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Effect of Temperature Annealing on Enhancement of High-T_c for BiPbSrCaCuZnO System Thin Film through Thermal Expansion

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Abstract
Annealing thermal plays an important role on the formation of high T_c-phase BiPbSrCaCuZnO through expansion and contraction layers which be associated with formation high and low phases respectively, The prepared samples composition BiPbSrCaCuZnO have been annealed at (1093,1113,1133,1153 k). It is observed the critical temperature T_c increase for films which annealed at (1093, 1113, 1153 k) while T_c decreases at T_a =1133 k.

Keywords: Super Conducting Thin Film.

الخلاصة
نبين في هذا البحث دور التلدين في احداث تمدد وتقلص بين طبقات الشبيكة وتأثيرهما على تكوين اطوار عالية وواطئة للتوصيلية الفائقة لغشاء رقيق لنظام BiPbSrCaCuZnO من خلال درجة حرارة الانتقال T_c المسجلة لكل درجة تلدين حيث كانت درجات حرارة الانتقال للعينات الملدنة عند (T_a=1093,1133,1153 K) هي (T_c=95,100,super .behavior K)

Introduction
Superconductor is a material that loss all resistance to the flow of electric current when it cooled below a certain temperature, which is called the critical temperature or transition temperature. above this temperature there is usually little or no indication that the material might be a superconductor .Below the critical temperature, not only does the superconductor suddenly vanish zero resistance, it gains other properties, where prevent magnetic flux to pentration[1].

In 1911, Kammerlingh Onnes discovered the phenomenon of superconductivity this phenomenon is actively studied to the present day and consider to be a major branch of the condensed matter physics[2].

Onnes discovered that at temperature close to 4K, the electrical resistance of mercury abruptly vanishes. This discovery was followed by a large amount of experimental studies[3].

The majority of superconductors are not pure element, but alloy and compounds. If one or more of the components in an alloy is a superconducting element, the electrical temperature of the alloy is different from that of its component, and is often higher[4][5].

The highest transition temperatures are in fact observed in alloys and compounds. In order to reach the superconducting state, three conditions must be met: The critical temperature (T_c), the magnetic field (H_c), and the critical current density (J_c). These three values is exceeded in some way its critical values, the material loses its superconductivity[4].

In this search, study relation between annealing temperature and critical temperature and it is effect on lattice construction.

Many properties of matter depend on temperature, the length of a metal rod increases when the rod becomes hotter; a steam boiler may explode if it becomes too hot. The electrical properties of materials change with temperature.

All of this behavior can be understood in greater depth based on the molecular structure of materials. The relationship between temperature and molecular motion is very important to understand that temperature and heat are inherently macroscopic concepts, and can be defined independently of any detailed consideration of molecular motion, also can be illustrate this by simple scheme as shown:

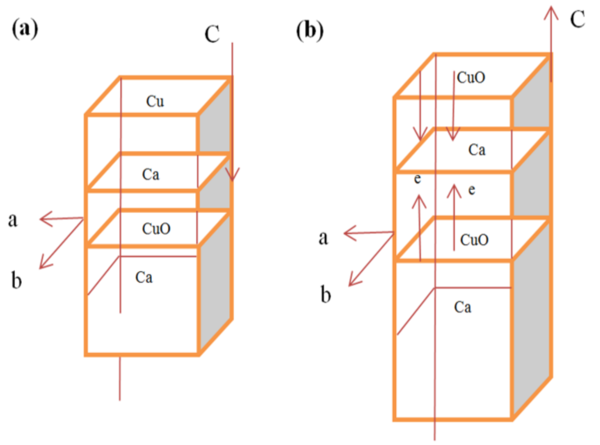

Figure 1: (a, b) Schematic illustrate expansion and contraction CuO layer.

The aim of this search is to investigate the ability of CuO layer in BSCCO system to expansion and contraction due to thermal stress for annealing and its effect on transition temperature.

Materials and Methodologies

All samples were grown at an optimal Si substrate (111) at 573 k with an oxygen background pressure of 2×10^{-3} mbar. BiPbSrCaCuZnO target mounted in vacuum chamber 10^{-4} m bar, and ablated frequency by a double frequency with Q-switched Nd:YaG pulse laser operated at 532 nm, pulse duration of about 7nsec and (0.4-8 J/cm^2) energy density was focused on the target to generate plasma plume. All the thin films of BiPbSrCaCuZnO undergone for heat treatment in oxygen flow 2lit/min for 2h under different annealing temperature (1093, 1113, 1133, 1153 k) with heating rate of 288 k/min. Four-probe dc method at low temperature was used to measure the resistivity ρ and to determine the T_c of the superconductor. The probe contacted to the surface of the samples using conductive silver paste, the sample was fixe under vacuum pressure of 10^{-2} m bar inside a crystal by using (Edward prini 12), and joined to a sensor of a digital thermometer type (RTD). Four wires have been connected to the cryostat, the outer connections were used for supplying the sample with current from dc power supply type (6236A triple output), while the inner connection were used for measuring the voltage droop by a digital nano rang voltmeter type (KETHLEY 180) with sensitivity of a bout (± 0.1 nV). The current pass through the sample (film) equal to (0.05 mA), the dimension of the film, thickness t=184.2 nm, width of the film b=1cm and the space between the points is L=29.272×10^{-6} m, The instrument locate in college of science, Baghdad University, The final equation employing to measure resistivity.

