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The Influence of Partial Substation of Antimony & Lanthanum Oxides on Electrical and Structural Properties for the Superconductor Compound $Bi_{2-x}Sb_xBa_2Ca_{2-y}La_yCu_3O_{10+\delta}$

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Abstract. In this research the $Bi_{2-x}Sb_xBa_2Ca_{2-y}La_yCu_3O_{10+\delta}$compound was prepared and studied the influence of partial substation of Sb_2O_3 and La_2O_3 on the electrical and structural properties Samples synthesis by solid state reaction method .The examination of XRD diffraction shown that all samples have bulk polycrystalline with orthorhombic structure. The results shows that the increasing of the c-axis lattice constant for the samples substation with Sb_2O_3 and La_2O_3 as compared with those have no content, It was found that changing in lattice parameters (a,b), ratio c/a ,mass density and volume fraction Vphases with increases of (Sb_2O_3,La_2O_3) concentration. All samples have highest phase 2223 major relative to the other phases. The electrical properties tested by using four probes technique to calculation critical temperatures, it was found the sample $Bi_{1.6}Sb_{0.4}Ba_2Ca_{1.8}La_{0.2}Cu_3O_{10+\delta}$ has a highest critical temperatures Tc=122.5K.

Keywords: critical temperatures, superconductor, X-ray diffraction, structural properties, electrical properties

INTRODUCTION

Superconductivity, is described as a phase of transition of electrons, in which the conductor loss all electric current resistance under particular circumstances and shows diamagnetism of complete.

Superconductivity is the phenomenon of complete lack of electrical resistance in specific materials when they cooled below appointed temperature called transition temperature or critical (Tc) which differs from material to material another [1-3]. Superconductors of copper oxide are the extreme important high critical temperature superconductors. The finding of a room temperature (300 K) superconductor must activate a rampage of large technological. There are claims of a superconductor making at (300 K) (for example, see, www.superconductors.org, 2011). But these claims are unaccepted by the community of scientific. Generally, it is accepted in the literature of scientific that the highest critical temperature is nearly up to 135 K at (760 mmHg) in the Hg-Ba-Ca-Cu-O system (Cantoni & Schilling, 1993). Though, critical temperature in this system can be increased to 180 K by external pressures of high.

We trust that the room temperature superconductor (300 K) discovery would be likely only when the microscopic mechanisms of oxide superconductors clarified [4].

Yet, up to date, the responsible of microscopic mechanisms for high critical temperature superconductivity are vague. In a modern article (Luiz, 2010), we have explain a simple manner to microscopic mechanisms of study in high critical temperature superconductors. It is well recognized that the superconducting state is described by a quantum macroscopic state that get up from a condensation of Bose-Einstein of paired electrons (pairs of Cooper)[4].

The discovery of high-TC superconductors of oxide like Bi (Pb)-Sr-Ca- Cu-O (BSCCO) and Y-Ba-Cu-O (YBCO) systems of ceramic was the starting point of a new rampage in chemistry and physics and in technology activities of high. Generally most ceramic high critical temperature superconductors are formed by sintering given mixes of raw constituents. Yet, it is tricky to get ceramics complex forms with durability of mechanically high by the sintering. A poorly sintered materials with low density was produced by the traditional solid state reaction (SSR) method of preparing BSCCO system.

Bi-based is family of cuprate superconductor symbolize by the generic formula $Bi_2Sr_2Ca_{n-1}Cu_nO_{2n+4}$ (n equal 1, 2, 3) (called Bi-2201, Bi-2212, and Bi-2223, correspondingly). The last two members are well-known to have remarkable properties for the essential research and uses in technology and industries [10-15].

