# Innovative microscope captures large, high-resolution images of curved samples in single snapshot

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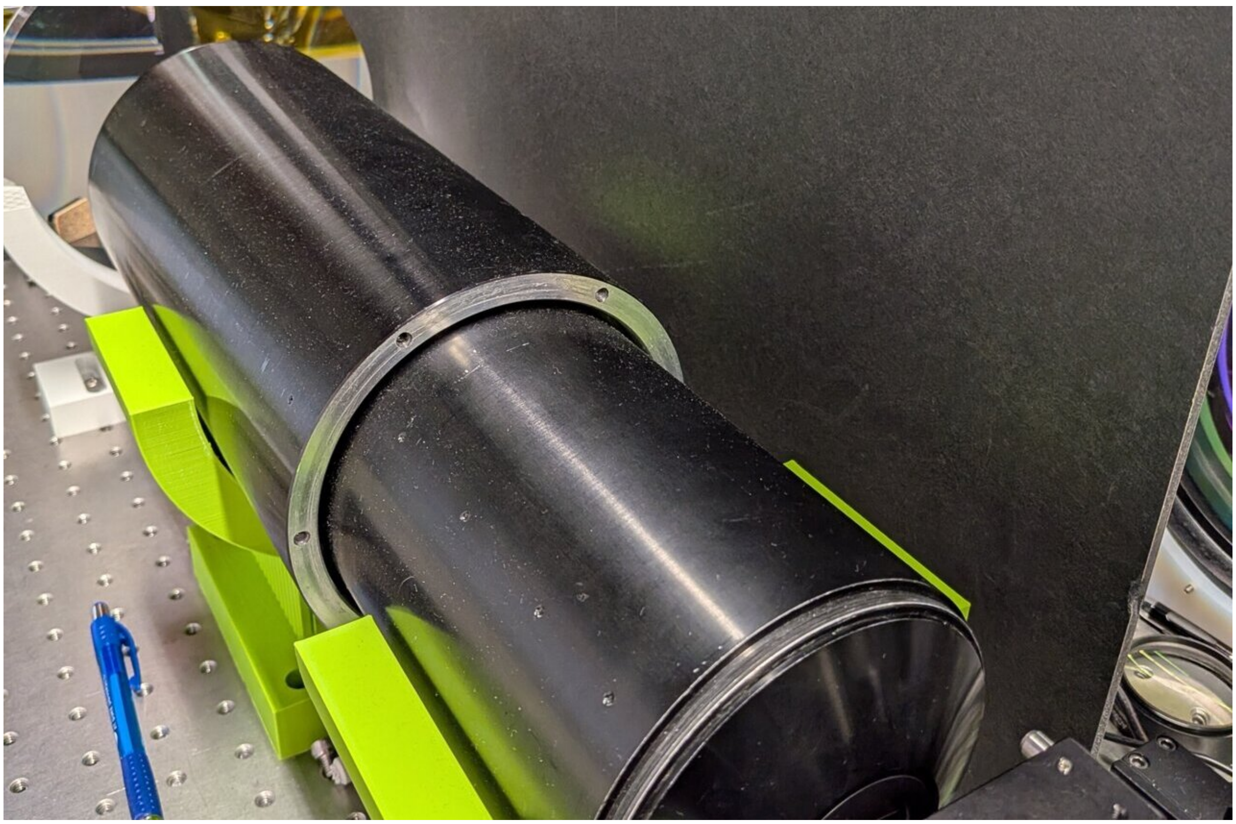


The microscope combines a big telecentric photolithography lens with a large tube lens to create sharp, detailed images of large and curved samples. These lenses project the image onto a flat array of 48 small cameras. Credit: Xi Yang, Duke University

Researchers have developed a new type of microscope that can acquire extremely large, high-resolution pictures of non-flat objects in a single snapshot. This innovation could speed up research and medical diagnostics or be useful in quality inspection applications.

