Interplays of Composition and Function at the Interphases of Lithium Metal Anodes

Dr. Betar M. Gallant
Associate Professor
Department of Mechanical Engineering
Massachusetts Institute of Technology
77 Massachusetts Avenue,
Cambridge, MA 02139

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LECTURE ABSTRACT

The lithium (Li) metal anode offers significantly higher capacity than graphite and is therefore central to strategies to develop advanced rechargeable battery chemistries that meet range and performance targets for electric vehicles. Although closer than ever, Li anodes still cannot meet the >99.9% Coulombic efficiency (CE) consistently needed for >1,000 cycle life. This shortfall arises from uncontrolled reactivity at the solid electrolyte interphase (SEI) and resulting SEI properties, leading to inhomogeneous plating and stripping, continuous electrolyte consumption and loss of active Li inventory. Despite progress in electrolyte development, the lack of precise understanding of the SEI still hinders attempts to rationally design an improved interface towards bridging remaining gaps in CE.

To inform such efforts, our work is advancing quantitative techniques to yield insights into SEI phases and the hidden interplays between their chemistry, properties and function. We developed approaches to isolate and synthesize exemplar ionic and organic phases relevant to the native SEI at nanoscale thickness on Li metal. These interfaces are then interrogated *via* targeted electrochemical and spectroscopy techniques to reveal their phase-specific transport properties, Li^+ exchange kinetics and chemical dynamics in different electrolytes. By extending these tools to native interfaces in high- and low-CE electrolytes alike, we are identifying effective performance descriptors to guide development of advanced electrolytes and additives. Most recently, such techniques helped to reveal that the leading phase underlying high performance of Li metal anodes is, unexpectedly, lithium oxide, opening new design trajectories for future electrolytes and reducing the reliance on costly, unsustainable yet pervasive fluorinated electrolytes.

SPEAKER BIOSKETCH

Betar M. Gallant is an Associate Professor and the Class of ‘22 Career Development Professor in the Department of Mechanical Engineering at MIT, where she leads the Energy and Carbon Conversion Laboratory. She obtained her SB, SM, and PhD degrees from this department. Following her PhD, Dr. Gallant was a Kavli Nanoscience Institute Postdoctoral Fellow at Caltech. Her research group at MIT focuses on advanced battery chemistries and materials for high-energy primary and rechargeable batteries, including fluorinated cathode conversion reactions and lithium and calcium metal anodes and their interfaces. Her group is also leading research into CO_2 capture and its integration with direct electrochemical conversion in the captured state. She is the recipient of multiple awards including an MIT Bose Fellow Award, Army Research Office Young Investigator Award, Scialog Fellow in Energy Storage, Scialog Fellow in Negative Emissions Science, National Science Foundation CAREER Award, The Electrochemical Society (ECS) Battery Division Early Career Award, an ECS-Toyota Young Investigator Award, and the Ruth and Joel Spira Award for Distinguished Teaching at MIT.