Melting experiments of Fe-FeO system under high pressure and temperature using Laser heated diamond anvil cell

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Seismic wave observation indicates that the Earth''s outer core is liquid state and the wave velocity is lower than that of a pure iron under the conditions corresponding to the Earth''s core. For the explanation, it is necessary that the outer core contains small amount of light elements. The incorporation of light elements into pure iron could decrease the melting temperature in the Earth''s core (Eutectic effect). There are lots of candidates for light elements in outer core, such as H, C, O, Si, and S. In this study, we have selected oxygen as possible light element in the core and studied the melting relationship between Fe (large dominant which consist the core) and FeO (host-mineral for oxygen) under high pressures and temperatures.

Diamond anvil cell was used for high-pressure experiments. Pressures were determined by Ruby fluorescence method. Samples were heated by a Nd:YAG laser and temperatures were measured by sample thermal radiations from heated spots. We performed experiments at 16GPa and 1700-2400K to compare with previous results of MA experiments. After the laser heating, the sample was recovered at ambient conditions and polished the reaction region for SEM observation and Wave Dispersive X-ray Spectroscopy (WDS) analysis. One of recovered samples was thinned by focus ion beam (FIB) milling, which can mill the desired region in the nm scale. We observed textures of the thinned foil by Transmission Electron Microscope (TEM) and analyzed the chemical composition in the nm-scale area by Electron energy loss spectroscopy (EELS), which has enough high energy resolution to decompose the O-K edge peak from Fe-L edge peak.

To overcome the problems in LHDAC, we tested many sample assemblages. As the result of them, we concluded that an assemblage sandwiched a FeO with two Fe foils can generate a stable high temperature field and is easy to identify the textural change in the heated region. From the texture of recovered samples we preliminary concluded that the central portion of the heated region consisted of Fe-rich liquid (Lm)) and FeO-rich liquid (Lo) and the margin of the heated region consisted of solid FeO and Fe-rich liquid at temperature around the eutectic temperature. From Results of WDS analyses of Lm regions, significant amount of Oxygen was not detected. Moreover, result of EELS analysis also demonstrated that negligible amount of oxygen was dissolved in Lm regions, although small amount of Oxygen was detected in some parts of them. This result is not consistent with the previous studies of MA at the same conditions. The possible reasons are as follows: stability of the high temperature, spatial scale of the liquid region and the duration time of laser heating. We are now performing some experiments in order to clarify them.

In summary, we developed a new combined technique with LHDAC and TEM-EELS to generate a stable high temperature field in time and space and to evaluate the nm-scale textures in TEM observations and EELS analyses of FIB-milling samples. Although we couldn''t clarify the difference between our results and previous results in the melting relation on a Fe-FeO system at 16 GPa, this combined technique is a powerful tool to study chemical reactions of constitution materials of the Earth''s interior at extremely high pressures corresponding to conditions from mantle to core.