FEI Lab - Nanostructured Materials Synthesis and Applications

Research Summary: My research group focuses on the design, synthesis, and engineering of nanostructured materials and their composites for applications in energy storage and conversion, surface coating, catalysis, and water purification. Among them, energy storage and conversion such as lithium ion batteries, are the primary focus of our research. Lithium ion batteries (LIBs) play a crucial role for portable electronics, electronic vehicles, and smart grids. However, the further development for lighter, smaller, and safer LIBs with longer lifespans is still limited by poor anode stability, low theoretical capacity of cathodes, and safety concerns caused by liquid organic electrolytes. My research aim is to tackle these challenges via developing novel functional nanomaterials for electrodes and electrolytes along with new methods for electrode fabrication, contributing to lighter, smaller, and safer LIBs with longer life span.

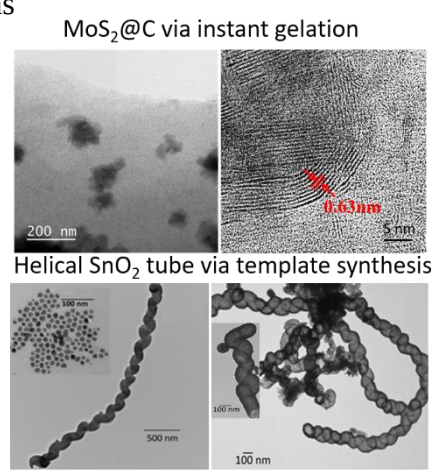

Fig. 1 nanomaterials for LIBs.

Ongoing projects: Currently, we have several projects going on. One NSF funded project in my lab is to study organic−inorganic hybrid ultrathin solid electrolytes for lithium ion batteries, in collaboration with the National Renewable Energy Laboratory. Organic solid polymer electrolytes (SPEs) have the advantages of simple fabrication and good flexibility, but have low ionic conductivity, thermal stability, and poor oxidation resistivity. Inorganic solid ceramic electrolytes (ISEs) have relatively high ionic conductivity and thermal stability, but very low flexibility. Due to the complementary properties of SPEs and ISEs, a lot of research progress has been made toward SPE and ISE composite electrolytes with either filler-in-bulk structure or ISE/SPE laminated multi-layer configuration. However, further development of the composite solid electrolyte is hindered by the lack of a good understanding of the interfacial properties in the electrolyte. Therefore, in this project, we designed an SPE and ISE composite electrolyte with a laminated bilayer configuration. The laminated bilayer electrolyte with one large interface area serves as a smart model for the study of ISE/SPE interface behavior. In addition to solid state electrolyte research, we are also interested in preparing battery electrode materials. The primary material fabrication method we use is electrospinning, a proven method of forming nanofibers.

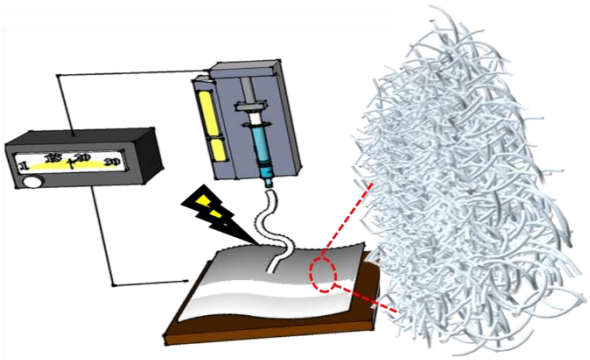
Fig. 2 Electrospinning for nanofibers.

Future Research: Future research will focus on fast rate all-solid-state energy storage materials.