Density measurements of liquid Fe-S at high pressure using in-situ synchrotron sink/float method

K Keisuke Nishida, Eiji OHTANI, Ryuji TATEYAMA, Yuki SHIBAZAKI, Akio SUZUKI, Takumi KIKEGAWA

1Tohoku University, Sendai, Miyagi 980-8578, Japan
2KEK-PF, Tsukuba, Ibaraki 305-0801, Japan

Introduction
Density of liquid Fe-S is a fundamental physical property in order to estimate the sulfur content in the Earth’s outer core based on the density deficit in the core. Previous works (e.g. [1]) estimated the light element content in the core assuming ideal-mixing behavior between iron and light element, i.e., neglecting their excess volumes. The excess molar volume ($V_{ex}$), which is defined as the difference volume subtracting ideal volume from actual volume of liquid Fe-S was reported to be large and to have a negative value [2], suggesting that the Earth’s outer core may contain more sulfur than the previous estimates. However, pressure effect on the $V_{ex}$ of liquid Fe-S has never been reported. In order to investigate the pressure effect on $V_{ex}$, we measured the density of liquid Fe-S at 0.5 GPa and 1650 °C using in-situ synchrotron X-ray sink/float method.

Experimental
Pressure was generated by the KAWAI-type multi anvil press (MAX-III) installed at beamline AR-NE7. Starting materials were mixtures of Fe and FeS powders. We used composite density markers, which is composed of a Pt core and Al$_2$O$_3$ tube and rids [2]. The composite marker can be made with different density markers by selecting different volumetric ratios between the Al$_2$O$_3$ mantle and the Pt core. We monitored the movement of the composite marker using X-ray radiography system [3] in situ. Pressure was evaluated by the unit cell volume of h-BN capsule [4]. Therefore, in-situ synchrotron X-ray sink/float method can provide more accurate density than ex-situ sink/float method.

Results and Discussion
Figure 1 shows a typical successive X-ray radiographic image of sinking density marker. When the sample started melting, the marker was sinking down into the bottom of the capsule, indicating the sample density is lower than that of the marker. Figure 2 shows the density of liquid Fe-S as a function of sulfur content. Downward and upward triangles denote the density of the sinking and floating markers. The sample density is in the range between upward and downward triangles. The dashed curves represent the fitted curve assuming regular solution. Considering pressure effect, this trend is consistent with that at 4 GPa [2] and 0.1 MPa [5]. Figure 3 shows the $V_{ex}$ as a function of Sulfur content. The negative $V_{ex}$ of liquid Fe-S decreases with increasing pressure. This result may suggest the excess molar volume of liquid Fe-S at the pressure of the Earth’s outer core might be small and negligible.

References

* nishidak@s.tohoku.ac.jp