$$\rho = \frac{bt}{L}\frac{V}{I}$$

$$\rho = 6.292\times10^{-5}\ \frac{V}{I} \qquad (1)$$

Equation (1) is special for film samples. Critical temperature could be found from the curve of resistivity versus temperature. T_c is the temperature at which the resistivity drop to 50% of its extrapolated normal state value at room temperature, or is the temperature at the mid-point between the resistivity at the onset of the transition (T_{c1}) and zero resistivity point (T_{c2}), as given by the following relation[1].

$$T_c = (T_{c1} + T_{c2})/2 \qquad (2)$$

Results and Discussion

Sintering temperature plays an important role on the formation of high-T_c phase of BSCCO system. Figure 2 illustrate relation transition temperature for composition $BiPbSrCaCu_{2.4}Zn_{0.6}O$ at different annealing temperatures as shown in Figure 2.

It is found from Table 2 and Figure 2 that transition temperature enhance with increasing annealing temperature while at T_a =1133 k shows decrease in the critical temperature T_c. The reason of enhancing T_c value at (1093, 1113, 1153 k) suggest the exciton and carriers can co-exist in the same spatial region due to annealing thermal, pairing occur by exchange of these virtual excitations.

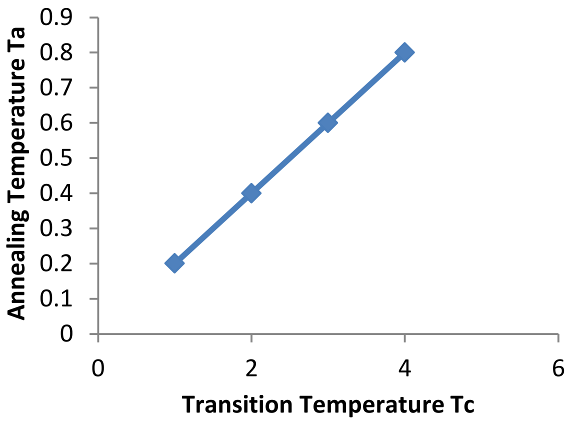

Figure 2: Transition temperature dependence for $BiPbSrCaCu_{2.4}Zn_{0.6}O$ with annealing temperature.

Table 1: Values transition temperature T_c for different annealing temperature.

T_a (k)	T_c (k)
1093	95
1113	100
1133	90
1153	Super behavior

The decrease in the critical temperature T_c and T_a=1133 k, a metal in to such intimate contact with a polari semiconductor, the electrons would be able to interact strongly with inter band excitations of the semiconductor; the exciton mechanism weakens the direct coulomb repulsion of electrons.

Table 2: Values of $T_{c(OFF)}$, $T_{c(ON)}$, a(Å), c(Å) and c/a for BiPbSrCaCuZnO compound as functions of annealing temperature.

T_a (k)	$T_{c\,(OFF)}$ (k)	$T_{c\,(ON)}$ (k)	a (Å)	c (Å)	c/a
1093	90	103	3.99	37.33	9.35
1113	95	110	3.38	36.96	10.93
1133	90	95	4.37	36.96	8.45
1153	Super behavior	Super behavior	4.49	36.96	8.23

Conclusion

From this research, it is concluded the important role of annealing, I believe the expansion and contraction of film caused by annealing temperature changes at T_a = (1093, 1113, 1153 k) the planes CuO expanded, this lead to increase spatial region between layers. This assist copper pairs stay longer time without break down, where the small atoms such as Cu, O, Ca, Zn influence more than the large atoms such as Bi, Pb, Sr, therefore occur motion for atoms along the planes of lattice that sizes of holes in a material expand just the same way as any other linear dimension while at T_a= 860 ˚C makes contraction in dimension of CuO layer which leads to decrease space region between layers and formation low phases. Can be express by relation:

$$\alpha = \frac{1}{c}\frac{\pm dc}{dT} \qquad (3)$$

α: linear expansion coefficient.
C: length of axis before annealing.
± dc: change of length where (+dc) refers to increase in length due to expansion while (-dc) refers to contraction in length.
dT: change of temperature.

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