Evaluating the Optical and Resist Contributions to Line-Edge Roughness in EUV Lithography Using Stochastic Simulation

Anindarupa Chunder, Azat Latypov, Harry J. Levinson
GLOBALFOUNDRIES Inc, 2600 Great America Way, Santa Clara, CA 95054
anindarupa.chunder@globalfoundries.com

John J. Biafore
KLA-Tencor Corp., 8834 N. Capital of Texas. Hwy., Austin TX

Extreme Ultraviolet (EUV) Lithography is considered a leading candidate for future node manufacturing due to its high resolution and simplified process compared to optical multi-patterning schemes. However, minimization and control of line-edge roughness (LER) and contact-edge roughness (CER) is one of the current challenges limiting EUV line and hole printability [1-3]. One significant contributor to roughness/irregularity at EUV is photon shot noise (PSN); others are the physical and chemical reactions encountered in photoresist processing. This paper comprises a simulation-based study using a physics-based stochastic EUV model to decouple the PSN contribution to LER from that of the resist. We present and test several computational methods using either explicit utilization of the Poisson statistics of PSN [2] or direct Monte-Carlo simulation of the average number of absorbed photons in resist to estimate the contribution of PSN to LER. We also discuss the approach to separate the optical and resist contributions based on Monte-Carlo stochastic simulations of certain ad hoc patterns by varying the incident dose within a wide range. Finally, the study concludes with an estimation of pattern variability as a function of resist parameters using a novel systematic resist parameter optimization approach. The current scope of this paper is to asses and compare several computational approaches to estimate PSN and other stochastic contributions to LER, which are otherwise inseparable in actual EUV lithography. A detailed understanding of the various stochastic mechanisms benefits LER mitigation efforts in EUV lithography.

References

1. Ma, Y; Levinson, H. J.; Wallow, T. Line edge roughness impact on critical dimension variation. *Proc. SPIE 6518*. 2007, 651824.
2. Smith, M.D.; Biafore, J.J.; Fang, C. Optimization of a virtual EUV photoresist for the trade-off between throughput and CDU. *Proc. SPIE 8682*, 2013, 868203.
3. Mack, C. A. Analytical expression for impact of linewidth roughness on critical dimension uniformity. *J. Micro/Nanolith. MEMS MOEMS*. 2014, 13(2), 020501