High Aspect Ratio Structures for Meta-surface Optics

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Meta-surface optics operate by imparting a phase discontinuity in an incident optical field to create a wide array of optical functionality not possible in conventional refractive optics. While the field was launched using plasmonic meta-atoms [1], recently high aspect ratio dielectric meta-atoms have shown excellent results. These dielectric meta-atoms consist of transverse (x,y) shapes extruded in the z-dimension. The size of the phase discontinuity imparted by the meta-atom is a function of the dielectric constant of the material and is directly related to the z-height of the meta-atom, and the performance of the meta-optic improves with larger phase swings. This, coupled with the small neighbor-to-neighbor dimensions necessary for the meta-optic to avoid diffractive effects drives the pursuit of high aspect ratio structures. Here we demonstrate high aspect ratio etched structures in both silicon and gallium arsenide. Initial etch development employs interferometric lithography while final patterns are realized using e-beam patterning. The paper will discuss this etch development process for both material sets.

Acknowledgements
This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government. This work was performed, in part, at the Center for Integrated Nanotechnologies, an Office of Science User Facility operated for the U.S. Department of Energy (DOE) Office of Science. Supported by the Laboratory Directed Research and Development program at Sandia National Laboratories, a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525. Partially supported by the Defense Advanced Research Projects Agency Defense Sciences Office (DSO) Program: DARPA/DSO EXTREME; Agreement No. HR0011726711.

References
[1] Yu, N.F. and Capasso, F., “Flat optics with designer metasurfaces,” Nat. Mater., 13, 139-150 (2014).

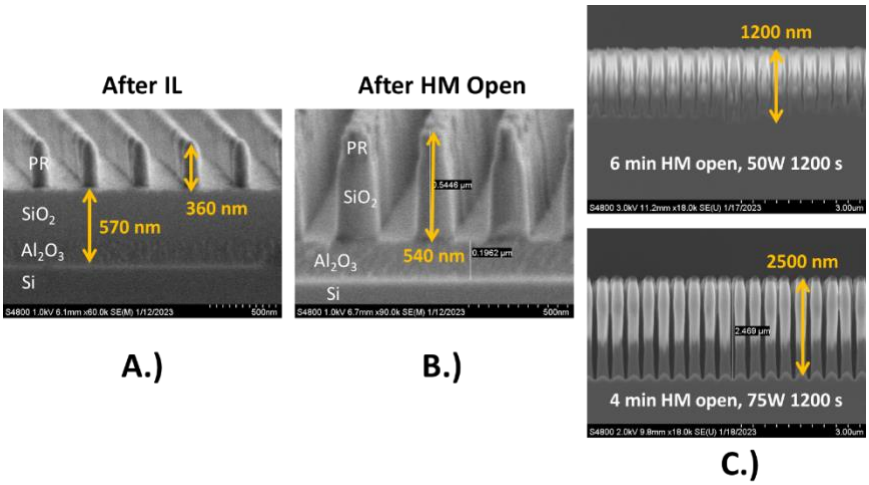

Figure 1: Silicon Etch Development: A.) SEM image showing photoresist pattern created with Interferometric lithography; B.) SEM Image showing the patterned hard mask; C.) SEM Images showing two different etch conditions for the hard mask and silicon etches.

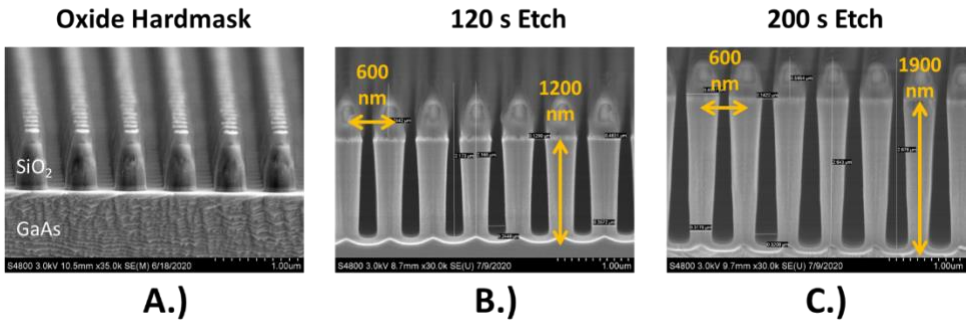

Figure 2: GaAs Etch Development: A.) SiO2 hard mask patterned with interferometric lithography; B.) SEM showing ICP etch after 120 seconds; C.) SEM image showing ICP etch after 200 seconds.

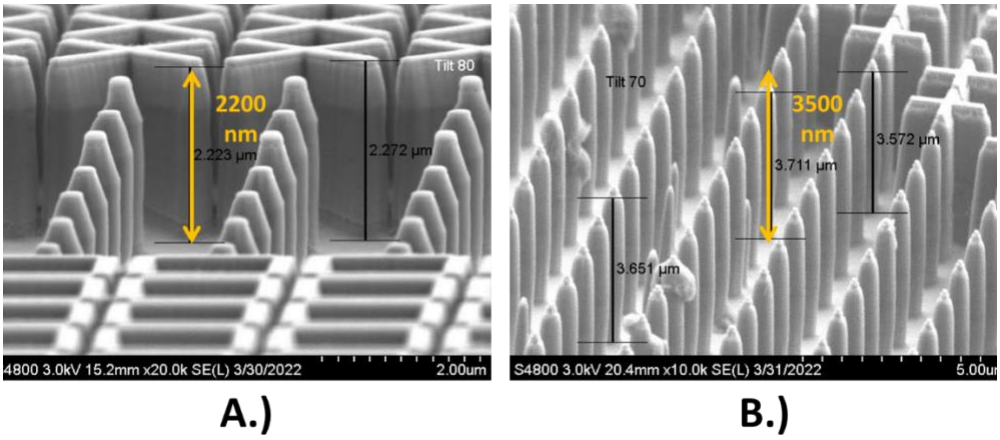

Figure 3: SEM Images showing high aspect ratio GaAs meta-atoms using the optimized etch parameters.