

Advances in 3D Laue Microscopy: Instrumentation, Data Analysis, and Applications

Understanding the evolution of micro- and nanoscale structural features such as dislocations, grain boundaries, twins, and local strain is critical for understanding the behavior and performance of advanced materials. Three-dimensional Laue microdiffraction uniquely enables non-destructive microscopy of crystallographic orientation and strain in bulk materials with sub-micrometer resolution. At the Laue microdiffraction instrument (34-ID-E) of the Upgraded Advanced Photon Source [1], an integrated framework combining advances in instrumentation, data acquisition, and analysis has been developed for efficient 3D characterization of complex microstructures.

The implementation of coded-aperture Laue microscopy [2] enables rapid depth-resolved measurements by encoding diffraction signals along the beam path, significantly reducing acquisition time while maintaining reconstruction fidelity and opening new opportunities for in-situ and operando studies of evolving microstructures. To address increasingly complex datasets, LaueMatching [3], a high-throughput indexing approach based on direct correlation with simulated diffraction libraries, was developed to enable robust analysis of multi-grain patterns. In parallel, the Laue Portal is being developed, a web-based platform for submitting reconstruction and indexing jobs for Laue datasets, integrating high-performance computing with user-friendly workflows.

The talk will present recent advances in instrumentation and data analysis for 3D Laue microscopy at 34-ID-E and highlight applications of X-ray Laue microdiffraction to a range of materials questions, including structural and nuclear materials, batteries, and microelectronics. These examples demonstrate how spatially resolved measurements of crystal orientation, strain, and microstructure can provide insight into materials behavior across diverse scientific and technological applications.

[1] Wenjun Liu, P. Zschack, J. Tischler, G. Ice, and B. Larson. "X-ray Laue Diffraction Microscopy in 3D at the Advanced Photon Source." AIP Conference Proceedings 1365, no. 1 (2011): 108–111.

[2] Doğa Gürsoy, Dina Sheyfer, Michael Wojcik, Wenjun Liu, and Jonathan Z. Tischler. "Depth-resolved Laue microdiffraction with coded apertures." Journal of Applied Crystallography 55, no. 5 (2022): 1104–1110.

[3] Hemant Sharma, Dina Sheyfer, Ross Harder, and Jonathan Z. Tischler. "LaueMatching: an approach for rapid and robust indexing of Laue diffraction patterns." Journal of Applied Crystallography 59, no. 2 (2026).