The Comparative Study Characterization between Y123 and Y13-20-33 Superconductors by Melt Process

Sutee Chantrapakajee
Department of Food science and Technology, Faculty of Home Economics Technology, Rajamangala University of Technology Phra Nakhon,Bangkok 10300, Thailand
E-mail: sutee.c@rmutp.ac.th

Piyamas Chainok
Department of science and Mathematics, Faculty of Science and Technology, Pathumwan Institute of Technology, Bangkok 10330, Thailand
E-mail: bpiyamas@hotmail.com

Supphadate Sujinnapram
Department of Physics, Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom 73140,Thailand

Thanarat Khuntak
Prasarnmit Physics Research Unit, Department of Physics, Faculty of Science, Srinakharinwirot University, Bangkok 10110, Thailand

Tunyanop Nilkamjon, Sermsuk Ratreng and **P. Udomsamuthirun**
Thailand Center of Excellence in Physics (ThEP), Si Ayutthaya Road, Bangkok 10400, Thailand
Udomsamut55@yahoo.com

Manuscript received February 3, 2016
Revised March 4, 2016

ABSTRACT

In this research, we studied the preparation and the physical properties of Y13-20-33 superconductor and Y123 superconductor synthesized by melt process and comparative studied characterization between Y123 and Y13-20-33. We found the critical temperature onset of Y13-20-33 and Y123 were 90 K and 94 K, respectively. The morphology of Y123 superconductor has flat surface and more clear grain boundary than Y13-20-33. The textures of Y13-20-33 superconductor showed more melted of grain boundary than that of Y123. The orthorhombic structure was found in both superconductors but c/a ratio of Y13-20-33 was higher than of Y123.

Keywords: *Y-Ba-Cu-O Superconductor, melt process, critical temperature*

1. INTRODUCTION

Superconductors was found by Kamerlingh Onnes [1] made of liquid helium since 1908. Properties of superconductor material are superconductivity at critical temperature, Meissner's effect. It can be a good candidate in magnetic applications such as magnetic bearing [2], maglev vehicle [3], etc. But the main problem is to use superconducting temperature control in order to stay in superconductivity. Superconductors were developed in critical temperature rise. Since 1987, Wu et al [4] discovered the first superconductor high critical temperature in Y-Ba-Cu-O compound. In 2009 Aliabadi et al [5] synthesized $Y_3Ba_5Cu_8O_{18}$ (Y3-5-8) by solid state reaction with 102 K critical temperature. Udomsamuthirun et al. [6] in 2010 found the new compound Y-Ba-Cu-O superconductors as Y5-6-11, Y7-9-16, Y5-8-13, Y7-11-18, Y1-5-6, Y3-8-11 and Y13-20-33. Chainok et al. [7] prepared $YBa_3Cu_4O_x$ (Y134) superconductor by solid state reaction and melt process technique which critical temperatures were at 97 K and 91 K, respectively.

In this research, $YBa_2Cu_3O_x$ (Y123) and $Y_{13}Ba_{20}Cu_{33}O_x$ (Y13-20-33) superconductors were synthesized by melt process technique and compared characterize of them.

2. EXPERIMENTS

$YBa_2Cu_3O_x$ (Y123) and $Y_{13}Ba_{20}Cu_{33}O_x$ (Y13-20-33) superconductors were synthesized by melt process. Exact stoichiometric ratios were mixed in 1:2:3 and 13:20:33 of Y_2O_3 99.99%, $BaCO_3$ 99.9% and CuO 99+%. All of them in corresponding weight ratio were grinded and calcinated in the air atmosphere at 950 °C twice times. These samples sintering at 980 °C and annealing at 500 °C were used. The temperature at 980 °C is in the range $\pm 50^0 C$ of peritectic temperature of YBaCuO superconductor. Finally, the samples obtained were pellets with 30 mm in diameter and about 5 mm in thickness. All the samples were characterized by the resistivity measurements with DC-four point probe technique, the crystal structures by SEM micrograph and EDX (JEOL JSM 6400), the XRD (Bruker D8-Discover).

3. RESULT AND DISCUSSION

Result of studies properties, the normalized resistivity curves as function of temperature were shown in Fig. 1. The samples have a single-step superconducting transition. The summaries of critical temperature onset were shown in Table 1. The average critical temperature of Y123 are higher than of Y13-20-33.

