Simulation of SEM Images by Using Monte-Carlo Technique for Quantitative Analysis of Semiconductor Devices

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A Monte Carlo simulation code is developed for simulation of scanning electron microscope (SEM) images. The code generates three dimensional trajectories of electrons in the samples in a SEM and those of subsequently generated secondary and backscattered electrons. Based on these data the code synthesizes SEM images of the samples.

Figure 1 shows a result of simulation for samples consisting of a cube on a silicon substrate: (a) is the cross section of a sample; (b) is the variation of the backscattered electron yield with the elemental composition of the cube; (c) and (d) are the images synthesized by using the simulated data for samples with a cube made of gold (c) and aluminum (d). Comparing (c) and (d), although the two samples have the same structure, difference in elemental composition is revealed in their images.

Figure 2 shows a result of simulation for samples of planar silicon substrates with a cubic trench filled with other element: (a) is the cross section of a sample; (b) is the variation of the backscattered electron yield with the elemental composition of the cube filling the trench; (c) and (d) are the images synthesized by using the simulated data for samples with gold (c) and aluminum (d) filling the cubic trench. Comparing (c) and (d), although the two samples have the same shape, difference in elemental composition is reflected in their images. The image of the sample with an aluminum cube filling the trench, (c) seems to be almost the same as that of a pure silicon substrate. This is because the aluminum and silicon have very similar electron scattering characteristics as their atomic numbers are 13 and 14, very close. Thus alternative method is needed to analyze SEM images in this case.

The Monte Carlo simulation code can be used in the analysis of the structure and composition of semiconductor devices by comparing the synthetic images with the corresponding real SEM images.

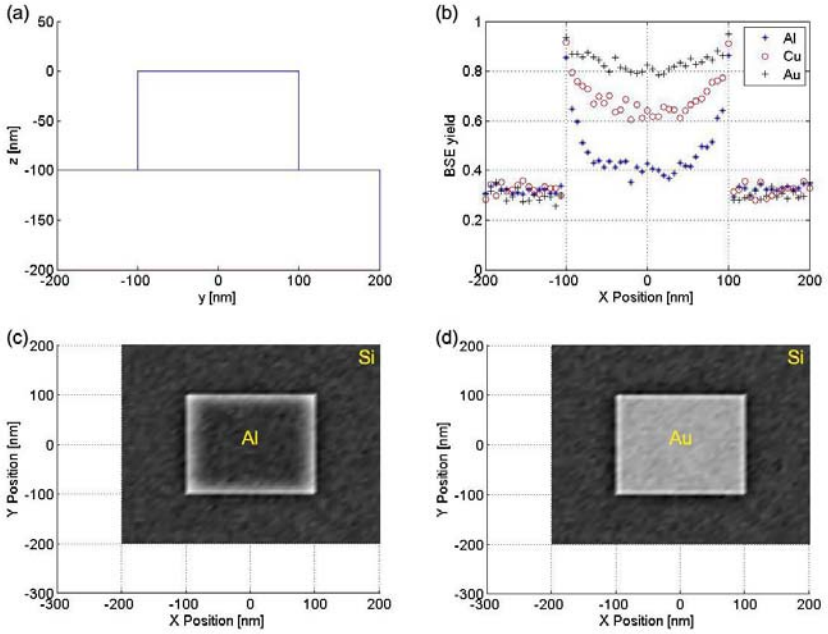

Figure 1. Simulation for a cube sitting on a Si substrate: (a) Cross section of the sample. (b) BSE yield of Al, Cu, and Au cubes. (c) Simulated image of an A1 cube on a Si substrate. (d) Simulated image of an Au cube on a Si substrate.

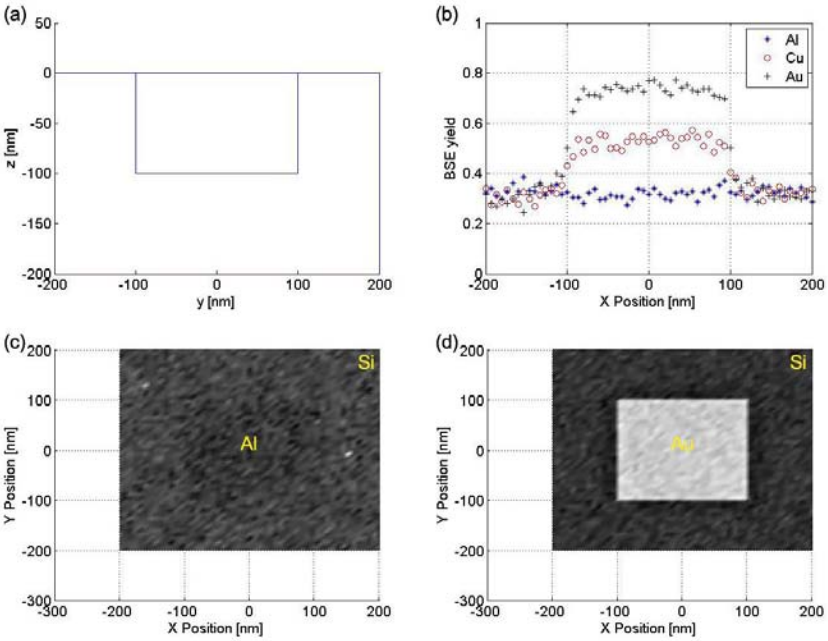

Figure 2. Simulation for a cube filling the rectangular trench in a Si substrate: (a) Cross section of the sample. (b) BSE yield of Al, Cu, and Au. (c) Simulated image of an A1 cube filling the trench. (d) Simulated image of an Au cube filling the trench.