



PRACTICAL TRAINING WORKSHOP FOR SEM, EDS AND RELATED SAMPLE PREPARATION EQUIPMENT AND INSTRUMENTS: OPERATION AND APPLICATION TECHNIQUES

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• Scanning Electron Microscope (SEM)

SEM stands for scanning electron microscope. The SEM is a microscope that uses electrons instead of light to form an image. Since their development in the early 1950's, scanning electron microscopes have developed new areas of study in the medical and physical science communities. The SEM has allowed researchers to examine a much bigger variety of specimens. The scanning electron microscope has many advantages over traditional microscopes. The SEM has a large depth of field, which allows more of a specimen to be in focus at one time. The SEM also has much higher resolution, so closely spaced specimens can be magnified at much higher levels. Because the SEM uses electromagnets rather than lenses, the researcher has much more control in the degree of magnification. All of these advantages, as well as the actual strikingly clear images, make the scanning electron microscope one of the most useful instruments in research today.

• Topography

The surface features of an object or "how it looks", its texture; detectable features limited to a few manometers

• Morphology

The shape, size and arrangement of the particles making up the object that are lying on the surface of the sample or have been exposed by grinding or chemical etching; detectable features limited to a few manometers

• Composition

The elements and compounds the sample is composed of and their relative ratios, in areas ~ 1 micrometer in diameter

- **Crystallographic Information**

The arrangement of atoms in the specimen and their degree of order; only useful on single-crystal particles >20 micrometers

- **SCANNING ELECTRON MICROSCOPY (SEM) AND ELEMENTAL X-RAY MICROANALYSIS IN SEM BY ENERGY DISPERSIVE SPECTROSCOPY (EDS)**

In scanning electron microscopy, (SEM) an electron beam is scanned across a sample's surface. When the electrons strike the sample, a variety of signals are generated, and it is the detection of specific signals which produces an image or a sample's elemental composition. The three signals which provide the greatest amount of information in SEM are the secondary electrons, backscattered electrons, and X-rays.

Secondary electrons are emitted from the atoms occupying the top surface and produce a readily interpretable image of the surface. The contrast in the image is determined by the sample morphology. A high resolution image can be obtained because of the small diameter of the primary electron beam.

Backscattered electrons are primary beam electrons which are 'reflected' from atoms in the solid. The contrast in the image produced is determined by the atomic number of the elements in the sample. The image will therefore show the distribution of different chemical phases in the sample. Because these electrons are emitted from a depth in the sample, the resolution in the image is not as good as for secondary electrons.

Interaction of the primary beam with atoms in the sample causes shell transitions which result in the emission of an X-ray. The emitted X-ray has an energy characteristic of the parent element. Detection and measurement of the energy permits elemental analysis (Energy Dispersive X-ray Spectroscopy or EDS). EDS can provide rapid qualitative, or with adequate standards, quantitative analysis of elemental composition with a sampling depth of 1-2 microns. X-rays may also be used to form color maps or line profiles, showing the elemental distribution in a sample surface.