Development of ultrasonic measurement technique under lower mantle conditions

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Abstract

Elasticity data on mantle minerals under high pressure and high temperature are critical to interpret the seismic velocity and density profiles in the Earth's deep interior. However, ultrasonic measurements of elastic wave velocities under high pressure and high temperature have been limited to those corresponding to the mantle transition region ($<$ 20GPa, $<$ 1673K), because of the technical difficulties. Since only a small sample can be used in the experiment under the lower mantle conditions, ultrasonic echoes are very weak and cannot perform a precise elastic measurement. In this study, to overcome this problem, the high-frequency arbitrary waveform generator, post amplifier and high-speed semiconductor relay were installed in BL04B1 at SPring-8. A tiny pure polycrystalline alumina (a-Al2O3) rod (Diameter = 1.0mm, Length = _˜0.5mm) was used as the test sample, because alumina is a very hard and stable material under high pressure and temperature conditions. An assembly of eight cubic anvils of WC with edge length of 26 mm and truncated corner of 3.0 mm has been used in Kawai-type multi-anvil apparatus (SPEED-1500). Travel times for both P- and S-waves passing through the sample were measured by the ultrasonic interferometry, and each sample length under pressure was determined from the X-ray image of the sample using a high-resolution CCD camera. At the same time, X-ray diffraction data from the sample were acquired, and the generated pressures were monitored throughout the run. We have successfully measured elastic wave velocities of alumina up to _˜30GPa, which corresponds to the lower mantle P-T condition. The waveforms observed very clear, and the echoes of P-wave and S-wave were identifiable at high pressure and high temperature. Precise elastic wave velocity measurement of the lower mantle minerals will be attained using this system. More recently, higher pressure ultrasonic measurements of Mg-perovskite have been started, combined with the sintered diamond anvils. In this presentation, the recent experimental results of lower mantle minerals under high pressure will also be present.

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