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MEASUREMENTS ON THE NEW HIGH-T_c SUPERCONDUCTOR Nd-Ba-Cu OXIDE SYSTEM

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Resistance measurements in samples prepared with nominal composition of $Nd_1Ba_2Cu_3O_{8-\delta}$ were performed. This compound shows a critical onset temperature for superconductivity of 76K. This experiment supports the idea that substitution of any rare earth in this type of compound does not inhibit superconductivity. Results in samples with Gd, that further ratify this idea, are also reported.

Recently, there has been much discussion about the role of Y, La and other rare earths in the properties of high-T_c superconducting compounds of the type A-B-Cu-O. We therefore consider it important to investigate the effects of substituting various elements in this group of compounds and, in particular, the modifications on the crystallographic structure and the superconducting critical temperature. Regarding the crystal arrangement, one can distinguish two different structures, on one hand, compounds like $(La_{1-x}B_x)_2CuO_{4-\delta}$ (B=Ba,Sr,Ca)[1-4] have the K_2NiF_4 structure and on the other, a material identified as $Y_1Ba_2Cu_3O_{8-\delta}$ [5-6] presents a distorted oxygen deficient perovskite structure. More recently a different structure has been reported, in $(Yb_{1-x}Ba_x)_3Cu_2O_{7-\delta}$ that is similar to the $Sr_3Ti_2O_7$ one[7]. Although these differences in crystallographic structure are substantial, they all preserve CuO_2 planes containing exclusively 180° Cu-O-Cu coupling [8-9], that probably is responsible for superconductivity[8]. It is important to note that this flexibility in changing the structure by substituting a number of elements in the compound, and by this procedure being able to improve their superconducting T_c, opens a wide field of research in materials.

The electronic structure of La compounds[10] show that the essential features are extremely similar to the Y compounds[11]. These important features are: 1) The La, Ba and Y bands are far from the Fermi level. 2) There is very little dispersion along the z-axis, perpendicular to the Cu-O short bonds, which gives the essentially 2-dimensional character to the compound. 3) Strong interaction between the Cu $d(x^2-y^2)$ and the O p(x,y) orbitals (pdσ). 4) A number of narrow bands below E_f essentially non-bonding (pdπ).

The previous considerations lead us to think that substitution of any element that preserves features 1 to 4 above, would not inhibit superconductivity, or even improve it in some cases. In particular, a number of rare earths have been reported to give high-T_c superconductors and, it is surprising that compounds with Nd and Tm were reported to be non-superconductors[12].

The main purpose of the present work is to show that a material prepared with Nd is also a high-T_c superconductor with onset temperature of 76K. We also report here, measurements in Gd compounds.

Samples with nominal composition $R_1Ba_2Cu_3O_{8-\delta}$ (R=Nd,Gd) were prepared through the reaction of appropiate amounts of Nd_2O_3 or Gd_2O_3, $BaCo_3$ and CuO. The mixtures were prepared and heat-treated at 900° for 24 hours, then ground and pressed and heat-treated again at 900° for 24 hours; this last process was repeated twice. The tablets were reground, pressed and then sintered in an O_2 atmosphere at 900° for 2 hours. The samples obtained were disks of 1.2 cm diameter and about 0.18 cm thick. Resistance vs. temperature measurements were performed with the usual four-point-probe technique. X-rays diffraction patterns of both compounds, with Nd and Gd, revealed that there is a single phase that corresponds to the one in $Y_1Ba_2Cu_3O_{8-\delta}$ that has been identified as the superconducting phase[8].

The results for the $Gd_1Ba_2Cu_3O_{8-\delta}$ sample are shown in Fig. 1, which shows that the onset of the superconducting state is at 93K and the zero resistance state is reached at 80K. Fig. 2 shows the results for the $Nd_1Ba_2Cu_3O_{8-\delta}$ sample; the onset is at 76K and the zero-resistance state at 28K.

Within our knowledge, this is the first time that a compound with Nd is reported to be a high-T_c superconductor.

Fisk et al.[12] reported that a Nd compound sample, prepared with the nominal composition $Nd_{1.5}Ba_{1.5}Cu_2O_x$ was not a superconductor. It is worth noticing that the nominal composition

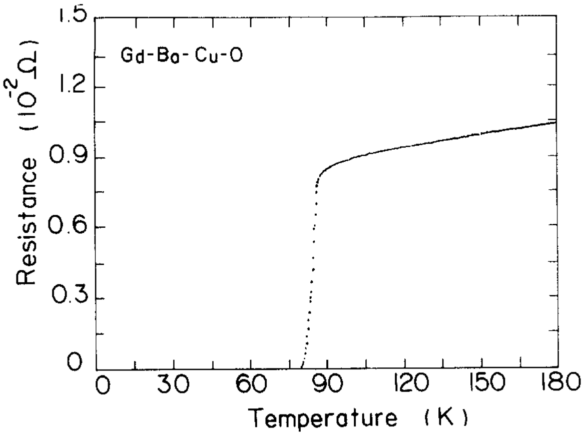

Figure 1. Resistance as function of temperature for the $Gd_1Ba_2Cu_4O_{8-\delta}$ sample.

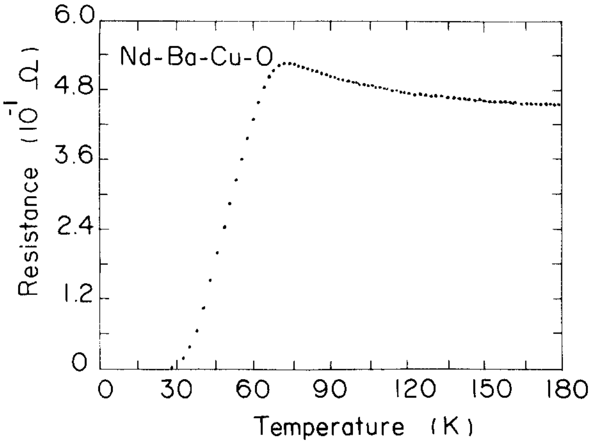

Figure 2. Resistance as function of temperature for the $Nd_1Ba_2Cu_4O_{8-\delta}$ sample.

used by Fisk et al. is not ideal for maximizing the superconducting state and that a reaction is needed to produce a good fraction of superconductor in their samples. From the present work we could further say that this reaction is easy in the case of Gd but not so in Nd.

From the technological point of view, we consider it very important to know if other elements can be introduced or substituted in the R-Ba-Cu-O system without changing the structure that produces the superconducting phase.

We have already initiated this type of study in the Y-Ba-Al-Cu-O and Y-Ba-Fe-Cu-O systems and will be the matter of a further communication.

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