Resist Characterization at 30 nm Wavelength using a Tabletop EUV Source

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The resolution scaling is governed by the Rayleigh criterion, which indicates that the smallest features that can be printed on a chip is limited by the diffraction limit. To achieve higher resolution in fabricating high-density chips, it is essential to reduce the laser wavelength with higher-energy photons, where EUV can reach those capabilities [1-2]. As EUV lithography becomes the main method for chip fabrication, there has been significant interest in developing better photoresist with high resist sensitivity to reduce exposure time, high contrast to reduce line edge roughness, and high etch selectivity for pattern transfer. While there has been a lot of development in novel EUV photoresist, experimental testing of such material requires a high-energy source that is not readily available. Existing tests are mostly conducted using expensive commercial EUV systems or synchrotron sources at government laboratories with limited access [3-5]. A tabletop source offers a cost-effective, efficient method for material testing, accelerating the development of novel EUV photoresists.

This work investigates the use of a tabletop EUV system for photoresist characterization at 30 nm, providing an alternative to limited-access synchrotron sources and establishing a protocol for research applications. The system exposes ZEP520A, a commercially available e-beam resist, to determine its clearing dose and contrast, demonstrating its viability for tabletop EUV lithography. The experimental setup utilizes a tabletop EUV source powered by a 40 fs ultrafast IR laser in argon gas for high-harmonic generation (HHG) [6]. The beam is spectrally filtered to 30 nm and measured using a calibrated silicon diode. It is then focused to a sub-100 µm spot in a vacuum chamber, where a 100 nm thick resist-coated wafer is exposed and developed for characterization.

Preliminary tests expose ZEP520A to doses ranging from 37–102 mJ/cm^2. Since the beam spot is elliptical, a knife-edge test (Figure 1b) measures its radius for accurate dose characterization. An optical image of the exposed spots is shown in Figure 1a. The resist response is modeled using a binary resist model, assuming a Gaussian beam profile. The binary model assumes a critical clearing dose D_o, where any resist receiving a higher dose will be completely dissolved after development and result in a thickness of 0. On the converse, any resist receiving a lower dose than D_o will result in a normalized thickness of 1.

Characterization is performed using confocal microscopy and atomic force microscopy (AFM). Confocal imaging provides topography maps, while AFM enables precise thickness measurements. Figure 2 demonstrates the comparison of the experiment vs a simulated dose test, which agrees well. The simulated values were estimated from a range of values for the width or length using the resist model, which was then compared to the experimental values to determine if the values fit each other. That data can be used to determine the max dose and show where the dose meets the clearing dose, as shown in Figure 3(a). The calculated normalized thickness vs dose are shown in Figure 3(b), from which the clearing dose is empirically fitted to be 35.4 mJ/cm^2 and the contrast is 2.9. We will present the system description of the EUV step, fabrication details, and characterized resist results.

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Figures

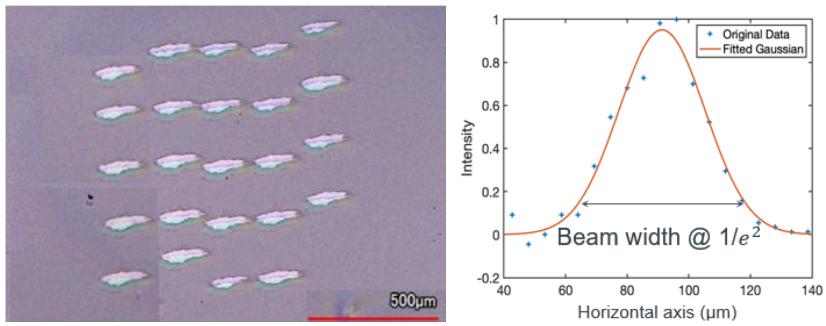

Fig.1: (a) Optical image of dose characterization test using ZEP 520A positive tone resist (b) Results from knife edge test in horizontal axis.

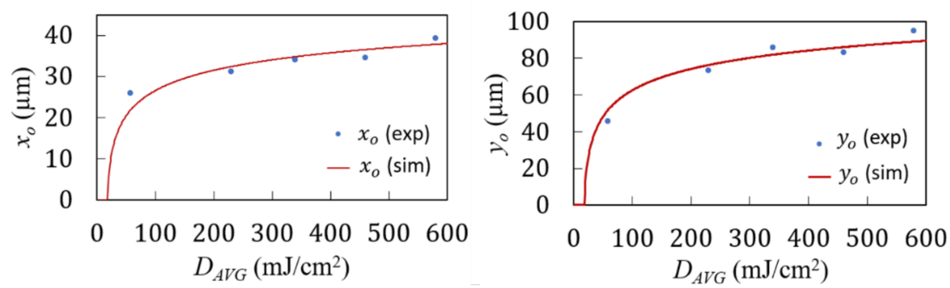

Fig.2: Experimental and simulated (a) *x* and (b) *y* radii of the patterned resist spot vs average exposure dose.

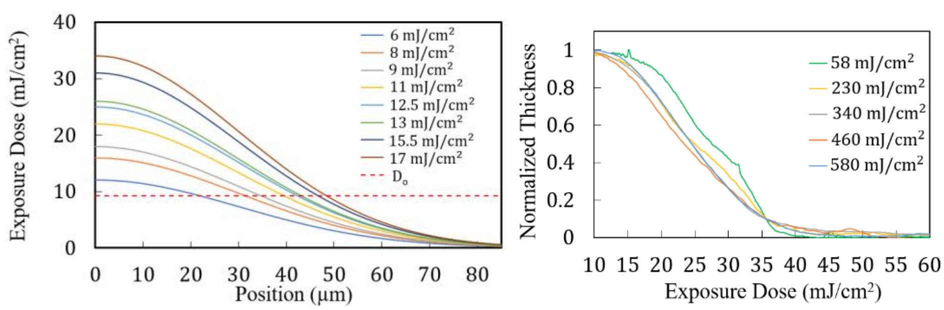

Fig.3: (a) Simulated dose distribution for the exposures with various average dose. (b) Measured normalized resist thickness vs exposure dose for the 5 exposures.

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