In situ Diagnostics of Coupled Electrochemical-Mechanical Properties of Solid Electrolyte Interphases on Lithium Metal Rechargeable Batteries

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

PI/Co-PI: Xingcheng Xiao(GM)/Brian W. Sheldon (Brown) /Huajian Gao (Brown)/Yue Qi (MSU)/YangTse Cheng (UK)

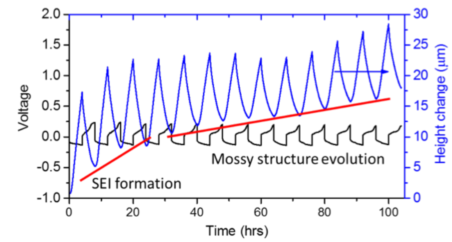
Objective:

to understand the coupled mechanical/chemical degradation of the SEI layer during Li cycling, identify the critical material properties, compositions, and structures of protective coatings, aiming for dendrite free and high cycle efficiency.

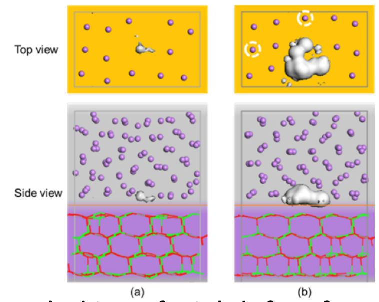
Impact:

- The diagnostic integrated with modeling is critical to the development of a strategy to protect Li metal and achieve long-term cycle stability, which can dramatically increase the energy density of Li batteries for EV applications.
- The tools and modeling developed can be applied to other battery systems to understand failure mechanism.

PVD integrated with glovebox for Li film electrode with well controlled loading



Correlated morphology evolution with electrode thickness change



Revealed interfacial defect formation mechanism between Li and SEI

Accomplishments:

- Developed a well-controlled Li thin film electrode model system for investigating mechanical behaviors of Li during plating and stripping.
- Developed in-situ diagnostic tools to capture the mechanical and transport properties of SEI and Li metal, including MOSS, Nanoindentation, Dilatometer, etc.
- Established a continuum framework to understand SEI failure mechanism on Li metal electrode
- Established a DFT– based modeling to predict key material properties, including modulus, interface work of adhesion, electron tunneling property, and Li ion conductivity for key coating components.

FY 18 Milestones:

- Identify governing mechanical/material properties of the SEI responsible for critical failure modes.
- Understand charge transfer properties at Li/SEI/electrolyte interfaces.
- Calculate activation energy of dynamic processes for Li stripping/plating.
- Establish a property design map aiming for high cycle efficiency/dendrite free.

FY18 Deliverables: A continuum model of SEI growth, which can predict potential SEI failure modes and incorporate them into protective coating design.

Funding:

— FY18: $464,139, FY17: $487,903, FY16: N/A