EXPERIMENTAL WORK

The Bi2-xSbx〚Ba〛_2 〚Ca〛_(2-y) 〚〚La〛_y Cu〛_3 O_(10+δ) with (x=0.1,0.2,0.3,0.4,0.5 and y=0.1,0.15,0.2,0.25) compounds were these samples synthesized by execution of (SSR)method, the amounts powders required of pure oxides .the utilized oxides high purity is nearly pure (99.99%) of Bi_2O_3,Sb_2O_3,La_2O_3 BaO,CaO and CuO.

The reactants were estimated by using a balance of sensitive, with sensitivity order (10-4) g. The reactants were mixed together by a gate mortar with isopropanol ($C_2H_3O_5$) addition to be homogenize. To get rid of the water vapor the powders dried for 1.5h under 150 ° C, , and Then grind and mixed by a 6h electric mixer of spiral for optimal homogenization and for precise powders. The resulting powder then compressed utilizing a piston of hydraulic for 2 minutes under pressure of 0.7G Pascal, in the shape of discs with a 0.75 cm radius and a 0.3-0.35 cm thickness. the samples sintering at 760°C for (160h) with average of (5°C per minute) to get a material of bonding and to guarantee optimum gradual diffusion between the atoms . Thereafter the samples were cooled at 5°C per minute (same heating rate) to room temperature. To obtain the structural properties of the samples. The samples were examined within the range of the diffraction angle (10-80). The constants (a, b, c) were calculated mathematically utilizing d-values and (Miller indices) reflections of the observed XRD pattern during the program of software In addition, the cell unit density was measured, and the phases formed percentages in the samples [16-17]. The fraction of volume of the phase calculation based on the formula of following [17].

$$\boldsymbol{Vph} = \frac{\sum \boldsymbol{I}^{o}}{\sum \boldsymbol{I}^{o} + \sum \boldsymbol{I1} + \sum \boldsymbol{I2}} *100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

P is the hole-carrier concentrations per Cu ion, It is calculated by means of the following relation [18]:

$$\boldsymbol{P = 0.16 - \left[\left(1 - \frac{T_c}{T_{c(max)}}\right)/82.6\right]^{1/2}} \quad \ldots\ldots\ldots\ldots\ldots (\mathbf{2})$$

RESULT AND DISCUSSION:

Structural properties

The XRD diffraction of pure and other samples replacement of Sb_2O_3, La_2O_3 were investigated at 2Ө =(10°- 80°), the results that shown in figure (1) were all polycrystalline with orthorhombic structure system and corresponded to the Bi-2223 phase. The x-ray diffraction patterns prove some impurities presence in very small concentration. fig (1) shows that there are two main phases in every specimens including the high critical temperature phase (2223) which is the dominant, the low critical temperature phase (2212) and impurities in little amount. The substitution of Bi by Sb_2O_3 and Ca by La_2O_3 causes shifting in diffraction angle 2Ө very small to ward increment angle and change in the magnitude of intensities of peaks. The lattice parameters calculated show in table (1) noticed that the increase of substitution concentration causes increasing in value of c-axis due to variation in ionic radius. The parameters of lattice based on method of Cohen's least square, calculation by software program [17].

Table .1. Values of lattice parameter a,b,c, c/a, ρ_M,V,V_{phase} of $Bi_{2-x}Sb_xBa_2Ca_{2-y}La_yCu_3O_{10+\delta}$ compound (x=0.1,0.2,0.3,0.4,0.5 y=0.1,0.15,0.2,0.25)

X	Y	a (A°)	b (A°)	c(A°)	c/a ratio
0	0	5.434	5.433	36.789	6.770151
0.1	0	5.4221	5.4227	36.899	6.805297
0.2	0.1	5.4201	5.4216	37.121	6.848767
0.3	0.15	5.4189	5.4198	37.266	6.877041
0.4	0.2	5.4178	5.4165	37.544	6.92975
0.5	0.25	5.411	5.4034	37.622	6.952874
v(A°)³	**dm(g/cm³)**	**V ph(1223)%**	**V ph(1212)%**	**V ph(1201)%**	**Vp impurities%**
1086.119	442.7493	74.102	8.826	7.953	9.117
1084.92	436.2161	71.2753	14.3902	5.7435	5.0503
1090.823	751.1744	74.2033	10.0957	9.6064	6.0944
1094.478	904.1952	76.395	13.003	5.865	4.734
1101.748	1052.24	81.737	12.7922	8.3812	5.1461
1099.984	1203.147	78.421	7.631	8.421	5.526

