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PRESSURE DEPENDENCE OF T_c FOR HIGH-T_c Cl-CONTEINED SUPERCONDUCTOR $(Sr,Ca)_3Cu_2O_{4+\delta}Cl_{2-y}$

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Chlorine-containing $(Sr,Ca)_3Cu_2O_{4+\delta}Cl_{2-y}$ (0212-Cl) superconductor is the high-T_c Cu-oxide superconductor (HTSC) with T_c = 80 K and was synthesized under high-pressure and high-temperature. The 0212-Cl has double $[CuO_2]$ planes and the apical oxygen are replaced by Chlorine. We measured the resistance of 0212-Cl under high pressure using a diamond-anvil cell up to 13.3 GPa and two-terminal ac-method to investigate the pressure dependence of T_c. T_c of 0212-Cl increases gently with increasing pressure.

Keywords: High pressure; high-T_c

1. Introduction

Since Bednorz and Müller discovered the high-T_c superconductivity in perovskyte-like cuprate oxides,[1] its high transition temperature have attracted and a large amount of oxide HTSC have been synthesized. The mechanism, however, of the superconducting in HTSC remains one of the greatest problem in condensede matter physics. Our sample, chlorine-containing $(Sr,Ca)_3Cu_2O_{4+\delta}Cl_{2-y}$ (0212-Cl) superconductor, has the superconducting transition temperature T_c = 80 K. The 0212-Cl has double $[CuO_2]$ planes and consists of Cl-containing off-plane block. The apical oxygen are replaced by Chlorine. It is considered that 0212-Cl has little abcent of apical oxigen compared with other HTSC

The pressure dependence of T_c for HTSC has been investigated extensively. The decrease in the distance between copper and apical oxygen in the pyramids or octahedra correlates with increase of T_c under pressure.[2,3,4,5,6,7] The study of an influence by the replacement on the physical properties and also by pressure is a matter of great importance.

2. Experiment

The sample 0212-Cl was synthesized using high-pressure technique. Sr_2CuO_3, Sr CuO_2, and Ca_2CuO_3, as well as Sr_2CuO_2 or C $a_2CuO_2Cl_2$ were mixed. The synthesis was performed under 5.0 GPa and $\sim$ 1000 °C for 30 min.[8] The obtained sample was $(Sr,Ca)_3Cu_2O_{4+\delta}Cl_{2-y}$ with $\delta = 0.7$ and $y = 0.7$ and nearly single phase of 0212-Cl. The space group of 0212-Cl is $I4/mmm$. The lattice partameters are $a = b = 3.8679$Å, $c = 22.16$Å.[8]

The high pressure aparatus for electrical resistance measuremants up to 13.3 GPa is a diamond-anvil cell (DAC). The DAC designed for experiments at low temperature and made of nonmagnetic materials of hardened Be–Cu alloy and a pair of diamonds. The Be-Cu metal gasket, which was coverd with Al_2O_3 powder for insulation, was used for electrical resistance measurements. The diameter of diamond-anvil culet is 800 μm. The sample size was $\sim$200×$\sim$200×50 μm and was placed into the pressure chamber, whose diameter is 300 μm, with several ruby chips. Since the sample is poly crystal, it is considered that the sample involved the crack in this size. A pressure medium is NaCl. The electrical resistance, R, was measured by an ac two-probe method. Two gold wires were pressed to sample as electrodes. The actual situation of sample arrangement is shown Fig. 1.

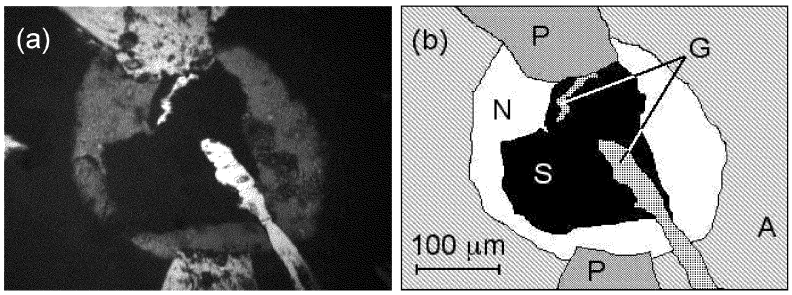

Fig. 1. The (a) photograph and (b) sketch of sample arrangement at 9.3 GPa. A; Al_2O_3 insulator layer, G; gold wires, P; Platinum electrodes, S; sample, N; NaCl pressure medium.

