# Investigation the influence of Partial Substitution of (Ag ,Bi) upon the Electrical -Structural characteristics for aSuperconductor compound $Bi_{2-x}Ag_x Sr_2Ca_2Cu_3O_{10+\delta}$

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## Abstract

The current work include the manufacturing of the compound **$Bi_2$-x$Ag_x$ $Sr_2Ca_2$Cu3O10+δ** with various ratiosof (x) which are (x =0,0.2 ,0.25, 0.3) with application of solid state reaction technique , by applying a hydrostatic pressure of 8 ton/cm$^2$ temperature of annealing 850 C$^{\circ}$ to investigate the extent of influence of partial substitution on the manufactured and electric specificationsfor themixture under study . After checking the XRD, it showed optimum substitution of Ag in Bi when (x=0) which itsthe values of lattice constants were a=5.4738 Å, b=5.3000 Å, c=36.6435Å and the crystalline mixture is of tetragonal sort. This work showed that the content of oxygenhas a vital role in augmenting the $T_c$. We observe in this work that the electrical specificationsand the critical temperature upon the substitution was $T_c$=146 K.

**Key words:** Partial Substitution, Crystal Structure, Super conductors.
**DOINumber:10.14704/nq.2022.20.8.NQ44646** **NeuroQuantology2022;20(8):6210-6217**



## 1. Introduction

Superconductivity is an effect happening phenomenon happening for several conductors, in which the atomic electrons accounts for conduction sufferingfrom many transition into an arrangedcase with several extinguished and excellent characteristics and these involve the disappearing of conductor resistance to the traffic of the current, the occurrence of a diamagnetism and some magnetic properties, is essential changing of several thermal characteristics, and appearance of quantum mechanical properties else notable at the atomic and subatomic level. The effect of Superconductivity was founded by H. K.Onnes in 1911 while he was engaged with investigation of the temperature reliance of the electrical resistance of Hg within several degrees near the absolute zero. He noted that the resistance dwindling to very tiny value at a temperature of −452◦F. Temperature at which the variation happened is named as critical temperature, $T_c$. The vanishingly tiny resistance (too much conductivity) under$T_c$proposed the noun given the Effect. [1]. Many uses of superconductors like ; Transportation , Medical, The double-relaxation oscillation SQUID,Power systems, Fundamental research, Computers ,Electronics,Military, Space research,Internet(Superconductors of a great importance in Internet communications soon),Pollution control and Refrigeration (future melding of superconductors into our lifewill also rely to a huge range on progress in the field of cryogenic cooling)[2].At the very beginning of Bi-based superconducting systems discovery, big quantities of work related the manufacturing superconducting specifications, and the structure of these mixture has been accomplished[3,4]. The development of understanding the physics of superconductivity and appearance of applications strongly rests upon the development in materials research that it is still in advance.

The superconducting properties controlled by the variation of an elements with different ionic radius and bonding features; Therefore, Pb and Nd are the majorvitality substituting ingredientwhich effect the microstructure, phase structure, and the linked superconducting specifications of the BSCCO system[5].The discovery of the high temperature superconducting system, Ti-BaCu-O,at the beginning was screened by the detection of the Bi-Ca-Sr-Cu-O samples [6-7].Researchers studied the Bi-based superconducting system due to poisonous Tielement and the requirements for intensive care for the treatment. It was mentioned that doping the superconducting phases $Ti_2Ba_2CaCu_2O_8$ (Ti-2212) and $Ti_2Ba_2Ca_2Cu_3O_{10}$ (Ti-2223) with Pb or Li approved only their critical currents, and when the superconducting phases $Bi_2Sr_2CaCu_2O_x$ (Bi-2212) and $Bi_2Sr_2Ca_2Cu_3O_x$ (Bi-2223) were substituted by Pb or Li, their critical temperatures and critical currents were approved [8-11].Shaheen S. et als superconductor samples with chemical composition ($Hg_{1-x}Pb_xBa_2Ca_{3-y}MgyCu$ $O10_{+\delta}$) were manufactured by solid state reaction method. The influence of partial substitution of Pb & Mg upon the structural and electrical specifications of this compound were studied.

