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Exploration of the Earth's inner core using synchrotron x-ray radiation

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1. Introduction

The seismic model, the Preliminary Reference Earth Model (PREM) [1], provides the profiles of sound velocity and density as a function of depth. Comparing the model with laboratory high-pressure experiments, pure iron cannot explain the sound velocity and density of the PREM core [e.g., 2]. Therefore, the density deficit of the core suggests some light elements may be dissolved in the Earth's core. Although the density is the property often used for discussing the constituent of the core, we need additional properties such as sound velocities, which are more reliable properties of the core derived from seismology. It is not possible to specify the light elements in the core without information of the sound velocities of iron-light element alloys. However, there are limited measurements of the sound velocity under the core conditions because of the experimental difficulties.

2. Results

We developed techniques to measure the sound velocity at high pressure and temperature by using Inelastic X-ray scattering (IXS) and performed the sound velocity measurements in diamond anvil cell combined with the double-heated laser heating system. The Inelastic X-ray scattering at high-pressure and high-temperature was made at the RIKEN beamline BL43LXU of SPring-8. We doubled the static pressure conditions for IXS and successfully measured the sound velocity of metallic iron at a pressure equivalent to ICB (˜330 GPa) and room temperature [3], and iron-nickel-silicon alloys up to the conditions of 130 GPa and 2300 K. These measurements revealed that the vp and vs of the Preliminary reference Earth model (PREM) inner core are 4(±2) % and 36(±17) % slower than those of the pure iron at the center of the core assuming the inner core temperature to be 6000 K. We also estimated the silicon and sulfur contents of the inner core by using the present and previous results on sound velocity measurements of the pure Fe, Fe-Ni-Si alloy, and Fe3S compound at high pressure and temperature. The inner core with the density and sound velocity of the PREM inner core can be explained by addition of 3(±1) wt.% silicon and 3(±2) wt% sulfur to iron–4˜5 wt.% nickel alloy.
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1. References

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