Arrays of Elliptical Pillars for Optical Detection of Bacteria

CNF Project Number: 2472-16
Principal Investigator(s): Gennady Shvets
User(s): Giovanni Sartorello

Affiliation(s): School of Applied and Engineering Physics, Cornell University
Primary Source(s) of Research Funding: National Cancer Institute (award number R21 CA251052), National Institute of General Medical Sciences (award number R21 GM138947) of the National Institutes of Health
Contact: gs656@cornell.edu, gs664@cornell.edu
Primary CNF Tools Used: Oxford 100 PECVD, JEOL JBX 9500FS, Oxford Cobra ICP Etcher

Abstract:

We fabricate prototype arrays of amorphous silicon nanopillars to be used for sensing bacterial binding.

Summary of Research:

Metasurfaces have been widely used for biosensing applications [1]. Organic matter, from proteins to cells, interacts with metasurfaces and changes their optical behavior, allowing detection by one of several optical techniques. In our case, we aim to use arrays of elliptical amorphous silicon nanopillars, spaced 1.2 μm in both directions, 1.2 μm tall, and in various sizes around 0.7 μm times 0.5 μm for the elliptical axes. They are intended to be used in immersion, with bacteria adhering to them. When the metasurface is illuminated in transmittance, there is a change in birefringence induced by the presence of the bound bacteria, allowing for their detection and localization.

We fabricated a prototype array by coating a glass wafer with amorphous silicon on the Oxford PECVD tool, followed by coating with a negative resist (HSQ) and EBL exposure on the JEOL 9500. After development, we used the Oxford Cobra etcher to transfer the pattern to the silicon. Timing the etching correctly was critical, because there is limited selectivity for silicon etching when using HSQ as the mask, requiring a rate measurement about midway through. Our arrays (Figure 1) match the design specifications.

Conclusions and Future Steps:

Fabrication was successful, proving the usefulness of HSQ as etching mask even with structures with relatively high aspect ratios, if etching is carefully monitored. The sample turned out not to work as hoped in the wavelength range of interest, but this can be fixed by tweaking the dimensional parameters of the metasurface. This procedure can also be applied to other devices, suited to this and many other detection techniques, by changing the design and/or materials of the metasurface.

References:

[1] Zhang, S., Wong, C. L., Zeng, S., Bi, R., Tai, K., Dholakia, K., and Olivo, M. (2021). Metasurfaces for biomedical applications: Imaging and sensing from a nanophotonics perspective. Frontiers in Optics and Photonics, 10(1), 265-299. https://doi.org/10.1515/9783110710687-023.

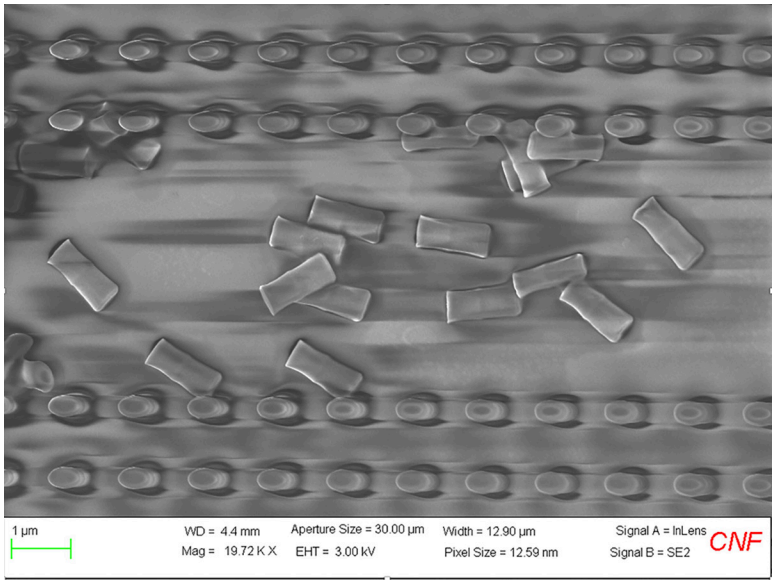

Figure 1: SEM image of one of the fabricated arrays. The pillars stand and are seen from above, except for those in the middle, which have been knocked down by the profilometer, which allows their height to be measured and shows a slight enlargement where the etching was interrupted for the rate measurement.