Mechanical Properties at the Protected Lithium Interface

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

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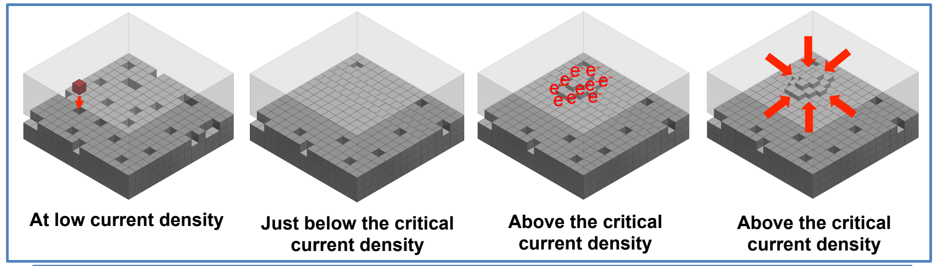
Objective:

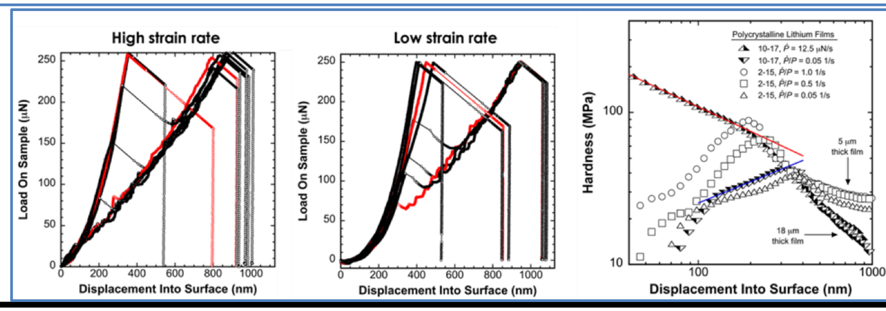
- Assess the mechanical properties that determine the stability of the of the solid electrolyte to Li metal interface.
- Evaluate the effect of cycling on the interface.

Impact:

- Critical interface, solid electrolyte, and lithium mechanical parameters are available for modeling and projections of performance.

Nanoindentation and a model indicate changes when defect diffusion in metal cannot match high ionic flux.





Accomplishments:

- The mechanical properties of pristine Lithium metal thin films has been probed by nanoindentation to extract elastic and ductile creep behavior. The observed volume and strain rate dependence have important implications for cracks emanating from critical flaws.
- The interface resistance of the Li-LLZO ceramic interface is strongly dependent on the fabrication methods. Measures of the adhesion strength shows a similar variation. Well formed interfaces are strong and conductive.

FY19 Milestones:

- Analysis of creep tests for glassy Lipon electrolyte (Q1)
- Analysis of neutron imaging for Li transport in LLZO (Q2)
- Evaluation of defect and microstructure in cycled Li (Q3)
- With German partners, assess whether dynamic impedance will detect early onset of voids in the Li (Q4)

FY19 Deliverables:

- Measures of how flaws, current density and materials properties effect the interface at Li metal anode.
- Incorporate results into models of the interface.

Funding:

— FY19: \$150,000, FY18: \$350,000, FY17: \$300,000

OVERCOMING INTERFACIAL IMPEDANCE IN SOLID-STATE BATTERIES

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

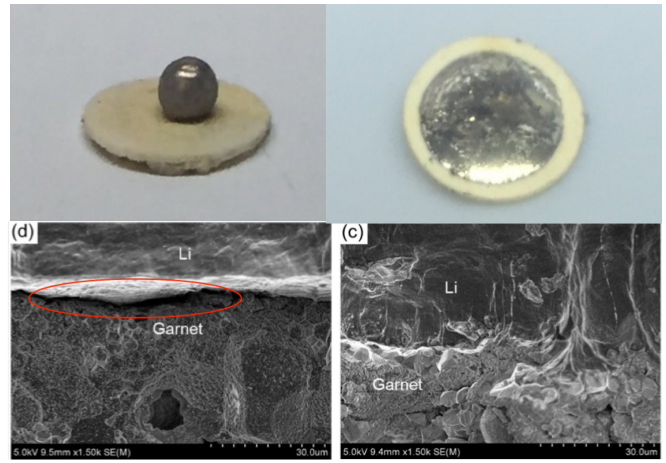
PI/Co-PI: Eric Wachsman (UMD)/ Liangbing Hu (UMD) / Yifei Mo (UMD)

Objective: Develop a multifaceted and integrated (experimental and computational) approach to reduce interfacial impedance of garnet-based solid-state Li ion batteries (SSLiBs).

Impact:

- Overcome primary issue with garnet electrolyte SSLiBs, interfacial impedance, thus enabling an entirely new safer (non-flammable) battery platform
- Enable highest capacity Li-metal anodes with no dendrites for higher energy density batteries (~500 Wh/kg)

Li-Metal Wetting of Solid-State Electrolyte



Developed surface treatment to allow Li-metal wetting thus dramatically reducing interfacial impedance

Accomplishments: (FY16)

- First comprehensive investigation of interface impedance in garnet based SSLiBs
- Determined interfacial impedance as function of electrolyte/electrode contact area in 3D controlled solid state structures
- Developed computational models to investigate interfacial ion transport with interlayers
- Developed multiple efficient interlayer solutions to decrease interfacial impedance
- Demonstrated low interfacial impedance (~10 Ω cm^2) between both electrolyte and Li-metal anode and between electrolyte and cathode

FY 17 Milestones:

- Demonstrate full cells with NMC cathode (Q1)
- Demonstrate full cells with Sulfur cathode (Q2)
- Develop models to investigate interfacial transport for Li-S and Li-NMC SSLiBs (Q3)
- Achieve full cell (Li-S or Li-NMC) performance of 350-450 Wh/kg and 200 cycles (Q4)

FY17 Deliverables: Submission of 12 improved cells for government testing and evaluation

Funding:

— FY17: $401,634, FY16: $401,635 FY15: $409,608