NUCLEAR ENERGY UNIVERSITY PROGRAMS

Fuel Performance Experiments and Modeling: Fission Gas Bubble Nucleation and Growth in Alloy Nuclear Fuels

PI: McDeavitt, Sean - Texas A&M University

Collaborators:
Kennedy, J. Rory - Idaho National Laboratory
Shao, Lin - Texas A&M University
Tsvetkov, Pavel - Texas A&M University
Wirth, Brian D. - University of California, Berkeley

Project Number: 09-357

Initiative/Campaign: AFCI/Fuels

Abstract

This project will establish ion beam methods to provide insight and validation for the fundamental models that will enable multi-scale fuel performance predictions from first principles. The project is focused on fission gas bubble nucleation and swelling in uranium-zirconium alloys containing transuranics (TRUs). Researchers will develop fundamental models for diffusion and fission gas mobility in the various phases present in U-TRU-Zr nuclear fuels, enabling the modeling of other critical fuel performance phenomena such as creep, component redistribution, and fuel-cladding mechanical or chemical interactions. This project has the following three objectives:

- Develop and customize in situ ion beam analysis tools to observe and characterize the nucleation and growth of gas bubbles in advanced U-TRU-Zr alloy fuel materials.
- Quantify and model the fundamental phenomena relevant to fission gas-induced swelling in advanced U-TRU-Zr alloy fuel materials.
- Validate and benchmark the new multi-scale fuel swelling models through critical experiments performed using new in situ ion beam methods and post-test analysis.

Many factors influence fission gas-induced swelling, including the accumulation of fission gas atoms into clusters and bubbles. Production of fission products, precipitates, and fuel restructuring strongly affect gas diffusion and bubble formation. Actual fuel materials are exposed to a great number of synergistic variables that complicate measurements and observations to quantify fission gas phenomena. By removing many of these variables, researchers expect to isolate and explicitly evaluate the underlying phenomena due to irradiation and gas intrusion into the crystal structure. The modeling activities in this project seek to quantify and connect the macroscopic and atomistic driving forces behind gas nucleation and growth.