# Bulk superconductivity at 36 K in $La_{1.8}Sr_{0.2}CuO_4$

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Cava, van Dover, Batlogg, and Rietman [Phys. Rev. Lett. **58**, 408 (1987)] have reported bulk superconductivity at 36 K in $La_{1.8}Sr_{0.2}CuO_4$ which is the highest reported bulk superconducting transition temperature at the writing of this paper. This discovery came in the wake of reported possible high-$T_c$ superconductivity in a mixture of crystalline phases of the Ba-La-Cu-O system by Bednorz and Müller [Z. Phys. B **64**, 189 (1986)]. We have also observed superconductivity in samples of $La_{1.8}Sr_{0.2}CuO_4$. The purpose of this paper is to describe briefly the results of our own measurements on this system. We find that our results are in very good agreement with those of Cava *et al.*

Our materials, with nominal composition $La_{1.8}Sr_{0.2}CuO_4$ were made using a procedure[1] which is somewhat similar to that used by Cava, von Dover, Batlogg, and Rietman.[2] The materials are single phase and belong to the tetragonal $K_2NiF_4$ structure. One of the samples was annealed in air and the other in an atmosphere of pure oxygen. The dc resistivity was measured in the temperature interval 300–1.5 K with a standard four-probe apparatus. The temperature of the sample was measured using two thermometers. A carbon glass thermometer was used from 1.5 to ~25 K and higher temperatures were monitored using a Pt resistance thermometer. The accuracy of reading the sample temperature was better than 0.1 K.

Figure 1 shows the resistance of the two samples as a function of temperature normalized to the value at 300 K. As can be seen from this figure, the two samples exhibit metallic behavior, viz., their resistivity decreases with temperature down to the superconducting transition temperature. These results must be compared with those of Cava *et al.* The resistive behavior of their air-annealed sample suggests that there were insulating (semiconducting) regions in the interior of the sample. It follows, therefore, that both of our samples, air annealed as well as the oxygen annealed, are more or less free from such regions. We believe that the difference in the performance of our air-annealed sample and that of Cava *et al.* is mainly due to the preparatory procedure that we have followed.

We have also been able to prepare a sample of $La_{1.8}Sr_{0.2}CuO_4$, that exhibits resistive behavior similar to the air-annealed sample of Cava *et al.* The resistance of this sample initially decreases when cooled from room temperature and reaches a minimum around 80 K. It starts rising again as the material is further cooled. Finally, at 35 K, the onset of superconductivity cuts short this rise. We have not shown these details in Fig. 1.

As inferred from the data of Fig. 1, the superconductivity onset temperature $T_{co}$, the full superconductivity temperature $T_{cf}$, the width $\Delta T$ of the resistive transition (10%–90%), and the midpoint $T_c$ of the transition are 36.0, 27.0, 6.4, and 32.2 K for the air-annealed sample, and 38.0, 28.5, 5.9, and 33.0 K for the oxygen-annealed sample, respectively.

To summarize, we have synthesized sintered samples of $La_{1.8}Sr_{0.2}CuO_4$ with the bulk superconducting transition temperature $T_c = 33.0$ K and the width $\Delta T = 5.9$ K of the transition. The Meissner-effect studies suggest bulk su-

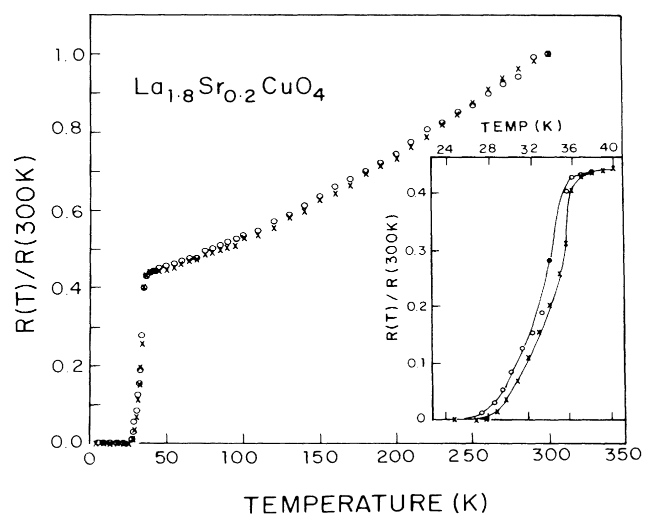


FIG. 1. Resistance of air- and oxygen-annealed samples of $La_{1.8}Sr_{0.2}CuO_4$ as a function of temperature, normalized to the value at 300 K. Open circles (O) represent the data points for the air-annealed sample and crosses (+) are the data points for the oxygen-annealed sample.

perconductivity in our sample. Therefore, we have been able to reproduce the results of Cava *et al.* about the occurrence of bulk superconductivity in these samples. Experiments are underway to examine the effects of introducing paramagnetic impurities at various sites.

[1]J. V. Yakhmi *et al.* (unpublished).
[2]R. J. Cava, R. B. van Dover, B. Batlogg, and E. A. Rietman, Phys. Rev. Lett. **58**, 408 (1987).