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Structural study of sulfide glassy electrolytes for all-solid-state batteries

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Sulfide glass ceramics are of interest for use as solid electrolytes in lithium ion batteries, because the realization of an all-solid-state battery will enable the miniaturization of battery packages and reduce safety issues. In general, the crystallization of glassy materials results in a decrease in the conductivity, although it increases in a few sulfide glasses owing to the crystallization of a highly conductive new phase. Significant progress has been made so far with the discovery of numerous sulfide crystalline compounds with high ionic conductivities such as $Li_7P_3S_{11}$, $Li_{10}GeP_2S_{12}$, $Li_7P_2S_8I$ and $Li_{10}SnP_2S$. Their conductivities are higher than those of the corresponding sulfide glasses. Recently, we reported that $75Li_2S$-$25P_2S_5$ glass in the binary Li_2S-P_2S_5 system with strongly polarized sulfur has high ionic conductivity. In the sulfide glasses as presented here, an interesting improvement in the conductivity is observed during annealing, which appears in the glassy phase. In this presentation, we report the local glassy structure with a mixture of glass and crystalline phases by using synchrotron X-ray pair distribution function (PDF) analysis. The differential pair distribution function is utilized as a methodology for the mixed materials in our work to extract the glassy structure in the $75Li_2S$-$25P_2S_5$ sulfide glass ceramic. This method quantitatively reproduced the fraction of mixed phases, which was in agreement with the result of NMR. The extracted glassy structure exhibited no changes during the annealing treatment. Owing to the crystallization of the majority phase, the ionic conductivity in this glass decreased after crystallization. We observed the formation of a nanocrystalline phase in the diffraction pattern obtained during the annealing. Thus, our present finding of minority component is expected to lead to further understanding for the development of solid electrolytes with high ionic conductivity.

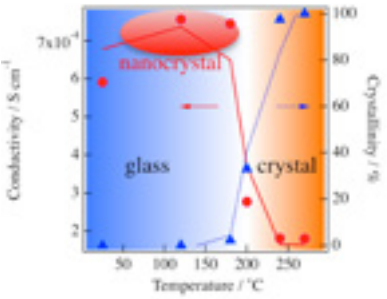

Figure-1: Crystallinity obtained from the pair distribution function under each annealing condition and the lithium ionic conductivity.

Biography

Koji Ohara has received his PhD in Condensed Matter Chemistry and Physics from Kyushu University of Japan, working with Prof. S. Takeda. He then did his Post-doctoral research with S. Kohara at Japan Synchrotron Radiation Research Institute (JASRI), where he studied elemental specific pair distribution function (PDF) analysis using anomalous X-ray scattering for disordered materials. After two years at JASRI, he moved to the position of Research Assistant Professor at Office of Society-Academia Collaboration for Innovation of Kyoto University in 2012. He has worked on structural studies of electrolytes in lithium ion batteries. He has been working as a Researcher at JASRI since 2015.

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