Electron Doping into Sr_2IrO_4 by Hydrogen Ion Beam Irradiation

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Iridates have large spin-orbit coupling comparable to the electron correlations leading to unique electronic properties. As a typical example, the layered perovskite compound Sr_2IrO_4 is known as an exotic $J_{eff} = 1/2$ Mott insulator derived from the spin-orbit coupling and the on-site Coulomb interaction.[1] Because of its similarity to cuprate, the carrier-doped Sr_2IrO_4 is considered to be a good candidate of superconductor. In recent years, theoretical studies on the possible unconventional superconductivity of carrier-doped Sr_2IrO_4 have encouraged experimental researches.[2,3] However, the superconductivity has not yet been observed experimentally in the layered iridates. Here we report electron doping into Sr_2IrO_4 by injecting hydrogen with a hydrogen ion beam apparatus.[4]

Thin films of Sr_2IrO_4 were deposited on $(LaAlO_3)_{0.3}(SrAl_{0.5}Ta_{0.5}O_3)_{0.7}$ (LSAT) (001) substrates by pulsed laser deposition (PLD) under the partial oxygen pressure (P_{O2}) of 1 mTorr at the substrate temperature of 800 ℃. The obtained Sr_2IrO_4 films showed strong 004n X-ray diffraction peaks of the K_2NiF_4-type structure, indicating *c*-axis-orientation of the epitaxial Sr_2IrO_4 thin films. Hydrogen was implanted into the Sr_2IrO_4 films at 103 K with an acceleration voltage of 2.5 kV. The dose of hydrogen was estimated by the ion current. We performed *in situ* electrical transport measurements and observed a large decrease in resistivity after the irradiation. In addition, the resistivity further decreased irreversibly when the sample was heated to room temperature and cooled again. The ex-situ Hall effect measurement revealed n-type carrier doping, indicating that hydrogen acts as a donor. Furthermore, the concentration of hydrogens in the irradiated Sr_2IrO_4 was investigated by nuclear reaction analysis (NRA). It confirmed heavy doping of hydrogens. Therefore, the low temperature hydrogen ion beam irradiation is a powerful method for controlling the physical properties of strongly correlated iridates.

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