High-T_c Superconductivity in a New Mixed-phase Y-Ba-Al-Cu-O Compound System

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Abstract. A reproducible superconductivity transition has been observed by resistance measurements in the new Y-Ba-Al-Cu-O compound system. An onset temperature for superconductivity at 90°K was measured.

Resumen. Transiciones reproducibles al estado superconductor han sido observadas con mediciones de resistencia en el nuevo sistema Y-Ba-Al-Cu-O. La temperatura medida de inicio de la superconductividad es de 90°K.

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One of the most challenging tasks in material research is to find new superconductors that have critical transition temperatures above room temperature. Until recently the transition-metal alloy compounds of A15 (Nb_3Sn) and B1 (NbN) structure have had the highest superconducting transition temperatures. Among the A15 compounds, thin films of Nb_3Ge have the highest $T_c = 23.3$°K reported by Gavalev *et al.* [1] and Testardi *et al.* [2] in 1973. Intercalated superconducting materials [3,4], organometallic compounds [5] and the newly discovered heavy Fermion systems [6] have not reached high T_c's. Among the oxides, superconductivity in the Li-Ti-O system with $T_c = 13.7$°K was reported by Johnston *et al.* [7] in $BaPb_{1-x}BiO_3$,

superconductivity was reported by Sleight *et al.* [8] and the highest transition temperature reported in this system was $T_c = 13°K$.

Recently Bednorz and Müller [9] reported, from resistivity measurements, that the Ba-La-Cu-O system with the composition $Ba_5La_{5-x}Cu_5O_{(3-y)}$ became a superconductor below 13°K with an onset of the superconducting state near 30°K. Shortly thereafter, high temperature superconductivity was confirmed, by susceptibility measurements, independently by Bednorz *et al.* [10] and Uchida *et al.* [11]. The superconducting phase was then identified by Takagi *et al.* [12] as $(La_{1-x}Ba_x)_2CuO_4$ of tetragonal K_2NiF_4 structure. Chu *et al.* [13] found that under hydrostatic pressure the onset of superconductivity increased from 35°K to above 52°K. Kishio *et al.* [14], Cava *et al.* [15] and Tarascon *et al.* [16], independently, found that $(La_{1-x}Sr_x)_2CuO_4$ is a high-T_c superconducting system having an onset temperature for superconducting at 48.6°K with a very sharp transition width of 2°K. Kishio *et al.* [14] also found that the $(La_{1-x}Ca_x)_2CuO_4$ is a high-T_c superconducting system and that together with the $(La_{1-x}Ba_x)_2CuO_4$ system and the $(La_{1-x}Sr_x)_2CuO_4$ system it forms a pseudo-ternary solid solution superconducting system [17].

More recently Wu *et al.* [18] reported onset critical temperature as high as 93°K in a multi-phase Y-Ba-Cu-O system. In a subsequent paper [19] they reported that in this system the pressure had only a slight effect on the superconducting transition temperature in contrast to what is observed in the La-Ba-Cu-O system. High-T_c superconductivity in the Y-Ba-Cu-O system has also been reported independently by other groups [20-23].

In this letter we report the discovery of high-T_c superconductivity in the Y-Ba-Al-Cu-O system, with on onset at 90°K.

The sample was prepared with nominal compositions represented by $(Y_{1-x-y}Ba_xAl_y)_2CuO_{4-\delta}$ with $x = 0.35$ and $y = 0.05$, through the reaction of appropriate amounts of Y, $BaCo_3$, CuO and Al_2O_3. The mixture was first calcined at 1000°C for 1 hour, ground and calcined again at 1000°C for 24 hours. For sample preparation the calcined

powder was cold pressed into disk shape, then sintered at 1100°C and slowly cool down to 500°C.

Dish shaped sample of 1.2 cm. diameter and about 0.18 cm. thick was prepared and resistance measurements were made with a bridge which has a low resistance sensitivity of $10^{-7}\Omega$, by the usual four-point-probe technique using silver paint contacts. The measurements between 300°K and 10°K were performed in a continuous-flow cryostat connected to a microcomputer to give a fully automatic system for temperature variation, data acquisition and processing.

The measurements of the resistance as a function of temperature are shown in Fig. 1; the onset of the superconducting state is around 90°K and the zero-resistance state is reached at 58°K.

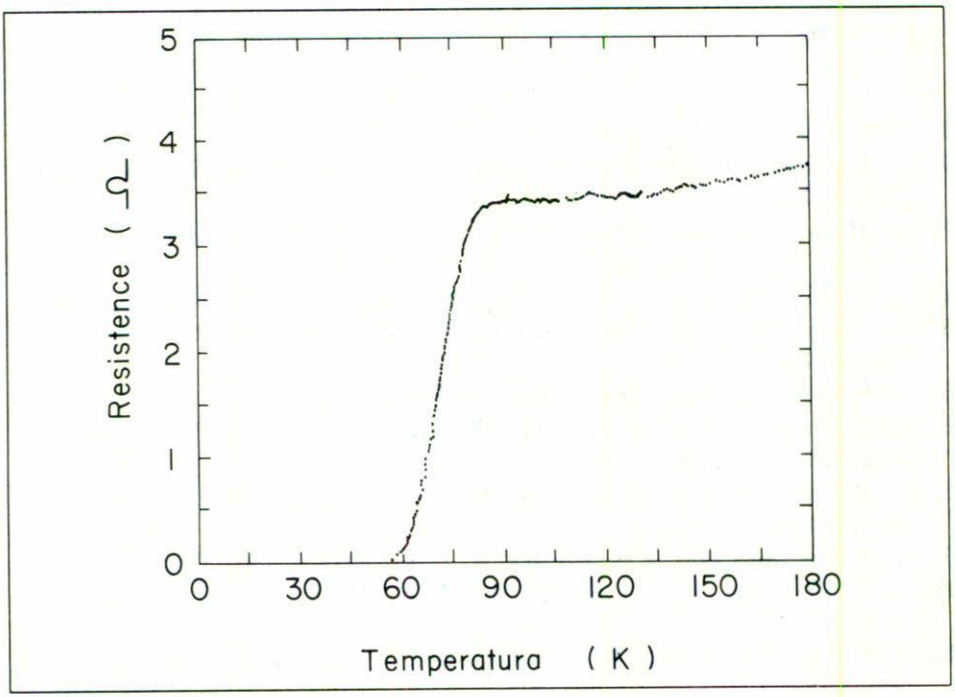

FIGURE 1. Resistance as function of temperature.

We find that inclusion of small quantities of Al in the Y-Ba-Cu-O system does not affect much the onset of the superconducting state, as compared to the onset reported by Wu *et al.* [19]; this knowledge could be important from the technological point of view. However, the role of the Al in the system is not yet clear, at this stage we do not know whether the Al is forming part of the structure or not.

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