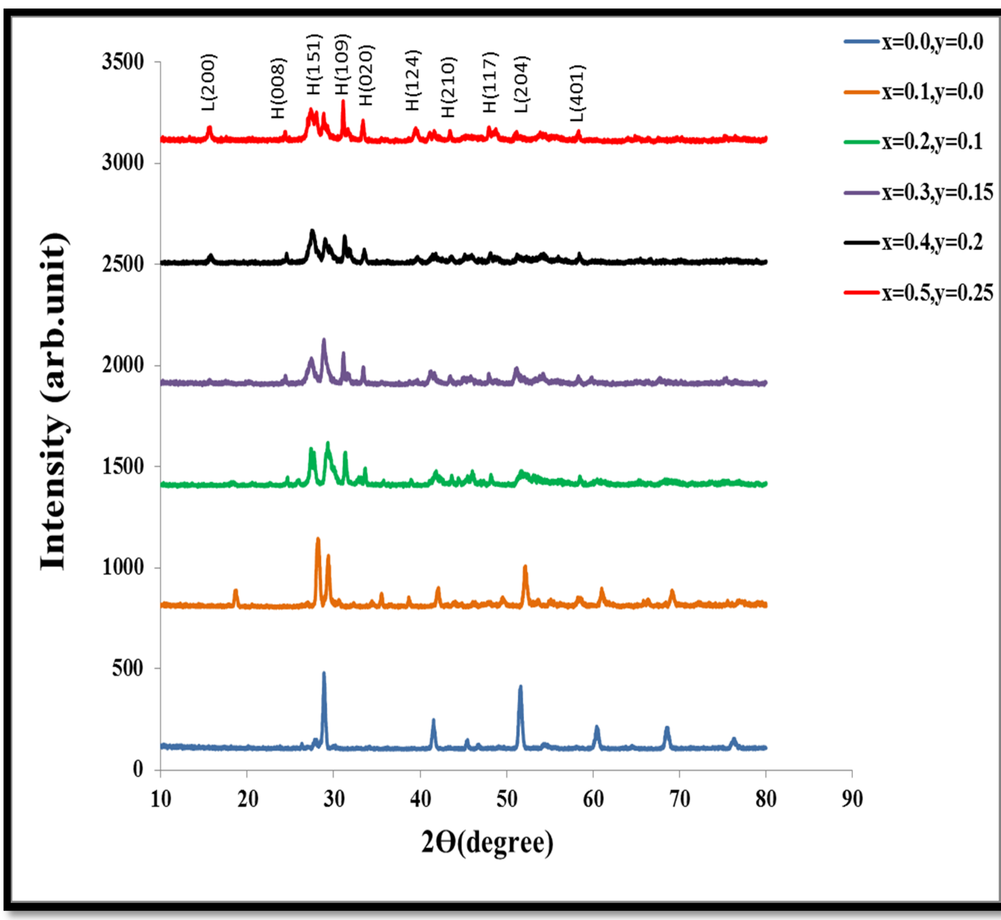

Figure.1. X-ray Diffraction pattern of $Bi_{2-x}Sb_xBa_2Ca_{2-y}La_yCu_3O_{10+\delta}$ compound (x=0.1, 0.2, 0.3, 0.4, 0.5 y=0.1, 0.15, 0.2, 0.25)

In the proportional intensities comparison of samples X-ray Diffraction patterns utilizing Sb_2O_3 = 0.0,0.1,0,2,0.3,0.4,0.5 and y=00,0.05,0.1, 0.15,0.2,0.25.

