Spectroscopic Study on Iron Oxide Based Bi-2223 Superconductors

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Abstract - The recent discovery of iron-based superconductors has evoked enthusiasm for extensive research on these materials because they form orthorhombic crystal structure of superconductor. It has also been verified Particle size, crystal size, cell parameter, type of crystal structure, vibration, bond length change and volume friction of Bi-2223 superconductor $Bi_2Sr_{4-x}Ca_xFe_{3-y}Cu_yO_z$.

Keywords: Iron oxide, crystal structure, volume friction.

I. INTRODUCTION

A quarter century has passed since the discovery of copper oxide high-temperature superconductors. Because of their unique physical properties such as the metal–insulator transition, the wave symmetry parameter, the unusual normal metal states and the weak links at grain boundaries [1]. The work concerning the preparation the superconducting properties and the structure of Bi-2223 system [2] . It is well known that the Bi- base system has layered structure. It has three different phases which are called Bi-(2201), Bi-(2212) and Bi-(2223) [3]. In the present work we have the general formula $Bi_2Sr_{4-x}Ca_xFe_{3-y}Cu_yO_z$ and x, y are variables in which CuO_2 layers is formed at different temperatures in superconducting phases. Iron oxide is in isostructural form in this general formula [4]. It is very difficult to prepare the Bi-(2223) phase at normal temperature, this phase is produced at the highest critical temperature among the family of the superconductors. The superconducting properties of these superconductors can be controlled by the addition or substitution of the elements with different ionic radius and different bonding characters. The enhancement or destructions of superconducting properties depends on the characteristic of the dopant in the crystal structure [5], But most of the research of efforts to improve to 2223 phase forming of the system were concentrated on the substituted studies [6]. However the measure limitations of the Bi-2223 superconductor applications are the intergrain weak links and weak flux pinning capability it is shown that one of the measure current limiting factors for Bi-2223 is the presence of residual secondary phases [7]. The resistivity drop in temperature measurements really characterizes the transition from a normal to superconducting state, but the magnetic manifestation of zero resistivity is a superconductor if it shows perfect diamagnetic. That is, its magnetic susceptibility (χ) in SI units is exactly -1[8]. But an AC susceptibility measurement can be used to determine critical temperature. We reported XRD measurements in order to calculate lattice parameters and the relative portions of bi-2223superconductor.

II. EXPERIMENTAL DETAILS

Samples of nominal compassion $Bi_2Sr_{4-x}Ca_xFe_{3-y}Cu_yO_z$ (x=0, y=0.2, 0.4, 0.6,0.8) were prepared by the solid state reaction method. The starting powders were corresponding stoichometric quantities 99.99% Bi_2O_3, $SrCO_3$, $CaCo_3$, Fe_2O_3, CuO the powders were weighted in necessary atomic ratios. Five samples were prepared. The samples were prepared by homogeneously mixing and grinding prescribed amounts of powders into planetary ball mill PM-100. The mixture grinding time is 6h initially with 400rpm by 25ml grinding jars and used 10mm grinding balls. In this processes the temperature of the sample arise about more than 800^0C. To study the effect of the iron oxide addition on the properties of BSCCO superconductor sample were characterized by X-ray diffraction (XRD) type BRUKER D8 ADVANCE. A computational program has been used to find the lattice parameter of the unit cell from the pattern of XRD by CuKα *(*1.5406 Å) radiation. The X-ray diffraction (XRD) pattern of samples with nominal composition $Bi_2Sr_{4-x}Ca_xFe_{3-y}Cu_yO_z$. XRD pattern was taken using fitting limit 10^0 to 90^0 measurements were taken at room temperature. Phase purity and the lattice parameters were obtained for these XRD parameters.

