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The crystal structure of the Earth's inner core

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Determining the crystal structure of the Earth's inner core is a key piece of information required to decipher the complex seismic structures observed there. Although recent static ultrahigh-pressure and -temperature (P-T) experiments (Tateno et al. 2010) revealed that iron adopts the hexagonal closed-packed structure up to 377 GPa and 5700 K under inner core P-T conditions, the effect of impurity element(s) on the stable crystal structure still remains controversial. We have studied stable form of Fe-10wt.%Ni and Fe-9wt.%Si in the inner core conditions by synchrotron X-ray diffraction measurements in-situ at ultrahigh P-T in a laser-heated diamond-anvil cell at BL10XU, SPring-8.

We found that hcp phase of Fe-Ni alloy is stable throughout the experimental conditions to 340 GPa and 4700 K, which is evident from the spotty diffraction ring (Tateno et al., 2012). Any other phases such as body-centered cubic (bcc) or face-centered cubic (fcc) phases was not observed. Similarly, we found wide stability of hcp-structured Fe-Si alloy. Pressure-volume data of hcp Fe-9wt.%Si to 305 GPa was collected after laser annealing at 1300-3000 K depending on pressure, which was fitted to Vinet's equation of state. Subsequently, phase relations of Fe-Si alloy was investigated from 320 GPa at 2000 K to 410 GPa at 5900 K. Appearance of diffraction peak from bcc in addition to hcp was observed above 5000 K, indicating decomposition to the mixture of Si rich bcc and Si poor hcp phase. This shows limited solubility of Si in hcp being close to 9wt.% in the inner core conditions. Si content in the inner core has been proposed to be 3-5wt.%, which is much less than maximum solubility in hcp phase (e.g., Alfe, 2002; Badro et al., 2007). If silicon is major light element in the inner core, Fe-Ni-Si alloy crystalizes to an hcp structure at inner core conditions.

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