The present research work involves manufacturing and investigation the properties and surface morphology as well as the electrical properties of the $\mathbf{Bi_{2-x}Ag_x\ Sr_2\ Ca_2\ Cu_3O_{10+\delta}}$superconductor at elevated temperature which manufactured and annealing temperature(850C°) and applied pressure of 8ton/cm$^2$ and with various ratios of (x)only. Scanning electron microscopy (SEM), AFM and x-ray diffraction (XRD) type AFM-SEM model Inspect-S50 were employed to investigate the surface topography and test the sample components.

## 2. Experimental Technique

PureSamples of $\mathbf{Bi_{2-x}Ag_x\ Sr_2\ Ca_2\ Cu_3O_{10+\delta}}$with reinforced with Agmanufactured with a conventional solid state reaction Technique. The stoichiometric quantities of ultra-purity powders (99,999%) of $Bi_2O_3$, $Sr(NO_3)_2$, CaO, and CuO and Ag were appendedinterm of weight percent(0, 0.2, 0.25,0.3)The powders were stroked down together by applying a gate mortar and pestle for 900sec. The compoundidentification happeningby adding enough amount of 2-propanol to form a paste through the process of grinding for half hour. The mixture was grounded to a fine powder and then calcined in air by using a tube furnace at 850°C for 1day with rate of 120°C/hr. The compound then compressed into granules of diameter 12mm and thickness of 1.2mm by application hydraulic press at of 8tons/cm$^2$.The granules were sintered at 850°C for 3days. All specimens wereundergo to overall structural identification by (XRD). A softwareemployed to evaluation the lattice parameter.

## 3. Results and Discussion

The first section of the current study includes a detailed discussion for the consequences of (XRD), which are represented in the high phase lattice constants.The lattice determines the structural properties of the compound. Hence x-ray diffraction results of the pure compound $Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$ are discussed when (x = 0, 0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5) respectively and at the same preparation conditions(with a sintering temperature of (850°C) and a hydrostatic pressure of (8 ton/cm$^2$), which represents the amount of partial substitution of silver with bismuth.

The second part of the present study, it includes a discussion of the results of electrical measurements and the results of measurements of the oxygen percentage in the compound, which determine the electrical properties and the critical temperature $T_c$ of the compounds that have been prepared and whose structural properties have been studied.The third aspect of the study concerned to investigation of the surface structural properties of all samples using a scanning electron microscope (SEM) and atomic force microscopy (AMF) with a sintering temperature of (850°C) and a hydrostatic pressure of (8 ton/cm$^2$) and for the compound ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$) prepared with a different concentrations of x.

**3-1 Investigate of the Structural specifications of the ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$)compound**.

