

Scanning Electron Microscopy

In general, a scanning electron microscope (SEM) can make images of solid samples and can determine the elemental composition of said samples. The low end of the magnification range for an SEM is typically on the order of 20X to 50X. The maximum magnification is generally determined by the size of the electron beam and can be as high as one million (10^6). These magnification levels generally correspond to measuring features from the mm scale down to nm size. The best resolution of a high end SEM is on the order of 0.5 nm.

The most common type of SEM data is the secondary electron image. The SE image is a map of secondary electron emission as a function of spatial position. SE images generally display the topography of the sample. The number of secondary electrons emitted from a surface generally depends on the angle of incidence between the surface and the beam. Since the electron beam is perpendicular to the sample over the analysis area, the number of secondary electrons emitted from the sample is generally a function of the topography of the sample.

Backscattered electrons (BSE) are the second most common imaging data collected with an SEM. This data is a map of backscattered electron emission as a function of spatial position. The number of BSEs that are emitted is a function of the atomic number of the sample. As the atomic number increases, so does the number of BSEs emitted. This means that images made with BSEs will generally show the composition of the sample. While it is not generally possible to observe a BSE image and know what materials are present, with some a priori knowledge of the sample's composition, it is usually possible to make a good guess about the material distribution from a high quality BSE image. It is possible to combine BSE images with EDS to determine both the material composition and distribution in the sample.

Since images are in the form of the electron emission from a sample vs. spatial position, it is not possible to determine the roughness of a sample from a plane view image of the sample as the electron emission from the sample may not depend on the height. Even if the electron emission does depend on the height, as in a secondary electron image, measuring a height from the electron emission is not generally possible. Roughness can only be determined from a cross-section of the sample.

In addition to collecting imaging data to show the morphology of a sample, SEMs also generate and can collect X-rays that are characteristic of the elements in the sample. This is usually done with an energy dispersive X-ray spectrometer or EDS system. EDS X-ray data can be used to determine the elements in the sample. If the X-ray data is mapped as a function of spatial position, an X-ray map showing the distribution of the elements in the sample can be created. The detection limit for EDS is generally on the order of 0.5% by weight within the X-ray generation volume.