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Density measurements of liquid FeS at high pressure using X-ray absorption image

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Introduction

Iron sulfide (FeS) has been thought to be one of the major constituents of the cores of terrestrial planets. Thus, density of liquid FeS at high pressure is fundamental to evaluate the internal structure of planets and their satellites. Here we report new experimental results on density of liquid FeS at 10 GPa using X-ray absorption image.

Experimental

Pressure was generated by the KAWAI-type 6–8 double stage system using the high-pressure apparatus, MAX-III installed at beamline BL14C2, KEK-PF. Tungsten carbide anvil cubes with a 5 mm truncated edge length were used as the second stage anvils. Cylindrical sapphire single crystal and boron nitride was used as a sample container and the composite material of $hBN+TiB_2$ was used as the heating substance. Temperature was monitored using a $W_{97}Re_3$-$W_{75}Re_{25}$ thermocouple. Pressure was calculated from the volume of the unit cell based on the equation of state of platinum.[1] Starting material was FeS powder.

The radiography system consists of a YAG:Ce crystal as a fluorescent screen and a cooled CCD camera (BITRAN BS-40L). The energy of the monochromatic X-ray beam was 30 keV. Transmitted X-rays through the sample were converted to a visible light at the fluorescent screen. This radiography image is based on the intensity of the transmitted X-rays(Fig. 1). The contrast of the image depends on the difference of absorption between the sample and assembly parts. Based on the linear conversion from X-ray intensity to image brightness and the Beer-Lambert law, the image Brightness B(z) in the sample area is expressed as

$$B(z) = I_0 K \exp\{(-\mu\rho t)_{FeS} + (-\mu\rho t)_{Al_2O_3} + (-\mu\rho t)_{environment}\}$$

where I_0 is the intensity of the incident X-ray, K the coefficient of X-ray intensity to radiograph brightness conversion, μ and ρ the mass absorption coefficient and density. Therefore, the sample density can be obtained by fitting above equation. The image was integrated over 45 pixels in a horizontal direction to obtain the brightness.

Results and Discussion

Fig.2 shows the temperature dependence of the brightness profiles (B(z)). The bottom of the profile depends on the sample absorption and the density and it becomes shallower with increasing temperature. This result implies that the density of FeS decreases with increasing temperature. The density reduction between 1800 °C and 1900 °C indicates melting of FeS. The density jump between 1400 °C and 1500 °C may be explained by a solid state phase transition in FeS[2].

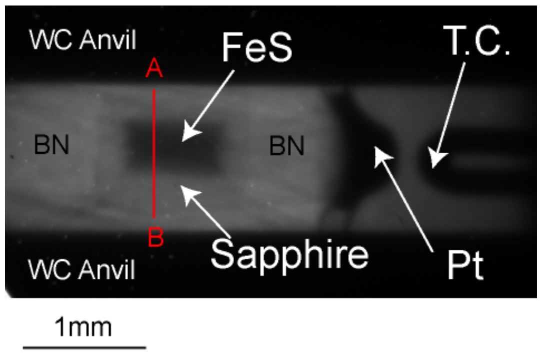

Fig. 1 An X-ray absorption image at 10 GPa and 700 °C. Exposure time was 70 seconds. A red line corresponds to the profile B(z) shown in Fig. 2.

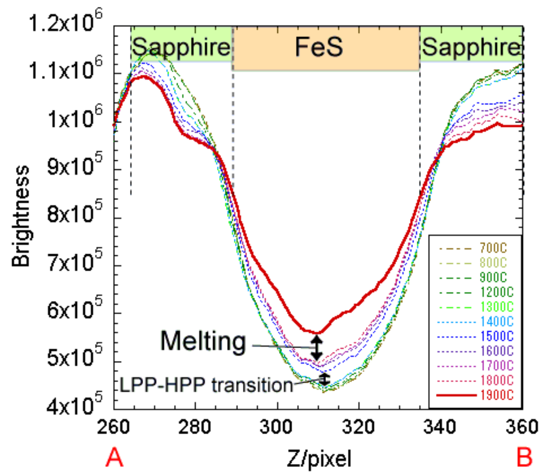

Fig. 2 Temperature dependence of the observed brightness integrated over 45 pixels in a horizontal direction (B(z)).

References

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