Correlative Atom Probe and Electron Microscopy Study of Radiation Induced Segregation at Low and High Angle Grain Boundaries in Steels

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Program: Nuclear Science User Facilities (NEET-NSUF-2)

ABSTRACT:

The objective of this work is to identify the defect sink characteristics of different grain boundary types by using radiation induced segregation (RIS) as a tracer mechanism for point defect capture and annihilation at sink sites within grain boundary planes. This can only be accomplished using systematic, correlative microscopy techniques that can probe the chemical features of an irradiated alloy on the atomic scale. This can be completed by combining two key microscopy techniques: (1) scanning transmission electron microscopy coupled (STEM) with ultra-high efficiency x-ray dispersive spectroscopy (EDS) using a holder capable of 360° rotation and using (2) atom probe tomography (APT) where care is taken in the run parameters to limit aberrations during data collection. This work will leverage the facilities already available through the NSUF to complete and combine these two advanced microscopy techniques to produce an atomic scale three dimensional (3D) reconstruction of the RIS processes in irradiated steels. Full 3D representation of RIS will enable a more robust understanding of defect, defect-sink phenomena and provide viable data for more accurate modeling efforts. These modeling efforts built on experimentally verified databases can then be used in alloy development efforts to make more radiation tolerant materials for current and future nuclear reactor designs. This has programmatic relevance to several DOE-NE programs including LWRS and FCRD-AFC.