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Understanding a lithium ion battery using high-energy synchrotron X-rays

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Lithium ion battery is one of the popular energy storage devices and its lifetime and safety are central issues in battery manufacturing. For this purposes, extensive and intensive studies have been carried out by various synchrotron X-ray techniques, including XRD, XAFS, XES, HAXPES, RIXS, Compton scattering and others. Among them, high-energy X-ray scattering, i.e Compton scattering, is better placed to measure disordered materials under various sample conditions. The electron momentum density observed by this technique is a ground-state property of an electron system, which allows us to interpret the experimental results straightforwardly with electronic structure calculations. Moreover, it can also probe materials inside a metal container, such as a commercial battery. Therefore, high-energy X-ray Compton scattering is a unique tool to investigate a battery at the quantum and product levels under in situ and operando conditions.

In this talk, we present our recent works: quantum-scale characterization of redox orbitals in an electrode material [1] and product-scale mapping of lithium distributions in a commercial battery (see Fig. 1) [2, 3].

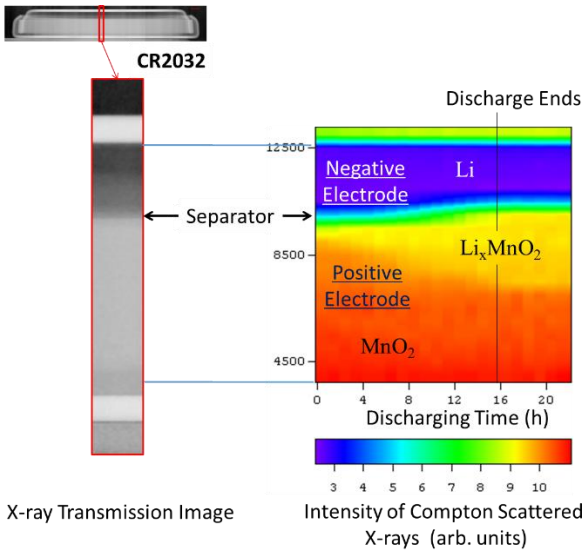

Figure 1. Intensity map of Compton-scattered X-rays as a function of vertical position and discharge time of the battery (CR2032) [2]. Lithium migration and internal structure change are clearly observed.

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