Ultracompact metalens microscopy breaks FOV constraints

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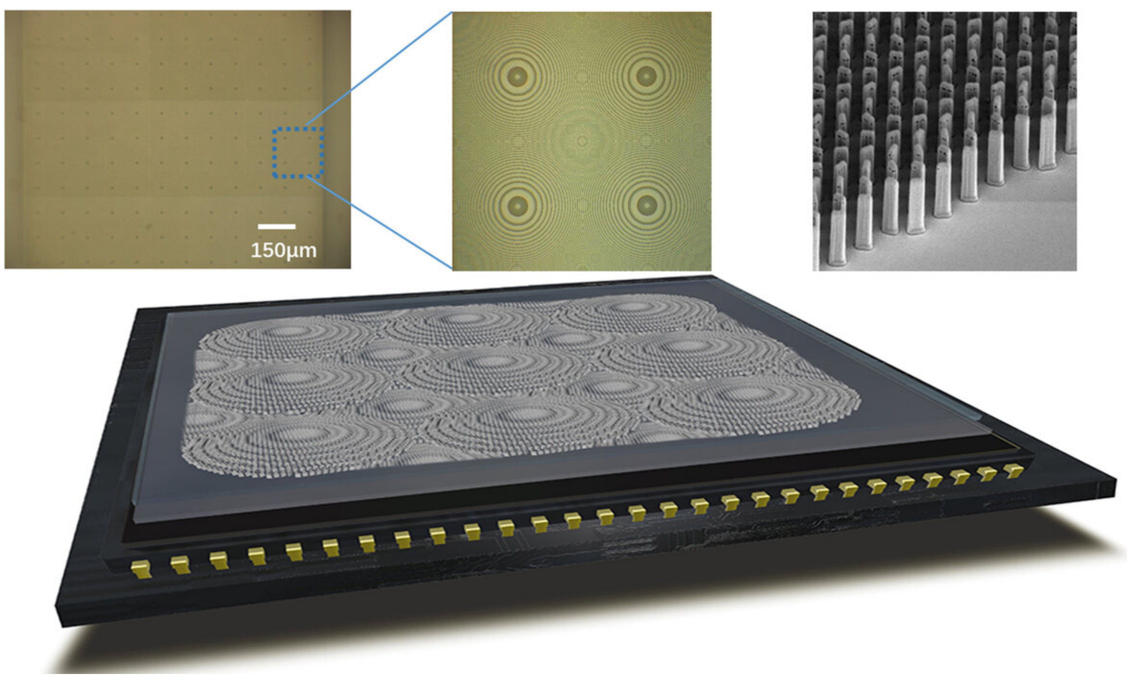


Metalens-integrated imaging device, from Xu et al., doi 10.1117/1.AP.2.6.066004 Credit: Xu et al., doi 10.1117/1.AP.2.6.066004

