# Studying the effect partial Ni<sub>2</sub>O<sub>3</sub> nano-particles compensation on the properties of the compound Bi<sub>2</sub>Sr<sub>2-x</sub>Y<sub>x</sub>Ca<sub>2</sub>Cu<sub>3-y</sub>Ni<sub>y</sub>O<sub>10+δ</sub> superconductors

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Partial compensation Ni2O3 nanoparticles have been considered in relation to their effects on the structure, electric, morphology, and composition of Bi-2223. X-ray diffraction was used to quantify structural characteristics, and the results showed that all of the crystals in the samples are orthorhombic, with the ratio at which the Bi-2223 phase develops increasing The constancy of the lattice along the c-axis was observed. The trend that has been observed suggests that there is a direct proportionality between the concentration of Ni2O3 and the magnitude of the increase. Suggestive of a high-temperature superconductor (Bi<sub>2</sub>Sr<sub>2-x</sub>Y<sub>x</sub>Ca<sub>2</sub>Cu<sub>3-y</sub>Ni<sub>y</sub>O<sub>10+ $\delta$ </sub>) composition, where y=0=0.03=0.12 Thanks to 3D AFM, the morphology of the surface has been thoroughly studied. The test specimens showed good crystalline structure and a smooth, uniform surface. We measured Tc with 4 separate probes. The maximum temperature constant (Tc) was measured to be 143 K at y=0.12.

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#### 1. Introduction

The fundamental barrier to widespread currently, the primary challenge associated with the utilization of high-temperature superconductors pertains to the production of a superconductive material possessing the requisite characteristics for implementation in electrical and electronic contexts [1,2]. The initial step in the quest to discover high-transition-temperature superconductors [3,16] The investigation pertained to the quest for molecules that encompassed the chemical composition of Bi-Sr-Ca-Cu-O. The Bi-Sr-Ca-Cu-O (BSCCO) material exhibits both the superconducting transition temperature Tc and the critical current density Jc. combination are relatively high. As a type of high-temperature superconductor (HTSC), it is widely regarded as one of the most interesting substances ever discovered. Most effectively [19,20]. Tapes and wires for high-current industrial use can be synthesized in the Bi-2223 phase [4, 18]. The formation of the Bi-2223 phase is particularly sensitive to a wide range of factorsSeveral factors can influence the synthesis of materials, such as sintering temperature, thermal processing duration, synthesis environment, precursor compositions, and the incorporation of different cations and anions through doping or replacement [27,28]. From what we can see, Ni2O3 micro Particles considerably enhanced the formation of Bi-2223 phase [5-10], suggesting that they may be somewhat compensating for Cu's slowing effect[21,26].

## 2. Experimental

Traditional solid state reaction technique was used to create  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  samples with y=0,0.03, and 0.12; agate motor was used to blend powders of high purity Bi2O3, SrO, CuO, and CaO. Pellets measuring 1.5 cm in diameter and 0.2 cm in thickness were manually pressed using a hydraulic press at a pressure of 7 t/cm2 after heating the mixture in a furnace at

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750°C for 24 hours (as estimated). Before being used, sintered pellets spend 120 hours in a furnace controlled by a programmable controller at 800 °C and 5 co /min. Slowly, at a rate of 0.5 °C per minute, the temperature was brought down to room temperature. By measuring the material's resistivity with a four-probe technique in a cryostat containing liquid nitrogen, the transition temperature could be determined. Nano mechanical force probes (AFM) were utilized to acquire roughness and surface morphology, while X-ray diffraction was employed to analyze the synthesis specimens' underlying structure.

#### 3. Discussion and results

The results of X-ray diffraction (XRD) showed that all of the samples examined had an orthorhombic polycrystalline structure, with level of elevation concentration regarding the phase of high temperature. Bi-2223 and numerous Prominent peaks of Bi-2212 at reduced temperatures, as well as the presence of unknown impurity phases, see references [11, 12,17]. The atoms may appear to be in two or three different phases if Ni is accidentally swapped with Cu in the original structure. Figures 1 and 2 indicate that as Ni concentration grew, so did peak intensities. The highest peak intensities are found only in the high (Tc) phase (Bi-2223), indicating that the high-Tc phase now constitutes a larger fraction of the material [24,25]. The high Tc (Bi-2223) peak increased with increasing Ni content across the board. The XRD data, including V, c/a, and dm (a, b, c), are presented in Table 1. Conclusions from Each sample has an orthorhombic crystalline structure, as shown by the calculated lattice parameters (a, b, and c). One of the most noticeable problems that can arise when substituting yttrium oxide for another element (Ni2O3) is an increase in the oxygen concentration. Since c is the lattice constant, it follows that the bonding forces between the ions inside the Cu-O stacking increase as the Ni concentration rises, owing to the double Cu-O layers absorbing the surplus energy. Yttrium oxide was used to partially replace the volume of nickel oxide in the (Bi-2223) phase. Observe this rise As the Ni concentration rises, it is absorbed by the twin Cu-O layers, where it raises the ionic forces created the lattice parameter c is affected by the Cu-O layers. As the c-parameter shifts, the (Bi-2223) phase's volume shifts in a predictable fashion. Density rises when lattice characteristics are altered to increase the unit cell's volume. The c/a rate plotted against (Ni) concentration is shown in Figure 2. Second, variations in ionic radius may affect lattice properties. [13,14,23].



