Ultrahigh-temperature and high-pressure experiment for determination of nitrogen isotope fractionation during Earth's core formation

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Nitrogen occupies approximately 78% of the Earth's atmosphere and is one of the essential elements of life. Especially, its isotope is important to understand early Earth’s evolution process. In previous studies, nitrogen isotope fractionation during Earth’s core formation has been investigated (Li et al., 2016; Dalou et al., 2019; Dalou et al., 2022). However, these previous experimental *P-T* conditions have been limited up to 7 GPa and 1800 ˚C, which do not reach those of the shallow magma ocean (e.g., Andrault et al., 2011). In contrast, isotope fractionation between metallic iron melt and silicate melt depends on temperature (e.g., Bigeleisen and Mayer, 1947; Urey, 1947). From these backgrounds, ultrahigh-temperature and high-pressure experimental methods to determine the isotopic fractionation are strongly needed.
Here, we will report an ultrahigh-temperature and high-pressure experimental method for the determination of nitrogen isotope fractionation during Earth's core formation. We used a Kawai-type multi-anvil apparatus (ORANGE-3000) installed at Geodynamics research center, Ehime University. We used tungsten carbide anvils with a truncation edge length of 8 mm and Co-doped MgO pressure mediums with an edge length of 14 mm. Rhenium was used as a heater to produce ultra-high temperatures and $LaCrO_3$ was used as a thermal insulator. The outer diameter and the height of the rhenium heater were 2.1 mm and 8.2 mm, respectively. MgO single crystal plates whose thickness is 0.5 mm were used for sample capsules and the sample volume was ~0.4 mm^3. Temperature was measured by a W-Re (W3%Re-W25%Re) thermocouple inserted in the octahedron and attached to the MgO sample capsules. Duration time was up to 70 seconds. The starting material is carbon and nitrogen-doped mixture of basaltic glass and metallic iron powder with a mass ratio of 7 : 3. We observed recovered samples by FE-SEM-EDS.
In this research, we succeeded in conducting ultrahigh-temperature and high-pressure experiments under 7 GPa and 2500 ˚C. Previous studies conducting ultrahigh-temperature experiments below 8 GPa by multi-anvil apparatus (e.g., Ohtani and Kumazawa, 1981) have been limited. The method which we report here can be useful for discussing shallow magma ocean and determining melting relation.

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