EUV resist performance on 22nm CH and on 22nm L/S

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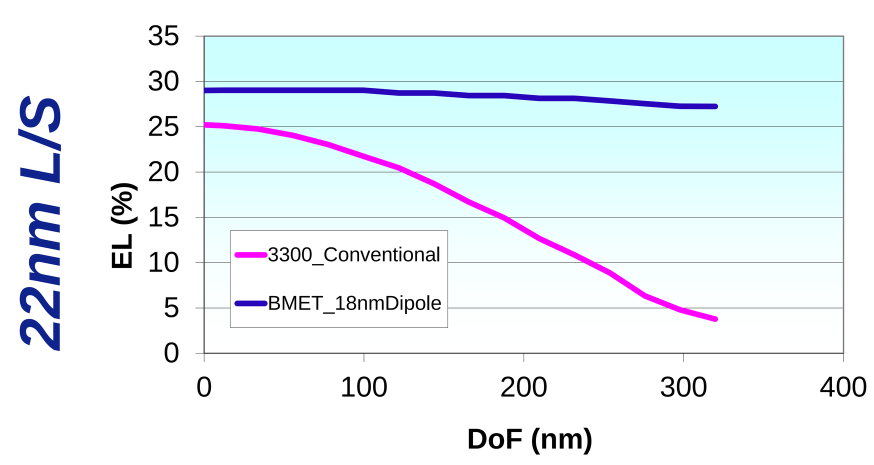
Introduction

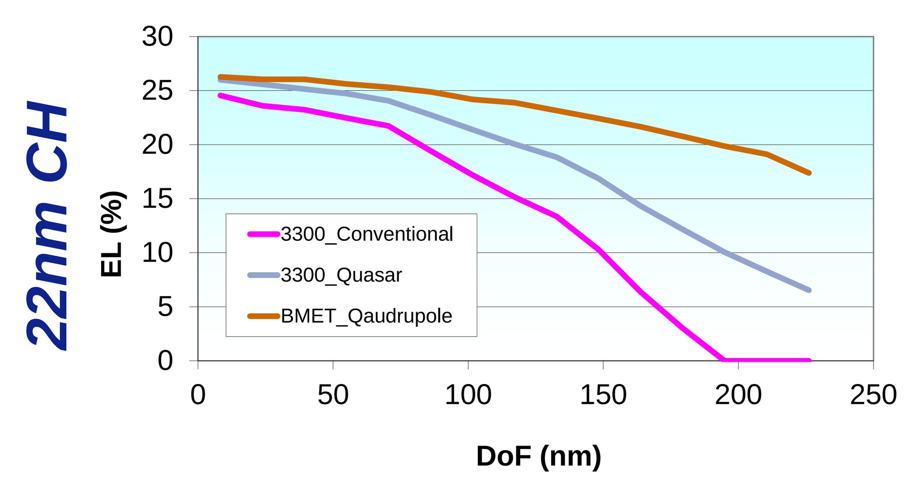
Previous investigations[1] have demonstrated the resolution limit of the NXE:3100 in terms of 1:1 lines and spaces by printing 16nm half pitch features. For contact holes, however, the resolution limit has not been reached yet. Furthermore, ASML's NXE:3300 EUV scanner using 0.33NA will first be used in a high volume manufacturing (HVM) environment, exposing contact hole device layers. This increases the need for a resist process mature enough to print 2D contact hole structures to be ready to take advantage of the NXE:3300 imaging capabilities. In order to deliver a qualified EUV resist process on time for HVM using NXE:3300, an ongoing micro-exposure tool (MET) based resist evaluation of leading resists throughout 2012 has been carried out . Both 22nm CH and 22nm L/S printability was evaluated for multiple advanced resist samples. Quadrupole illumination setting was used for CH printing, and 18nm Dipole illumination setting was used for L/S printing. A 25% positive reticle bias was used for CH exposures

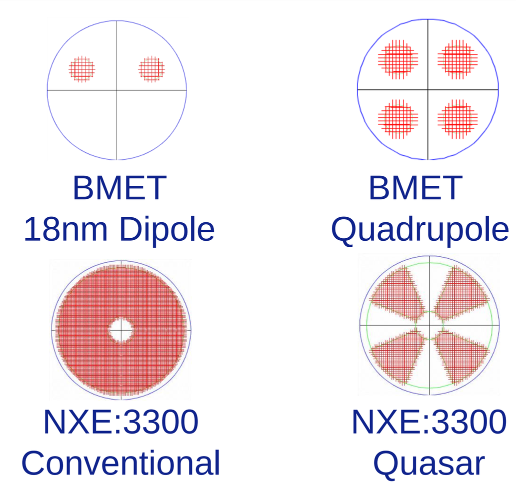
Our EUV resist evaluation strategy is to collect state of the art EUV resist samples from all major resist vendors, and run a pre-evaluation on MET tool in Berkeley USA LBNL. The best performing resists from the exposures on the Berkeley EUV MET tool will be exposed on both NXE:3100 and NXE:3300. In these evaluations the following figures of merit have been investigated: resist resolution, depth of focus, exposure latitude, dose, LWR for L/S and LCDU for CH. In this publication the BMET imaging performance of the latest EUV resists will be presented.

