NEUP Nuclear Energy University Program
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Project Title

Fundamental understanding of grain boundary cracking in LWR environments

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Program: NE-5

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ABSTRACT: The objective of this proposal is to understand the details and the mechanisms of stress corrosion cracking (SCC) and irradiation-assisted stress corrosion cracking (IASCC) by targeted experiments guided and interpreted by modeling efforts. We aim to produce a comprehensive mechanism-based model that predicts the conditions under which these failure modes occur and when the materials may see the onset of failure modes. Our proposal will advance our understanding of SCC/IASCC such that nuclear operators can anticipate the crack initiation phase and reduce the error margin in the crack propagation phase. This work will directly impact the nuclear industry by refining predictive models of component lifetime.

The focus of the work to be performed within this proposal is centered around the interplay between irradiation, temperature, alloy composition, and service conditions. Advanced experimental techniques with nanoscale resolution including transmission electron microscopy (TEM), scanning electron microscopy (SEM), and electron backscattering microscopy (EBSD) will be deployed in conjunction to approach the problem from a variety of angles. The resulting insights will be used to inform an original model for plastic flow localization in polycrystalline microstructures that is coupled to a kinetic solute-and-ion transport model that is sensitive to local stress variations. The modeling will furnish spatially-resolved distributions of stress accumulation which will offer unambiguous indicators of IASCC susceptibility. The model predictions will be validated by a focused campaign involving experimental characterizations of strained irradiated specimens and EBSD (electron backscatter diffraction) maps to analyze stress accumulations in relation to microstructure alterations and compositional banding (solute segregation). The validated IASCC susceptibility metrics will be offered for implementation in the NEAMS ToolKit modules such as Diablo and/or BISON. All team members have direct access to all the required facilities in their respective institutions to fulfill the stated scope of work.