Figure.1 shows that every have reflective intensity of high phase (H-peaks) reflections and low phase (L-peaks) reflections and lower critical temperature reduced by Sb. The high-critical temperature phase reflections of the free specimen Sb, La = 0 have a decrease intensity than those containing Sb, La. The lattice parameters (a, b, c), density of mass (ρM) and fraction of volume (Vphase) revealed in Table (1), It was clear that the increasing of the Sb,La concentrations of every our specimens yield variations on the lattice parameter values, c/a, ρM and volume of unit cell.

Electrical properties

We examined the electrical properties for the samples by the four probe technique. Difference the temperature with the resistance as synthesized $Bi_{2-x}Sb_x$ $Ba_2Ca_{2-y}La_yCu_3O_{10+\delta}$ (with y=0.0,0.05,0.1,0.15,0.2,0.25 and x=0.0,0.1,0.2,0.3,0.4,0.5). Resistance of natural to every mineral specimens like metal behavior with regard to temperature. Fig. (2) Demonstrate a measured pattern of temperature versus resistivity (T-ρ) with altered concentrations.

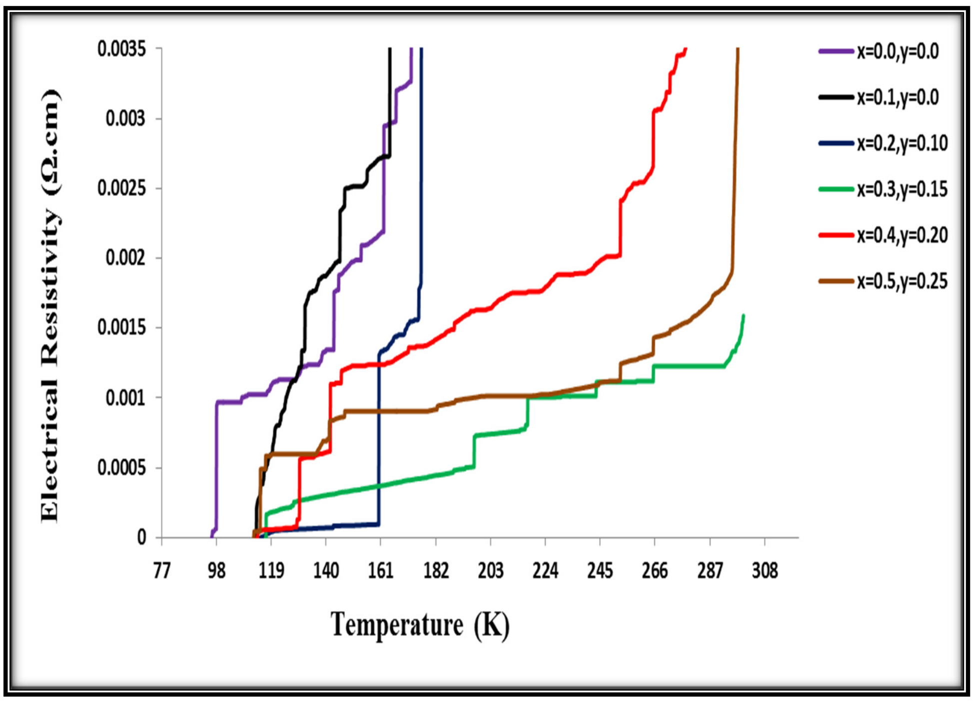

Figure.2. The resistivity as function of temperature of $Bi_{2-x}Sb_xBa_2Ca_{2-y}La_yCu_3O_{10+\delta}$ compound (x=0.1, 0.2, 0.3, 0.4, 0.5 y=0.1, 0.15, 0.2, 0.25)

