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Studying the Addition Effect of Nano WO_3 on the $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_{10+\delta}$ Superconductors

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Abstract: Different concentrations of WO_3 nanoparticles were added to $Bi_{1.6}Pb_{0.4}Sr_2Ca_2Cu_3O_{10+\delta}$ composite its superconducting properties as well as its microstructural development were studied. Powder pellets made-up using method of solidstate reactions. Critical transition Temperatures T_c of samples measured by technique of fourpoint probe. It found that addition of nanoparticles WO_3 up to the 0.2 wt.% enhances the T_c, the highest T_c was exhibited at 120 K while excessive addition suppressed it. WO_3 nanoparticles introduced effective pinning centers. The gross structural characteristics of synthesized High-T_c Superconductors (HTSc) was investigated through X-ray diffractions. The results showed both high and low phases exist in models with orthorhombac structures for all samples. Grains shape and their connectivity studied with SEM. EDX analysis used to test the chemical compositions of the $Bi_{1.6}Pb_{0.4}W_{0.2}Sr_2Ca_2Cu_3O1_{0+\delta}$ superconductor. XRD, SEM and electrical measurements were done on the samples to deduce the best properties desired for the superconductor.

Key words: BSCCO superconducting system, WO_3 addition, high-2223 phase, pinning center, (HTSc), grains shape

INTRODUCTION

Supercondectivity is an interesting wonder recognized by transitions phases at a T_c where both condecting and the superconducting phases are in equilibrium. Discovering the High-T_c Superconductors (HTSc) is in great demand for technological development and industrial applications (Luiz, 2010; Rahman *et al*., 2015).

Material sciences and engineering researchers concerned in the prediction and the clarification of the HTSc properties from the standpoint of structure (Rashid *et al*., 2011). One of the most special features of the HTSc layered superconductors is the correlation between superconductivity and the lattice structure. The Bi.Sr.Ca.Cu.O system the most promising HTSc has general chimical formola $Bi._2Sr._2Ca._nCu._{n+1}O._{2n+6+\delta}$ (n = 0-2) (Kharissova *et al*., 2014). T_c is mainly determined by the structure and the chemical composition; the chimical compositions of the materials withinthe grains also at the grains boundaryes of a superconductor consumes a considerable result above it's propertyes. It is known that inter-grain regions behave like nonconducting area, thus, grain connectivity becomes more important for the sharpness of transition and other critical parameters.

Considerable effort has been made on the possibility of modifying the structure (Al-Bermany, 2017) and the superconducting chattels of Bi.based compound by increasing the number of charge carriers chemically by cation substitution change the number of oxygen atoms (Parinov, 2013).

Recently, remarkable progress in the development of nanotechnology materials has led to a continuous studying ofthe influences of doping with various nanoparticles on the properties of the BSCCO such as Al_20_3, ZrO_2, TiO_2, Nd_2O_3, Co_3O_4, SnO_2,Y_2O_3 (Parinov, 2013; Abbas *et al*., 2018; Hamid, 2009; Aljurani and Shyaa, 2015; Saritekin *et al*., 2016; Jannah *et al*., 2013; Garnier *et al*., 2002; Oboudi, 2017). These studies showed that doping the layered HTS materials with nanoparticles has different effects, the dopants formulate innovative phase by reaction vigorously with Bi. 2223 and 2212 phaseswhich adversely affect the properties of superconductor or the nanoparticles could doing like pinioning centres, improve inter-granular contacts, so, improving the supercondecting critically parameter. Furthermore, BSCCO actual delicate to carriers doping and are superconductors only for the particular range of doping levels.

In this research, samples of (Bi. 2223) dissimilar concentrations of added WO_3 nanoparticles (0, 0.1, 0.2 and 0.3 wt.%) set by technique of the solid state reaction. The electrical and structural results were assumed together to investigate the role of tungsten over the superconductor properties.

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MATERIALS AND METHODS

Experimental: $Bi_{1.7}Pb_{0.3}W_xSr_2Ca_2Cu_3O_{10+\delta}$ structures with (x = 0, 0.1, 0.2 and 0.3%) set by the process of the solid state reactions. To make this an correct molar ratio of high purities powder of the Bi_2O_3, PbO, $Sr(NO_3)_2$, CaO, CuO with WO_3 nanoparticles with size 20 nm were mixed. The mixture was grounded to a fin powders, calcenied in air for 24 h at 820°C. This was following by intermediates grinding. The powder hard-pressed into disc-shaped pellets, 3 mm thickness and 13 mm in diameter with the manually hydraulic press (type specac) that was under pressure 0.6 GPa. These pellets were sintered for 140 h in air at 845°C.

