Laser-shock experiments of dense polymorphs of Mg_2SiO_4: technical developments using synthetic single crystals

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Mg_2SiO_4 polymorphs (α-phase as forsterite, β-phase as wadsleyite, and γ-phase as ringwoodite) are the major constituents of our Earth’s mantle and also for Earth-like planets. Thus studying these polymorphs at extreme pressure and temperature conditions will lead to understanding their changes of chemical and physical properties at extremely high pressure and temperature conditions, such as those occurring during the giant impacts phenomena of such planets at their final stage of accretion. Shock compression of forsterite has been studied up to ~ 1000 GPa by using polycrystalline and single crystal samples [1-3]. The studies have reported contradicting results for the shock compression of forsterite. Sekine et al (2016) reported that there are several phase transformations in the liquid state of Mg_2SiO_4 at > 270 GPa, while other two studies were reported no phase transformation [1, 3]. Thus it is interesting to see how the Hugonoit relations of Mg_2SiO_4 polymorphs will come up at different pressure and temperature conditions. However, Hugoniot relations of wadsleyite and ringwoodite have not been studied well. Especially, there is any data on the densest polymorph ringwoodite. Shock compression of wadsleyite was carried out up to 200 GPa by using polycrystalline samples [4]. In addition, there are no studies by using single crystal samples for both wadsleyite and ringwoodite. To newly conduct such studies, the denser polymorph of Mg_2SiO_4 are needed to be synthesized and grown at their relevant conditions of deep mantle corresponding to the 15 –21 GPa and 1000 –1500 °C in the laboratory. Most importantly, the synthesized minerals must be chemically, physically and optically homogenous and should have suitable sizes for the laser-shock experiments. Here, by utilizing the results of our previous efforts for growing such quality of single crystals, we made possible to obtain Hugoniot relation of wadsleyite and ringwoodite by laser-shock compression. Their crystals were synthesized and grown by using a scaled-up Kawai-type cell by together with applying our pre-established a slow-cooling method at their relevant conditions [5]. Recovered crystals were up to 1 mm in sizes and confirmed to be chemically homogenous and free from twinning, cracks, and inclusions. The crystals were then doubly polished separately down to 100 mm in thickness and with an area of > 500 mm. They were assembled to form targets which are optimized for the laser-shock experiments. laser-shock experiments at GEKKO XII were conducted at Institute of Laser Engineering, Osaka University. The crystals are optical to give very clean VISAR (Velocity Interferometer System for Any Reflector) images. The details of our technical developments will be discussed on the poster.

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