Simulation of CD-SEM signal at various substrate materials and detectors

S. Babin, S. Borisov, A. Ivanchikov, I. Ruzavin

Abeam Technologies
5286 Dunnigan Ct., Castro Valley, CA 94546; sb@abeamtech.com

CD-SEM is the main instrument to measure linewidth. The accuracy of this measurement is a critical problem in semiconductor manufacturing; sub-nanometer accuracy is required. However, a cross-correlation of CD-SEMs, while demonstrating a good relative trend, is often subject to a significant absolute linewidth error. There is no proven algorithm for edge detection in CD-SEMs. The signal is determined by scattering of an electron beam in a microstructure, generation of secondary electrons, and characteristics of the detector. Because of this complexity, understanding the signal formation mechanism and accurate extraction of edge position are problematic.

It was demonstrated, that the signal threshold for correct detection of the edge position depends on such parameters as beam size and wall angle of the pattern.[1] In this paper, the study was further extended: substrate materials and beam voltages were varied as well as geometry and energy transfer function of a detector.

A CD-SEM signal was simulated using advanced Monte Carlo software. Input data for the modeling was 3D microstructure, e-beam parameters, and characteristics of a detector. CHARIOT software[1] considers elastic and inelastic electron scattering, generation of fast and true secondary electrons, plasmon mechanisms, electron propagation between layers, and trajectories of secondary electrons in the presence of electrical field. Detector geometry, location, and its energy transfer function are also taken into account.

The linewidth was simulated for a variety of pattern materials and SEM setups. The target was a profiled line on silicon. Detector size and shape were varied, and its energy transfer function was also varied. In addition, an electrical field between the sample and a detector was turned on and off. SEM signals were simulated for this type of input condition and the corresponding linewidth was extracted.

A simulated signal was then compared to a known pattern. Such a comparison allowed us to define the edge position and calibrate a SEM so that any absolute error was removed. An algorithm for automatic edge detection can be tuned for CD-SEM parameters and the type of pattern.

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

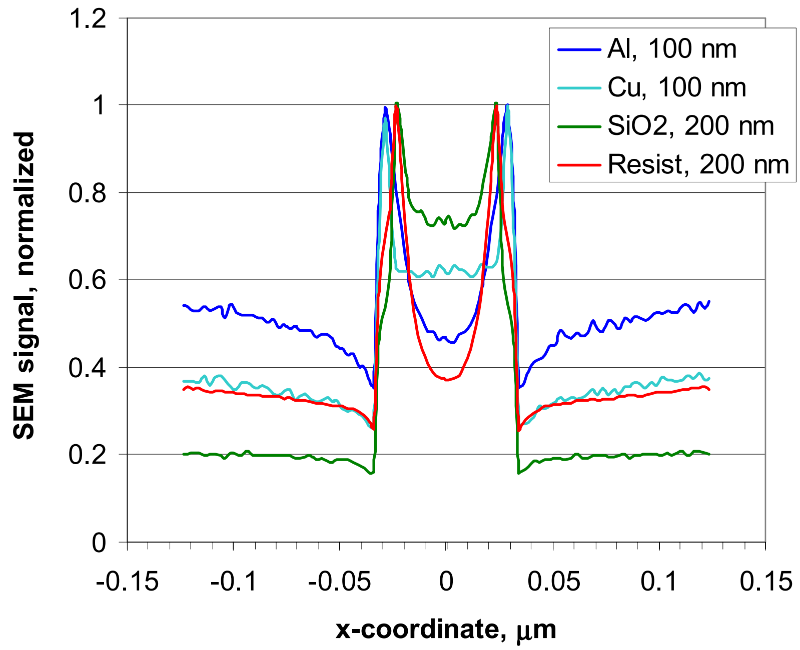

Figure 1. SEM signals of a profiled line made of various materials on silicon, 1 KeV

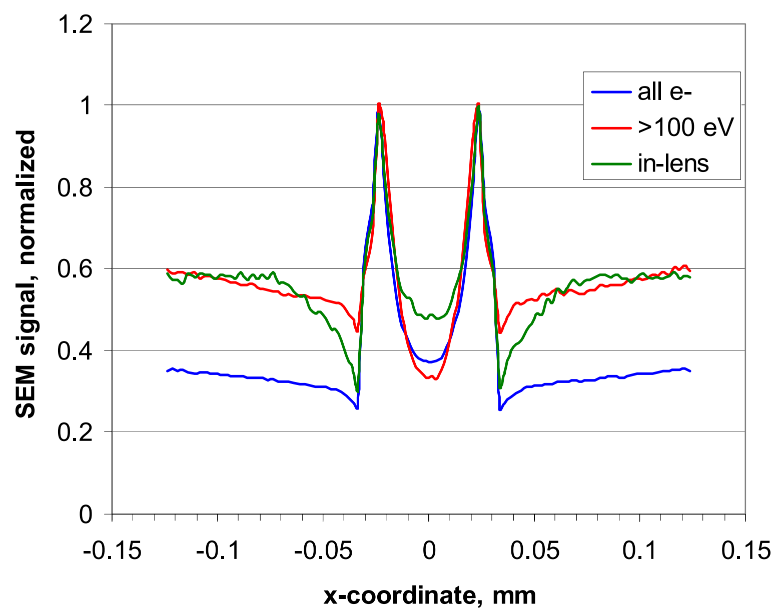

Figure 2. CD-SEM signals at various settings of detectors. Detector was capturing all outgoing electrons, only backscattered; or in-lens detector with specific geometry. Resist on silicon, 1 KeV