Studying the Partial Substitution of (Pb) instead of (Bi) for superconducting compound Bi2-xPbxBa2Can-1CunO6+δ.

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Abstract

The present study the partial substitution of Bismuth (Bi) instead of lead (Pb) for (Bi2-xPbxBa2Can-1CunO6+δ) superconducting compound Where (X=0,0.05,0.1,0.15,0.2) Samples were prepared by solid state reaction method with sintering temperature 750C0 for 48h Then the samples were cooled to room temperature at the same heating rate. To determine the critical temperature, the XRD analyses for all superconductor specimens was found that the crystal structure was for all specimens were (Orthorhombic structure).

Keywords: *Bi2-xPbxBa2Can-1CunO6+δ, superconductivity, SSR, XRD, critical temperature.*

INTRODUCTION

High-temperature superconducting compounds such as the BBCCO system have been detected and prepared. [1] is an abbreviation for HTSC which consists of element oxides (bismuth, barium, calcium, copper) and its general chemical formula (Bi2-xPbxBa2Can-1CunO6+δ) where (n = 1,2, 3), it has great interest due to its high frequency, high temperature, good chemical resistance against moisture. Therefore, great efforts have been made in studying the preparation methods, treatments and characteristics of this system.[2-4].Where (Cu-O2) The superconducting system (BBCCO) has a layer structure, indicating the number of copper oxide layers (CuO) with a critical grade (110,80,10) Kelvin, respectively, where the electrical resistance becomes zero(R=0). [5,6] The superconducting properties and the transition properties of high-temperature CuO compounds are very differentiated. [7,8] Also, the not supported of the alternating conductivity of the frequency, as well as having a low insulation constant at high frequencies (60 GHz) at room temperature, and the polarization of the material may include the adoption of conductivity at frequency. The qualitative difference in the conductivity between the two directions (level (a, b) and direction (c)) suggests that there are two different mechanisms of conductivity that can work in both directions, which are towards the level (a, b) which is in the direction of the axis (c) and is still the place of difference and controversy [9]. Bi-based superconductive systems have layer structure so it consists of three phases namely (Bi-2201), (Bi-2212) and (Bi-2223). The last number of each phase refers to the number of layers of CuO which consequently has the critical temperatures (10K,80K&110 K); the last means the temperature at which the electrical resistance is equal to zero (R=0)]10].

EXPERIMENTAL METHOD

By utilizing a sensitive balance to suitable weights of pure powders of (BI2O3, CaO, CuO, BaO, NiO) synthesis the specimens with chemical form (Bi2-xPbxBa2Can-1CunO6+δ), with x = 0 to 0.2 by solid state reaction(SSR) method, as starting materials After the weight of all reactants, the powders were mixed with each other by utilizing "agate mortar" to homogenization the mixture and to shape slurry through the process of grinding for about 30 minute. The powder was compressed into disc shaped pellets (1.5) cm in diameter and 0.25 cm in thickness, utilizing "hydraulic piston" under a pressure of (7ton/cm2 (for) 1min (. The pellets were presented at (750) Cº for 48h by utilizing furnace of electric (Carbolite) at heating range 10 ºC per min and cooling to the temperature of room at the same range of heating. The crystal structures for the specimens prepared the (Bi2-xPbxBa2Can-1CunO6+δ) compounds (x=0,0.05,0.1,0.15) were obtained by utilizing X-Ray diffracto-meter type(Shimadzu) having the features of following: Source; Cukaα, Current;30*10-3(A), Voltage;40*10+3(V), Wavelength;1.5405, 2θ range;10-80(dig), scan speed; 8(dig/min). A program of computer was utilized to calculate the lattice parameters a, b and c.

A program of computer was utilized to calculate the lattice parameters a, b and c. This program is established on Full Prof Suite toolbar, [11].

The XRD peaks of (Bi-2201) phase have been utilized for the appreciation of the volume fraction (Vph) of the phase utilizing the following form, [12]:

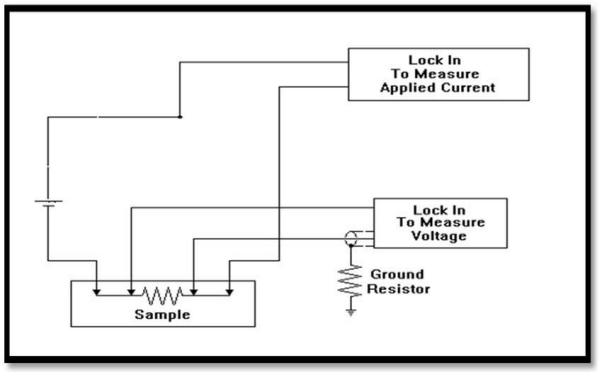
$$v_{ph}=\frac{\sum Io}{\sum Io+\sum I1+\sum I2+\sum I\text{other peaks}}x100\ \%\ \ldots\ldots\ldots\ldots.(1)$$

Where Io is The X-ray diffraction peak-intensity of the phase which were specified]12, I3[. In" are the all XRD peaks-intensity of The densities (dm) the prepared specimens were calculated via utilizing.

