Characterization of ZEP520A Resist Response at EUV Wavelength

Ethan Flores*, Saurav Mohanty, Andrew Tunell, Chih-Hao Chang
Walker Department of Mechanical Engineering, The University of Texas at Austin, Austin, TX 78712, USA

In the semiconductor industry, there is a trend to make devices and materials smaller through multiple methods. Extreme ultraviolet (EUV) lithography has been pushing the capabilities of optical lithography techniques to pattern sub-50 nm features [1-2]. However, EUV lithography come with few inherent challenges to pattern nanostructures, such as requiring precise incidence angles, expensive multilayer optics, and resist material with limited etch selectivity [1]. There is a consensus for the industry to accept EUV and introduce studies for improvements on EUV interactions of materials with EUV [3]. EUV photoresists should be specifically designed since EUV since it has unique properties [4]. ZEP520A (Zeon Corp.) is a commercially available positive tone resist that has been well known for its use in electron-beam lithography, but there is scarce literature when it comes to the estimating the resist performance using EUV photons. The use of existing resist material can reduce the development time of novel EUV lithography processes and system.

In this work we investigate the use of ZEP520A resist as a positive EUV photoresist. The goal of this work is to demonstrate the viability of using ZEP resist for developing EUV lithography systems and configurations. The experimental set up involves a tabletop EUV powered by a 40 fs ultrafast femtosecond IR laser [2]. The laser is directed through a series of optics to pass through a glass capillary with argon gas for high harmonic generation (HHG) which outputs a EUV beam of roughly sub-100 μm diameter spot size. The average beam intensity was measured using a silicon diode with calibrated responsivity. The beam is then spectrally filtered to output 30 nm EUV light. It is further focused onto a vacuum experimental chamber using a pair of multilayer mirrors, where a 100 nm thick resist coated wafer is exposed. For the experiment, the sample was exposed to various doses at wavelength of 30 nm, ranging from 10 to 100 mJ/cm^2. A microsphere image of the spots can be seen in figure 1. The exposed wafer was developed in an n-amyl acetate solution and the exposure dose was characterized. The resist response can be modeled by a binary resist model, where the normalized beam spot is assumed to have a Gaussian intensity profile given as $x_o/\sigma = \sqrt{-2\ln(D_o/2D_{ave})}$. In this equation, x_o is the width of the beam spot, σ is the estimated width of the exposure beam spot, D_o is the clearing dose of the resist, and D_{ave} is the average exposed dose during the experiment.

The characterization tests were conducted using multiple imaging methods such as confocal microscopy and atomic force microscopy (AFM). Using a confocal microscope, topography maps can be obtained to visualize the dimensions of the exposed resist. Followed by an AFM, to obtain precise measurements of post resist development thickness and identifying the clearing dose of the post development EUV exposed beam spot. The results show that exposed beam spots vary between 75 to 100 μm, depending on the exposure dose. 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. We will present the process details, fabrication results, and measured results in more details.

**ethan.flores@utexas.edu*

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Figures

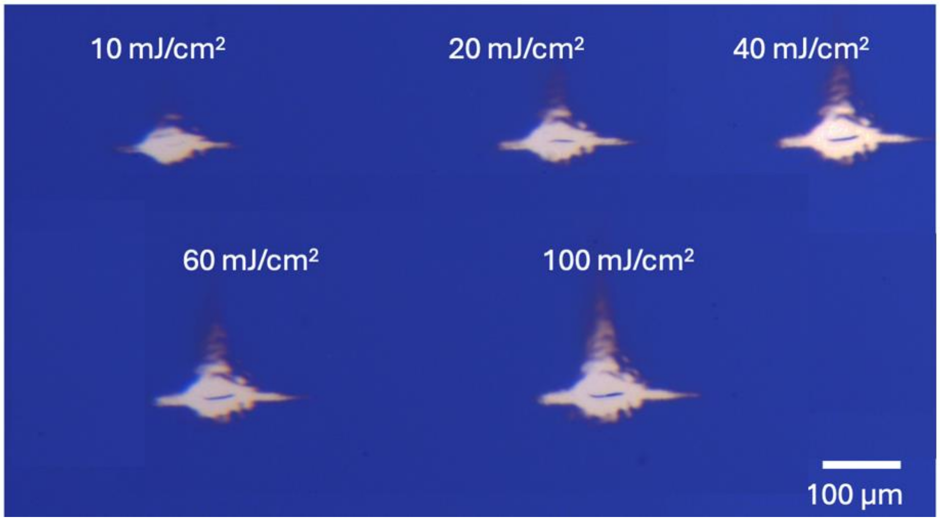

Fig.1: Optical image of dose characterization test using ZEP 520A positive tone resist.

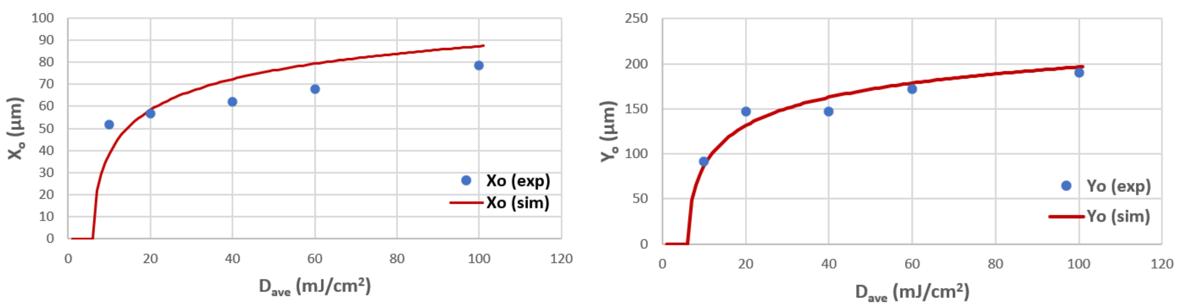

Fig.2: Experimental and simulated (a) width and (b) length of the exposure beam spot vs average dose average.