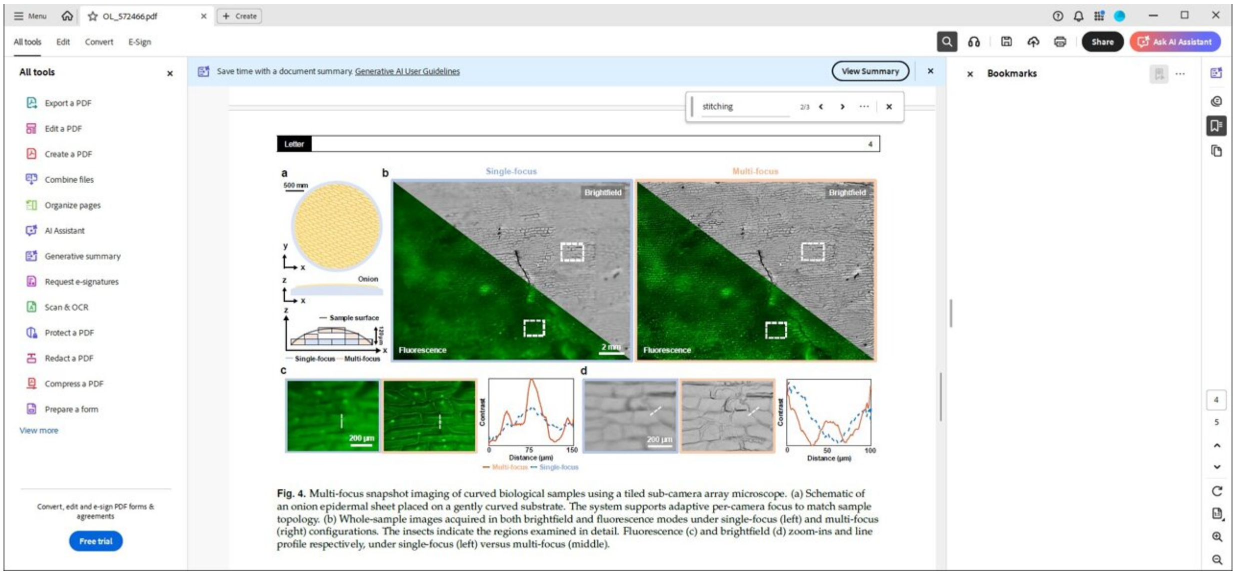
"Although traditional microscopes assume the sample is perfectly flat, real-life samples such as tissue sections, plant samples or flexible materials may be curved, tilted or uneven," said research team leader Roarke Horstmeyer from Duke University.

"With our approach, it's possible to adjust the focus across the sample, so that everything remains in focus even if the sample surface isn't flat, while avoiding slow scanning or expensive special lenses."

In the journal *Optics Letters*, the researchers show that the microscope, which they call PANORAMA, can capture submicron details—1/60 to 1/120 the diameter of a human hair—across an area roughly the size of a U.S. dime without moving the sample. It produces a detailed gigapixel-scale image, which has 10 to 50 times more pixels than the average smartphone camera image.

"This tool can be used wherever large-area, detailed imaging is needed. For instance, in medical pathology, it could scan entire tissue slides, such as those from a biopsy, at cellular resolution almost instantly," said Haitao Chen, a doctoral student in Horstmeyer's lab.

"In materials science or industrial inspection, it could quickly inspect large surfaces such as a chip wafer at high detail."




The researchers used the microscope to simultaneously acquire brightfield and fluorescence images of onion skin laid over a gently curved surface (a). Whole-sample images (b) were acquired in both brightfield and fluorescence modes under single-focus (left) and multi-focus (right) configurations. When all the cameras were forced to a single focal plane (single focus), the edges of the images are blurred. But when each camera was focused on the local curvature (multi focus), the entire curved layer stayed sharp. Fluorescence (c) and brightfield (d) zoom-ins and line profile, respectively, under single-focus (left) versus multi-focus (middle). Credit: Haitao Chen, Duke University

