Title

Characterization of Line Edge Roughness (LER) Propagation from Resist: Underlayer Interfaces in Ultra-thin Resist Films

Permalink

https://escholarship.org/uc/item/368224mq

Authors

George, Simi
Naulleau, Patrick
Wu, Se Yu
et al.

Publication Date

2010-01-25

Characterization of Line Edge Roughness (LER) Propagation from Resist:Underlayer Interfaces in Ultra-thin Resist Films

Simi George[1,4], Patrick Naulleau[1], Ze Yu Wu[2], Joseph Kennedy[2], Song Yuan Xie[2], Kyle Flanigan[2], Thomas Wallow[3]

[1]Center for X-Ray Optics, Lawrence Berkeley National Laboratory, Berkeley CA 94720
[2]Honeywell, 1349 Moffett Park Drive, Sunnyvale CA 94089 USA
[3]GlobalFoundries, 1050 E. Arques Avenue, Sunnyvale CA 94085 USA
[4]Corresponding author. Email: *sageorge@lbl.gov*

It has been understood for some time that physical properties of thin polymeric films coated on substrates are dominated by their surface interactions with the substrate. For glassy polymers such as those employed in photoresists, perturbation of bulk properties at the substrate interface may propagate more than 50 nm into the polymer film.[1]

As semiconductor lithography moves toward pitches below 80 nm, resist films with thicknesses of 100 nm and below will be required. Behavior of these films will become increasingly dominated by their substrate interactions. Numerous previous studies have demonstrated that properties of photoresist materials such as glass transition temperature, acid diffusivity, and imaging behavior change systematically as film thickness is decreased.[2] Recent work in EUV photoresist development has highlighted that substrate materials play a critical role in affecting imaging performance and can improve LER, resolution, and process window.[3]

In this presentation, we describe another aspect of ultrathin resist behavior, specifically LER evolution along the resist sidewall of EUV resists. We amplify on Foucher's observation[4] that LER both increases and becomes less isotropic as the resist sidewall approaches the substrate interface. We observe that the sidewall topography of multiple EUV photoresists is dominated by striated features that originate at the substrate and propagate toward the top of the resist film. These findings are in contrast to observations of isotropic, pebbled roughness of larger resist sidewalls described in previous studies[5] and predicted by recently developed stochastic models.[6] We detail systematic efforts to reduce these striated structures based on resist and substrate characterization (chemical, AFM, etc.) and engineering of the surface interaction between EUV resists and high-silicon content spin-on hardmask materials.[7] We use the results of these studies to assess several hypotheses regarding the origins of the striated structures.

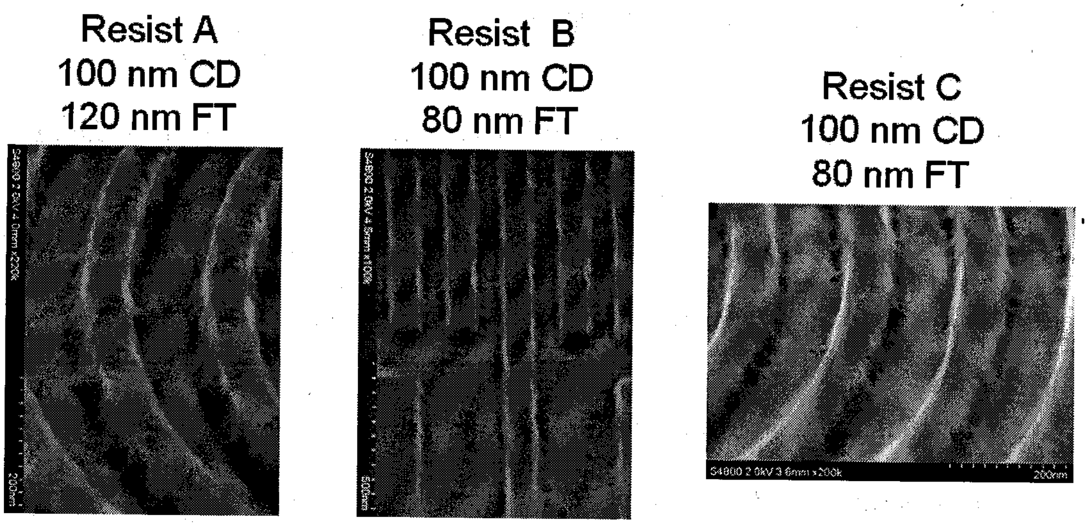

Figure 1: SEM Characterization of EUV resist sidewalls. Anisotropic propagation of striations from substrate up the resist sidewall is observed for many EUV resists.

This work was supported by the Director, Office of Science, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

1. See, for instance, J. D'Amour et al., Microelectronic Engineering 73-74, 209-217 (2004) and references therein.
2. See, for instance, a) D. Fryer et al., J. Vac. Sci. Technol. B. 18(6), 3376-3380 (2000); b) C. Soles et al., Proc. SPIE 5039, 366-379 (2003); c) L. Singh et al., Proc. SPIE 5376, 1007-1016 (2004).
3. a) P. Naulleau et al., J. Vac. Sci. Technol. B. 27(1), 66-70 (2009); b) G. Vandentop et al., Proc. SPIE 7271, 727116-1-9 (2009).
4. J. Foucher, Proc. SPIE 5752, 966-976 (2005).
5. a) D. Goldfarb et al., J. Vac. Sci. Technol. B. 22(2), 647-653 (2004); b) J. Foucher et al., Proc. SPIE 6518, 65181Q1-14, (2007).
6. G. Gallatin, Proc. SPIE 5754, 38-52 (2005).
7. J. Kennedy et al. Proc SPIE 7273, 72733M-1-12 (2009).