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THE INFLUENCE OF THE ADDITIONAL PHASES ON THE SUPERCONDUCTIVITY OF THICK LAYER BISMUTH HTSC FILMS

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It was investigated the specific resistive of Bi-based superconducting thick films in 65÷350K temperature interval. The X-ray analysis show that, the investigated samples are two phases. The calculations were carried out according to the two-phase theory. It were determined several physical parameters as: the 2D-3D crossover of the fluctuation conductivity, the width of crossover, the coherent lengths, the interlayer coupling strength for the investigated samples.

As is known, the longitudinal and cross-section coherent lengths of high temperature superconductors (HTSC) are very small [1,2]. Short coherent lengths lead to suffice small coherent volume where only a few cooper pairs contains. As a result of this thermodynamic fluctuations play an essential role in such systems; fluctuations of order parameter affects to transport, magnetic and thermodynamic properties.

On the other hand, special interest is represented with kinetic coefficients researches in such films at the phase transition area (if these samples contain inclusions of additional phases). Such phases are some kind of defects, the pinning centres, as it is important for application practice view of second kind superconductors [3]. On aim of revealing the additional phases influence on superconducting parameters at the phase transition area have been investigated thick layer HTSC films on the bismuth basis.

EXPERIMENTAL RESULTS AND DISCUSSION

The temperature dependence of specific resistance of the bismuth basis (2212) thick layer HTSC films with 50÷120 microns thickness at the 65÷350 K temperature interval was investigated. The X-ray analysis of grown thick films was carrying out on DPON-3 diffractometer (CuKα - radiation, the Ni-filter). The X-ray structure analysis has showed, that samples are polycrystals with some inclusions of a 2223 and 2201 high-temperature phases. Let's mark, that the structural characteristic investigated by us samples on a diffraction picture and lattice parameters, are agreed the similar data obtained in works [4,5]. The received roentgenograms are shown on Fig.1. The basic structure of the received samples corresponds to a phase 2212 with the lattice parameters a=b=3,81Å and c=30.8Å. Experimental interplane distances d, relative intensity I/I_0 and an reflection h, k, l index's are shown in the table.

The HTSC ceramic grown technique and crystals is described in details [6,7]. On the basis of synthesized HTSC materials have been received thick layer film on a sapphire and 22XC substrates. For this purpose samples Bi-Sr-Ca-Cu-O were frayed in an agate mortar and were located on a substrate, after then heated up to HTSC fusion temperature. At this temperature samples were maintained during one hour, and then the temperature went down till 830º÷840ºC, 5÷10hours were additionally maintained in this mode, further were slowly cooled till a room temperature. Measurements of specific resistance were carried out by a direct current four-probe method. The current density did not exceed limiting value of a critical current for a superconductor. Current contacts were rendered by indium. Contact resistance did not exceed 1,2Ohm. Temperature stabilization in lower then 77K area was supported by a steam regulator of liquid nitrogen and not exceeds

0.1K. The temperature gradient was created by a bifilar 0,2mm diameter constantan wire furnace and mounted on a butt-end face of a researched sample.

Table

2θ,degree	I/I_0,%	d_{exp}	hkl	Samples
13.85	6	6,421	-	101
17.25	3,8	5,137	006	101
20.8	3,3	4,281	-	101
21,9	11,9	4,055	-	101
23	6,8	3,872	008	101
23.48	41,8	3,795	008	97
23,5	55,3	3,779	008	96
24.85	8,1	3,584	103	101
25,4	23,5	3,502	103	96
27.7	100	3,210	105	101
27.96	57,6	3,184	105	96
28.1	13,6	3,171	105	97
29	71	3,082	00,10	101
29.4	25,4	3,053	00,10	97
29.74	100	2,998	00,10	96
31	13,3	2,886	107	101
31	16,4	2,886	107	97
31.48	41,2	2,843	107	96
32	21,4	2,792	107	101
32.58	15,3	2,742	-	96
33.15	17,6	2,704	110	101
33.5	17,3	2,675	110	97
33.72	95,3	2,657	110	96
35	49,5	2,568	00,12	101
35.35	50	2,535	00,12	97
35.48	76,5	2,526	00,12	96
36.95	5,7	2,431	116	101
37.7	10,6	2,385	116	96
42.45	5,7	2,128	119	101
44.65	9,3	2,028	11,10	101
45	9,1	2,055	11,10	97
45.22	30,6	2,007	11,10	96
47.5	18,6	1,907	200	101
47.6	17,3	1,907	020	97
48.2	54,1	1,888	200	96
50.5	11	1,809	10,15	101
51	32,9	1,788	10,15	96
54	9,4	1,697	208	96
56.35	15,4	1,632	215	97
56.4	17,6	1,629	216	96
57.3	27,6	1,609	215	101
58	23,5	1,589	216	96
60.1	9,5	1,538	20,12	101
60.5	26,4	1,529	20,12	97
60.7	27,1	1,526	20,12	96
65.7	4,7	1,422	21,12	101

