In-Operando Optical Observation/Visualization of Lithium-Sulfur Battery Discharge Process

Ana Claus, Mikel Tohme, Osama Awadallah, and Bilal El-Zahab*

Department of Mechanical and Materials Engineering, Florida International University, Miami, FL, USA

*E-mail: belzahab@fiu.edu

Lithium−Sulfur (Li-S) batteries have attracted attention due to their high-energy density, 2500 Wh/kg_{cell} [1], and theoretical capacity of 1672 mAh/g-$_S$ [2]. In addition to that, sulfur abundance makes it a good candidate for rechargeable batteries. However, Li-S system has a few challenges that hinder its commercialization. Such as the insulating nature of the sulfur element, volume expansion, capacity fade due to intermittent polysulfide dissolution in the electrolyte and drop in capacity during the initial discharge cycles [3]. Herein, we have designed a Li-S in-operando optical observation cell, which allowed us to visualize the formation of higher to lower-order polysulfides as well as the polysulfide formation and dissolution at different voltages and under different testing conditions. Subsequently, we investigated and compared the loss in capacity when using a modified cathode structure, which was designed to minimize the loss of active material upon lithiation. The real-time recording of the cell under an optical microscope clearly shows a significant loss of active material upon first discharge. Nevertheless, a substantial increase in initial discharge capacity is observed with the use of the modified cathode structure. To further analyze the loss in the battery capacity, we develop a mathematical model that uses fundamental governing equations to predict the loss of active material over cycles.

References

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