WBP3-1

Development of New Scribing Technique by using Multiple-laser Beams for Multi-filamentary Coated Conductors

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The $REBa_2Cu_3O_{7-d}$ (RE123) coated conductors (CCs) with the multi-filamentary structure is very useful for controlling the AC-loss and the shielding current. We have developed laser scribing technique to fabricate multi-filamentary structure by irradiating a rectangular beam using excimer laser source (KrF, λ~248nm). Since the reflectance of stabilized silver and copper at the wavelength of Nd:YAG or fiber laser (~ 1 μm) is 98% or more, destructive thermal processing must be required for processing in that wavelength range, which was the reason why we chose the excimer laser as light source. Actually, we successfully fabricated scribing structure with high precision.
On the other hand, the improvement of the processing speed has been an important issue to be solved. Although the multi-laser beam system is effective for this purpose, the uniform intensity distribution in the width direction has to be realized. There is no strong Gaussian component in the excimer laser compared with a solid laser. The uniformity is useful for a single beam, however, it is not enough for the multi-beam system. In order to solve this issue, we have modified the beam intensity distribution by using homogenizer. Concretely, the beam intensity in the minor axis direction was flattened by a homogenizer using a plurality of horizontally elongated cylindrical lenses. This modification made the uniform range wider and it was confirmed that multi-laser beams can be applicable as a high-speed scribing technique.
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Keywords: Coated Conductors, Multi-filament, Scribing, AC-loss

WBP3-2

Development of surface planarization process using MOD-Y_2O_3 bed layer

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$REBa_2Cu_3O_y$ (RE: rare-earth element) coated conductors (CCs) have a high critical current density under a magnetic field at the liquid nitrogen temperature and a high potential performance for high magnetic field applications. In the case of CC tapes, a well-textured buffer layer is required for obtaining a biaxially oriented high-performance REBCO layer. The ion-beam assisted deposition (IBAD) is one of the popular techniques for fabrication of the well-textured buffer layer even on the non-textured metal substrate such as Hastelloy™. However, high surface smoothness is indispensable to the non-textured substrate using the IBAD technique. Therefore, an inexpensive surface planarization process has been required for fabrication of REBCO CCs with lower-cost and high-uniformity. In this study, we have investigated the surface planarization process using the MOD bed layer on the metallic Hastelloy™ substrate. The MOD-Y_2O_3 bed layer was prepared by dip-coating and heat-treating the solution containing of yttrium 4-oxopentanoate on Hastelloy™ substrate. Then, the buffered layer of PLD-CeO_2 / sputter-$LaMnO_3$ / IBAD-MgO was prepared on the MOD-Y_2O_3 / Hastelloy™. In this buffer layer-system, the requirements for polishing can be relieved and the number of bed layers can also be reduced into one from two, which both lead to the cost reduction.

The values of Ra roughness of the MOD-Y_2O_3 surface became smaller than that of the Hastelloy™ substrate (Ra = ～9－10 nm) with increase in coating times. Minimum value of Ra roughness of the MOD-Y_2O_3 surface achieved less than 2 nm, which is smooth enough for obtaining the highly texturing of IBAD-MgO layer. We will discuss the performance of the REBCO CCs using the substrate of PLD-CeO_2 / sputter-$LaMnO_3$ / IBAD-MgO / MOD-Y_2O_3 / Hastelloy™.

This work was supported by the New Energy and Industrial Technology Development Organization (NEDO).

Keywords: MOD bed layer, Y2O3, uniformity, low-cost

WBP3-3

Angular Dependence of J_c in YBCO Films with C-axis Correlated Nano-Rods and In-Plane Distributed Nano-Particles

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The quasi-multilayered films consisting of $YBa_2Cu_3O_y$ layers with $BaSnO_3$ nano-rods and the pseudo layers of in-plane distributed $BaSnO_3$ nano-particles were fabricated using a multilayering process in a PLD method, in order to clarify the pinning landscape simultaneously improving the critical current densities, J_cs, both at $B \mid\mid c$ and at $B \mid\mid ab$. The insertion of the impurity layers into $YBa_2Cu_3O_y$ films causes not only an enhancement of J_c at $B \mid\mid ab$ but also a reduction of J_c at $B \mid\mid c$. When the density of the in-plane distributed nano-particles is decreased, by contrast, the J_c peak at $B \mid\mid c$ by the nano-rods is maintained with the J_c peak at $B \mid\mid ab$ enhanced. This is attributed to the fragmentation of the channel for flux creep motion through the impurity layers. Furthermore, the J_c at $B \mid\mid c$ in high magnetic field and/or in tilted magnetic field off the c-axis enhances as the layers with the fragmented $BaSnO_3$ nano-particles are increased. These results indicates that the in-plane distributed nano-particles can have both the features of 2D- and 3D-pinning: the formation of the in-plane distributed nano-particles is one of the important factors for the hybrid flux pinning consisting of nano-rods and nano-particles which achieves the improvement of overall J_c.

