Non-equilibrium Pathways during Electrochemical Reactions in Battery Materials

Scientific Achievement

Nanoscale *operando* visualization of the chemical and microstructural evolution of single crystal particles of $Li_{1+x}Mn_{2-x}O_4$ on electrochemical cycling.

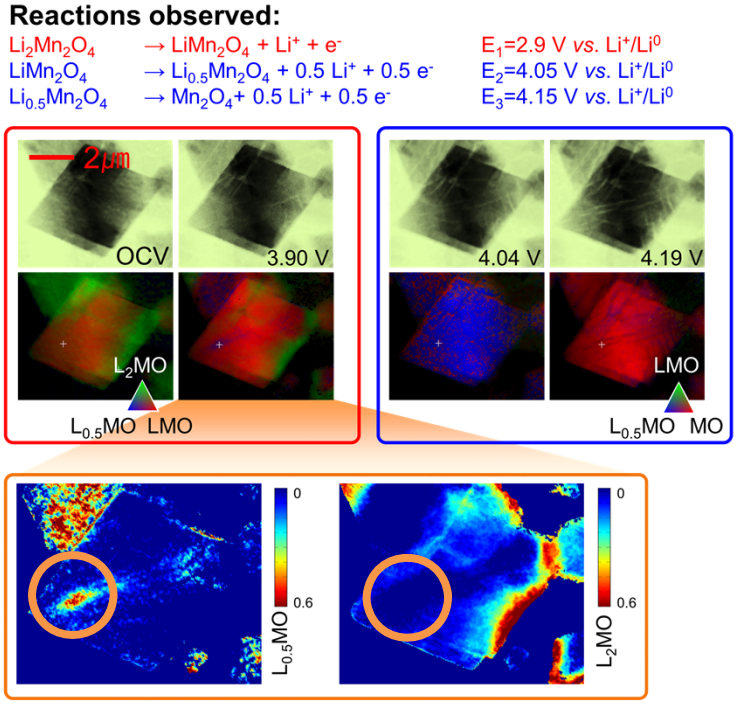
Significance and Impact

The existence of directional fracture and non-equilibrium reaction pathways identify limitations to performance that inform the engineering of optimized electrode morphologies and architectures.

Research Details

- *Operando* full-field transmission X-ray microscopy was coupled with spectroscopy to follow the chemical and microstructural evolution in a technologically relevant Li-ion battery cathode.
- The onset and propagation of a series of complex phase transitions was visualized.
- Directional particle fracture, which causes degradation, was correlated to these transformations.

Work performed at U. Illinois, Chicago, UC San Diego and Santa Barbara, and SSRL and LBNL



Spatio-chemical imaging of morphological changes (top row) and phase distribution (middle row) during electrochemical reactions from $Li_2Mn_2O_4$ to Mn_2O_4 (potentials indicated). Co-existence within the same single crystal particle of reduced (L_2MnO, right) and oxidized ($L_{0.5}MnO$, left) phases formed at potentials that are 1 V apart (circle in lower row).

Y.-S. Yu, C. Kim, Y. Liu, A. Van der Ven, Y. S. Meng, R. Kostecki, and J. Cabana, Adv. Energy Mater., DOI: 10.1002/aenm.201402040 (2014).