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STUDY AND COMPARE THE EFFECT OF PARTIAL SUBSTITUTION ON THE STRUCTURAL AND ELECTRICAL PROPERTIES OF A HG-BASED COMPOUND

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Abstract

In this research, we prepared the compound ($HgBa_2Ca_2Cu_{3-x}Zn_xO_{8+\delta}$). based on mercury and studied the effect of partial substitution of zinc oxide (ZnO) instead of copper oxide (CuO) at a concentration of x = (0.0, 0.1,0.2 and 0.3) and the samples were prepared by the state reaction method. Solid at sintering temperature (800°C) for 24 hours Then the samples were cooled to room temperature at the same heating rate. To determine the critical temperature, four-probe technique have been used and the test of resistivity as a function temperature show that all specimens have a metallic behavior. The highest critical temperature we have found (115.7 k), when(x=0.2) The XRD analyses for all superconductor specimens was found that the crystal structure were tetragonal for all specimens. All the specimens were consist of a major 1223 high - phase, and minor low - phase 1212 and (1201) and very small amounts of secondary phases with lattice parameter a, b, and c .

Keywords: Superconductors, Tetragonal structure, X-ray diffraction, Electrical Resistivity, Critical temperature.

INTRODUCTION

It is generally known that the most intriguing homologue series from high temperature cuprate superconductors is represented by the Hg-based superconducting cuprates "HgBa2Can-1CunO2n+2+" (where n=1, 2, 3,....8, n is Cu-O layers). Because this series has a high transition temperature (Tc), [1, 2]. If n=1 (Hg-1201), Tc = (94) Ko, n=2 (Hg-1212), Tc = (127) Ko, and n=3 (Hg-1223), Tc = (135) Ko, respectively, are the values. Under high pressure, the critical temperature (Tc) has been further raised to (150-160) [3]. Every one of the "HgBa2Can-1CunO2n+2+" super phases (n=1, 2,.... 8) crystallizes with a tetragonal structure cell and layers of perovskite, according to one study., [4]. The structure of Hg-based superconductor is almost the same Tl and Cu-based superconducting cuprates together a solo (Tl-O) layer but an important variance is that, the (TlO1-δ) layers include highly few vacancies of oxygen, whilst the Hg-Oδ layers are more oxygen weakly. The atoms of oxygen are deficient bound to Hg and their occupancy is probable to differ over a wide range relying on the preparation; it has been displayed for various members of the Hg homologous series, [5,6]. Where (Cu-O2) planes are present, which are responsible for the high-temperature superconductivity, [7]. Regrettably, there are yet problems concerning the phase stability, chiefly the existence of CO2 and moisture. Several reports display that the formation of phase and superconducting properties of (Hg-1223) are increased via means of cation substitutions. The current density of critical (Jc) and formation of phase for (Hg-1223) can be improved upon at doping via high valence type (Cd) or other elements, [8,9]. Resistivity of electrical (ρ) is one of the most significant characteristics of material, it's the most widespread method of determining the (Tc) of a superconductor. In this paper, we study the leverage of CdO on

the electrical and structural properties of HgBa2-xCdxCa2Cu3O8+δ superconductors' installation at the optimum conditions**,** there are fundamental measurements X-ray diffraction and resistivity of electrical.

The primary goal of the study is to determine how substitution affects raising the critical temperature (Tc).

