SUPERCONDUCTIVITY IN THE Sn-Ba-Sr-Y-Cu-O SYSTEM


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Since Bednorz and Müller /1/ discovered high-\(T_c\) superconductivity in the La-Ba-Cu-O compound, several families of superconducting oxides have been synthesized /2/. In this paper we report the results of search for superconductivity in the compounds based on tin which has a lone electron pair like Bi, Tl, Pb.

The following compounds were synthesized: Sn\(_1\)Ba\(_1\)Sr\(_1\)Cu\(_3\)O\(_x\), Sn\(_1\)Ba\(_1\)Ca\(_1\)Cu\(_3\)O\(_x\), Sn\(_1\)Ba\(_1\)Sr\(_1\)Mg\(_1\)Cu\(_3\)O\(_x\), Sn\(_1\)Sr\(_2\)Ca\(_2\)Cu\(_3\)O\(_x\), Sn\(_1\)Sr\(_2\)Mg\(_1\)Cu\(_3\)O\(_x\), Sn\(_1\)Ca\(_1\)Ca\(_1\)Cu\(_3\)O\(_x\). The initial components were oxides and carbonates of the appropriate elements. Standard firing-grinding procedure was used. Final heating was carried out at 960\(^\circ\)C during 12 hours. Then the samples were cooled inside the furnace. All the synthesis cycles were carried out in air atmosphere.

Among the synthesized compounds only Sn\(_1\)Ba\(_1\)Sr\(_1\)Cu\(_3\)O\(_x\) showed remarkable conductivity (\(\rho \approx 10\) Ohm-cm). Other compounds were practically dielectrics (\(\rho > 1000\) Ohm-cm). Presence of a possible superconductivity in Sn\(_1\)Ba\(_1\)Sr\(_1\)Cu\(_3\)O\(_x\) was defined by using the Meissner effect. At low temperature a deviation from paramagnetic behaviour is observed. The hysteresis loops obtained at lower temperatures undoubtly testify to the presence of a superconductive phase in the sample. However, the part of the superconductive phase in the Sn\(_1\)Ba\(_1\)Sr\(_1\)Cu\(_3\)O\(_x\) ceramic turned out to be small, less than 2%, which agrees with the estimation from magnetic data. In order to increase the content of the superconductive phase two-valent cations Ba, Sr were partially substituted by univalent (K) and three-valent ones (Y). Two samples were obtained: Sn\(_2\)Ba\(_0.7\)Sr\(_0.7\)K\(_0.7\)Cu\(_3\)O\(_x\) and Sn\(_2\)Ba\(_0.7\)Sr\(_0.7\)Y\(_0.7\)Cu\(_3\)O\(_x\). The former is a typical paramagnet without any anomaly down to 4.2K. The latter has shown the magnetic and electric properties undoubtly indicating the presence of a superconductivity phase with the onset temperature \(T_c \approx 55\)K. The superconductive properties of the sample do not seem to be caused by the phase YBaSrCu\(_3\)O\(_7\) /3/. This conclusion follows from the study of the Sn\(_2\)Sr\(_2\)Ba\(_0.5\)Y\(_0.5\)Cu\(_3\)O\(_x\) and Sn\(_2\)Ba\(_2\)Sr\(_2\)Y\(_0.5\)Cu\(_3\)O\(_x\) samples that were synthesized by analogy with the recent communications on superconductivity in Pb\(_2\)Sr\(_2\)(Y, Ca)\(_1\)Cu\(_3\)O\(_6\) /4, 5/. One may expect equal probability of the YBaSrCu\(_3\)O\(_7\) content for both samples, however their electrical properties are quite different. The compound Sn\(_2\)Sr\(_2\)Ba\(_0.5\)Y\(_0.5\)Cu\(_3\)O\(_x\) is a good dielectric while Sn\(_2\)Ba\(_2\)Sr\(_2\)Y\(_0.5\)Cu\(_3\)O\(_x\) has clearly expressed superconductive properties /6/. The magnetic moment was measured in an external field \(H = 100\) Oe. At \(T < 86\)K the sample exhibits a clearly defined diamagnetic behaviour characteristic of superconductors. At these temperatures the hysteresis loop has the form typical of high-\(T_c\) superconductors. The amount of the superconductive phase in this sample, as a magnetic estimation in powder, is \(\approx 15\)% of the volume of the sample.
A comparative analysis of the X-ray powder diagrams leads us to believe that the main motive of the $Y_1Ba_2Cu_3O_7$ structure is preserved in the structure of $Sn_2Ba_2Sr_0.5Y_0.5Cu_3O_x$. The unit cell parameters are: $a = 4.1 \AA$, $c = 12.4 \AA$ (or multiple).

We have also used the same procedure for $Sn_1Ba_2Sr_0.5Y_0.5Cu_3O_x$. The sample is a typical paramagnet without any anomaly down to 4.2 K.

The presence of superconductivity in the system based on tin allows us to suggest that other cations, besides the well-known Bi, Tl, Pb, having the lone electron pair effect, should also form superconductive compounds. If we limit ourselves to consideration of copper-containing oxides, we may suppose that definite alkali-earth ions (or their combination) would suit for each of the ions: Hg, Sb, In, ... in order to form a superconductive phase.

References