The prepared samples structure was obtained applying X-ray diffract meter (Philips with the Cu-K• radiation). The electrical resistivity (•) was studied to evaluate the critical Temperature T_c.

The nature of the grains and the surface morphology for some samples were analyzed using FEL Inspect S50 Scanning Electron Microscope (SEM) (Netherlands). The compositional information of the elements in $Bi_{1.7}Pb_{0.3}Ti_{0.2}Sr_2Ca_2Cu_3O_{10+d}$ sample were achieved by FEI-SEM Model Inspect-S50, Energy Dispersive X-ray spectrometer (EDX).

RESULTS AND DISCUSSION

XRD results of the analysis achieved on WO_3 added to samples shown in Fig. 1. both (Bi, Pb)-2223 and -2212 phases coexist in the samples, the majority of the peaks correspond to the Bi-(2223). This shows that the addition of WO_3 supports growth of high T_c phase. According to the model suggested by Abbas *et al*. (2017), Abbas and Abdulridha (2017) the (Bi,Pb)-2223 phase is formed through a growth process and distinct nucleation. Therefore, the slightly larger volume fraction of the (Bi, Pb)-2223 phase exist in the $Bi_{1.6}Pb_{0.4}W_{0.2}Sr_2Ca_2Cu_3O_{10+\delta}$ composition may be the reason of the faster conversion rate for this composition.

Additionally, the X-ray result of these samples demonstrates that there is a difference the position of the

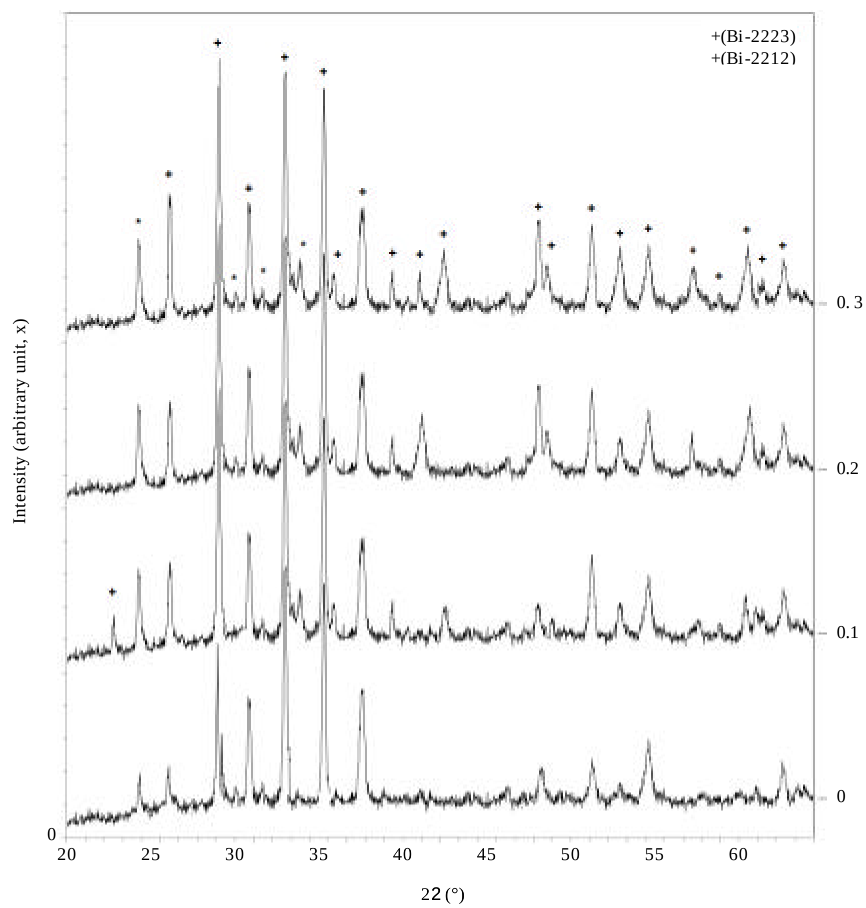

Fig. 1: The X-ray diffraction patterns of the $Bi_{1.6}Pb_{0.4}W_xSr_2Ca_2Cu_3O_{10+\delta}$ samples