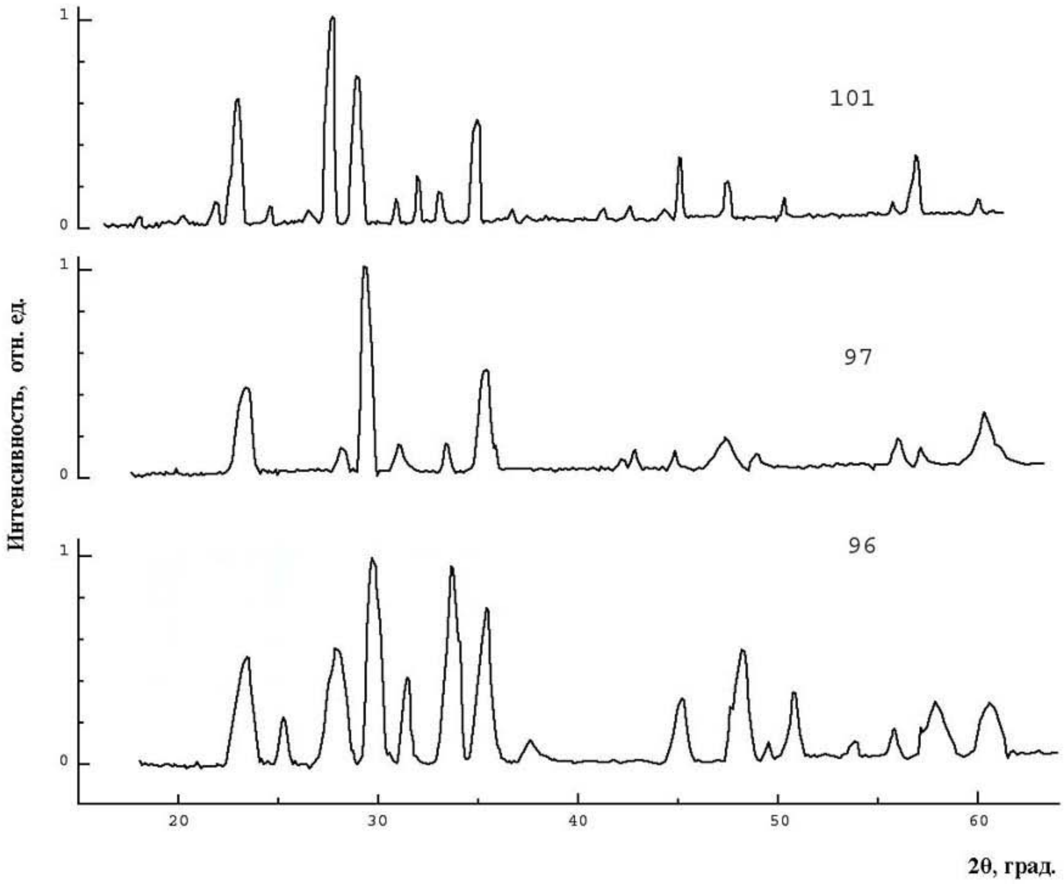

Fig.1.
X-ray difractogram of the $Bi_2Sr_2CaCu_2O_{8+x}$ samples at 300 K.

On Fig.2 are shown the temperature dependences of specific resistance ρ(T) of the investigated samples are resulted. As is seen, the temperature dependences of specific resistance show transition on superconductivity state for sample N96 –75 K, sample N97 – 80 K, sample N101-68 K.

