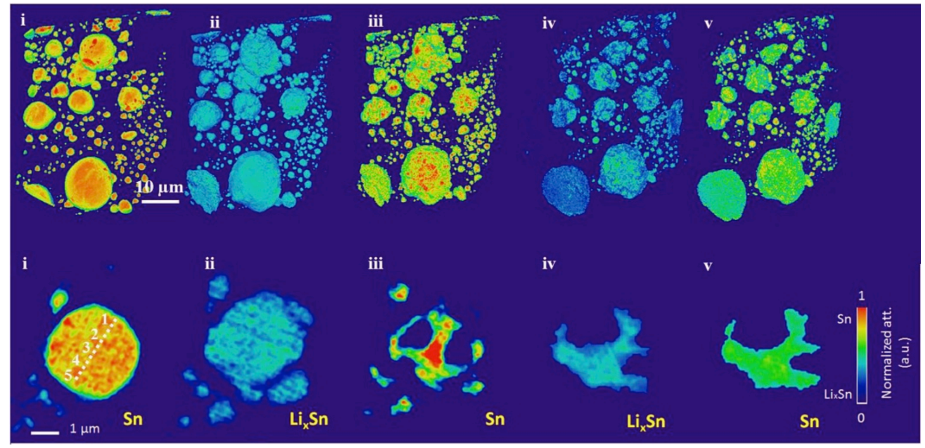
3D Nanoscale Changes in Rechargeable Battery Material During Operation

Scientific Achievement

Made the first 3D observations of electrochemical reactions and structural evolution of a lithium-ion battery anode at the nanoscale in a real battery cell as it discharges and recharges.

Significance and Impact

Understanding the mechanism behind electrode degradation points to new ways to engineer battery materials to increase the capacity and lifetime of rechargeable batteries.



Battery materials during charge and discharge: a) 3D morphological evolution of Sn particles during the first two lithiation–delithiation cycles; b) Pseudo cross-sectional images of a single Sn particle during the first two cycles. The particle shows severe fracture and pulverization at the initial stage of cycling, but stays mechanically stable afterwards while the electrochemical reaction still proceeds reversibly. The color scale of this cross-sectional view corresponds to the normalized linear attenuation coefficient, which provides a direct visualization of the chemical composition.

Research Details

- Built a fully functioning battery cell with all three battery components -- the electrode being studied, a liquid electrolyte, and the counter electrode -- supported by relatively transparent materials to allow transmission of the x-rays, and contained within a quartz capillary measuring one millimeter in diameter.
- Produced more than 1400 2D x-ray images of the anode material with a resolution of approximately 30 nanometers, which were later reconstructed into 3D images.

Jiajun Wang, Yu-chen Karen Chen-Weigart, Jun Wang. *Angewandte Chemie* (2014)

Work was performed at Brookhaven National Laboratory and Western University, Canada.

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