High-energy X-ray Studies of Nuclear-Relevant Materials

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High-energy x-rays from 3rd generation synchrotron sources, including the APS, possess a unique combination of high penetration power with high spatial, reciprocal space, and temporal resolution. These characteristics can be exploited to non-destructively measure phase, texture and strain distributions under extreme environments including thermo-mechanical loading, high-pressure, irradiation and supercritical environments. Over the past several years, the 1-ID beamline has developed a number of programs for these purposes, namely (i) high-energy diffraction microscopy (HEDM), in which grain and sub-grain volumes are mapped in polycrystalline aggregates, and (ii) combined small-and wide-angle x-ray scattering (SAXS/WAXS) which permits information over a broad range of length scales to be collected from the same (micron-level) volume. These programs have been increasingly used to test and extend predictive simulations of materials behavior over size scales ranging from nm to mm.

Current opportunities, as well as limitations, associated with use of these techniques to study advanced materials associated with advanced nuclear energy systems will be discussed. The talk will include recent work on microstructural and strain evolution in ferritic-martensitic steels and Zr-based alloys under in-situ thermo-mechanical deformation. Extension of these studies to investigate post-irradiated samples, as well as possibilities for in-situ irradiation at the APS, will also be discussed.