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

PI: **Todd Allen** **Proposal No.: 99-0155**

Institution: **Argonne National Laboratory**

Collaborators: **University of Michigan**

Title: **Developing Improved Rx Structural Mterials Using Proton Irradiation a Rapid Analysis Tool**

The objective of this work is to design improved reactor structural materials toward preparation for advanced reactor systems. The work will provide fundamental new knowledge that will improve both environmental cracking resistance and void swelling resistance in reactor structural materials. The tools used to provide this new knowledge will be grain boundary engineering and bulk composition engineering. Radiations will be performed using proton irradiation, which will allow the testing of a large number of materials improvements in a relatively short period of time. This project will also provide fundamental information about radiation damage and lead to improvements in the ability to model radiation effects in structural components. Based on the results of these experiments, a plan will be developed for validating material improvements by using test reactor irradiations.

Two methods will be used to improve environmental cracking resistance and void swelling resistance of reactor components: grain boundary engineering and compositional modification. Grain boundary engineering describes methods used to manufacture desired grain boundary structure and composition. Thermomechanical treatments combined with solute additions will be used to develop crack resistant grain boundaries. Composition modifications will be used to improve swelling resistance without compromising strength. Solute additions that decrease the rate of void nucleation and growth will decrease the swelling for a given irradiation dose. This project will identify a well chosen set of solute additions that create alloys that are *both* swelling resistant and resistant to environmental cracking.

Proton irradiation will be used as a rapid analysis tool to test material improvements. With proton irradiation, we will be able to conduct many irradiations over a wide range of parameters at modest cost in an effort to provide a better fundamental understanding of grain boundary properties and compositional effects.

This project directly supports the NERI program goals of: overcoming the principal technical and scientific obstacles to expanded future use of nuclear energy in the U.S.; and improving the performance, efficiency, reliability, economics, and other attributes to enhance nuclear energy applications. The development of reactor structural materials with long lifetimes and minimal component replacement and repair costs is fundamental to the success of future reactor designs. Structural materials that are more radiation resistant improve the efficiency and reliability of nuclear

power generation plants, making the plants more economically competitive. Improved structural materials need to retain adequate strength, ductility, and swelling resistance during radiation while exhibiting a resistance to environmental cracking. This work will provide fundamental new knowledge on the behavior of structural materials that is required for advanced reactor design.