The structural properties of the compound have been studied upon partial substitution of the element Ag in the element Bi with different proportions of (x) and the results of x-ray diffraction shows regularity in the crystal structure and existence of clear peaks with application the Braggs law $2d\sin\theta=n\lambda$ , we obtained the values of ($d_{hkl}$) through the angles of reflection (2θ), the Miller indices were obtained after that determination the values of the lattice dimensions, as they were a ≈ b where a = 5.4738 , b = 5.3000 , c = 36.6435 when x = 0 (as shown in fig.1), generally we notice a small relative reduction in thelength of the c-axis for the sample at (x=0.2as shown in fig.2), due to the presence of a partial displacement of electrons between the layers of Miller's indices ($d_{hkl}$) through which the electron density calculated.This partial displacement led to a decrease in the electronic density and thus led to a small dwindling in the length of the c axis, due to the growing in the compression, which in turn this compression increment leads to a reduce in the regularity of the crystal structure [13]. When the compensation ratio was increased up to x=0.25, we noticed by studying XRD results that the crystal structure remains tetragonal, with an increase in the intensity of the peaks, which led to an increment in the length of the c-axis, and the values of the lattice dimensions in this state were a = 5.4624, b = 5.4338 , c = 37.0142 and the value of the high phase HTP = 66.75%, and these results can be explained that the lattice constant C increases when the silver Ag is partially replaced with bismuth Bi with an increase in the concentration x in the compound from (zero up to 0.25), due to the increment length of the (C) axis, orlattice parameter (C)which refers to difference in ionic radius of each of the additive element and the host element, as the ionic radius of silver Ag is greater than the ionic radius of bismuth Bi, as well as the annealing temperature, which has a significant role in improving the crystal structure, as it led to an increase Granule size, where these results agree with [14,15].As for increasing the compensation ratio of the element Ag in the element Bi to x = 0.3, we notice by studying the consequences of the XRD a decrease in the intensity of the prominent peaks and clearly, which led to a decrease in the length of the c-axis and as shown in Table (1), and these results in good agreement with previous studies [14 ,15] .The copper ions turn into copper oxides during the annealing stages, that's meaning the material oxidizes during the crystallization stages, so the factors affecting the preparation conditions lead to a change in the oxygen concentration.From thecurrent study ,we can be concluded that the optimum substitution for Ag in Bi is when x = 0.25(fig.3) because increasing the substitution ratio to <0.25 led to an irregular state in the crystal structure.

