Unique Vibrational Excitations in Superionic Conducting Glass

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One of the most famous unsolved question in science is as follows; *Why do the disordered structures such as a superionic conducting glass show high ionic conductivity?* Superionic conducting glasses are also technologically important materials, because they can play a prominent role in many solid electrolyte applications including batteries, sensors, and displays[1]. In this study, the phonon dynamics in low energy region for $(AgI)_x(Ag_2S)_x(AgPO_3)_{1-2x}$ glass systems is investigated by inelastic neutron scattering measurement using a TOF chopper spectrometer.

We have obtained the dynamical structure factor, $S(Q, E)$, for $(AgI)_x(Ag_2S)_x(AgPO_3)_{1-2x}$ glasses with $x = 0$ (insulator phase, $\sigma \sim 10^{-7}$ S/cm at RT) and 0.33 (superionic phase, $\sigma \sim 10^{-2}$ S/cm at RT). The integrated intensities of $S(Q, E)$ over Q for both $x = 0$ and $x = 0.33$ samples are given in Fig. 1. These data were measured at room temperature and corrected by Bose factor. The intensity in low energy region (below 5 meV) of $x = 0.33$ sample is much larger than that of $x = 0$ sample.

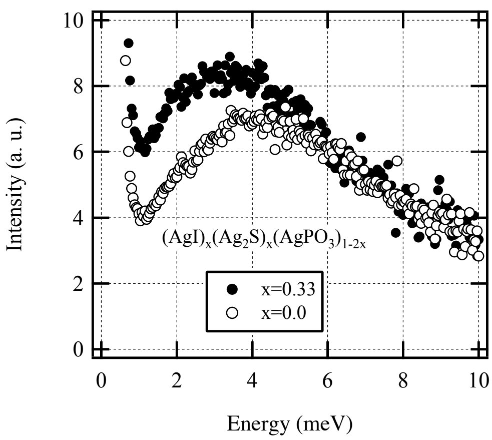

Figure 1: $S(Q, E)$ integrated over Q for $(AgI)_x(Ag_2S)_x(AgPO_3)_{1-2x}$ glasses with x=0.00 and 0.33. Both data were taken at room temperature and corrected by Bose factor.

In order to clarify the origin of an excess intensity in superionic phase glass, the Q dependences of $S(Q, E)$ for both samples are compared in Fig. 2. An excess intensity of $x = 0.33$ sample is undoubtedly caused by the unique dynamics in the Q range beyond 1.8 Å^{-1}. We can also observe the peak profile at around $Q = 2.2$ Å^{-1} only in the $x = 0.33$ sample. Similar result is also confirmed in another superionic glass $(AgI)_{0.5}(AgPO_3)_{0.5}$[2]. A peak at around $Q = 2.2$ Å^{-1} should be related to a distance in real space by $2\pi/Q = 2.8$ Å, which can be assigned to Ag-Ag bond length. These results suggest the *coherent* Ag-Ag correlations in low energy region occur only in the superionic phase glass, and should provide clues to understanding high ionic conductivity in superionic conducting glasses.

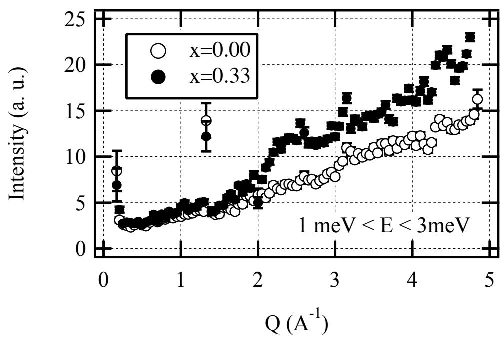

Figure 2: Q dependences of $S(Q, E)$ integrated from 1 meV to 3 meV are plotted for the $(AgI)_x(Ag_2S)_x(AgPO_3)_{1-2x}$ glasses with x=0.00 and 0.33.

References

[1] M. Balkanski, Physics World **3** (1990) 29.

[2] M. Nakamura *et al.*, (to be published).