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

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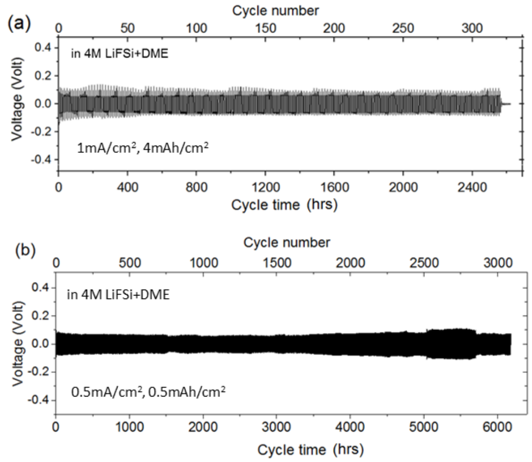
Objective:

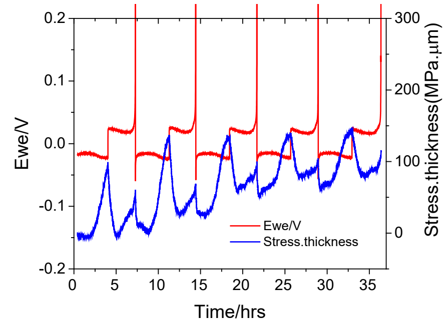
To understand the coupled mechanical/ chemical degradation of the SEI layer during Li cycling, identify the critical material properties/compositions/structures of protective coatings, and achieve dendrite free and high cycle efficiency.

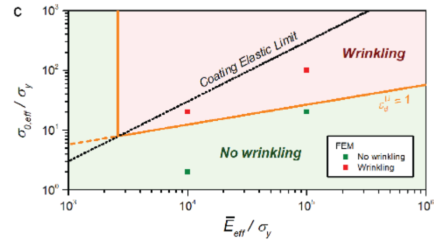
Impact:

- 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 ion batteries for EV applications.
- The tools and modeling developed can be applied to other battery systems to understand failure mechanism.



Fluorine polymer films as artificial SEI effectively protect Li electrode and significantly improve the cycle stability





Established design criteria for mechanically stable SEI/Li interface

Accomplishments:

- Identified governing mechanical/material properties of SEI responsible for critical failure modes, and established a design criteria for mechanical stable SEI/Li interface.
- Investigated charge transfer properties at Li/SEI/electrolyte interfaces and activation energy of Li stripping/plating.
- Investigated the mechanical response of SEI in both carbonate and ether based electrolyte, and identified that ether based electrolyte can effectively inhibit the formation of Li dendrites by forming mechanically robust SEI and the tensile stress during Li plating/stripping.
- Developed fluoropolymer films as artificial SEI layer which effectively protects Li and improves the cycle stability.

FY19 Milestones:

- Validate circuit models that represent experimental impedance data. (Q1)
- Identify failure modes of protective coatings on Li (Q2)
- Develop coating with desirable mechanical and transport properties. (Q3)
- Establish a continuum framework for designing surface coatings as artificial SEI. (Q4)

FY19 Deliverables:

A property map illustrating the ranges of governing SEI properties within which battery failure can be suppressed.

Funding:

— FY19: $ 625,792 , FY18: $ 580,174 , FY17: $ 609,879