ENGINEERING APPROACHES TO DENDRITE FREE LITHIUM ANODES

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

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Objective:

The project involves strategies to deliver high energy density Li anode based battery cells comprising high specific capacity novel Lithium ion conductor (LIC) coated structurally isomorphous alloy-porous foams (SIA-PFs) integrated electrodes (IE) coupling various cathodes (lithium-free and lithium-rich).

Impact:

1. Novel Li anode generation enabling Li metal-free cathodes
2. Expedite developments in high energy battery systems such as lithium-sulfur and lithium-air batteries
3. The proposed Lithium-anode battery technology will cost ~$125/kWh less than the current limit of $500/kWh offering 75% cost reduction to the end-user.

Post-cycling SEM Images of Porous Foam Electrode

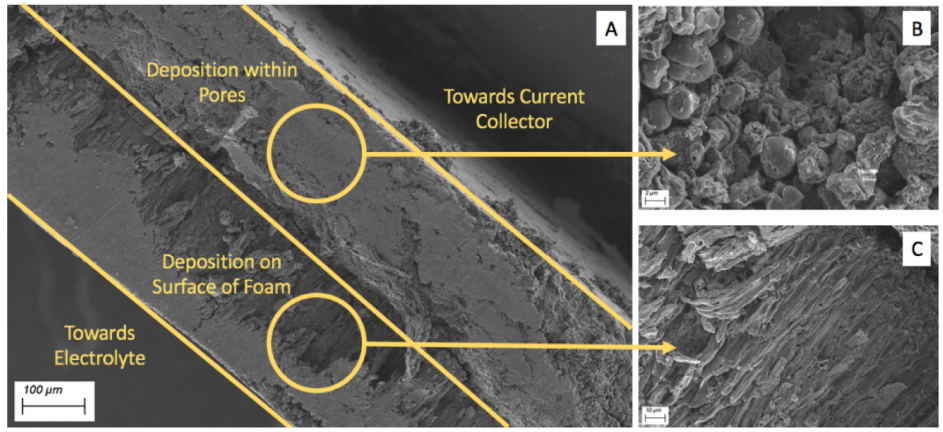

Fig.1 – Post-cycling image of porous foam electrode showing globular deposition within the foam and columnar lithium plating on top of the foam surface.

Accomplishments:(FY17)

- Facile synthesis of a metal porous foam electrode showing high coulombic efficiency (~95%) for 100 cycles
- Preliminary optimization of porous foam electrode synthesis to increase stability and coulombic efficiency
- Elimination of dendrites within the porous electrode structure
- Modification of electrochemical cell to include non-conductive polymer to restrict the deposition region to the working electrode
- Identification and preliminary investigation of structurally isomorphous alloy (SIA) as anode material

FY 18 Milestones:

- Synthesis and testing of structurally isomorphous alloy (SIA) electrodes
- Design and engineering of high capacity multilayer anode (CMA)
- Optimization of porous foam electrode to improve capacity and stability for scaling

FY18 Deliverables:

- SIA electrode demonstrating specific capacity of >1400 mAh/g for >500 cycles

Funding:

— FY17: $416,687, FY18: $416,687, FY19: $416,687

OVERCOMING INTERFACIAL IMPEDANCE IN SOLID-STATE BATTERIES

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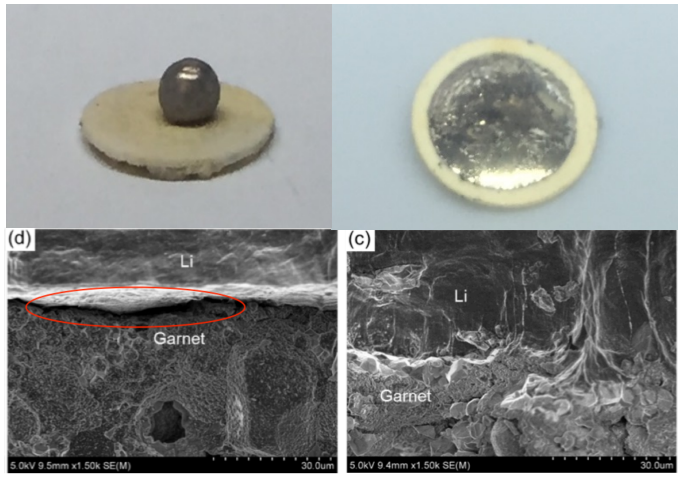
PI/Co-PI: Eric Wachsman (UMD)/ Liangbing Hu (UMD) / Yifei Mo (UMD)

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

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

Funding:

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