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Phase stability of subsolidus phases in Fe-Ni-S system at the core pressure

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It is considered that the Earth's core is composed of iron and small amounts of light elements based on comparison between the density of pure iron and that of the Earth's core (Birch, 1952). Sulfur is one of the major candidates of the light element due to its high solar abundance, formation of iron alloys easily, and existence in iron meteorites as troilite, FeS. In the Fe-S system, Fei et al. (2000) reported that Fe_3S phase (Tetragonal structure, space group: I-4) is stable as subsolidus phase at pressures above 21 GPa. It is reported that Fe_3S phase is stable up to 80 GPa and 2500 K (Seagle et al., 2006). On the other hand, an $(Fe,Ni)_3S$ phase has been identified up to 4 0 GPa and 1520 K based on the analysis of the recovered sample (Stewart et al., 2007), however, the crystal structure and its stability of $(Fe,Ni)_3S$ under the high pressure and temperature conditions are still unknown. On the other hand, Small amount of sulfur can dissolve into metallic phase (e.g., Tsuno and Ohtani, 2008), S-bearing Fe-Ni alloy coexists with $(Fe,Ni)_3S$ at high pressure. Here we report the phase stability of the S-bearing Fe-Ni alloy and $(Fe, Ni)_3S$ at core pressure condition.
S-bearing Fe-Ni alloy and $(Fe,Ni)_3S$ was synthesized at 21 GPa and 1173 K using a multi-anvil apparatus. Diamond anvil cell was used for high pressure experiments. Samples were placed in the sample chamber with sodium chloride pressure medium. We performed in situ powder diffraction experiments at BL10XU in SPring-8. The composition of S-bearing Fe-Ni alloy was Fe-9.6wt.%Ni -1.6wt.%S determined by an electron probe microanalyzer. S-bearing Fe-Ni alloy has a bcc structure at ambient pressure and unit cell parameter was a=2.951 A, V=25.71 A^3. The bcc phase transform to a hcp structure above 19 GPa which is stable up to 339 GPa. $(Fe,Ni)_3S$ with tetragonal structure was observed up to 141 GPa without any phase transition.

Keywords: Diamond anvil cell, core, Fe-Ni-S