WB1-1-INV

Progress in ultrafast transient liquid assisted growth of high current density superconducting films and coated conductors

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High current superconducting wires have been one of the most challenging achievements during all the HTS era which encompasses many materials science and engineering challenges. Coated conductors of $YBa_2Cu_3O_7$ (CC-YBCO) have emerged as the most attractive opportunity to reach unique performances at high an low temperatures, while reducing the cost/performance ratio continues to be a key objective for their marketability. Chemical solution deposition (CSD) is a very competitive cost-effective technique which has been used to obtain nanocomposite films and CCs, however their growth rates is rather small (0.5-1 nm/s). To address this challenge, we are developing a novel growth approach, entitled Transient Liquid Assisted Growth (TLAG), which is able to combine chemical solution deposition methodologies with ultrahigh growth rates of liquid-mediated approaches (100 nm/s), being compatible with nanocomposite growth and coated conductors. In this presentation, I will revise our recent progress in TLAG-CSD in terms of growth mechanisms, nucleation kinetics, and growth rate, determined by in-situ X-ray imaging (100 nm/frame) under synchrotron radiation. Critical current densities up of 5 MA/cm2 at 77K are already realized in thin films. I will present the new defects landscape and the role of preformed nanoparticles in the vortex pinning of TLAG-CSD nanocomposites. Finally, the approaches followed to grow thick coated conductors will be discussed.

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Keywords: YBCO films, liquid assited growth, chemical solution deposition

WB1-2

Recent results on in-field properties in nanoparticle-doped TFA-MOD $REBa_2Cu_3O_y$ Coated Conductors

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Nanostructural modifications, in particular incoherent nanoparticle additions, have been shown to have great success in improving superconducting material performance[1], such as $REBa_2Cu_3O_y$ (REBCO) superconducting films and iron pnictide films [2,3]. To be effective, the nanoparticle (NP) size has to be tuned, and the density needs to be higher with no degradation of the matrix crystallinity and critical temperature (T_c) for greater enhancement.

We show how it is possible to tune to obtain both small size and high density of NPs while maintaining the crystallinity of the REBCO matrix deposited by metal organic deposition. We get significant improvement of the in-field critical current density (J_c) over a broad temperature range by changing the nanoparticle material and by modulating the precursor chemistry. The enhancements are seen not only in J_c but also in the reduction of the effects of thermal fluctuations (flux creep) over broad ranges of magnetic field and temperature. Moreover, we developed our simple pinning model in the case of adding NPs, and this model is in good agreement with experimental results for both cuprate and pinictide films. Detailed microstructural and superconducting properties for nanocomposite REBCO CCs will be presented.

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Keywords: Critical Current Density, Flux Pinning, Nanoparticles

WB1-3

Strongly Enhanced Critical Current in thickened $BaHfO_3$-doped $YBa_2Cu_3O_y$ Coated Conductors prepared by Vapor-Liquid-Solid Growth Technique

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In order to apply $REBa_2Cu_3O_y$ coated conductors (CCs) , it is indispensable to increase deposition rate and critical current (I_c). Therefore, to achieve a high deposition rate, Vapor-Liquid-Solid (VLS) growth technique, which combines PLD and LPE methods, has been proposed, [1]. Using VLS growth technique, it is possible to fabricate thin films with 5.3 nm/sec in the deposition rate [2]. In order to increase superconducting properties in magnetic fields, it is necessary to introduce Artificial Pinning Centers (APCs) in films. However, there are few reports of introduction of APC using VLS growth technique. Recently, we fabricated $BaHfO_3$ (BHO)-doped $YBa_2Cu_3O_y$ (YBCO) CC by using the VLS growth technique in 26.0 nm/sec of deposition rate and 1.4 μm in the thickness, and we confirmed the BHO-doped YBCO CC was increased I_c compared with that of pure YBCO samples[3]. In this study, we fabricated thickened BHO-doped YBCO CCs (1.4 – 4.2 μm) and investigated thickness dependence of crystallinities and I_c.

