Laser-driven shock compression experiments of synthetic wadsleyite and ringwoodite crystals

*Takuo Okuchi[1], Narangoo Purevjav[1], Norimasa Ozaki[2], Takayoshi Sano[3], Yuhei Umeda[2], Ryosuke Kodama[2,3]

1. Institute for Planetary Materials, Okayama University, 2. Graduate School of Engineering, Osaka University, 3. Institute of Laser Engineering, Osaka University

Dense mineral polymorphs of Mg_2SiO_4 (β-phase as wadsleyite, γ-phase as ringwoodite, and ε-phase as poirierite [1,2]) are possible major constituents of mantles of terrestrial planets, as well as of extrasolar super-Earths. Physical properties of these polymorphs at high pressure and temperature conditions are essential for understanding the past evolution history and current status of these rocky planets. Laser-shock Hugoniot measurements of α-Mg_2SiO_4 forsterite with the lowest initial denstiy, previously conducted at GEKKO-XII high-power laser system at Osaka University, had provided significant evidences on its incongruent melting and crystallization phenomena at ˜ 300 GPa and ˜ 10^4 K [3], which has stimulated discussion on physical and chemical processes of Mg_2SiO_4 system during the growth histories of the large-sized rocky planets. On the other hand, Hugoniot equation of states of the other polymorphs of Mg_2SiO_4, as represented by those of wadsleyite with ˜ 8 % larger density and of ringwoodite with ˜14 % larger density than forsterite, were not yet systematically studied; these will provide independent evidences on the relevant properties of $Mg_2SiO_{4,}$ such as the existences of inhomogenious liquids generated by incongruent melting at wide pressure and temperature regimes.

We are therefore conducting systematic measurements on the Hugoniot states of these polymorphs by using GEKKO-XII laser system [5], which includes the regimes of their melting. The target sample crystals of dense minerals were synthesized using our pre-established slow-cooling method at static high pressure and temperature conditions [4]. These sample crystals are physically homogeneous and optically perfectly transparent, which give very high quality datasets of velocity interferometer system coupled with the high-power laser. The current results and technical developments will be presented and discussed.

References

[1] Tomioka, N. and Okuchi, T. (2017) Sci. Rep. 7, 17351.
[2] Tomioka, N. et al. submitted.
[3] Sekine, T. et al. (2016) Sci. Adv. 2, e1600157.
[4] Okuchi, T. et al. (2015) Am. Mineral. 100, 1483.
[5] Purevjav et al. (2019) JpGU abstract PCG22-P04.

Keywords: dense polymorphs of Mg2SiO4, shock compression, Hugoniot, melting

