

HIGH-T_c SUPERCONDUCTING MATERIALS. THE INFLUENCE OF Pb ADDITION ON THE T_c AND MAGNETIC PROPERTIES

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ABSTRACT: In a previous paper, a comprehensive study of preparation methods of Bismuth based superconductor compounds has been reported. A comparison between the properties of the superconducting materials obtained by conventional method of solid-state reaction and unconventional method of oxalate coprecipitation has been performed. In the present paper the BSCCO superconducting compounds with partial replacement of the Bi by Pb has been synthesized by the conventional and chemical method. The influence of the Pb addition on the T_c and magnetic properties of the superconducting compounds has been studied. The Pb addition determines a decrease of the thermal treatment temperature required for 2212 and 2223 phases formation and promotes the strontium preferential incorporation in the superconducting lattice.

KEYWORDS: T_c temperature; thermal treatment; Bi-based superconductors; (Bi,Pb)SrCaCuO system

1 INTRODUCTION

The Bi-Sr-Ca-Cu-O system was the first superconductor to display a reproducible critical temperature in excess of 100K. A Bi-based cuprate superconductor exists in two main superconducting phases identified as the (2212) low-T_c phase and the (2223) high T_c phase. It was found to be very difficult to obtain the high-T_c (2223) single phase. The partial replacement of Bi by Pb in the BSCCO system has been found to facilitate the formation of the higher T_c material, although even after extended heating, the lower T_c phase is generally present as a minor impurity. The present work reports the influence of the Pb addition on the superconducting phase formation and the magnetic properties of the BSCCO system, synthesized by solid state reaction as well as coprecipitation method.

2 EXPERIMENTAL

The solid state samples were prepared by the wet mixing of the solid components: Bi₂O₃, PbO, CuO, SrO, CaCO₃ and SrCO₃ (reagent grade) for one hour. The coprecipitation method has been realized according to the procedure described in a previous paper [3-5].

The samples without and with Pb addition were prepared by both solid state and coprecipitation method. The nominal compositions were: Bi₂Sr₂Ca₂Cu₃O_x and (Bi_{1.8}Pb_{0.2})Sr₂Ca₂Cu₃O_x. The obtained materials were characterised by DTA/TG analysis and X-ray diffraction. The schedule of thermal decomposition of the coprecipitated samples was established on the base of the DTA/TG data. The low and high T_c superconducting phase formation were identified by X-ray diffraction analysis. On the samples thermally treated, the magnetic measurements were performed and the T_c values were determined.

3 RESULTS AND DISCUSSIONS

The DTA/TG curves of oxalate coprecipitates are presented in Fig.1. According to the decomposition curves, it can be established that both coprecipitates have a similar behavior.

Comparing the evolution of the phases formed during thermal treatment of the two oxalate coprecipitates may conclude that the presence of Pb determines at intermediate temperatures, successive formation and decomposition of different secondary phases which increase the global reactivity of the mixture and favors, over 800°C, the formation of 2212 and 2223 superconducting phases.

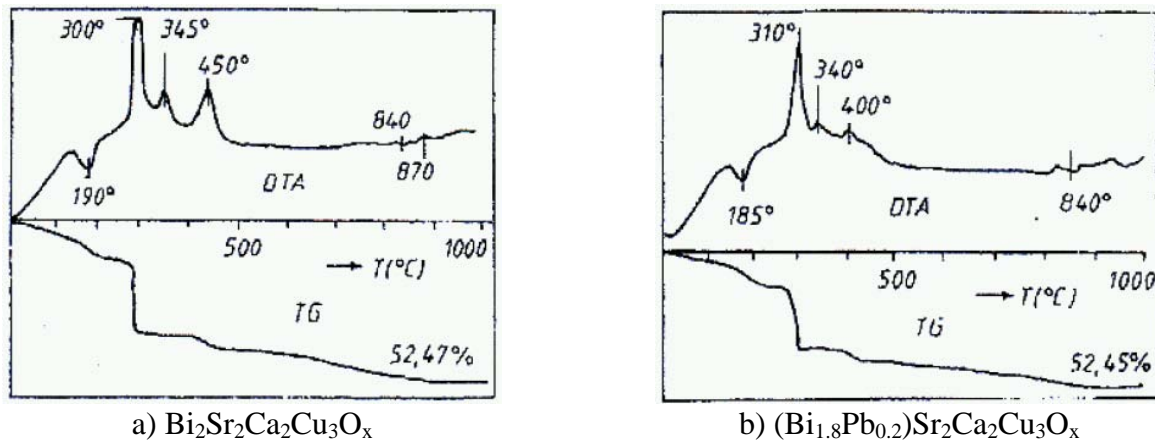


Figure 1. ATD-TG curves for oxalate coprecipitate

AC susceptibility diagrams shows the behavior of samples with and without lead addition at different thermal treatment schedule. The BSCCO sample P1 without lead, for only 28 hours of thermal treatment, has only one phase transition at low temperature (80K) - see Fig. 2.

