PREPARATION AND CHARACTERISTICS OF SUPERCONDUCTING CUPRATE THIN FILMS: $Nd_{2-x}Ce_xCuO_4$ AND SUBSTITUTED Bi-SYSTEM

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Characteristics of the electron-doped-type $Nd_{2-x}Ce_xCuO_4$ system and substituted $Bi_2(Sr,Ln)_3Cu_2O_y$ system have been systematically studied using the high quality thin-film samples.

The $Nd_{2-x}Ce_xCuO_4$ thin films with various Ce concentrations, x, have been prepared by rf magnetron sputtering on $SrTiO_3$ heated at around 500°C. After subsequent annealing at 1100°C in air, the films showed the c-axis orientation normal to the substrates. By means of the reducing treatment (annealing in a vacuum), superconductivity was induced for the films with $0.14 \leq x \leq 0.18$. The superconductivity and transport properties of the films were strongly affected by the reducing treatment. The x=0.15 film exhibited a sharp superconducting transition with zero resistivity at 22 K, in consistent with the diamagnetic properties. The resistivity of the films was fairly low with metallic characteristics, and the sigh of the Hall coefficient was negative in the normal state. On the other hand, the normal-state optical measurements showed that the undoped Nd_2CuO_4 is a semiconductor with a charge transfer gap of 1.3 eV, and that, when Ce ions were doped, a plasma reflection due to the free-carriers came to be seen with the plasma frequency of 1.07 eV for $0.14 \leq x \leq 0.18$. Moreover, x-ray photoemission study revealed that the Cu valence of the film decreased from 2+ for x=0 to 1+ for x=0.15. These physical properties are in contrast with those of hole-doped-type cuprate superconductors.

$Bi_2(Sr,Ln)_3Cu_2O_y$ thin films have also been prepared on MgO substrates heated at 800-700°C by similar methods. It was found that the growth conditions for Bi-system with two CuO_2 planes were different for each composition and species of lanthanoid in the films. Moreover, preparation of Bi-system with three CuO_2 planes was very difficult when lanthanoid atoms were doped in the system. Their electric transport properties and x-ray photoemission spectroscopy were investigated. Carrier concentration and Cu valence were discussed with regard to the superconductivity.