Microstructural Studies of Eu Doped High T_c Superconducting $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ System for SEM & Elastic Moduli

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ABSTRACT

We have investigated the high T_c superconducting microstructural properties of $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ system with x= 0.02, 0.04, 0.08 and 0.1 by scanning electron microscopy at room temperature and elastic moduli measurement with porosity and density. The substitution of Eu for Ca has been found to drastically change the superconducting properties of the system. The Scanning electron microscope of Eu doped compound shows change in grain size and grain boundaries .The average grain size is found to be decreased with increase in concentration of Eu dopant. Increase in the grain boundaries takes place as concentration increases. The porosity of the sample also increases ranging from 25 to 35 %. The present investigation shows that in pure sample the grains are 4.1 - 6.7 μm and widely distributed shape. As dopant concentration increases the grain size found to be decreased for higher concentration of Eu in $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ compounds and SEM shows the mixed phase nature.

In Elastic moduli Young's modulus (E) and Rigidity modulus (η) are found to be decreased as concentration of Eu increased. The porosity of material increases with concentration of Eu. The experimental data obtained in the present investigation may be interpreted in terms of binding forces between the atoms. Elastic moduli decrease continuously with increase in Eu concentration in Bi_{2223} compounds which concluded that the binding force between the various ions of the sample is decreases continuously. i.e. mechanical strength decreases continuously which is in agreement with increasing porosity.

Key words: Superconductivity, $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ system, SEM, Porosity and Elastic moduli.

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INTRODUCTION

In the Bi-based system three phases are observed with the general formula $Bi_2Sr_2Ca_{n-1}Cu_nO_y$ where n = 1 (2212), n = 2 (2212), n = 3 (2223), with corresponding superconducting temperature of 10K, 85k and 110K respectively. These phases were isolated by Chu et al in 1988 [1-2], but n = 3 phase is very difficult to prepare in pure form as it undergoes a change to the 2212 (85K) phase. Partial substitution of Pb for Bi has been found to help the growth of the 2223 phase [3-5]. In many high T_c superconducting families of compounds, the rare-earth plays an important role in establishing the proper structure. The substitution Ca^{2+} (divalent) by trivalent rare-earth elements in $Bi_2Sr_2Ca_1Cu_2O_{4+\delta}$ (2212) causes a drastic changes in carrier concentration and results in transition from superconductor to an insulator [6-10]. Many reasons have been suggested for decrease in the carrier concentration such as structural modulations or change in oxygen stoichiometry or change in Cu valency or both [11-13]. The magnetic interaction of the rare-earth ions with electrons/holes responsible for superconductivity is generally found to be very weak in this system so that superconductivity is not affected by presence of rare-earth ions with otherwise acts as pair breaking in many systems [14-16].

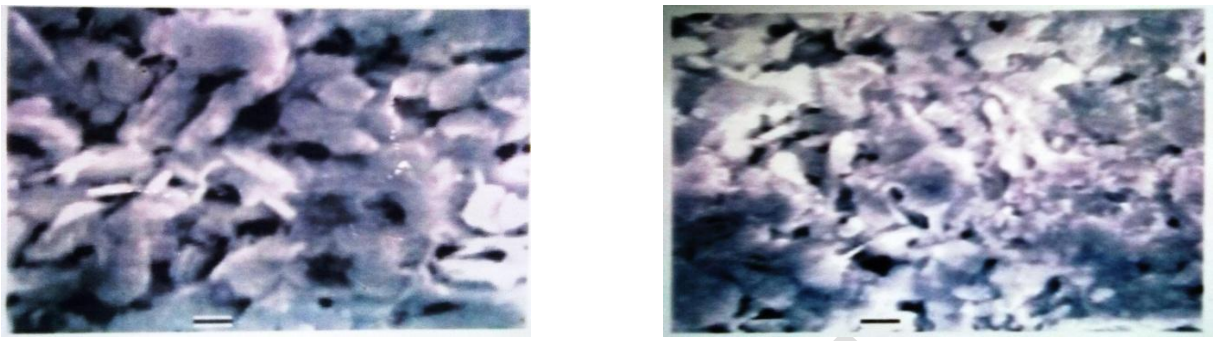
The transition temperature of the system decreases with Eu substitution, when percentage of the dopant is increased. We have substituted Eu with very small concentration (0.00 to 0.1) in the lead-doped Bi-2223 system. The scanning Electron Microscopy (SEM) and Elastic Moduli studies have been done as a function of Eu substitution and discussed here. $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ system with x = 0.02, 0.04, 0.08 and 0.1 high T_c superconducting compounds at room temperature using the elastic moduli as Young's modulus, Rigidity modulus and Porosity of the samples.

