

# Development of High-Energy Lithium-Sulfur Batteries

U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy

**PI/Co-PI:** Dongping Lu/Jun Liu (PNNL)

## **Objective:**

- Develop high-energy lithium-sulfur (Li-S) batteries.
- Improve the performance of sulfur cathodes at both high mass loading and lean electrolyte conditions.
- Use advanced techniques to understand fundamental reaction mechanism in Li-S batteries.

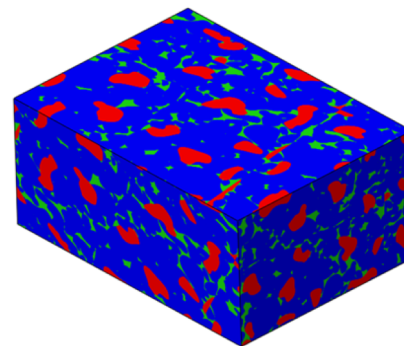
## **Impact:**

- Li-S batteries have potentially 2-3 times higher energy than that of state-of-the-art Li-ion batteries at a largely reduced cost. If successful, the proposed work will accelerate the market penetration of long-range electrical vehicles (EV), required by the EV Everywhere Grand Challenge proposed by DOE/EERE.

## **Accomplishments:**

- Delivered high-loading sulfur cathodes ( $>4 \text{ mg/cm}^2$ ) that have high sulfur utilization (1000 mAh/g) at very low E/S ratio ( $< 4 \text{ } \mu\text{L/mg}$ ).
- Design of a generic hybrid (ceramic-liquid) cell for focused mechanism study of cathode, and study of fundamental reasons of low sulfur utilization in high-loading electrodes.
- Developed functionalized separators to suppress polysulfide shuttle and improve interfacial stability of Li anode.
- Published 3 Papers, gave 5 presentations, and filed 2 invention disclosure for potential patent application.

*To extend cycle life of high-loading sulfur cathodes through a hybrid-Li<sup>+</sup>-conductor electrode design*



- The hybrid-Li<sup>+</sup>-conductor electrode design will be employed to address key challenges of low Li<sup>+</sup> conductivity of sulfur/Li-sulfide, polysulfide shuttle, and limited cycle life of high energy Li-S batteries.

## **FY 19 Milestones:**

- Demonstration of high Li<sup>+</sup> conductive sulfur cathodes enabled by Li<sup>+</sup> conductors with r.t. conductivity  $> 1 \text{ mS/cm}$ .
- Electrode preparation method for S/Li<sup>+</sup>-conductor cathodes with S loading  $> 4 \text{ mg/cm}^2$  and S content  $>75 \text{ wt. } \%$ .
- Complete electrode optimization for low porosity sulfur electrodes (electrode density  $>1 \text{ g/cm}^3$ ).
- Complete electrochemical study of the S/Li<sup>+</sup>-conductor cathodes ( $> 4 \text{ mg/cm}^2$ ) at low E/S ratio ( $<3 \text{ } \mu\text{L/mg}$ ).

## **FY19 Deliverables:**

High energy sulfur cathode ( $> 4 \text{ mg/cm}^2$ ,  $> \text{wt. } 75\% \text{ S}$ , and  $>1 \text{ g/cm}^3$ ); quarterly/annual reports.

**Funding:** FY19: \$400k, FY18: \$400K, FY17: \$400K