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Article

Examine the Impact on the Electrical and Structural Properties of Superconducting Compounds of Partial Substitution of Ag for Ba

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Abstract

We manufactured the compound $(Bi_{1.8}(Pb_{0.2})Ba_{2-x}Ag_xCa_2Cu_3O_{10+\delta})$ for this research. based on bismuth and evaluated the impact of substituting silver oxide (AgO) for barium oxide (BaO) at concentrations of x = (0.0,0.05,0.1,0.15,0.2, and 0.25 The samples were made using the state solid reaction method. After being consolidated for 26 hours at the sintering temperature of 720°C and a heating rate of 10°C per minute, the samples were cooled to room temperature at the same heating rate. The critical temperature has been determined using the four-probe technique, and the resistivity as a function of temperature test shows that every specimen behaves metallically. When x=0.05, the maximum critical temperature we have discovered is 124.2k. The surfaces of these systems were also inspected using atomic force microscopy, or AFM. It was used to compute the root mean square (Rg), average roughness (Ra), and average diameter (nm). According to the findings, the sample with the lowest average diameter (131.5)was the one with the replacement ratio (0.2).

Keywords: superconductivity, Critical temperature, SSR technique , Electrical Resistivity, high-TC superconductors.

1. Introduction

Ceramic-based materials are non-metallic, inorganic substances. They might possess all of the crystals or just a few. Heat action and subsequent cooling are what lead to their creation. They are rigid, brittle, and weak in shearing and tension, yet they are strong in compression. They are resistant to the chemical corrosion that happens in acidic environments. Ceramics can generally endure extremely high temperatures, such as those between 1000 and 1600 °C. High dielectric constant (High-K) ceramic composites are now being explored as potential high frequency electronics applications. A comprehensive understanding of this class of materials will help the electronic industry plan, design, and process these materials.[1]

Because of the important roles that crystal shape and particle size play in applications, scientists have concentrated on the production of new materials. The phases, crystal lattice properties, crystallite sizes, and crystallinity levels of the materials were ascertained using quantitative investigation. The Scherrer equation is one of the specialized methods employed in the quantitative examination.The most popular technique for determining crystallite sizes among the various technologies available is the X-ray diffractometer.[2] [3]

2. Experimental method

A The ($Bi_{1.8}Pb_{0.2}Ba_{2-x}Ag_xCa_2Cu_3O_{10+\delta}$) samples with varying Ag (x=0,0.05,0.1,0.15, 0.2,0.25) were produced using a solid state reaction method utilizing mixed oxide powder of (BiO,PbO, BaO,AgO, CaO, CuO) with a 99.99%

purity. The SSR the samples were prepared using the solid state reaction method. The proper weights of the elemental oxides are calculated in the first step, and then the grinding process is carried out using an electric mixer and a hand mixer.

After the samples were sintered in a specialized oven after the mixture was compressed with a hydraulic press for one minute at a pressure of eight tons per centimeter at 720°C for 26 hours at a heating rate of 10 °C per minute to create a bonding material and guarantee that the atoms diffused gradually. After that, the samples were cooled until they reached room temperature using the same heating rate.

Next, the superconducting samples' energy gap was computed using the subsequent formula[6]

$$E_g = 3.53*K_B*T_c \quad …………………(1)$$

where KB is the Boltzmann constant 1.38*10-23 J/K and Eg is the energy gap.

All samples were run at a constant current in a liquid nitrogen-cooled chamber, and the four-sensor method was used to measure the electrical resistivity as a function of the generated samples' critical temperature [6, 7]. Figure (1) displays the circuit schematic for this method.