Fig. 1. X-ray diffraction pattern of  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  specimen with y = (0, 0.03, 0.12).



Fig. 2. Shows rate of change of the lattice constants (c/a) vs (Ni) concentration. D of a specimen of  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  with y=(0, 0.03, 0.12).

Table 1. Lattice parameters of  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  with y = (0, 0.03, 0.12).

| Х | У    | a (Å)  | b (Å)  | c (Å)   | V (Å <sup>3</sup> ) | c/a   | w (g/mole) | $\rho_{m}$ | HTP %  |
|---|------|--------|--------|---------|---------------------|-------|------------|------------|--------|
|   |      |        |        |         |                     |       |            | $(g/cm^3)$ |        |
| 0 | 0    | 5.4907 | 5.5623 | 36.3761 | 1110.959            | 6.625 | 1023.99    | 7.652      | 67.63% |
| 0 | 0.03 | 5.4765 | 5.5915 | 36.2695 | 1110.656            | 6.623 | 1023.842   | 7.653      | 67.73% |
| 0 | 0.12 | 5.4806 | 5.3470 | 36.3181 | 1064.293            | 6.627 | 1023.406   | 7.983      | 68.25% |

The topic of discussion pertains to the concept of electrical resistivity denoted by the symbol  $\rho$ . The temperature dependence of the electrical resistivity of a (Bi<sub>2</sub>Sr<sub>2-x</sub>Y<sub>x</sub>Ca<sub>2</sub>Cu<sub>3-y</sub>Ni<sub>y</sub>O<sub>10+δ</sub> ) sample with varying values of y (0, 0.03, and 0.12) is illustrated in Figure 3. The critical transition temperature was determined using resistivity data obtained from a four-probe test. The sample (S) exhibits a significant critical transition temperature (Tc) when subjected to low temperatures, commencing at approximately (145) k and concluding at approximately (134) k. The analysis revealed that the sample exhibited a superconducting transition width ( $\Delta Tc$ ) of 11k. The criticality of transition temperature was determined using resistivity results obtained from a fourprobe test [15,22]. Upon cooling, the specimen denoted as S1 exhibits a critical transition temperature at the onset (Tc(onset)) of approximately 142 K and at the offset (Tc(offset)) of approximately 134 K. The value of the superconducting transition width ( $\Delta Tc$ ) was found to be 8 k based on the sample analyzed. The critical transition temperature was determined through the utilization of resistivity data obtained via a four-probe test. Upon cooling, the sample denoted as S2 exhibits a transition critical temperature (Tc) of approximately 145 kelvin at the onset and approximately 140 kelvin at the offset. Table 2 indicates that the critical temperature of the sample is 143 K, and its superconducting transition exhibits a breadth of 5 K ( $\Delta$ Tc).



Fig. 3. The relationship between temperature and electrical resistivity for  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$ where y = (0, 0.03, 0.12).

Table 2. Offset, onset, transition width T(K), and transition time Tc(K) for  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$ with y = (0, 0.03, 0.12).

| Symbol | х | У    | T <sub>C(onset)</sub> K | T <sub>c(offset)</sub> K | $\Delta \mathbf{T}$ | <b>T</b> <sub>C</sub> K |
|--------|---|------|-------------------------|--------------------------|---------------------|-------------------------|
| S      | 0 | 0    | 145                     | 134                      | 11                  | 140                     |
| S1     | 0 | 0.03 | 142                     | 134                      | 8                   | 138                     |
| S2     | 0 | 0.12 | 145                     | 140                      | 5                   | 143                     |

The findings of the Atomic Force Microscopy (AFM) analysis. The aforementioned compound is denoted as  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  where the variable y takes on the values of 0, 0.03, and 0.12. The specimens are observed utilizing an atomic force microscope subsequent to their synthesis via the SSR methodology, as depicted in Figures 4, 5, and 6.



Fig. 4. AFM images of  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  with x = (0.00), y = (0,00).

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Fig. 5. AFM images of  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  with x=(0.00), y=(0.03).



Fig. 6. AFM images of  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  with x = (0.00), y = (0.12).

The compound elements undergo a reduction in size to the level of microscopic dimensions. The statistical measures of mean diameter and surface area were presented for each individual specimen. It has been observed that the median size range values exhibit variation with respect to the Ni content. The images presented herein depict the homogeneity and uniform distribution of features in the examined specimens, devoid of any pinholes or island-like structures.

## 4. Conclusion

In this study, we examine the superconductor molecule  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  that was synthesized using solid-state reaction (SSR) for three different values of y, namely 0, 0.03, and 0.12. The X-ray diffraction pattern of the Bi-2223 superconductor has been found to possess an orthorhombic structure. Moreover, it has been observed that the c-axis lattice parameter experiences a rise with an increase in the concentration of Ni. The optimal value for Ni in the complex compound  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  is observed at y = 0.12. This is indicative of the highest ratio of Bi-2223 phase. The compound  $(Bi_2Sr_{2-x}Y_xCa_2Cu_{3-y}Ni_yO_{10+\delta})$  exhibits a noteworthy variation in electronic state, hole carrier concentration, and bargaining position, as evidenced by the fact that Tc attains its highest value (143K) at y=0.12. Atomic force microscopy was utilized to determine the surface roughness and average diameter of the samples at a ratio of y=0.12 owing to the uniformity of the surfaces.

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