Simulations

Aerial image simulations were performed using Panoramic Hyperlith to compare the different illumination settings used in the (pre-evaluations) and what will be used in the full field exposures on the NXE:3300. Expected performance on the NXE:3300 will be different based on the conditions used in the resist evaluation.



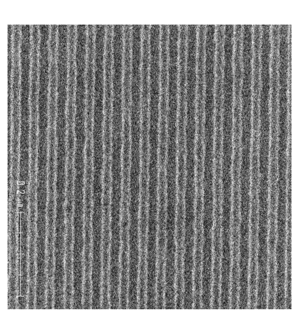




BMET performance of the reference resist selected in 2011

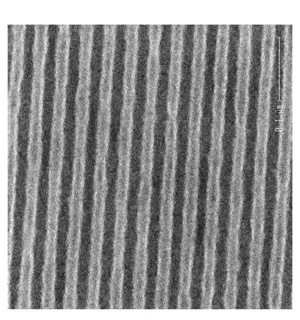
From our BMET resist evaluation in 2011, one outperforming Chemically Amplified (CA) resist (reference resist) was tested, showing down to16nm HP L/S printability and 22nm HP CH printability with a reticle bias of 25%CD. The biggest disadvantage of this resist is the high dose needed to print these features.

22nm HP L/S



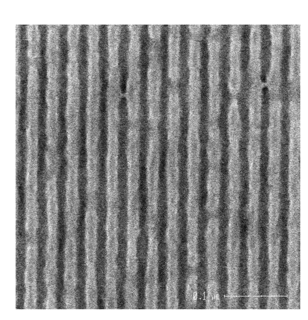
PW:	280 nm
EL:	17 %
LWR:	3.7 nm
Dose:	40 mj/cm2

18nm HP L/S



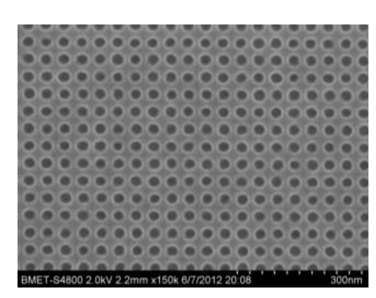
PW:	280 nm
EL:	10 %
LWR:	4.0 nm
Dose:	40 mj/cm2

