Modern X-ray Scattering Methods for Nanoscale Materials Analysis

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Abstract

Since its discovery by von Laue in 1912, X-ray diffraction has become an indispensable tool for structure determinations in the physical and biological sciences. X-rays are characterized by high energies and by wavelengths that are commensurate with nanometer-sized structures – unlike optical probes, whose wavelengths are several orders of magnitude larger. Additionally, X-rays couple only weakly with matter, and the refractive indices of X-rays differ only slightly from unity. The interactions of X-rays with solids thus follow the "Goldilocks principle" (not too strong, not too weak, but just right) and are well suited for the analysis of nanostructured and thin film materials. This talk will focus on key applications of a variety of X-ray analytical methods in nanotechnology research and development. In advanced semiconductor device fabrication, for instance, parameters such as thickness, density, and interfacial roughness are critical to the performance of ultra-thin polycrystalline films and are routinely measured by X-ray reflectometry, while strain and composition in advanced single crystal structures rely on high resolution double- and triple-axis diffraction methods. Other X-ray techniques (such as texture analysis, grazing incidence diffraction, small-angle scattering, and diffuse scattering) have important application to nanomaterials characterization and will be discussed. The overarching goal of this talk will be to illustrate the wide applicability of X-ray methods in current nanoscale materials research.