Phonon excitations in an anisotropic metaphosphate glass

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Abstract

Usually, inorganic glasses are structurally and elastically isotropic unlike organic glasses, and thus, an azimuthal angle dependence of momentum transfer in scattering experiments is totally meaningless. However, Inaba et al. [1] recently found that (Li2O)12.5(Na2O)12.5(K2O)12.5(Cs2O)12.5(P2O metaphosphate glass shows an entropic shrinkage by heating beyond its glass transition temperature, Tg. The experimental findings are as follows. The glass rod was stretched at a temperature higher than Tg and cooled down to room temperature. When it was again heated up to a temperature higher than Tg, the rod was shrunk automatically and endothermically in the longitudinal direction by a large value of about 35%, while it was expanded in the lateral direction so as to keep the total volume of the rod. They measured several anisotropic properties, such as birefringence, polarized Raman spectra, x-ray diffraction [1], and elastic constants [2], and discussed the origin of such an interesting anisotropic behavior of this glass in the sense of microscopic structure.
To clarify the mechanism of the entropic shrinkage for this metaphosphate glass, an anisotropy of the microscopic elastic properties is a key knowledge. For this, inelastic x-ray scattering (IXS) is very powerful since the small size of the x-ray beam matches the diameter of the sample rod of sub mm. We have carried out high-resolution IXS measurements at BL35XU of the SPring-8 by changing the sample rod directions, perpendicular and parallel to the x-ray scattering plane. The obtained IXS signals exhibit at least two phonon excitation modes, and those with the rod direction perpendicular to the x-ray polarization are slightly larger than those with parallel. The further data analyses are now in progress.

S. Inaba et al., Nature Mater. 14, 312 (2015).
J. Endo et al., J. Am. Ceram. Soc. 98, 2767 (2015).

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