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Melting relationships of the Ni-NiS system under pressure and the stability field of the Ni3S

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The planetary core consists of iron-nickel alloy and lightening elements, such as sulfur and silicon. Study of melting relations of iron alloys is of important to understand formation, evolution, and the present state of the planetary core. An addition of nickel to iron affects significantly the phase relations of iron alloys. It is, therefore, reasonable to investigate the phase relations of the Ni alloys under pressure. Here, we report the results of quenching experiments and synchrotron radiation experiments on the phase relations of the Ni-NiS system up to 10 GPa.
Melting relations of the Ni-NiS system at 10 GPa were studied by quenching method using a KAWAI type high pressure apparatus at Okayama University, and the phase relations of the Ni-NiS system were investigated by synchrotron based in-situ observation using the MAX80 system at Photon Factory, at the pressure range from 1 to 10 GPa.
At 10 GPa, the system Ni-NiS is a eutectic system with the intermediate compounds, the Ni_3S and the Ni_3S_2. The Ni_3S is a new phase and it is an isostructural with Fe_3S which has a Fe3P-type structure with a tetragonal symmetry (space group I-4). The Ni3S is stabilized above 5 GPa and it melts incongruently into Ni and liquid. Although the stability filed of the Fe_3S is limited to the higher pressure than 18 GPa, solid solution of the Ni_3S into the Fe_3S might extends its stability field to the lower pressure. The eutectic temperature of the Ni-NiS system is lower than that of the Fe-S system by at least 500 K at this pressure range. Therefore the addition of Ni to the Fe-S system lowers significantly its melting temperature, which is consistent with the previous studies. Although the eutectic point of the Ni-NiS system gradually moves towards Ni-rich with pressure, its location is confined between Ni_3S and Ni_3S_2. The eutectic point of the Fe-FeS system is rich in sulfur relative to the Ni-NiS system below 10 GPa, but it becomes sulfur less composition with pressure and locates the Fe-rich side of Fe_3S above 20 GPa. Thus the addition of Ni can affects significantly not only the temperature but also the composition of the eutectic point of the Fe-FeS system. We will also discuss the physical properties of the Ni_3S determined by synchrotron experiments.

Keywords: planetary core, melting of iron alloy, Fe-FeS, Ni3S