

Simulation of dose variation and charging due to fogging in electron beam lithography

Sergey Babin, Sergey Borisov, Elena Patjukova

Abeam Technologies, Inc., 5286 Dunnigan Ct., Castro Valley, CA 94546; USA

Improvements in the variation of critical dimensions (CD) and placement accuracy in electron beam lithography (EBL) are of high practical importance in the nanofabrication and semiconductor industry. especially in the modern maskmaking industry where acceptable variations are on the one nanometer range over an entire mask area. Primary electrons scatter in resists and substrates; they produce backscattered and secondary electrons that reach objective lens. These electrons, in turn, produce third generation electrons from the lens; they come back to the resist and provide additional exposure and charging. This fogging effects both CD variation and placement accuracy; they can be corrected if the fogging point spread function is known in detail. In this paper, we present simulations of fogging at various conditions.

The Monte Carlo simulation tool CHARIOT was further developed in order to enable the simulation of multiple generations of fast and slow electrons from global objects over the substrate. The 3D simulation mesh was able to model electron scattering at a sub-nanometer scale to achieve the required accuracy, while still allowing the simulation area to be centimeters in area, combining two competing requirements.

The simulation results of the absorbed dose variations due to fogging are presented, as well as simulations of charges deposited on the resist. The dose variations resulted in CD variation; the CD uniformity can be corrected similarly to proximity effect corrections if the point-spread function of fogging is known. The point spread functions of fogging for multiple conditions of EBL system setups were simulated: beam voltage, working distance, and the diameter of the hole in the objective lens were varied.

While dose variation is produced mostly by relatively high speed electrons, resist charging due to fogging is produced mainly by low voltage electrons. The resist charging was simulated for a variety of EBL setups; the results are presented.

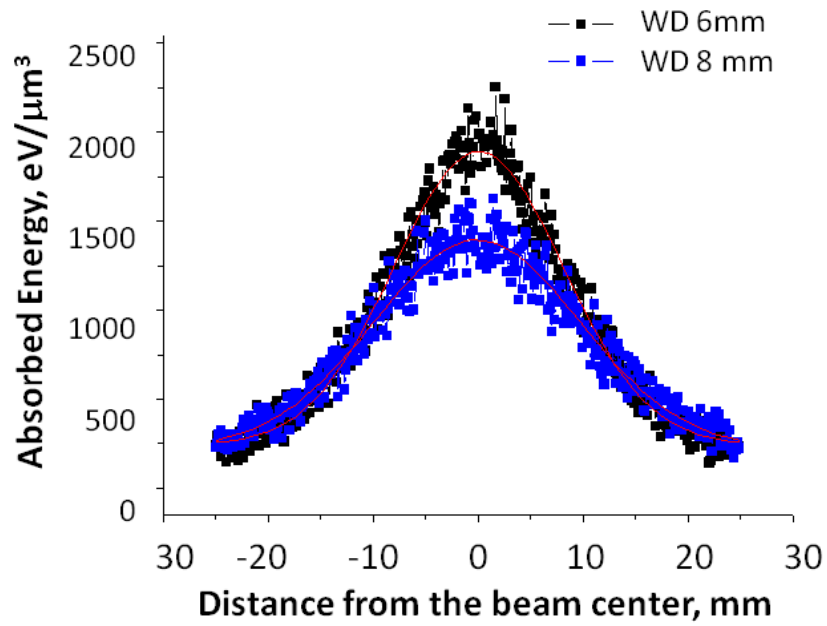


Figure 1. Point spread function of the absorbed dose due to fogging, with the dose as a function of distance from the beam center at 1 mm diameter opening in the objective lens; two values of working distance were used.

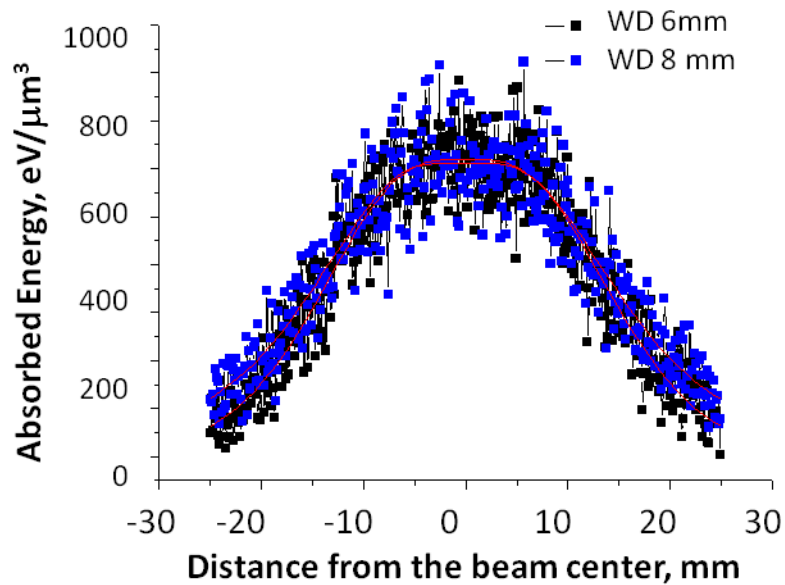


Figure 2. Point spread function of the absorbed dose due to fogging at a 6 mm diameter opening in the objective lens; taken at two values of working distance.