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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: $Sn_1Ba_1Sr_1Cu_3O_x$, $Sn_1Ba_1Ca_1Cu_3O_x$, $Sn_1Ba_1Mg_1Cu_3O_x$, $Sn_1Sr_1Ca_1Cu_3O_x$, $Sn_1Sr_1Mg_1Cu_3O_x$, $Sn_1Ca_1Mg_1Cu_3O_x$. The initial components were oxides and carbonates of the appropriate elements. Standard firing-grinding procedure was used. Final heating was carried out at 960°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 $Sn_1Ba_1Sr_1Cu_3O_x$ showed remarkable conductivity ($\rho \sim 10$ Ohm·cm). Other compounds were practically dielectrics ($\rho > 1000$ Ohm·cm). Presence of a possible superconductivity in $Sn_1Ba_1Sr_1Cu_3O_x$ 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 $Sn_1Ba_1Sr_1Cu_3O_x$ 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: $Sn_1Ba_{0.7}Sr_{0.7}K_{0.7}Cu_3O_x$ and $Sn_1Ba_{0.7}Sr_{0.7}Y_{0.7}Cu_3O_x$. 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 $T_c \simeq 55$K. The superconductive properties of the sample do not seem to be caused by the phase $YBaSrCu_3O_7$ /3/. This conclusion follows from the study of the $Sn_2Sr_2Ba_{0.5}Y_{0.5}Cu_3O_x$ and $Sn_2Ba_2Sr_{0.5}Y_{0.5}Cu_3O_x$ samples that were synthesized by analogy with the recent communications on superconductivity in $Pb_2Sr_2(Y,Ca)_1Cu_3O_8$ /4,5/. One may expect equal probability of the $YBaSrCu_3O_7$ content for both samples, however their electrical properties are quite different. The compound $Sn_2Sr_2Ba_{0.5}Y_{0.5}Cu_3O_x$ is a good dielectric while $Sn_2Ba_2Sr_{0.5}Y_{0.5}Cu_3O_x$ has clearly expressed superconductive properties /6/. The magnetic moment was measured in an external field H = = 100 Oe. At T < 86K 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 ~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 $Sn_2Ba_2Sr_{0.5}Y_{0.5}Cu_3O_x$. The unit cell parameters are: $a = 4.1$ Å, $c = 12.4$ Å (or multiple).

We have also used the same procedure for $Sn_1Ba_2Sr_{0.5}Y_{0.5}Cu_3O_x$. 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

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