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Development of (Cu, C)-system high temperature superconducting films with low growth temperature

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1. Introduction

This thesis mainly comprises about synthesis and characterization of (Cu, C)-system high temperature superconducting films with low growth temperature and non-toxicity. Recently, high-speed performance and high-sensitivity of sensors have been required with developing of information exchange and sharing. Superconductors are promising materials because of low power consumption, ultra-high speed performance and ultra-sensitivity of sensor. They, however, must be compound with semiconductors in device fabrications, and requirements of superconducting thin film fabricating conditions are limited. Therefore, it is difficult to realize industrialization of superconducting electronic devices because of requirement of non-toxic materials and low growth temperature. So, I have studied the synthesis and characterization of low temperature growth and non-toxicity (Cu, C)-system high temperature superconducting films for electronics.

2. Results and Discussions

The synthesis of (Cu, C)-Ba-O system thin films has been attempted. Specimen films were grown on (100) plane of $SrTiO_3$ substrate at a temperature in the range of 450 ~ 560 ˚C under reactive atmosphere: $O_2 + CO_2$ + Ar by PLD using KrF excimer laser. As a result, all of the films showed tetragonal symmetry and epitaxial growth. An introduction of CO_2 into the growth atmosphere results in a growth of higher conductive (Cu, C)Ba_2CuO_x[(Cu, C)-1201] phase. Simultaneous control of the CO_2 pressure and target composition resulted in a remarkable highly conductivity in normal state ($\rho < 1$m Ωcm). Most of the highly conductive (Cu, C)-1201 phase showed superconductivity. The 1201 films deposited at 500 °C using $BaCu_{0.75}O_x$ target showed superconducting transport, T_c = 60 ~ 47 K

Transport properties of (Cu, C)-1201 films have been characterized by *in-situ* four probe method without breaking vacuum, subsequent to their growth by pulsed laser deposition, in order to clarify intrinsic transport properties. Obtained results reveal the films exhibit $T_{c(\rho=0)} > 20$ K on the cases of $\sigma_{[290\ K]} > 4 \times 10^2$ S/cm and TCR $> 1.5 \times 10^{-3}$ K^{-1}. The temperature-linear dependence of resistivity and the absence of saturation of T_c with an increase of TCR indicate that doping level of the films in this study should be in between under-doped to optimally-doped states. This suggests there would be some room for further increases of T_c.

Characterization of electronic structure of the (Cu, C)-1201 films with T_c = 16 - 42 K has been carried out by *in situ* photoemission spectroscopy. The finite spectral weight at the Fermi level in the valence band of (Cu, C)-1201 superconducting films and a rigid-band-like approach of the main peak of the valence band toward Fermi level with a rise of T_c has been observed, which reveals hole-doping-induced super-conductivity of this system. The changes of core signals with T_c and comparisons of the obtained data with other cuprate superconductor compounds suggest that the (Cu, C)-O charge reservoir in this system is in the heavily hole-doped state, similar to that of Cu-O chain in YBCO.

3. Conclusions

(Cu, C)-1201 high temperature superconducting films with low growth temperature 500 ˚C and non-toxicity were successfully obtained and had excellent dopability. The obtained data by photoemission spectroscopy reveal an easiness of hole-doping into the 1201 phase and heavily hole-doped states of (Cu, C)-1201 superconducting films. Consequently, high potential (Cu, C)-1201 superconducting film is a promising material for practical application.

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