DE LA RECHERCHE À L'INDUSTRIE

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Séminaires

SRMP

Mercredi 25 juin 2014 à 10h30

Salle de réunion du SRMP – Bâtiment 520 - Pièce 109

Microstructure-Mechanical Property Relationships in Advanced Materials for Nuclear Energy Systems

Janelle P. Wharry
Boise State University, Boise, Idaho, USA

The objective of this talk is to present ongoing research at Boise State University on the microstructure-mechanical property relationship for materials for nuclear energy systems. The primary research thrust aims to improve the understanding of irradiation hardening mechanisms, by linking defect sink strength with measured hardness. In this research, a direct proportionality is found between sink strength and Orowan hardening. This suggests an analogous relationship between nucleation and growth of defect sinks under irradiation, and the interaction of those sinks with dislocations.

This theory was confirmed with experimental observation of an irradiated Fe-9Cr oxide dispersion strengthened (ODS) ferritic/martensitic (F/M) alloy. ODS F/M alloys are leading candidates for structural components in fusion and fast fission nuclear reactors, because of their high strength, dimensional stability, and low activation. In novel reactor concepts, these materials will be subject to extreme operating conditions, accumulating doses of irradiation up to a few hundred displacements per atom (dpa) at temperatures as high as 700°C. The high temperature performance and irradiation tolerance of ODS alloys is attributed to their dispersion of Y-Ti-O nanoclusters. In this work, a Fe-9CrODS alloy was irradiated with 5.0 MeV Fe^{++} ions at 400°C to 100 dpa. Irradiation hardening was measured with nanoindentation. Microstructure evolution was characterized with a combination of transmission electron microscopy (TEM) with electron energy-loss spectroscopy (EELS) and local electrode atom probe (LEAP) tomography. Irradiation-induced microstructure changes include dislocation loop and void nucleation and Y-Ti-O nanocluster dissolution. The microstructure was related to nanoindentation measurements using the dispersed barrier hardening model, but only after accounting for solid solution hardening due to nanocluster dissolution. Sink strengths calculated from the microstructure were confirmed to be proportional to their hardening contributions.

This talk will also discuss new research thrusts in microstructure-mechanical property relationships at Boise State University. The martensitic transformation in ODS alloys and its implications on mechanical properties is being investigated. The effects of cold rolling and recrystallization are also being studied in Ni-base alloys for nuclear applications.

Role of Alloying on Phase Transformations in Ni-Cr Alloys

Julie D. Tucker
Oregon State University

The development of long range ordered phases in Ni-Cr alloys can degrade material properties and is a potential concern for nuclear power systems. The ordering rate and the factors that influence it need to be better understood to predict behavior of Ni-Cr alloys during long term service at intermediate temperatures. In order to quantify the ordering kinetics, we apply a combined computational-experimental approach on model alloys, with Ni/Cr atomic ratios near 2:1. Isothermal agings were conducted at temperatures between 333°C-470°C for times up to 10,000 hours. The effects of alloying (0-9 wt.% Fe), cold work and excess vacancies were investigated and ordering was assessed by changes in the lattice parameter and hardness. Kinetic Monte Carlo simulations and experiments show that ordering is well described by Kolmogorov-Johnson-Mehl-Avrami kinetics. Solute-vacancy interactions of common alloying elements (Mo, Mn, Si, and Nb) were investigated *via* first-principles to better understand ordering in complex engineering alloys.

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DEN/DANS/DMN Service de Recherches de Métallurgie Physique
Centre de Saclay – Bât. 520 - 91191 Gif-sur-Yvette Cedex – France

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Séminaires - Martine Logé ☎ 01 69 08 51 67 et Manuel Athenes ☎ 01 69 08 37 69