The applied pressure was determined by a standard ruby fluorescence method at room and low temperatures. The electrical resistance measurements ware performed in the temperature range between 15 and 300 K.

3. Result and Discussion

The temperature dependence of electrical resistance at 0.5, 4.7, 8.0, 10.4, and 13.3 GPa are shown in Fig 2. Unfortunately, zero resistance is not observed below T_c. This result seems to be due to the contact resistance between the poly crystal sample, and between the sample and gold wires. Actually, the resistance value at room temperature is decreased and the drop is clearly with increasing pressure. Then we defined the superconducting transition temperature from the temperature

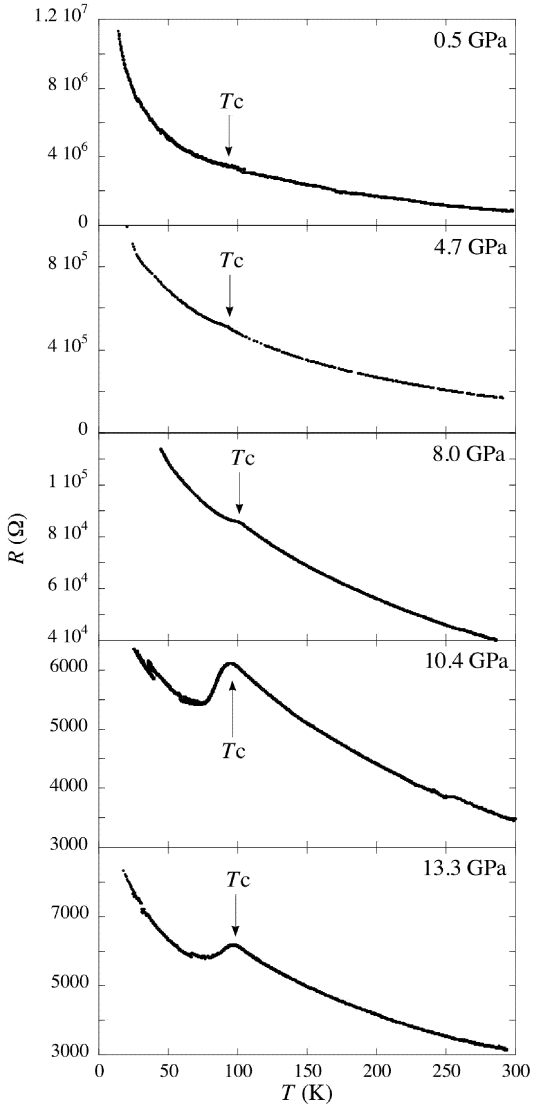

Fig. 2. Temperature dependence of electrical resistance R of 0212-Cl for various pressure.

differentiation of resistance. The transition temperatures are defined as shown in Fig. 2.

The pressure dependence of superconducting transition temperature T_c is shown in Fig. 3. The temperature dependence of T_c is seemed to be a slow changing concave curve. The pressure coefficient of 0212-Cl is small value but positive, which suggests that 0212-Cl is in the underdoped region.[7] The weak dependence is considered to be due to "apical oxygen doping", which is the p-type doping mechanism through a partial substitution of divalent O^{2-} for the monovalent Cl^{1-}. Thus it is considered

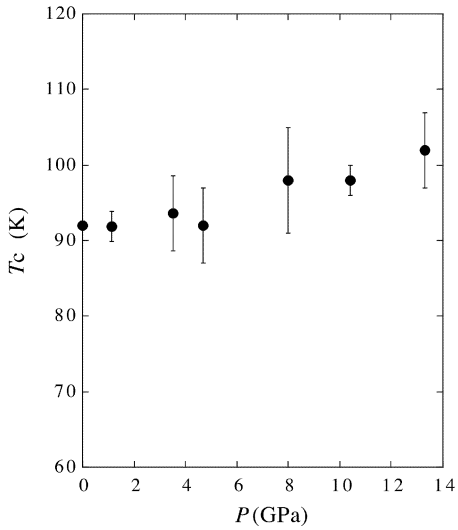

Fig. 3. Pressure dependence of T_c for 0212-Cl.

that 0212-Cl has little abcent of apical oxigen and more stable for pressure than other HTSC. Further investigation of the structure and of the electrical resistance under higher pressure is needed.

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