College of Engineering
Department of
Mechanical & Industrial Engineering

# The Sidney E. Fuchs Seminar Series

3:00-4:00pm, Friday, October 14th, 2016
Frank H. Walk Design Presentation Room

## Defect and Microstructural Evolution in Advanced Alloys to Extreme Irradiation - Progress Toward Structural Materials by Design


by Yanwen Zhang*

**Distinguished R&D Staff, Oak Ridge National Laboratory**



Performance enhancement of structural materials in extreme radiation environments has been actively investigated for many decades. In sharp contrast to the traditional alloys, recently developed single-phase concentrated solid-solution alloys (CSAs) contain multiple elemental species in equiatomic or high concentrations with different elements randomly arranged on a crystalline lattice. Due to the lack of elemental predictability in these CSAs, they exhibit significant chemical disorders and unique site-to-site lattice distortions. While it has long been recognized that specific compositions of traditional alloys have enhanced radiation resistance, it remains unclear how the atomic-level heterogeneity affects defect formation, damage accumulation, and microstructural evolution. Recent work has demonstrated that extreme compositional complexity can substantially reduce electron, phonon, and magnon mean–free paths, alter coupling strengths, and therefore modify transport properties. Compositional complexity can significantly modify defect formation energies and migration barrier landscapes, and therefore affect defect production and microstructural evolution. Disorder resulting from randomly arranged elemental species in NiFe and NiCoCr alloys, compared to elemental Ni, leads to a considerable reduction of damage accumulation under prolonged irradiation. The mechanism is attributed to reduced defect mobility that leads to slower growth of large defect clusters. Tuning compositional complexity can localize defects to a more confined region in the alloys, which promotes defect recombination and leads to an improved radiation tolerance. Contrary to conventional alloys with low solute concentration but multiple phases, energy dissipation and defect evolution at the level of electrons and atoms in CSA systems with extreme compositional disorder is an unexplored frontier in materials science. Further discoveries on chemically disordered single-phase alloys with increasing chemical complexity may lead to new paradigms for developing radiation-tolerance alloys.


* Dr. Yanwen Zhang is a Distinguished R&D Staff at Oak Ridge National Laboratory with a joint faculty appointment at the University of Tennessee. Dr. Zhang's research experience covers a range of topics in both theoretical and experimental materials science and engineering. Her two PhD degrees, one based on experimental work on ion–solid interaction and the other on simulation on radiation transport, uniquely qualify her to effectively communicate with experimental, simulation, and theoretical researchers. The central aspect is the interaction of ions and electrons with materials and how these interactions can be applied to the analysis and modification of materials. Her work has included radiation effects in materials, nanoscale defect/interface engineering, ion-beam modification and synthesis of nanostructured materials, electronic stopping in solids, ionization-induced recrystallization, radiation detector physics, defect-property relationships, long-term performance of materials under extreme environments, and nanostructures in materials and environmental degradation of materials. She was awarded the Presidential Early Career Award for Scientists and Engineers in 2006 for internationally recognized, seminal contributions to the fields of ion–beam physics and ion–solid interactions in materials, and for her commitment to education and outreach. Her research has resulted in 258 refereed journal articles and 19 conference proceedings, including 70 as the lead author; over 60 invited presentations.