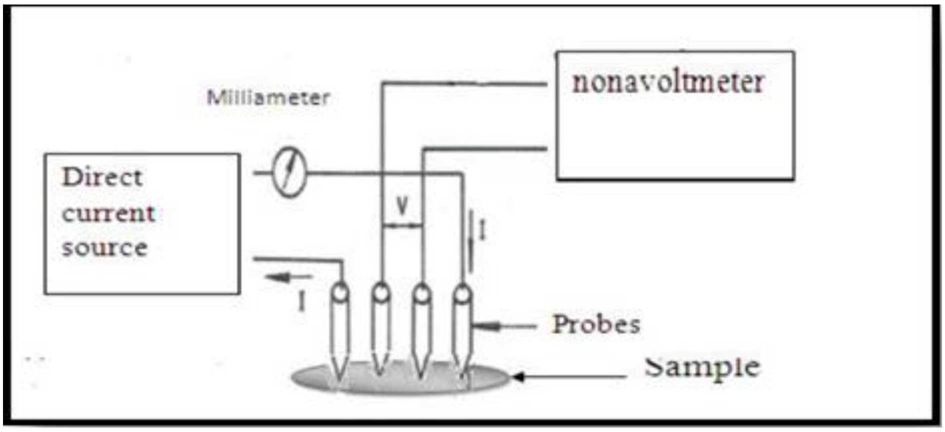


Figure (1) depicts the four-sensor method for determining the connection between electrical resistivity and temperature. [6]

A digital thermometer (Thermocouple, type-K) is positioned extremely close to the refrigerated chamber to measure the sample's temperature. A rotary pump is connected to the refrigeration chamber in order to empty it and raise the internal pressure to 6x10-2 mbar.The cooling chamber is additionally wired with four connections. The sample must be connected to four points in order for resistivity to work, and the two final destinations must be connected to a DC power source in order to provide the nanometer-scale sample with a steady current measurement. The critical transition temperature can be determined from the electrical resistivity curve as a function of temperature using the following relationship.[6,8]

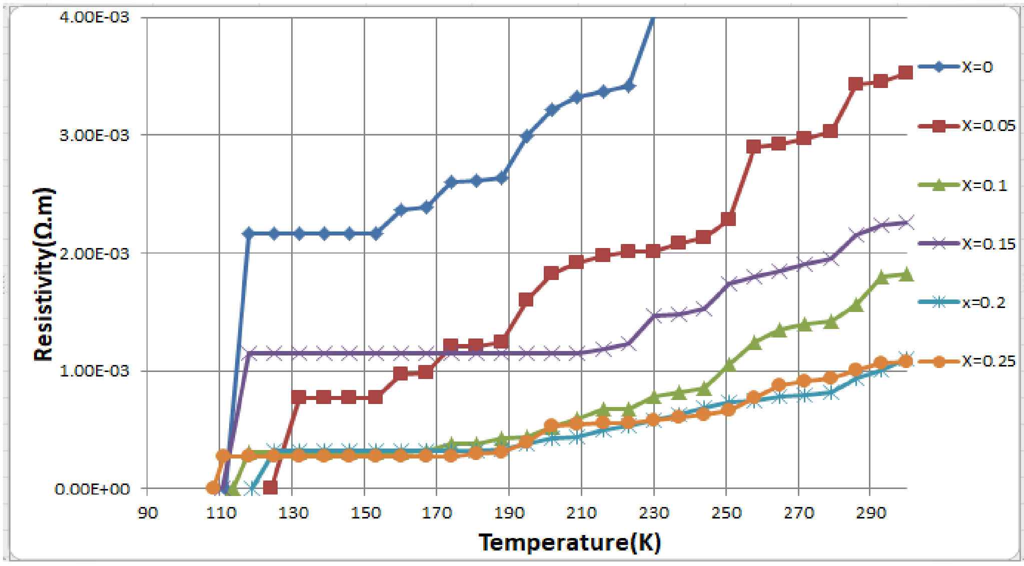
$$T_{c(mid)} = \frac{T_{c(onset)} + T_{c(offset)}}{2} \ldots\ldots\ldots\ldots\ldots (2)$$

Since oxygen and copper combine to create a number of copper oxide layers that can be added to the crystal structure of the system to let oxygen come in and go out the composition, the superconducting ceramic system (BBCCO) can be thought of as an electrically active mass. As a result, it offers a way to produce the precise cavity concentration required for superconductivity to happen in a crystalline system.