Experimental

The ($HgBa_2Ca_2Cu_{3-x}Zn_xO_{8+\delta}$) samples with different Zn (x=0,0.0.1, 0.2,0.3) were prepared by using solid state reaction method using mixed oxides powder of (HgO, BaO, CaO, CuO, CdO), with a purity of 99.99%. Samples were prepared by SSR solid state reaction method. In two stages the first is the calculation of the appropriate weights of the oxides of the elements, and the second is the grinding process using a hand mixer and an electric mixer. The samples were also dried in a special oven at 200 degrees to get rid of moisture. Then the samples were formed in the form of discs by compressing the mixture using a hydraulic press at a pressure of (7 tons / cm2) for a minute, where samples were sintered in a special oven at a temperature of(800°C), and heating rate (10 °C/min) for 24h, in order to obtain a bonding material and to ensure a gradual diffusion between the atoms occur, then samples were cooled at the same heating rate until it reached room temperature. Four probe method at temperature range (77-300) K was used to measure the resistivity (ρ) calculated using the relation.[6]

The solid-state reaction method SSR prepared the samples. The materials were used in pure oxides according to the superconducting system (HBCCO), where appropriate weights were used for high-purity oxide powders (HgO,CaO, BaO, CuO, ZnO)

. The first stage of sample preparation is calculating the appropriate weights from the oxides of the elements, followed by the grinding process using a manual mortar and electric mixer. Then the samples were formed in the form of tablets by compressing the mixture using a hydraulic piston with pressure (7 tons / cm 2) for one minute, and finally the samples were sintered in a special oven under a temperature of 800 ° C at a heating rate (10 ° C / min) for 24 hours, then the samples were cooled at the same heating rate until they reached room temperature. The samples were also dried in a special oven to get rid of moisture.

With the help of measuring the temperature-dependent impedance (T), the conventional four-sensor technique was utilized to calculate the transition temperature throughout a temperature range of (77 K to 300 K). The specific resistance (ρ) was calculated using the equation and recorded [5]. This was accomplished by encircling the sample with compressed air from a cooling system coupled to a rotating discharger to achieve a pressure of 6 x 10-2 mbar in the refrigeration system. A thermocounter detector with superior technology has been installed near the sample placement, and it has been linked to it as well. Electrical points were created on the sample by adhering fine wires of Cu together using Ag glue. A direct current (DC) source with a current of 20 mA was then connected to the sample. A considerable drop in the voltage difference was seen in the voltage counter when many allergens were present. [8]

$\rho = (R * A)/L$…… (1)

Where R is electric resistance, A is area of specimens and L is length of specimens. The lattice parameters a, b and c were calculated by using d-values and (hkl) reflection of the observed XRD using standard card.

To calculate the volume fraction for any phase using the relation: [7]

$$(V_{Ph})\% = \frac{\sum I_0}{\sum I_1 + \sum I_2 + \sum I_{other(peaks)}} \times 100\% \dots\dots\dots (2)$$

Where I° is the XRD peak intensity of the phase which were determined, [1,12] In are the peaks intensity of all XRD [8].

