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# Effect the Partial Substitution of (Pb, Ag) on Structural and Electrical Properties of $Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ High Temperature Superconductor

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**Abstract** This research involved the preparation of samples of $Bi_{2-(x+y)}Pb_xAg_y\ Sr_2Ca_2Cu_3O_{10+\delta}$ compounds and with different concentration of (x,y) which are (x=y=0) (x=0.05,y=0.15) (x=y=0.1) (x=0.15, y=0.05) by the method of solid state reaction under hydrostatic pressure of 8 ton/cm$^2$ temperature of annealing 850 k to know the range of effect of partial substitution on the synthetic and electric properties of compound. After undergoing the test of x-ray diffraction, it looked like the best substitution ratio of pb and Ag in Bi is when (x=0.05,y=0.15 ) where the values of lattice dimensions were a=b=5.4056 c=37.4226 A$^\circ$ and the crystalline composite is of tetragonal type this research also revealed that the oxygen has a vital role in increasing the critical temperature, we noticed by studying the electrical properties the critical temperature in this substitution Tc=143 k.

***Keywords:*** *partial substitution, electrical properties, superconductor*

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## 1. Introduction

The superconductive property is defined as the phenomenon of electric resistance and magnetic field inside a number of materials when they're cooled to low degrees of temperature and symbolized by (Tc). One of the superconducting materials is (Ceramics) and (Boro carbides) [1]. There are many benefits and applications of superconductors such as; in electric energy transmission wires [2], magnetic resonance imaging (MRI) [3], super recognition radars [4], and flying trains [5].

Since the discovery of Bi-based superconducting systems, a tremendous amount of work concerning preparation, superconducting properties, and the structure of these compounds has been carried out [6,7]. The BSCCO system mainly contains three phases in the general formula $Bi_2Sr_2Ca_nCu_{n+1}O$ (where n=0, 1 and 2 refers to the number of $CuO_2$ layers which yields 10,85,110 k transition temperatures respectively) which commonly have a multiphase structure. Although it is difficult to obtain pure high Tc phase Bi-2223, it is still one of the important materials that have been investigated extensively.

This research involves the studying of synthetic properties and surface morphology and also the results of electrical properties of the $Bi_{2-(x+y)}Pb_xAg_y\ Sr_2Ca_2Cu_3O_{10+\delta}$ superconductor at high degrees of temperature which was prepared at annealing temperature(850k) and under pressure of 8ton/cm$^2$ and with different concentrations of (x,y). The samples were characterized by XRD and electrical resistance measurement.

## 2. Materials and Methods

Samples of $Bi_2Sr_2Ca_2Cu_3O_{10+\delta}$ with and without an addition of Pb and Ag were prepared by a conventional solid state reaction method. The stoichiometric amounts of high purity powders (99,999%) of $Bi_2O_3$, $Sr(NO_3)_2$, CaO, and CuO, Pb and Ag were added by weight percentages (0.0), (0.05, 0.15), (0.1, 0.1), (0.15, 0.05)). The powders were mixed together by using a gate mortar and pestle for 15 minutes. The mixture homogenization takes place by adding a sufficient quantity of 2-propanol to form a paste during the process of grinding for about 30 minutes. The mixture was grounded to a fine powder and then calcined in air by using a tube furnace at 850°C for 24hr with rate of 120°C/hr. The mixture then pressed into pellets of diameter 12mm and thickness of 1.2mm by using hydraulic press under pressure of 8tons/cm$^2$.The pellets were sintered at 850°C for 72hr. All samples were subjected to gross structural characterization by X-ray diffraction (XRD). A computer program was used to calculate the lattice constant.

## 3. Results and Discussion

a. Study of synthetic properties of the compound.

The study of synthetic properties was done 850k and under hydrostatic pressure of 8ton /cm$^2$ and the x-ray

diffraction study revealed the regularity in the crystalline composite and using Brack low in diffraction $2d\sin\theta=n\lambda$ it was calculated $d_{hkl}$ which is the distance between parallel planes through reflection angles 2θ miller indices was found and using on application in the computer values of dimensions of cell unit was found and its tetragonal which means it has superconductive property [8,9] in which the values of dimensions were a=b=5.4184, c=37.1250 when x=y=0.

The results of x-ray diffraction revealed that during the substitution of x=0.05,y=0.15 the crystalline composite keeps its tetragonal type and appearance of conspicuous peak and increase in length of c-axis and values of lattice dimensions were a=b=5.4056, c=37.4228, but when x=y=0.1 is substituted we notice a decrease in length of c-axis but the crystalline composite keeps its type and this is a proof that a substitution at this ratio led to irregularity in crystalline composition and values of reticule dimension were a=b=5.4011, c=37.0660 but at substitution of x=0.15, y=0.05, it turned out that the crystalline composite is regular and appearance of peak of narrow bases and a conspicuous increase in c-axis length as seen in Figure (1-1) and values of lattice parameter were a=b=5.4037, c=37.4019.