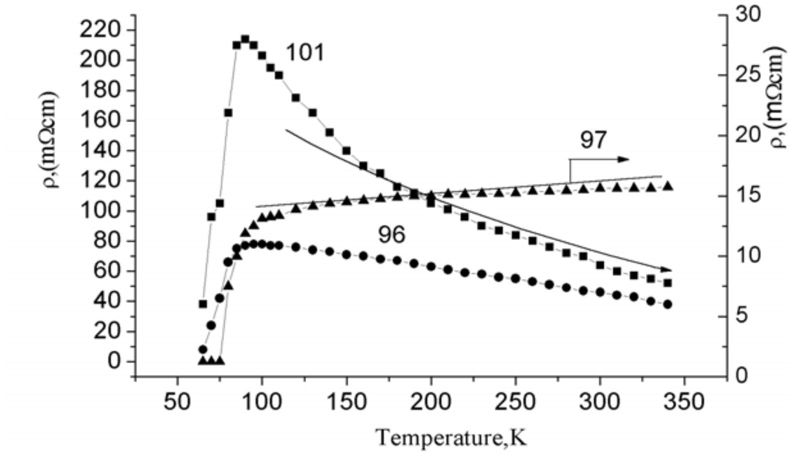

Fig.2.
The temperature dependences of specific resistivity of $Bi_2Sr_2CaCu_2O_{8+x}$ samples.

The attention a course of temperature dependences ρ pays to itself for the investigated samples. For samples N96 and N101 ρ (T) has a semiconductor type course, while for samples N97 – metal type. As is seen from Fig.2, temperature dependences ρ for samples N96 and N101 have a semiconductor type course in a normal condition, though sample N96 has been synthesized on sapphire, but samples N97 and N101 on 22XC substrates. Proceeding from this, it is possible to conclude, that a semiconductor or metal type courses of ρ does not depend on that on what substrate the sample is brought up; most likely it is bounded with maintenance of the structure. It is known [6,8], that bismuth systems samples grows not single-phase since at bismuth HTSC synthesis some phases can be formed as a 2201, 2212, 2223. Depending on what phase dominated at synthesis, a different temperatures 20 K (2201), 85 K (2212), 115 K (2223) superconductivity transition condition is observed on experiment. The X-ray phase analysis shows presence of some share of other phases. Therefore it would be reasonable, to take into account influence of additional phases on conductivity. Such attempt has been made in this work. The percentage of phases is taken on the basis of X-ray phase analysis. It was supposed, that samples consist of two phases. Calculations have been lead on the basis of biphasic system [9,10]. According to this theory if conductivity of phases not strongly differ, expression for electro conductivity looks like:

$$\sigma = \langle\sigma\rangle\left[1 - \frac{X_1}{3}\frac{\left(\sigma_1 - \langle\sigma\rangle\right)^2}{\langle\sigma\rangle^2} - \frac{X_2}{3}\frac{\left(\sigma_2 - \langle\sigma\rangle\right)^2}{\langle\sigma\rangle^2}\right], \tag{1}$$

where $(\sigma)=\sigma_1X_1+\sigma_2X_2$ and $(\sigma)^2=(\sigma_1X_1+\sigma_2X_2)^2$, X_1 and X_2 - volume fractions of both phases. At the calculations the temperature dependences of ρ of 2223 and 2101 are taken from [11,6] accordingly. Results of calculation are submitted on Fig.2 by continuous lines. As is seen the account of a volume fraction of 15% and 25% of the second low temperature phases 2201 leads to the satisfactory consent with experimental data. Thus, a semiconductor or metal course of a ρ and more exact consent with experiment can be received, taking into account the volume part of other phases.

On Fig.3 dependence $\ln\Delta\sigma/\sigma$ of $\ln(T-T_c)/T_c$ is submitted from ln(T-Tc)/Tc for samples 96, 97 and 101.

