UC Irvine Samueli
Department of Chemical and Biomolecular Engineering

May 29, 2026
ISEB 1200
11:00 am – 12:00 pm

Progress on Solid-State Lithium-Sulfur Batteries

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Abstract: Solid-state lithium-sulfur (Li-S) batteries promise high energy density, long cycle life, and low cost. They naturally address the polysulfide shuttle problem that has plagued that stability of Li-S batteries with liquid electrolytes. However, realizing long cycle life and high utilization for the sulfur cathode is extremely challenging due to low conductivity, low reactivity, and volume change induced microstructural failure. On the other hand, enabling a stable lithium metal anode is a difficult task in its own right.

We will discuss our progress on tackling challenges of both electrodes. On the cathode side, we have focused on improving sulfur-based and lithium sulfide-based cathodes. To improve the conductivity of sulfur, we have shown that introducing halide dopants can form new compounds with appreciable electronic conductivities. Sulfur iodide, for example, also appear to stabilize the polysulfide intermediates, which are otherwise known to be unstable in the solid state. Recently, we have also revisited the approach of activated Li_2S as the cathode. One potential advantage is the reduced volume change. To improve the reactivity, we have introduced several dopants (both metal and non-metal). Selected dopants have shown the ability to improve electronic and ionic conductivities and to enhance reactivity through the stabilization of polysulfide intermediates in the solid state.

The challenges of the lithium anode are related to its reactivity with the sulfide electrolytes. Carbon-based interlayers which often contain alloy-forming metals have been shown to be effective. We have focused on understanding the selection rules for the interlayer material and how carbons with high surface area and lithiophobility can serve as an effective mixed ion/electron conductor. We will also discuss recent progress in interface control to reduce the need for interlayers which can simplify the manufacturing process. Collectively, these advancements promise to push the energy density and cycle life of solid state Li-S batteries towards practical utility.

Bio: Dr. Ping Liu is William Coles Chair Professor of Nanoengineering and Director of the Sustainable Power and Energy Center (SPEC) at UC San Diego. Prof. Liu’s research focuses on electrochemical materials science including its applications in energy conversion and storage as well as nanomaterials synthesis. His work on rechargeable lithium batteries include design of both solid and liquid electrolytes, sulfur cathodes, and safety. Prior to joining the Jacobs School faculty in 2016, Prof. Liu was a Program Director at the Advanced Research Projects Agency – Energy (ARPA-E), where he initiated and managed research programs in energy storage for electric vehicles and thermal management technologies to improve building energy efficiency. He was the manager of the Energy Technology Department at HRL Laboratories and was a research staff member with the National Renewable Energy Laboratory (NREL). Prof. Liu has published over 180 peer-reviewed papers and has been issued 60 US patents. He is a co-founder of Tyfast Energy and a founding advisor to Sonocharge. He is a Fellow of National Academy of Inventors and received an R&D 100 Award for a solid state battery technology developed at NREL.

Hosted by: *Prof. Plamen Atanassov, Prof. Iryna Zenyuk*