PURDUE UNIVERSITY

Nuclear Engineering
COLLEGE OF ENGINEERING

Nuclear Engineering Seminar

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Microstructure-based modeling of nuclear materials in extreme conditions

Abstract

The reliable performance of materials in nuclear reactors is critical for the safe and economic utilization of nuclear energy. During operation, nuclear materials are subject to significant degradation caused by the extreme reactor conditions, including high temperature, stress, radiation and corrosive media. While the degradation phenomena usually emerge at the engineering scale, their cause originate from the atomic scale. The huge gaps in time and length scales make it a grand challenge to uncover the degradation mechanisms for predicting the degradation rates. In this talk, a microstructure-based, multiscale modeling approach will be presented for investigating the degradation mechanisms. Coupled with materials theories and experiments, this approach targets revealing the degradation mechanisms based on microstructure evolution. The scientific understanding will be integrated for predicting materials behaviors at the engineering scale and for designing advanced materials for improved performance. This approach will be demonstrated by a few examples, including the formation of void/gas-bubble superlattices in metals and alloys under irradiation, fracture in oxide fuels, and hydrogen diffusion in Zr-based fuel cladding. This approach is currently being applied for various nuclear fuels and structural materials in both light water reactors and advanced reactors.

Dr. Yongfeng Zhang is currently a staff scientist at Idaho National Laboratory, INL. He leads the Computational Microstructure Science group in the Fuel Modelling and Simulation Department. He has served as the PI of multiple Department of Energy (DOE) program work packages and INL laboratory directed research & development (LDRD) projects. He is also a co-PI of a core program and an Energy Frontier Research Center supported by DOE Office of Science. Dr. Zhang obtained his PhD in Mechanical Engineering from Rensselaer Polytechnic Institute in 2009 and joined INL after that. His research focuses on microstructural level modeling of materials behavior in extreme conditions, including high temperature, stress, irradiation and corrosive media. The topic areas including radiation effects, mechanical deformation, and property degradation. He has authored and co-authored over 50 peer-reviewed journal publications and delivered over ten invited talks at conferences and university seminars. He has been awarded multiple times at INL, including the Laboratory Director's Award for Leadership for 2016.