

CO₂レーザー両側加熱ダイヤモンドアンビルセルを用いたMgO-MgSiO₃系の溶融実験 Melting experiments on the MgO-MgSiO₃ system using double CO₂ lasers heated diamond anvil cell

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Seismological studies suggest the presence of ultralow-velocity zones (ULVZ) near the core mantle boundary (CMB). Partial melting of the lower mantle materials has been proposed to explain these zones, but experimental validation at the appropriate temperature and pressure regimes remains challenging. The melting curve of the lower mantle material is a key to constrain the existence of melt at the base of the mantle. A laser heated diamond anvil cell (LHDAC) provides an enabling tool for determination of melting temperatures of materials under high P - T conditions. Although YAG, YLF lasers (the wavelengths are about 1 μm) have been generally used for LHDAC experiments, the use of metal absorber is required to heat silicate materials. However, the thermal absorber may cause a chemical reaction and a temperature gradient in the sample. The accuracy of temperature determination is suffered from the chemical reaction and the temperature gradient. In contrast, the CO₂ laser with the wavelength of about 10 μm can directly heat silicate materials. For the minimization of temperature gradients, double-sided heating system for LHDAC was suggested by Shen *et al.* (1996). This technique using the YAG laser has been widely used to study the behavior of materials under high P - T conditions. However, the double CO₂ laser heating system has not been used due to the wavelength of this laser is different from that of visible light.

The requirements for the pressure medium in laser heating experiments are low thermal conductivity and chemical inertness. Ar, which is a noble gas, is one of the suitable pressure mediums. However, loading Ar into the DAC is difficult under room temperature and ambient pressure. Therefore, a simplified method to load Ar into the DAC is required. In this study, I established new experimental technique for the minimization of temperature gradients and chemical reactions and performed melting experiments of the lower mantle materials using LHDAC.

First, a double-sided heating system using CO₂ laser was developed by separating optical elements. This system consists of the heating system using two CO₂ lasers which have the high power (100 W), the observation systems and the temperature measurement system. By using lenses designed for the CO₂ laser wavelength, the laser system is separated from observation and temperature measurement system. Two dimensional images and radiation spectrums are observed by Charge Coupled Device (CCD) camera and spectrometer, respectively.

Second, a simplified method to load Ar into the DAC was developed by the cryogenic technique. In this technique, Ar is cooled using liquefied N₂ until it forms a liquid, and the liquefied Ar is loaded into the sample chamber of the DAC. Cu was used to enhance cooling efficiency.

Finally, I performed melting experiments of the lower mantle materials using the double CO₂ lasers heated diamond anvil cell and Ar as the pressure medium. I used forsterite (Mg₂SiO₄) and mixtures of MgO and MgSiO₃ as the starting material. After the complete pressure release, the sample was recovered from the DAC and examined by FE-SEM. From the surface texture of recovered samples, I discussed melting temperatures of the lower mantle materials under high P - T conditions.

The double CO₂ laser heating and loading Ar methods developed in this study could powerful tool for determination of melting temperatures of the lower mantle materials.