Table 1 *The critical temperature (T_C) of Y123 and Y13-20-33*

Superconductors	T_c (K)		
	T_c,offset	T_c,middle	T_c,onset
Y123	86.0	90.0	94.0
Y13-20-33	78.0	84.0	90.0

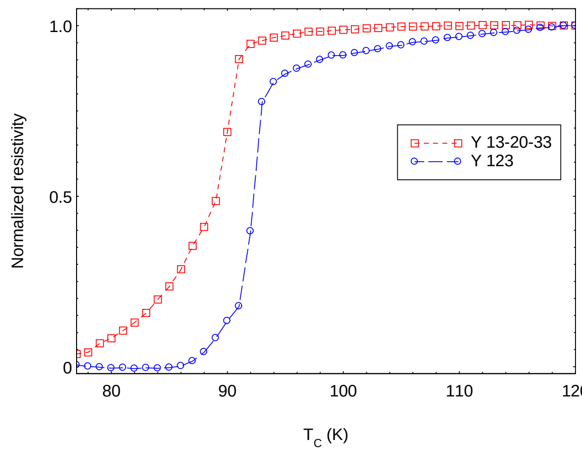
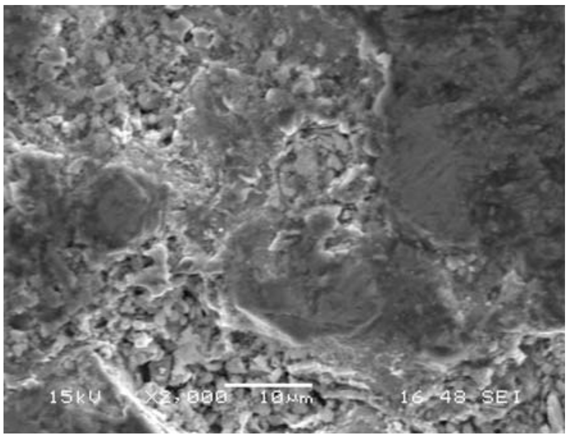
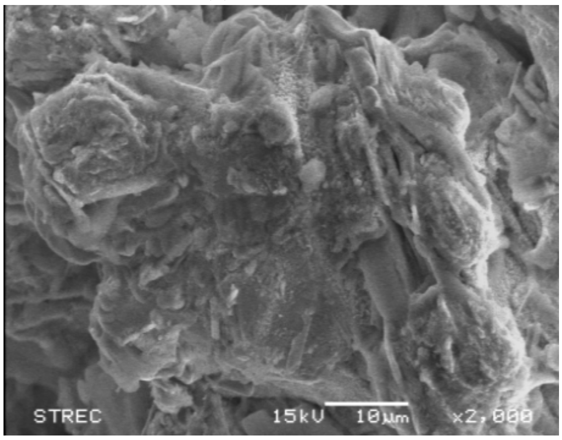


Fig. 1 *Show the normalized resistivity of Y123 and Y13-20-33*



(a) Y123

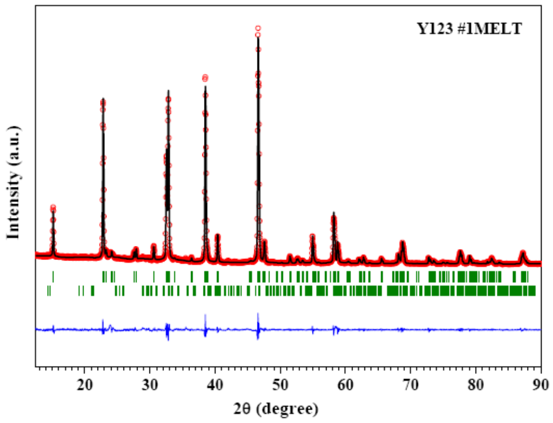


(b) Y13-20-33

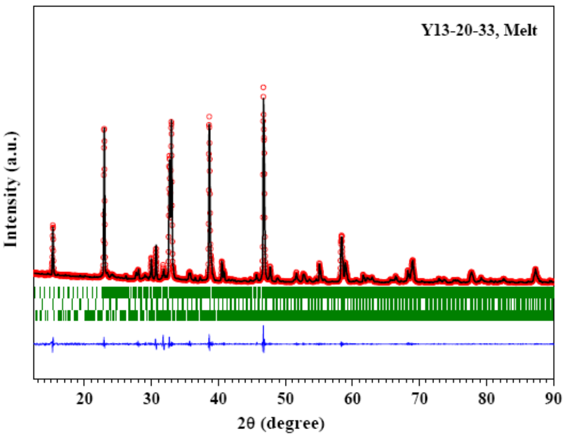
Fig. 2 *Shows SEM and EDX of Y123 and Y13-20-33*

The result of Y123 and Y13-20-33 by used SEM and EDX for synthesize structure were shown in Fig. 2. They were no impurity in both samples. It was seen that these pores are party eliminated.

