Ionic conductivity of lithium lanthanum niobate polycrystals: Electrochemical impedance spectroscopy analysis

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All solid-state lithium ion batteries are considered to be the next generation energy storage devices [1]. Some oxide based lithium ion conductors are good candidates for solid electrolytes since they show such high ionic conductivities at room temperature [2]. Lithium lanthanum niobate ((La,Li)NbO_3:LLNbO) attracts attention as a chemically stable solid-state electrolyte [3]. Solid electrolytes are commonly used in the form of polycrystals and total ionic conductivity is strongly suppressed by the grain boundaries [4]. Although several characterizations have been performed on LLNbO, electrical characteristics of LLNbO grain boundaries are still not well established.

In this study, we have synthesized LLNbO polycrystals and investigated the ionic conductivity by using electrochemical impedance spectroscopy. We evaluated respective ionic conductivities of the bulk and the grain boundary by fitting the impedance spectra with random walk Metropolis Hastings algorithm. At room temperature, the ionic conductivity of LLNbO grain boundary is estimated to be $(5.9 \pm 1.0) \times 10^{-5}$ S/cm, which is evidently larger than that of the bulk ($(1.40 \pm 0.04) \times 10^{-5}$ S/cm). We also measured the activation energy of the bulk and the grain boundary by investigating the temperature dependence of ionic conductivity. The activation energy of the grain boundary is 0.23 ± 0.01 eV, which is distinctly smaller than that of the bulk (0.38 ± 0.01 eV). This result suggests that lithium ion conduction properties of the LLNbO grain boundary behave differently from other oxide conductors. A part of this study was supported by NEDO-RISING2 project.

References:

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