Non-destructive characterization of crystalline defects in bulk specimens

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Electron microscopy is a widely used technique for analyzing the micro- and nano-structures of crystalline materials. Two main types of electron microscopes provide complementary insights: Transmission Electron Microscopy (TEM) at the micro/nano-scale and Scanning Electron Microscopy (SEM) at the macro/mesoscopic scale.

TEM is well-established for characterizing crystalline defects at sub-micron and nanoscales in electron-transparent thin foils (approximately 100 nm thick). These detailed investigations provide crucial information for understanding the material's macroscopic behavior.

However, the characterization of crystalline defects is not limited to thin foil samples observed by TEM. SEM can also offer diffraction contrast in bulk materials through electron channeling. This phenomenon occurs when electrons travel along crystal planes, allowing deeper penetration before scattering. The varying BackScattering of Electrons from different crystal orientations generates orientation contrast, enabling the imaging of crystalline defects (see Figure 1).

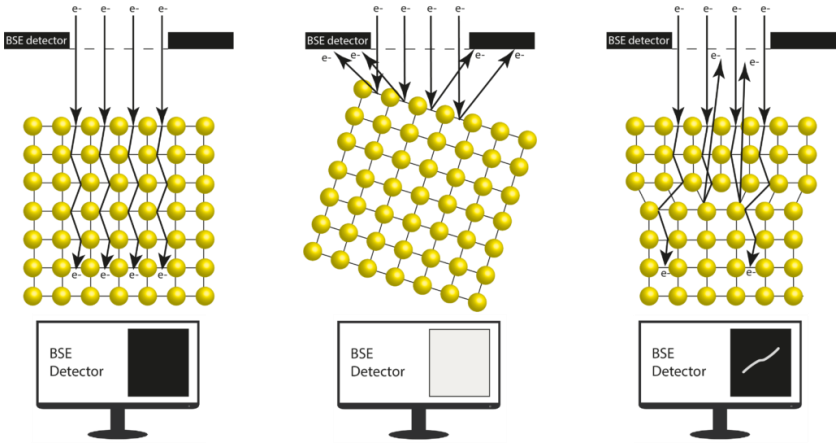

Figure 1: Explanation of the electron channeling and observation of crystalline defects.

Electron Channeling Contrast Imaging (ECCI) is a non-destructive technique that provides diffraction contrast imaging of sub-surface defects (up to around 100 nm deep) on centimeter-sized bulk specimens within an SEM. This technique exploits the significant variation in Backscattered Electrons (BSE) yield depending on the crystal's orientation relative to the incident electron beam, or the optic axis of the SEM.

Leveraging these capabilities, ECCI has emerged as a powerful tool for exploring new frontiers in both fundamental and industrial research. This presentation will provide an overview of the technique, covering its underlying physics and diverse applications in these fields.