Table 1: The values of lattice parameters, volume of unit cell and phase volume fraction for $Bi_{1.6}Pb_{0.4}Sr_2 Ca_2Cu_3W_xO_{10+\bullet}$ superconductors

X (%)	a = b (A•)	C = (A•)	V (A•)^3	c/a	T_C (K)
0.0	5.472	37.151	1112.4040	6.968	114
0.1	5.454	37.148	1086.8749	6.811	116
0.2	5.321	37.110	1084.6463	6.781	120
0.3	5.358	37.095	1065.3517	6.923	115

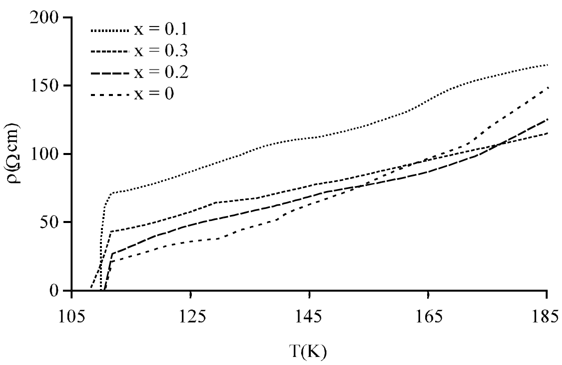

Fig. 2: Temperature dependence of resistance of the $Bi_{1.6}Pb_{0.4}W_xSr_2Ca_2Cu_3O_{10+\bullet}$ superconductors

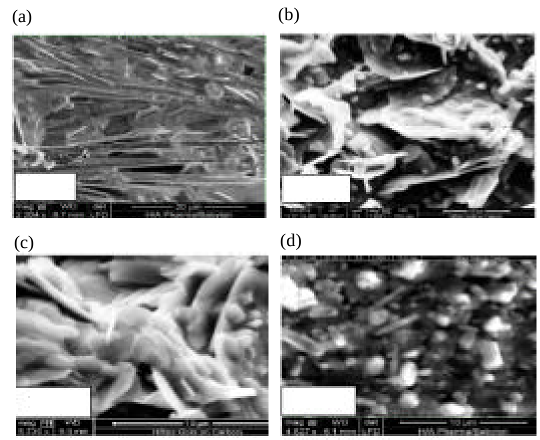

Fig. 3: The SEM surface micrographs of the $Bi_{1.6}Pb_{0}4W_x$ $Sr_2Ca_2Cu_3O_{10+d}$ samples for different W content: a) X = 0; b) X = 0.1; c) X = 0.2 and d) X = 0.3

peaks and in the intensity with the variation of WO_3 concentration which is evidence of the change in phase composition of the samples and the crystalline arrangement degree.

However, there is no substantiation that WO_3 may react actively with the $Bi_{1.7}Pb_{0.3}W_{0.2}Sr_2Ca_2Cu_3O_{10+\bullet}$ compounds to form new phases which as a rule, degrades the properties of superconducting material. The additions may act to stabilize the 2223 phase to increase its volume in the compounds.

The parameters a, b, c and c/a values proved an orthorhombic structure for all samples. Table 1 summarizes the lattice parameters of $Bi_{1.6}Pb_{0.4}W_x$ $Sr_2Ca_2Cu_3O_{10+\bullet}$ superconductors for various WO_3 concentrations. It was important to mention that the addition concentration increases, the cell volume decreases due to both the oxygen vacancies and the cations arrangements acting at the same time (Al-Bermany, 2017; Xu *et al*., 1987).

Lattice parameteres c decreases with the increases of W concentrations to x = 0.2 afterward c decreases as shown in Fig. 2. The increases of c tells that, Ca^{2+}, Cu^{2+} in addition, to Bi^{3+} may partly be substituted by W^{+6} ions, comparable performance observed by Nihal *et al*. (Turk *et al*., 2014). Though the decreasing in c attributed to the charges organization phenomena, also, changes in the oxygens contented, the attractive interactions among the added band created by adding WO_3, crossing level of Fermi pulls from CuO bands some holes and causes the distance reduction among planes of $Cu\text{-}O_2$ which resulting in reduction in c axis (Azhan *et al*., 2009).

Furthermore, the existence of Pb in the Bi-system is supposed to reduce the modulation by affecting charges equilibrium, the oxygens contented and the structure of the related sheets (lkeda *et al*., 1988).

