Superconductivity of the system Tl–Ba–Ca–Cu–O at 115 K

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A reproducible loss of the resistivity and the appearance of diamagnetism at a temperature of 115 K, effects which are related to the superconducting transition, have been studied in a complex oxide of the composition $Tl_2Ba_2Ca_2Cu_3O_x$.

After the discovery of high-temperature superconductors based on rare-earth oxides with the superconducting transition[1] at 95 K, a vigorous search for new high-temperature oxide superconductors, including those without rare-earth elements, is continuing. The discovery of superconductors in the system Tl–Ba–Cu–O, with the superconducting transition temperature of 81 K, has recently been reported.[2]

We have investigated several compositions in the system $Tl_v Ba_w Ca_u Cu_y O_x$, with different values and combinations of indices, ranging from 1 to 3. Appropriate oxides, carbonates, and nitrates were used in synthesizing the samples, whose basic material amounted to no less than 99% by mass. The samples were synthesized in a regime of self-propagating high-temperature synthesis[3] and subsequently heat treated. X-ray analysis of the products showed that the system is characterized by an array of layered polytypical modifications which belong to the orthorhombic ($a \sim 5.4$ Å) and tetragonal $a = a/2\sqrt{2} \sim 3.86$ Å systems. The thin, black, twinned single crystals, synthesized under special conditions, measured 0.5×0.5 mm at a thickness of 0.01–0.02 mm (the direction of the largest structural period, the lattice constant c). The identified modifications are characterized by the following lattice constants (Å):

1. $a = b = 5.45$; $c = 25.46$;
2. $a = b = 5.45$; $c = 29.64$;
3. $a = b = 5.44$; $c = 27.40$;
4. $a = b = 5.48$; $c = 27.40$;
5. $a = 5.38$; $b = 5.45$; $c = 27.27$;
6. $a = b = 5.58$; $c = 25.50$.

The lattice constant c varies in the range 0.2–0.3 Å from sample to sample. X-ray data showed that the structure of the single crystals is characterized by a pronounced disorder.

All synthesized samples exhibited a high-temperature superconductivity. A typical example of the temperature dependence of the electrical resistivity of a $Tl_2Ba_2Ca_2Cu_3O_x$ sample, ignoring its porosity and susceptibility, is shown in Fig. 1. The dc measurements (10-mA current) of the resistivity were carried out using the four-contact method. The diamagnetic susceptibility was determined from the change in the Q of the coil containing the sample, at a frequency of 30 MHz.

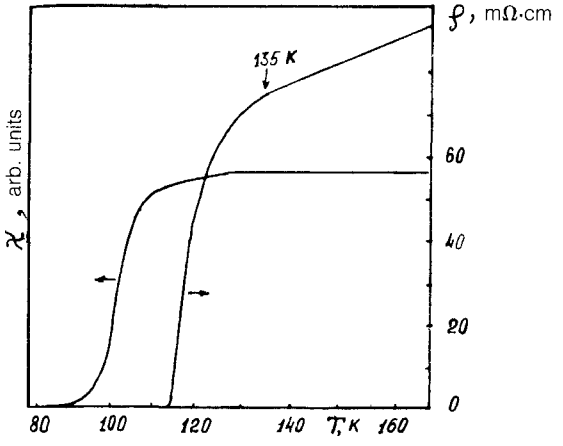

FIG. 1. Temperature dependence of the electrical resistivity and susceptibility of a $Tl_2Ba_2Ca_2Cu_3O_x$ sample.

We clearly see a marked decrease in the sample's resistivity below 135 K and its final disappearance at 115 K. As a result of the Meissner effect, the diamagnetism is clearly seen below this temperature.

The properties of the ceramic samples which we have studied can easily be reproduced.

[1]M. K. Wu, I. R. Ashburn, C. J. Torng *et al.*, Phys. Rev. Lett. **58**, 908 (1987).
[2]Z. Z. Sheng, A. M. Hermann, A. El. Ali *et al.*, Phys. Rev. Lett. **60**, 937 (1988).
[3]A. G. Merzhanov and I. P. Borovinskaya, Dokl. Akad. Nauk SSSR **204**, 366 (1972) [Sic.]

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