Effect of Processing Factors on Critical Current Density in Bi2212/Ag Wires

Sang-Cheol Kim[1,3,a], Dong-Woo Ha[2,b], Sang-Soo Oh[2,c], Il-Yong Han[1,d],
Hong-Soo Ha[2,e] and Ho-Sang Sohn[3,f]

[1]Nexans Korea Ltd., 165 Sadongri, Namemyun, Cheongwongun, Chungbuk, 363-812 South Korea
[2]Korea Electrotechnology Research Institute, 28-1 Sungjudong, Changwon, Gyeongnam, 641-120 South Korea
[3]Kyungpook National University, 1370 Sankyukdong, Bukgu, Daegu, 702-701 South Korea
[a]sckim999@msn.com, [b]dwha@keri.re.kr, [c]ssoh@keri.re.kr,
[d]il-yong.han@nexans.com, [e]hsha@keri.re.kr, [f]sohn@knu.ac.kr

Abstract

Five kinds of double stacked 385 (55 x 7) filamentary Bi2212/Ag round wires and 55 filamentary tapes with different Ag ratios (silver area/superconductor area) have been fabricated via PIT method, and the effects of Ag ratio and processing factors on critical current density were studied. The effects of the maximum temperature and average filament diameter on critical current density were also studied. The wire of 0.74 mm diameter having Ag ratio 3.7 showed critical current density of 2,218 A/mm² at 4.2 K, 0 T.

Keywords : Bi2212 wire, Ag ratio, Critical current density

1. Introduction

Bi2212 HTS(High Temperature Superconductor) is a promising material that has a number of avantages. Bi2212 has very high critical current density, J_c, in the fields from 10 to 30 T compared with other superconductors [1]. It is likely that Nb_3Sn magnet can not generate above 25 T due to the limit of upper critical field, B_{c2}, so Bi2212 can be used for high field applications. Bi2212 also has a better phase stability and easily can be manufactured into a long length. Since Bi2212 wire needs only single heat treatment, Wind & React method can be used. Moreover it can be fabricated as the various types of round, rectangular wire, tape, and before heat treatment it can be assembled as multiple strand cable such as Rutherford cable and round stranding [2].

In this paper, we study the effect of Ag ratio and processing factors on J_c in five kinds of Bi2212/Ag wires and tapes. Hasegawa et al. reported that reducing Ag ratio enhanced critical current, I_c, value to almost triple of the previous value [3]. It is shown that Ag ratio is one of the import factors to increase I_c and possibly to improve J_e and J_c to the some extent that wire breakages does not occur and configuration of filaments is uniformly maintained.

2. Experimental and Results

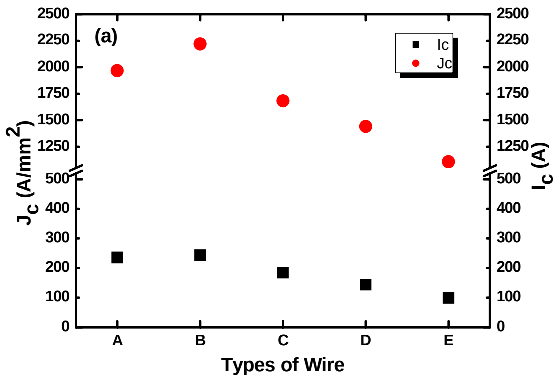
Multifilamentary Bi2212/Ag round wires and tapes were fabricated via Powder-In-Tube(PIT) method using precursor of composition $Bi_{2.17}Sr_{1.94}Ca_{0.89}Cu_{2.00}O_x$, which was analysed by X-ray fluorescence. The peritectic decomposition temperature T_p estimated from DTA/TGA traces in 100 %O_2 of BSCCO/Ag mixtures was 881±2 ℃.

Ag ratios were changed by means of the control of the thickness of the Ag tube. To make monocore wire, precursor powder was packed into four kinds of Ag tube having different Ag ratios of 0.3(A), 0.42(B), 0.42(C), 0.55(D), and 0.72(E) after powder filling. The monocore wires were drawn to hexagonal shape monocores. While B and C wires have the same Ag ratio, different area reduction ratio at drawing process were used to see the effect of drawing process. Ag tube size was the same for all the samples during the process excluding the monocore. Area reduction ratios of A and B wires at all drawing process were 10 ~ 15 %, while those of C, D, and E wire were 20 %. After cutting operation, 55 monocores were stacked into Ag tube, to build up the first bundle, and then it was drawn to hexagonal shape multifilaments. After cutting operation, 7 multifilament wires were again stacked into AgMg tube, to obtain the final configuration (second bundle), and it was drawn to 1.34 ~ 0.74 mm diameter. For fabrication of the tapes, 55 filamentray wires were drawn to the diameter of 1.23 mm, and then flat rolled to the thickness of 0.24 mm and the width of 3.92 to 4.15 mm.

