WBP9-1

Study of hetero junction between RE123 and Bi2223 tapes with JIM method

*Shintetsu Kanazawa[1]

Muroran Institute of Technology[1]

In this study we studied to develop a superconducting joint between RE123 and Bi2223 as hetero junction. This type of joint is called as RB joint. The fabrication method for the RB joint is JIM [1]. The joint is useful to develop a high-field RE123/Bi2223 persistent magnet, also it is useful to joint between RE123-coated conductors and between Bi2223 wires, as RBR and BRB, respectively. In the heat treatment for joint, Bi2223 phase is melted and the RE123 keeps the crystal orientations. In experiment, several samples were prepared and all samples show a superconducting behavior at 77 K. The fabrication method and properties of resistance for the RB joints will be presented in ISS2019.

[1] X. Jin, et al., Superconductor Science and Technology 32 (2019) 035011.

Acknowledgements:
This work was supported by MEXT project of Leading Initiative for Excellent Young Researchers (LEADER) Project ID 16810210, and JSPS KAKENHI Grant Number JP18K04719, Japan.

Keywords: joint, Bi2223, RE123

WBP9-3

Superconducting Joints of *In Situ* PIT and IMD Processed MgB_2 Conductors

*Dipak Patel[1], Akiyoshi Matsumoto[1], Hiroaki Kumakura[1], Su-Hun Kim[2], Minoru Maeda[3], Seyong Choi[3], Jung Ho Kim[4]

National Institute for Materials Science (NIMS), Tsukuba, Ibaraki, Japan[1]
Department of Electrical Engineering, Kyungpook National University, Daegu, Republic of Korea[2]
Department of Electrical Engineering, Kangwon National University, Kangwon, Republic of Korea[3]
Institute for Superconducting and Electronic Materials, University of Wollongong, North Wollongong, NSW, Australia[4]

Superconducting joints are essential to use magnesium diboride (MgB_2) conductors in liquid helium (LHe)-free magnetic resonance imaging (MRI) magnet system operated in a persistent mode by forming a closed-loop using superconducting joints. *In situ* PIT (powder-in-tube) processed multifilament MgB_2 conductors are known to have good potential to use in LHe-free MRI magnet. However, internal magnesium diffusion (IMD) processed MgB_2 conductors show superior performance compared with *in situ* PIT processed MgB_2 conductors. Therefore, if high current capacity joints using IMD conductors can be fabricated, it will be certainly advantageous. We have fabricated superconducting joints using unreacted multifilament (18 + 1) *in situ* PIT and monofilament IMD processed MgB_2 conductors and evaluated their performance in different temperatures up to 25 K and magnetic fields up to 12 T. Our joints fabricated using 18 + 1 filaments *in situ* PIT and monofilament IMD processed conductors attained critical current of 121.7 A at 10 K in 0.5 T and 128.6 A at 20 K in 1 T, respectively. The current retention in the joint fabricated using IMD processed conductors in compared with the bare wire was close to 100% at 20 K in the field range from 7 T to 2 T. The joint resistances evaluated using the field-decay measurement by forming a closed-loop of the *in situ* PIT and IMD processed conductors were 5.16 $\times 10^{-15}$ Ω and 2.01 $\times 10^{-13}$ Ω at 20 K in self-field, respectively. The detailed joint fabrication process, transport measurement results, microscopy analysis of the joint part, and the field-decay measurement results of both types of joints will be presented.

Keywords: Magnesium Diboride (MgB2), Magnetic Resonance Imaging (MRI), Superconducting Joints

WBP9-4

The development of superconducting joint technologies for MgB_2 wires

*Akiyoshi Matsumoto[1], Dipak Patel[1], Yuka Hara[1], Toru Hara[1], Hiroaki Kumakura[1]

National Institute for Materials Science[1]

Magnesium diboride (MgB_2) has a high critical temperature (T_c = 39 K) as a metal-based superconductor and one of candidate materials for superconducting application operated free from liquid helium. The superconducting joint between MgB_2 wires is an important technique in consideration of applications such as MRI magnet. We have been developing an internal magnesium diffusion method (IMD) wire with high critical current density J_c, and succeeded in developing a good superconducting joint for unreacted wires, and its joint resistance is 10^{-13} Ω. On the other hand, the superconducting joint of the reacted wire has many unsolved problems. In this research, the superconducting properties and the microstructures about the influence in the second heat treatment for fabricating of superconducting joint part.

We prepared unreacted 19-multifilaments wire made by Hypertech Research Inc. of the United States. These wires heat treated in a tube furnace under an argon atmosphere at 650 °C for 1 hour. Furthermore, the same heat treatment was performed again on the same sample to evaluate the superconducting properties like making a superconducting joint. We have been used a FIB-SEM for understanding the microstructures the obtained image was constructed as a three-dimensional image.

Fig.1 shows the results of the magnetic field dependence of J_c of single heat treatment and dual heat treatment. It was found that J_c of single heat treatment was improved in the entire magnetic field region in the two-time heat-treated wire. As a result of the 3-D microstructural observation, as shown in Fig. 2, a filament containing a large amount of unreacted Mg could be observed in a single heat treatment (a), but those filaments were reduced in a dual heat treatment wires.

