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Structure and Magnetic Properties of Electron-doped Superconductor

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**Keywords:** DC-magnetic susceptibility, electron-doped superconductor, Ni impurities, under-doped region.

**Abstract.** Electron-doped superconducting cuprates of Eu2-xCexCu1-yNiyO4+α-δin under-doped regionwith x = 0.12 and y = 0, 0.01 and 0.05 have been prepared, characterized and investigated in order to study the effect of Ni impurity to the magnetic properties of electron doped superconducting cuprates. all main peaks of tetragonal and T’ structure configuration of ECCO were observed in all samples. Temperature dependence of dc magnetic-susceptibility on field cooling at 5 Oe for Eu1.88Ce0.12Cu1-yNiyO4+α-δ with y = 0, 0.01, 0.005 and δ values from 0.0496 to 0.08322 shows diamagnetic behavior for sample with y = 0, starting from about 11 K. For sample with y = 0.01, Tc onset decreases to be around 4 K and superconductivity disappeared at y ≥ 0.05.

Introduction

Superconducting cuprates with single-layer of CuO2 plane called 214 cuprates have been one of great interests to be studied both in hole- and electron-doped systems [1-9]. For some reasons, research on electron doping superconductors is still very limited [10]. In general materials of electron-doped system, the excess oxygen in the samples is a problem that must be reduced by performing annealing process. Superconductivity at specific range of doping concentration can only occur when the material is annealed at a certain temperature and time, which causes the superconductivity in this system depend not only on the amount of doping concentration but also the amount of oxygen content [10-12].

 Here, we report the study of effect of magnetic impurities of Ni to the physical properties of the structure and magnetic properties of the superconducting material of ECCO in under-doped region with x = 0.12.

Experiments

Electron-doped superconducting cuprates of Eu2-xCexCu1-yNiyO4+α-δ(ECCNO)in under-doped regionwith x = 0.12 and y = 0, 0.01 and 0.05 was prepared by a solid-state reaction method. The complete experimental procedures including samples preparation, pre-fired and sintering process are reported in previous reports [9,12]. To reduce the oxygen content in the as-grown sample, annealing process was carried out at 900°C for 11 hours in high purity of Ar gas flow [10,12].

All samples were characterized by x-ray diffraction (XRD) measurements to study crystal structure and Superconducting Quantum Interference Device (SQUID) to study magnetic susceptibility at Graduate School of Engineering, Tohoku University, Japan.

Result and Discussion

Figure 1 shows XRD spectra of ECCNO with x = 0.12 and y = 0, 0.01 and 0.05. All the main peaks can be observed and matched with the diffraction peaks of tetragonal with a planar shaped of CuO2 plane configuration, called T’ structure. Small one impurity peak at 33.05º was found in samples with y = 0.01 and 0.05 and identified to be the peak of CeO2.

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| **Figure 1.** Results of XRD characterization of ECCNO samples with x = 0.12 and y = 0, 0.01, and 0.05. |
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| --- |
| **Table 1.** Lattice parameter values ​​of ECCNO with x = 0.12 and y = 0, 0.01 and 0.05. |
| Ce (x) | Ni (y) | a (Å) = b (Å) | c (Å) | V (Å3) |
| 0.12 | 0 | 3.9071 | 11.8570 | 181.0075 |
| 0.01 | 3.9068 | 11.8567 | 180.9752 |
| 0.05 | 3.9079 | 11.8576 | 181.0936 |

 |

All lattice parameter values are calculated from dhkl values ​and Miller index as shown in Table 1. It is found that the lattice parameter value of a-axis ranges from 3.9068 Å to 3.9079 Å, while in the c-axis ranges from 11.885675 Å to 11.857766 Å. The volume of unit cells ranges from 180.9752 Å3 to 181.0936 Å3. It is known that the radius of the Ni2+ ion is larger than that of Cu2+ and the size of Cu2+ is in the horizontal conduction plane of CuO2.

The magnetic moment per unit volume can be expressed as shown in Eq. (1).

 $χ=\frac{μ\_{0} n m^{2}}{3 k\_{B} T},$ (1)

where *m* is magnetic moment per atom, *n* is the number of atoms per unit volume, $k\_{B}$ is Boltzmann’s constant.

Summary

Electron-doped superconducting cuprates of Eu2-xCexCu1-yNiyO4+α-δ with x = 0.12 and y = 0, 0.01, and 0.05 have been successfully synthesized in order to study the effect of Ni impurity to the magnetic properties of electron-doped system in under-doped region. From XRD measurements, all main peaks of XRD data were observed in all samples indicating the electron-doped system of ECCO with tetragonal and T’ structure configuration was successfully prepared. From magnetic susceptibility data, superconducting phases with T*c* about 11 K and 4 K ware observed at samples with y =0 and 0.01, respectively. Superconductor phase disappeared in samples with y = 0.05 which is also followed by a weakening of the spin-spin correlation and a reduced a magnetization value.

**Acknowledgment**

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