Revealing 3D Microstructures using X-ray Scattering Tomography

Jonathan Almer[1)], John Okasinski[1)], Peter Kenesei[1)], Jun-Sang Park[1)] and Stuart Stock[2)]
[1)] X-ray Science Division, Argonne National Lab, IL, USA
[2)] Fienberg School of Medicine, Northwestern University, Chicago, IL USA

High-energy (E>40 keV) x-rays from 3rd generation synchrotron sources, including the Advanced Photon Source (APS), possess a unique combination of high penetration power and spatial, reciprocal space, and temporal resolution. In addition to benefitting absorption-based imaging, these characteristics have enabled development of diffraction/scattering-based 3D imaging techniques including high-energy diffraction microscopy (HEDM or 3DXRD) and scattering tomography. These approaches are complementary, as HEDM provides diffraction information (strain, orientation, shape and size) of individual grains in polycrystalline aggregates while x-ray scattering tomography yields spatially-resolved but grain-averaged information, relevant for fine-grained polycrystalline materials below HEDM limits and for amorphous materials.
This talk will focus on the scattering tomography technique and two of its implementations at the APS using high-energy x-rays. The first uses monochromatic x-rays and 2D area detectors, while the second uses polychromatic x-rays and an energy-resolving linear detector. We will discuss key instrumentation, measurement and analysis protocols, and illustrate the power of the technique through examples of biological systems studies. Finally, prospects for these techniques after the planned APS upgrade to a diffraction-limited source will be presented.