Synthetic Metals, *29* (1989) F741–F744

THERMOELECTRIC POWER STUDY OF THE HIGH Tc SUPERCONDUCTOR: Y-Ba-Cu-O

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ABSTRACT

Temperature dependent thermoelectric power of the high Tc superconductor $Y_xBa_yCu_zO$ with various combinations of x:y:z are studied to investigate the electronic structure. The results are very sensitive to the composition ratios and the preparation conditions of Y-Ba-Cu-O even if the superconducting transition temperatures are more or less identical (Tc ≃ 90K). A systematic approach to understand the evolution of the band structure upon different compositions of Y-Ba-Cu-O is presented.

INTRODUCTION

The high Tc superconductor Y-Ba-Cu-O has been studied extensively since last two years. Many important physical properties have been reported to understand the mechanism of the superconductivity for these high Tc superconductors. However, relatively small number of thermoelectric power measurements were done on these compounds and the data of each group do not agree.[1-6] Here, we present the thermoelectric power data of a series of the Y_x-Ba_y-Cu_z-O samples with different ratios of x:y:z as a function of temperature.

EXPERIMENT

Samples were fabricated by mixing the individual raw materials of Y_2O_3, $BaCO_3$ and CuO directly. Figure 1 shows the ternary phase diagram of Y_2O_3-$BaCO_3$-CuO system. The structure of the sample A(645) is likely to be the K_2NiF_4-type which is found to be a superconductor in $(La_{1-x}Ba_x)_2CuO_4$ system. Samples B to F are the ABO_y-type, i.e., typical perovskite-type

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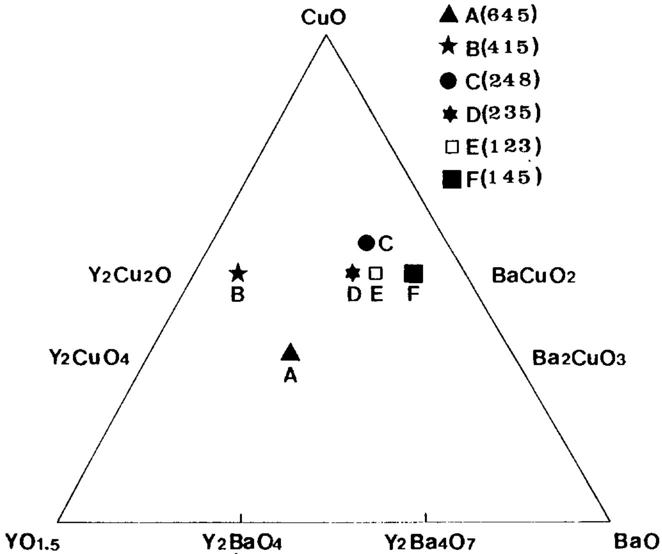
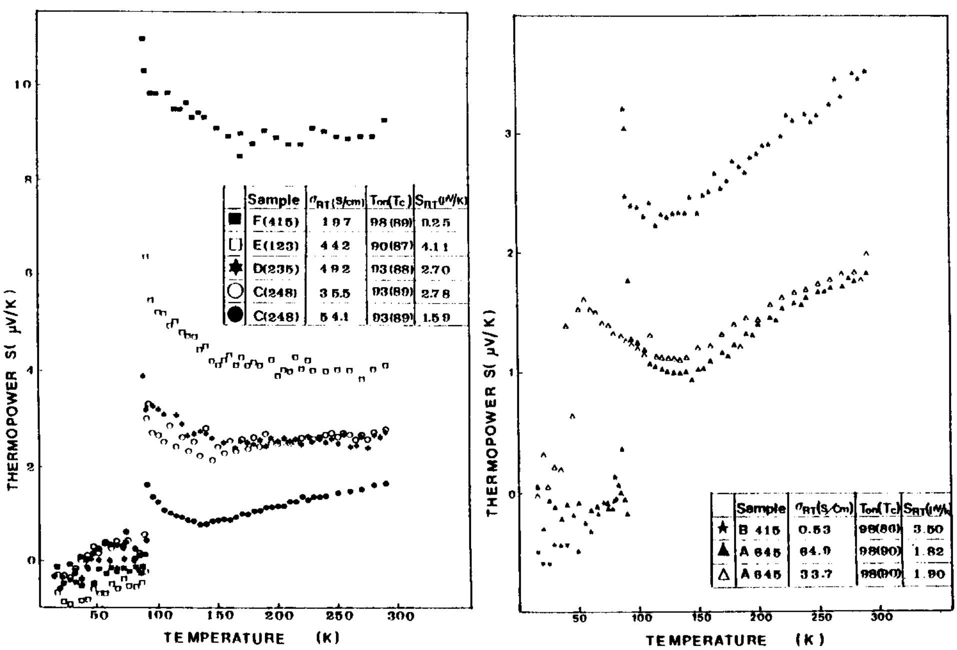


