Modeling of Charge and Discharge in Scanning Electron Microscopy

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Calibration of scanning electron microscopy (SEM) for accurate measurement of critical dimensions (CD) poses a significant problem. Measured CDs depend on the specific SEM setup, such as voltage and beam size, as well as the materials and shape of the sample.[1] CD-SEM calibration can be significantly improved when measurements are complemented by accurate simulations. Charging of a sample is an additional problem involving dynamic components. The problem has been addressed; however, the complexity of models and long simulation times have resulted in a very limited application in the industry.

Physical models for charge and discharge of a sample have been developed. Charge accumulation is tracked while modeling electron scattering in a 3D sample. To do so, generation of fast and true secondary electrons, plasmon mechanisms, electron propagation between layers, and trajectories of secondary electrons in the presence of an electrical field are considered.

Discharge of a sample involves a few models: bulk conductivity, diffusion, drift in the local electrical field, and electron-beam-induced conductivity. The main focus was on speeding up the simulation. A special mesh of a 3D sample has been developed to improve both accuracy and speed of simulations.

The charging model has been implemented in CHARIOT Monte Carlo software. In CHARIOT, input data for the modeling was 3D microstructure, e-beam parameters, and the characteristics of the detector. Advanced models of electron scattering, as well as detector geometry, location, and its energy transfer function, were taken into account.

Simulations of linewidth measurement in SEM were made for low voltage measurements (see Figure 1). The beam was scanned across a line. The SEM signal from the line represents a valley and two peaks from line edges. The peaks are symmetric if no charging occurs. In the presence of charging, the edges are charged differently, depending on the direction of the scan. It was found that the right peak of the SEM signal is significantly wider and lower than the left peak. This corresponds to published experimental observations.

1. S. Babin, S. Borisov, A. Ivanchikov, I. Ruzavin, J. Vac. Sci. Technol., B6 (2006) 3122

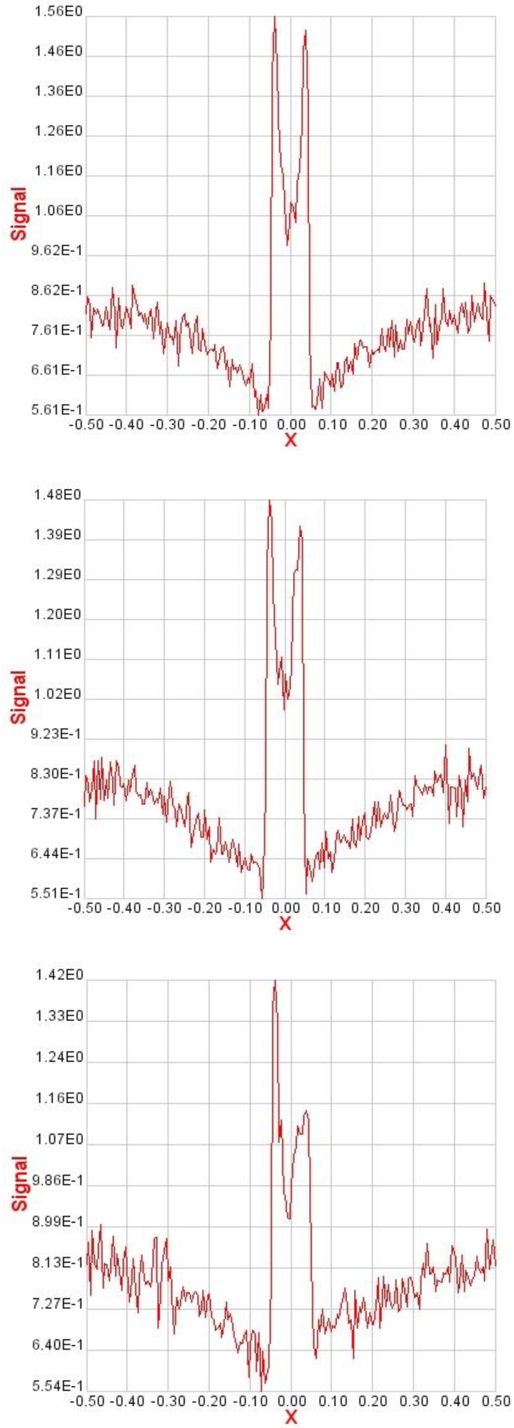

Figure 1. Simulated SEM signals across a 90 nm wide line.
Resist on silicon, 1 KeV beam, at various beam currents:
a) no charging, b) 10 pA, c) 100 pA