surface. The same scan generator is used for scanning the observation screen. Image magnification is given by the ratio of screen width with the length of a scan line on the sample.

Imaging system: The interaction of the primary electrons (beam) and the atoms of the sample surface yields secondary electrons, backscattered electrons, as well as characteristic X-ray photons. All these signals can be used for imaging.

- The secondary electrons, emitted by ionization of the atoms of the specimen, produce topographic contrast, that is, the information on the geometric structure of the specimen. As these electrons are detected from a very thin surface layer (a few nanometers), they give a very good spatial resolution: superior to 5 nm in the best cases and, in general, 10 to 15 nm. Topographic contrast is the usual imaging method for lyophilized materials.
- The backscattered electrons, primary electrons "bouncing" on the specimen surface, yield information on the atomic number of the atoms encountered, thus giving a basic chemical contrast if the specimen is not coated with too thick a layer of gold (see "specimen preparation"). Backscattered electrons are less sensitive to the electric charging of the specimen and may give better images than secondary electrons on poor conductors.
- X-ray photons, emitted by the ionized atoms, carry accurate information on their chemical nature. The photons are detected by an energy dispersive X-ray spectrometer (EDX). Qualitative and quantitative information is obtained by processing the spectroscopic data. The picture made with intensity of the photons of the specific energy corresponding to an emission ray of an element is a map of the repartition of that element on the sample surface. This method is a more accurate and precise way to localize the element than backscattered electron imaging.
- Other signals, such as absorbed current, induced electromotive force, and cathodoluminescence, are not suitable for the study of lyophilized materials.

Modern SEMs (Fig. 2) are fully computerized with digital imaging and image processing capacities. Typically, the magnification range is from 1× to 50,000×. The field-emission gun scanning electron microscopes (FE-SEMs) can magnify up to 500,000× in good conditions. Microscopists prefer to mention the resolution, that is, the size of the smallest detail that can be seen, instead of the magnification. For classical SEM, it is 10 nm. The field depth is very high, producing sharp images even on very rough specimens (Fig. 3).

The analytical SEMs are fitted with EDX equipment for total (morphochemical) material characterization, both morphological and chemical. It should be kept in mind that EDX spectrometry gives information on the nature of the atoms of the specimen from Be to Pu, but not on the chemical bonds. Therefore, it is not suitable for the characterization of organic material.

Specimen Preparation

Specimen preparation is the most important phase of the electron microscope study of any material. It is senseless to own expensive observational equipment if the sample has been modified during preparation.

As the SEM works under vacuum, imperative for the propagation of electrons, only dry specimens can be observed (except in environmental or