7.2: Electron Microscopy - SEM and SAM

The two forms of electron microscopy which are commonly used to provide surface information are

Secondary Electron Microscopy (SEM)
- which provides a direct image of the topographical nature of the surface from all the emitted secondary electrons

Scanning Auger Microscopy (SAM)
- which provides compositional maps of a surface by forming an image from the Auger electrons emitted by a particular element.

Both techniques employ focusing of the probe beam (a beam of high energy electrons, typically 10 - 50 keV in energy) to obtain spatial localisation.

A. Secondary Electron Microscopy (SEM)

As the primary electron beam is scanned across the surface, electrons of a wide range of energies will be emitted from the surface in the region where the beam is incident. These electrons will include backscattered primary electrons and Auger electrons, but the vast majority will be *secondary electrons* formed in multiple inelastic scattering processes (these are the electrons that contribute to the background and are completely ignored in Auger spectroscopy). The secondary electron current reaching the detector is recorded and the microscope image consists of a "plot" of this current, I, against probe position on the surface. The contrast in the micrograph arises from several mechanisms, but first and foremost from variations in the surface topography. Consequently, the secondary electron micrograph is virtually a direct image of the real surface structure.

The attainable resolution of the technique is limited by the minimum spot size that can be obtained with the incident electron beam, and ultimately by the scattering of this beam as it interacts with the substrate. With modern instruments, a resolution of better than 5 nm is achievable. This is more than adequate for imaging semiconductor device structures, for example, but insufficient to enable many supported metal catalysts to be studied in any detail.

B. Scanning Auger Microscopy (SAM)

The incident primary electrons cause ionization of atoms within the region illuminated by the focused beam. Subsequent relaxation of the ionized atoms leads to the emission of Auger electrons characteristic of the elements present in this part of the sample surface (see the description of Auger spectroscopy in Section 5.2 for more details).

As with SEM, the attainable resolution is again ultimately limited by the incident beam characteristics. More significantly, however, the resolution is also limited by the need to acquire sufficient Auger signal to form a respectable image within a reasonable time period, and for this reason the instrumental resolution achievable is rarely better than about 15-20 nm.

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