Table 1 Thermal Treatment Schedule

Sample	BSCCO	Tc (K)	Thermal Treatment (temperature[°C]/time[h])
P1	1112	80	750/4, 800/24.
P2	2223	111	800/24, 860/24, 790/4, 830/4, 860/48.
P3	1(Pb)112	76, 108.3	800/24, 830/48.
P4	1(Pb)112	75	800/4, 840/24.

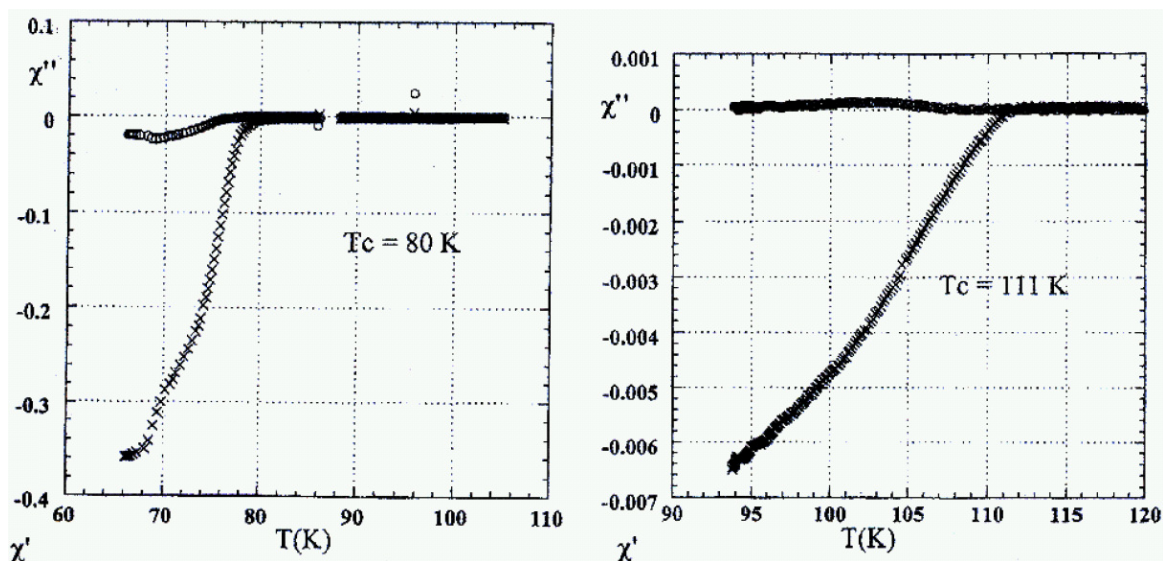


Figure 2. Magnetic susceptibility vs. temperature for samples P1 and P2

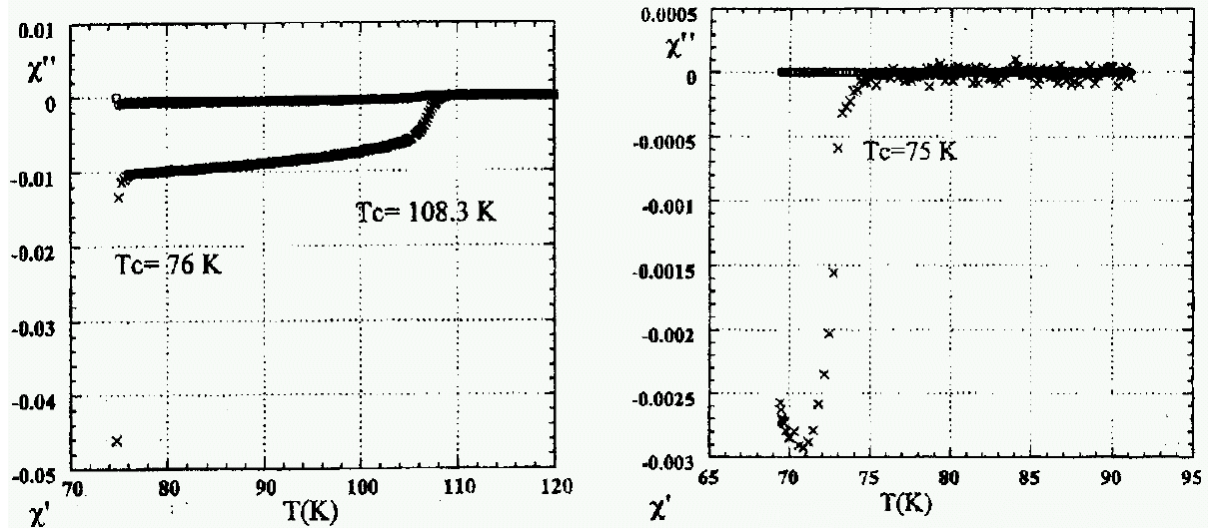


Figure 3. Magnetic susceptibility vs. temperature for samples P3 and P4

The X-ray diffraction patterns of the coprecipitated samples without and with Pb addition are presented in Fig. 4.

