PEAK SWELLING TEMPERATURE IN ION IRRADIATED HIGH-PURITY Fe AND Fe-Cr ALLOYS

Yan-Ru Lin[1], Arunodaya Bhattacharya[2], Jean Henry[3] and Steven J. Zinkle[1,2*]
[1]*University of Tennessee, Knoxville, TN 37996, USA*
[2]*Oak Ridge National Laboratory, Oak Ridge, TN 37831 USA*
[3]*CEA, DEN-Service de Recherches Métallurgiques Appliquées, Laboratoire d'Analyse Microstructurale des Matériaux, Université Paris-Saclay, F-91191, Gif-sur-Yvette, France*

A strong interest is building toward reduced activation ferritic and ferritic/martensitic (FM) steels for the proposed Generation IV advanced fission reactors and proposed fusion reactors due to their attractive mechanical properties and volumetric swelling resistance. Experimental studies of irradiated Fe–Cr alloys have reported void swelling suppression by the addition of Cr to the Fe matrix. Furthermore, the addition of Cr can prevent corrosion and accidental breaking of clad in fission environment. Some studies have reported a much narrower range of temperatures for observable void swelling in ion irradiated samples (which may be partially affected by implanted ion and/or near-by surface effects). Furthermore, significant discrepancies have been reported regarding the peak swelling temperatures and temperature range of void-swelling under ion versus neutron irradiation conditions. In this context, we have performed multi-temperature (400, 435, 470, 500, 550°C) simultaneous dual beam ion irradiations (using 8 MeV Ni^{3+} ions and energy-degraded 3.5 MeV He^{2+} ions) on a series of ultra-high purity bcc Fe and Fe-Cr alloys with Cr content ranging from 3-14%. A heavy ion energy of 8 MeV (2.5 μm range) was selected to provide a relatively wide mid-range region (~0.5-1.5 μm) for quantitative analysis that is not affected by near-surface or implanted ion effects. Mid-range (1.0 μm) irradiation conditions were 35 dpa, 0.1 appm He/dpa, 1.4×10^{-3} dpa/s. Using state-of-art transmission electron microscopy (TEM) and scanning TEM (STEM) the cavity size and density were quantified as a function of depth. Comparing with published neutron irradiated results we reveal the peak swelling temperatures in Fe/FeCr alloys under ion irradiations with emphasis on the extent of the swelling temperature regime in neutron vs ion irradiations. In addition, temperature-dependent void denuded zone widths near grain boundaries of the irradiated Fe and Fe-Cr alloys at 400-550°C will also be discussed.

This research was sponsored by the Office of Fusion Energy Sciences, U.S. Department of Energy under contract DE-AC05-00OR22725 with UT-Battelle, LLC and grant # DE-SC0006661 with the University of Tennessee. The ultra-high purity Fe and Fe-Cr samples were supplied by the EUROfusion consortium.

* *ylin52@vols.utk.edu*