Resistivity measurement is the most widespread method of calculating the Tc of a superconductor "resistivity as a temperature function" via utilizing the 4-point probe technique at temperature range (77-300) Ko, the specimen was fixed in the cryostat device which was connected to a rotary pump to obtain a pressure of (6 x10-5 bar) inside the cryostat, and also connected to a sensor of digital thermometer thereabout the specimen position. Find copper wires attached to the specimen via furnace dried silver paste served as the voltage and current leads Figure (1). A 20mA current was equipped with to the specimen via a current source (D.C) power supply; the voltage drop was measured Nano voltmeter with sensitivity of a bout (NV) was utilized for measurements of voltage. The resistivity (ρ) could be found from the rapport:

$$P=\frac{v\,wt}{I\,L}$$ where (I) is the current crossing through the specimen, (V) is the drop of voltage across the electrodes, (t) is the specimen thickness, (L) is the efficient length between the electrodes, (ω) is the width of the specimen

Figure 1. Circuit diagram of the resistivity measurement



DISSECTION AND RESULTS

The intensities of XRD for phase (Bi-2201), patterns as a function of 2Ɵ for the (Bi2-xPbxBa2Can-1CunO6+δ), system with x=0, 0.05, 0.1 , 0.15 and 0.2 are shown in figure2. From this figure (2) founded that when the Partial Substitution 0f (Pb) change in high (H) and low (L) phases. And founded the crystalline structure was (Orthorhombic) with a clear increase in the length of c. and we noticed an increase in the intensity of the peaks for phase (Bi-2201).

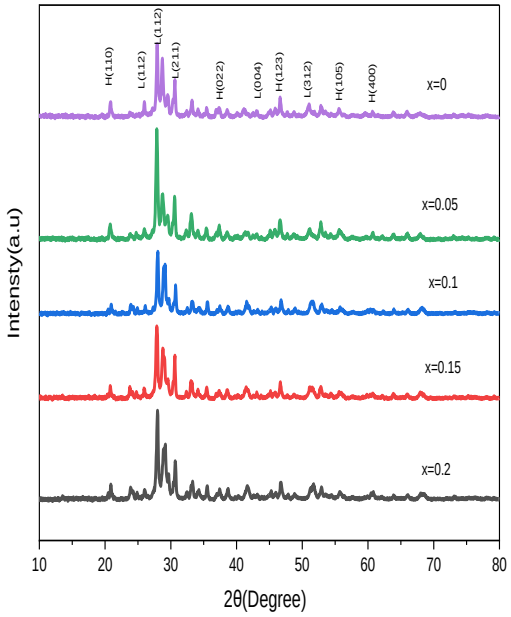


Figure (2). X– Ray diffraction pattern of (Bi2-xPbxBa2Can-1CunO6+δ) system with x= 0, 0.05, 0.1, 0.15 and 0.2.

Table 1: Demonstrates the generated samples' phase ratios, lattice coefficients, (c/a).

X	$V_{ph(H)}$%	$V_{ph(L)}$%	a (A°)	b(A°)	C(A°)	c/a
0	25.00	75%	6.83	6.318	8.26	1.209
0.05	27.70	72.30%	6.82	6.22	8.28	1.214
0.1	30.00	70.00%	6.56	6. 21	8.3	1.265
0.15	33	67%	6.55	6.18	8.31	1.268
0.2	41.66	58.34%	6.51	6.16	8.33	1.275

Note that the sample prepared by(SSR) method is optimal in terms of structural properties compared with other preparation methods. It is possible that the preparation conditions will have a significant effect on the properties of the resulting samples in terms of (granular size of the powder, mixing method, grinding, sintering temperature, length of time sintering), where the effect of the temperature of the sintering and its length is not limited to the possibility of generating microscopic cracks in the sample, but also possible to reach a state closer to the solubility, which supports the growth of low phases and impurities at the expense of the high phase and its formation therefore, the temperature and duration of sintering are critical factors in the production of high-frequency samples. It has been shown that the best temperature of sintering is the temperature near the melting point. [13]

Figure 3 Show Resistivity as a function of temperature for (Bi2-xPbxBa2Can-1CunO6+δ) system with (x= 0, 0.05, 0.1, 0.15 and 0.2)

