Evaluation of EUV resist performance below 20-nm critical dimension using helium ion lithography

Paul Alkemade, Anja van Langen–Suurling
Kavli Institute of Nanoscience, Delft University of Technology
Delft, The Netherlands
p.f.a.alkemade@tudelft.nl

Diederik Maas, Emile van Veldhoven
TNO, Stieltjesweg 1, Delft, The Netherlands

Sander Wuister, Rik Hoefnagels, Coen Verspaget, Timon Fliervoet
ASML, De Run 6665, Veldhoven, The Netherlands

For the introduction of EUV lithography, development of high performance EUV resists is of key importance. This development involves studies into resist sensitivity, resolving power and pattern uniformity. We have used a sub-nanometer 30-keV helium ion beam to expose chemically amplified (CAR) EUV resists.

There are distinct similarities in the response of resists to He^+ ions and EUV photons. Both primary particle beams traverse the resist and meanwhile interact with the target atoms. The low backscattering of the He^+ ions results in ultra-low proximity effects, which is similar to EUV exposure. Absorption of an EUV photon creates a high-energy electron that relaxes by the generation of secondary electrons (SEs). A collision of a 30-keV He^+ ion with a target atom directly releases low-energy SEs. Each ion scatters several times in the resist layer, enabling resist exposures at very low doses. The energy spectra of SEs generated by EUV and He^+ ions are remarkably alike. These SEs, in turn, activate the resist.

In this paper we show 30-keV He^+ exposures of contact holes and lines with a critical dimension (CD) of 8 to 30 nm at 40-nm pitch in a chemically amplified EUV resist. Two examples are given in Figs. 1 and 2. We will demonstrate the potential of using He^+ ion lithography [1] in the study of EUV resists.

[1] V. Sidorkin et al., *Sub-10-nm nanolithography with a scanning helium beam*, J. Vac. Sci. Technol. B **27**, L18 (2009)

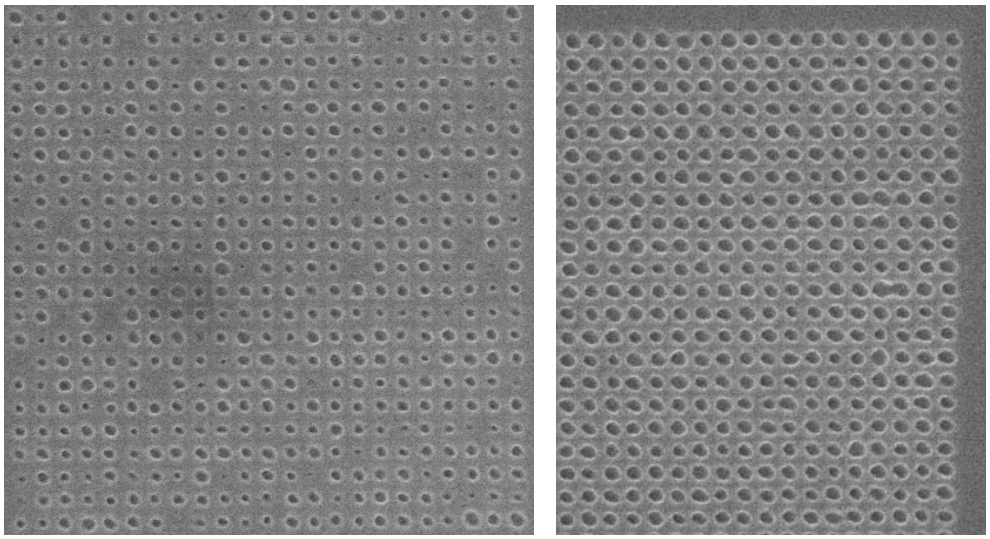

Fig. 1. Left panel: SEM image of contact-hole array (40-nm pitch) exposed by Scanning Helium Ion Beam Lithography.
Right panel: same, for a 1.5 times higher He^+ dose. Note the absence of proximity effects: the contact holes at the edge and inside the array are remarkably similar.

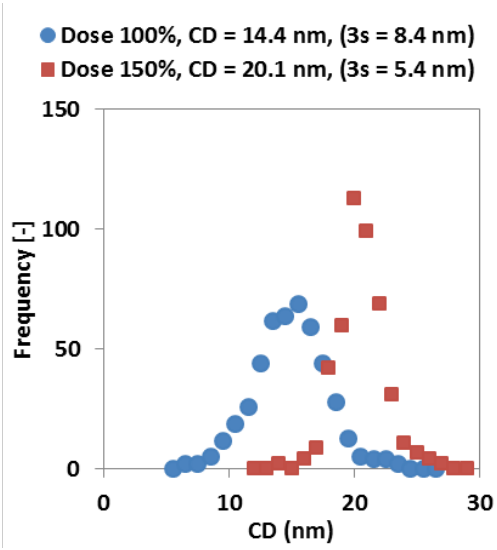

Fig. 2: Histogram of the critical dimension (CD, or diameter) of the contact holes. The variation of the CD can partly be attributed to He^+ dose fluctuations, which are significant at an estimated dose of a few He^+ ions per contact hole.