Advances in electrode diagnostics and design for low-cost Pt-free fuel cells and safer, high energy density Li-ion batteries

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Improving the performance of porous electrodes for fuel cells and batteries is a crucial component of achieving viable energy storage and conversion systems for sustainable energy. This talk will present imaging, modeling, and experimental techniques for characterizing electrodes and identifying opportunities for better performance. Nano-scale resolution X-ray computed tomography (nano-CT) is a non-destructive method of obtaining high resolution 3D images of the complex, internal structure of materials and devices. A high resolution of 50 nm (16 nm 3D voxels) is achieved using advanced X-ray optics. With the use of the Zernike phase contrast mode, the high resolution is even achieved on materials with low atomic numbers; i.e. materials with low absorption contrast, such as the organic materials and polymers used in fuel cell and battery fabrication. This talk will highlight the application of nano-CT in our ongoing fuel cell and battery research. The work includes morphological characterization, degradation analysis, and chemical mapping of fuel cell and battery electrodes and the development of in-operando imaging. These studies include the characterization of emerging non-precious metal catalyst cathodes for polymer electrolyte fuel cells that can reduce electrode costs by two orders of magnitude. Nano-CT is used to resolve the hierarchical electrode structure as well as chemically map the polymer electrolyte additive. Morphological and simulated transport properties from nano-CT images are implemented in models for optimizing future electrode designs for these promising low cost catalysts. Recent imaging and analysis of Li-ion graphite anode degradation will also be covered as well as the development of cells for in-operando imaging of battery electrode charging/discharging processes using lab-scale nano-CT.

Biography

Shawn Litster is a Professor and the Russell V. Trader Faculty Fellow in the Department of Mechanical Engineering at Carnegie Mellon University in Pittsburgh, PA. He also has a courtesy appointment in the Department of Materials Science and Engineering. He received his Ph.D. in mechanical engineering from Stanford University (2008) and his B.Eng. and M.A.Sc. degrees from the University of Victoria in Canada. His current research focus is micro- and nano-scale transport phenomena in energy conversion technologies where electrochemistry and electrokinetics play a dominant role, including fuel cells, batteries, and ultra-capacitors. His research interests also include multiphase flow in porous media and micro-channels, non-linear dynamics, catalytic gasification, and microfluidic pumping. He is also the director of Carnegie Mellon's X-ray Computed Tomography Facility. He is a recipient of Carnegie Mellon's George Tallman Ladd Research Award, a National Science Foundation CAREER award, the University of Victoria's Lieutenant Governor's Silver Medal, and best paper/presentation awards from The Electrochemical Society and the American Society for Mechanical Engineers. He is an author of over 50 journal papers and three book chapters. He is also an inventor for three US patents on fuel cell design.