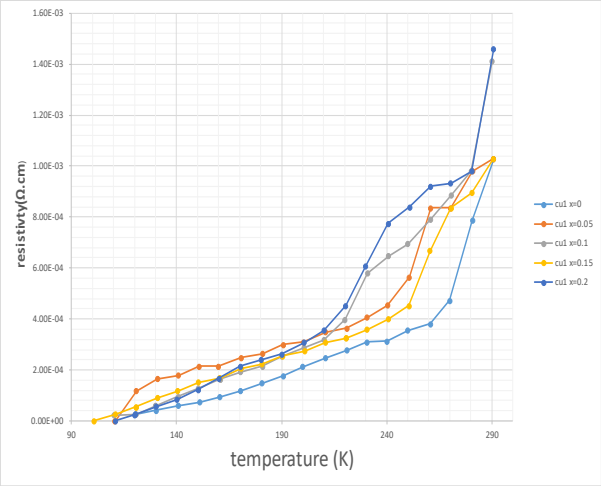


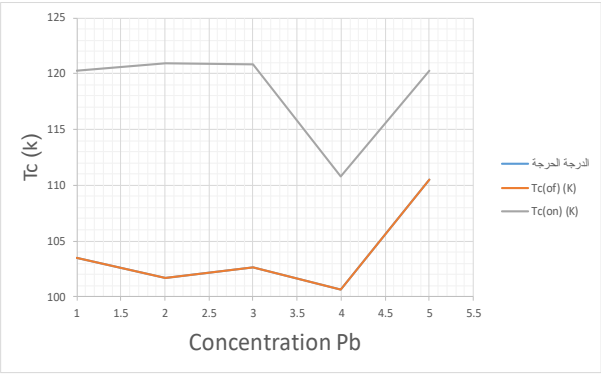
TABLE 2 Shows the critical temperature, energy gap and concentration of gaps for the samples and concentration of gaps for the samples.

X	الدرجة الحرجة	Tc(of) (K)	Tc(on) (K)	ΔT (K)	Tc(mid) (K)	Eg (eV)
0	103.5	103.5	120.3	16.8	111.9	0.0315
0.05	101.7	101.7	120.9	19.2	111.3	0.0309
0.1	102.6	102.6	120.8	18.2	111.7	0.0312
0.15	100.6	100.6	110.8	10.2	105.7	0.0306
0.2	110.5	110.5	120.3	9.8	115.4	0.0336

In Table (2), we notice that the decrease in the electrical resistance in the superconducting samples was gradual. As for the transition width (ΔTc), we note that it was of small values, which indicates the homogeneity of the sample, and the reason for this behaviour is due to the containment Samples have low phases and impurities in different proportions, and it is possible to explain why the critical temperature of the samples differs from the pure sample by a considerable drop in the phase (Bi-2201) and an increase in other phases (XRD)

In Figure 4: we observe a rise in the behavior of the samples in terms of critical temperature by increasing the substitution ratio of Lead (Pb) instead of Bismuth (Bi), which can be attributed the drop in the phases (Bi2201) compared to the other pure sample and this is consistent with (XRD). Where more gaps are created in layers (CuO) and the introduction of extra oxygen atoms into the structure by the partial substitution process and generate more gaps in the phase (Bi-2223) will improve both Tc (offset) and Tc (onset)) [14].

Figure: 4. Tc (offset) and Tc (onset) as a function of Pb Concentration for (Bi2-xPbxBa2Can-1CunO6+δ) system with (x= 0, 0.05,0.1,0.15 and 0.2)



Conclusions

In the current study, we have successfully prepared (Bi2-xPbxBa2Can-1CunO6+δ) samples (x =0,0.05,0.1,0.15and0.2). Specimens have been prepared (SSR)-solid state reaction process.

We have investigated the influence of simultaneous doping of Pb with Bi site of ca-O layer in (Bi2-xPbxBa2Can-1CunO6+δ) with special assurance on correlation between superconducting properties and the noted microstructural distinctive. The XRD information collected from different Specimens show that all the specimens are(Orthorhombic) and correspond with (Bi-2201) phase. The temperature of critical Tc(offset) of the Bi doped (Bi-2201) compounds range between (120.5 to 120.8) Ko. Substitutions of Bi produce change in lattice parameter, mass density and volume fraction.

Reference

Haider MJ. Haider a," Studying the Partial Substitution of Barium with Cadmium oxide and its effect on the Electrical and Structural, (2019).

H.Maeda, Y.Tanaka, M.Fukutomi and T.Asamo; Jap.J.Appl. Phys., 27,PP.L209-L210, (1988).

Harkrishan, And Anil K. Tyor, J. K. B. (2020). Sublethal Effects of Imidacloprid On Haematological and Biochemical Profile of Freshwater Fish, Cyprinus Carpio. Journal of Advanced Zoology, 41(01-02), 75–88. Retrieved From Http://Jazindia.Com/Index.Php/Jaz/Article/View/59

T.D. Xiao, K. E Gonsalves and P. R. Strutt, "Synthesis of Aluminum Nitide/Boron Nitide Composite Materials," Journal of the American Ceramic Society, Vol. 76, No. 4, (1993),pp. 987-992.

