PRINCETON
Mechanical & Aerospace Engineering

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Structural and interfacial challenges in energy storage systems

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Rapid growth of electric vehicles has stimulated the development of high-energy storage systems, especially the lithium–sulfur and lithium–air batteries that employ lithium metal anodes. However, the wide deployment of Li-metal batteries has been hindered by its poor cycling efficiency and safety concerns, both of which stem from the uncontrollable Li deposition-stripping process.

This talk will start with the texturing behavior of Li metal in batteries and reveal the mechanism of Li electro-deposition from crystallographic perspective. Combining the pole-figure analysis and exchange current density characterization, we bridge the gap between electrolyte recipe and morphology of Li deposits. Following that, I will cover the formation of nano-void at interface of Li and SEI during the lithium stripping, which is attributed to the accumulation of Li metal vacancies. The polarization behavior, pitting potential and metallurgical factors are systematically investigated by ultramicroelectrode (UME), 3-electrode cell and focus ion beam (FIB). The understanding of the electro-crystallization and stripping beneath interface process provides invaluable insights for future lithium anode and electrolyte design. Lastly, this talk will address the fundamental mechanism of "superionic conductivity" of all-solid-state Li batteries (ASSBs), which has emerged as very attractive alternatives to conventional liquid electrolyte cells for automotive transportation. We will highlight the diffusion path of the Li in the composite electrolyte by tracking labeled Li isotope with Auger electron spectroscopy (AES) and secondary ion mass spectroscopy (SIMS), followed by a combination of structural and interfacial elucidation via wide angle X-ray scattering (WAXS), small angle X-ray scattering (SAXS) and Resonant Soft X-ray Scattering (RSoXS). The localized electronic structure and binding energy of Li ion and interface will be revealed by X-ray absorption spectroscopy (XAS) and X-ray photoelectron spectroscopy (XPS). These comprehensive characterizations lead to an overarching understanding of Li^+ migration on heterogenous interface.

Dr. Feifei Shi is currently a post-doctoral researcher at Stanford University, Feifei obtained her B.S. degree in Chemistry from Fudan University, China in 2010. Her excellent academic record and contribution to catalysis research as an undergraduate student earned her very pretigious Sumitomo Corporation Scholarship and Honors for B.S. degree. In 2010, Feifei went to University of California, Berkeley to pursue her Ph.D. degree in Mechanical Engineering. Under the joint supervision of Professor Kyriakos Komvopoulos (ME), Professor Gabor A. Somorjai (Chemistry) and Dr. Philip N. Ross (Lawrence Berkeley National Lab), Feifei's Ph.D. research work mainly focused on the electrochemical and mechanical processes at surfaces and interfaces of advanced materials for energy storage. The excellence of Feifei's Ph.D. research work was recognized by John and Janet McMurtry Fellowship. Since 2016, Dr. Shi has been working in Professor Yi Cui's group (Material Science and Engineering) at Stanford University. Her current research project is to investigate the interfacial and structural behavior of Li metal and solid electrolyte in next-generation batteries. Dr Shi's research interests lie broadly at the intersection of surface chemistry, material science and mechanical engineering, with particular emphasis on integrated energy systems, i.e. innovation in conversion, storage, transport and consumption systems.