transition temperature values (T_c) for $Bi_2Ba_2Ca_2Cu_3O_{10+\delta}$, $Bi_{1.9}Sb_{0.1}Ba_2Ca_2Cu_3O_{10+\delta}$, $Bi_{1.8}Sb_{0.2}Ba_2Ca_{1.9}La_{0.1}Cu_3O_{10+\delta}$, $Bi_{1.7}Sb_{0.3}Ba_2Ca_{1.85}La_{0.15}Cu_3O_{10+\delta}$, $Bi_{1.6}Sb_{0.4}Ba_2Ca_{1.85}La_{0.2}Cu_3O_{10+\delta}$ phases are 101.6 K, 113 K, 118 K, 119.5 and 122.2 K respectively we can observed growth in degree of critical temperature values (T_c), then be go down in concentration of x=0.5,y=0.25 $Bi_{1.5}Sb_{0.5}Ba_2Ca_{1.8}La_{0.25}Cu_3O_{10+\delta}$ equal to 117.5K .Can be listed of categorically that specimens under this labor are "a good quality", where the optimal extreme value of transition temperature is found to be concentration $Bi_{1.6}Sb_{0.4}Ba_2Ca_{1.85}La_{0.2}Cu_3O_{10+\delta}$ resemble to the doped hole optimal level shows in table (2)

Table.2. Transition temperature $T_{c(onset)}$, ($T_{c(offset)}$, and Hole concentration of $Bi_{2-x}Sb_xBa_2Ca_{2-y}La_yCu_3O_{10+\delta}$ compound (x=0.1,0.2,0.3,0.4,0.5 y=0.1,0.15,0.2,0.25)

X	Y	$T_{c(ON)}$ K	$T_{c(OFF)}$ K	T_c K	P (Hole) concentration
0	0	105.2	98	101.6	0.114552
0.1	0	122	104	113	0.129359
0.2	0.1	126	110	118	0.138911
0.3	0.15	127	112	119.5	0.142781
0.4	0.2	127.5	117	122.5	0.154555
0.5	0.25	120	115	117.5	0.137771

The AFM images show a uniform granular surface morphology. The surface morphology of compound was illustrated in the figure (3). It can be seen that the morphology of surface results appeared that the surface roughness increased, the increases could be possibly due to the increasing of La_2O_3,Sb_2O_3 concentration and time of sintering.