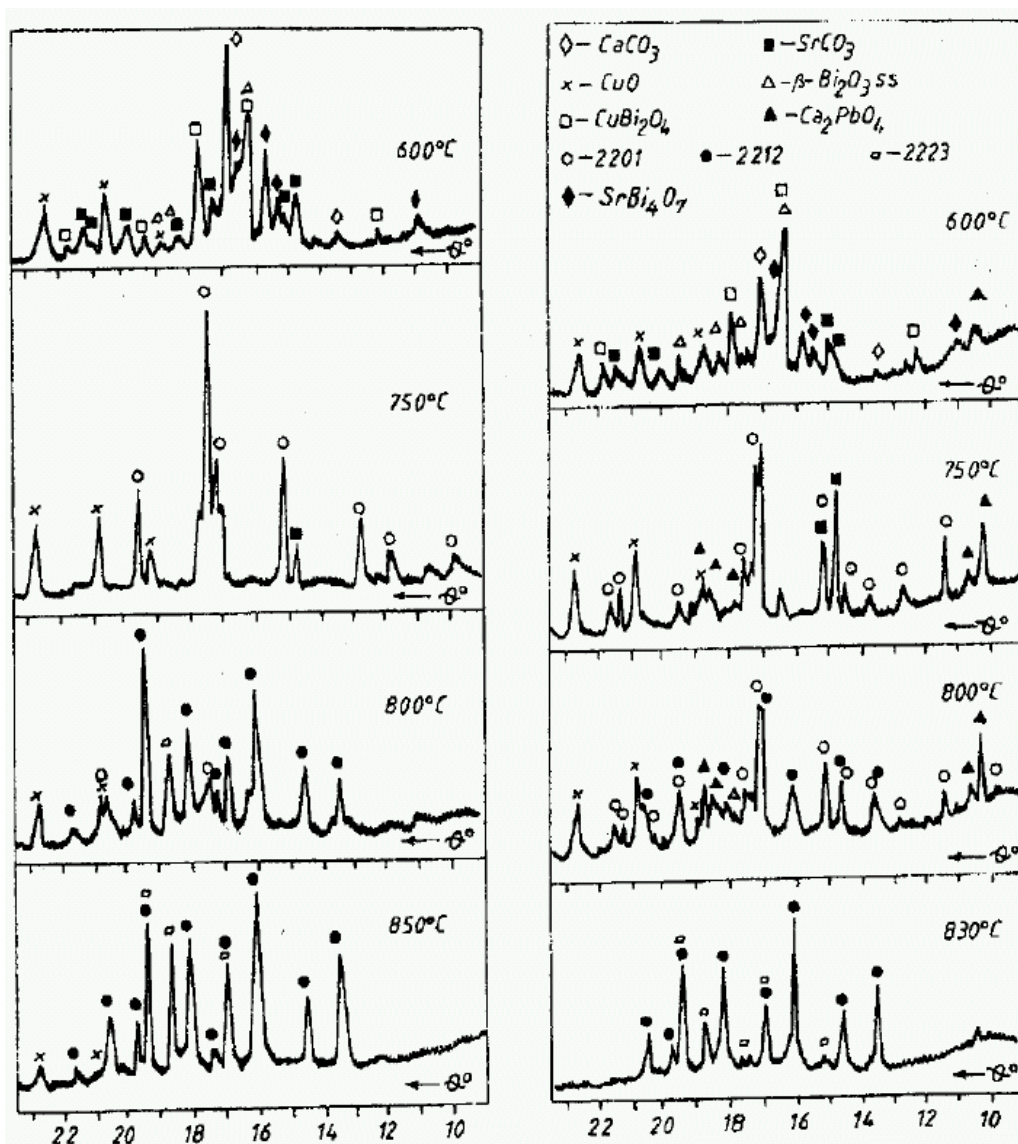


Figure 4. The X-ray diffraction diagrams for the coprecipitate thermal treated above 600°C

The BSCCO sample P2 without lead exhibits quite good phase transition at $T_c = 111\text{K}$ after double prolonged thermal treatment, that indicate presence of 2223 phase, that is not present in sample P1. Samples P3 and P4 (see Fig. 3) contain a small addition of Pb (0.2%). It can be seen that lead addition facilitates the formation of superconducting phase 2223 at shorter treatment time comparatively to samples without lead.

The X-ray diffraction patterns show also a higher quantity of high T_c 2223 phase in the presence of Pb addition at the same time of the thermal treatment.

4 CONCLUSIONS

The DTA-TG and X-ray diffraction data indicate that the mechanism of the thermal decomposition. Samples with lead addition show that the lead addition it increases the reactivity of the precursor and favors the formation of 2212 and 2223 superconducting phases.

There is no significant difference in the mechanism of thermal decomposition of the samples with lead addition compared to pure BSCCO samples.

The ac susceptibility measurements show that for an almost similar thermal treatment schedule the presence of lead determines the formation of higher quantity of high T_c superconductor phase 2223. From the magnetic measurements and T_c determination for the both type of samples, is observed that the quantities of 2223 phase and T_c values are quite low and supplementary prolonged thermal treatment is required.

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