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Achievements in M-PACC Project and Future Prospects on R&D of Coated Conductors in Japan

Teruo IZUMI*

Superconductivity Research Laboratory (SRL), International Superconductivity Technology Center (ISTEC)

Abstract

A national project of Materials & Power Applications of Coated Conductors (M-PACC) including R&D of coated conductors (CC) and the applications in Japan had been promoted for 5years and was finished at the end of February in 2013. In the R&D of coated conductors, the necessary specifications required from the applications were set as the targets and all of them were successfully achieved. Through the development, there were lots of remarkable results had been obtained, such as high in field I_c value of 54A/cm-width at 77K under 3T in 200m long tape, one-tenth of AC loss reduction in 100m long tape with 10 filaments etc. Although these achievements could make the lots of applications of coated conductors realize, further improvement is needed to obtain an absolute advantages to competitive technologies. Based on this situation, the development should be continued to have the coated conductors with much higher specifications, which is called as 3rd generation wire.

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Keywords: YBCO; Coated Conductor; Critical Current; AC loss; Delamination

1. Introduction

$REBa_2Cu_3O_{7-y}$ (RE: rare earth, REBCO) coated conductors (CC) are highly expected as a promising candidate for high performance tapes which could be used at the liquid nitrogen temperatures (64 -77 K). In order to start the development of applications using CC, long REBCO CC with high critical currents (I_c) are required. The national project of “Fundamental Technologies for Superconductivity Applications (FTSA)” (FY03-07) had been taken place by the collaboration of private companies and universities etc. In this project, the goal of CC such as a 500 m long tape with 300 A/cm-width was successfully satisfied. According to the achievements of FSTA, the new national project was started at FY2008 concentrating the development of the electric power applications of SMES, cable and

*Corresponding author. Tel.: +81-44-850-1617 ; fax: +81-44-850-1613
E-mail address: izumi@istec.or.jp

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transformer. However, the requirements for the coated conductors in the market spreading stages are still higher level than the above one. Then, the development of the coated conductors has been constructed as one of the themes in this project. In this theme, several kinds of topics were selected as the common factors in the above-mentioned applications such as "high in-field I_c, low AC loss, high mechanical strength, low technical cost etc. as shown in Table 1. In this paper, the achievements in this project were summarized and the future prospects of the development of coated conductors were also stated.

Table 1. Goals of the R&D of coated conductors in M-PACC project

Themes	Final Goals (2012)
(1) Degradation of Properties	• Degradation by "Humid", "Strain" etc. • Delamination Behavior and Solution
(2) High Ic under Magnetic Fields	•50A/cm-w @77K,3T-200m •400A/cm-w @65K,0.1T-100m
(3) Low AC Loss	• 2mm-width & 500A/cm-w @77K,0T-200m • 5mm-width & 10 filaments → Loss Reduction to 1/10
(4) High Strength & High Je	•500A/cm-w-1Gpa @77K,0T-50m •Je=50KA/cm^2 – 200m
(5) Low Cost & High Yields	• Low Cost toward $20/kAm

2. Achievements of R&D for CC in M-PACC project

2-1 In-field Performance

As a requirement from magnetic applications such as SMES et al., the superconducting performance under magnetic fields should be improved. In this field, the progress in the physical vapor deposition system has been firstly carried out. In the development in the PLD process for superconducting layers, the $BaZrO_3$(BZO) nano-rods[1] were successfully dispersed and the J_c/I_c performance under the magnetic field, especially for them under the magnetic field parallel to the c-axis of the GdBCO films, has been improved. However, the in-field performance in thick films was saturated in the thickness dependence of I_c(B). For this problem, $BaHfO_3$ was found to be effective for maintaining the liner relationship between in-field I_c and the GdBCO thickness up to 3μm in thickness[2]. Then, a high I_c value of 85A at 77K and 3T was realized in the BHO doped GdBCO film as shown in Fig.1. According to the TEM observation, nano-rods of BHO are shorter comparing with BZO and inclined from the c-axis of GdBCO films. Additionally, the morphologies of the BHO nano-rods were uniform from the bottom near the CeO_2 to the surface. Reflecting these features, the BHO doped GdBCO films reveal the isotropic behavior in J_c-B-θ properties and the difference in the shape cannot be recognized for the different thickness as shown in Fig.2. Additionally, another advantage of this system was also found. Although the advantages in J_c-B properties to non-doped films at high temperature disappears at low temperature region in the case of BZO doped GdBCO films, those in the BHO doped films is maintained in wider range of temperature and magnetic field. Furthermore, a 200m long tape with BHO doped EuBCO is successfully fabricated and a high in-field I_c value of 54A/cm-width at 77K and 3T was recognized as a minimum value (Fig.3).

On the other hand, the BZO nano-particles were dispersed in the YGdBCO films derived from the TFA-MOD process[3]. And the heating profile was modified to make the particles finer, which is called as the interim annealing[4]. Additionally, the coating process was modified to make a uniform thickness of the coating films in the transverse direction. This can prevent crack formation in the thick films. These developed technologies were applied to fabricate the thick films with BZO fine particles. As a result, the high I_c value of 55A/cm-width at 77K and 3T was obtained in the short tape as shown in Fig.4. Furthermore, the long tape fabrication is also realized and 200m long tape with 50A/cm-width at 77K and 3T was realized.