Effects of PAG Incorporation into the Polymer Main Chain on Chemically Amplified Resist Behavior and Lithographic Performance

Cheng-Tsung Lee, Clifford L. Henderson*
School of Chemical & Biomolecular Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0100
Mingxing Wang, Kenneth E. Gonsalves
Department of Chemistry, University of North Carolina-Charlotte, Charlotte, NC
Wang Yueh, Jeanette M. Roberts
Intel Corporation, Hillsboro, OR

Manufacturing high density integrated circuits with feature sizes below sub-50 nm will be realized both by advancements in the exposure tools and resist materials used for such patterning processes. While 193 nm immersion and extreme ultraviolet (EUV) lithography are promising patterning technologies for achieving 32 nm node and below devices, chemically amplified resist materials that can resolve such patterns with the desired line width roughness (LWR) control are not currently available.[1] In this paper, the ability to dramatically improve chemically amplified resist performance by incorporating photoacid generator (PAG) units directly into the resist polymer main chain is investigated in detail. By applying the extremely-high aerial image contrast available in electron beam lithography, the intrinsic resolution, CD control, and LWR behavior of ArF and EUV resist materials made from blended, cation-bound, and anion-bound PAGs have been systematically investigated.[2] The results show that the PAG-bound resists possess the capability to achieve higher resolutions with lower LWR than their analogous blended-PAG materials. Comparison between different PAG incorporation methods also shows that the anionic PAG bonding provides the best lithographic performance, supporting the idea that it is reduced photoacid diffusivity that leads to the observed performance improvements. Furthermore, it is shown that the exposure and focus latitude in anion-bound PAG materials is improved significantly as compared to blended-PAG resists. Additional fundamental material studies will also be discussed.

1. Internal Technology Roadmap for Semiconductors (ITRS) 2005, Lithography, http://public.itrs.net/.
2. C.-T. Lee, M. Wang, N. D. Jarnagin, K. Gonsalves, W. Yueh, J. M. Roberts, C. L. Henderson, *Advances in Resist Technology and Procesing XXIV,* 2007

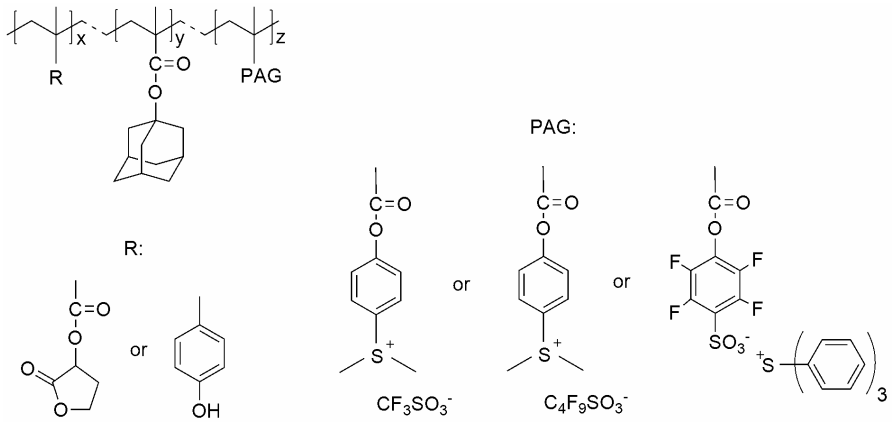

Figure 1. Structures of polymer-bound PAG resists investigated and compared in this work.

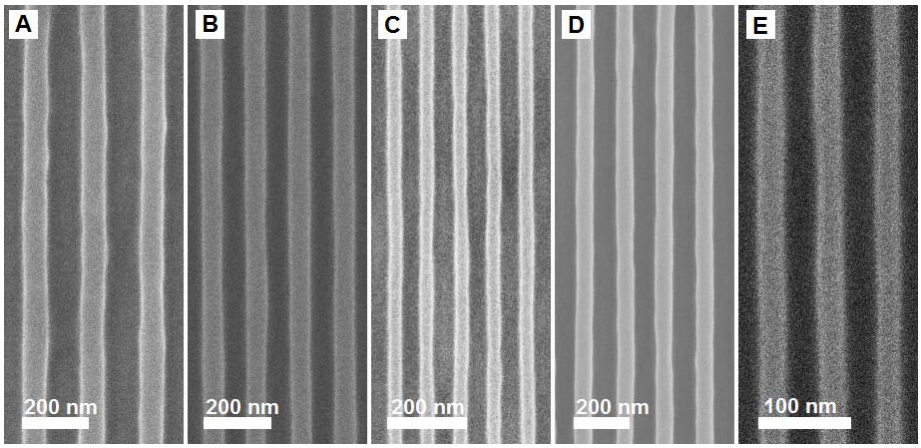

Figure 2. SEM images showing examples of patterns obtained in (A) a blended PAG resist and (B) PAG-bound resists, and the comparison between (C,D) cationic PAG-bound and (E) anionic PAG-bound resists. Comparison of this imaging data shows that the limiting resolution and LWR is found to be better for the anion-bound PAG resists than other blended PAG or cation-bound PAG resist materials.