3.Results and discussion

Figure (2) shows the electrical resistivity behavior as a function of temperature for the pure sample and the group samples with x = 0,0.05,0.1,0.15,0.2, and 0.25. The samples' metallic behavior is clearly seen in the region before Tc (onset), after which they began to exhibit superconducting activity, which is defined by critical degrees that are greater than the pure sample's critical temperature. Furthermore, Table (1) shows that the sample with substitution (x = 0.05) at (Tc = 124.2K) had the best substitution ratio.

which we observe that In the superconducting samples, the electrical resistance gradually decreased. We observe that the transition width (ΔTc) was minimal, indicating the homogeneity of the sample. The samples' low phases and impurities in different amounts are the cause of this phenomenon. [9, 10] , which It might result from the substitution of barium (Ba) for silver (Ag), which tends to alter the concentration of charge carriers in this system's conductive and charge storage layers. [11]



Fig(2):the resistivity is a function temperature for ($Bi_{1.8}(Pb_{0.2})Ba_{2-x}Ag_xCa_2Cu_3O_{10+\delta}$) system

Table (1) In the Bi1.8(Pb0.2)Ba2-xAgxCa2Cu3 O10+δ system, the critical temperature, energy gap, and gap concentration are displayed at 720 °C with x = 0, 0.05, 0.1,0.15,0.2, and 0.25.

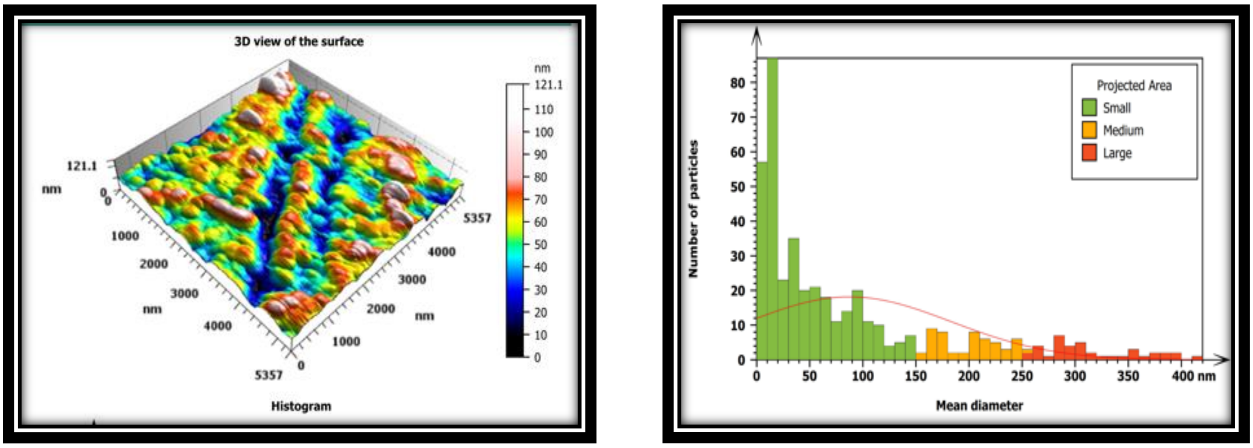
X	Tc(of) (K)	Tc(on) (K)	ΔT (K)	Tc(mid) (K)	Eg (ev)
0.0	111.6	118	6.4	114.8	0.033978015
0.05	124.2	132	7.8	128.1	0.037814243
0.1	113.4	118	4.6	115.7	0.0345260048
0.15	110.7	118	7.3	114.35	0.033703999
0.2	118.8	125	6.2	121.9	0.036170145
0.25	108	118	10	113	0.03288195

AFM, or atomic force microscopy, is an excellent method for analyzing the texture and morphology of different surfaces. Knowledge of surface topography at nanometric precision has enabled research into mechanical manufacturing, tribological qualities, biological processes in motion, and mainly thin film surfaces . Compared to other microscopic approaches . The versatility of this technique allows for more in-depth examinations and sessments of the films'morphological and textural characteristics. Surface roughness was calculated using the roughness parameters (Rq) and (Ra). where the average roughness (Ra) throughout the whole measured length/area equals the mean height. The square root of the surface height distribution is known as root mean square (RMS) roughness (Rq), and it is thought to be more sensitive to significant departures from the mean line or plane than average roughness.

