Investigation into Shot Noise Effects of Direct Write Electron Beam Lithography Using High Energy Electron Beams

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In electron beam lithography (EBL) statistical fluctuations or shot noise in the beam are believed to determine the lower limit on line edge roughness (LER) and critical dimension uniformity (CDU). These effects have been investigated before[1-3], however, there is discrepancy in the results. Since these investigations were conducted, resist thicknesses have thinned to the point where the mean free path (MFP) of high energy electrons are on the order of the resist thickness.

The purpose of this work is to assist in resist optimization for high voltage EBDW by investigating the effect of shot noise on line edge roughness (LER) and critical dimension uniformity (CDU), for electron beam lithography (EBL), when the MFP of the electron beam is greater than or equal to the thickness of the resist. To model the effect of electron beam exposure a comprehensive software model is used. KLA-Tencor has two separate software packages EDGE and PROLITH that were combined to form a comprehensive model. EDGE was developed to calculate proximity effect and dose profiles for the REBL system. PROLITH is a commercially available package that calculates resist exposure and development. A flow diagram, Fig.1, shows how the SW is used. First the pattern is generated using a commercial GDS editor DW2K. Next a rendering algorithm is used to calculate proximity effects and determine the dose profile. A Monte Carlo simulation is then used to calculate the release of acids from bound PAGs. Then PROLITH is used to handle the PEB and develop.

Experiments on a single commercial resist (JSR-1682J) were conducted to validate parameters used in the software models. The Monte Carlo simulation uses the method of Grysinski[1] to determine the MFP of electrons in resist. The accuracy of this model was verified by conducting EELS experiment on thin films of PMMA 50nm, 80nm, 150nm and 300nm thick at three different energies 80keV, 120keV and 200keV. Fig. 2 shows that there is reasonable correlation between theory and experiment.

Exposures were made on a typical commercially available EUV resist, JSR-1682J, and the values from the CD measurements were then used to extract parameters in PROLITH. Results and conclusions from experiments and simulations will be discussed.

1 P. Kruit, JVST B22(6) (2004)
2 B. Wu and A R. Neureuther, JVST B19(6) (2001)
3 G Galatin et. al.JVST B21(6) (2003)
[1] M. Gryzinski, Phys. Rev. **138**, A336 (1968)

