# Exploiting the Ionic Conductivity of Solid-State Electrolyte ($Li_7La_3Zr_2O_{12}$) by High Frequency Limit

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Solid state electrolytes (SSE) holds the promise to bring high energy density and extremely safety to the next generation Lithium ion batteries owing to their high dimensional and electrochemical stability. The bottleneck of low ionic conductivity of SSE is reported to be overcoming soon with the introduction of superionic glass type $Li_{10}GeP_2S_{12}$ ($10^{-2}$ S/cm) [1] and garnet type $Li_7La_3Zr_2O_{12}$ ($10^{-3}$ S/cm) [2]. However, there are still unanswered questions that needs to be addressed first before going in to the next stage of SSE research. While the structure of the SSE and their basic mechanism of ionic conduction is studied more rigorously, the effect of different variables such as the temperature, relaxation time, and frequency limits are often ignored. Specifically, the effect of frequency limit is completely ignored in the previous works; different high frequency limit is adopted in different works (Fig. 1) - even for the same SSE by the same research group. More importantly, the frequency limit that is used to calculate the ionic conductivity is far above than the practical battery testing condition of 1kHz. In this work, we have shown that the ionic conductivity of the $Li_7La_3Zr_2O_{12}$ solid-state electrolyte is strongly dependent on the frequency limit during measurements, relaxation time, and temperature. With a growing number of solid-state battery and its electrolyte research, we believe that now it is the time to establish a common standard to measure ionic conductivity for the solid-state electrolyte in Li-ion batteries.

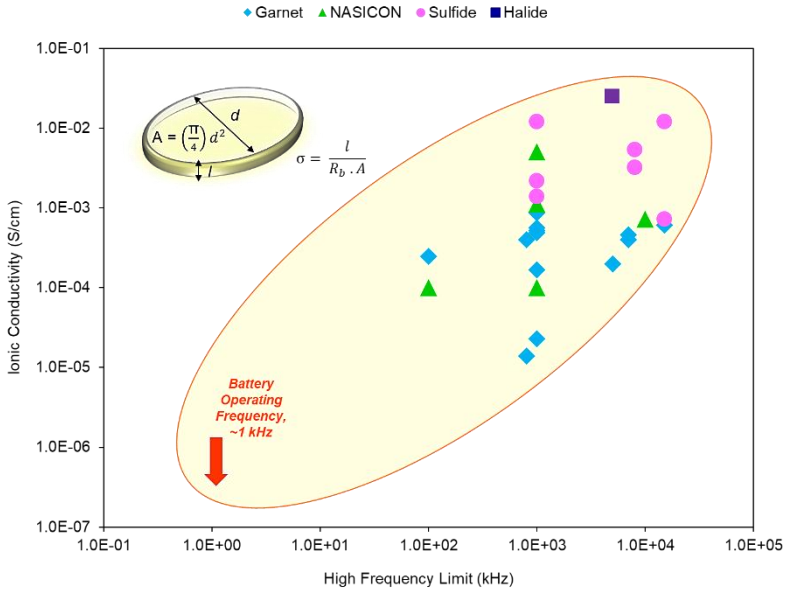


Figure 1 Variation in the high frequency limit in impedance spectroscopy measurements by different published works and their corresponding ionic conductivity.

**References:**

[1] N. Kamaya, K. Homma, Y. Yamakawa, M. Hirayama, R. Kanno, M. Yonemura, T. Kamiyama, Y. Kato, S. Hama, K. Kawamoto, A. Mitsui, Nat. Mater. 10 (2011) 682–686.

[2] V. Thangadurai, S. Narayanan, D. Pinzaru, Chem. Soc. Rev. 43 (2014) 4714