Next Generation Chemically Amplified Molecular Resists for E-beam Lithography Based on Epoxide Cross-Linking

Richard A. Lawson, Cheng-Tsung Lee, Clifford L. Henderson*
School of Chemical & Biomolecular Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0100
Laren Tolbert
School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, GA 30332
Wang Yueh
Intel Corporation, Hillsboro, OR

E-beam resists have a great importance in both research and industry, and they have a number of applications including mask making and imprint template fabrication. Non-chemically amplified systems, such as PMMA[1], ZEP[2], and HSQ[3], have been used for many of the applications because they provide very high resolution and low line-edge-roughness (LER). Unfortunately, the long write times required for many of these resists make them impractical for an increasing number of applications. Chemically amplified resists (CARs) provide orders of magnitude faster write times, but usually at the cost of reduced resolution and LER. We have recently reported on a series of negative tone chemically amplified molecular resists that combine both high resolution and sensitivity with excellent LER (see Fig. 1).[4-5] The resist is based on epoxide ring opening polymerization to create a highly cross-linked film. The two systems (compounds I and II in Fig. 1) studied so far have each achieved 35 nm resolution, a low LER (3σ) of 2.3 nm, and an e-beam sensitivity of approximately 10-30 $\mu C/cm^2$ at 100 keV. Examples of high resolution patterns in compounds I and II are shown in Figures 2 and 3.

This study further examines these resists and new similar molecular resists in an attempt to both improve the current performance and to determine why this family of resists exhibits such excellent properties. Systematic studies of changes in factors such as molecular size, rigidity, solubility, and degree of functionality are performed to develop structure-property relationships in these materials. The effects that modifications of processing conditions and structure have on imaging performance are also examined. These studies are used to design optimized resist structure and processing conditions for high resolution e-beam patterning.

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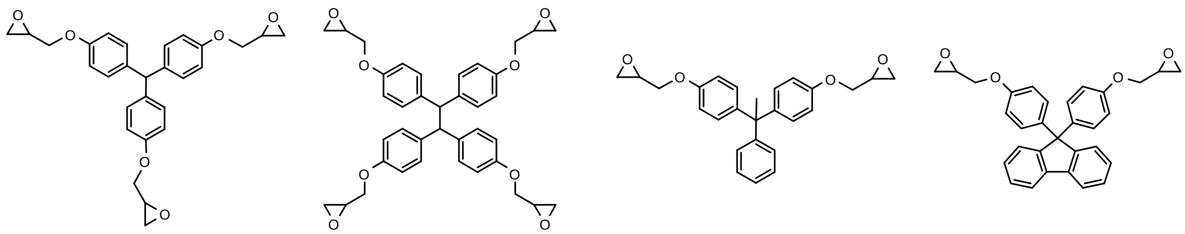
[1] Hu, W., et. al. *J. Vac. Sci. Tech. B.* (2004), 22(4), 1711-1716.
[2] Hosaka, S. et. al. *Applied Physics Letters* (2006), 89(22), 223131/1-223131/3.
[3] Baek, In-Bok, et. al. *J. Vac. Sci. Tech. B.* (2005), 23(6), 3120-3123.
[4] Lawson, R.A., et. al. *J. Vac. Sci. Tech. B.* (2007), 25(6), 2140-2144.
[5] Lawson, R.A., et. al. MNE 2007 Presentation



I **II** **III** **IV**

Figure 1. Examples of molecular resists based on epoxide cross-linking.

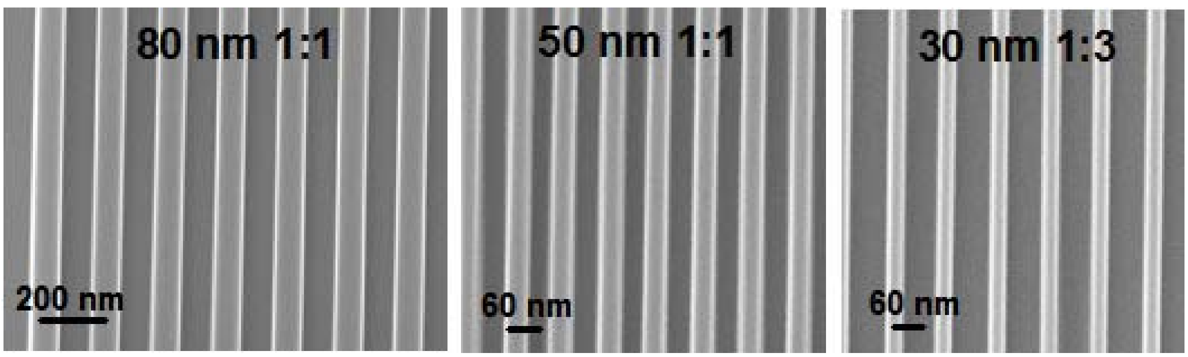


Figure 2. SEM of e-beam patterning of epoxide molecular resist **I**, imaged at 50 μC/cm^2 (100keV) with 3σ LER of 2.3 nm.

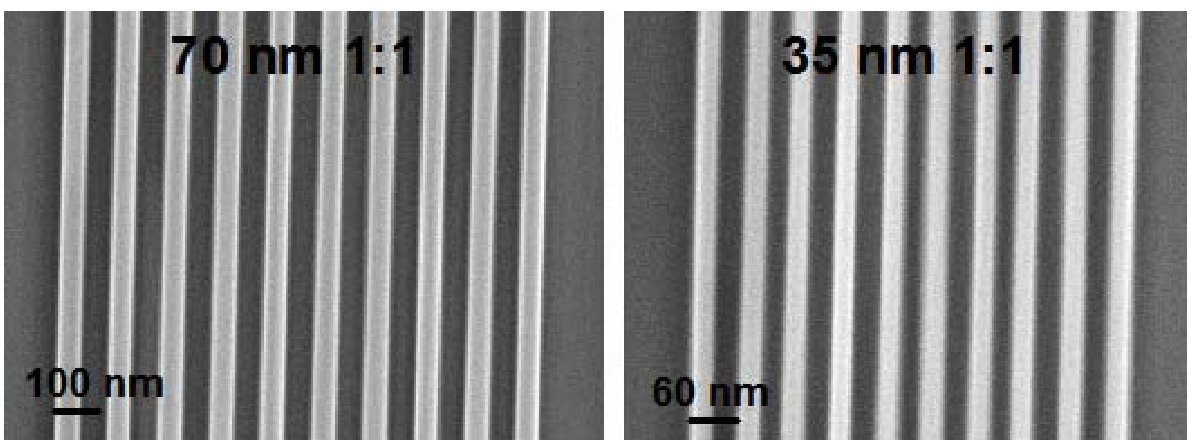


Figure 3. SEM of e-beam patterning of epoxide molecular resist **II**, imaged at 50 μC/cm^2 (100keV) with 3σ LER of 2.3 nm.