Electron doping into Sr_2IrO_4 under epitaxial strain using hydrogen ion beam method

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Keywords: Hydrogen Ion Beam, Iridium Oxide, Transport Property, Epitaxial Strain

Hydrogen (H) takes various charge states in solids, from −1 (hydride, H^-) to +1 (proton, H^+), and can drastically change the physical properties of solids as a dopant. The H doping also has an advantage that it is unlikely to cause a large lattice distortion. However, the conventional H doping methods such as exposure to hydrogen gas and electrolytic charging are applicable to limited materials, and the amount of doped H is generally small. Hydrogen ion beam irradiation is an excellent H doping method applicable to all materials. In addition, with our home-made apparatus, desorption of H is suppressed by a low-temperature irradiation, and a large amount of H doping can be realized[1].

A layered perovskite compound Sr_2IrO_4 is an exotic J_{eff} = 1/2 Mott insulator derived from spin-orbit coupling and on-site Coulomb interaction, and it is a candidate of novel superconductor due to its similarity to cuprate high-T_c superconductors. Theoretical studies have predicted the existence of superconducting phase[2,3], but it has not yet been observed. For observation of superconducting state, it is necessary to control carrier concentration by chemical doping or to control band structure by lattice distortion. However, it is difficult to decouple chemical doping and lattice distortion effects, because most of conventional doping methods such as fluorine doping[4] inevitably cause lattice distortion. Hydrogen ion beam irradiation method is expected to avoid this problem because it is unlikely to cause lattice distortion. In the previous research, it is already found that heavy carrier (electron) doping is possible in Sr_2IrO_4 by hydrogen ion beam irradiation without introducing the lattice distortion using $(LaAlO_3)_{0.3}(SrAl_{0.5}Ta_{0.5}O_3)_{0.7}$ (LSAT) substrate[5]. Therefore, lattice distortion and carrier concentration can be freely controlled by the combination of epitaxial strain and hydrogen ion beam irradiation. In this study, we report on an attempt of electron doping into Sr_2IrO_4 thin films grown on $LaAlO_3$ substrate which impose compressive epitaxial strain using hydrogen ion beam irradiation, and compare with the previous results for Sr_2IrO_4 thin films grown on LSAT substrate.

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