16nm HP L/S

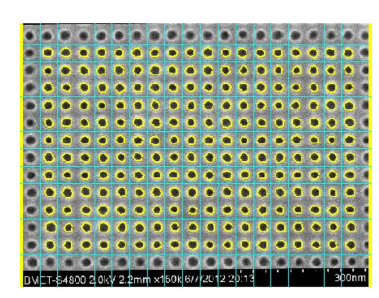


PW:	0 nm
EL:	0 %
LWR:	5.5 nm
Dose:	40 mj/cm2

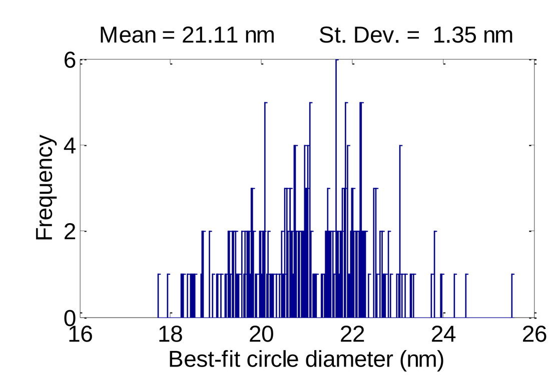
22nm HP CH, +25% reticle Bias,



Dose: 62mj/cm2

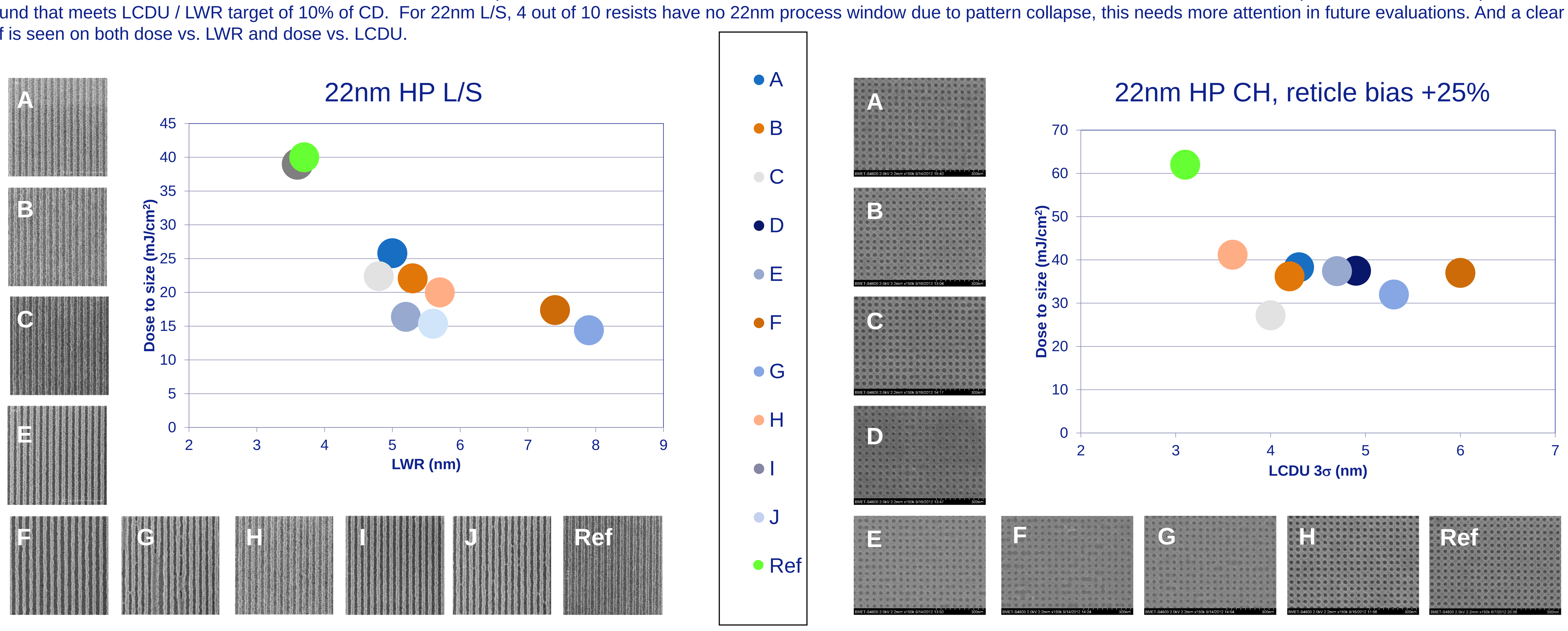


216 CH image measured



Performance of resist samples tested on BMET in 2012

The goal of the 2012 BMET resist evaluation is to find a resist which has equal or better imaging performance than our reference resist preferably with higher sensitivity. In total more than 20 CA resist samples were tested, resist film thickness of 40nm was used as standard for all resist samples. About 10 resists demonstrated printing capabilities of 22nm HP L/S as well as 22nm HP CH. The imaging performance of these 10 resists are summarized below. Resist I performs similar as the reference resist at 22nm L/S. Resist C is outside the LCDU vs. dose trend compared to the other samples. No resist is found that meets LCDU / LWR target of 10% of CD. For 22nm L/S, 4 out of 10 resists have no 22nm process window due to pattern collapse, this needs more attention in future evaluations. And a clear trade off is seen on both dose vs. LWR and dose vs. LCDU.



Conclusions

Based on our 2012 BMET resist evaluation results so far, two conclusions can be drawn:

- Clearly there are improvements on resist developments. Multiple resists are able to print 22nm L/S and 22nm CH. However resist performance improvement does not seem to be big enough.
- Trade off of large LWR on L/S and large LCDU on CH is clearly seen with low dose to size resist samples. Process optimization (for instance FIRM rinse or resist Film Thickness optimization) may help in some degree on LWR / LCDU reduction. A major improvement in resist chemistry is needed to support the critical LCDU requirements for the sub 20nm EUV nodes.

Future work

- Future work will be focused on reducing pattern collapse for L/S and further reduction of LWR and LCDU. Furthermore the performance of the best resists will be verified on the NXE:3300.

Acknowledgements

- ASML Hitachi team for SEM measurements.
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Reference

T. Wallow, D. Civay, S. Wang, H. F. Hoefnagels, C. Verspaget, G. Tanriseven, A. Fumar-Pici, S. Hansen, J. Schefske, M. Singh, R. Maas, Y. van Dommelen and J. Mallman, "EUV resist performance: current assessment for sub-22-nm half-pitch patterning on NXE:3300", Proc. SPIE 8322, 83221J (2012).