Optimization of resolution enhancement technology and dual layer bottom antireflective coatings in hyper numerical aperture optical lithography

Yanqiu Li [a*], Yuan Zhou [a,b]

a. Institute of Electrical Engineering of Chinese Academy of Sciences

b. Graduate School of the Chinese Academy of Sciences

No.6 Bei-Er-Tiao, Zhong Guan Cun, Beijing 100080, P.R. China

Resolution enhancement technology (RET) and dual - layer bottom antireflective coatings (BARC) will be used in hyper-numerical aperture (NA) ArF lithography at 45-nm node. RET and hyper-NA cause light to diffract at high angles and the images in a resist are formed by oblique waves, where the oblique incident angle and polarization will yield increased reflectance both at air/resist and resist/substrate interfaces, consequently results in an increase in both the standing wave and critical dimension (CD) swing. Hence an optimization of RET and BARCS to maintain low reflectance for small CD, good CD uniformity (CDU) and reasonable process window (PW) is required. Though RET and single layer BARC have been used in dry ArF lithography for years, which will be not suitable in hyper NA lithography.

In this study, an optimization of RET and dual-layer BARCs are capable of suppressing reflectivity through a wide range of incident angles and to provide good CD, CDU and PW. The off axis polarization illumination, attenuated and alternative phase shift mask are employed in conjunction with the optimization of dual-layer BARCs design by using commercial software Prolith 9.0 ProData, ProLE and in house software MicroCruiser. The optimization of RET and optical properties of BARC as well as thickness is a biggest challenge as ArF scanners designed to meet the needs of the 45nm node will have a very small depth-of-focus (DOF) and the controlling of CD is much tight. The optimization of RET and dual-layer BARCs provide multi-solution of BARC materials and thickness

Key words: Lithography simulation, Prolith, 45nm node, Resolution enhancement technology, antireflective coatings

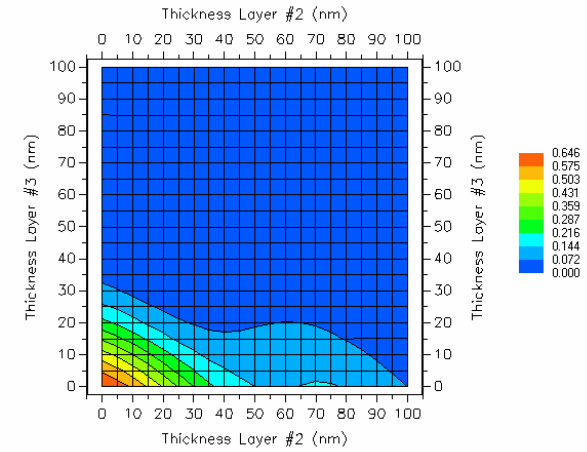
Acknowledgments: This research is supported by National Funds of Sciences under Grant **No.** 10674134 and Grand Fundamental Research 973 Program of China under Grant No. 2003CB716204.

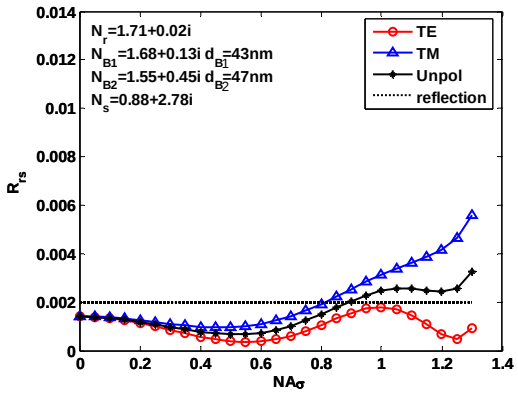
**Corresponding author: Yanqiu Li, Phone/Fax: 86-10-62561490*

E-mail: yanqiuli@hotmail.com, liyanq@mail.iee.ac.cn

Reference

1. Victor Huang, TS Wu, Mars Yang, Francis Lin, Elvis Yang,TH Yang, KC Chen, Joseph Ku and CY Lu, Dual Anti-reflection Layers for ARC/Hard-Mask Applications, Optical Microlithography XIX, edited by Donis G. Flagello, Proc. of SPIE Vol. 6154, 61543Q-1 (2006)
2. James B. Claypool, Marc Weimer, Vandana Krishnamurthy, Wendy Gehoel, Koen van Ingen Schenau, New advanced BARC materials for ultra-high NA applications, Advances in Resist Technology and Processing XXII, edited by John L. Sturtevant, (SPIE, Bellingham, WA), Proceedings of SPIE Vol. 5753, 679 (2005).
3. John S. Petersen, Mark J. Maslow, Robert T. Greenway, An Integrated Imaging System for the 45-nm Technology Node Contact Holes Using Polarized OAI, Immersion, Weak PSM, and Negative Resists, Optical Microlithography XVIII, edited by Bruce W. Smith, SPIE, Bellingham, WA, Proceedings of SPIE Vol. 5754, 488 (2005).
4. Sean Burns, Dirk Pfeiffer, Arpan Mahorowala, Karen Petrillo, Alexandra Clancy, Katherina Babich, David Medeiros, Silicon containing polymer in application for 193 nm high NA lithography process, Advances in Resist Technology and Processing XXIII, edited by Qinghuang Lin, Proc. of SPIE Vol. 6153, 61530K-1, (2006) ·
5. D. J. Abdallah, M. Neisser, R. R. Dammel, G. Pawlowski, S. Ding, F. M. Houlihan, A. R. Romano,193nm dual layer organic B.A.R.C.s for high NA immersion Lithography, Advances in Resist Technology and Processing XXII, edited by John L. Sturtevant, SPIE, Bellingham, WA, Proceedings of SPIE Vol. 5753, 417 (2005).





$\lambda = 193nm$

$NA = 1.2(water\ immersi\ on)$

$\sigma = 0.94/0.74$

$attPSM\ 6\%$

$45nm\ line/space$