraunhofer IPMS in Cottbus

Fraunhofer IPMS is a leading international research and development service provider for electronic and photonic microsystems.

Research on the mirror technology presented here is being conducted at the “Integrated Silicon Systems” (ISS) division of Fraunhofer IPMS in Cottbus, where the institute works with partners from academia and industry to develop innovative MEMS and microsystem technologies for applications in fields such as medical technology, sensor technology, and photonics. The planned new building at the site will further expand research and development capacities in Lusatia. The groundbreaking ceremony for the new research building is scheduled for early October and highlights Cottbus’s growing importance as a hub for application-oriented high-tech research.

About the OASYS Project

The OASYS collaborative project will run for five years (September 1, 2023, through August 31, 2028) and is funded with approximately 12.5 million euros by the Federal Ministry of Research, Technology, and Space (BMFTR). The project is coordinated by the Brandenburg University of Technology Cottbus-Senftenberg (BTU). In addition to Fraunhofer IPMS, the consortium includes the Ferdinand Braun Institute (FBH) and the IHP – Leibniz Institute for Innovative Microelectronics.

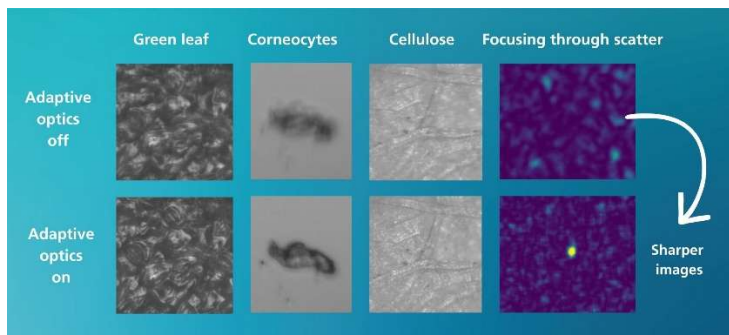
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Dr. Maxim Darvin and Felix Bennewitz are conducting research at Fraunhofer IPMS in Cottbus on innovative micromirrors designed to improve the resolution of microscopes. © Sascha Thor, BTU



Fraunhofer IPMS's micromirror technology delivers sharper microscope images of biological tissue. The micromirrors can be adjusted to focus light through scattering materials with high contrast, thereby enabling the analysis of structures in deeper tissue layers at higher resolution. © Fraunhofer IPMS