Effect of heating on the first sharp diffraction peak for amorphous SiO_2 under high pressure

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Introduction

Permanent densification of glassy material is of great interest for understanding glass structure. 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 certain differences exist in the intermediate range structure. In last decade, the intermediate range structure of SiO_2 glass has been studied by the first sharp diffraction peak (FSDP) of structure factor $S(Q)$. Previously we studied the FSDP of silica glass at room temperature under pressures (1997B0180ND-np)[1]. In the present report, we have observed the FSDP during heat treatment under high pressures.

Experimental

We performed energy-dispersive x-ray diffraction measurements for silica glass on the BL04B1 at SPring-8. White x-ray beam was introduced into a high pressure and high temperature generation system equipped with a Ge solid state detector (SPEED1500). The instrument has been described elsewhere in detail[1]. The diffraction angle, 2θ, was fixed at 3.5 degree. X-ray intensities were detected in the x-ray energy range from 2 to 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 at room temperature, 300°C and 600°C under 15GPa. The FSDP observed at 1.5 $Å^{-1}$ became broad and shifted to 1.9 $Å^{-1}$ with increasing pressure. The peak position of the FSDP shifted toward higher Q values and the width decreased with increasing temperature up to 300°C. There was little difference between the positions at 300°C and 600°C. The correlations which contribute to the FSDP such as Si-$O_{2nd,3rd}$, O-$O_{1st,2nd,3rd}$ and Si-$Si_{2nd,3rd}$ are shifted to lower distances by different amounts under pressure. This might lead to the shift of the FSDP. However, the reason of narrowing in FSDP during the heat treatment is not clear yet.

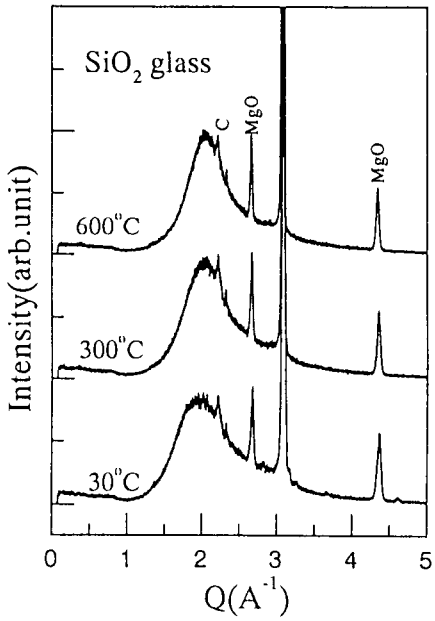

Figure 1 X-ray diffraction pattern of silica glass during heat treatment under 15GPa.

[1] N. Kitamura et al., submitted to SPring-8 report.
[2] S. Urakawa et al., SPring-8 PROJECT SCIENTIFIC PROGRAM 1998, No.5, p.65