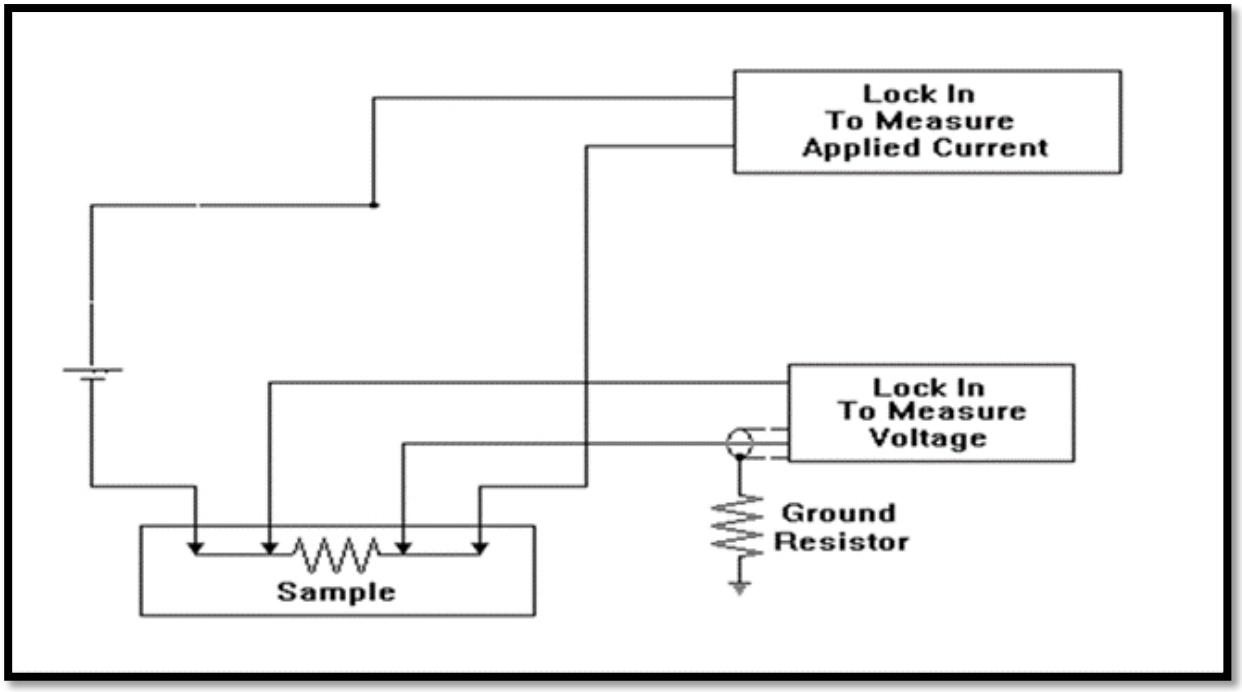

Figure (1). Circuit diagram of the resistivity measurement

Results and Discussion

In the beginning, the X-ray diffraction analysis of the superconducting system (HBCCO), where we noticed an increase in the intensity of the peaks for the high phase (Hg-1223), indicating There is a large proportion of the significant phase (Hg-1223) in the pure sample, and the strength of peaks for all other phases is decreasing. In addition to the presence of minor quantity of impurities and the emergence of distinct phases in the pure sample in

specific and the rest of the samples, there were also small percentages of impurities. Dislocations of atoms, absence of oxygen, or irregularities in positive ions may all contribute to the buildup of defects in the stacked along the (c) plane, which finally leads to crystallization. After that the lattice constants (a,b,c) of the sample were extracted and calculated mathematically based on Braque's law in X-ray diffraction. By determining Miller's coefficients (hkl) and (2θ) for each peak and using equation (2). [7]

