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

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Title: **Random Grain Boundary Network Connectivity as a Predictive Tool for Intergranular Stress-Corrosion Cracking**

Intergranular stress corrosion cracking (IGSCC) is one of the most pervasive degradation modes in current light water reactor systems and is likely to be a limiting factor in advanced systems as well. In structural materials, IGSCC arising from the combined action of a tensile stress, a "susceptible" material, and an "aggressive" environment has been recognized for many years and the mechanisms widely investigated. Recent work has demonstrated that by sequential thermomechanical processing, properties, such as corrosion, IGSCC, and creep of materials can be dramatically improved. The improvements have been correlated with the fraction of so-called "special" grain boundaries in the microstructure. A mutli-institutional team comprising of researchers from Lawrence Livermore National Laboratory (LLNL), University of Michigan (UM), and General Electric Corporate Research & Development (GECRD) propose an alternative explanation for these observations: that the effect of grain boundary engineering is to break the connectivity of the random grain boundary network through the introduction of low energy, degradation resistant twins and twin variants. We propose to carry out a collaborative science and technology research project aimed at verifying the mechanism by which sequential thermomechanical processing ameliorates IGSCC of alloys relevant to nuclear reactor applications and prescribing processing parameters that can be used in the manufacture of IGSCC resistant structures.

In this work, we will develop methods to quantify the interconnectivity of the random grain boundary network, measure the interconnectivity of a series of materials where the interconnectivity has been systematically altered. We then perform property measurements on the materials and compare their performance ranking with the boundary network measurements, and characterize the materials to correlate actual crack paths with the measurements of the random grain boundary network.

With this data, we will then evaluate and improve the methods that have been chosen to describe the random grain boundary network. We will test the characterization method by evaluating the interconnectivity of the random grain boundary network in a series of as-received materials, rank their expected performance, and compare the results with property measurements.

The major accomplishments of this project are expected to be (1) the determination that the random boundary network connectivity (RBNC) is a major driver of IGSCC in low to medium stacking fault energy austenitic alloys, (2) the development of a predictive tool for ranking IGSCC performance of these alloys, and (3) the establishment of thermomechanical processing parameters to be applied in the manufacture of IGSCC resistant materials. The outcome of the project will be identification of a mitigation strategy for IGSCC in current LWR conditions that can then enable the development of economically and operationally competitive water-cooled advanced reactor systems.