Multi-scale, multi-modal neutron imaging studies of electrochemical systems

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Abstract

Electrochemical energy storage devices are key to decarbonizing our modern world. Whether a battery, a fuel cell or a flow battery, the devices share many common features: electrolyte, porous electrodes, impermeable separator save for the exchange ion, current collectors, and some kind of container. In short, they are hierarchical structures, with interactions at the nanoscale impacting structures at the centimeter and vice versa. Studying such systems in operando is essential to improving their robustness and performance, but the variety of materials and the breadth of length scales makes such measurements a challenge. Neutron imaging provides several opportunities to address such challenges. When combined with X-rays, one obtains conventional attenuation tomography for 3D spatial and time evolution of a system, where X-rays are most sensitive to metallic components and neutrons the light elements (H, Li). Using Bragg edge imaging, one tracks the phase evolution of a particular crystal phase during charge and discharge cycles. With dark field imaging, one measures the microstructure and how it changes on charged and discharged states depending on the history of the battery. An introduction to each of these methods will be given, with specific examples. Tutorials on analysis will focus on multi- mode tomography and segmentation.

Bio

Dr. Daniel S. Hussey is a research scientist at the National Institute of Standards and Technology where he leads a team in the development of novel neutron imaging and optics techniques for materials science applications, with a focus on electrochemical energy storage and conversion devices. Dr. Hussey began his career at NIST in 2004 as a National Research Council Postdoctoral Fellow. Dr. Hussey holds one U.S. and one world patent in the area of signal processing, has co-authored over 180 peer-reviewed journal articles and book chapters, has been a co-PI on three funded NIST Innovations in Measurement Science projects, is a fellow of the American Physical Society, and has received several awards including the Presidential Early Career Award for Scientist and Engineers, the Arthur S. Flemming Award, an R&D 100 award for NIST-NeXT, and the Department of Commerce Silver Award.