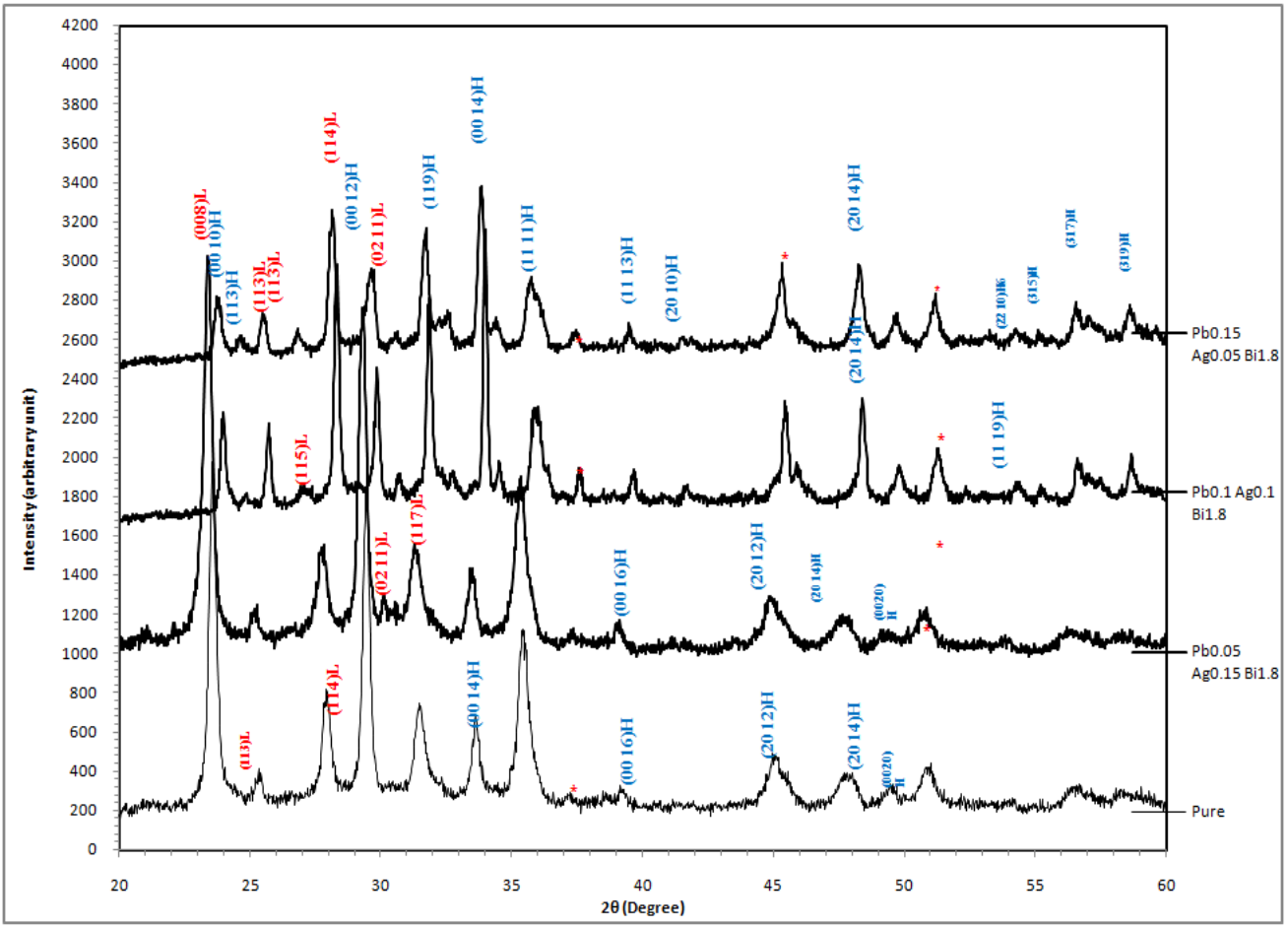


**Figure 1.** x-ray diffraction compound $Bi_{2-(x+y)}Pb_xAg_y\ Sr_2Ca_2Cu_3O_{10+\delta}$ different value (x,y) where (x=y=0)(x=0.05, y=0.15) (x=y=0.1)(x=0.15, y=0.05)

**Table 1. Lattice parameters c/a volume of unite cell (v) and density of unite cell (ρm) for different composition $Bi_{2-(x+y)}Pb_xAg_y\ Sr_2Ca_2Cu_3O_{10+\delta}$**

| Pb | Ag | $\rho_m$ (g/cm$^3$) | a (Å) | c (Å) | c/a | V (A°)$^3$ | HTP Phase% |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 1.5938 | 5.4184 | 37.1250 | 6.8517 | 1.06669 | 73.83 |
| 0.05 | 0.15 | 1.5440 | 5.4056 | 37.4226 | 6.9230 | 1.08473 | 58.47 |
| 0.1 | 0.1 | 1.6228 | 5.4011 | 37.0660 | 6.8627 | 1.03711 | 75.81 |
| 0.15 | 0.05 | 1.6298 | 5.4037 | 37.4019 | 6.9215 | 1.03776 | 79.19 |

b. Study of electrical properties.