## Large-scale clarity

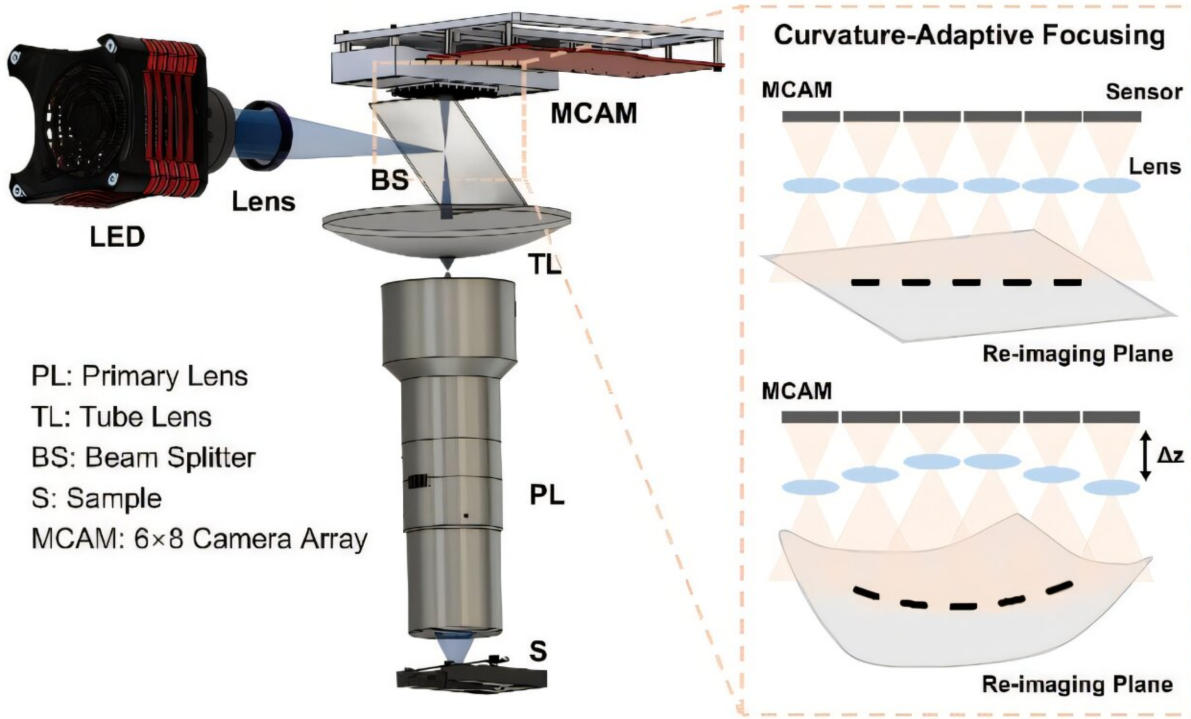
Conventional microscopes almost always have a trade-off between imaging a small area with high detail or a large area in low detail. Producing high-resolution gigapixel images typically requires complex optics or the time-consuming task of tile scanning of a sample.

Additionally, real samples are rarely perfectly flat across a centimeter-scale view, which typically requires mechanically scanning the sample up and down to keep various parts in focus, further slowing down the imaging process.

To overcome these challenges, the researchers created what can be thought of as a multiple-camera system that acts like a single giant microscope. The microscope combines a telecentric lens originally developed for chip-making with a large tube lens that projects an image of the sample onto a flat array of 48 small cameras, each imaging a portion of the scene or sample.

Because each camera can be independently focused to match the sample surface, the entire field of view stays sharp even if the sample is curved. This eliminates the need for scanning, which can take up to an hour. The images from each camera are automatically stitched together into a continuous picture using software, a process that takes about five to 10 minutes.

"The telecentric lens makes it possible to image a very wide field without distortion, while the multi-camera approach overcomes the usual size-and-resolution limit of a single sensor," said Chen. "This combination lets us acquire a seamless, gigapixel image in a single snapshot, flattening out any curvature adaptively."




The microscope combines a telecentric lens, a tube lens, and an array of micro cameras, each with its own focus control, making it possible to acquire a seamless, gigapixel image in a single snapshot, flattening out any curvature adaptively. Credit: Haitao Chen, Duke University

## One shot, high detail

The researchers tested the new microscope by imaging a prepared slide of rat brain tissue under brightfield illumination, which uses white light to reveal tissue structure. Without any scanning, the 48-camera array captured the entire slice—a 630 MP image—in one snapshot. The resulting image clearly showed cellular structures measuring as small as 0.84 µm, as well as neurons and dendrites across the sample.

They also used the microscope to simultaneously acquire a brightfield and fluorescence image of onion skin laid over a gently curved surface. When they focused each camera on the local curvature, the entire curved layer stayed sharp. The brightfield images revealed crisp cell walls, while the fluorescence images clearly showed stained nuclei.

"In practical terms, we saw a huge jump in throughput and flexibility: no more moving parts, no tedious focus-stacking, and no blind spots between cameras," said Horstmeyer.

"Compared to older multi-camera microscopes that needed scanning to fill gaps and maintain focus, our approach gives continuous full coverage at sub-micron resolution."

The researchers are now working to improve the microscope by adding more cameras or larger sensors to capture an even bigger field—such as an entire petri dish—in a single shot.

They are also developing an automated focus system so each camera no longer has to be adjusted manually for every sample. Computational advances could also enable 3D reconstructions, real-time depth maps or live video of microscopic processes.

**More information:** Xi Yang et al, Curvature-adaptive gigapixel microscopy at submicron resolution and centimeter scale, *Optics Letters* (2025). DOI: 10.1364/OL.572466

Provided by Optica