Simulation and Experimental Studies of Blanking Speed Limitations on Exposure Speed of Electron Beam Lithography

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Electron Beam Lithography (EBL) is one of the most important and widely used methods for nano-fabrication. The primary advantages of electron beam lithography are its high resolution, and its ability to expose nanometer scale features without a mask. One of the key limitations of electron beam lithography is throughput, exposure times are typically measured in hours per wafer and not wafers per hour. Slow blanking speed is one of the potential bottlenecks for the system speed in single pixel, probe forming systems. A blanker is used for switching the electron beam on and off in order to pattern selected area, and it utilizes electrostatic deflection to move the electron beam towards a beam stop. Because of the nature of electronics, the voltage on the electrostatic deflector can not switch on and off instantly, and the blanking voltage has a characteristic rise time, which could be in the ranges of nanoseconds to milliseconds. During this rise time, time dependent image placement errors can be introduced. In this paper, simulation results will show that the exposure time of an e-beam lithography system has to be much larger than the rise time of the blanking voltage in order to achieve high pattern fidelity. A variety of blanker configurations are examined and flash time limitations are determined as a function of driver rise time. For example, when single-deflection blanking is used, the exposure time has to be 100 or more times longer than the voltage rise time, but with a double-deflection blanker this ratio can be reduced to 5. We will also present experimental data to demonstrate this dependency. Patterns will be printed with different blanking voltage rise time to flash time ratios.

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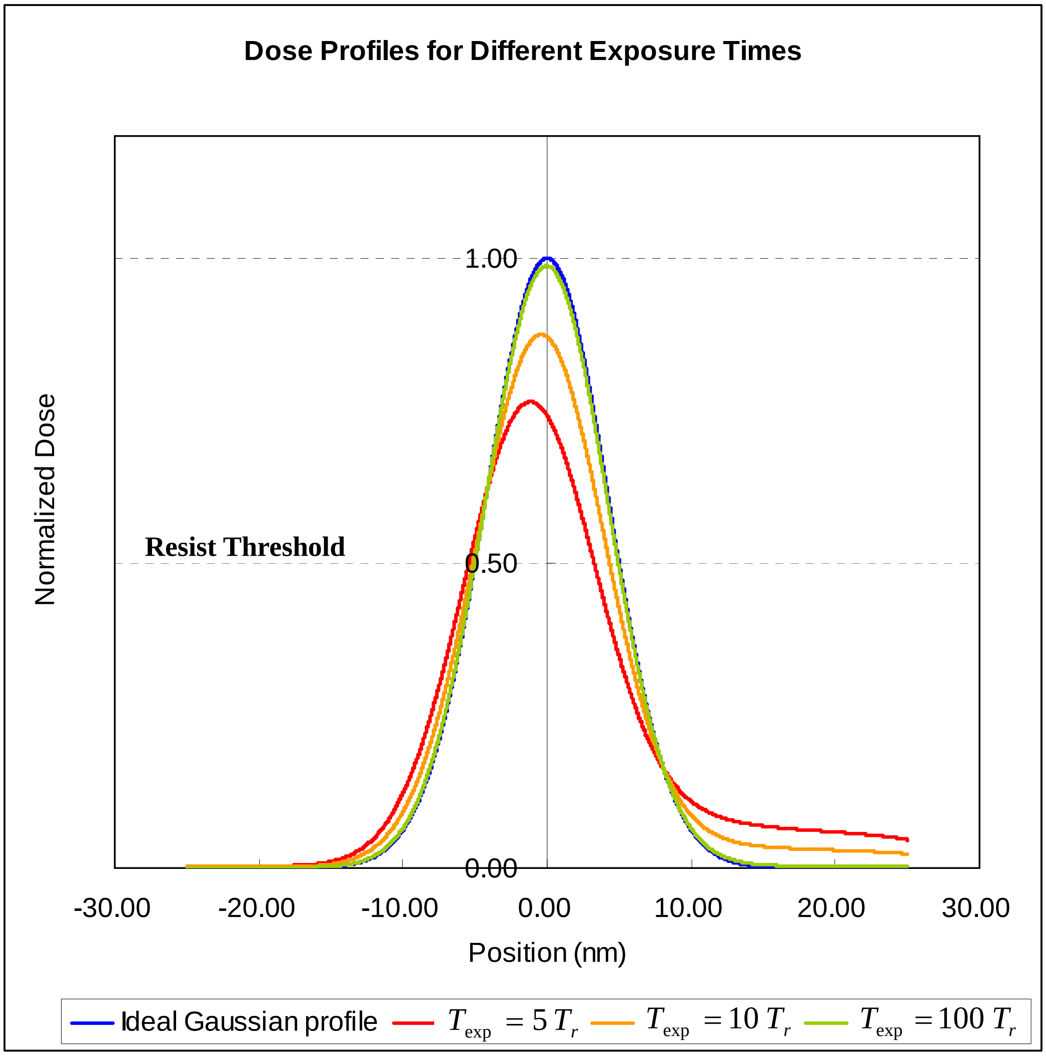

Simulated dose profiles for 1) exposure time equals to 5 times blanking voltage rise time, 2) exposure time equals to 10 times blanking voltage rise time and 3) exposure time equals to 100 times blanking voltage rise time. These dose profiles are intended to print a 10 nm pixel on the resist, and they are compared to an ideal Gaussian dose profile on this plot.

A shorter exposure time can be achieved by using a faster resist or a higher beam current, but the results here show that because of the slow blanking speed, slower exposure has to be used. Depending on the design of electronics, the blanking voltage rise time could be in the range of nanoseconds to milliseconds.