Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SIT06-P05 Room:Convention Hall Time:May 25 18:15-19:30

Melting relationships in the Fe-S-Si system at high pressure and temperature

SAKAIRI, Takanori[1*] ; OHTANI, Eiji[1] ; SAKAI, Takeshi[2] ; KAMADA, Seiji[1] ; SAKAMAKI, Tatsuya[1] ;
HIRAO, Naohisa[3]

[1]Graduate school of Science, Tohoku Univ., [2]Geodynamics Research Center, Ehime Univ., [3]JASRI

It is widely accepted that the Earth's core is mainly composed of iron and contains light elements to account for its density deficit. Alloying with light elements significantly affects the physical properties of iron and depresses its melting temperature. Therefore, the melting relation of the Fe-light elements system is the key to clarify the thermal structure of the Earth's core. Although there are many candidates for light elements in the core, sulfur and silicon are considered to be the major light elements. Some geochemical models predicted that sulfur and silicon could be present not only in the core of the Earth but also in the core of other terrestrial planets such as Mars and Mercury. In spite of the importance of the effect of sulfur and silicon on the physical properties of iron, there are few previous reports and the melting relationships in the Fe-S-Si system at high pressure were not revealed in details. To better understand the properties of the planetary cores, we investigated the melting relationships of the Fe-S-Si system under high-pressure conditions.

Here, we report the phase relationships and melting temperatures in the Fe-S-Si system up to 60 GPa. Melting experiments were performed in the pressure range of 20-60 GPa and the temperature range of 1300-2500 K using a double-sided laser-heated diamond anvil cell combined with X-ray diffraction technique. The sample compositions used in this study were $Fe_{80.1}S_{12.7}Si_{7.2}$ (Fe-8wt.%S-4wt.%Si) and $Fe_{74.4}S_{18.5}Si_{7.1}$ (Fe-12wt.%S-4wt.%Si). In situ X-ray diffraction experiments were conducted at the BL10XU beamline of the SPring-8 facility. The melting detection was based on disappearance of the X-ray diffraction peaks of the sample. On the basis of X-ray diffraction patterns, we confirmed that iron-silicon alloy which hcp and fcc structure and Fe_3S are stable phases under subsolidus conditions. Because of dissolution of silicon into iron, the boundary of fcc and hcp phase of this study shifts towards higher pressure compared to that of pure iron. Both solidus and liquidus temperatures are significantly lower than the melting temperature of pure Fe and increases with pressure in this study. In addition, the present melting curve is lower than the melting temperature of the Fe-Si system reported by Asanuma et al. (2010) and slightly lower than the eutectic temperature of the Fe-Fe_3S system (Kamada et al., 2012) and that of the Fe-O-S system (Terasaki et al., 2011). In order to draw the melting curve as a function of pressure, we fitted the present results using the Simon's equation. The obtained fitting parameters are T_{mR} =1277(6), a=116.1(21) and c=1.06(2) for the solidus and T_{mR} =1582(13), a=127.9(48) and c=1.00(3) for the liquidus. Because sulfur and silicon are the candidates for the light elements in the cores of Earth, Mars, and Mercury (e.g., Malavergne et al., 2007), the present results on the solidus and liquidus temperatures can be applicable to the core formation processes in the Earth, Mars, and Mercury.

Keywords: Core, Melting relationships, Diamond Anvil Cell, Light elements, Fe-S-Si system