

Fabrication of Near-UV Multilevel Diffractive Lenses Using Grayscale E-Beam Lithography and TASTE

C. Fasano, C. C. Cheung, M. Christopherson

*US Naval Research Laboratory,
4555 Overlook Avenue SW, Washington, DC 20375
cecilia.r.fasano.ctr@us.navy.mil*

Optical components created for operation in the near-UV, such as metalenses, flat optics, and multilevel diffractive elements, require small feature sizes and precise height control for efficient performance. These requirements increase the complexity of their fabrication. In this work, we focus on the fabrication of multilevel diffractive lenses (MDLs), a flat, high-numerical-aperture alternative to metalenses¹ composed of concentric height-varying rings.

To fabricate these profiles, we employ grayscale electron beam lithography (EBL), which encodes topography through spatially varying exposure dose. Grayscale EBL is a well-established technique, but its effective use still depends on iterative calibration and process tuning. Recent improvements in commercially available energy-deposition simulation tools (e.g., BEAMER²) have helped reduce this burden by providing more reliable predictions of dose-to-height behavior and three-dimensional proximity effect. We describe our efforts to integrate these tools into the design workflow and to refine pattern layouts, dose assignments, and development conditions to achieve MDLs with high fidelity to modeled specifications.

When fabricating devices using grayscale EBL, surface roughness in partially exposed regions of resist presents a significant challenge. To improve surface quality and mitigate artifacts associated with discretely dosed grayscale features, we incorporate thermally activated selective topography equilibration (TASTE) as a post-patterning step. TASTE leverages differential thermal reflow in variably exposed regions. At lower temperatures TASTE smooths the surface of multilevel profiles, while at higher temperatures it can achieve near-continuous height transitions. Smoothing the surface improves performance of the optic and the ability to generate continuous structures expands the achievable design space. We report our process development for combining grayscale EBL with TASTE to fabricate MDLs in poly(methyl methacrylate) (PMMA) for near-UV applications, where PMMA exhibits high transmission.

This work was supported by the Office of Naval Research.

Distribution Statement A. Approved for public release; distribution is unlimited.

¹ Banerji, S., Meem, M., Majumder, A., Vasquez, F. G., Sensale-Rodriguez, B., & Menon, R. (2019). Imaging with flat optics: Metalenses or diffractive lenses? *Optica*, 6, 805–810.

² <https://www.genisys-gmbh.com/beamer.html>