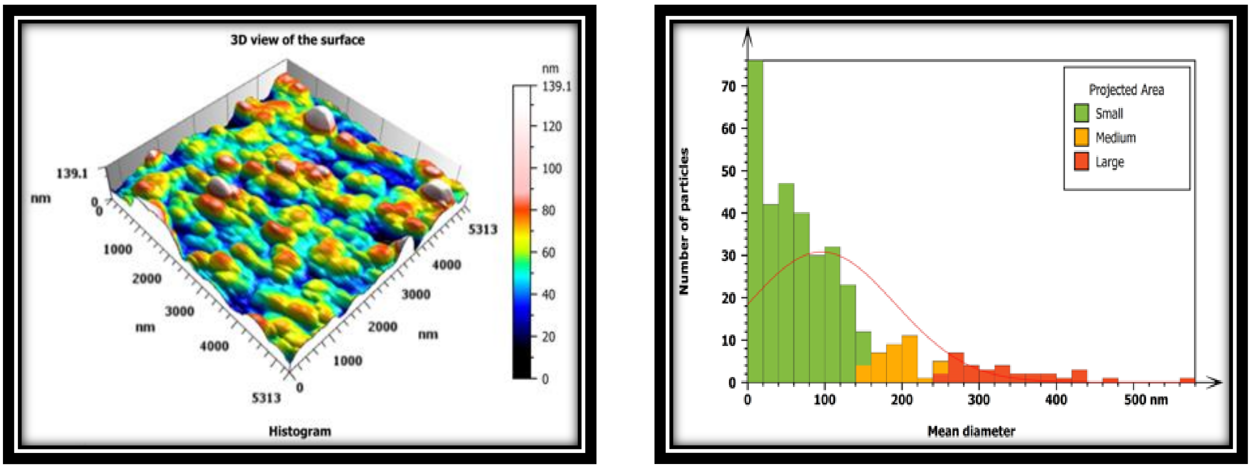
Table (2) : average roughness (Ra) , root mean square (RMS) roughness (Rq), Meandimeter(nm) for x=0 , 0.05 ,0.1 , 0.15 , 0.2,0.25

X	Ra(nm)	Rq(nm)	Mean dimeter(nm)
0	22.01	31.20	365.0
0.05	22.20	28.40	331.5
0.1	157.6	204.0	456.0
0.15	305.9	390.3	240.1
0.2	24.75	34.18	131.5
0.25	36.87	59.18	348.9

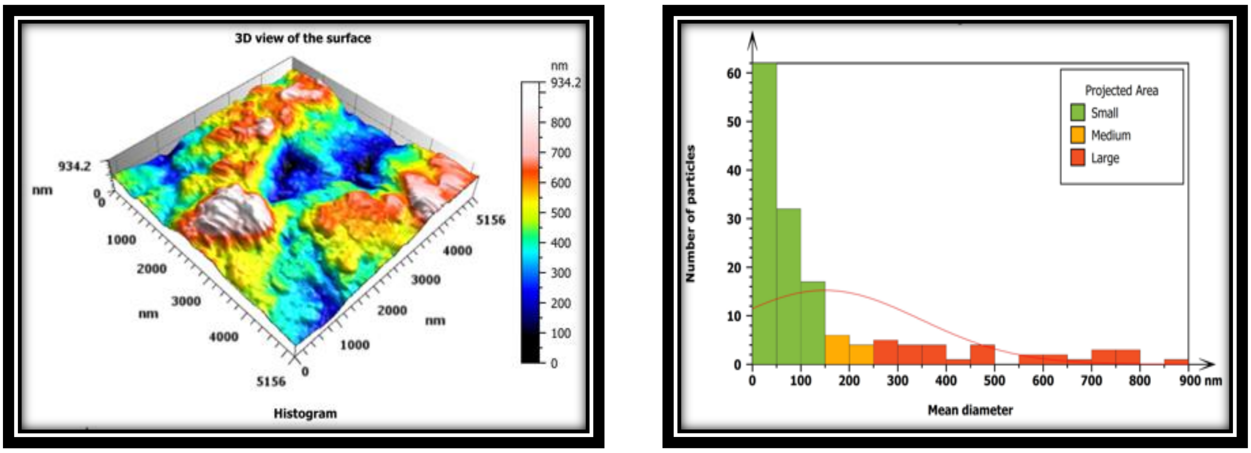
From table(2), the values of the (mean diameter (nm)), average roughness (Ra), and root mean square (Rq) are all affected by variations in the substitution ratio between Silver (Ag) and Barium (Ba). The sample with the replacement ratio (0.15) had the lowest mean diameter (240.1), among other characteristics. Additionally, Ra value of 305.9 nm and an Rq value of 390.3 nm . It was also observed that when the substitution ratio between Silver and Barium elements decreased 0.0 it leads to an increase in the mean diameter to 365.0nm.