The XRD result was shown in Fig. 3. The patterns of X-ray diffraction for samples at room temperature in 2θ vary from 10-90 degree. The characteristic peaks were determined by using the fullprof software program. The crystal structures have lattice parameter of Y123 and Y13-20-33 were shown in Table 2.



(a) Y123



(b) Y13-20-33

Fig. 3 *Shown the X-ray diffraction patterns.*

Table 2 *Show lattice parameter of Y123 and Y13-20-33*

Superconductors	Lattice parameter (Å)		
	a	b	c
Y123	3.82072	3.88454	11.68409
Y13-20-33	3.81934	3.88848	125.98630

Lattice parameter of Y123 has lattice parameter a = 3.82072 Å, b = 3.88454 Å and c = 11.68409 Å. And a = 3.81934 Å, b = 3.88848 Å and c = 125.9630 Å for lattice parameter of Y13-20-33. The crystal structure was orthorhombic. Y123 is close to the a and b of Y13-20-33 but the c of sample Y123 less than Y13-20-33 about 10.78 times.

4. SUMMARY

The Y123 and Y13-20-33 was synthesized by melt process of Y_2O_3 99.99%, $BaCO_3$ 99.9% and CuO 99+%. The samples obtained were characterized by four-point probe technique, SEM, EDX, and XRD. The critical temperature onset of Y123 and Y13-20-33 are 93 K and 88 K, respectively. The crystal structures of both samples were orthorhombic with a = 3.82072 Å, b = 3.88454 Å and c = 11.68409 Å for Y123 and a = 3.81934 Å, b = 3.88848 Å and c = 125.9630 Å for Y13-20-33. It can be seen that the c-axis of Y13-20-33 more than Y123 about 10.78 times but range of average critical temperature less than about 8 K. Range of critical temperature onset to offset of Y13-20-33 is about 12 K and 5 K of Y123. Show that the c-axis affects the critical temperature.

5. ACKNOWLEDGEMENTS

The author would like to thank the financial support of the Office of the Higher Education Commission, Faculty of Science Srinakharinwirot University, ThEP Center, Pathumwan Institute of Technology and Rajamangala University of Technology Phra Nakhon**.**

REFERENCES

[1] W. Buckel, Superconductivity, New York: VCH publisher lnc, pp. 1-27, 1991.

[2] J. R. Hull, “Superconducting bearings”, Supercon. Sci. Technol., vol. 13, 2000.

[3] W. Jiasu, W. Suyu, R. Zhongyou, D. Xiaogang, L. Guobin, L. Jisan, Z. Cuifang, H. Haiyu, D. Changyan and Z. Dequi, “A scheme of Maglev vehicle using high Tc bulk superconductors”, IEEE Trans. App. Supercond., vol. 9, pp. 904-907, 1999.

[4] M. K. Wu, J. R. Ashburn, C.J. Torng, P. H. Hor, R. L. Meng, L. Gao, Z. J. Huang, Y. Q. Wang and C. W. Chu, “Superconductivity at 93 K in a new mixed-phase Y-Ba-Cu-O compound system at ambient pressure”, Phys. Rev. Lett, vol. 58, pp. 908-910, 1987.

[5] A. Aliabadi, A. Farshchi and M. Akhavan, “A new Y-based HTSC with Tc above 100 K”, Physica C, vol. 469, pp. 2012-2014, 2009.

[6] P. Udomsamuthirun, T. Kruaehong, T. Nilkamjon and S. Ratreng, “The new superconductors of YBaCuO materials”, Journal of Superconductivity and Novel Magnetism, vol. 23, pp. 1377-1380, 2010.

[7] P. Chainok, S. Sujinnapram, T. Nilkamjon, S. Ratreng, K. Somsri, N. Phomphuang, P. Mychareon and P. Udomsamuthirun, “The synthesis $YBa_3Cu_4O_x$ superconductor and comparison with $YBa_2Cu_3O_x$”, Advanced Materials Research, vol. 979, pp. 220-223, 2014.

Sutee Chantrapa, photograph and biography not available at the time of publication.

Piyamas Chainok, photograph and biography not available at the time of publication.

Supphadate Sujinnapram, photograph and biography not available at the time of publication.

Thannarat Khuntak, photograph and biography not available at the time of publication.

Tunyanop Nikamjon, photograph and biography not available at the time of publication.

Sermsuk Ratreng, photograph and biography not available at the time of publication.

P. Udomsamuthirun, photograph and biography not available at the time of publication.