Nanostructural characterization of superconductor joint between $GdBa_2Cu_3O_y$ coated conductors

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$REBa_2Cu_3O_y$ (RE: Y, Gd, Eu etc.) coated conductors with a few hundred meter long can be produced. In order to develop nuclear magnetic resonance (NMR) or magnetic resonance imaging (MRI) systems using these coated conductors, which are operated in a persistent-current mode, a superconducting joint technique for high-temperature superconductor (HTS) is necessary. Recently the HTS joint between $GdBa_2Cu_3O_y$ (GdBCO) coated conductors was achieved using a GdBCO intermediate layer which was fabricated by an alcoholic solution of fluorine-free metallo-organic complexes with a Gd:Ba:Cu molar ration of 1:2:3 [1,2]. The critical current (I_c) value of the jointed coated conductor was 81 A at 77 K and in the self-field. The jointed coated conductors were sectioned by an Ar ion beam at an accelerating voltage of 6 kV. The cross-section was further milled by Ar at 1 kV. The specimen was examined in a Hitachi SU8000 scanning electron microscope (SEM) and a JEM-6330F SEM with an electron back scattering diffraction (EBSD) system operated at 1 kV and 25 kV, respectively. In addition, a transmission electron microscopy (TEM) specimen of the jointed coated conductors was prepared in a Hitachi NB5000 focused ion beam (FIB)-SEM system using a microsampling technique. An Ar ion beam at an accelerating voltage of 1-0.5 kV was applied to the TEM specimen to remove damaged layers formed by the FIB on the specimen surfaces. The specimen was investigated in a TOPCON EM-002BF TEM with twin energy dispersive spectroscopy detectors operated at 200 kV.

SEM images indicated some pores, CuO or Gd_2O_3 grains in the jointed region of the GdBCO coated conductors [2]. However, the boundary of the jointed GdBCO coated conductors could not be clearly seen in the SEM images. The results of EBSD orientation maps showed the angle difference of the out-of-plane (*c*-axis) and the in-plane (*a*-axis) between the jointed GdBCO layers was 5 degrees or less [2]. The intermediate layer which connected both the GdBCO layers was confirmed by TEM. The intermediate layer mainly composed of GdBCO grains had a thickness ranging from a few ten nm to 200 nm. The *c*-axis of both the GdBCO layers and the GdBCO grains in the intermediate layer were well aligned. The intermediate layer was connected to the both the GdBCO layers atomically without any spaces [2]. In addition, periodic strain contrasts considered to be formed during the jointed process were found in both the GdBCO layers and the intermediate layer. Thus, super current should be able to flow through these jointed regions. Furthermore, if the volume of the oxides and the pores at the jointed boundary can be reduced, the I_c values of the jointed region will increase.

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