Abstract: Backscattering spectrometry*

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Backscattering spectrometry is the microanalysis of the surface and near-surface regions of materials utilizing energetic (typically 1–2 MeV) He and H ions as the analytical probe. [1–4] The ions in the collimated beam provided by a particle accelerator penetrate into the target and are scattered at various depths. Analysis of the energy spectrum of the particles backscattered from the target provides information in three areas: identification of atomic mass of the target constituents, the target composition, and depth profiles. Mass identification is provided by the kinematics of the energy transfer between the projectiles and target atom in the collision process. For MeV He ions, the mass resolution is ± 1 atomic mass unit (amu) up to about mass 40, and deteriorates to about ± 10 amu for the heaviest elements. Quantitative analysis of the number of target atoms per cm^2 is provided by the scattering cross section which connects the measured yield of backscattered particles to target composition. In compositional analysis, backscattering only provides atomic ratios, for information on the chemical nature of the material, x-ray diffraction or other tools with chemical sensitivity must be used. Backscattering techniques are most useful to examine heavy elements in a light-element matrix as the sensitivity is rather poor for light elements unless proton resonance techniques are used.

Depth information is provided by the energy loss of the projectiles on their inward and outward paths through the sample. The energy loss of the projectiles per unit path length depends on the energy of the particle as well as on the projectile and target. Compilations [5] and reviews of stopping cross sections are available. For MeV ^{4}He ions, the depth resolution is about 200–300 Å for depths up to 0.5 μ. At greater depths, energy straggling causes a degradation in depth resolution.

Surveys of the applications of backscattering spectrometry are provided in Ref. 1–4. The technique has been used to analyze ion-implanted samples, thin-deposited films, metal–metal thin film interdiffusion, metal film–bulk silicon reactions, solubility of impurities in bulk samples, oxidation processes and other phenomena occurring in the near-surface region of materials.

A typical beam spot is 1 mm^2 in area, but for convenient handling, samples should preferably have a size of 1/2–1 cm^2. The uniformity of the sample over the area of the beam spot is critical. Since backscattering analysis has no laterial resolution, the samples have to be checked with scanning electron microscopes or with optical microscpoes to verify this assumption.

The primary strength of backscattering analysis is the ability to provide quantitative information on atomic composition ratios and on absolute thicknesses of films in the range of several thousand Angstroms without resorting to standards. Routine accuracies for this information are of the order of $\pm 5\%$.

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