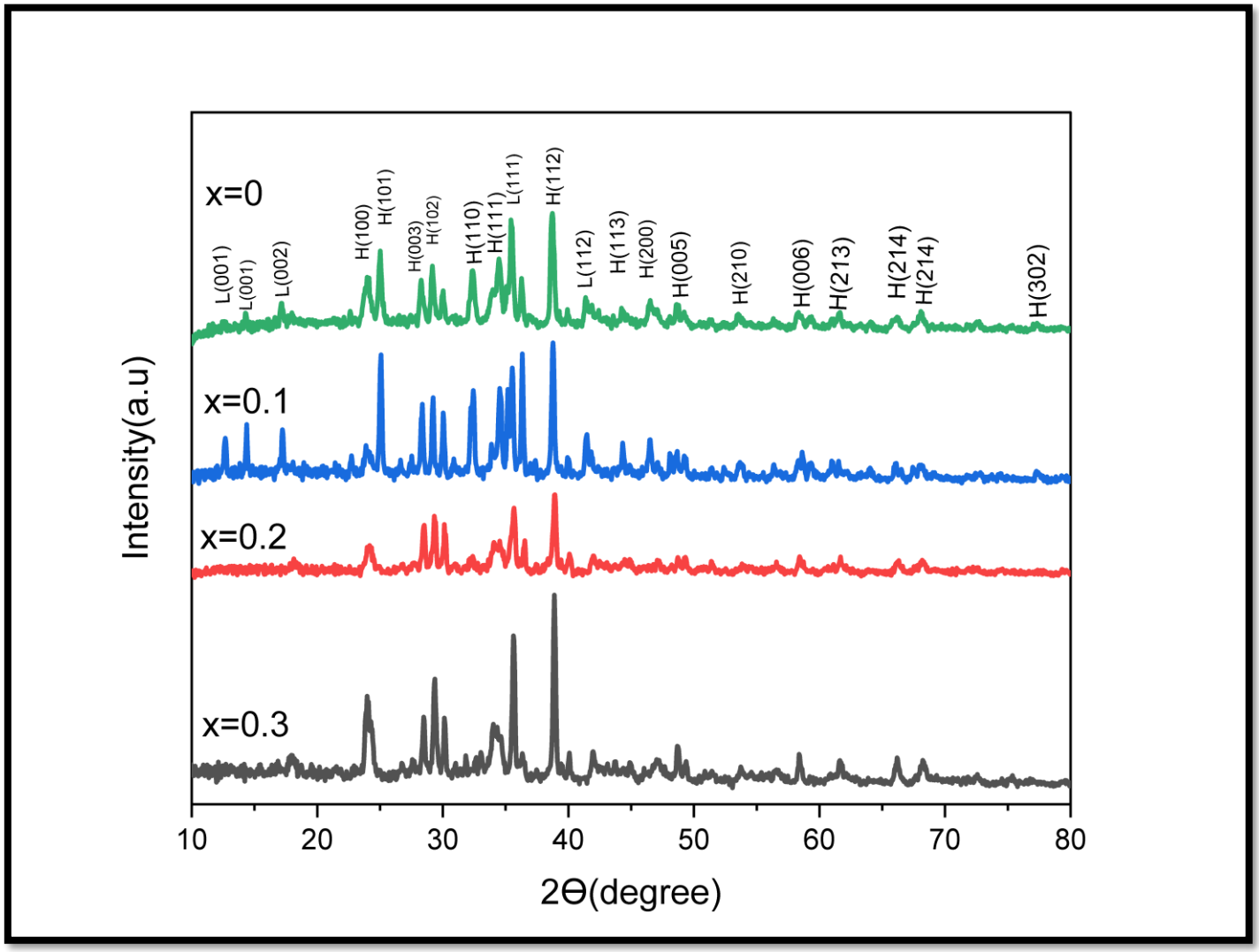

Figure (2) shows the X-ray diffraction diagram of the group samples

$$\frac{1}{d^2} = \frac{h^2 + k^2}{a^2} + \frac{l^2}{c^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

It was very close to the standard calculations, which showed that the sample has a tetragonal crystal structure, and then using the conventional techniques, the phase ratios were determined after ascertaining the peaks, their strength, and type. The following mathematical formula was used to determine the ratio of each phase. [11]

$$(V_{ph})\% = \frac{\Sigma I_o}{\Sigma I_1 + \Sigma I_2 + \Sigma I_{Other(peaks)}} * 100\% \ \ldots\ldots\ldots (4)$$

where I represent the intensity of the peaks in each phase.

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	76.19%	23.81%	3.84	3.84	9.389	2.445
0.1	71.42%	28.58%	3.868	3.868	9.498	2.455
0.2	84.21%	15.79%	3.888	3.888	9.5463	2.4553
0.3	76.92%	23.08%	3.84	3.84	9.588	2.496

It is vital to understand the electrical resistance of a material as a function of temperature since it provides us with a good idea of the value of the critical transformation temperature (Tc) as well as the nature of the interaction between the particles of the material

