# Metasurfaces Embracing a Phase Change

**RESEARCHERS**

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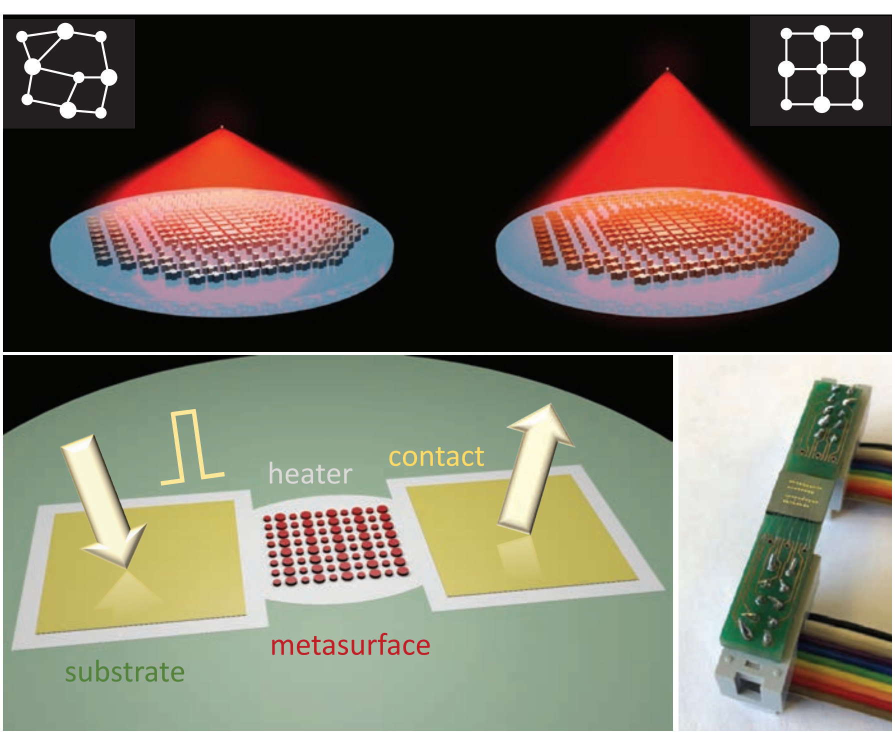
Recent progress in nanophotonics has enabled planar optical systems, termed metasurfaces, that hold potential to enable agile light manipulation and provide size, weight, power and cost (SWaP-C) benefits compared with traditional optics. Active metasurfaces, the optical properties of which can be modulated post-fabrication, have attracted a surge of interest in recent years, given their broad potential applications in imaging, sensing, display and optical ranging. A cohort of non-mechanically switchable meta-devices has been already demonstrated; however, most of them either operate within a limited tuning range or suffer from large optical losses.

Our team has developed a novel approach for implementing high-performance reconfigurable metasurfaces made of optical phase-change materials. More specifically, we have synthesized a new class of nonvolatile chalcogenide alloys, $Ge_2Sb_2Se_4Te_1$, exhibiting giant index contrast as well as broadband transparency in both amorphous and crystalline states.[1]

Capitalizing on this material platform and metasurface design innovation, we demonstrated an all-dielectric varifocal metalens in mid-infrared.[2] By annealing the entire metasurface, we showed that the lens shifted its focal plane between the distances of 1.5 mm and 2 mm and produced multi-depth imaging with diffraction-limited resolution and a record-high switching contrast ratio of 30 dB.

This year also witnessed an important milestone in this field: The first demonstrations of electrically switched phase-change metasurfaces. Our group and a team from Stanford University, USA, independent from each other, implemented phase-change-material metasurfaces integrated with electrical micro-heaters.[3,4] We showed reversible switching of a tunable metasurface and produced a record half-octave spectral shift with a large relative optical contrast exceeding 400%. By exploiting the same device architecture, we also prototyped a polarization-insensitive deflector for beam steering.

Our advances in phase-change-material meta-optics demonstrate that active metasurfaces can achieve optical quality on par with conventional precision bulk optics involving mechanical moving parts. The work points to exciting applications fully unleashing the SWaP-C benefits of active-metasurface optics. OPN




Top: Rendering of a $Ge_2Sb_2Se_4Te_1$ varifocal metalens. The focal-spot position is shifted by changing the crystallinity of the phase-change-material meta-atoms collectively. Bottom: Illustration of an on-chip, electrically switchable metasurface with beam-steering functionality, and photograph of a metasurface chip wire-bonded onto a custom-made printed circuit board.