NUCLEAR ENERGY RESEARCH INITIATIVE

The Effect of Hydrogen and Helium on Irradiation Performance of Iron and Ferritic Alloys

PI: Dr. James Stubbins, University of Illinois at Urbana-Champaign

Project Number: 05-116

Collaborators: None

Related Program: Gen IV

Project Description

The goals of this research project are to develop a fundamental understanding of irradiation-induced defects on ferritic alloys, to understand the roles of hydrogen and helium in damage evolution, to extend this knowledge to increasingly complex iron alloy materials that are of interest for use in advanced reactor and accelerator-based applications, and to develop more irradiation-resistant alloys. Researchers will accomplish these goals through a combination of experiments and modeling.

Ferritic alloys are the prime choice for structural and component applications in several advanced reactor and accelerator-based system concepts. This class of alloy has relatively high irradiation resistance and retains good structural properties in temperatures ranging from 400 to 700 °C. However, as the existing irradiation performance data was developed for the fast breeder program, the database represents fast fission neutron spectra. This research project will address irradiation damage and effects in advanced reactor and accelerator-driven systems concepts. The project will encompass substantial new developments in experimental analysis and high-speed computational modeling of the formation and evolution of defects in ferritic metals and alloys during radiation exposure. This work will also focus on the influence and possible synergistic effects of hydrogen and helium during defect production, clustering, and extended damage structures during irradiation. The experimental program will examines the evolution of point defects and defect structures as a function of radiation exposure, irradiation temperature, and H/He production in increasingly complex materials, ranging from the simplest single crystal iron, to polycrystalline iron and iron alloys, through advanced ferritic/martensitic steels.

Work Scope

- Perform microstructural and microchemical analyses for a set of irradiation exposure conditions. Materials include single crystal iron and increasingly complex binary, ternary, and commercial alloy systems, using ion irradiation to accurately control hydrogen and helium levels and irradiation dose.
- Perform large-scale molecular dynamics and kinetic lattice Monte Carlo simulations to understand the effects of irradiation on material properties and damage processes.