Development of a new internally-resistive heated diamond-anvil cell for planetary mineral physics

E. Sugimura-Komabayashi[1,2]*, T. Komabayashi[1,2], and R.S. McWilliams[2,3]

[1]*School of GeoSciences, University of Edinburgh, Edinburgh EH9 3FE, UK*
[2]*Centre for Science at Extreme Conditions, University of Edinburgh, Edinburgh EH9 3FD, UK.*
[3]*School of Physics and Astronomy, University of Edinburgh, Edinburgh EH9 3FD, UK.*

Keywords: diamond-anvil cell, high-temperature, resistive heating

*e-mail: emiko.komabayashi@ed.ac.uk

For the past few decades, diamond-anvil cell (DAC) has been commonly used to reproduce simultaneous high-pressure (*P*) and -temperature (*T*) conditions of deep planetary interiors. In particular, laser-heated DACs achieved ultrahigh *P-T* conditions corresponding to the centre of the Earth [1]. However, laser fluctuation and a steep temperature gradient across the sample induce large uncertainty (±10%) in temperature measurements. Precise experimental temperature determination is crucial to implications for planetary interior models. For example, the location of the phase transition is a key to understanding the origin of the seismic discontinuity; the melting temperatures of the planetary materials under high-pressure place important constraints on the temperature of a planet's deep interior.

Here we present a new heating system for the DAC that offers stable and homogenous heating of a sample under high-pressure condition. The new system is based on the so-called internally-resistive heated DAC (IHDAC) [2]. In an existing IHDAC, a metallic foil heater, which is the sample at the same time, is heated by supplying electricity to the foil. Although it requires extremely delicate fabrication of the heater, the internal-heating benefits from smaller temperature uncertainty (< 5%) due to more stable, uniform heating compared to laser-heating. The very recent study on high-pressure melting temperature of iron has shown its capability of achieving 290 GPa and 5360 K, *P-T* conditions close to the inner core boundary of the Earth [3]. A drawback of this system, however, is that the sample must be metallic. To overcome this limitation, we have employed thin-film deposition technique to fabricate a thin-film heater together with an insulation layer on each of the opposing anvils, enabling double-sided heating of non-metallic samples including rocks and ices. This unique feature not only ensures the homogenous heat distributions in the non-metallic sample but also simplifies the heater instalment process for a liquid sample, which is particularly challenging with the existing IHDAC.

Acknowledgments: This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 753858.

[1] S. Tateno, K. Hirose, Y. Ohishi, Y. Tatsumi, *Science* 2010, **330** (6002) 359-361.
[2] T. Komabayashi et al., *Earth Planet. Sci. Lett.* 2019, **512**, 83-88.
[3] R. Sinmyo, K. Hirose, Y. Ohishi, *Earth Planet. Sci. Lett.* 2019, **510,** 45-52.