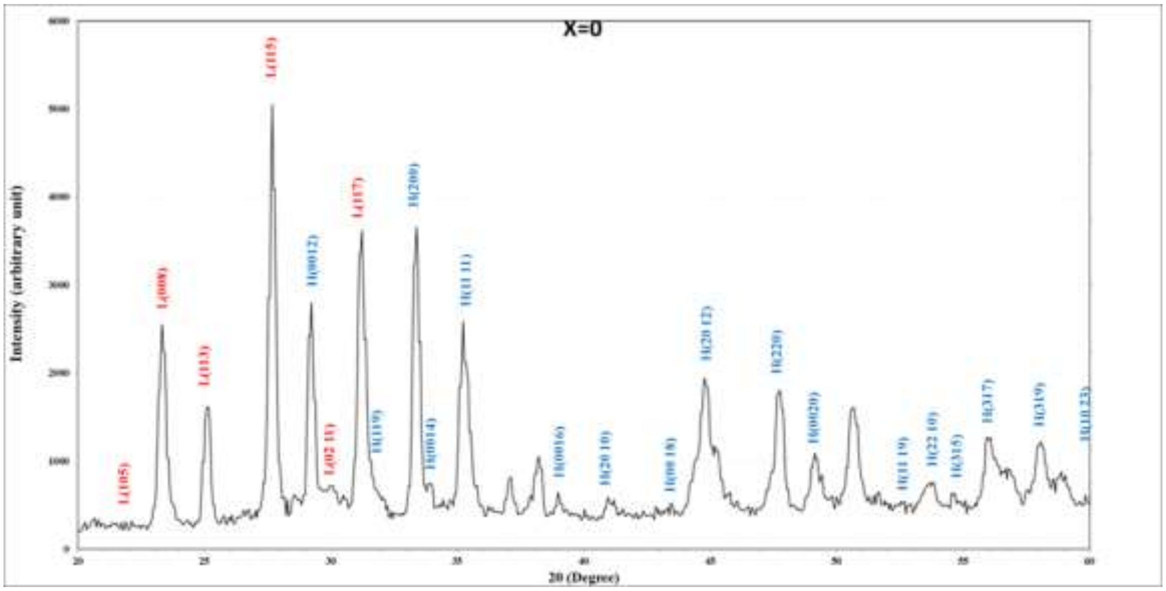
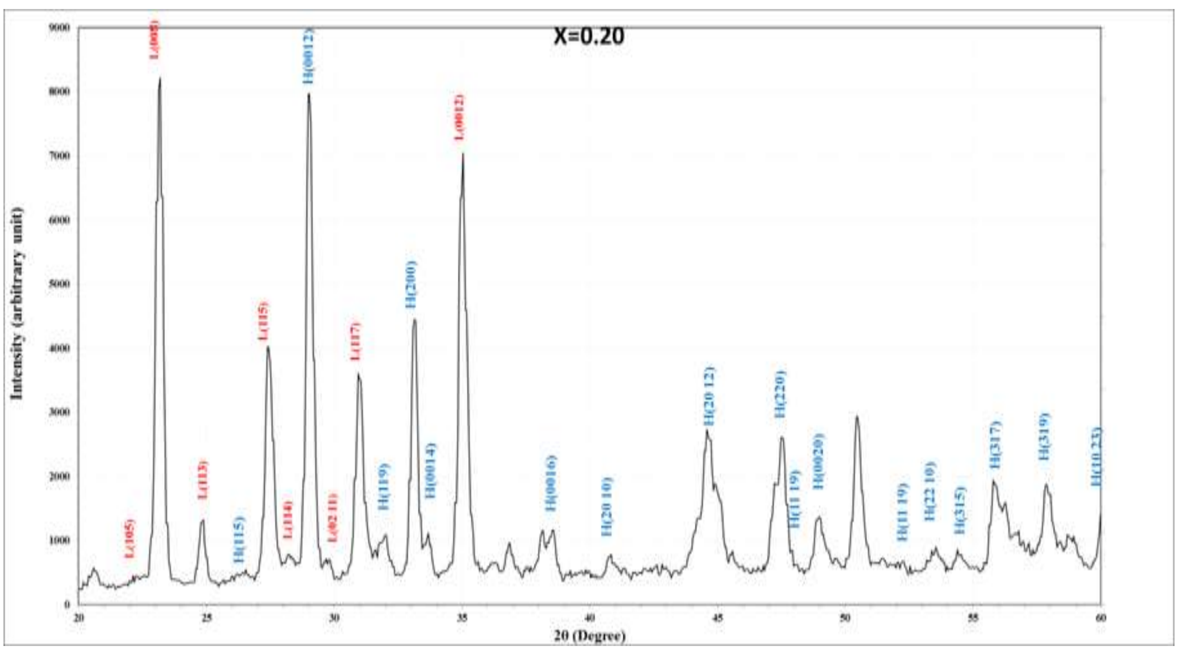



Fig.(1) represents the X-ray diffraction of the compound ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$) when (X=0).






Fig(2) represents the X-ray diffraction of the compound ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$) when (X=0.20).