EXPERIMENTAL

The samples of the system $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ with concentration x = 0.00, 0.02, 0.04, 0.08 and 0.1 were prepared by conventional solid state reaction route. Stoichiometric proportions of starting materials Bi_2O_3, PbO, $SrCO_3$, Eu_2O_3 and CuO were taken. Then the powders were mixed and ground for 3 hours in agate and mortar pestle and precalcined at 800^0C for 24 hour. The calcined powders were ground and recalcinied again at 810^0C for 36 hours. The mixer was grounded again and pressed into pellets. The samples were sintered at 240 hours (10 days) and annealed by furnace cooling to room temperature. The samples were examined by Scanning Electron Microscopy using JEOL840 Scanning Electron Microscope at TIFR Mumbai to determine grain size and grain boundaries. The Elastic moduli Young's Modulus (E) and Rigidity Modulus (η) measurement of the samples were performed and interpreted in terms of binding forces between the forces.

Eu Conc=0.00
Average Grain size=6.67μm

Eu Conc=0.02
Average Grain size=6.26μm



Eu Conc=0.04
Average Grain size=5.68μm

Eu Conc=0.08
Average Grain size=4.93μm

Fig1: SEM images of Eu doped $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ system with concentration x = 0.00, 0.02, 0.04 and 0.08

RESULT AND DISCUSSION

The scanning Electron Microscopy (SEM) studies on the Eu substitution at Ca site in $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ system with x = 0.02, 0.04, 0.08 and 0.1 high T_c superconducting compounds shows that change in grain size and grain boundaries. The average grain size of Eu dopent concentration is found to be decreased with increase in concentration. The present investigation shows that in pure sample the grains are 4.1-6.7 μm and widely distributed shape shown in Fig.1. The SEM shows mixed phase nature. The elastic moduli as Young's modulus, Rigidity modulus and Porosity of the samples at room temperature, Table (1&2) shows the concentration of Eu increased the bulk density decreases where as porosity increases shown in Fig.2.. These results are matching with SEM results.

Eu concentration X	Bulk density (ρ) 10^3 Kg/m^3	Porosity (C) %
0.00	4.536	27.3
0.02	4.407	29.8
0.04	4.350	31.0
0.08	4.230	33.2
0.1	4.188	34.1

Table1: Bulk density and porosity of Bi_{2223}/Eu compounds.

Eu. Conc. *x*	V_l (m/s)	V_s (m/s)	ρ_m 10^3 Kg/m^3	η GPa	E GPa	σ
0.00	2785.4	1256.8	6.26	7.1	19.48	0.37
0.02	2727.5	1211.7	6.27	6.5	17.90	0.38
0.04	2667.3	1158.3	6.28	5.8	16.04	0.38
0.08	2614.4	1104.6	6.30	5.2	14.47	0.39
0.1	2571.4	1059.4	6.31	4.7	13.14	0.40

Table2: Elastic moduli of Bi_{2223}/Eu samples at room temperature.

