Solubility of noble gas in silica melt under high pressure

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INTRODUCTION

Reaction of noble gas with silicate melts under high pressure plays important role for understanding the evolution of the Earth. Particularly important is the solubility of noble gas into silicate melt under pressure, which becomes crucial for discussing the origin of the Earth's atmosphere, and many studies have been carried out up to about 10 GPa. Some studies were made using multi-anvil experiment (MA), which indicate that the solubility increases with pressure and saturates above about 5 GPa. Some other studies obtained by using diamond-anvil cell (DAC) reported that the solubility drops considerably above about 5 GPa, which is completely inconsistent with the MA experiment. The number of DAC experiment is very limited so far and the reliability of the result is not yet clear.

In the present study, we have measured the solubility of Ar into SiO2 melt under pressure up to about 15 GPa using laser-heated diamond anvil cell and the reliability of the results were checked carefully.

EXPERIMENTS

DAC combined with CO2 laser heating system was used for high pressure and high temperature experiments. A small chip of nonhydrous single crystal of silica was placed in the sample chamber of DAC, together with a ruby pressure marker. The chamber was filled with argon gas of 150 MPa. After increasing the pressure to a desired value at room temperature, CO2 laser light was irradiated to the silica. The laser power was increased gradually until the silica melts and forms a droplet. After keeping the droplet for about one second, the temperature was dropped by stopping the irradiation and the sample was quenched to room temperature. No temperature measurements were made during heating and the pressures were determined at room temperature before and after the heating using ruby fluorescence technique. Experiments were made from 1.5 GPa to about 15 GPa. In this pressure range, the melting temperature of silica is higher than that of argon and the reaction occurs between two melts of silica and argon. The recovered silica sample was examined by Raman spectrum to check whether it has turned into a complete glass or partially crystallized. Further analysis was made using SEM(EPMA) and mass spectrometer for texture observation and solubility measurements.

RESULTS AND DISCUSSION

It was proved that by adopting proper experimental technique, a complete glass of silica can be formed up to about 15 GPa. The Raman spectrum of silica glass changes systematically with increasing pressure, which may result from the change of the structure and density of glass. Preliminary results of the EPMA analysis indicate that the argon concentration is uniform within the glass and the solubility increases with increasing pressure until it reaches to a critical value. This result is inconsistent with the previous report using DAC. Further analyses to determine the absolute value of solubility, effect of crystallization, and isotope ratio, are in progress using mass spectroscopy.