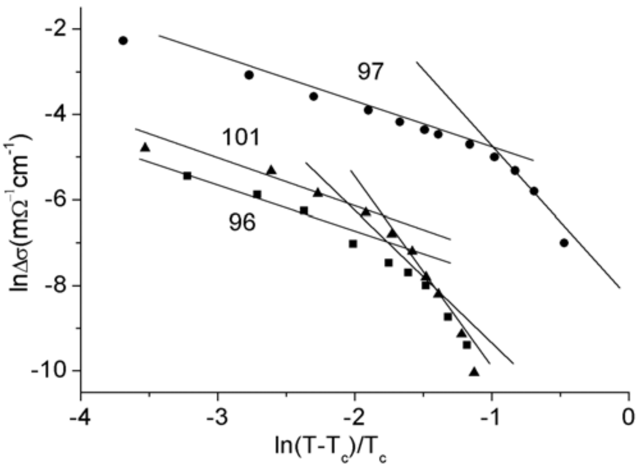

Fig.3.
The temperature dependences of reduced electrical conductivity of $Bi_2Sr_2CaCu_2O_{8+x}$.

As is known, in the phase transition (FT) to conductivity superconducting fluctuations essentially influence. Within the framework of Ginzburg – Landau theory, fluctuations amendment to conductivity for HTSC materials has been calculated by Varlamov and Livanov [12]. According to this theory additional conductivity looks like:

$$\Delta\sigma = \left(\frac{e^2}{16\hbar d}\right)\left(\frac{T}{T_c} - 1\right)^{-1}\left[1 + J\left(\frac{T}{T_c} - 1\right)^{-1}\right]^{-1/2}, \tag{2}$$

where $J=(2\zeta_c(0)/d)^2$ - a constant of interplane pairing. It is seen from the equation (2), that at high temperature $T>>T_c$ (where $J<<\varepsilon$; $(\varepsilon=(T/T_c-1))$), $\Delta\sigma$ is proportional ε^{-1} (2D-conductivity), and at approach to the transition temperature T_c (where $J>>\varepsilon$), $\Delta\sigma$ changes proportionally $\varepsilon^{-1/2}$ (3D - conductivity). According to experimental data, by (2) the temperature of 2D-3D crossover of fluctuation conductivity for samples 96, 97 and 101 has been calculated. Has been calculated also the width of 2D-3D transition $\Delta T_{23}(96)=4K$, $\Delta T_{23}(97)=3K$, $\Delta T_{23}(101)=4.5K$. Apparently that depends on structure of a researched sample. It was analysed influence of the second phase on ΔT also and is established, that with increase volumetric the maintenance of the second phase on the ΔT 2D-3D a crossover increases.

The constant of interplane pairing J ($85\cdot10^{-3}$ – samples 97, $56\cdot10^{-3}$ – 96, $48\cdot10^{-3}$ – 101), coherent length ζ_0 is appreciated also (2.2 Å – sample 97, 1.82Å – sample 96, 1.75Å – sample 101). It is received, that with increase in a share of the second phase width of transition in superconductivity condition also increases, covering wider interval of temperatures.

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VİSMUT ƏSASLI YTİK-Cİ QALIN TƏBƏQƏLƏRİN İFRATKEÇİRİCİLİYİNƏ ƏLAVƏ FAZALARIN TƏSİRİ

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Vismut əsaslı (2212) yüksəktemperaturlu ifratkeçirici qalın təbəqələrdə 65-350K temperatur intervalında xüsusi müqavimət tədqiq edilmişdir. Rentqenfaza analizi göstərmişdir ki, tədqiq edilən nümunələr ikifazalıdır. İkifazalı sistemlər üçün nəzəriyyəyə əsasən hesablamalar aparılmışdır. 2D-3D fluktuasiya keçiriciliyi temperaturu, keçidin eni, koherentlik uzunluğu və laylararası cütlənmə sabiti kimi bəzi fiziki parametrlər təyin edilmişdir.

ВЛИЯНИЕ ДОПОЛНИТЕЛЬНЫХ ФАЗ НА СВЕРХПРОВОДИМОСТЬ ВИСМУТОВЫХ ТОЛСТОСЛОЙНЫХ ВТСП ПЛЕНОК

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Проведено исследование удельного сопротивления толстослойных висмутовых сверхпроводящих пленок (2212) в температурном интервале 65÷350К. Рентгеноструктурный анализ показал, что исследованные образцы являются двухфазными. Проведен расчет на основе теории двухфазных систем. Определены некоторые физические параметры такие как, температура и ширина перехода 2D-3D флуктуационной проводимости, постоянная межплоскостного спаривания и длина когерентности.

Редактор: Э.Гусейнов