Technical development and improvement for sound velocity measurements of liquid Fe-S up to 15 GPa using ultrasonic pulse-echo method

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Knowledge of the physical properties of liquid iron alloys is important for understanding the liquid core of the Earth and other terrestrial planets and satellites. Sound velocity is a key physical property to know the structure and composition of these cores because it can be directly compared with seismic observations. However, sound velocity measurements of liquid iron alloy by ultrasonic methods combined with multi anvil apparatus have been limited to below 8 GPa (Nishida et al. 2013; Jing et al. 2014; Kuwabara et al. 2016). Therefore, we have been developing and improving techniques that enable us to measure sound velocities of liquid iron alloys up to 20 GPa. Here we report newly established techniques for sound velocity measurements of liquid Fe-S up to 15 GPa. High-pressure and high-temperature experiments were conducted at the AR-NE7A beamline at the KEK PF-AR synchrotron facility. High pressure was generated by Kawai-type multi anvil apparatus (MAX-III). High temperature was generated using cylindrical resistive heater made of Al_2O_3 + TiC composite. The sample was enclosed in a flat-bottomed cylinder container made of BN with a buffer-rod and a backing plate made of sapphire single crystal. We determined the pressure and temperature simultaneously without a thermocouple from the unit-cell volumes of NaCl and MgO by employing their equations of state. Sound velocity was measured by ultrasonic pulse-echo overlap method. The sample melting was identified during the experiments using X-ray diffraction, and was confirmed afterwards from textural observations of the run products.
Preliminary results show the error in sound velocity of liquid Fe-S at 15 GPa is approximately 2.5% under good conditions. In our previous experiments, the error in sound velocity below 7 GPa was approximately 1% under the best conditions. Taking it into account, our newly techniques can provide satisfactory accuracy. Details and latest experimental results will be presented.

Keywords: core, sound velocity, liquid Fe-S, high pressure

