U.S. DEPARTMENT OF ENERGY
NUCLEAR ENERGY RESEARCH INITIATIVE
ABSTRACT

PI: **Gary S. Was** **Proposal No.: 99-0101**

Institution: **University of Michigan**

Collaborators: **Pacific Northwest National Laboratory, Oak Ridge National Laboratory**

Title: **A Novel Approach to Materials Development for Advanced Reactor Systems**

The degradation of reactor core components by radiation is a major impediment to the advancement of nuclear technology in the world. Advanced reactor systems will be even more demanding in terms of efficiency and performance and the these demands will translate to more hostile environments for materials. The decay of test reactor capability in the U.S. and the long lead times for irradiation programs has increased pressure to develop more efficient tools and capabilities for studying radiation damage in materials. We propose the use of proton irradiation as primary tool to assess radiation damage and lead the development of new materials for advanced reactor systems. The short irradiation times, high doses and minimal residual radioactivity make this tool ideal for material assessment and development. In this proposal, we apply proton irradiation to the determination of the mechanism of irradiation assisted stress corrosion cracking (IASCC) and to radiation damage in Zircaloy and pressure vessel steels.

IASCC is a widespread, generic to water reactor core components that is due to irradiation-induced changes in the alloys. The main obstacle to solving the problem is understanding whether cracking is controlled by changes to the microstructure (dislocation loop density and size) or the microchemistry (radiation-induced segregation - RIS) as both develop together and are inseparable under LWR irradiation conditions. The first objective of this proposal is to separate microstructure effects from microchemistry effects and to determine their relative roles in causing IASCC susceptibility of 304 stainless steels. This will be accomplished by isolating each feature and evaluating its effect on IASCC susceptibility. RIS will be isolated by creating radiation damage under nominal irradiation conditions, and then selectively annealing out the dislocation microstructure while causing little change to grain boundary RIS profiles. The radiation-damaged microstructure will be isolated either by irradiating at low temperature (to suppress RIS), implanting with He, and then annealing to grow a stable dislocation loop structure in the absence of RIS, or by irradiating a sample with grain boundaries pre-enriched with Cr, thus removing the preenrichment and creating the requisite damage structure. Subsequent SCC tests in oxidizing and non-oxidizing conditions will identify the relative roles of microstructure and RIS in IASCC. High resolution microscopy will be used to assess changes to the grain boundary structure that may play a role in IASCC.

The second objective extends the applicability of proton irradiation to the study of radiation effects in Zircaloys and reactor pressure vessel steels, both essential components in advanced reactor designs as well. These objectives address the primary NERI goal of supporting innovative research that can address the principal technical and scientific obstacles to future use of nuclear power in the U.S., and strengthening the nuclear science and engineering infrastructure in the U.S.
