NUCLEAR ENERGY RESEARCH INITIATIVE

Fundamental Studies of Irradiation-Induced Defect Formation and Fission Product Dynamics in Oxide Fuels

PI: James Stubbins, University of Illinois

Collaborators: Los Alamos National Laboratory

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Program Area: AFC R&D

Project Description

This project will address performance issues of oxide-type nuclear fuels in the proposed fast-spectrum Advanced Burner Test Reactor (ABTR). Studying radiation effects and fission product transport processes in oxide-type nuclear fuels will establish a fundamental understanding of fuel performance. Researchers will model irradiation effects in CeO_{2+x}, UO_{2+x}, and $(CeU)O_{2+x}$ surrogate fuels, comparing their performance with mixed oxide (MOX) fuels. The irradiation effects will be induced by ion implantation over a range of energies and doses to simulate the effects of fission product damage. Transport and trapping of simulated fission products will also be examined. Researchers will use inert gas ions (e.g., Kr and Xe) both for ion implantation experiments to cause irradiation damage, and for dynamic transport studies to understand trapping and defect mobility processes in these fuel forms. They will also examine ions that simulate fission products and can substitute for U or Ce atoms in the oxide structure.

The experimental studies will be complimented by modeling using molecular dynamics (MD) simulations of damage cascades in the oxide lattice and kinetic Monte-Carlo (KMC) to study defect dynamics. The MD approach is useful in understanding the early stages of damage during energetic displacement cascades under irradiation. KMC is useful for using the defect configuration energies from MD to examine defect and fission product transport mechanisms.

Workscope

This project will perform the following principal tasks:

1. Assess Damage in Pure CeO_2, UO_2
    - Perform irradiations of He, Kr, Xe, Mo
    - Conduct PAS, TEM, and other analyses
    - Develop MD and KMC simulation models
2. Assess Damage in Complex Oxides
    - Perform irradiations of He, Kr, Xe, Mo
    - Conduct PAS, TEM, and other analyses
    - Develop MD and KMC simulation models
3. Develop Transport Properties
    - Annealing studies
    - Conduct PAS, TEM, and other analyses
    - Develop KMC model