The 91st GREEN Seminar

In-situ X-ray Studies for Understanding Charge Storage Mechanisms of Advanced Electrode Materials for Lithiun and Sodium-Ion Batteries

Chair: Dr. Denis Yu(GREEN)

Prof. Han-Yi Chen

(Department of Materials Science
and Engineering National Tsing Hua University, Taiwan)

Li-ion batteries (LIBs) have been commonly used in portable electronic devices and electric vehicles because of their high energy density. However, the limited resources of lithium and the high cost are the main challenges for LIBs. Na-ion batteries (NIBs) have attracted significant attention recently as promising alternative candidates for energy storage because of their low-cost advantages. Here we proposed various elecftrode materials for LIBs and NIBs, including high-entropy oxides (HEOs), oxygen redox-based oxides, polyoxometalates (POMs), and bimetallic chalcogenides.

HEOs are metal oxides that consist of five or more cations in the crystal structure and exhibit high entropy of the system. The high-entropy effect enables excellent cycling stability. Oxygen redox-based cathode materials with an extra anionic redox reaction (O2–/On–) deliver a higher capacity than the conventional layered oxides in NIBs. However, they usually show irreversible structure evolution, which leads to a fast capacity fading. Therefore, we investigate stable anionic redox chemistry for high-energy and long-cycle-life layered oxide cathode materials deriving from a framework of P2-type Na0.67[Mg1/3Mn2/3]O2 by Ca-doping, which serve as pillars in layers to stabilize the structure. The above-layered oxide cathodes deliver high capacity and well-cycling stability. POMs are transition metal oxide clusters that can provide multiple redox reactions during charging/discharging processes. Various POMs were also synthesized and showed high capacity with good cycling stability in our work. Due to their high pseudocapacitive effects and large capacities, transition metal sulfides/selenides have been reported as promising materials for alkali-ion batteries. However, these materials undergo significant volume expansion, which results in poor cycling retention. Hence, an amorphous bimetallic chalcogenide, MoSnSe1.5S1.5, was synthesized to mitigate the volume expansion and enhance the cycling stability. Several in-situ synchrotron X-ray techniques, including X-ray diffraction, X-ray absorption spectroscopy, and transmission X-ray microscopy, were conducted to understand the charge storage mechanism of those electrode materials. In-situ Raman and gas chromatography were also employed. The results revealed that those materials are promising electrode materials for LIB and NIBs.

Venue: Rm. 409/410, 4F, Collaborative Research Bldg., Namiki-site

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Contact: YU.Denis@nims.go.jp