University of Louisville
Department of Chemistry

Parisa Naji

Literature Seminar

When: April 11, 2024
Time: 12:00 p.m.
Location: CBLL-16

Lithium-ion conductivity in solid state electrolytes

Abstract:

The rapid economic development and growth in energy demand have led to the unsustainable consumption of non-renewable energy sources. For the development of large-scale energy grids and electric vehicles, energy storage plays a crucial role. Currently, lithium-ion batteries have become ubiquitous, powering various applications such as smartphones, laptops, electric vehicles, and aerospace technologies, owing to their high energy density, low self-discharge rate, and long lifespan. However, the prevalent use of liquid organic electrolytes in commercial lithium-ion batteries poses safety concerns due to the presence of flammable and toxic compounds. Moreover, uncontrolled reactions between the liquid electrolyte and electrodes can lead to the formation of thick solid electrolyte interfaces (SEI), impacting battery performance. To address these challenges, researchers have proposed all-solid-state Li-ion batteries devoid of liquid organic electrolytes, utilizing non-flammable solid materials throughout. Solid electrolytes, as a critical component of these batteries, have garnered significant attention. Some of the desired properties of solid electrolytes for all-solid-state lithium batteries include high Li-ion conductivity, negligible electronic conductivity, wide electrochemical stability, low solid–solid interface resistance, and environmental friendliness. Achieving high lithium-ion conductivity in solid-state electrolytes involves optimizing various factors. One approach is through defect engineering and doping, particularly with high valence transition metals, [1,2] inducing structural changes verified through techniques such as X-ray diffraction and Raman spectroscopy. Additionally, optimizing grain size and grain boundaries can enhance ionic conductivity by altering the structure of the electrolyte,[3,4] as evidenced by Electrochemical Impedance Spectroscopy (EIS). It is noteworthy that while these structural modifications enhance ionic conductivity, they do not significantly impact electronic conductivity. Thus, by refining the structure and microstructure of the electrolyte, higher ionic conductivity can be achieved, contributing to the advancement of all-solid-state Li-ion batteries.

References:

1. Jiayao Lu, Ying Li, Yushi Ding.(2021). Li-ion conductivity and electrochemical stability of A-site deficient perovskite-structured $Li_{3x-y}La_{1-x}Al_{1-y}Ti_yO_3$ electrolytes. Mater.Res.Bull 133 (2021) 111019

2. Rui Gu, Jingrui Kang, Xu Guo, Jing Li, Kun Yu, Ruiping Ma, Zhuo Xu, Li Jin, Xiaoyong Wei .(2022). Microstructure and ionic conductivity of $Li_{0.5-x}La_{0.5}(Ti_{1-x}Nb_x)O_3$ solid-state electrolytes. J. Alloys Compd. 896 (2022) 163084,

3. Zeya Huang, Linhui Chen, Bing Huang, Biyi Xu, Gang Shao, Hailong Wang, Yutao Li, and Chang-An Wang.(2020). Enhanced Performance of $Li_{6.4}La_3Zr_{1.4}Ta_{0.6}O_{12}$ Solid Electrolyte by the Regulation of Grain and Grain Boundary Phases. ACS Appl. Mater. Interfaces 2020, 12, 56118−56125

4. Tom Lee, Ji Qi, Chaitanya A. Gadre , Huaixun Huyan, Shu-Ting Ko, Yunxing Zuo, Chaojie Du, Jie Li , Toshihiro Aoki , RuqianWu ,Jian Luo , Shyue Ping Ong & Xiaoqing Pan. (2023). Atomic-scale origin of the low grain boundary resistance in perovskite solid electrolyte $Li_{0.375}Sr_{0.4375}Ta_{0.75}Zr_{0.25}O_3$. Nat. Commun. (2023) 14:1940