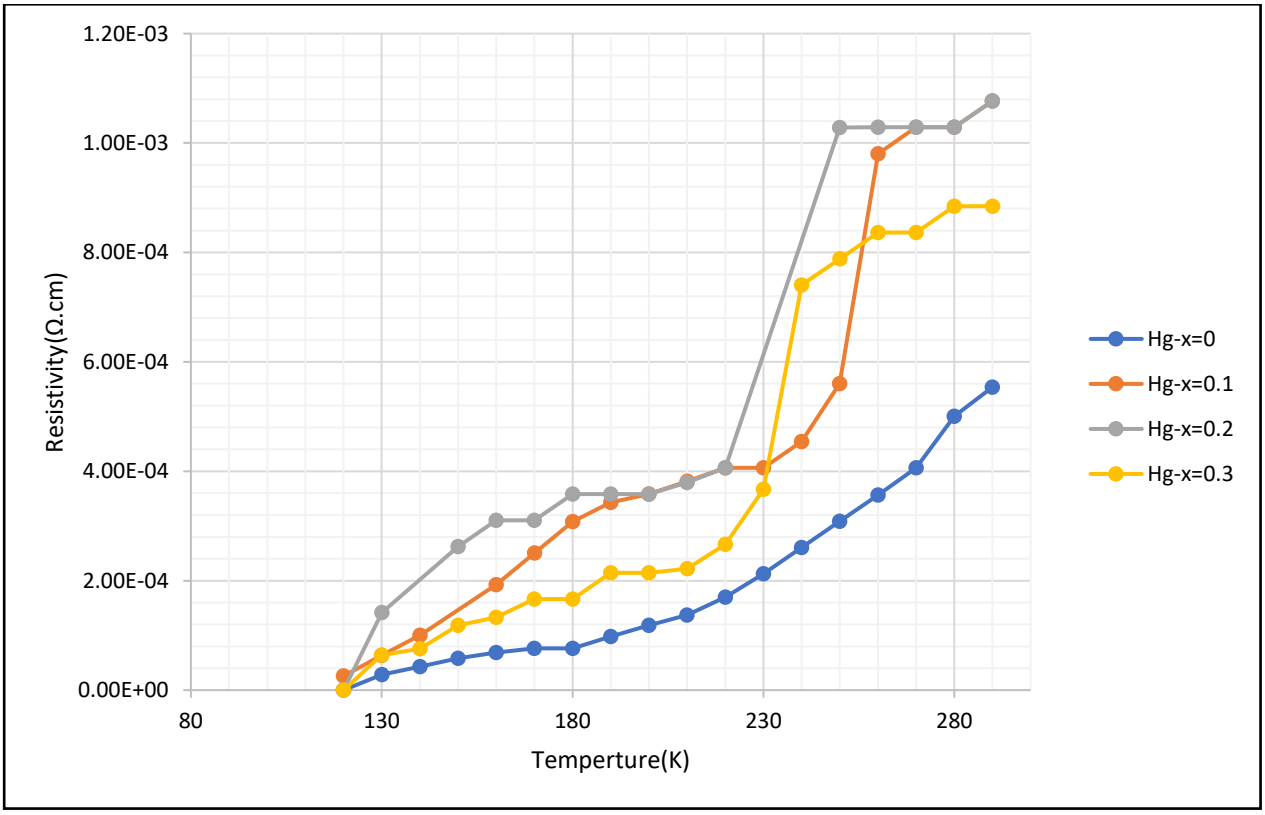

Figure (3) shows the change in electrical resistivity as a function of temperature for the group samples.

In Figure (3), which represents the behavior of electrical resistance as a function of temperature in which (x=0, ,0.1, ,0.2,0.3) and in which, we note that all samples had metallic behavior in the region that precedes (Tc(onset)) Which then the material turns into a superconducting state, where all samples showed

superconducting behavior with a difference in critical transition temperatures, noting the increase in the width of the transition to the superconducting state, which is attributed to the presence of impurities and low phases, as well as to the generation of some internal distortions in the crystal structure Because of the replacement