P. L Chen and I. W. Chen, "Sintering of Fine Oxide Powders; I, Microstructural Evolution," Journal of the American Ceramic Society, Vol. 79, No. 12, (1996),pp. 3129-3135.

Gul, I. H., Amin, F., Abbasi, A. Z., Anis-ur-Rehman, M.,Maqsood,A.:Physica C 449,139-147 (2006).

Lal Choudhary, N. ., & Chishty, N. . (2021). Copulation Behaviors of Indian Vulture (Gyps Indicus) in Udaipur District, Rajasthan, India. Journal of Advanced Zoology, 42(01), 07–19. Https://Doi.Org/10.17762/Jaz.V42i01.3

Gul, I. H., Rehman, M.,A.,Ali. M.,Maqsood, A. : Physica C 432,71-80 (2005).

S. Martin et al., Phys.Rev.Lett.58,2687(1987).

T.R. Dinger et al., Phys.Rev.Lett.60,2194(1988).

Jassim.K.A., Hussein.H.S.,"The partial Substitution by Lanthanum (La) and its effect on Dielectric Properties for BSCCO superconductor compound (Bi2Sr2Ca2 Cu3-xLaxO10 + δ)", Karbala University Journal, V.15, No.2 /Scientific/, pp. 318-328, (2017).

Biswas, S. ., Bhagyasree, V. ., & Rathod, V. N. . (2022). A Checklist of Birds And Diversity of Avian Fauna in Mudasarlova Reservoir of Visakhapatnam, India. Journal of Advanced Zoology, 42(02), 165–175. Https://Doi.Org/10.17762/Jaz.V42i02.51

Suzan Malike Shakouli, Ph.D,Thesis,University Of Baghdad Collage Of Science,(2012).

Haider MJ. Haider , Kassim M. Wadi , Hind A. Mahdi , Kareem A. Jasim, Auday H. Shaban," Studying the partial substitution of barium with cadmium oxide and its effect on the electrical and structural

properties of HgBa2Ca2Cu3O8+δ superconducting compound" AIP Conference Proceedings 2123, 020033,17 July (2019).

K.A.Jassim,H.S.Hussein,"Effect of Partial Substitution of Lanthanum(La) on the Structure and Electric Properties of (Bi2Sr2Ca2Cu3-xLaxO10+δ(",Ibn AL-Haitham Journal for Pure and Applied Science,VOL.30,Issue 3,(2017).

W.wong-Ng, L.P. cook, nd A. kearsky and W.Green Wood,1999, Vol.104 .

K. A.Jasim,M. A.N.Thejeel, R.S.Al-Khafaji," The Effect of Doping by Sr on the Structural,Mechanical and Electrical Characterization of La1Ba1-xSrxCa2Cu4O8.5+δ ", Ibn Al-Haitham Journal . for pure & Appl . Sci . vol . 27 (1), (2014).

Singh, N. ., & Gautam, P. . (2021). Comparative Analysis of Hypochlorite Method On Transgenic Strain By250. Journal of Advanced Zoology, 42(01), 01–06. Https://Doi.Org/10.17762/Jaz.V42i01.1

Kapinder, Tarkeshwar, & Kumar Singh, A. . (2021). Influence Of Different Odours On The Associative Learning Of Larval Parasitoid Cotesia Plutellae (K.) (Hymentoptera: Braconidae). Journal of Advanced Zoology, 42(01), 20–33. Https://Doi.Org/10.17762/Jaz.V42i01.2

And Pulikeshi M. Biradar, M. F. N. S. R. P. . (2021). Growth and Reproduction Of The Epigeic Earthworm, Eisenia Fetida (Savigny, 1826) Cultured In Various Organic Wastes. Journal of Advanced Zoology, 42(01), 43–60. Https://Doi.Org/10.17762/Jaz.V42i01.5

Burezq, H. . (2021). Biochar In Cattle Farming: An Innovative Solution For Soil Fertility And Cattle Productivity. Journal of Advanced Zoology, 42(01), 61–96. Https://Doi.Org/10.17762/Jaz.V42i01.6

Wankhade, L. N. . (2022). Study on Butterfly Fauna of Karanja (Ghadge) Tahsil Of District Wardha (Maharashtra). Journal of Advanced Zoology, 42(02), 186–193. Https://Doi.Org/10.17762/Jaz.V42i02.53

S.K. Tiwari, A. C. And. (2020). Binary Action of Chlorpyrifos-Methyl and Methoprene On The Larval Biochemistry Of Almond Moth, Ephestia Cautella Walker (Lepidoptera:Pyralidae). Journal of Advanced Zoology, 41(01-02), 117–131. Https://Doi.Org/10.17762/Jaz.V41i01.25