Department of
Materials Science and Chemical Engineering (MSCE)

Special Joint MSCE and IACS Colloquium

Friday, October 12, 2018, 1:00 – 2:00 PM
Laufer Center Auditorium,
Institute for Advanced Computational Science (IACS).

Prof. Brian Wirth
Governor's Chair Professor
of Computational Nuclear Engineering,
Department of Nuclear Engineering,
University of Tennessee
and Oak Ridge National Laboratory

Title: Overview of Modeling Plasma Surface Interactions in Tungsten with a Focus on Connecting Computational Predictions to Experimental Observations

The performance of plasma facing components (PFC) is one of the main issues facing ITER and future magnetic fusion reactors. Tungsten will be used in ITER as the PFC material and is considered to be one of the primary candidates for future reactors. However, recent experiments that exposed tungsten to He plasma exposure or He ion irradiation with ion energy less than about 100 eV (well below the threshold energy for physical sputtering or Frenkel pair production in tungsten) reveal significant surface modification, including the growth of nanometer-sized "fuzz", and formation of a layer of nano-bubbles in the near-surface region. It is widely accepted that He atoms in tungsten, like in other metals, are insoluble and tend to form small clusters, which serve as the nucleating event for the formation of larger gas bubbles. It is also clear from atomistic simulations that the processes of trap mutation produce W interstitial atoms that lead to surface morphology modification as the interstitials diffuse to and annihilate at the surface, in addition to plastic flow and dislocation loop punching processes driven by high compressive stresses caused by over-pressurized clusters, or nanometer-sized bubbles, and these processes can alter both the tungsten surface morphology and the He clustering dynamics.

Host: Prof. Jason Trelewicz and Prof. Lance Snead

**Refreshment will be served 12:15 – 1 pm outside of the colloquium room.*

One of the challenges with describing these effects for the large-extrapolations in performance required for the PFCs in next-step devices beyond ITER is the large span of spatial and temporal scales of the governing phenomena and, therefore, the theoretical and computational tools that can be used. Fortunately, recent innovations in computational modeling techniques, increasingly powerful high performance and massively parallel computing platforms, and improved analytical experimental characterization tools provide the means to develop self-consistent, experimentally validated models of plasma materials interactions that govern the performance and degradation of the divertor and PFCs in the fusion energy environment. This presentation will describe the challenges associated with modeling the performance of divertor PFCs in ITER and next-step fusion materials environment, results from integrated PMI modeling predictions of a 100 MW, D-T burning plasma discharge in ITER indicate that neon is the dominate contributor to the tungsten sputtering outside the private flux region, and that the size of the net deposition and erosion regions decrease (relative to the lower power, helium-only discharge) to about 2 cm < $R-R_{sep}$ < 10 cm and 10 cm < $R-R_{sep}$ < 45 cm, respectively. Within this region, the highest hydrogenic species and helium concentrations are predicted to occur. The recycling coefficients of hydrogenic species are essentially 1.0, with some deviation predicted to occur from about 2 < $R-R_{sep}$ < 45 cm. PMI predictions indicate that much higher T concentration (by nearly 10X) develop as a result of the initial sub-surface helium concentrations implanted during prior helium plasma discharge. The discussion concludes with a comparison of modelling predictions to experiments meant to validate the physical understanding and integrated PMI modeling.

About the Speaker:

Brian Wirth is Governor’s Chair Professor of Computational Nuclear Engineering in the Department of Nuclear Engineering at the University of Tennessee, Knoxville and Oak Ridge National Laboratory, which he joined in July 2010. Professor Wirth’s research investigates the performance of nuclear fuels, structural materials and plasma facing components in nuclear environments. This research will improve predictions about the longevity of nuclear reactor components and ultimately lead to the development of high-performance, radiation resistant materials for advanced nuclear fission and fusion energy power plants.

Brian received a BS in nuclear engineering from the Georgia Institute of Technology in 1992 and a PhD in mechanical engineering from the University of California, Santa Barbara in 1998, where he was a Department of Energy Nuclear Engineering Graduate Fellow. Dr. Wirth spent four years in the High Performance Computational Materials Science Group at Lawrence Livermore National Laboratory, where he lead efforts to investigate the microstructural stability of structural materials in nuclear environments. In 2002 he joined the faculty at the University of California, Berkeley as an Assistant Professor of Nuclear Engineering and was promoted to Associate Professor in 2006.

He has received a number of awards, including the 2014 U.S. Department of Energy Ernest O. Lawrence Award in Energy Science and Innovation, the 2016 Mishima Award from the American Nuclear Society for outstanding work in nuclear fuels and materials research, the 2007 Fusion Power Associates David J. Rose Excellence in Fusion Engineering Award and the 2003 Presidential Early Career Award for Scientists and Engineers (PECASE). He is a Fellow of the American Association for the Advancement of Science (AAAS, 2016 Fellow, Physics Section) and the American Nuclear Society (ANS, 2017 Fellow).