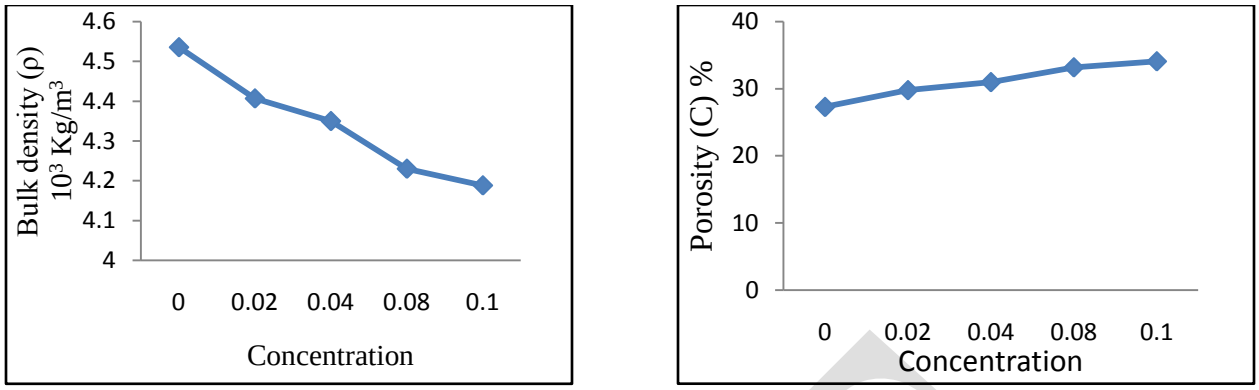


Fig2: Porosity and Bulk density of Eu doped $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ system with concentration

CONCLUSION

An analogous study was performed on an Eu-substituted $Bi_{1.7}Pb_{0.3}Sr_2Ca_{2-x}Eu_xCu_3O_{10+\delta}$ system for (x = 0.00, 0.02, 0.04, 0.08 and 0.1). We observed that the concentration of Eu increased, the bulk density decreases where as porosity increases. SEM gives average grain size decreases with concentration of Eu, also SEM show mixed phase nature. Elastic moduli decrease continuously with increase in Eu concentration in Bi_{2223} compounds which concluded that the binding force between the various ions of the sample is decreases continuously. i.e. Mechanical strength decreases continuously which is in agreement with increasing porosity.

REFERENCE

[1] C.W. Chu, J. Bechtod , L. Gao, P.H. Hor, Z.J. Hung, R.L. Meng, Y.Y.Sun, Y.Q. Wang and Y.Y. Xue, Phys. Rev. Lett. 60, 94 (1988)
[2] R.R. Kothawale, B.N. Dole, S.S. Shah, Pramana J.Physics, 58 (5&6). 871 (2002)
[3] S.A. Sunshine, T. Siegrist, L.F. Schneemeyer, D.W. Murphy, R.J. Cava et al, Phys. Rev. B38, 893 (1988).
[4] M. Murlidhar, D.M. Rao and V. Hari Babu, Mater. Chem. Phys. 27. 297 (1991).
[5] K. Nanda Kishor, M. Murlidharn & Hari Babu .Mater. Sci. Engg. B14,401 (1992).
[6] P.V.S.Awana, S.K.Agrawal, R.Ray, S.Gupta & A.V. Narlikar, Physica C 191, 211 (1989).
[7] J.M. Tarascon, P. Barboux, G.W. Hull, R. Ramesh et al Phys. Rev.. B39, 4316 (1989)
[8] H.J. Borneman, D.E. Morris, H.B. Liu and P.K. Narwankar, Physica C 191, 211 (1989).
[9] B. Chevalier, B. Lepine, A. LeLirzin, J. Darriet, J. Etourneau and J.M. Tarascon, Mater. Sci. Engg. B2, 277 (1989).
[10] N. Fukushima, H.Niu, S.I. Nakamura, S. Takeno, M. Hayashi and K. Ando, Physica C, 59, 777 (1989)
[11] H. Jin, N.L. Wang, Y. chong, M. Dong, L.Z. Cao and Z.J.Chao, J. Crystal Growth 149, 269 (1995)
[12] R.R. Kothawale, R.M. Mohite, S.S. Shah etc. I. J. Adv. Sci. Rea. Tech., 2,3, 79 (2012)
[13] E.Laxmi Narsaia, U.V.Suba Rao, O.Penna & A.Perrin, Solid state Commun.83,689 (1992)
[14] P.V.S.Awana, Latika Menon & S.K.Malik, Phys. Rev. B53, 2245 (1992).
[15] Isvael Felner and Israel Nowik, Supcond. Sci. and Technol.,8, 121 (1995).
[16] R.M. Mohite, IJETSE, vol5, no1, 6, (2011).