The study of electrical properties of the compound was done before and after partial substitution of Pb, Ag elements in Bi element and the Tc was 138 k when x=y=0 and upon substitution by( x=0.05 y=0.15) the Tc increased to 143 k and this can be explained by saying that the substitution at this ratio lead to increased grained volume and increase regularity in crystalline composite with an increase in oxygen lead where the compound was perfect at this substitution while substitution at a rate x=y=0.1, we noticed a decrease in Tc where it was 135 k and this explains irregularity in crystalline composite and the decrease in c-axis length and led to decrease in Tc and upon substitution at rate of (x=0.15, y=0.05 ) the Tc increase up to 140 k.

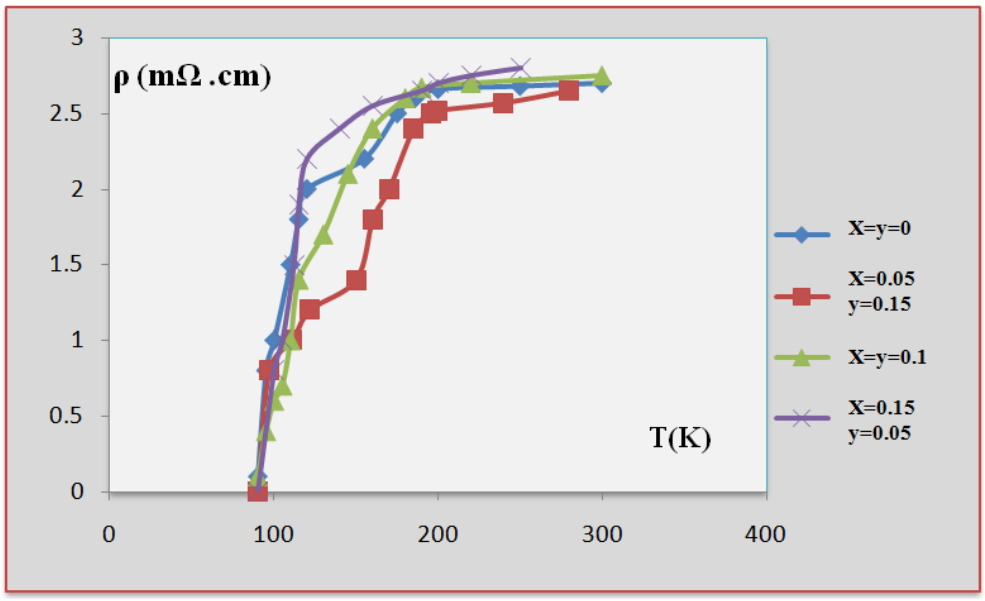


**Figure 2.** Relation between resistance &critical temperature compound of $Bi_{2-(x+y)}Pb_xAg_y\ Sr_2Ca_2Cu_3O_{10+\delta}$ different value (x,y) where (x=y=0)(x=0.05, y=0.15) (x=y=0.1)(x=0.15, y=0.05)

**Table 2. Relation between ratio substitution & critical temperature and oxygen level**

| Substitution rate of x, y | Tc(k) | δ |
|---|---|---|
| x=y=0 | 138 | 10.26 |
| X=0.05,y=0.15 | 143 | 10.52 |
| X=y=0.1 | 135 | 10.23 |
| X=0.15, y=0.05 | 140 | 10.40 |

## 4. Conclusion

This research involved the preparation of samples of $Bi_{2-(x+y)}Pb_xAg_y\ Sr_2Ca_2Cu_3O_{10+\delta}$ using the method of solid state reaction at annealing temperature 850 k and under pressure of 8ton /$cm^2$ and they are the best condition to obtain samples of Bi2223 compound.

The x-ray diffraction results revealed that the compound has a tetragonal crystalline composition and there is an increase in c-axis length with an increase Tc, where the regularity in crystalline composite provides safe pathway for charge carriers cooper pairs in superconductors.

We notice the value of critical temperature increase from 138K to 143 K when (x=y=0) (x=0.05,y=0.15), but we notice a decrease in critical temperature to 135 k when (x=y=0.1), while upon substitution at a rate of (x=0.05,y=0.15) the regularity increased in crystalline composite and critical temperature where it become Tc=140 k.

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