Three-Dimensional Microstructural Imaging and Analysis of Energy Materials

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Abstract
Materials used in energy storage and conversion (e.g. fuel cells, batteries, electrolyzers, CO_2 separation membranes) all consist of heterogeneous functional materials that exhibit functional behavior in a manner that controls their collective performance as an energy system. There is a critical need to understand the role of a material's structure, morphology, and composition on system performance[1]. This talk presents a non-destructive approach to image and characterize energy materials using synchrotron-based transmission x-ray microscopy, including XANES nanotomography[2] to analyze chemical and structural changes in materials during operation, and high temperature in situ imaging of Ni particles during oxidation and reduction[3]. Several theoretical approaches including numerical methods (lattice Boltzmann, finite element[4]) and analytical methods (electrochemical fin theory[5]) are used to analyze mass transfer, heat transfer, ionic/electronic charge transfer, and chemical / electrochemical reaction rates. To demonstrate this approach, solid oxide fuel cell and ceramic composite gas separation membranes are examined to provide fundamental insight into the origins of microstructured-induced transport losses during operation.

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4. A.S. Joshi et al., *J. Power Sources* **164**: 631-638 (2007); M.E. Lynch et al., *Nano Energy* **2**:105 (2013).
5. G. J. Nelson et al., *J. Power Sources* **246**: 322-334 (2014); *J. Power Sources* **196**: 4695 (2011).

About the Speaker
Wilson K. S. Chiu earned his M.S. and Ph.D. degrees in Mechanical Engineering from Rutgers University in 1997 and 1999, respectively. His research was supported by the U.S. Department of Energy, National Science Foundation, Office of Naval Research, Army Research Office, and industry. He published 96 journal articles and 148 conference articles/abstracts. Among his honors, he was elected fellow of ASME in 2013, into the *Connecticut Academy of Science and Engineering* in 2013, received the *Rutgers University School of Engineering Medal of Excellence Award for Distinguished Young Alumnus* in 2010, the *United Technologies Corporation Professorship in Engineering Innovation* in 2008, and the *ASME Bergles-Rohsenow Young Investigator Award in Heat Transfer* in 2006. Starting on July 1, 2015, he will serve as the Editor of the *Journal of Fuel Cell Science and* Technology. He also serves on the editorial board of *Scientific Reports*, as an associate editor for the *ASME Journal of Heat Transfer* and the *International Journal of Thermal Sciences*, executive committee co-chair for the *ASME Advanced Energy Systems Division*, and executive committee member for the *ECS High Temperature Materials Division*. He has given over 90 plenary, keynote and invited lectures in the United States and abroad.