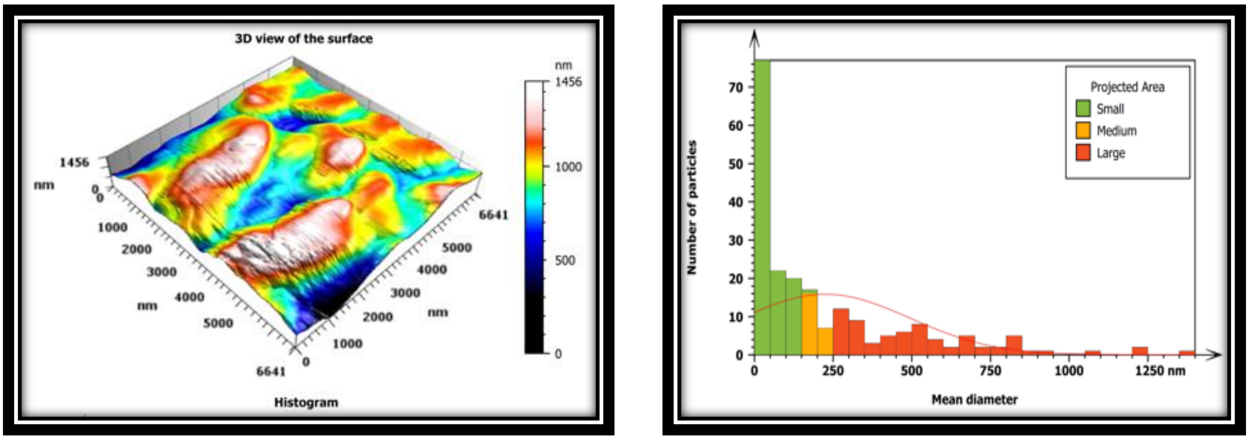
X=0



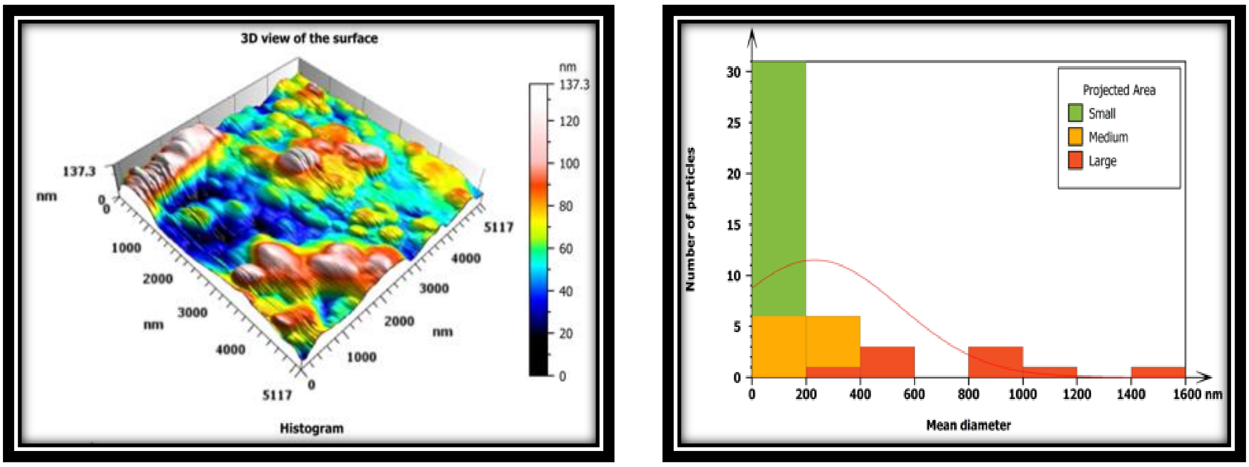
x=0.05


3D view of the surface
934.2
nm
5156
Histogram
Projected Area
Small
Medium
Large
Number of particles
Mean diameter
900 nm

