Effects of Backscattered Electrons on the Analysis Area in Scanning Auger Microscopy

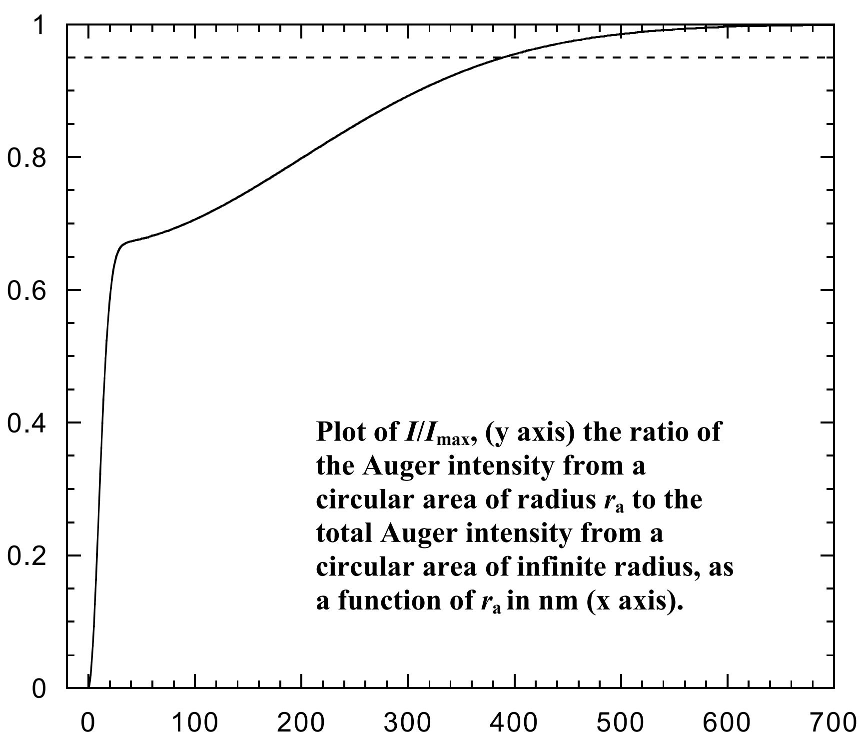
C.J. Powell (837) and A. Jablonski (Institute of Physical Chemistry, Warsaw, Poland)

The CSTL-led research team seeks to provide reference data, models, and reference procedures to enhance the accuracy and efficiency of surface analyses made by Auger-electron spectroscopy (AES) and X-ray photoelectron spectroscopy (XPS), thereby improving the traceability of chemical measurements.

Auger-electron spectroscopy (AES) is a commonly used technique of surface analysis. For example, it is used in the semiconductor industry to identify unwanted particulates and other defects on wafer surfaces that are detected after various processing steps. In this and similar applications, a focused electron beam (with a width of about 10 nm) is directed onto the feature of interest, and a measurement made of the surface composition. Analysts typically assume that the detected Auger-electron signal originates from an area defined by the width of the incident beam. The analysis area, however, is generally much larger due to the detection of Auger electrons resulting from inner-shell ionizations induced by multiply scattered primary electrons in the vicinity of the sample surface (i.e., by so-called backscattered electrons).

The research team utilized a simple analytical model to estimate the effects of backscattered electrons on the analysis area in scanning Auger microscopy (SAM). For normally incident electrons, the radius r_a of the analysis area was calculated corresponding to detection of 80%, 90%, and 95% of the total Auger-electron signal as a function of two sample parameters, the backscattering factor R and a Gaussian parameter σ_b describing the radial distribution of backscattered electrons. For a reasonable range of these parameters, r_a depended linearly on σ_b and to a lesser extent on R. Values of r_a can be appreciably larger, by up to a factor of 100, than the typical widths of the incident beam in modern SAM instruments.

As an example, the figure shows the ratio of the Auger signal within an area of radius r_a to the maximum Auger signal (for an infinite radius) for an illustrative case in which σ_b = 200 nm and R = 1.5 (typical values for a primary-beam energy of 20 keV). In this example, two-thirds of the total Auger signal originated from ionizations by the primary beam and was emitted from an area of radius 30 nm. The remaining one-third of the total signal originated from ionizations by backscattered electrons and was emitted from a much larger area, with 90% from an area of radius about 310 nm, 95% from an area of radius of about 390 nm, and 99% from an area of radius of about 530 nm. The parameter σ_b can be up to about 1 μm for some materials at a primary energy of 20 keV, and r_a can then be up to about 2 μm (for detection of 95% of the total Auger intensity).



Plot of I/I_{max}, (y axis) the ratio of the Auger intensity from a circular area of radius r_a to the total Auger intensity from a circular area of infinite radius, as a function of r_a in nm (x axis).

Monte Carlo simulations were made to investigate the radial distributions of Auger electrons from a thin copper film on substrates of silicon and gold for normally incident primary electrons with energies of 5 keV and 10 keV.

These simulations confirmed the general trends found in the first phase. Values of r_a (for detection of 95% of the total Auger intensity) ranged from 30 nm (Au substrate, primary energy of 5 keV) to 680 nm (Si substrate, primary energy of 10 keV).

A new NIST database for the Simulation of Electron Spectra for Surface Analysis (SESSA) of multilayered thin films by AES and XPS will be released in FY 2005. We plan to extend the capabilities of this database in the future to allow simulations of AES spectra for fine particles on surfaces and inclusions within samples.

Most "point" analyses by AES have been previously based on the implicit assumption that the entire detected signal originated from the feature of interest. When Auger analyses are required of fine particles on surfaces or of inclusions in matrices, it will generally be necessary to reduce the beam energy to ensure that most of the signal comes from the feature rather than from regions far from the feature. As a result, a tradeoff may have to be made between spatial resolution, analytical sensitivity, and validity of the analysis.