Shock compression of heated iron including light elements using compact oblique two-stage light gas gun

Toru Sakurabayashi[1]; Eiji Ohtani[2]; Kazuyoshi Takayama[3]; Akio Suzuki[4]

[1] Mineralogy, Petrology and Economic Geology, Faculty of Sci., Tohoku Univ.; [2] Institute of Mineralogy, Petrology, and Economic Geology, Tohoku University; [3] Shock Wave Research Center, IFS, Tohoku Univ.; [4] Faculty of Science, Tohoku Univ.

Seismological observation and high pressure experiments demonstrated that the density of the Earth's outer core is 10% lighter than that of pure iron, which indicates that the core consists mainly of an iron-nickel liquid alloy with light elements (e.g. H, C, O, Si, S). Physical properties of liquid iron including light elements are important to consider the structure, compositional convection and formation process of the Earth's core.

Sanloup et al. (2000, 2002, and 2004) measured densities and structural properties of Fe-S and Fe-Si liquid alloys at high pressure and high temperature (-6 GPa, 2300 K) by X-ray absorption method and X-ray diffraction. They reported that sulfur strongly modifies the local structure of liquid iron whereas silicon has only small structural effects. Balog et al. (2003) also investigated the equation of state of molten Fe-10wt%S by sink/float method. They measured the density up to 20 GPa and up to 2123 K. However, the pressure ranges of these experiments are much lower than that of the Earth's outer core so that it is necessary to perform the experiments in the iron-light elements system at higher pressure.

In order to study the properties of liquid iron containing light elements at higher pressure, we have improved Compact Oblique Two-Stage Light Gas Gun (at the Institute of Fluid Science, Tohoku University) for compressing samples which is heated in advance. For heating the samples, a 20 kW high-frequency induction heater was installed in the light gas gun. Since the electric power required to melt a pure iron sample is calculated to be 15.2 kW, the power of the induction heater is enough to melt the samples.

In general, an induction heater increases the temperature of the sample as a function of the sample's resistivity, generating eddy current in its interior. However, each light element has different effect on the resistivity of iron therefore the heating efficiency is also quite different. Therefore, the induction heater heats a molybdenum container of the sample and then the sample is heated by thermal conduction from the container. This heating system enables us to use several light elements for the experiments.

We have been improving the ignition system of Compact Oblique Two-Stage Light Gas Gun for safer and smoother experiments. Discharge experiments without induction heating system will be performed in advance. We will report the latest experimental result.