Temperature dependence of the electrical resistivity (•-T) of WO_3-doped samples (0• x• 0.3) have been studied in (Fig. 2). The resistivity exhibited well defined metallic behavior and superconducting transitions to zero resistance for all compositions with narrow superconducting transition widths. Another feature can be observed: the superconducting transition of all the samples is composed of only a one-step transition. This reveals that the sample consists predominantly of (2223) phase. This tendency is also, a good evidence of the homogeneity of the (2223) phase (Iqbal and Mehmood, 2009). The T_c values measured from the •-T curve of the samples were 114, 116, 120 and 115 K for x = 0.0, 0.1, 0.2 and 0.3%, respectively.

The SEM images of the $Bi_{1.6}Pb_{0.4}W_xSr_2Ca_2Cu_3O_{10+\bullet}$ samples (0.0• x• 0.3) obtained Fig. 3. Surface was composed of plate like grains of different orientation, indeed is the characteristic grains structures of (Bi-2223) (Abbas *et al*., 2018). The porous are formed on the grains during the sintering process.

Increasing the W nanoparticles content in the samples achieves densification by decreasing the porosity. Thus, these surface becomes distinctly composed of thick small and large grains. The reason for this significant improvement is that WO_3 nanoparticles fill

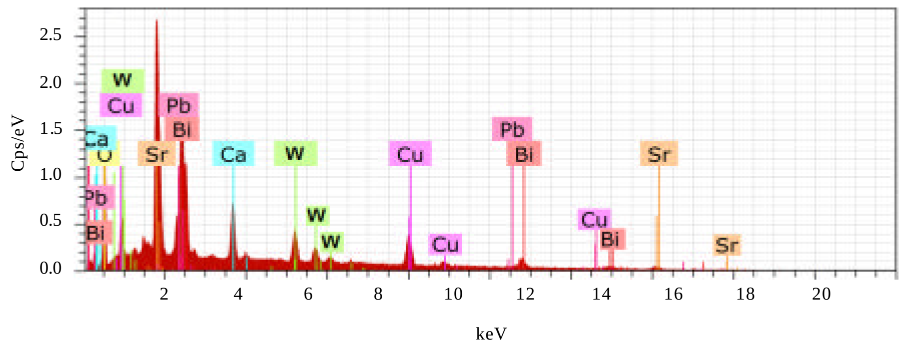

Fig. 4: The EDX spectra of the $Bi_{1.7}Pb_{0.3}Ti_{0.2}Sr_2Ca_2Cu_3O_{10+}$. superconductor

resulting in a smoother and denser surface this is in good agreement with the studies reported by Yazici *et al*.. The EDX spectra of the $Bi_{1.6}Pb_{0.4}W_{0.2}Sr_2Ca_2Cu_3O_{10+}$. superconductor are demonstrated in Fig. 4, authorizes the wanted element in the chemicals compositions presented. There are no unwanted element in the sample, proving that there is no contamination during the preparation process. A crowning of carbon elements distinguished, perhaps due to tinny carbons layer evaporated above samples through the combination procedure. some peaks Pb, Bi with similar energy values detected, representing the ions of Bi substituted incompletely by ions of Pb in structure. Same crowning can observed for W ions for both Bi and Cu ions.

A significant standpoint got from the research is that WO_3 additions support and stabilize the creation of Bi high phase. Besides, it reduces the sintering temperature, since, some kind of a liquid phase was present in the samples beyond X = 0.2 concentration.

Hence, it is possible to control the grain growth and tailor the microstructure hence the T_c values, flux pinning properties of (B_i, 2223) superconductors by the appropriate choice of the W addition.

CONCLUSION

Investigation the superconducting properties and understanding the mechanism of the superconductivity by the addition of WO_3 additions but it is essential to control the amount of addition. Minor concentration of W on the Bi high phase lattice could useful. The $Bi_{1.6}Pb_{0.4}W_{0.2}Sr_2Ca_2Cu_3O_{10+}$. superconductor yields the highest T_c value of 120 K at the high Bi-2223 phase formation. The improvement is attributed to the shift in hole concentration of the system from the underdoped to the optimal doped state. Oxide additions did not display solid propensity for substitution straight in supercondoctor lattices.

It is worth noting that increasing the W concentrations decreasing T_c values but it's not prevent the creation of (Bi highphase. It increases the possibility of occupying the positions of W nanoparticles (interstitially or in substitutionel site).

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