

7.4: SIMS - Imaging and Depth Profiling

The basic ideas behind the SIMS technique have already been discussed in the Section on [Secondary Ion Mass Spectrometry](#). Since the technique utilizes a beam of atomic ions (i.e. charged particles) as the probe, it is a relatively easy matter to focus the incident beam and then to scan it across the surface to give an imaging technique.

Surface Imaging using SIMS

If the aim of the measurement is to obtain compositional images of the surface formed from the secondary ion spectrum with minimum possible damage to the surface, then the main problem is to ensure that sufficient signal is obtained at the desired spatial resolution whilst minimizing the ion flux incident on any part of the surface.

This is most easily achieved by switching from the traditional instrumental approach of using continuous-flux ion guns and quadrupole mass spectrometer detectors, to using pulsed ion sources and time-of-flight (TOF) mass spectrometers. The TOF mass spectrometers are a much more efficient way of acquiring spectral data, and also provide good resolution and sensitivity up to very high masses. Using such instruments, SIMS images with a spatial resolution of better than 50 nm are obtainable.

SIMS Depth Profiling

The aim of depth profiling is to obtain information on the variation of composition with depth below the initial surface - such information is obviously particularly useful for the analysis of layered structures such as those produced in the semiconductor industry.

Since the SIMS technique itself relies upon the removal of atoms from the surface, it is by its very nature a destructive technique, but also, ideally suited for depth profiling applications. Thus a depth profile of a sample may be obtained simply by recording sequential SIMS spectra as the surface is gradually eroded away by the incident ion beam probe. A plot of the intensity of a given mass signal as a function of time, is a direct reflection of the variation of its abundance/concentration with depth below the surface.

One of the main advantages that SIMS offers over other depth profiling techniques (e.g. Auger depth profiling) is its sensitivity to very low (sub-ppm, or ppb) concentrations of elements - again this is particularly important in the semiconductor industry where dopants are often present at very low concentrations.

The *depth resolution* achievable (e.g. the ability to discriminate between atoms in adjacent thin layers) is dependent upon a number of factors which include:

1. the uniformity of etching by the incident ion beam
2. the absolute depth below the original surface to which etching has already been carried out
3. the nature of the ion beam utilized (i.e. the mass & energy of the ions)

as well as effects related to the physics of the sputtering process itself (e.g. ion-impact induced burial).

With TOF-SIMS instruments the best depth resolution is obtained using two separate beams; one beam is used to progressively etch a crater in the surface of the sample under study, whilst short-pulses of a second beam are used to analyze the floor of the crater. This has the advantage that one can be confident that the analysis is exclusively from the floor of the etch crater and not affected by sputtering from the crater-walls.

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