The VLS growth technique consists of the following three steps. The first step is to fabricate 3vol% BHO-doped YBCO layer as a solid layer. The second step is to form a liquid layer consisting of Ba-Cu-O on the solid layer. The last step is to supply BHO-doped YBCO through the vapor phase on the liquid and solid layers.

Fig. 1 shows thickness dependence of *a*-axis oriented ratio and FWHM of YBCO 006. Using VLS growth technique, there are no *a*-axis oriented grans in the thickened CCs. Moreover, it was confirmed that the FWHM of the YBCO 006 reflection decreases with increasing the film thickness. Fig. 2 shows applied magnetic field dependence of I_c in thickened CCs with the thickness of (a) 1.4μm (b) 2.8 μm and (c) 4.2 μm. I_c increased from 23 to 123 A/cm-w (77 K, 1 T) and from 7 to 56 A/cm-w (77 K, 3 T), respectively. We will discuss the superconducting properties in magnetic field at various temperature and investigate shapes of BHO nanostructures introduced into thickened YBCO CCs using TEM.

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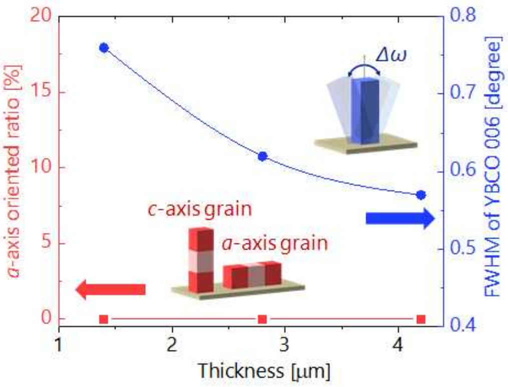

Fig. 1 Thickness dependence of *a*-axis oriented ratio and FWHM of YBCO 006

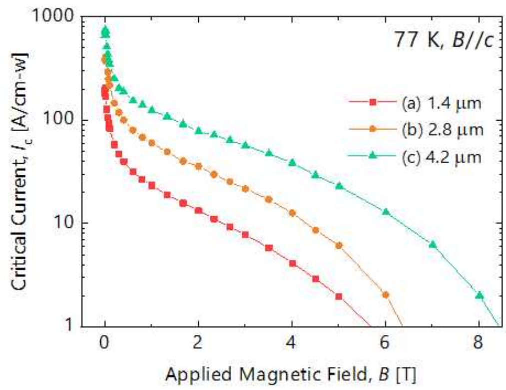

Fig. 2 Applied magnetic field dependence of I_c of (a) 1.4 μm (b) 2.8 μm (c) 4.2 μm thickened CCs.

Keywords: Vapor-Liquid-Solid Growth Technique, Thickened Film, High deposition rate, High magnetic field

WB1-4

Effectiveness of flux pinning by ion-beam induced defects at low temperatures

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Columnar defect tracks created by the passage of high-energy ions are well known to contribute strongly to flux pinning at 77K when the applied magnetic field is parallel to the tracks. A large and distinct peak can be observed in the angle dependence of the critical current (I_c) corresponding to the overlap of vortices and columnar defects. This is often offset though by a decrease of I_c at other angles due to reduced transition temperature T_c or reduced current percolation. When measured at lower temperatures, these peaks change significantly in shape and tend to broaden out approaching 20K. Coupled with being less sensitive to the reduced T_c this can lead to an enhancement of I_c over a wide angular range.

We have irradiated (Y,Dy)BCO coated conductor tapes from AMSC with 185 MeV Au ions or 50 MeV to 100 MeV Ag ions, and measured the magnetic anisotropy of I_c at temperatures from 20 K to 77 K and fields up to 8 T. We have seen that annealing at 200°C to 500°C following irradiation is generally beneficial, which we interpret as the restoration of oxygen order, but without the recrystallisation of the ion tracks.

The maximum entropy approach can be used to decompose the magnetic anisotropy into contributions from populations of pinning centres. We use this tool to track the evolution of peaks arising from ion irradiation over the available range of temperatures to understand how they combine with the background pinning landscape in different regimes.

Keywords: ion irradiation, flux pinning, critical currents, maximum entropy