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Bucharest, ROMANIA

CS-11-1987 April

Preparation and properties of high-temperature superconductors in the Y-Ba-Cu-O system

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Abstract : Some experimental results concerning the synthesis of high-temperature superconducting materials in the Y-Ba-Cu-O system and their electrical, magnetic and structural properties are presented.

1. Introduction

In spite of the great efforts, the superconducting transition temperature T_c has remained until recently below 23.2 K, the T_c of Nb_3Ge. This fact largely limited the practical applications of superconductivity, when the utilization of the expensive liquid helium as a cryogenic refrigerant is needed. The position of layers of high superconductivity in the 30 K range reported by Bednorz and Müller /1/ in the La-Ba-Cu-O system and confirmed by Chu et al. /2/ opens a new era in the development of superconductivity. Further investigations have shown that high-temperature superconducting materials can also be obtained in systems like La-Sr-Cu-O /3/ and Y-Ba-Cu-O /4,5/ with superconducting transitions at 36.2 K and between 80 and 93 K, respectively.

We report in this paper our results on the preparation of high T_c superconductors in the Y-Ba-Cu-O system. Some electrical, magnetic and structural properties of the obtained materials are also presented.

2. Sample preparation

The investigated samples have the nominal composition given by $YBa_2Cu_3O_{6.5+\delta}$, with δ undetermined until now, and were prepared by a solid-state reaction method /6/. Appropriate amounts of dried oxides Y_2O_3, CuO and carbonate $BaCO_3$ were mixed in agate mortar and fired in porcelain crucibles. The mixtures were then grinded, the resulted powders were pressed into pellets at 3 Kbar and sintered in oxygen atmosphere. Three samples were prepared under the conditions given in Table 1. The samples No. 2 and 3 have undergone three intermediate grindings before sintering and the sample No. 2 was maintained for 20 h at 940 °C in oxygen atmosphere as a final heat treatment.

Table 1

Sample	Presintering			Sintering		
	time (h)	t (°C)	atmosphere	time (h)	t (°C)	atmosphere
1	24	940	flowing O_2 at normal pressure	22	940	flowing O_2 at normal pressure
2	24	940	air	22	970	- // -
3	24	940	air	6	940	- // -

3. Experimental results and discussion

The standard four-probe technique was used for electrical resistance measurements. Current and potential leads were attached to the sample with silver paste. The temperature was measured with a copper-constantan thermocouple. In Fig. 1 the

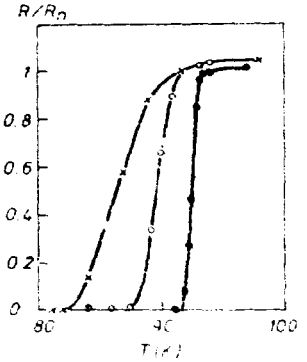

Fig. 1 Temperature variation of the electrical resistance: (•)-sample 1; (○)-2; (×)-3.

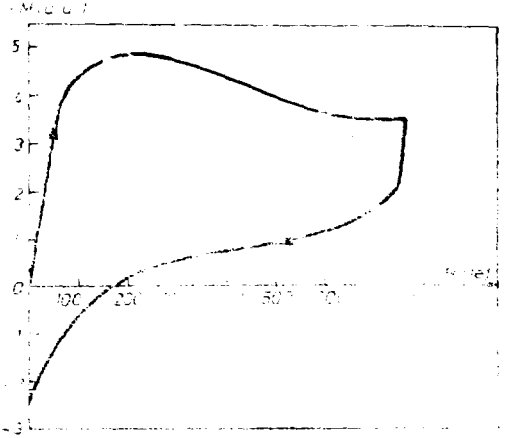

Fig. 2 Magnetization curve at 77 K for the sample 1.

superconducting transitions for our samples are illustrated. The T_c (see Table 2) was taken at the midpoint of the transition and the transition width ΔT_c was defined as the temperature interval in which the sample resistance increases from 1/4 R_n to 3/4 R_n, where R_n is the electrical resistance of the sample in normal state just above the transition. All the samples show metallic conductivity with an approximate linear R(T) dependence and a ratio $R(300\ K)/R_n \simeq 2 \div 3$.

Magnetization curves were traced at 77 K (Fig. 2) for many samples (cylinders of 2.5 mm diameter and minimum 10 mm long) in longitudinal field using an electronic integrating amplifier. All the measured samples exhibit a magnetization characteristic of hard, nonideal type-II superconductors. The lower critical magnetic field values H_{c1} for our samples are between 80 and 108 Oe.

Table 2

Sample	T_c (K)	ΔT_c (K)	% vol. (±1%)	Lattice parameters a(Å)	b(Å)	c(Å)
1	92.6	0.6	91	3.826(3)	3.897(3)	11.668(10)
2	89.6	1.3	89	3.830(3)	3.897(3)	11.680(10)

Structural investigations by X-ray diffractions were performed. The main phase in our samples (the superconducting phase) has orthorombic symmetry. Besides the orthorombic phase a minor tetragonal phase appears. The latter seems to be the semiconducting green phase Y_2BaCuO_5 observed in /5/ in similar compositions. We give in the Table 2 the volume concentration and the lattice parameters of the superconducting phase in our samples.

The superconducting transition which is sharper and occurs at

higher temperatures in the sample No. 1 seems to be related to the percent of semiconducting phase in the sample. The lattice parameters show significant variation. High lattice distorsion (low a and c) seems to be connected with a higher T_c and with the annealing time in oxygen. The sample prepared and investigated in /5/ seems to be intermediary between 1 and 2.

References

1. J. G. Bednorz, K. A. Müller, Z. Phys. B64, 189 (1986).
2. C. W. Chu, P. H. Hor, R. L. Meng, L. Gao, Z. J. Huang, Y. Q. Wang, Phys. Rev. Lett. 58, 405 (1987).
3. R. J. Cava, R. B. van Dover, B. Batlogg, E. A. Rietman, Phys. Rev. Lett. 58, 408 (1987).
4. M. K. Wu, J. R. Ashburn, C. J. Torng, P. H. Hor, R. L. Meng, L. Gao, Z. J. Huang, Y. Q. Wang, C. W. Chu, Phys. Rev. Lett. 58, 908 (1987).
5. R. J. Cava et al., Preprint AT&T Bell Laboratories.
6. C. Michel, B. Raveau, J. Sol. St. Chem. 43, 73 (1982).