Multiscale energy materials research for better batteries

KIST, Center for Energy Materials Research, Jihyun Hong

Multi-length scale scientific/engineering phenomena in batteries

Tens mm ~ tens cm scale
Neutron imaging
(mechanical failure, electrolyte distribution, cell-to-cell diagnosys)

Hundreds μm ~ mm scale
Neutron imaging
(direct imaging of Li concentration)
X-ray spectro-microscopy

Hundreds nm ~ tens μm scale
X-ray microscopy/tomography
X-ray spectro-microscopy
Electron microscopy

Atomic scale
Neutron diffraction
Neutron inelastic scattering
Spin state analysis
X-ray diffraction
EXAFS & XANES

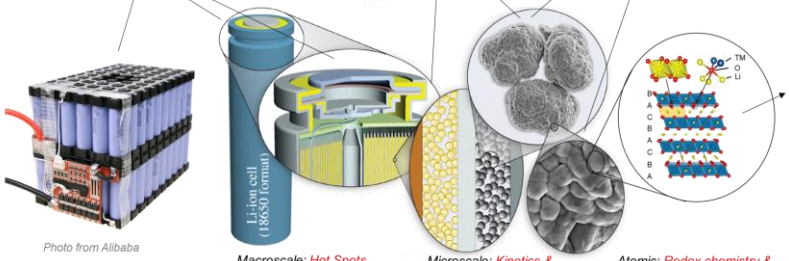


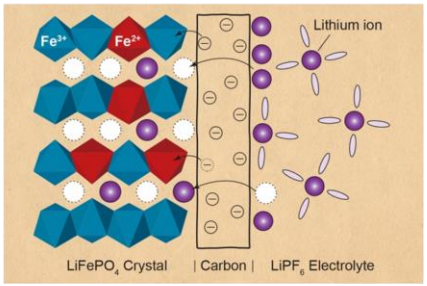
Photo from Alibaba
Image courtesy: prof. William Chueh Stanford University

Macroscale: Hot Spots Mechanical failure

Microscale: Kinetics & Chemo-mechanics

Atomic: Redox chemistry & Phase transformation

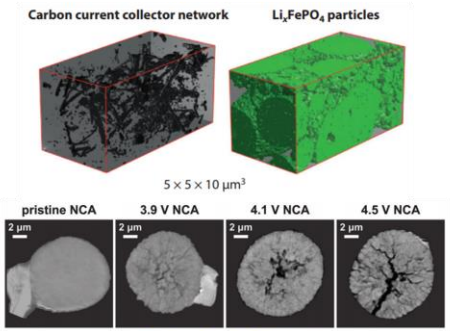
Nano/atomic scale



Solid diffusion
Structural transformation
Redox couples

Charge transfer reaction
Solid-Electrolyte interplay

Microscale

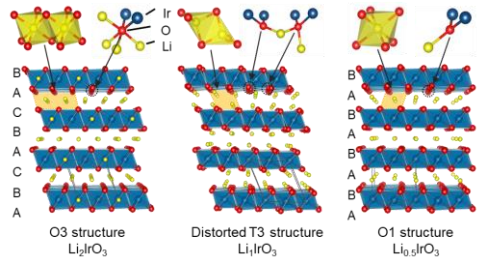


Electrochemical hotspots
Ion storage dynamics
Electro-chemo-mechanics

Y. Li and W.C. Chueh., *Ann. Rev. Mater. Res.*, **48**, 137, (2018)

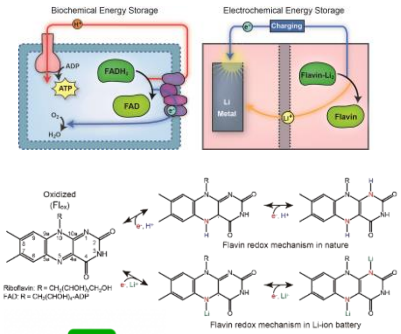
- Rechargeable batteries are composed of multi-length scale components, and, therefore energy storage phenomena needs to be understood by multi-length scale materials' characterization solution.
- Energy storage reaction happens at the interface of electrode active materials and liquid electrolytes inside the batteries.
- We utilize comprehensive characterization tools, such as electrochemistry, spectroscopy, electron microscopy, X-ray techniques, and synchrotron techniques (at Pohang or abroad) to investigate materials' crystal structure, surface structure/composition, and microstructure, in order to improve the performance of rechargeable batteries.

Inorganic intercalation compounds

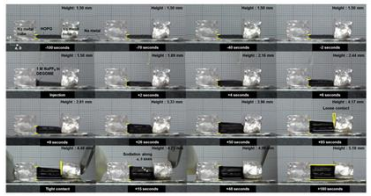


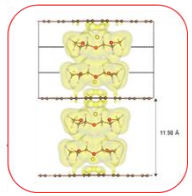
J. Hong and W. Gent et al., Nature Materials, 2019

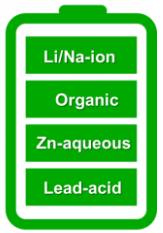
Organic redox compounds for sustainable batteries



Carbon-based materials for future batteries



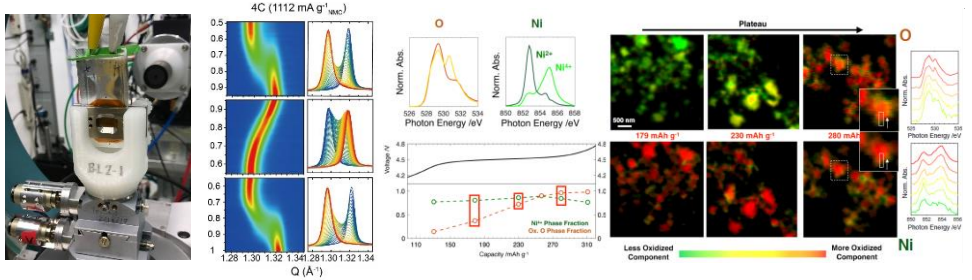




J. Hong, H. Kim, G. Yoon et al., Energy & Environmental Science, 2015

J. Hong and M. Lee et al., Nature Communications, 2014
J. Hong and M. Lee et al., Angewantde Chemie International Edition, 2013
J. Hong and M. Lee et al., Advanced Materials, 2014
J. Hong and M. Lee et al., Green Chemistry, 2017.

- We cover a variety of materials including transition metal-based inorganic intercalation compounds, carbon-based materials for next-generation batteries, organic redox motifs for more sustainable batteries.
- We study various rechargeable batteries including Li-ion, Na-ion, organic-rechargeable, and Zn-aqueous batteries.



- Comprehensive characterization techniques allow us thoroughly understand the details of the electrochemical reactions happening in the rechargeable batteries during charge and discharge process.