Available online at www.sciencedirect.com
SCIENCE DIRECT®
Physica C 426–431 (2005) 938–944
PHYSICA C
www.elsevier.com/locate/physc

Progress on TFA-MOD coated conductor development

Hiroshi Fuji [a,*], Ryo Teranishi [a], Yutaka Kito [a], Junko Matsuda [a], Koichi Nakaoka [a], Teruo Izumi [a], Yuh Shiohara [a], Yutaka Yamada [b], Akimasa Yajima [c], Takashi Saitoh [d]

[a] *Superconductivity Research Laboratory, ISTEC, Shinonome 1-10-13, Koto-ku, Tokyo 135-0062, Japan*
[b] *Superconductivity Research Laboratory, ISTEC, Nagoya Coated Conductor Center, 2-4-1, Mutsuno, Atsuta-ku, Nagoya 456-8587, Japan*
[c] *Asahidenka Kogyo K.K., 2-35, Higashi-ogu, 7-chome, Arakawa-ku, Tokyo 116-8553, Japan*
[d] *Fujikura Ltd., 1-5-1, Kiba, Koto-ku, Tokyo 135-8512, Japan*

Received 23 November 2004; accepted 16 February 2005
Available online 10 August 2005

Abstract

The recent progress in coated conductor development by the TFA-MOD process was reviewed. Much progress was recognized in the R&D on TFA-MOD processing for satisfying several requirements, such as high superconducting performance, long tape production, high production rate, etc., considering the real application. For high superconducting performance, the high I_c value of 413 A was achieved in a short sample with an architecture of MOD-YBCO/IBAD-GZO/IBAD-GZO/Hastelloy. It was realized by improving the in-plane crystal grain alignment of the CeO_2 buffer layer and optimizing conditions of the heat treatments in the calcination and crystallization processes. In the calcination process, it was found that lower heating rate was effective to improve the morphology of the multi-layered precursor by preventing from pore generation and segregation of Cu elements. In the crystallization process, it was found that high humid gas partial pressure was effective to improve the J_c values by reducing the amounts and size of pores in the YBCO layers. Furthermore, in the case of thicker firm, it was found that the low heating rate in the crystallization process was effective to prevent from the crack formation. On the other hand, in order to obtain the long tape with uniform I_c values, in the crystallization process, the gas flow condition in a large scale equipment for the continuous long tape process was investigated using a computer simulation technique. Consequently, the 8.6 m YBCO on PLD-CeO_2/IBAD-$Gd_2Zr_2O_7$/Hastelloy tape which shows high I_c performance of 119 A as an end-to-end value at 77.3 K in self fields, was successfully obtained. As a result, $I_c \times L$(length) value of 1024Am was achieved.

* Corresponding author. Tel.: +81 3 3536 5711; fax: +81 3 3536 5705.
E-mail address: hfuji@istec.or.jp (H. Fuji).

0921-4534/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.physc.2005.02.153

PACS: 81.15.−z; 74.72.Bk; 81.10.Jt

Keywords: YBCO TFA-MOD process; IBAD

1. Introduction

For the application of high temperature superconductor (HTS), tapes and wires have been developed in order to apply the wide areas such as cables, transformers, magnets, etc. In the previous developments, Bi-system Ag-sheathed tapes had been developed for the applications. Since, it was relatively easy to obtain long tapes with high performance [1]. However, in the case of high magnetic field application at high temperatures such as 77 K, it has a serious issue which is degradation of critical current density (J_c), under the magnetic fields [2]. In order to overcome this point, YBCO coated conductors have been expected to be developed. Essentially, YBCO superconductor has a high performance even under the magnetic fields. However in order to achieve the high performance, a three dimensional grain alignment is required for this purpose, the several kinds of processing such as IBAD [3], ISD [4], RABiTS [5] have been developed. Additionally, fabrication of a superconductive layer with low cost is also important for applications of coated conductors. MOD process for YBCO films using metal trifluoroacetate (TFA) precursors is considered to be a strong candidate as a low cost process for coated conductors, since the TFA-MOD process is essentially a non-vacuum process. Additionally, it has been well confirmed that this process has an advantage to provide a high J_c film of a MA/cm^2 class [6]. In our previous work, it was confirmed that the combination of CeO_2 by PLD on $Gd_2Zr_2O_7$ by IBAD is effective one for buffer layers on a metal substrate for the TFA-MOD process. In order to obtain high I_c, the processing for thicker YBCO films was investigated using the multi-coating method [7]. Considering the real applications of coated conductors, several requirements have to be satisfied simultaneously. In this paper, we focused on the progress in the developments for (1) high superconducting performance, (2) long tape production.

2. High superconducting performance

From the application point of view, the high critical current (I_c) is one of the important factors in superconducting performance. In order to obtain high I_c values, thicker films with maintaining high J_c have to be realized. The progress on the optimization of the conditions in both (A) *calcinations process* and (B) *crystallization process* for thick films were reviewed.

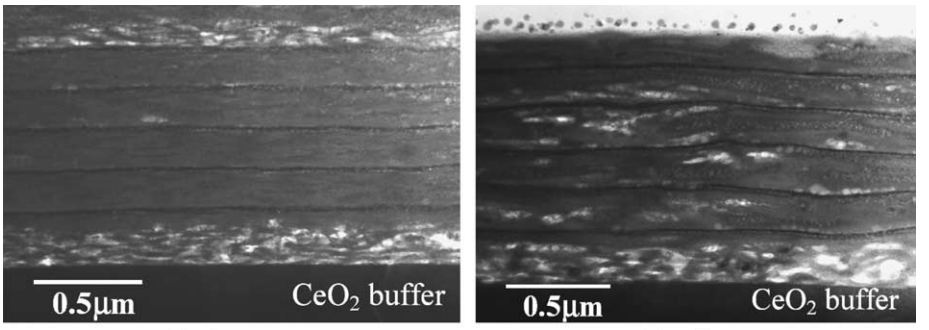

Fig. 1. Cross-sectional TEM images of precursors in the case of (a) low heating rate of 2 °C/min and (b) high heating rate of 10 °C/min.