III. FIGURE AND TABLES

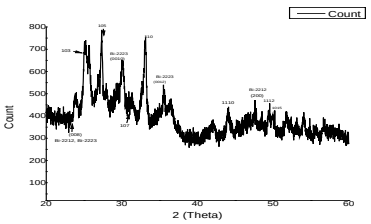

Fig. 1 Indexed X-ray pattern of $Bi_2Sr_4CaFe_{2.8}Cu_{.2}O_z$ Superconductor

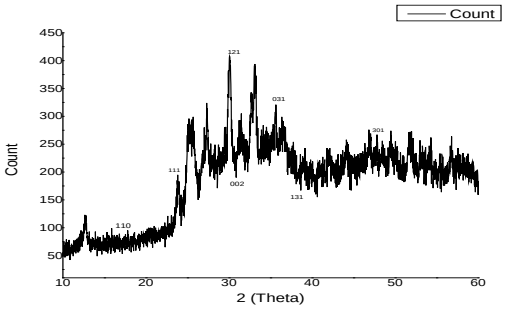

Fig.2 Indexed X-ray pattern of $Bi_2Sr_4CaFe_{2.6}Cu_{.4}O_z$ superconductor

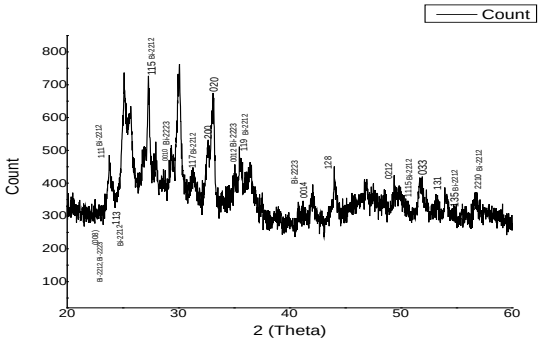

Fig. 3 Indexed X-ray pattern of $Bi_2Sr_4CaFe_{2.4}Cu_{.6}O_z$ superconductor

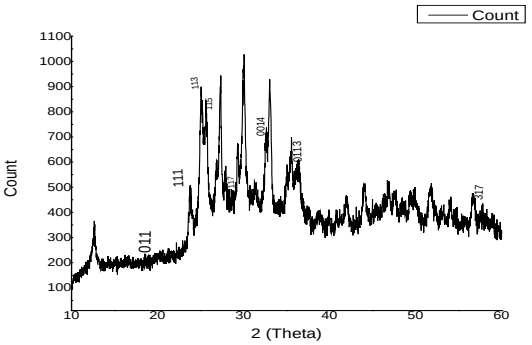

Fig. 4 Indexed X-ray pattern of $Bi_2Sr_4CaFe_{2.2}Cu_{.8}O_z$ superconductor

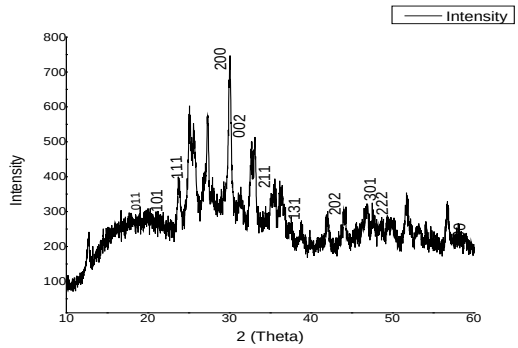

Fig. 5 Indexed X-ray pattern of $Bi_2Sr_4CaFe_2CuO_z$ superconductors

IV. EXPERIMENTAL RESULTS AND DISCUSSION

X-ray diffraction (XRD) pattern of the samples $Bi_2Sr_{4-x}Ca_xFe_{3-y}Cu_yO_z$ (x=0, y=0.2, 0.4, 0.6,0.8) Represented that samples consisted 2212and 2223 phases and contained small amount of CuO and Fe_2O_3 as show in figure 1-5. The experimental results of these XRD patterns is shown Table-1.

TABLE1. DATA OF XRD PATTERN

S. No.	Compound	Bi-2212 & Bi-2223		Miller Indices	Cell parameter
		$2\theta^0$	d(A)	(h,k,l)	A
1.	$Bi_2Sr_4CaFe_{2.8}Cu_{.2}O_z$	23.23	3.825	(008)	a=3.180
		29.16	3.060	(0010)	c=30.60
		35.16	2.550	(0012)	
		47.68	1.905	(200)	
2.	$Bi_2Sr_4CaFe_{2.6}Cu_{.4}O_z$	18.45	4.803	(011)	
		23.73	3.745	(111)	
		29.71	3.004	(200)	a=6.008
		30.47	2.930	(002)	b=8.376
		35.17	2.549	(211)	c=5.863
		48.52	1.874	(222)	
		63.41	1.465	(004)	
3.	$Bi_2Sr_4CaFe_{2.4}Cu_{.6}O_z$	23.15	3.837	(008)	
		24.82	3.583	(113)	
		27.47	3.244	(115)	
		29.13	3.062	(0010)	
		31.01	3.880	(117)	a=5.426
		35.11	2.553	(0012)	b=5.402
		35.21	2.546	(119)	c=30.64
		41.20	2.189	(0014)	
		50.60	1.802	(1115)	
		55.80	1.646	(135)	
		56.64	1.623	(2210)	
4.	$Bi_2Sr_4CaFe_{2.2}Cu_{.8}O_z$	12.45			
		16.45	4.80	(011)	
		23.50	3.74	(111)	
		24.32	-	(113)	
		25.31	-	(115)	a=5.114
		27.27	-	None	b=5.420
		28.75	-	(117)	c=37.29
		29.71	-	-	
		32.89	2.93	(0014)	
		35.80	2.52	(0113)	
		56.80	1.46	(317)	
5.	$Bi_2Sr_4CaFe_2CuO_z$	18.16	4.87	(110)	
		21.18	4.19	(101)	
		23.73	3.74	(111)	
		29.71	3.00	(200)	a=6.010
		30.47	2.93	(002)	b=8.380
		35.17	2.54	(211)	c=5.870
		43.11	2.09	(202)	

