WPI MATERIALS SCIENCE & ENGINEERING

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PhD Proposal

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Zoom meeting:
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Study of Amorphous Li0.35La0.55TiO3 as Solid Electrolyte and Applications in All-Solid-State Li-ion Batteries

Abstract:
Lithium ion batteries have been widely used in portable electronic devices, electric vehicles, and emergency power systems because of their high energy density, high power density and long cycle life. However, safety is one of the intrinsic issues of current lithium ion batteries with flammable liquid electrolyte. Therefore, All-solid-state Li-ion batteries (ASSLiB) attract lots of attention mainly due to their higher safety compared with commercial Li-ion batteries. Among all the candidates of solid electrolyte materials, amorphous Li0.35La0.55TiO3 (LLTO) shows promising ionic conductivity and electrochemical stability. In this work, we successfully synthesize both amorphous LLTO thin film and powder by sol-gel process. The ionic conductivity, which is a critical parameter for solid electrolyte, increases from 2.32×10-8 S/cm to 9.01×10-6 S/cm with the control of annealing time. The morphology of the thin film changes accordingly, solvent evaporation, surface refinement and crystallization phases occur sequentially. It also indicates that there is an optimal synthesis condition for the LLTO film. In order to further increase the ionic conductivity to meet the requirements of ASSLiB, Strontium (Sr) is introduced as dopant and the ionic conductivity further reaches 8.38×10-5 S/cm at 30 ℃ with 5% of Sr doping, which is about one order of magnitude higher than that of undoped LLTO. It is also confirmed that amorphous Li0.35La0.5Sr0.05TiO3 (LLSTO) is stable in direct contact with lithium and with electrochemical stability window up to 10V. Thiophosphate-based electrolytes also have shown great promises because of their high ionic conductivity. However, the narrow operation voltage and poor compatibility with high voltage cathode materials impede their application in the development of high energy ASSLiB. With a facile wet chemical approach, we coated a thin layer of amorphous LLSTO with 15-20 nm at the interface between NMC and Li6PS5Cl. Attributed to the high stability of Li6PS5Cl with NMC/LLSTO and outstanding ionic conductivity of the LLSTO interfacial coating and Li6PS5Cl, the electrochemical stability window of Li6PS5Cl was greatly improved to 4.0 V (vs. Li-In). At room temperature, the ASSLiB exhibits outstanding capacity of 107 mAh/g and keeps stable for 850 cycles with a high capacity retention of 91.5 % at C/3.