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Joint of $REBa_2Cu_3O_{7-\delta}$ Coated Conductors using Metal Organic Deposition

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Abstract

Joint techniques connecting $REBa_2Cu_3O_{7-\delta}$(REBCO) coated conductors (CCs) are required to fabricate long length CCs and to repair locally damaged one. Two pieces of REBCO CC were attempted to be jointed using a metal organic deposition (MOD) method. The starting solution for YBCO layer was coated on GdBCO layer of CCs and calcined to fabricate precursor films, two of which were stuck together in a face to face manner, and then these films were pressurized and crystallized to joint them. Two CCs were successfully jointed together with c-axis oriented YBCO without pores and reacted phases at the joint interface.

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Keywords: Joint; Coated conductor; MOD

1. Introduction

There have been several techniques to joint REBCO CCs together to fabricate long length superconducting wires for magnet for applications, such as a diffusion joint using stabilizing layer [1,2], a solder joint [3,4], and a superconducting joint [5]. Among these joint techniques, the diffusion joint and the solder joint are very simple techniques with low resistances from stabilizing layer and solder layer between two REBCO layers, respectively. Even the resistance at the jointed interfaces is low enough, it still causes the current loss and the transition to the normal conducting state due to the resistive heating, unquestionably.

Recently, Park et al. reported that the success of zero joint resistance using the direct superconducting joint

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techniques with complicated processes, including high temperature heat treatment (1123 K) for jointing in high vacuum [5]. Nevertheless, lower temperatures and ambient pressures are desired to achieve zero joint resistance for industrial applications.

In this paper, we propose a possible fabricating technique of a superconducting joint by the MOD method at lower heating temperatures than previous report [5] in ambient pressure.

2. Experimental

Fluorine-free starting solution for YBCO films was spin-coated onto 5×10 mm^2 GdBCO CCs as substrate. The coated samples were calcined at 823 K for 2 hours, and the two pieces of precursor film were held together in a face to face manner with 5×6 mm^2 overlapped in an Inconel holder, as schematically shown in fig. 1. The overlapped sample was pressurized by two bolts and tightened by torque of 5 N·m, followed by annealing at 1043 K to crystallize two calcined layers and to joint them, then oxygenating at 773 K for 2 hours.

The crystal orientation of the sample was examined by an X-ray diffractometer (XRD, Rigaku-RINT2100) mounted on a horizontal θ/2θ goniometer, surface morphology of the sample was investigated by a scanning electron microscope (SEM, Zeiss-ULTRA55), and microstructure of the jointed sample was examined by a transmission electron microscope (TEM; JEM-3200FSK).

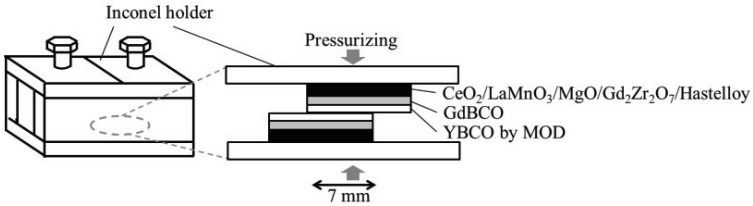

Fig. 1. Schematic illustration of sample jointing.

3. Results and discussion

3.1. Evaluation of crystal orientation

The jointed sample was peeled off and the crystal orientation of the REBCO layers was investigated from a whole region of the overlapped area by XRD θ/2θ profiles. Figs. 2a and 2b show XRD patterns of GdBCO CC and overlapped area of the jointed sample, normalized by the peak intensity of CeO_2 200, respectively. Fig. 2a has GdBCO 00ℓ peaks and Gd_2BaCuO_5 131 and 321 peaks. In addition to fig. 2a, new peaks locating at 2θ =16° and 27° appeared in fig. 2b, which were assigned to $Y_2Cu_2O_5$ 200 and 111, respectively. The integrated intensities of the REBCO 005 peak were compared between GdBCO CC (fig. 2a) and jointed sample (fig. 2b) by using the relative value to the CeO_2 200 substrate peak. As a result, ratio of integrated intensities of REBCO to the CeO_2 increased from 0.54 (fig.2a) to 1.02 (fig.2b). This result suggests the formation of c-axis oriented YBCO layer on c-axis oriented GdBCO layer. It can be seen in fig. 2b that there were other peaks at lower angular side of each main 00ℓ peak, indexed as “lower 00ℓ peak”, probably caused by the phase with oxygen under doping. Table 1 shows c-axis lattice parameters calculated from lower 00ℓ peaks and main 00ℓ peaks, and oxygen contents were estimated from these lattice parameters [6]. From the results of table 1, oxygen under doped YBCO estimated from lower 00ℓ peaks was present in overlapped area. It suggested the presences of two YBCO phases, one with oxygen under doping, and another one with adequate oxygen doping. XRD patterns of jointed region (including non-jointed region) and non-jointed region are shown in figs. 3a and 3b, respectively. It can be seen in fig. 3a that there were both main 00ℓ peaks and lower 00ℓ peaks, as shown in fig. 2b, but lower 00ℓ peaks were not present in fig. 3b. It was clear from these results that jointed region was the phase which oxygen content was under doped. It was thought that jointed region has no oxygen paths while annealing because of adhesion between YBCO layers.