		48.52	1.87	(222)	
		61.68	1.50	(400)	
		66.04	1.41	(420)	

In sample-1 the radius ratio (R/R0) is 5.08 which is related to coordination number it is related to crystal stricture. So crystal structure is Tetragonal of superconductor Bi-2212 and 2223 but 2223 phases are dominated. Whose planes are (008), (0010), (0012). Its refinement (RWP) is 80.5 and space group I(0). The cell parameter a= 3.810A^0 and c= 30.600 A^0 which is approximately same and volume friction of Bi-2223 is 61.68 its crystal size is 12.68 nanometre. Therefore particles is also nano size in this system. This superconductor is in single phase because all single lines may be indexed and un indexed lines can be observed the diffraction lines observed at 2theta = 23.23, 29.16, 35.16 and 47.8 degree are attributable to the Bi-2223 phase [9]. Thus ball mill and annealing method revels same results of 2223 system. The peak displacement is 0.13mm. in this pattern some peaks are more intense and some are weak intense in Bi-2223 superconductor with Fe_2O_3.Because volume friction of Bi-2223 is more than Bi-2212. There is no peak observed of iron oxide in XRD pattern-1 at room temperature.

In sample-2 the coordination number of this structure is related to radius ratio 4.96. This revels that the structure of Bi-2223 is Orthorhombic. Its refinement (RWP) is 84.5 and space group I(0). The cell parameter a= 6.008A^0, b=8.376 and c= 5.863A^0 and crystal size is 37.32 nanometre and volume friction 36.56 but nano size particle is more effective then the micro size particle. Therefore, this superconductor is in single phase because all single lines may be indexed and un indexed lines can be observed the diffraction lines observed at 2theta =18.45, 23.73, 29.71, 30.47, 35.17, 48.52 and 63.41 degree are attributable to the Bi-2223 phase. The successive distance between crystal planes is varied from 4.803 A^0 to 1.465 A^0.

In sample -3, crystal structure of this sample is Base cantered Orthorhombic because radius ratio is 5.08. This ratio is associated with coordination number. The dimension of cell parameter are a=5.426 A^0, b=5.402 A^0, c=30.643 A^0. Volume of this cell is 898.18 and crystal size 14.14 nanometre. Volume friction of Bi-2223 is 46.38. The results obtained in this study were good agreement with the theoretical results of Bi-2223 system. We observed that the lattice parameters of the samples with iron oxides did not change significantly from the theoretical values. The primarily reported of all three samples has been published [10].

In sample-4, The delta displacement is 0.015mm and the cell parameter of crystal structure a=5.4110A^0, b=5.420A^0, c=37.290A^0 and volume of this cell 295.09. These parameter is represent that the structure of sample is orthorhombic. Miller indices of Bi-2223 structure is(113), (115),(117),(0014), refinement (RWP) is 91.6 and the radius ratio (R/R0) is 7.72. Bi-2223 structure is related to single phase at room temperature. The superconducting properties of this structure can be controlled by the addition and substitution of the elements with different ionic radius and different bonding characteristics. This is verified FTIR analysis as reported earlier paper [10].

In sample-5, the radius ratio of this sample is 4.96, cell parameters a=6.0108 A^0, b=8.380 A^0, c=5.870 A^0 and volume 295.09cd. These parameters describes the structure of the sample is Orthorhombic. This Bi based system has layered structure by their compositions. It has two different phases which are called Bi-2212 and Bi-2223 [11]. Volume friction of this sample 61.96. The successive distance between crystal planes is varied from 4.87 A^0, to 1.41 A^0. There is no iron oxide peak at room temperature. This is confirmed by Mossbauer spectroscopy.

V. CONCLUSION

The composition of $Bi_2Sr_{4-x}Ca_xFe_{3-y}Cu_yO_z$ were prepared by solid state reaction method and grinding by ball mill. The systematic observation of the influence iron oxide mixing on the phase formation and superconducting state properties of $Bi_2Sr_{4-x}Ca_xFe_{3-y}Cu_yO_z$ for different concentration revels that Bi-2223 superconductor structure. The results of these samples is identical to reported sample of Bi2223 structure. The room temperature X-Ray diffraction represented the formation of large amount of Bi-2223 phase is larger than Bi-2212 phase. The volume friction was calculated from the x-ray intensities of Bi-2223 and Bi-2212 phases. None of sample are not represent of iron oxide in XRD pattern at room temperature. Bond length of crystal structure is slightly change due to doping of iron oxide.

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