SIX-AXIS SEM STAGE

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The primary function of an SEM specimen stage is to optimize the orientation of the specimen to the signal detectors. The ease and precision with which the stage executes this function determine its utility to the microscopist. While the majority of scanning electron microscopes are equipped with general purpose five-axis specimen stages, a six-axis stage can significantly enhance specimen orientation. Specimen manipulation can be further simplified by incorporation of a six-axis hand controller that enables the microscopist to move the specimen intuitively as if the specimen were held directly in the hand.

SEM manufacturers typically install general purpose five-axis specimen stages in their scanning electron microscopes. In addition to translation along the X and Y axes, these stages are capable of tilt (T), elevation (Z motion), and rotation (R). Tilt directs the specimen surface toward the secondary electron detector to optimize signal collection. Elevation adjusts the working distance while rotation orients specific image features within the picture frame.

While this set of movements has been adequate for most imaging tasks, the microscopist often encounters limitations that can only be resolved by special fixturing to optimize geometric conditions.

The limitations of the general purpose five-axis system originate from the fact that it has only two rotational degrees of freedom. This limitation can be corrected by the addition of a sixth axis (BANK). Bank is defined as the rotation about an axis perpendicular to the tilt axis. This additional degree of freedom gives the microscopist complete control over orientation of a specimen surface.

One implementation of a six-axis stage consists of a three-axis goniometer head mounted on a three-axis Cartesian platform. The stage

To create a stereo pair image, one needs to make two micrographs. In the second image, the specimen has been tilted 4 to 10 degrees relative to the first. Several texts and articles provide procedures for creating stereo pairs. Producing stereo pairs with a 5 axis stage can be tedious and non-intuitive. The tilt axis of the stage does not usually coincide with the vertical parallax axis. In addition, the apparent direction of specimen illumination in the finished stereo pair is from the side rather than from the top.

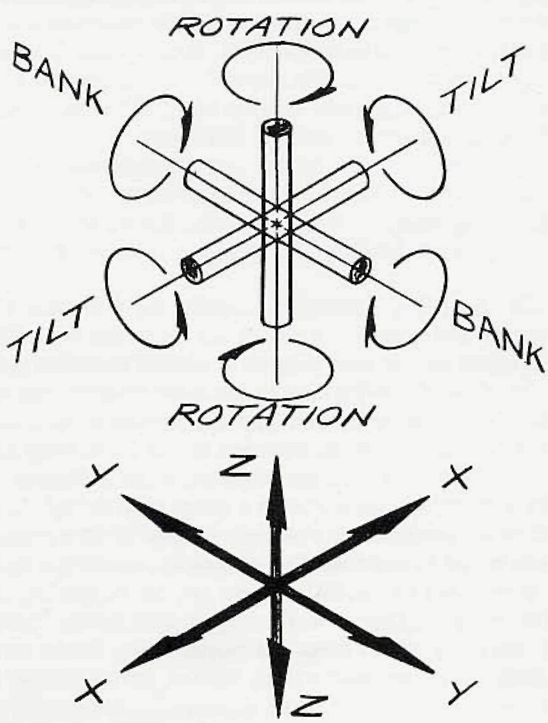
The six-axis stage simplifies the production of the two views because adjustment of the bank angle allows creation of parallax about the vertical axis. The procedure becomes intuitive. This is the ideal situation because the apparent top illumination is achieved in the stereo pair as perceived by the observer.

Fractography: When examining fractures or any surface exhibiting a great deal of irregularity, the microscopist needs a method of rapidly determining the three-dimensional nature of the specimen. A common problem is determining if an observed feature is extended or depressed. Simultaneously tilting and banking the specimen is an intuitive manipulation that helps the microscopist answer this question.

Topography (Backscattered Electron Contrast): Backscattered electron contrast enhances the topographic features of a specimen. When the Everhart-Thornley detector is used in backscattered mode, the contrast resembles directional illumination. Orientation of the specimen with both tilt and bank facilitates arbitrary placement of shadowing.

Electron Channeling Contrast: The microscopist can exploit the electron channeling phenomenon to determine the orientation of crystalline materials. In this technique, the backscatter coefficient for incident electrons abruptly disappears for very specific angles between the incident beam and the orientation of the material's periodic structure. Using backscattered electron contrast, the microscopist observes a pattern of dark lines called pseudo-Kikuchi patterns. By adjusting tilt and bank, the microscopist can determine the orientation of the material under investigation.

In the above examples, we have shown that a six-axis stage can hance the microscopist's ability to orient the specimen for maximum llection of information. A six-axis stage performs these tasks because a nimum of six degrees of freedom is required to completely specify the echanical state of an extended body. As scanning electron microscopes h multiple detectors become more common, we expect to see these croscopes equipped with six-axis stages. ■



Six-Axis Stage Translations

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