The ends of the samples were wrapped by Ag tape and pressed before heat treatment. Partial melting heat treatment was performed in 100 %O_2. Maximum temperature, T_m, was varied from 882 to 896 ℃ for 0.5 h.

I_c at 4.2 K was measured using four point method at the criterion of 1 μV/cm. Total sample length and voltage tap distance were 60 and 20 mm, respectively. J_c was estimated by means of the method that I_c was divided by superconducting ceramic cross section area.

J_c and I_c as a function of wires and tapes having different Ag ratios are shown in Fig. 1. 0.81 mm diameter wires were heat treated at T_m 888 ℃ (a) and tapes at the thickness of 0.24 mm were heat treated at 884 ℃ (b). B wire having Ag ratio 3.73 showed best I_c of 244 A and J_c of 2,218 A/mm^2, while A tape having Ag ratio 1.9 showed best I_c of 633 A and J_c of 1,872 A/mm^2.



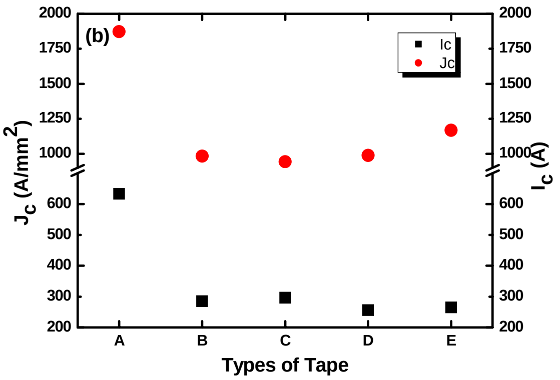


Fig. 1. J_c and I_c of various types of wires and tapes measured at 4.2 K, 0 T. (a) 0.81 mm diameter wires heat treated at T_m 888 ℃ (b) 0.24 mm thickness tapes heat treated at T_m 884 ℃.

A and B wires, which were drawn at the area reduction ratio of 10 ~ 15 %, have similar value of I_c, but J_c of B wire showed 13 % higher than that of A wire.

It is thought that B wire has higher Ag ratio at the same diameter, resulting in smaller superconductor area and higher J_c. When it comes to C, D, and E wires which were drawn at the area reduction ratio of 20 %, as Ag ratios increased from 3.75 to 4.78, J_c of the wires decreased linearly. It is thought that increasing Ag ratio above a certain value is detrimental to J_c as well as I_c. Considering that B and C wires have the same Ag ratio and process excluding the area reduction ratio of the drawing process, it is thought that the J_c difference comes from drawing process. I_c, 633 A, of A tape was higher than that, 236 A, of A wire, but J_c of the tape was lower than that of the wire. It is thought that higher I_c of the tape comes from larger superconductor area and, increased core density and texture induced by rolling, and higher J_c of the wire comes from larger interface area between superconductor and silver. Ag ratio 1.9 of A tape is a lower value compared with other four different tapes having the Ag ratio from 2.4 to 3.2. Because processing factors of five tapes were similar, it is thought that higher I_c of A tape is derived from lower Ag ratio.

3. Summary

The effect of Ag ratio and processing factor on J_c were investigated using five kinds of wires and tapes fabricated by PIT method. The 385 filamentary wires having Ag ratio from 3.25 to 3.73 showed better J_c value compared with other wires having Ag ratio from 4.2 to 4.78. The wire having the area reduction ratio of 10 ~ 15 % showed better J_c value compared with other wires having the area reduction ratio of 20 %. The 55 filamentary tapes having Ag ratio 1.9 showed better J_c value compared with other tapes having Ag ratio from 2.4 to 3.2. The wire of 0.81 mm diameter having Ag ratio 3.7 and heat treated at T_m 888 ℃ showed J_c of 2,218 A/mm^2 at 4.2 K, 0T.

4. References

1. P.F. Hermann, J. Bock, C.-E. Bruzek, C. Cottevieille, G. Duperray, J. Hascicek, D. Legat, A. Leriche, T. Verhaege, and Y. Parasie, Supercond. Sci. Technol., **13**, p.477(2000)
2. C.-E. Bruzek, N. Lallouet, E. Flahaut, D. Bourgault, J.-M, Saugrain, A. Allais, S. Arac, J. Bock, J. Ehrenberg, D.E. Wesolowski, and M.O. Rikel, presentation at EUCAS 2003.
3. T. Hasegawa, J. Nishioka, N. Ohtani, Y. Hikichi, R. Scanlan, R. Gupta, N. Hirano, and S. Nagaya, IEEE Trans. Appl. Supercond. ,**14**, p. 1066(2004)