Understanding the Effects of Photoacid Distribution Homogeneity and Diffusivity on Lithography Performance in Polymer-Bound PAG Photoresists

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Chemically amplified resists (CARs) have served for more than twenty years as the high sensitivity, high resolution patterning media for transferring patterns from photomasks to semiconductor substrates. Novel polymer-bound photoacid generator (PAG) CARs have been recently developed to improve the lithographic capabilities of 193 nm and extreme ultraviolet (EUV) resists.[1] Direct incorporation of PAG molecule into the polymer main chain offers enhancements to resist performance through several possible mechanisms including: (1) increasing the maximum possible PAG loading, (2) improving PAG distribution homogeneity, and (3) reducing photoacid diffusivity.[2] Although such polymer-bound PAG CARs display improved performance[3], the connections between resist design and lithographic performance in such systems is not well understood. In this work, a combination of experimental (see Fig. 1) and modeling work (see Fig. 2 & 3) has been used to both quantify and understand the lithographic advantages of polymer-bound PAG CARs. These experimental and simulation results will be discussed as they pertain to the design of future advanced resist CAR materials.

1. Wang, M.; Jarnagin, N. D.; Lee, C. –T.; Henderson, C. L.; Yueh, W.; Roberts, J. M.; Gonsalves, K. E. Novel Polymeric Anionic Photoacid Generators (PAGs) and Corresponding Polymers for 193 nm Lithography, *J. Mater. Chem.* 2007, *16*, 3701.
2. Lee, C. –T.; Wang, M.; Jarnagin, N. D.; Gonsalves, K. E.; Roberts, J. M.; Yueh, W.; Henderson, C. L. Photosensitivity and line edge roughness of novel polymer-bound PAG photoresists, *Proc. SPIE* 2007, *6519*, 65191E.
3. Lee, C. –T.; Henderson, C. L.; Wang, M.; Gonsalves, K. E.; Yueh, W. Effect of photoacid generator incorporation into the polymer main chain on 193 nm chemically amplified resist behavior and lithography performance, *J. Vac. Sci. Technol. B* 2007, *25*, 213.

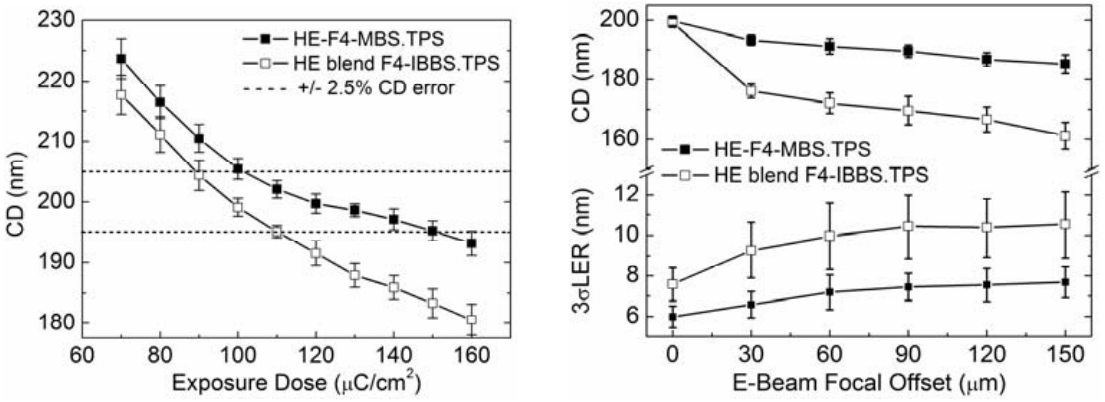

Figure 1. Examples of exposure (left) and focal (right) latitudes of analogous polymer-bound PAG and blended-PAG resists showing superior performance of polymer-bound PAG resist.

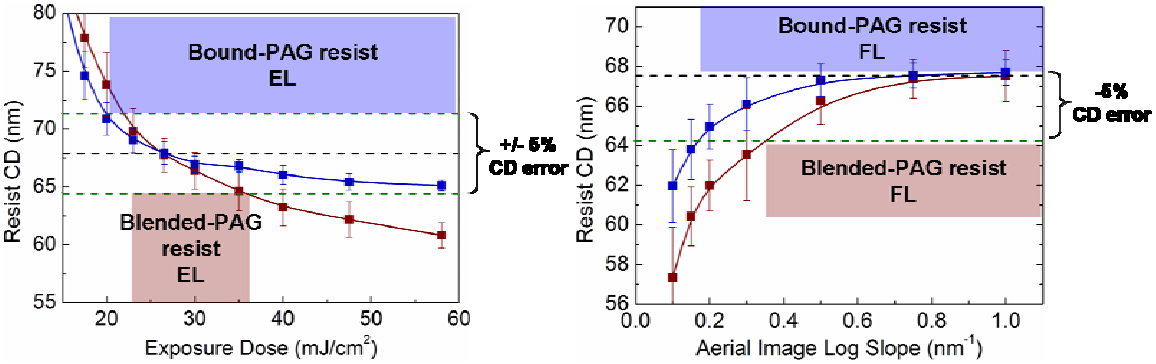

Figure 2. Simulation results exposure dose (left) and aerial image quality (right) effects on the CD control for analogous polymer-bound PAG and blended-PAG resists.

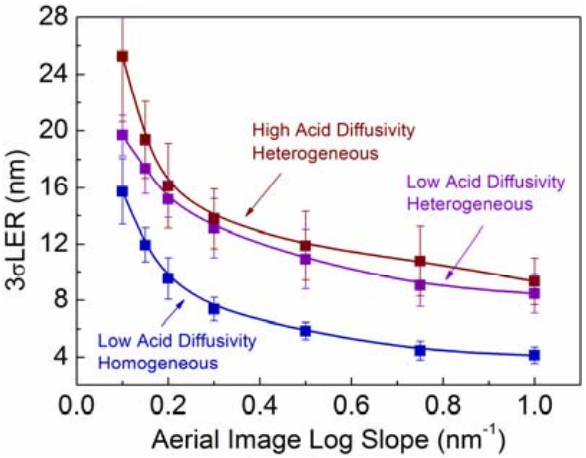

Figure 3. Effects of PAG distribution homogeneity and photoacid diffusivity on line edge roughness of the patterned photoresist film. It is clear that significant improvement in LER is only achieved for low photoacid diffusivity in the cases where PAG is originally homogeneously distributed in the film.