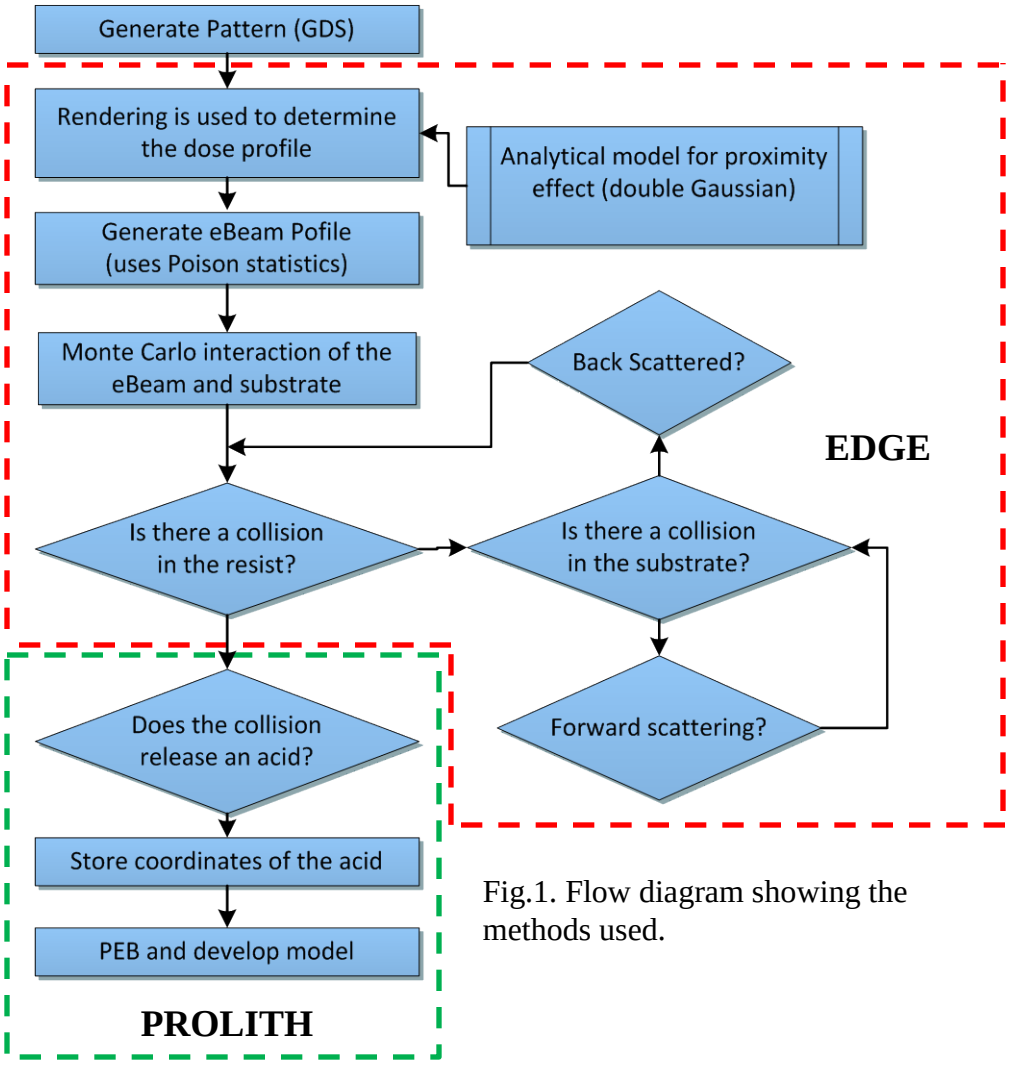

Fig.1. Flow diagram showing the methods used.

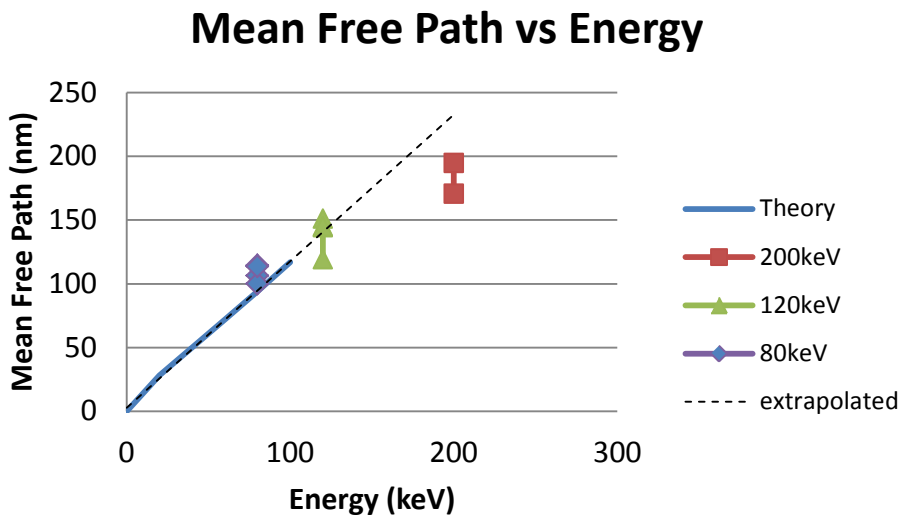

Fig.2. A comparison between theoretical and experiment measurements of the mean-free-path of electrons as a function of energy in PMMA.

This work is supported by DARPA under contract HR0011-07-9-0007. The views, opinions, and/or findings contained in this article/presentation are those of the author/presenter and should not be interpreted as representing the official views or policies, either expressed or implied, of the Defense Advanced Research Projects Agency or the Department of Defense.