Surface and Subsurface Characterization of Lithium-Ion Battery Materials Using FIB-SEM with Integrated ToF-SIMS

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In recent years, significant attention has been directed towards enhancing lithium-ion batteries, widely utilized for electrical energy storage across various devices. Ongoing battery research and development are geared towards optimizing existing battery technologies and innovating new energy storage solutions. These endeavors aim to deliver ample battery capacity, prolonged lifespan, rapid charging capabilities, enhanced safety, and eco-friendliness, contributing to a fossil fuel-free future. Meeting the demands for battery innovation hinges on the thorough and efficient multiscale structural and chemical characterization of battery materials.

This study delves into the micro- and nano- characterization of battery electrochemical materials using the Focused Ion Beam Scanning Electron Microscope (FIB-SEM) with integrated Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS). This analytical tool facilitates the identification of lithium-ion battery capacity fade mechanisms associated with the deactivation of active materials and loss of lithium inventory. Additionally, this analytical instrument enables the chemical identification of contaminants within the battery material, examination of electrode particle degradation processes, and exploration of solid electrolyte interphase (SEI) properties. The ability to correlate SEM observations with ToF-SIMS and other analytical techniques like Energy Dispersive X-ray Spectroscopy (EDS) and Raman Spectroscopy on the same FIB-SEM system offers expanded 2D and 3D analytical capabilities, thereby providing a comprehensive understanding of lithium-ion battery material behavior from chemical, electrochemical, and mechanical perspectives.

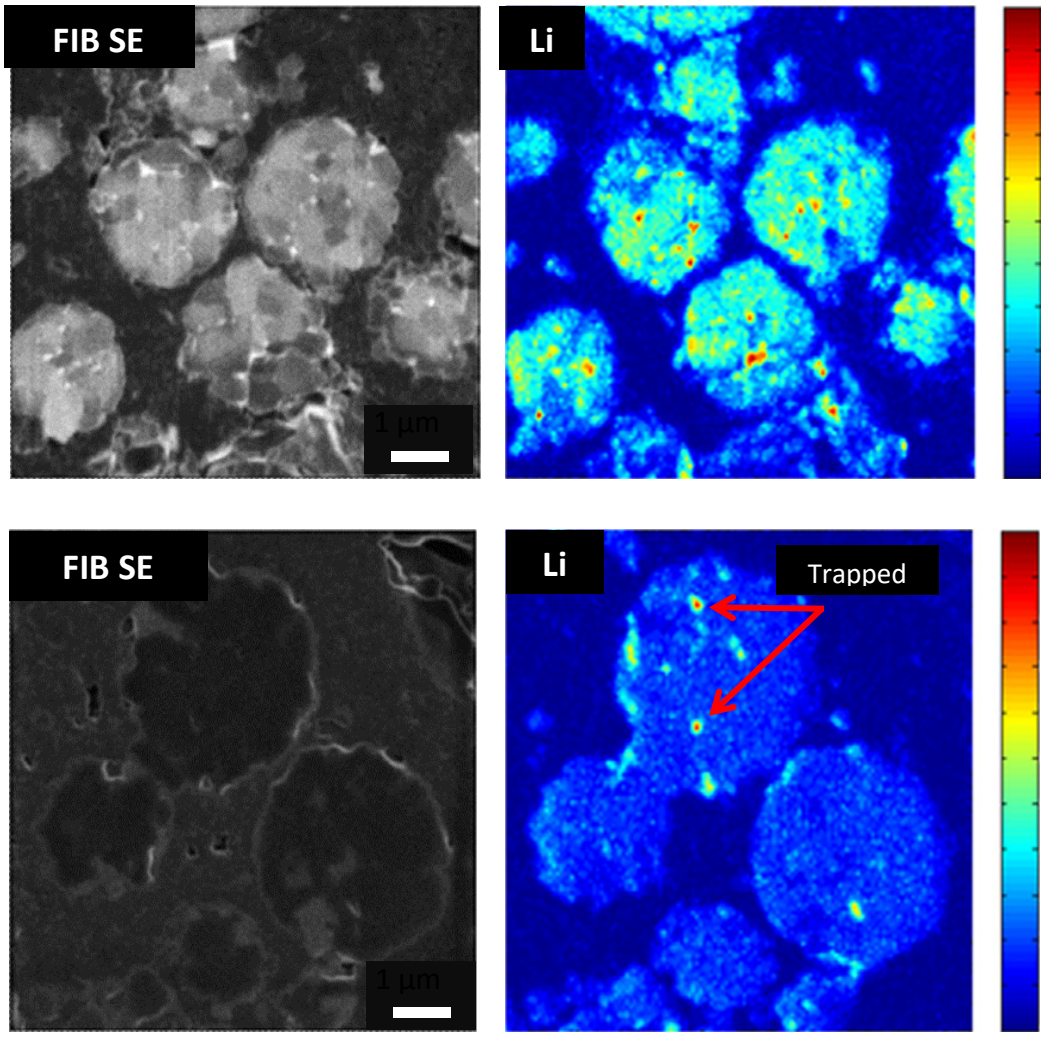

Figure 1: FIB SE images and lithium distribution maps of cathode particles for the battery's fully discharged and charged state (analysis in the cross-section), where lithium inside fully discharged particles represents lost active material not participating in battery charging.