In-situ observation of first sharp diffraction peak for amorphous SiO_2 under high pressures

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Introduction

Permanent densification after applying high pressure is a peculiar phenomenon for glassy materials. In a short range scale, the densification is explained by a decrease of bond angle between SiO_4 structural units. Ultimate density and properties of densified glass depend on the history of applied pressures and temperatures. This means that the intermediate range structure is changed during the densification. In last decade, the intermediate range structure of SiO_2 or GeO_2 glass has been studied by the first sharp diffraction peak (FSDP) of structure factor $S(Q)$. In this paper we report an in-situ observation of FSDP in x-ray diffraction for silica glass under pressure.

Experimental

We have performed energy-dispersive x-ray diffraction measurements for silica glass at room temperature on the BL04B1 at SPring-8. White x-ray beam was introduced into high pressure and high temperature generation system equipped with a Ge solid state detector(SPEED1500). The instrument has been described elsewhere in detail[1]. Diffraction angle, 2θ, was fixed at 3.5 degree. X-ray energy range detected was 2-170 keV. A bulk synthetic silica glass (Sumikin Quartz Products, Inc.) was used as a sample.

Results and discussion

Figure 1 shows x-ray diffraction intensities of silica glass before applying pressure, under 15 GPa and after releasing pressure. The FSDP was observed at 1.5 A^{-1}, but the second peak at around 3 A^{-1} was hard to recognize. The FSDP of silica glass became broad and shifted from 1.5 to 1.9 A^{-1} with increasing pressure. The FSDP shifted to low

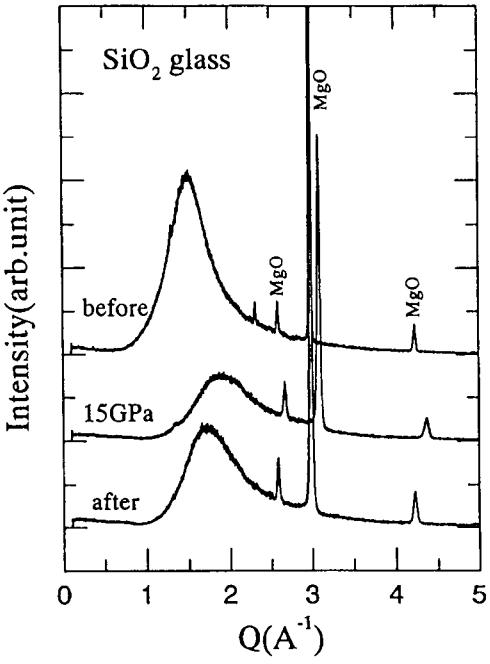

Figure 1 X-ray diffraction pattern of silica glass under high pressure.

Q side and became narrow with releasing pressure. However, the position and width of FSDP were not recovered entirely even after the release of pressure. On the other hand, they were fairly reversible in a case of pressing to 8 GPa. The correlations, Si-O, O-O and Si-Si, which contribute to the FSDP, are shifted to lower distances by different amounts under pressure. This might lead to the shift and broadening of the FSDP.

[1] S. Urakawa et al., SPring-8 PROJECT SCIENTIFIC PROGRAM 1998, No.5, p.65