Print based estimation of probe size distribution in electron beam lithography

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Spot profile in the writing plane is important as it determines the quality of features printed in electron beam lithography. Spot size has typically been measured using a knife edge technique. In this work a new method of characterizing the probe shape is presented by analyzing features printed on resist.

The size of features printed on resist is a convolution of the beam size distribution and the energy deposition of the electron beam in resist. The second factor is typically known as the point spread function. By accurately modeling the point spread function in the sub-100 nm regime, the spot size distribution can be de-convolved from the experimental data. A technique called point exposure distribution measurements[1] is used which involves printing a series of dots at successively higher doses. The resulting plot of dot diameter vs. dose serves as a measure of the combined effect of the spot size and point spread function.

The experiment is carried out using a Vistec VB300 Gaussian beam lithography tool with a beam energy of 100 keV. The exposures are done using XR-1541-002 (HSQ) resist on a 300 mm bare silicon wafer. This enables making use of advanced processing capabilities at the College of Nanoscale Science and Engineering’s 300 mm research facility. Automated SEM metrology is used to enable precise measurements even at the smallest feature sizes. Isolated dots fabricated in this manner varied from 10 nm to 50 nm. This is shown in figure 1 which plots the dependence of diameter on the incident dose for three different beam currents.

By using high beam energy and thin resist, the effect forward scattering is negligible. The main contribution to exposure events is the secondary electrons generated by inelastic scattering between the primary electrons and those in resist. A secondary electron model described previously[2] is used here to accurately describe scattering in the sub-100 nm regime. The method uses no prior assumptions about the beam profile and can also be useful in predicting low level tails in the beam.

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[1] S. A. Rishton and D. P. Kern, J. Vac. Sci. Technol. B **5**, 135 (1987)
[2] A. Raghunathan and J. G. Hartley, J. Vac. Sci. Techol. B **31**, 011605 (2013)

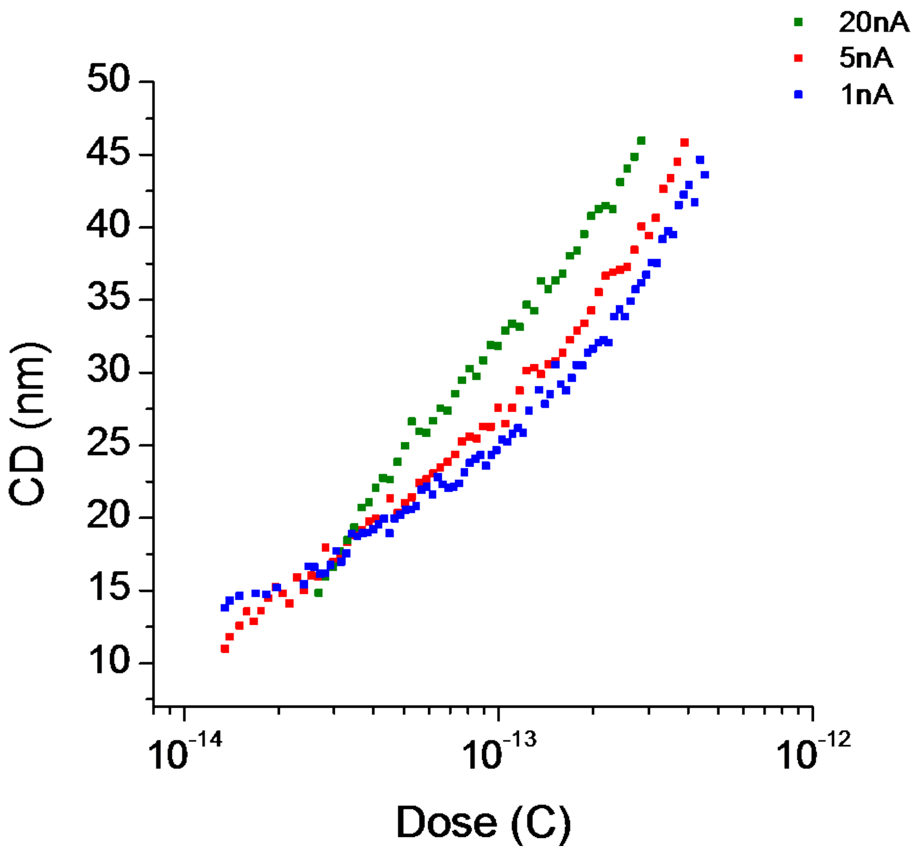

Figure 1 A plot of measured dot diameters as a function of incident dose for three different beam currents. This plot is used to de-convolve the spot size distribution