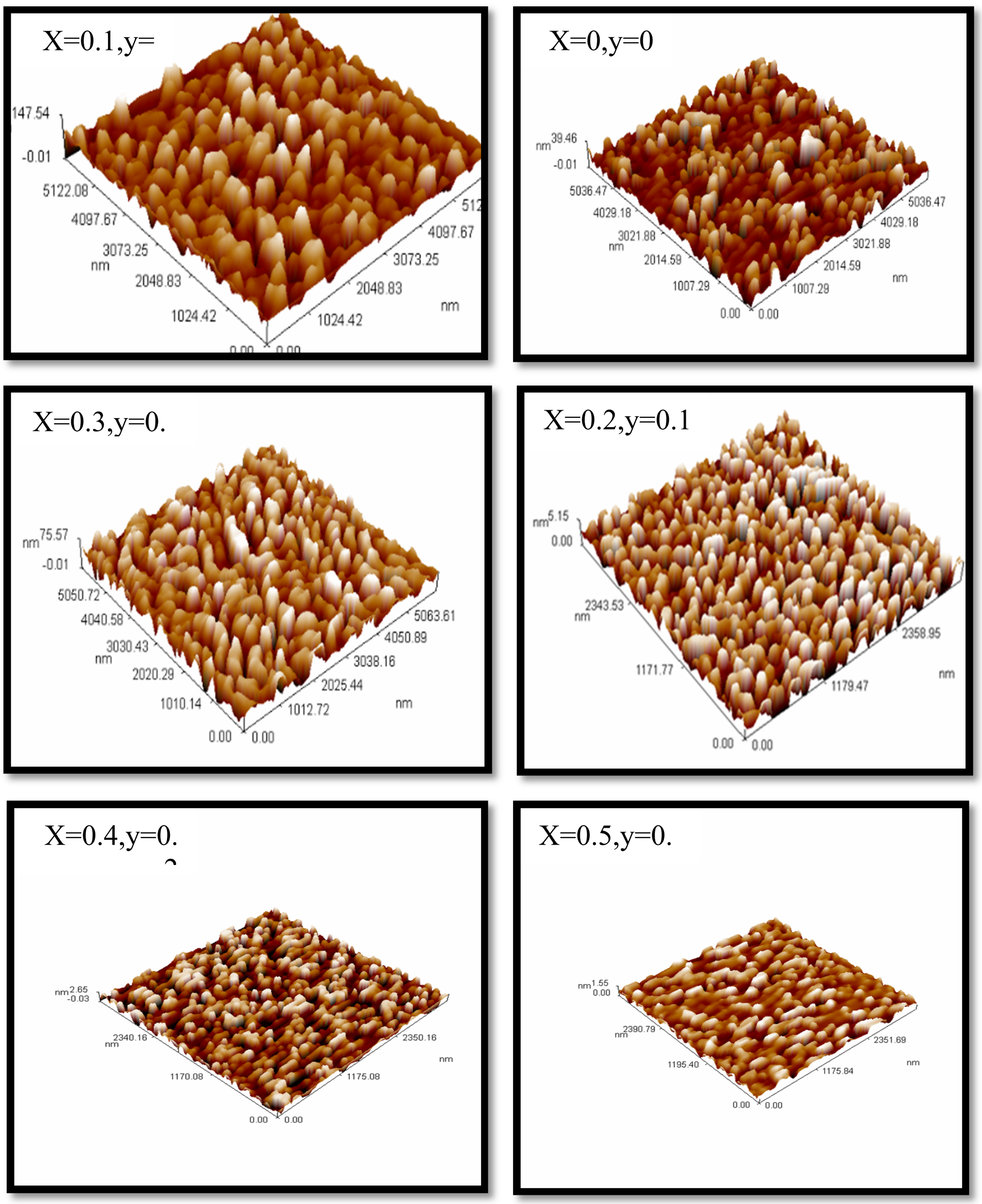

Figure 3. Reveals the (3-D) AFM images f surface morphology of $Bi_{2-x}Sb_xBa_2Ca_{2-y}La_yCu_3O_{10+\delta}$ compound (x=0.1, 0.2, 0.3, 0.4, 0.5 y=0.1, 0.15, 0.2, 0.25)

CONCLUSION

In our work prepared compound superconductor $\mathbf{Bi_{2-x}Sb_xBa_2Ca_{2-y}La_yCu_3O_{10+\delta}}$ where x=0.1, 0.2, 0.3, 0.4, 0.5 and y=0.1, 0.15, 0.2, 0.25 using solid state reaction method and structural electrical properties examination. The results of XRD diffraction test appeared that the compound had polycrystalline with a orthorhombic structure .The transition temperature (T_c) of the grown samples up to x=0.4,y=0.2 have been have observe that maximum T_c 122.2K, In all samples The critical temperature were sensitive to the Sb, La concentrations. Transition temperature and volume fraction (V_{phase}) increment and holes concentration with increase (Sb,La)concentration

REFERENCES:

