Positron Annihilation Studies of Neutron-Irradiated Ferritic Alloys

PI: James Stubbins, University of Illinois

Program: Nuclear Science User Facilities Access Only (NSUF-2)

Collaborators:
Maria Okuniewski, Purdue University
Ayman Hawari, North Carolina State

Abstract:

The objective of this research program is to understand the evolution of sub-nanoscale to nanoscale defect clusters in neutron irradiated Fe-Cr alloys. These clusters are too small to resolve using other experimental microstructural analysis techniques such as high resolution transmission electron microscopy (TEM and HRTEM) or atom probe tomography (APT). Positron Annihilation Spectroscopy (PAS) provides a mechanism for probing these very small defect structures produced during irradiation. This technique is important since it is able to measure defects with dimensions smaller than those that can be imaged using even the highest resolution TEM techniques. In fact, these very small defect structures can account for a very large fraction of the total displaced atom defect structures. In many cases where only TEM is used, it is impossible to gain a clear picture of the sub-5nm diameter clusters. This can leave a large fraction of the total atomic displacements unaccounted for. This has an impact on void nucleation calculations, that is "how many of these invisible defect structures grow to become visible voids and how many are lost or migrate to various sinks?" Thus PAS can provide an important link to the modeling of damage evolution. In addition to the role in damage structure evolution, the invisible defects, when they exist, can have an important impact on dislocation movement and overall deformation behavior. This is critical to help develop a basis for understanding the void nucleation and void incubation processes, about which very little is presently known. This understanding is particularly important for FeCr ferritic/martensitic alloys where some of the best performing alloys resist void formation for several hundred dpa. The reasons for this irradiation damage resistance in this class of alloys are still not clear and will be the major focus of this study.