

フェロペリクレスのスピントランジション圧力への鉄の量の影響

Effect of iron content on spin transition pressure of ferropericlasite

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The pressure-induced electronic spin transition of iron in ferropericlasite, which is thought to be the second abundant mineral in the lower mantle, has been theoretically predicted. In fact, enormous evidence for spin pairing transition of iron from high-spin (HS) to low-spin (LS) states in ferropericlasite have been confirmed using various ways. Pressure at which the HS-LS transition occurs would depend on the iron content in ferropericlasite. Fei et al. (2007) suggested that the spin transition pressure decreases with decreasing iron content in ferropericlasite based on the P-V relation. When the iron content in ferropericlasite is low, it becomes more difficult to detect the spin transition because of weak signal from the electronic state of iron. Lin et al. (2007a) and Ohta et al. (2007) measured electrical conductivity of the ferropericlasite using diamond anvil cell (DAC) to pressures over 100 GPa. The electrical conductivity gradually increases by an order of magnitude up to 50 GPa but decreases by a factor of approximately three between 50 to 70 GPa. This decrease in the electrical conductivity has been interpreted by the isosymmetric HS to LS transition of iron in ferropericlasite. The electronic spin transition of iron would result in a decrease in the mobility and/or density of the charge transfer carriers in the low-spin ferropericlasite. Therefore, electrical conductivity measurement would be a powerful tool to detect the spin transition pressure of ferro-periclasite as a function of iron content.

The starting materials were sintered aggregate of ferropericlasite with a various amount of iron content ($x = 0.07, 0.10, 0.13, 0.17, 0.24$). Firstly the starting powder was synthesized from Mg and Fe metals by the sol-gel method. Then the ferropericlasite was synthesized from the gel at 1673 K for a few hours with a CO₂ and H₂ gas mixture to control just above the IW buffer. The powder was placed in Mo capsule and was sintered at 1 GPa and 1273 K for an hour in a piston cylinder apparatus.

The high pressures and high temperatures were generated using a Kawai-type multianvil apparatus with a DIA-type guide block system installed at the SPring-8 (SPEED mkII). We used sintered diamond cubes with an edge length of 14 mm as a second stage anvil. The anvil truncation was 1.5 mm. The generated pressures were calibrated by in situ X-ray diffraction with the Au pressure scale (Anderson et al., 1989). Electrical conductivity was measured by means of a 2-wire method with alternating current signal with an amplitude of 1V and a frequency range of 0.1-1 Hz. The samples were once heated to 500 or 600 K and cooled to room temperature while measuring the conductivity.

The electrical conductivity of ferropericlasite with various iron content at 500 K was measured as a function of pressure. At lower pressures, the electrical conductivity of all ferropericlasite samples increases with increasing pressure. Both activation energy and activation volume of ferropericlasite

decrease with increasing iron content. For the ferropericlaise with higher iron content ($x = 0.17$ and 0.24), the electrical conductivity monotonically increases with pressure up to 38 and 52 GPa, respectively. For the ferropericlaise with lower iron content ($x = 0.07$ and 0.10), the electrical conductivity once slightly decreases or becomes constant with increasing pressure. Further increase in pressure lead to an increase of electrical conductivity. This trend is consistent with those of electrical conductivity of ferropericlaise through the HS-LS transition measured at room temperature in the DAC (Ohta et al, 2007; Lin et al., 2007b). If these changes in the electrical conductivity are attributed to the isosymmetric high to low spin transition of iron in ferropericlaise, this conductivity change suggests that the spin transition pressure would decrease with decreasing iron content in ferropericlaise.

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