Keywords: MgB2, Superconducting joint, 3D images, multifilament

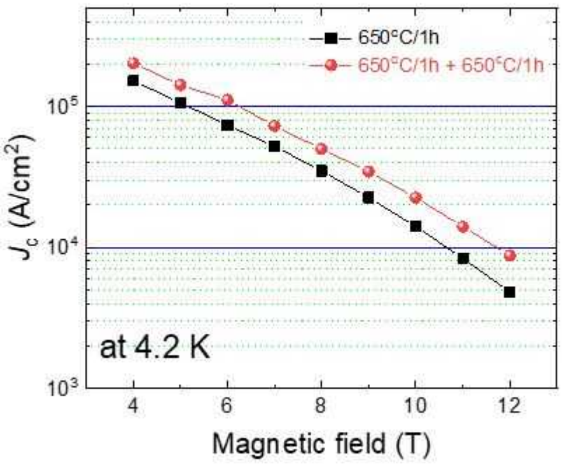


Fig. 1. Magnetic field dependence of critical current density at 4.2 K for single and dual

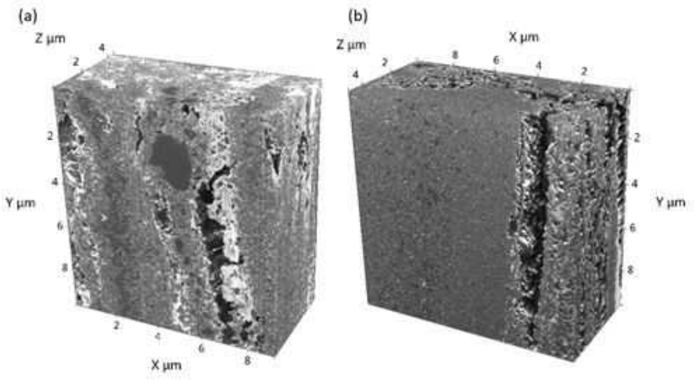


Fig. 2. 3D-microstructure inside filament after (a) heat treatment single and (b) dual.

WBP9-5

Superconducting Joint Between $Ba_{1-x}K_xFe_2As_2$ Tapes by Using a Cold-press Technique

*Shota Imai[1,2], Shigeyuki Ishida[2], Yoshinori Tsuchiya[2], Akira Iyo[2], Hiroshi Eisaki[2], Taichiro Nishio[1], Yoshiyuki Yoshida[2]

Department of Physics, Tokyo University of Science Japan[1]
National Institute of Advanced Industrial Science and Technology Japan[2]

Significant progresses toward high performance iron-based superconducting wires/tapes have been made over recent years [1]. Especially for $(Ba,K)Fe_2As_2$, the critical current density exceeded 1.5×10^5 A/cm^2 at 4.2 K under 10 T [2]. For the practical use, a superconducting joining technique is of critical importance. Recently, Zhu *et al.* reported that the superconducting joints fabricated via a hot press (HP) technique show a critical current ratio (CCR) of 63 % at 4.2 K under 10 T. [3] Although the achieved high CCR demonstrates the high potentiality of iron-based superconductors, the CCR value has not been obtained without the HP process unfavorable for industry. Thus, it is necessary to achieve high CCR using a simple process.

In this study, we fabricated superconducting joints between $(Ba,K)Fe_2As_2$- tapes by using a simple cold uniaxial press technique and evaluated their performance. Figure.1(a) shows critical currents (I_c) and CCR of the joint at 4.2 K under magnetic fields parallel to the tape surface. CCR values of 63 % in the self-field and 29 % in 3.5 T at 4.2 K were achieved. Figure. 1(b) shows a SEM image of the cross section of the joint. Micro-cracks were not observed around the jointed part, which is well connected. On the other hand, as shown in Figure. 1 (c), inhomogeneous deformation and macro-cracks were observed at the joint end part. These results suggest that joint end parts prevent CCR from increasing to more than 63%.

[1] Yao. C *et al.*, Supercond. Sci. Technol. **32**, 023002 (2019).
[2] Huang. H *et al.*, Supercond. Sci. Technol., **31**, 015017 (2018).
[3] Zhu. Y *et al.*, Supercond. Sci. Technol., **32**, 024002 (2019)