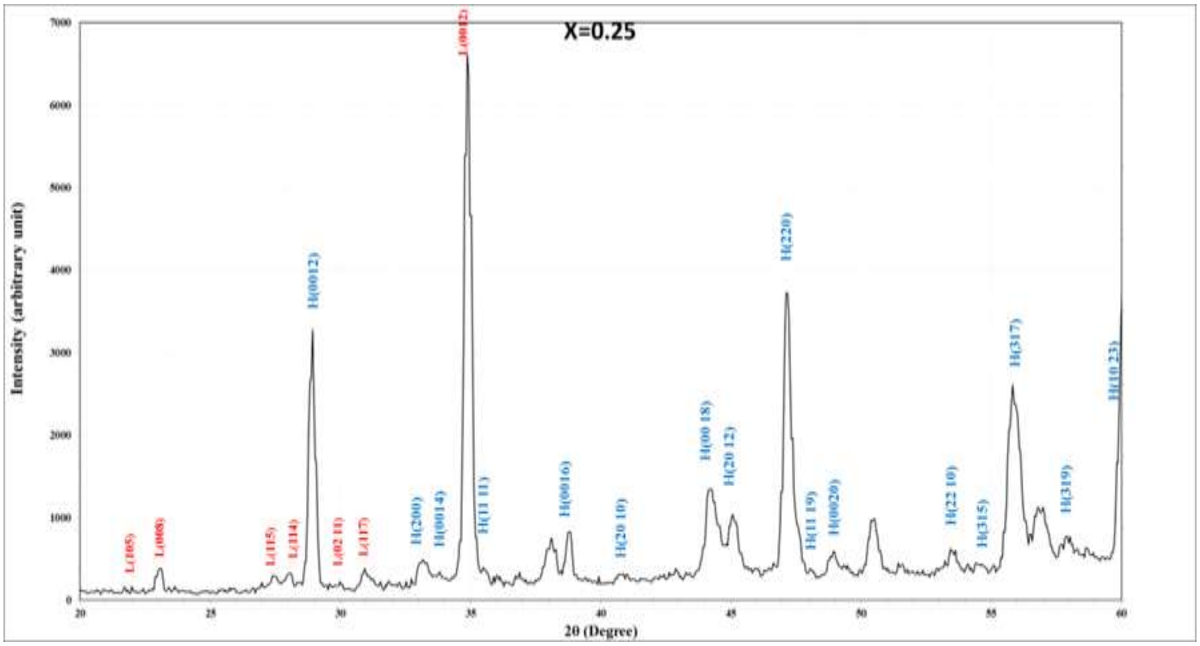



Fig.(3) represents the X-ray diffraction of the compound ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$) when (X=0.25).



**3-2Study of the electrical specification of the mixture ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$)**

The electrical specificationof the mixture ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$) have been investigated with different compensation ratios of x. It was found that the electrical specification of the manufactured samples that when that the critical temperature$T_c$ increased to $T_c$=127°K, when a compensation ratio x=0, but when the compensation ratio was increased up to x=0.25, the critical temperature increased to $T_c$=146K. The reason for this is that the critical temperature of the compound proportional with the increase in the percentage of oxygen linearly(see table 2). These outcomes are in good match with the consequences [16-17]. Which in turn led to an increase in the regularity of the crystal structure with an increase in the length of the c-axis.The latest case is considered the best compensation ratio for silver in bismuth, and these consequences are in good match with others research [14 ,16] while we noticed a decrease in the critical temperature when the concentration ratio increased to x= 0.3 as shown in fig. 4 ), as it became, respectively ($T_c$ = 144 K), which indicates the irregularity that occurred in the crystal structure, which led to a dwindling in the length of the c-axis, and these results are consistent with previous studies [14,17] as illustrates appearance of copper oxides led to a decrease in the critical temperature as shown in fig .5.