1. Khalid. R.; E. Abdul-Majeed; Abdul Kareem. A. "Effect of Partial Substitution of Hg.sr on Structure and Electrical of High Temperature Bi2-xHgxBa2 ySryCa2Cu3O10+δ Super conductor" Tikrit journal of pure science.(2012), 17, 1, 198-203.
2. John, B.; Fredrich, M. The development of SQUID- based gradiometere. MSC thesis. Stellenbosch University. (2010).
3. Laheeb A. Mohammed, Kareem A. Jasim," Synthesis and Study the Structural and Electrical and Mechanical Properties of High Temperature Superconductor Tl0.5Pb0.5Ba2Can-1CunxNixO2n+3-δ Substituted with Nickel Oxide for n=3", Ibn Al-Haitham Jour. for Pure & Appl. Sci. 31 (3)(2018).
4. - Adir Moysés Luiz "superconductivity – theory and applications", (2011).
5. Hong B., J. Hahn, T.O. Mason"Phase Composition and Compatibilities in the Bi-Sr-Ca-Cu Quaternary Oxide System at 800°C in Air", Journal of the American Ceramic Society 73 (1990) 1965.
6. Michel C., M. Hervieu, M.M. Borei, A. Grandin, F. Dasiandes, J. Provost, B. Raveau, Zeitschrift für Physik"BSCCO superconductors processed by the glass-ceramic route Critical aspects of process, Crystallization and incorporation of oxygen, Composition dependence on phase formation", B 68 (1987) 421.
7. Maeda H., Y. Tanaka, M. Fukotomi, T. Asano, K. Togano, H. Kumakura, M. Uehara, S. Ikeda, K. Ogawa, S. Horiuchi, Y. Matsui, "New high-Tc superconductors without rare earth element" Physica C 153-155 (1988) 602.
8. Majewski P., S. Kaesche, F. Aldinger, "Phase diagram studies in the system Ag-"Bi2Sr2CaCu2O8", Journal of the American Ceramic Society 80 (1997) 1174.
9. Majewski P., "Materials Aspects of the High-temperature Superconductors in the System Bi2O3–SrO–CaO–CuO", Journal of Materials Research 15 (2000) 854.
10. Yildirim G., E. Yücel, S. Bal, M. Dogruer, A. Varilci, M. Akdoğan, C. Terzioğlu, Y. Zalaoğlu, "The Influence of Postannealing on Structural and Superconducting Properties of Bi-2212 Ceramics", J. Supercond. Nov. Magn. doi 10.1007/s10948-011-1284-4 (2011).
11. Okada M., "High Temperature Superconductivity 1", Supercond. Sci. Technol. 13, 29 (2000)
12. Runde M., "Application of high-T/sub c/ superconductors in aluminum electrolysis plants", IEEE Trans. Appl. Supercond. 5, 813 (1995)
13. Godeke A., D. Cheng, D.R. Dietderich, C.D. English, H. Felice, C.R. Hannaford, S.O. Prestemon, G. Sabbi, R.M. Scanlan, Y. Hikichi, J. Nishioka, T. Hasegawa, "Development of Wind-and-React Bi-2212 Accelerator Magnet Technology ",IEEE Trans. Appl. Supercond. 18, 516 (2008)
14. Miao H., M. Meinesz, B. Czabai, J. Parrell, S. Hong, "Microstructure and Jc improvements in multifilamentary Bi-2212/Ag wires for high field magnet applications", AIP Conference Proceedings, 986, 423 (2008)
15. Biju A., R.P. Aloysius, U. Syamaprasad, "Enhanced Critical Current Density in Gd-Added (Bi, Pb)-2212 Bulk Superconductor", Supercond. Sci. Technol. 18, 1454(2005).
16. K A Jasim and L A Mohammed," The partial substitution of copper with nickel oxide on the Structural and electrical properties of HgBa2 Ca2 Cu3xNix O8+δ superconducting compound", Journal of Physics: Conference Series, 1003, (2018).
17. Laheeb A. Mohammed, Kareem A. Jasim," Improvement the Superconducting properties of TlBa2 Ca2 Cu3xNixO9-δ superconducting compound by partial substitution of copper with nickel oxide on the
18. Azzouz B.F., A. Mchirgui, B. Yangui, C. Boulesteix, B.M. Salem, "Synthesis, microstructural evolution and the role of substantial addition of PbO during the final processing of (Bi, Pb)-2223 superconductors", Physica C: Superconductivity, 356, 83 (2001).