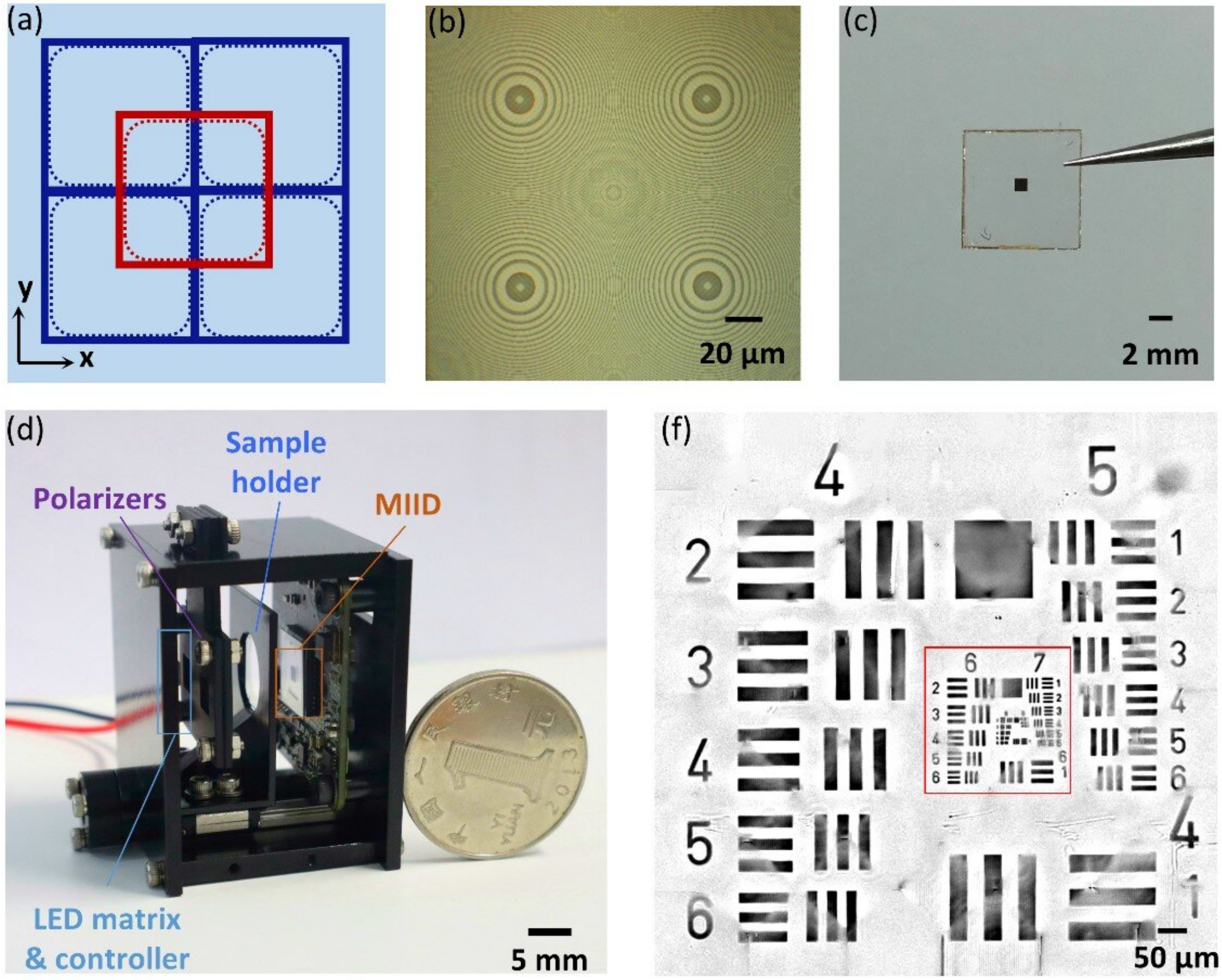
The pursuit of ever-higher imaging resolution in microscopy is coupled with growing demands for compact portability and high throughput. While imaging performance has improved, conventional microscopes still suffer from the bulky, heavy elements and architectures associated with refractive optics. Metalenses offer a solution: they're ultrathin, ultralight, and flat, and benefit from lots of recent research that has improved their efficiency, FOV, and polarization functionalities.

According to Tao Li, professor of engineering and applied sciences at Nanjing University, "An ultra-compact metalens for imaging will miniaturize and even revolutionize conventional optical devices." Despite all the ongoing work to improve metalenses, most research groups are using them as a substitute for conventional refractive lenses in conventional optical settings. For metalenses to move toward real-world application, it's important to learn how to integrate metalenses into ultracompact optical devices.

In pursuit of a compact integrated microscope system, Li's team mounted a metalens on a CMOS image sensor to create a prototype of a coin-sized imaging device. As reported in *Advanced Photonics*, their metalens-integrated imaging device (MIID) exhibits an ultracompact architecture with a working imaging distance in the hundreds of micrometers. Using a simple image-stitching process, they are able to obtain wide-field microscope imaging with large FOV and high resolution.

Pocket microscope system

The MIID prototype involves a millimeter-sized silicon metalens in a well-designed 6 x 6 array. Despite the integration of multiple lenses, imaging distance remains relatively small (~500 μm) because each single lens is sized about 200 μm. According to the authors, it can be extended to centimeter scale to cover the whole CMOS sensor.



Imaging of MIID integrated with polarization multiplexed dual phase (PMDP) metalens array. (a) Phase distribution of PMDP metalens in x-y plane. The blue and red squares denote the phase distribution for LCP and RCP metalens regions respectively. The corresponding dashed boxes demonstrate the limited FOV. (b) Optical microscope image of a PMDP metalens with size 200 μm. (c) Photograph of the fabricated 6×6 PMDP metalens array. (d) Photograph of the prototype of MIID in size about 3.5 cm × 3 cm × 2.5 cm. (f) Stitched image of the USAF 1951 resolution chart. Credit: Xu et al., doi 10.1117/1.AP.2.6.066004

The metalens array, which is a polarization multiplexer, has two different phase profiles corresponding to two circular light polarizations.

According to Li, this arrangement ensures the elimination of blind areas.

The authors hope that the new MIID prototype heralds a new era of the pocket microscope system. They acknowledge that the imaging performance needs improvement and suggest a variety of approaches, such as adopting low-loss materials like GaN and SiN. They anticipate continuing advances in microscopy based on meta-technology in the future.

More information: Beibei Xu et al, Metalens-integrated compact imaging devices for wide-field microscopy, *Advanced Photonics* (2020). DOI: 10.1117/1.AP.2.6.066004

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