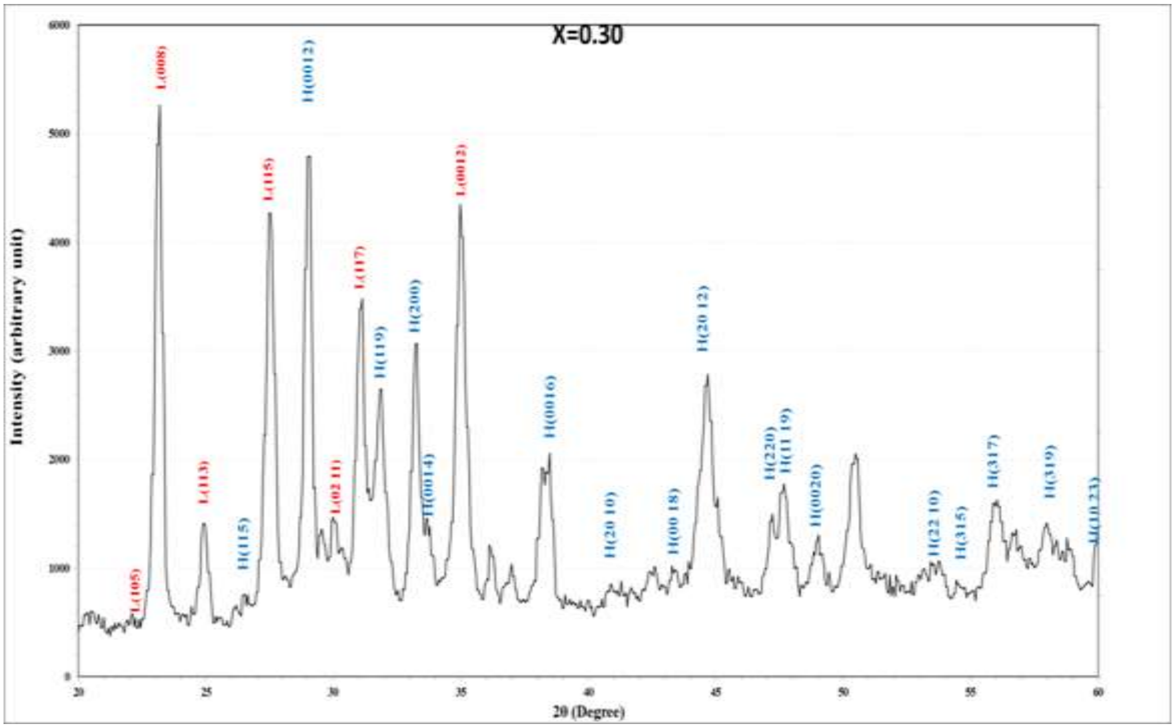





Fig.(4) represents the X-ray diffraction of the compound ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$) when (X=0.30).

Table (1)represent the axis's values a,b, and c for the compound **$Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$**.

| X | a (Å) | b (Å) | c (Å) | V (Å3) | c/a | w (g/mole) | ρm ((g/cm³) | %HTP |
|---|---|---|---|---|---|---|---|---|
| 0 | 5.4738 | 5.3000 | 36.6435 | 1063.080 | 6.6943 | 1023.988 | 6.3970 | 61.15% |
| 0.2 | 5.4768 | 5.3316 | 36.9314 | 1078.402 | 6.7433 | 1008.8215 | 6.2127 | 49.82% |
| 0.25 | 5.4624 | 5.4338 | 37.0142 | 1098.647 | 6.7761 | 998.7105 | 6.0371 | 66.75% |
| 0.3 | 5.4554 | 5.4217 | 36.8764 | 1090.701 | 6.7596 | 993.655 | 6.0503 | 57.90% |