Keywords: High-Tc superconductors, Critical current density, Flux pinning, Jc anisotropy

WBP3-4

Investigation of Particles formation in $GdBa_2Cu_3O_{7-\delta}$ coated conductors prepared by pulsed laser deposition

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$GdBa_2Cu_3O_{7-\delta}$ (GdBCO) coated conductors are expected as a promising candidate for practical superconductive wire, since the critical temperature of it is higher than that of YBCO. Particles such as REBCO (RE : Rare Earth) and second phase with submicron diameters are commonly observed on the surface of coated conductors prepared by pulsed laser deposition (PLD) [1] [2]. Nevertheless, second phase particles such as Gd_2O_3 and CuO are burying and observed in coated conductor, which degrades the c-axis orientation [3]. Furthermore, regarding number densities of particles that were including REBCO and second phase on coated conductors, in the case of GdBCO was found higher than that of YBCO. As a result, it seems that in case of GdBCO is more affected by particles than that of YBCO. The aim of our research is to reduce the number densities of these nanoparticles on the surface of coated conductors. First, we researched either targets are including second phase or not.
GdBCO target was sintered at the temperature of 960 °C, furthermore, YBCO target for comparison was sintered by same process. Both targets were examined by X-ray diffraction analysis (XRD).
Fig.1 (a) and (b) show XRD pattern of GdBCO and YBCO target, respectively. Both figures show random orientation of REBCO phase. Furthermore, it was found that the second phase such as RE_2O_3 and CuO was absent from the target. So that it seems that there is cause of second phase formation during PLD process.
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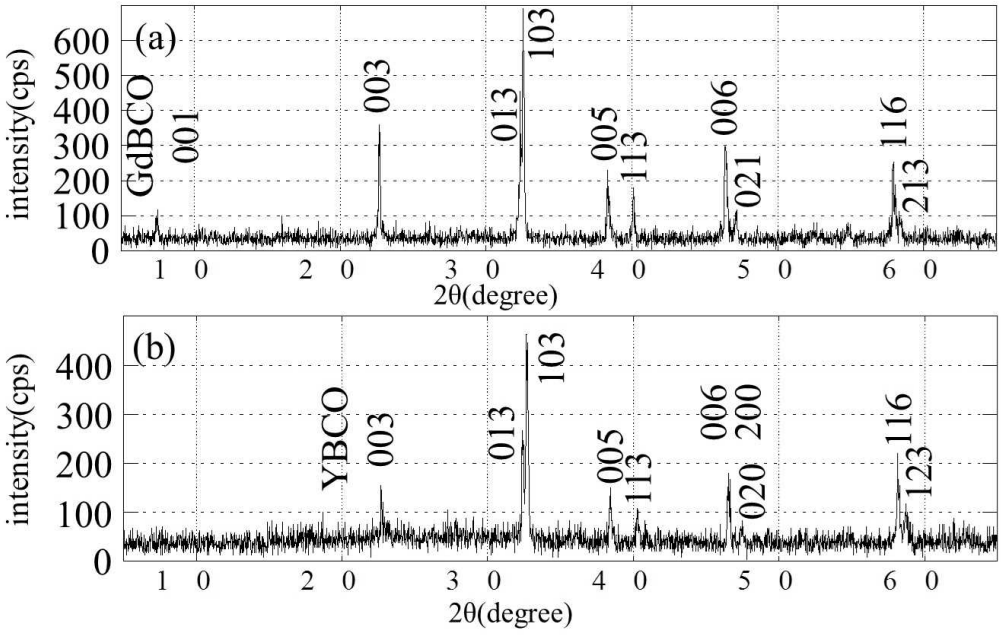

Keywords: GdBCO, YBCO, PLD

WBP3-5

Enhanced pinning properties of $EuBa_2Cu_3O_{7-\delta}$ films with Eu_2O_3 nanoparticles fabricated by Pulsed Laser Deposition

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Recently, the EuBCO coated conductor (CC) have been reported to be very promising for next generation superconducting wire due to a negligible reduction in critical current (I_c) with increasing film thickness up to ~3.6 μm. In this study, we tried to investigate the effect of the Eu_2O_3 nanoparticles on the pinning properties of EuBCO superconducting films. Both undoped and Eu_2O_3-doped EuBCO films were fabricated by PLD using KrF (λ=248 nm) laser on CeO_2-buffered MgO (100) single crystal substrates. The Eu_2O_3-doped EuBCO films with various x mol% (x = 0, 2, 4, 5, 6, and 8) of Eu_2O_3 relative to EuBCO were deposited by varying the area of Eu_2O_3 sector which was attached on the top of EuBCO target. 4 mol% Eu_2O_3-doped EuBCO film exhibited the highest pinning properties at relatively low temperature (<65K) and high magnetic field. Enhanced pinning properties are attributable Eu_2O_3 nanoparticles of ~ 20 nm diameter dispersed in the EuBCO matrix, which were analyzed by transmission electron microscopy (TEM). Further details will be presented for a discussion. This work was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) and the Ministry of Trade, Industry & Energy (MOTIE) of the Republic of Korea (No. 20131010501800). And Part of this study has been performed using facilities at IBS Center for Correlated Electron Systems, Seoul National University.

Keywords : EuBCO film, Pulsed Laser Deposition, Flux pinning

WBP3-6

The effect of composition ratio of Sm:Ba:Cu on the flux pinning centers in the SmBCO coated conductor

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We fabricated SmBCO coated conductor with flux pinning centers by controlling the composition ratio of Sm:Ba:Cu. The SmBCO film was deposited on the IBAD-MgO template with the structure of SmBCO/LMO/MgO/Y2O3/Al2O3/Hastelloy using EDDC(Evaporation Using Drum in Dual Chambers) process. We investigated the phase formations as pinning centers with the change of composition ratio of Sm:Ba:Cu. We found out that several phases were observed in the SmBCO matrix such as Sm2O3 and Sm/Ba anti-site when compositional ratio of Sm:Ba:Cu=1+x:2:3, which was confirmed by TEM analysis. Therefore five samples were prepared with the different Sm composition variation except for Cu/Ba ratio of 1.5, and Field dependence and angular dependence of critical current were measured for those samples to investigate the effect of Sm-related phases. We found out that Sm composition highly influenced the phase formation as pinning centers, and good superconducting properties under high magnetic field could be achieved by optimizing the compositional ratio of Sm:Ba:Cu.

Keywords: SmBCO, flux pinning center, reactive evaporation, superconducting coated conductor