A new Formula based EBL Nanopatterning Approach for large Metalens Fabrication

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Metalenses with a high numerical aperture and high efficiency have gained widespread attention in both academia and industry due to their ultra-flatness, compact size, and high-resolution imaging quality. These features qualify metalenses for potential future integration in common everyday products such as cellphones, cameras or bio-diagnostic, augmented and virtual reality components. The basic unit blocks of metalenses are typically subwavelength spaced nanostructures, such as nanofins, nanorods, and nanocylinders. These nanostructures are designed across the substrate with varying rotation angles or sizes, depending upon the design of the optical properties and specific planar position of these structures. Since high precision placement of shapes and good minimum line edge roughness (LER) definition are essential for the fabrication of these nanostructures, electron beam lithography (EBL) has been widely used for patterning. Due to the large number, complexity, and only minimally varying rotation angles of the features, exposing such patterns poses significant challenges on EBL in terms of pattern fidelity and throughput.

Corresponding conventional GDSII designs can easily exceed several 100MB if not TB of design data file size, something that is extremely demanding for the classical data processing paths of the EBL tool. Even if the amount of data can be handled at all, typically a lot of overhead is generated as well such that exposure times can get extremely unattractive.

In order to circumvent this situation and to totally avoid the necessity to create a flat GDSII design file, two alternative approaches of formula based, lean data generation and processing have been implemented in the dedicated Raith EBL systems EBPG and VOYAGER. This has been accomplished by creating the exposure data algorithmically based on scripts [1,2] or C programming respectively. Applying this method, large area metalenses with cm-dimension were fabricated while increasing throughput by factors of~10.

References

[1] Colburn, S., Zhan, A. and Majumdar, A., “Verifocal zoom imaging with large area focal length adjustable metalenses,” Optica 5 (7), 825-831 (2018)

[2] She, A., Zhang, S., Shian, S., Clarke, D.R., and Capasso, F., “Large area metalenses: design, characterization, and mass manufacturing” Optics Express 26 (2), 1573-1585 (2018)

Figures

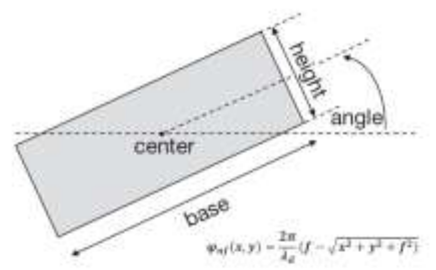

Figure 1: Definition of a cube shape (nanofin) used for algorithmic patterning of a metalens. The angle rotation can be changed in the nano degree regime.

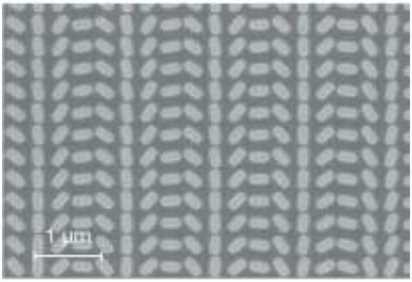

Figure 2: SEM images of the metalens pattern in 100 nm ZEP520 A resist on a silicon substrate.