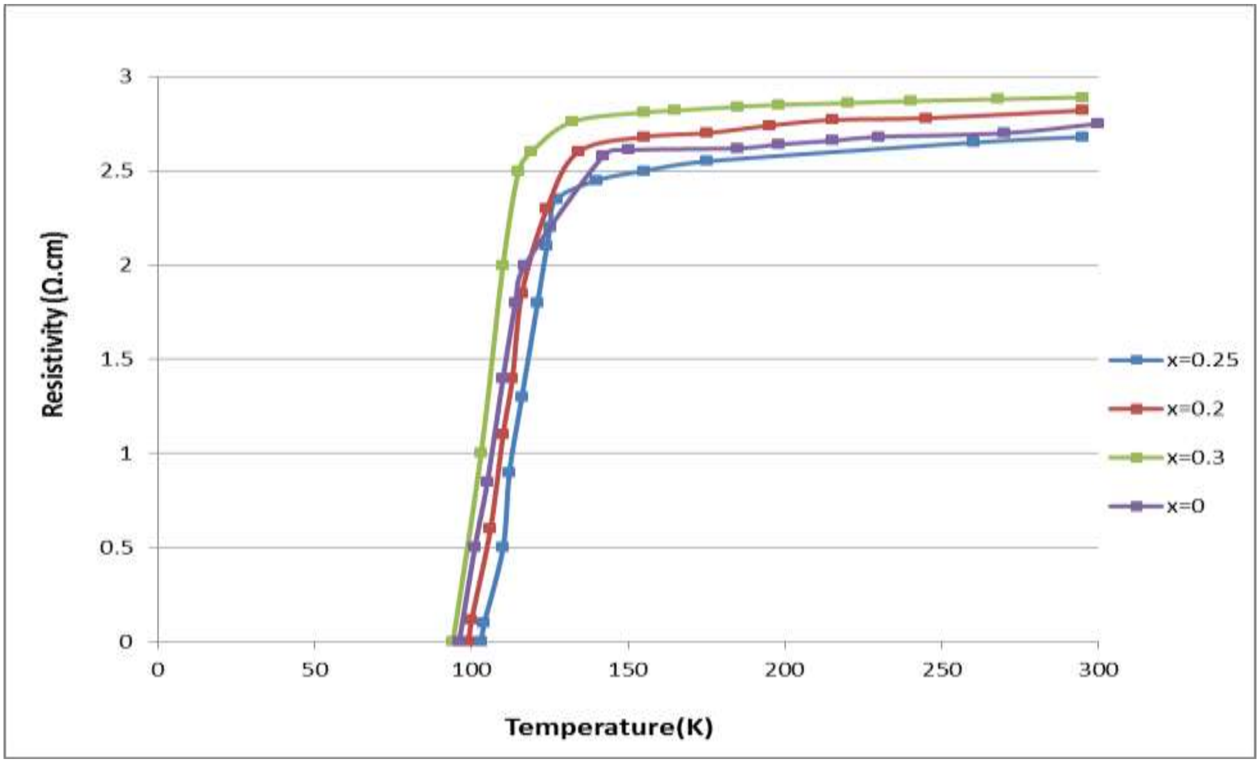



Fig.(5) represents the change of resistance with temperature $T_C$ of the compound ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$) when x=0,0.2,0.25,0.3.



Table(2) represents the relationship between the critical temperature and the percentage of oxygen with a concentration ratio of (x).

| Series No. | Compensation ratio | Temperature | Oxygen ratio |
|---|---|---|---|
| 1 | X=0 | 127 | 10.16 |
| 5 | X=0.2 | 140 | 10.27 |
| 6 | X=0.25 | 146 | 10.29 |
| 7 | X=0.3 | 144 | 10.28 |

**4.Conclusions**

Increasing the preparation temperature (sintering) for the pure compound ($Bi_{2-x}Ag_xSr_2Ca_2Cu_3O_{10+\delta}$) at 850 °C led to an increase in the high $T_c$-phase H-2223 ratio, critical temperature $T_c$ and the lattice constant c, as well as the increment in the applied pressure at (8 ton/cm$^2$) upon the pure compound led to an increase in the critical temperature $T_c$, the high phase ratio and the lattice constant c, where the critical temperature increased to ($T_c$=146 K) , the high phase ratioHigh $T_c$-phase H-2223 and the amount of the lattice parameter c with the increase in the partial compensation concentration of silver (Ag) with bismuth (Bi) from x = 0 to x = 0.25 and it decreases after these concentration value . Any distortion in the crystal structure is considered, whether it is an increase or dwindling in the length of the c-axis is always a reason for the high conductivity in the case of the multi-layer perovskite, which leads to a certain type of polarization, and this type raises the critical temperature $T_c$. As this polarization will allow the holes or electrons to move for a large distance without being subjected to scattering processes. The study of the surface features using the SEM scanning electron microscope for the best six samples showed a shift in the composition of the pure compound from the cluster structure towards the spherical structurewhich plays a very important role in increasing the conductivity. The EDX results also showed that there were unwanted elements in the patterns, which intend that the specimenwere not polluted through the industrialization procedure. Results of the atomic force microscopy (AFM) of the samples showed that the samples are well homogeneous.

**5.References**

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