Detection and characterization of buried structures by exploring patterns in angle- and energy- filtered back-scattered electrons

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Abstract

A scanning electron microscope can be used to image buried structures by collecting backscattered electrons but the image will be blurred[1,2]. Here we report, via Monte-Carlo simulation[3], characteristics of the energy- and angle-filtered backscattered electron population to see how much such filtering might improve the image. By studying the spectra of the angle-filtered backscattered electrons, we are able to identify different backscattered electron population patterns in light and heavy atom materials, as well as different depths, so we could identify the buried structure inside the sample. The pattern in electron loss spectroscopy is used to calculate the depth and thickness of the buried structure, or identify the possible gap in the buried structure. In a Monte Carlo simulation of both 50KeV and 100KeV electrons striking a planar sample with a buried copper layer 300nm beneath the SiO_2 surface, we identify the buried layer and achieve vertical resolution of around 22nm for depth and 15nm for thickness. Estimating lateral resolution is more difficult but preliminary indications are that this is about the same as the vertical resolution.

References

[1] D. C. Joy, *Monte Carlo Modeling for Electron Microscopy and Microanalysis* (Oxford University Press, New York, 1995)
[2] L. Reimer, *Image Formation in Low-Voltage Scanning Electron Microscopy* (The International Society for Optical Engineering Press, Washington, 1993)
[3] NISTMonte, a computer program freely available from NIST. http://www.cstl.nist.gov/div837/837.02/epq/index.html

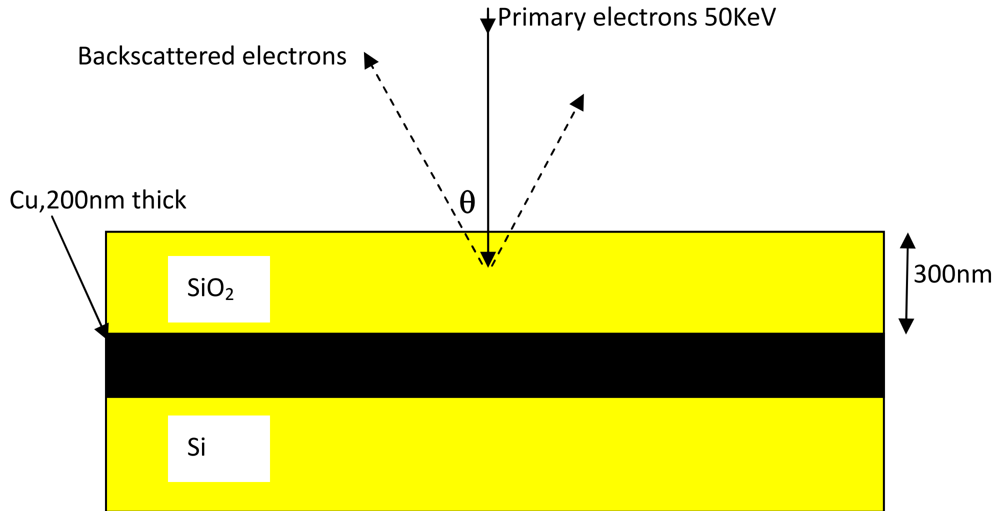

Fig. 1 Sample used for the simulations in Fig 3. For Fig 2, the sample is the almost the same except that the Cu layer is missing

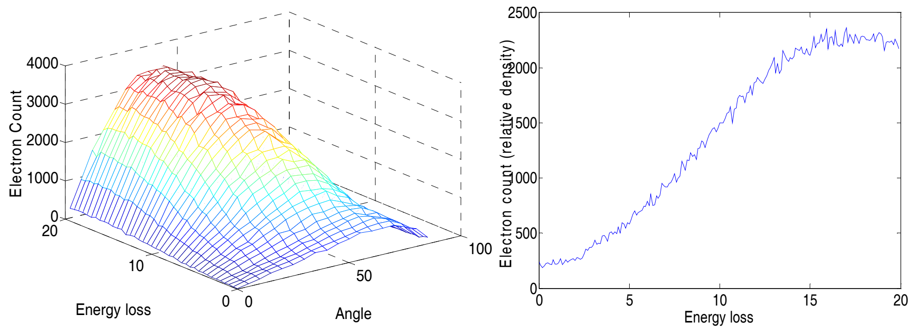

Fig. 2 Left: Backscattered electron population classified according to energy loss(in KeV) and exit angle, when no buried structure is present and the sample is made of 300nm SiO_2 layer on top of Si substrate. Right: Energy loss spectrum of electrons with exit angle below 30 degrees. The energy resolution is 100eV.

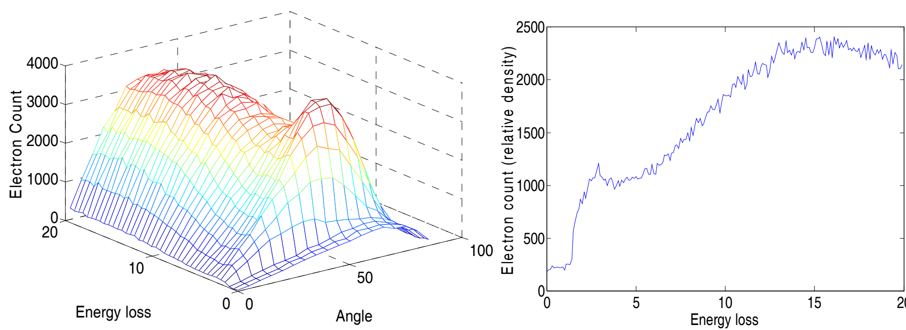

Fig. 3 Results for a sample 200nm thick copper layer buried beneath 300nm thick SiO_2. Note the significant difference in the spectra at an energy loss of 2 to 3 KeV.