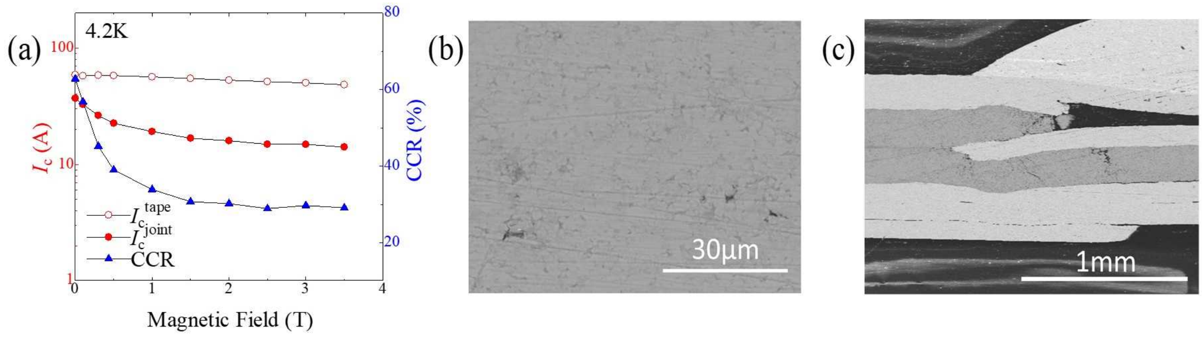


Figure. 1: (a) Magnetic field dependence of I_c and CCR of $(Ba,K)Fe_2As_2$ tape and joint at 4.2 K under field parallel to the tape surface. SEM images of (b) the cross section and (c) the end part of $(Ba,K)Fe_2As_2$ joints.

Keywords: Iron-based superconductors, Superconducting joint, Critical Current Ratio, Critical current

WBP9-6

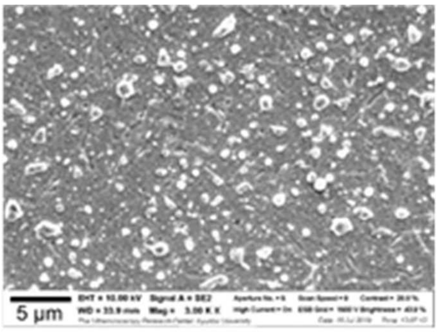
Fabrication of additional deposited layer of $GdBa_2Cu_3O_{7-\delta}$ on coated conductors for joint

*Shotaro Yasuyama[1], Tomohiro Miyajima[1], Ryo Teranishi[1], Yukio Sato[1], Kenji Kaneko[1], Valery Petrykin[2], Sergey Lee[2], Satoshi Awaji[3], Tatsunori Okada[3], Akiyoshi Matsumoto[4]

Kyushu University, Japan[1]
SuperOx Japan, Japan[2]
Tohoku University, Japan[3]
National Institute For Materials Science, Japan[4]

$REBa_2Cu_3O_{7-\delta}$ coated conductors (REBCO CCs) have been longed for electric power application with lengthening by superconducting joint due to its high critical temperature (T_c), critical current (I_c), and low toxicity(1)(2). We have reported jointing GdBCO CCs via crystallization of additional deposited precursor layers on GdBCO CC(3), and which showed I_c of 0.096 A/cm^2(4), however that is lower than that of 10^3 A/cm^2 in YBCO c-axis(5). Existence of secondary phases and voids at joint interface would deteriorate current and formation of them are affected by the structure of additional layer after film growth. In this study, surface morphology of additional layer were observed to clarify the information of microstructure.

Additional layers were fabricated by a metal organic deposition(3) method. Firstly, starting solutions were spin-coated onto GdBCO CCs, and the samples were calcined at 823 K. Next, they were heated at 1073 K under the oxygen pressure of 200 Pa to crystallize and oxygenated at 773 K for 2 hours. Then the film surface was observed by a Scanning Electron Microscopy (SEM). Fig.1 show SEM images of film surface of GdBCO layer before (a) and after (b) additional deposition onto GdBCO CC. The contrast difference is small in whole area in Fig.1 (a), showing smoothness. On the other hand, the contrast difference is large in Fig.1(b), showing roughness. In addition, the number of grains is large in Fig.1(b), which indicates the roughness is due to the existence of many grains. The roughness of film surface may cause voids at the joint interface of the jointed sample. It is necessary to fabricate additional layer with smooth surface to increase I_c, so improving heat treatment conditions is needed.



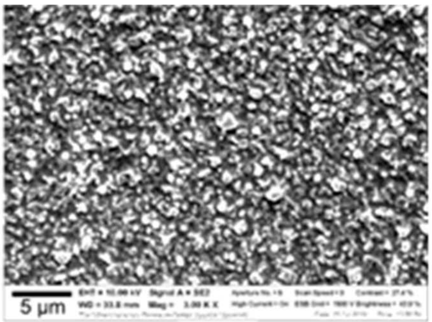


Fig.1 SEM images of film surface of GdBCO layer before (a) and after (b) additional deposition onto GdBCO CC

(1)Y. J. Park, M. W. Lee, Y. K. Oh, H. G. Lee, Supercond, Sci. Technol. 27 (2014) 1-8
(2)T. Izumi, OYO BUTURI, The Japan Society of Applied Physics, 79 (2010)14-19
(3) K. Hiramatsu, R. Teranishi, K. Yamada, Y. Sato, and K. Kaneko, Physics Procedia, 81 (2016) 109-112
(4)S. Yasuyama et al, The Japan Institute of Metals and Materials, Kyushu branch, June 23 (2018) 34
(5)Y. Jia, J. Hua, G. W. Crabtree, W. K. Kwok, U. Welp, A. P. Malozemoff, M. Rupich, S. Fleshler, Supercond. Sci. Technol. 23 115017 (2010)1-4

Keywords: REBCO coted conductors, Joint, Additional deposited layer, Surface morphology