Soft X-ray Spectroscopy for Energy Storage: What We Get and What We Offer

Wanli Yang
Lawrence Berkeley National Laboratory

Improving the energy-density, power, and safety of the electric energy storage system remains a formidable and critical challenge. Synchrotron based soft x-ray spectroscopy, including soft x-ray absorption, emission, and resonant scattering spectroscopy, is one of the incisive tools that probe the electronic states in the vicinity of the Fermi Level, which defines the operation of electrochemical devices.

This presentation will focus on the concepts of how the electronic structure revealed by soft x-ray spectroscopy could help the battery material research, in both fundamental understandings and practical developments. Several recent spectroscopic results will be discussed from both chemical and physical point of view: First, we will explain how the spin states and crystal fields of 3d transition-metals could regulate the electrochemical behavior. We demonstrate that such information could be directly detected by soft x-ray spectroscopy with both ***elemental and site sensitivities***. Second, we will show that the interfaces of battery electrodes are formed not only through the decomposition of electrolyte. The formation heavily involves the electrode material itself, but often leads to the stability problem of the electrolyte. With the ***chemical-bond and valence sensitivities***, such information could again be detected directly by soft x-ray spectroscopy. At the end, we will briefly discuss the recent developments towards in-situ/operando soft x-ray spectroscopy of electrochemical devices, and showcase several practical achievements of battery materials through soft x-ray spectroscopy.