# Serial Sectioning Equipment for 3-D Characterization of Microstructure and Composition Effects on Mechanical Behavior of Enhanced Uranium Oxide Fuels

**PI**: Pedro Peralta, Arizona State University

**Collaborators**: N/A

**Program**: General Scientific Infrastructure

**ABSTRACT:**

This project seeks to take advantage of expertise available at ASU on characterization of oxide fuel surrogates containing depleted Uranium Oxide (d-UO2) by expanding existing capabilities for 3-D microstructure characterization via serial sectioning with mechanical polishing to use ion beam polishing over large areas, so that imaging, compositional and crystallographic measurements can be made over volumes with a statistically significant number of grains, but with high enough resolution, particularly in the sectioning direction, to capture fine details related to porosity and second phase inclusions, as well as triple junction and grain boundary geometry in both pure UO2 as a main component of typical fuels and "enhanced" UO2 fuels, which are doped with small amounts of other oxides in an effort to increase their mechanical properties.

This will make it possible to formulate models that account for variability on the behavior of these fuels based on true 3-D microstructural and composition heterogeneity and provide insight on microstructural and composition effects on thermo-mechanical properties of nuclear fuels. The use of serial sectioning techniques over large areas based on ion-beam polishing is key to achieving these high fidelity models and map interactions among microstructure, composition, deformation and failure modes in nuclear fuels. This requires upgrades to facilities at ASU. In particular, a current constraint is that serial sectioning via mechanical polishing, which can be performed over large areas, is limited, in practice, to a resolution of about 1 μm, which leads to very coarse microstructure reconstructions given the typical grain sizes in UO2 (5-10 μm), and it is too small to resolve porosity and second phases in enhanced UO2, which can be 0.5-2 μm in diameter. Focused Ion Beam (FIB), on the other hand, can provide submicron resolution, but is limited to volumes that do not have enough grains to perform a statistically meaningful analysis. Data collection will require the use of existing Energy Dispersive Spectroscopy (EDS) and Electron Backscattering Diffraction (EBSD) equipment to map composition as well as microstructure, which were obtained through a previous NEUP infrastructure grant.

Funds are requested to purchase an ion polishing system that can provide submicron resolution over much larger areas than those possible using FIB systems, but with comparable depth resolutions. Samples will be ion-polished, and transferred to the electron microscope for characterization using existing EBSD/EDS detectors. Maps of microstructure and composition in 3-D for d-UO2 with and without minor additions of other oxides will be generated via serial sectioning, both before and after heat treatments to grow grains, as well as hardness and creep testing, so that effects of dopants on microstructure, microstructure evolution and mechanical properties can be evaluated.