LiPO₃ based fast ionic conductor for solid state lithium secondary batteries

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According to Moore's law, stated in 1965, the number of components in an integrated circuit doubles every year which has now changed to every two year. The doubling of component density per integrated circuit is to achieve high performance with smaller size. Today electronic components are highly miniaturized and printable which offers flexibility to electronics with compactness. But the power source to drive the electronics has not acted according to Moore's law. The reason for this is the unavailability of high energy density solid state secondary batteries. In the present work superionic glassy/amorphous ionic conductors or solid electrolytes having benefits such as high ionic conductivity, negligible electronic conductivity, ease of fabrication, no grain boundaries, low activation energy for ionic conduction etc. have been studied in detail [1]. The glassy system, $[x(\text{AgI})(0.4-x)(\text{AgBr})]_{0.4}(\text{LiPO}_3)_{0.6}$ ($x = 0.1, 0.2$ and 0.3) has been synthesized by melt-quenching method using the brass twin rollers operated at 1500 rpm. The LiPO₃ is amorphous while melt quench systems show crystalline bright phase in micron range corresponding to AgI.

Figure 1: Complex impedance plots for (AgI)_{0.3}(AgBr)_{0.1}(LiPO₃)_{0.6} (a) 192 – 232 K and (b) 242 – 282 K

With increase in AgI content, the conductivity increases maximum up to $\sim 10^{-3}$ S/cm in (AgI)_{0.3}(AgBr)_{0.1}(LiPO₃)_{0.6} system from 10^{-11} S/cm (pure LiPO₃) at room temperature. Figure 1 shows Complex impedance plots for (AgI)_{0.3}(AgBr)_{0.1}(LiPO₃)_{0.6} at different temperatures. Electrical conductivity as a function of frequency for (AgI)_{0.3}(AgBr)_{0.1}(LiPO₃)_{0.6} is shown in Figure 2. Ionic transport number of melt quenched system came ~ 1 (0.9998) which is ideal for ionic conductors. Contribution of the mobile ions to ionic conductivity in these solid electrolytes is analyzed using the Summerfield scaling approach, master curve shows dependency on temperature which may be due the both ion contributing to ionic conduction [2].

Figure 2: Electrical conductivity as a function of frequency for (AgI)_{0.3}(AgBr)_{0.1}(LiPO₃)_{0.6} (a) 192 – 272 K and (b) 282 – 352 K.

References

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