Fig.1. Ternary phase diagram of Y_2O_3-$BaCO_3$-CuO



(a) (b)

Fig.2. Thermoelectric power vs temperature

crystal structure. After mixed, calcined and pulverized few times, the products were cold-pressed in 1cm diameter with pressure of 1 ton/cm^2. Finally the ceramic samples were obtained by sintering in the air. As the ratio of $BaCO_3$ to Y_2O_3 is increased, the color of samples changes from dark green to black and the mass density becomes larger. Detail of the sample preparation is published elsewhere[7]. The silver paint contact was used and the technique for the thermoelectric power measurement was the same as the one published earlier[8].

RESULTS AND DISCUSSION.

Figure 2(a) and (b) show the temperature dependent thermoelectric power of the samples labeled in figure 1. All the samples shown have more or less the same superconducting transition temperature Tc ≃ 90K in the dc conductivity measurement. First of all, the sign of the thermoelectric power is positive for all samples indicating that the major carrier is hole-like. But the temperature dependences are different. The samples D(235), E(123) and F(145) show the temperature independent thermoelectric powers for 150K <T < 300K and then increase sharply upon cooling until Tc becoming zero for T < Tc. For samples A(645) and B(415), the linear temperature dependences are observed in 150K < T < 300K region. Below 150K, the thermoelectric power increases until T reaches to Tc and then it drops to zero abruptly for T < Tc. The temperature dependence of the two C(248) samples are somewhat peculiar. One sample shows the temperature independent region at T > 150K and the other is linearly in T at the same temperature range. The preparation condition of these two samples is identical and they are the two different portions of the same compressed pallet. This suggests that the microscopic scattering mechanism could vary very sensitively from sample to sample. The A(645) samples show another differences. One is linear temperature dependent showing the superconducting transition at Tc ≃ 90K which is the same as the one measured by the dc donductivity of the same sample. But the other sample does not show any superconducting transition and it rather looks like the thermoelectric power of copper itself. Therefore, clearly the thermoelectric power data are very semsitive to the sample conditions.

The temperature independent thermoelectric power for 150K < T < 300K observed in samples D(235), E(123) and F(145) suggests that the Coulomb correlation is important in these samples. Whereas, the linear temperature dependence shown in samples A(645) and B(415) indicates that they are the independent particle like metals at this temperature range. The sample C(248) is somewhere in border line, since one sample shows the temperature independent region while the other sample shows the linear temperature dependence. If we consider the fact that the (123) compound is known to have the best superconducting properties, the Coulomb correlation is very important for the compounds around (123). But as the composition ratio becomes farther apart from the (123) region, the independent particle like behavior begins to appear.

One thing universally appeared in our thermoelectric power data is the rapid increasing behavior for $Tc < T < 150K$. This enhancement could be related to the phonon drag effect shown in normal metals. If it is indeed due to the phonon drag effect in our samples, the pairing in superconducting state could be mediated by the extra phonons created right above Tc. However, the enhancement could be originated from some other extra scattering contributions such as excitons, plasmons, etc. Therefore, it is not clear which mechanism is responsible for the pairing at this moment.

ACKNOWLEDGEMENTS

The thermoelectric power measurement research is supported by the Korea Science and Engineering Foundation (KOSEF) and the sample fabrication work is supported by the Special Fund of the Ministry of Science and Technology (MOST), Korea.

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