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


Kirensky Institute of Physics, USSR Academy of Sciences, Siberian Branch, 660036 Krasnoyarsk, USSR

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: \(\text{Sn}_1\text{Ba}_1\text{Sr}_1\text{Cu}_3\text{O}_x\), \(\text{Sn}_1\text{Ba}_1\text{Ca}_1\text{Cu}_3\text{O}_x\), \(\text{Sn}_1\text{Ba}_1\text{Mg}_1\text{Cu}_3\text{O}_x\), \(\text{Sn}_1\text{Sr}_1\text{Ca}_1\text{Cu}_3\text{O}_x\), \(\text{Sn}_1\text{Sr}_1\text{Mg}_1\text{Cu}_3\text{O}_x\), and \(\text{Sn}_1\text{Ca}_1\text{Mg}_1\text{Cu}_3\text{O}_x\). The initial components were oxides and carbonates of the appropriate elements. Standard firing-grinding procedure was used. Final heating was carried out at 960°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 \(\text{Sn}_1\text{Ba}_1\text{Sr}_1\text{Cu}_3\text{O}_x\) showed remarkable conductivity (\(\rho\sim 10\) Ohm·cm). Other compounds were practically dielectrics (\(\rho > 1000\) Ohm·cm). Presence of a possible superconductivity in \(\text{Sn}_1\text{Ba}_1\text{Sr}_1\text{Cu}_3\text{O}_x\) 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 \(\text{Sn}_1\text{Ba}_1\text{Sr}_1\text{Cu}_3\text{O}_x\) 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: \(\text{Sn}_1\text{Ba}_{0.7}\text{Sr}_{0.3}\text{K}_{0.7}\text{Cu}_3\text{O}_x\) and \(\text{Sn}_1\text{Ba}_{0.7}\text{Sr}_{0.3}\text{Y}_{0.7}\text{Cu}_3\text{O}_x\). 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 \(T_c \approx 55K\). The superconductive properties of the sample do not seem to be caused by the phase \(\text{YBa}_2\text{Sr}_2\text{Cu}_3\text{O}_7\) /3/. This conclusion follows from the study of the \(\text{Sn}_2\text{Sr}_2\text{Ba}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x\) and \(\text{Sn}_2\text{Ba}_2\text{Sr}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x\) samples that were synthesized by analogy with the recent communications on superconductivity in \(\text{Pb}_2\text{Sr}_2(Y,\text{Ca})_1\text{Cu}_3\text{O}_8\) /4,5/. One may expect equal probability of the \(\text{YBa}_2\text{Sr}_2\text{Cu}_3\text{O}_7\) content for both samples, however their electrical properties are quite different. The compound \(\text{Sn}_2\text{Sr}_2\text{Ba}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x\) is a good dielectric while \(\text{Sn}_2\text{Ba}_2\text{Sr}_{0.5}\text{Y}_{0.5}\text{Cu}_3\text{O}_x\) has clearly expressed superconductive properties /6/. The magnetic moment was measured in an external field \(H = 100\) 0e. 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 \(\sim 15\%\) 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 $Y_1\text{Ba}_2\text{Cu}_3\text{O}_7$ structure is preserved in the structure of $\text{Sn}_2\text{Ba}_2\text{Sr}_{0.8}\text{Y}_0.5\text{Cu}_3\text{O}_7$. The unit cell parameters are: $a = 4.1$ Å, $c = 12.4$ Å (or multiple).

We have also used the same procedure for $\text{Sn}_1\text{Ba}_2\text{Sr}_{0.8}\text{Y}_0.5\text{Cu}_3\text{O}_7$. 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