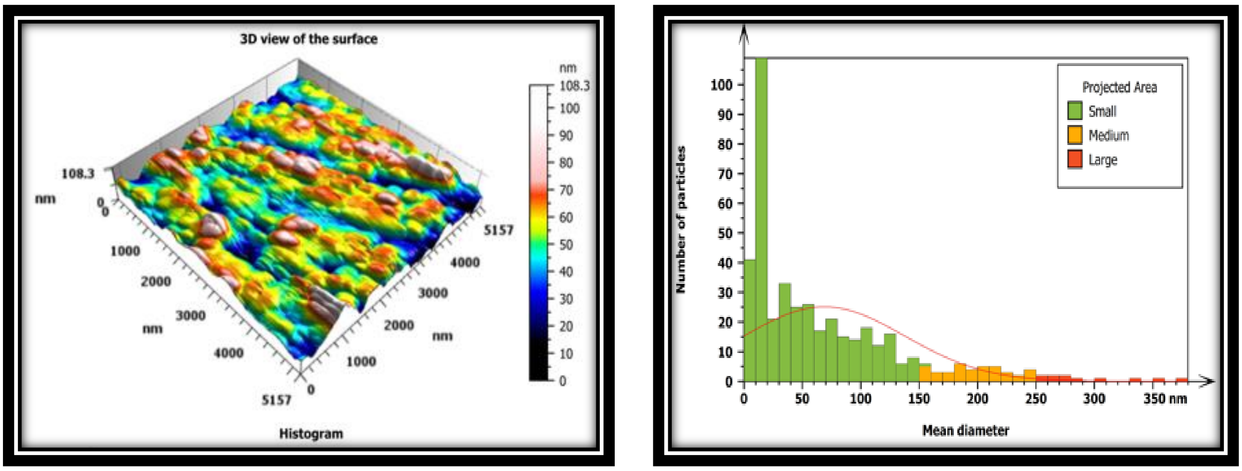
x=0.1


3D view of the surface
1456
nm
6641
Histogram
Projected Area
Small
Medium
Large
Number of particles
Mean diameter
1250 nm

X=0.15


3D view of the surface
137.3
nm
5117
Histogram
Projected Area
Small
Medium
Large
Number of particles
Mean diameter
1600 nm

X=0.2



X=0.25

Fig (3): reveals the chart distribution and three-dimensional AFM pictures of $Bi_{1.8}(Pb_{0.2})Ba_{2-x}Ag_xCa_2Cu_3O_{10+\delta}$

4. Conclusions

In the present research , we've finished preparing ($Bi_{1.8}(Pb_{0.2})Ba_{2-x}Ag_xCa_2Cu_3O_{10+\delta}$) samples with(x=0 , 0.05 , 0.1 , 0.15 , 0.2,0.25) The solid state reaction technique (SSR) has been used to prepare specimens . The majority of the samples exhibited metallic behavior, meaning that as temperature dropped, their electrical resistance changed before they reached the superconducting state. The critical temperature fluctuated randomly when replacement ratios were changed, with the exception of samples where the Silver concentration was (Ag =0.1, 0.2) where the critical temperature clearly increased for this group, but it clearly declined and deteriorated for the samples with Silver concentrations of (Ag=0.0 , 0.15,0.25) .We got the maximum critical transfer temperature (Tc=124.2K) in the sample with concentration (Ag= 0.05), which also had the optimal substitution ratio, AFM techniques were used to examine the picture composition of the ($Bi_{1.8}(Pb_{0.2})Ba_{2-x}Ag_xCa_2Cu_3O_{10+\delta}$) system with x = 0, 0.05, 0.1, 0.15, 0.2 ,0.25 . It shows that the less mean diameters (nm) was at (x=0.15).

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