# Two-Dimensional Lithography for Three-Dimensional Sculpting of Optical Metasurfaces

## Scientific Achievement

Demonstrated optical metasurfaces comprised of nanostructure elements with lithographically-defined and spatially-varying heights.

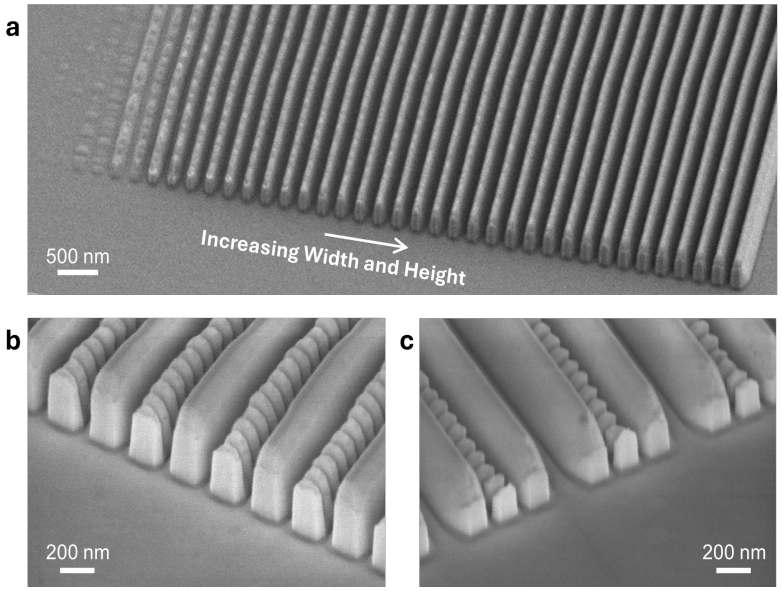


**Figure:** Scanning electron micrographs of fabricated devices in GaN. (a) Nanostructures with many different lithographically-defined heights within a single device. (b-c) Multi-height metasurfaces that support high-quality (*Q*) factor optical resonances.

## Significance and Impact

Multi-height metasurfaces in epitaxial materials can be fabricated through the subtractive process method. Having lithographic height control enables precise out-of-plane symmetry breaking which is essential for tailoring optical chirality and enhancing chiral light-matter interactions. For purely optical devices, further development of three-dimensional design strategies holds promise for increasing performance and expanding the functionality of augmented-reality headsets and chip-scale light sources and detectors.

## Research Details

- Developed nanofabrication process that uses deliberately fragile etch masks to make narrower nanostructures shorter than wider ones.
- Introduced symmetry design framework for versatile control over optical resonances within nanofabrication constraints.
- Experimentally demonstrated multi-height metasurfaces made of GaN that support optical resonances in the visible and near-infrared.

Work was performed, in part, at the Center for Integrated Nanotechnologies.

Malek, S. C.; Sovinec, C. L. H.; Martinez, W. M.; Doiron, C. F. Nonlocal Metasurfaces with Lithographically Defined Vertical Symmetry Breaking. *ACS Photonics.* 2026.