APS Colloquium

Argonne NATIONAL LABORATORY

EARLY CAREER RESEARCHER SERIES

Advances in X-ray Microscopy

for the Study of Battery Reactions in Single Particles

The existing performance limitations of Li-ion batteries can be tracked to slow transport and irreversibilities in the compositional, structural, and morphological changes undergone by the electrode materials during operation. Tools that provide insight into the onset and propagation of these transitions are critical for identifying the mechanisms of electrochemical function. This information must be generated at the single crystal level, where irreversibilities trigger architecture degradation. Since active electrode materials are used in the form of micro- and even nano-powder form, nanoscale resolution is required. Synchrotron-based x-ray microscopy currently combines nanoscale spatial resolution with a suite of possible contrasts mechanisms, such as diffraction and spectroscopy. In recent years, we have witnessed an explosion in studies using x-ray microscopy to study battery reactions. However, the capabilities of this suite remain to be fully exploited to offer increased chemical, spatial, and temporal insight. In this talk, I will discuss recent developments in x-ray microscopy for the chemical imaging of electrochemical reactions in battery electrodes, tailored to suit the scales and phenomena to be probed, but focusing on single particles. I will highlight the new fundamental insight generated by the tools, with particular attention to phenomena at increasing temporal resolution, framed in the context of operando measurements (see Figure). Because thermodynamic pathways can be controlled by the presence of electrical potential, the harvesting of a sample from a cycled battery, while providing a useful preliminary insight, can cast doubt on the results due to the possibility of relaxation of components into a different state that is more stable under open circuit conditions. The mechanisms of transformation will be related to their impact on material and architecture properties.

Jordi Cabana is an Assistant Professor in the Department of Chemistry at the University of Illinois at Chicago (UIC). Prior to his appointment at UIC, he was a Research Scientist at Lawrence Berkeley National Laboratory from 2008 until 2013. Professor Cabana completed his Ph.D. in Materials Science at the Institut de Ciència de Materials de Barcelona (Spain) in 2004, and worked in the Department of Chemistry at Stony Brook University as a postdoctoral associate. He is generally interested in the physical and inorganic chemistry of materials, with emphasis on redox and transport properties. His research group aims to provide chemistry solutions to technological problems in energy applications, with current focus on electrochemical energy storage, which is critical in the development of a green economy based on renewable sources.

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