

LETTER TO THE EDITOR

HIGH T_c SUPERCONDUCTIVITY AND STRUCTURE OF $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$
ALLOYS

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The synthesis and resistance measurements of the high T_c superconductor $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ ($x = 0, 0.15$ and 0.20) are described. The highest T_c value obtained is about 38 K with the transition width of 2—3 K. Structural data are also reported in order to establish the role of the structural changes which favour superconductivity.

In a recent report¹⁾ Bednorz and Müller proposed the model of the percolating superconductivity in order to explain the dramatic increase of the electrical conductivity of the La-Ba-Cu-O system below 30 K. In the subsequent investigations²⁾ the superconducting phase was identified to be of the form $\text{La}_{2-x}\text{Ba}_x\text{CuO}_4$. As regards the structure this composition corresponds to the tetragonal K_2NiF_4 lattice. The application of the hydrostatic pressure³⁾ or the substitution of strontium instead of barium⁴⁾ leads to an increase of the superconducting critical temperature (T_c). At present, T_c values for these systems range between 30 and 38 K and are much higher than those for classical A-15 structure compounds.

We report here on our initial success in the synthesis and characterisation of the high T_c superconductor $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ with $x = 0.15$ and $x = 0.20$. The sintered polycrystalline samples were prepared by two methods as suggested in the literature⁽¹⁻⁴⁾, either from the mixture of lanthanum, strontium and copper oxides or by the controlled coprecipitation of the corresponding insoluble salts from the aqueous solutions. The resultant precipitate was heated at 820°C for several hours (where the solid state reaction sets in), ground and pressed into pellets. The sintering of the pellets was carried out at 1100°C at ambient atmosphere. Parts of the sintered samples were used for the X-ray powder diffraction measurements. Generally, we have found that the coprecipitation technique offers much better control over the mixing the exact oxide amount of the reacting components.

In order to test the superconducting properties of the samples we have measured the electrical resistance as a function of temperature. This was done by using the usual four point contact technique between 4.2 K and room temperature. The sample current was typically 2 mA. The temperature was monitored by a platinum thermometer. In the superconducting state the zero resistance was also confirmed by the dc measurements.

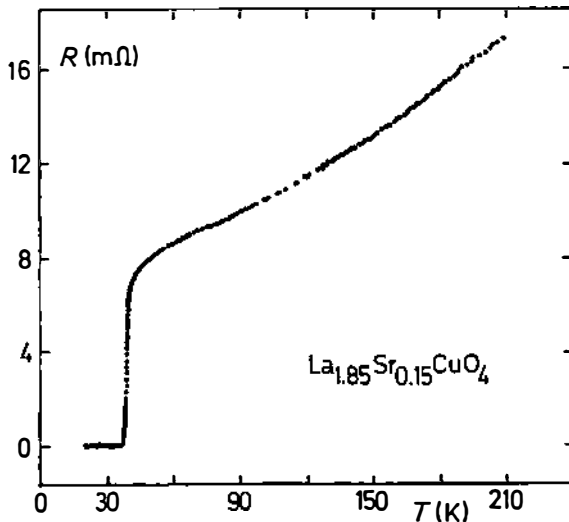


Fig. 1. Electrical resistance vs. temperature for $\text{La}_{1.85}\text{Sr}_{0.15}\text{CuO}_4$ alloy.

Our results are presented in Figs. 1 and 2. In Fig. 1 the data for the electrical resistance as a function of temperature for the $x = 0.15$ sample are presented. The resistance decreases monotonously from room temperature down to about 39 K where the onset of the superconducting transition is observed. The mid-point temperature of the transition is 38 K. Below 36 K the sample becomes completely superconducting. For the $x = 0.20$ sample, an equally progressive decrease of the resistance with decreasing temperature is observed, but the transition sets in at lower

temperature (Fig. 2). The transition interval is broader and the resistance drop below T_c is not so pronounced. We also note that our measurements of the pure La_2CuO_4 sample showed a drastic increase of the resistance at low temperatures.

For all the measured alloys ($x = 0, 0.15$ and 0.20) the structural data based on the X-ray powder diffraction patterns have been collected. Diffractograms of the pure systems showed patterns characteristic of the orthorhombic lattice in agreement with the previous investigations⁵). Alloying with strontium gives rise to the increase of the lattice symmetry which turns out to be purely tetragonal in the case of $x = 0.15$ and $x = 0.20$ (Fig. 3). It is obvious that the structural changes are very important for the nature of the low temperature state (either insulating or superconducting) and generally stimulate the phonon-based electron-electron pairing mechanism. The correlation of the structural changes (induced by gradual strontium doping) with the transport properties will be subject of a separate publication⁶). We also believe that the planned investigation of the temperature dependent structural changes will provide a better insight in their relevance concerning the transport properties.