Table 2. Shows the ratios of phases, critical temperature, energy gap and concentration of gaps for the samples and concentration of gaps for the samples

x	Tc (K)	Tc(of) (K)	Tc(on) (K)	ΔT (K)	Tc(mid) (K)	Eg(ev)
0	112.8	112.8	130.01	17.21	121.405	0.0343
0.1	113.6	113.6	120.1	6.5	116.85	0.0345
0.2	115.7	115.7	120	4.3	117.85	0.0352
0.3	114.3	114.3	120.02	5.72	117.16	0.0348

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 behavior 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 high phase (Hg-1223) and an increase in other phases (XRD)

FIGURE 4 shows the change of the ratio of lattice parameter c/a by increasing Sb concentration. Because the increasing of Zn content causes a decreasing in the percentage of oxygen, which makes them less than optimum value which gives the greatest value for the Hg-1223 phase.

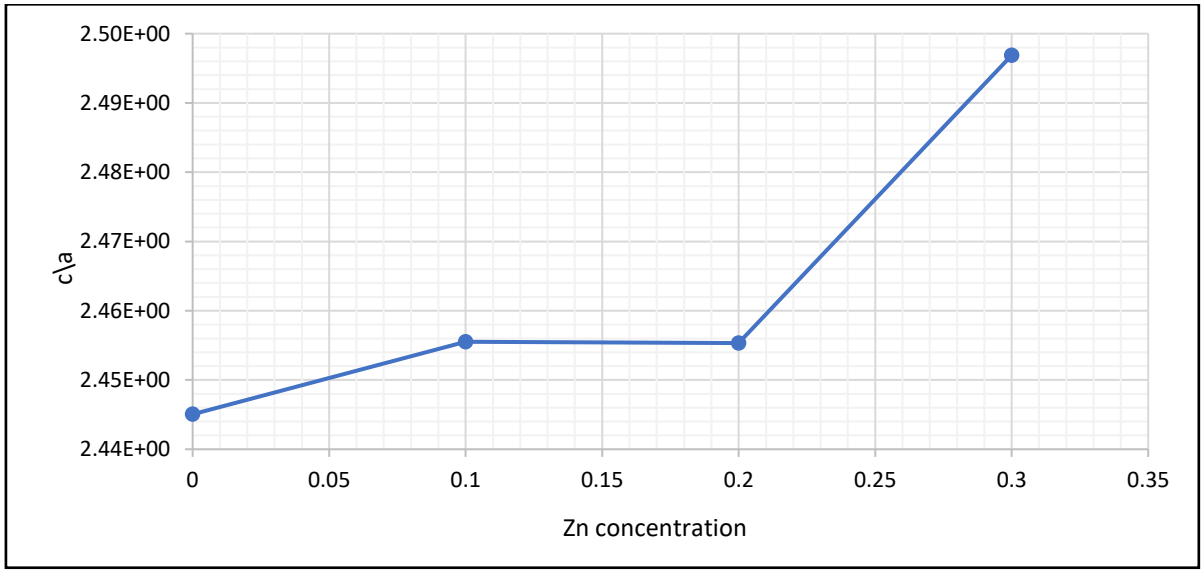

FIGURE 4. The (C/a) change as a function of the change in antimony (Zn) concentration.

CONCLUSIONS

In the current study, we have successfully prepared ($HgBa_2Ca_2Cu_{3-x}Zn_xO_{8+\delta}$). samples "(x = 0, 0.1, 0.2 and 0.3)". Specimens have been prepared via (SSR)-solid state reaction process. The XRD information collected from different Specimens show that all the specimens are polycrystalline and correspond with (Hg-1223) phase. We concluded that most of the samples have metallic behavior in changing their electrical resistance with decreasing temperature before they are superconducting. It was also observed that changing the critical temperature with an unexpected change of replacement ratios except in the case of samples with concentration (x=0.2), which was at (Tc(offset) = 115.7K, raising the amount of zinc replacement resulted in an apparent shift in the critical temperature.

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