Evaluation and comparison of ZEP520A and mrPosEBR resists by electron beam and extreme ultraviolet lithography

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For over a decade, ZEP520A (Nippon Zeon Co.) has been one of the leading positive tone resist for electron beam lithography (EBL). It consists of a copolymer of chloromethacrylate and methylstyrene and features high resolution and higher sensitivity in comparison to poly(methyl methacrylate) (PMMA) and other novolak resin-based resists.[1] Its plasma etch selectivity to SiO_2 makes it attractive for pattern transfer and sub-μm patterning, such as fabrication of devices and lithographic masks; and also for thermal reflow in grayscale lithography.[2]

The mrPosEBR (micro resist technology GmbH) is a recently released positive tone resist for EBL, consisting of an organic copolymer of an acrylic, chlorine-containing monomer with an acrylic monomer bearing aromatic side-groups. It has been recently demonstrated to have good etch selectivity (CF_4/SF_6) to silicon and about as high sensitivity as its competitor, the ZEP520A. Notably, the resolution of mrPosEBR reached to an unprecedented feature size of 35 nm.[3]

So far, few works have explored the performance of these resists at extreme ultraviolet (EUV) lithography. Among these, only one work has recently reported the sensitivity ratio between EBL and EUV.[4] It is of interest to assess the patterning capability of such non-chemically amplified resists at dose of few mJ/cm^2.

Flood exposures were used to determine the sensitivity and contrast at EUV, as shown in Fig. 1, left. In comparison to PMMA, the ZEP520A was about twice as sensitive; while the mrPosEBR was even about four times faster. Notably, a different response was detected in e-beam exposures, where ZEP520A was faster than mrPosEBR (Fig. 1, right). The reasons for this discrepancy (among which, density and dissociation efficiency, and absorption at EUV) are examined.

The patterning performance at EUV was assessed in terms of critical dimension and line width roughness. Dense lines/spaces patterns, from 100 nm to 44 nm pitch, were carried out by EUV interference lithography. ZEP520A showed good patterning down to pitch 50 nm (Fig. 2, top) at dose as low as ≈ 6.4 mJ/cm^2. However, the same layout was not clearly resolved in mrPosEBR (Fig. 2, bottom). In the last part of the talk, the optimization of the lithographic process conditions – post-application bake, developer, post exposure bake – is discussed.

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[1] H. Miyoshi et al., Microelectronic Engineering **155**, 7 (2016).
[2] R. Kirchner et al., Microelectronic Engineering **153**, 71 (2016).
[3] S. Pfirrmann et al., Microelectronic Engineering **155**, 67 (2016).
[4] T. G. Oyama et al., AIP Advances **6**, 085210 (2016).

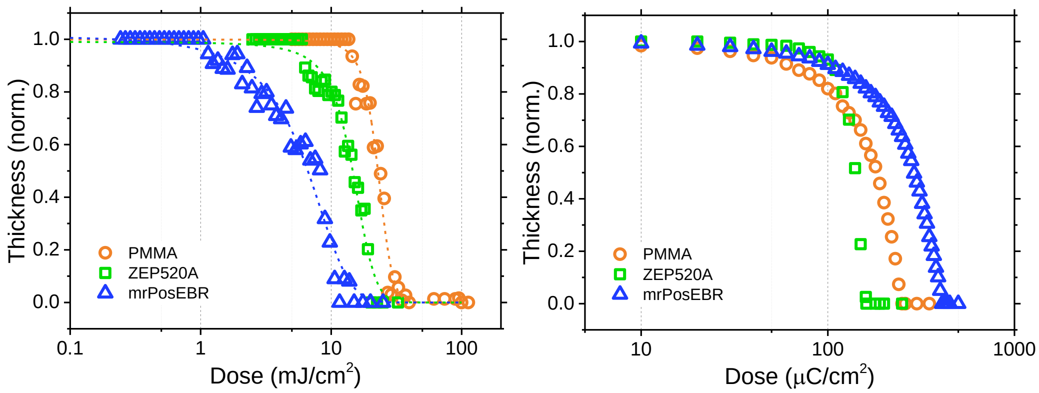

Figure 1: Measured contrast curves of PMMA (orange circles), ZEP520A (green squares) and mrPosEBR (blue triangles) from flood exposures to EUV light (left) and to 100 keV electron beam (right). The remaining thickness of resist after development is normalized to the initial film thickness.

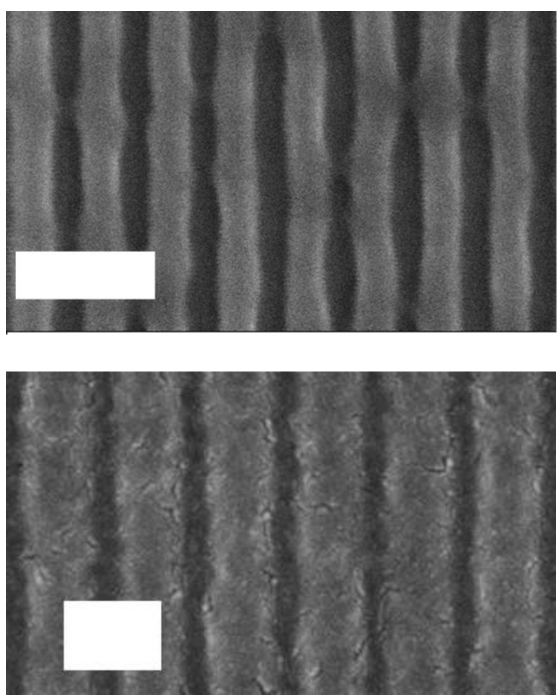

Figure 2: Scanning electron micrographs of dense lines/spaces patterns obtained by EUV interference lithography in ZEP520A of period 50 nm (top), and mrPosEBR of period 100 nm (bottom). In both samples, the thickness was 35 nm and the incident dose on wafer was about 6.4 mJ/cm^2. Both scale bars are 100 nm wide.