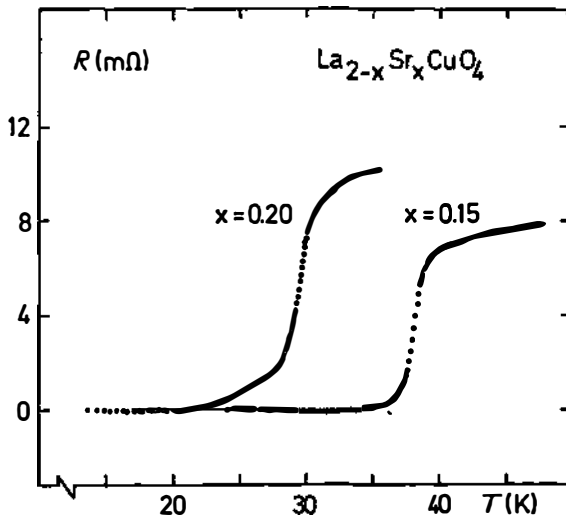


Fig. 2. Electrical resistance vs. temperature for two $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ samples with $x = 0.15$ and $x = 0.20$.

In conclusion, we have presented the data on the electrical resistance of $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ ($x = 0.15$ and 0.20) samples which show superconducting properties with high T_c values. For $x = 0.15$ alloy, $T_c \approx 38$ K which is among the highest values obtained so far for this system. Investigations of other physical properties of these systems as well as of new systems displaying similar superconducting behaviour are in progress.

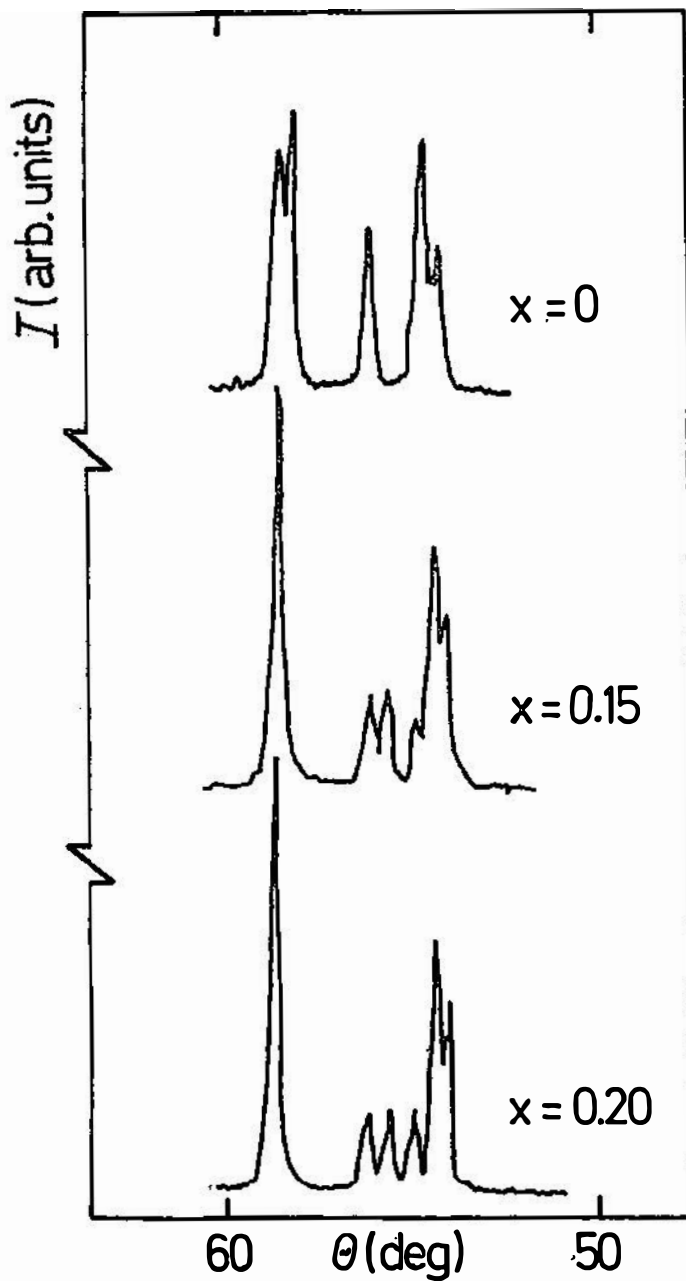


Fig. 3. Characteristic sections of the X-ray powder diffraction patterns for $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ samples. The change of the orthorhombic to the tetragonal structure is clearly seen as the function of strontium content.

Acknowledgement

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VISOKOTEMPERATURNNA SUPRAVODLJIVOST I STRUKTURA $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ LEGURA

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Opisana je sinteza i rezultati mjerenja električnog otpora $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ s visokom temperaturom supravodljivog prijelaza T_c . Najviša izmjerena T_c vrijednost je oko 38 K sa širinom prijelaza 2—3 K. Izloženi su također i rezultati strukturnih mjerenja koji ukazuju na ulogu strukturnih promjena na pojavu supravodljivosti.