**Nanomechanical Testing of Irradiated Materials**

**Abstract:** The objective of this talk is to demonstrate the potential for transmission electron microscopic (TEM) in situ mechanical tests for coupled qualitative and quantitative assessment of mechanical performance of irradiated materials.

Conventional mechanical testing in accordance with ASTM standards typically requires large specimen volumes having homogeneous properties and microstructures throughout that volume in order to obtain meaningful quantitative results. But these test geometries are unfeasible for volume-limited materials such as shallow ion irradiated layers or hazardous specimens that are difficult to handle in large quantities, such as radioactive materials. On the other hand, in situ TEM nanomechanical testing utilizes specimens with sub-micron-sized dimensions and the entire tested volume can be located within a shallow near-surface layer. Hence, in situ TEM nanomechanical testing may offer a transformative method to evaluate the mechanical properties of irradiated and nuclear materials. In situ TEM mechanical testing also offers the distinct advantage of enabling concurrent TEM-resolution imaging/video with quantitative mechanical testing, enabling one to directly link fundamental plastic phenomena to mechanical performance.

We demonstrate in situ TEM mechanical testing on ion irradiated Fe-9Cr oxide dispersion strengthened (ODS) alloy or Cu-10Ta. We investigate four test geometries: micropillar compression, indentation, cantilever, and 4-point bend tests. Compression tests are found to be subject to a size effect if pillars have a minimum dimension <100 nm, owing to the high stress needed to nucleate dislocations that can subsequently induce plastic deformation. But above this size threshold, TEM in situ compression tests accurately measure yield stress values for both the irradiated and unirradiated specimens. Elastic modulus values can also be analyzed to fall in agreement with expected values. Indentation tests enable one to discern relative strengths of microstructural barriers to dislocation plasticity. Cantilever tests can meaningfully measure flow stress. Finally, 4-point bend geometries enable us to estimate fracture toughness.

**Biography:** Dr. Janelle Wharry is an assistant professor in the School of Nuclear Engineering at Purdue University, and also holds a courtesy appointment in the School of Materials Engineering. Dr. Wharry is an expert on microstructure, characterization, and nano- and micro-mechanics of irradiated metals and alloys. She has pioneered the use of transmission electron microscopy in situ quantitative mechanical testing for irradiated alloys. In addition, Dr. Wharry received the Department of Energy contract to code-qualify structural alloys produced by powder metallurgy and hot isostatic pressing for irradiation-facing components in nuclear power plants. She has mentored 9 graduate and more than 30 undergraduate researchers, and she has published more than 40 peer-reviewed journal articles and conference papers. Dr. Wharry is an affiliate faculty of the Center for Advanced Energy Studies in Idaho Falls, Idaho. She received her Ph.D. from the University of Michigan in 2012.

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