CHARACTERIZATION AND MODELING OF RADIATION DAMAGE ON MATERIALS: STATE OF THE ART, CHALLENGES, AND PROTOCOLS

This special issue of the Journal of Materials Research contains articles that were accepted in response to an invitation for manuscripts.

Introduction

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A comprehensive understanding of the mechanisms of radiation damage, accumulation, and materials evolution is essential for the development and optimization of advanced materials for advanced nuclear fission and fusion reactors, and nuclear waste isolation. However, characterization of radiation damage and its effects can be difficult for a variety of reasons associated with the available techniques and/or the materials of interest for nuclear reactors.

Due to the dynamic nature of irradiation-induced and –enhanced phenomena, the development of in-situ characterization techniques provides a more accurate depiction of radiation damage evolution under irradiation conditions. Three-dimensional tomography and atomic-scale characterization better characterize radiation damage structures and interface processes. Whether because of the radioactivity induced in neutron-irradiated samples or the shallow depth of penetration of ion irradiation, characterization of radiation damage and effects must be done in small volumes, which calls for the development of small-scale testing of irradiated materials.

This Focus Issue is dedicated to the most recent advances in the characterization of radiation damage and effects in nuclear materials, such as fuels, structural materials, and waste forms. It includes articles on radiation damage formation and evolution, changes in microstructure (such as bubble and void formation), micro and nanochemistry of irradiation-induced phenomena (such as radiation-induced segregation, grain-boundary enrichment/depletion, solute segregation at loops), phase transformations under irradiation, mechanical property changes due to irradiation, using various characterization techniques including transmission electron microscopy (TEM), in-situ TEM, TEM tomography of radiation damage, atom probe tomography, synchrotron radiation characterization, in-situ synchrotron techniques and small scale testing of irradiated materials.

In addition to experimental characterization of radiation damage, modelling efforts are a critical element for understanding and advancing of the science of radiation damage. In this Focus Issue multi-scale modeling approaches are presented to investigate radiation damage and its effects on materials.

We are grateful to both the authors and reviewers of the many high-quality manuscripts submitted to this *JMR* Focus Issue on Characterization and Modeling of Radiation Damage on Materials: State of the Art, Challenges, and Protocols.

ON THE COVER:

In addition to experimental characterization of radiation damage, modeling efforts have contributed to the better understanding and advancing of the science of radiation damage. To illustrate this concept, the cover figure superimposes the perspective projection of the primary damage state obtained from molecular dynamics simulations at the atomic level on an image illustrating a high density of defects such as clusters, dislocation loops, and extended defect structures at the nanometer level obtained experimentally using transmission electron microscopy.

The computational figure comes from molecular dynamics simulations of an ion track formed in CeO_2 by a thermal spike resulting from the energy deposition of 36 keV/nm, with Ce vacancies, O vacancies, Ce interstitials, and O interstitials (Yablinsky, Devanathan, Pakarinen, Gan, Severin, Trautmann, Allen). The TEM figure comes from a sample of Mo irradiated to 2 dpa by 1 MeV Kr^{++} at 80 °C, using Bright-Field Kinematic conditions (Kirk, Yi, and Jenkins).

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