Pressure dependence of electric conductivity of the $Fe_{3-X}Ti_XO_4$ spinel solid solution

Takamitsu Yamanaka[1]; Takaya Nagai[2]; Tomoyuki Masuda[3]

[1] Dept. Earth and Space Osaka Univ.; [2] Earth and Planetary Sciences, Hokkaido Univ.; [3] Earth and Space Sci,Osaka Univ

Introduction Iron-bearing oxides are plausibly major earth interiors controlling the electrical conductivity in mantle. Titanomagnetite solid solutions between Fe_3O_4 and Fe_2TiO_4 with an inverse spinal structure (Fd3m, z=8) are the most important oxides among them. Their electric conductivity measurements under high pressure together with phase studies are crucial for understanding the electrical conduction mechanism. Their cation distributions in the tetrahedral site (43m) and octahedral site (3m) are represented by

$(Fe^{3+}{}_u,Fe^{2+}{}_{1-u})[Fe^{2+}{}_{1.0},Fe^{3+}{}_u.Ti^{2+}{}_{1-u}]O_4$. It has been know the low electric resistivity of Fe_3O_4 is induced from Fe^{3+}- Fe^{2+} electron hopping. On the other hand that of Fe_2TiO_4 can be explained by band conduction mechanism.

Experiment Single crystals of the sold solutions $Fe_{3-x}Ti_xO_4$ (x=0.30, 0.56, 0.73, 0.96, 1.00) were synthesized at about 1600 C. Electrical resistivity measurements of these samples under high pressures up to 10GPa have been carried out by lever type diamond anvil cell at ambient temperature. Direct-current method with two lead terminal was applied. Sample and pressure-transmitting media of NaCl powder were placed in the gasket hole. Powder diffraction study of Fe_2TiO_4 under high pressures up to 10GPa has been conducted through diamond anvil cell using synchrotron radiation at KEK BL13A.

Result and Discussion Electrical resistivities of all samples are extremely reduced with compression as exponential function. The solid solutions become more electrically conductive with increasing iron content. Compression of Fe_2TiO_4 yields a change in the resistivity curve at about 7GPa. The curve is apparently relaxed with further compression. Powder diffraction study supports that the resistivity change is originated from pressure-induced structure transition. Phase transition from cubic spinal to tetragonal structure was found at above 7.6GPa. The high-pressure phase has the following topotactic axial relations: [110]Cubic//[001]Tetr, [1-11]Cubic //[100]Tetr and [1-12]Cubic //[010]Tetr. The tetragonal phase at 10.4GPa has the lattice constants c=11.7350A and a=4.8730A. The reversible transition is proved by the fact that the single crystal recovered from 12GPa is spinal structure using multianvil apparatus. The resistivity of $Fe_{3-x}Ti_xO_4$ solid solution is fairly constant over 7GPa. The lattice-electron interaction mechanism such as electron transfer and lattice deformation reflects the electron conductivity.