WB6-1-INV

Recent results on flux pinning in nanoparticle-doped $REBa_2Cu_3O_y$ Coated Conductor by TFA-MOD

*Masashi Miura[1], Michio Sato[1], Takeharu Kato[2], Tomohiro Kato[2], Ryoji Yoshida[2], Koichi Nakaoka[3], Teruo Izumi[3]

Seikei University[1]
Japan Fine Ceramics Center[2]
National Institute of Advanced Industrial Science and Technology[3]

Nanostructural modifications, in particular nanoparticle additions, have been shown to have great success in improving Superconducting material performance, such as $REBa_2Cu_3O_y$ (REBCO) superconducting films [1-3] and iron pnictide films [4]. For REBCO coated conductors (CCs), NPs disrupt the superconducting parameter locally while maintaining crystallinity unperturbed elsewhere, thus pinning vortices at the NPs and therefore preventing dissipation. To be effective, the NP size has to be tuned, and the density needs to be higher for greater enhancement.

We show how an economically viable method, namely trifluoroacetate metal organic deposition (TFA-MOD), can be tuned to obtain both small size and high density of NPs while maintaining the crystallinity of the REBCO matrix. We achieve these goals in two ways: by changing the nanoparticle material and by modulating the precursor chemistry with the result of constraining the NPs spatially. We get significant improvement of the in-field critical current density (J_c) for NP-doped REBCO CCs over a broad temperature range. The enhancements are seen not only in J_c but also in the reduction of the effects of thermal fluctuations (flux creep) at all magnetic fields measured. Detailed microstructural and superconducting properties for nanocomposite REBCO CCs will be presented.

Acknowledgements: M.M. is supported by JSPS KAKENHI (17H03239 and 17K18888). A part of this work was supported by a research grant from the Japan Power Academy.

Reference: [1] J. Gutiérrez, J. et al. Nature Mater. **6** (2007) 367-373. [2] B. Maiorov, et al., Nature Mater. **8**, (2009) 398. [3] M. Miura et al., Scientific Reports, **6** (2016) 20436. [4] M. Miura et al., Nature Commun. **4** (2013) 2499

Keywords: Critical Current, Nanoparticles, Pinning, TFA-MOD

WB6-2-INV

Fast PLD growth of nanostructured YBCO coated conductors with artificial pinning centers

Max Sieger[1], Patrick Pahlke[1], Jens Hänisch[2], Mayraluna Lao[2,3], Michael Eisterer[3], Alexander Meledin[4], Gustaaf Van Tendeloo[4], Kornelius Nielsch[1], Ludwig Schultz[1], *Ruben Hühne[1]

Institute for Metallic Materials, IFW Dresden, Germany[1]
Institute for Technical Physics, Karlsruhe Institute of Technology, Germany[2]
Atominstitut, TU Wien, Vienna, Austria[3]
EMAT, University of Antwerp, Belgium[4]

$YBa_2Cu_3O_{7-x}$ (YBCO) and related compounds are promising materials for magnet and energy applications. The required flexible conductors are realized with the coated conductor technology using biaxially textured templates. More recently, significant efforts are devoted to enhance the current transport capability of the superconducting layers in magnetic fields by nano-engineering the microstructure using artificial pinning centers (APC) with an optimized size, density and distribution.
We prepared thick YBCO layers using PLD with a typical growth rate above 1 nm/s on industrially fabricated biaxially textured templates incorporating additional APC such as $BaHfO_3$ and the mixed double-perovskite $Ba_2Y(Nb/Ta)O_6$. Detailed TEM studies revealed size and distribution of the nanoparticles in dependence of the growth parameters showing typically a combination of *a*-*b*-oriented platelets and *c*-axis aligned nanorods. A critical current density J_c of up to 2 MA/cm^2 was determined at 77 K in self-field for 1 µm thick films. Electrical transport property measurements showed a reduced J_c anisotropy in magnetic fields for the doped samples. We will discuss how the anisotropy might be tuned on the textured templates by the deposition conditions and the resulting distribution of the APC. Additionally, nanocomposite YBCO films with a thickness of up to 7 µm were grown on these templates. The incorporation of APC leads to a denser microstructure and a reduction of misoriented YBCO grains. We found that the influence of the granularity is significantly reduced in particular for RABiTS-based conductors. Nevertheless, a strong increase of *a*-axis oriented YBCO grains was observed for films with a thickness above 5 µm reducing the overall J_c values.
The authors acknowledge financial support from EUROTAPES, a collaborative project funded by the European Union's Seventh Framework Programme (FP7 / 2007 - 2013) under Grant Agreement no. 280432.

Keywords: YBCO coated conductors, pinning, PLD

WB6-3-INV

Present status of High Performance REBCO Conductors and Recent Progress of Advanced MOCVD

*Goran Majkic[1,2,3,4]

University of Houston[1]
Department of Mechanical Engineering[2]
Texas Center for Superconductivity[3]
Advanced Manufacturing Institute[4]

We present on recent progress and current status of high performance, high engineering current densities (J_e) REBCO conductors. A substantial effort has been devoted towards improving the in-field performance of 2G-HTS conductors over a broad range of temperatures and fields via introduction of artificial pining centers, with particular focus on perovskite nanorods. We will present our recent progress in understanding the factors affecting $BaZrO_3$ nanorod growth and their effect on in-field performance, leading to increasing the critical current density to 20 MA/cm^2 at 30 K, 3 T. We will also present recent progress on Advanced MOCVD (A-MOCVD) reactor development, aimed at addressing the issues found in most superconductor deposition techniques such as a-axis grain formation, degradation of texture in thick films and poor precursor conversion efficiency. The progress is demonstrated by growing 4.8μm thick, BZO doped REBCO films in a single pass, achieving critical currents of 8705, 5586 and 3606 A/12mm at 3 T (B||c) and 30, 40 and 50 K, respectively, and corresponding J_e of 7068, 4535 and 2928 A/mm^2, which is a factor of ~7x higher than that of typical commercial HTS tapes with 7.5 mol% Zr addition. Such performance in thick films is a demonstration that growing thick REBCO films with high critical current density (J_c) in high magnetic fields is possible, contrary to the usual findings of strong J_c degradation with film thickness.

This work is supported by the U.S. Department of Energy Advanced Manufacturing Office, Office of High Energy Physics and the Office of Naval Research

WB6-4-INV

Progress in low cost chemical solution Nanocomposite $YBa_2Cu_3O_{7-x}$ coated conductors

*Teresa Puig[1], Ziliang Li[1], Cornelia Pop[1], Natalia Chamorro[1,2], Bohores Villarejo[1], Flavio Pino[1], Ferran Vallés[1], Bernat Mundet[1], Laia Soler[1], J. Jareño[1], Silvia Rasi[1,3], J. Banchewski[1], R. Guzmán[1], J. Gázquez[1], M. Coll[1], A. Palau[1], S. Ricart[1], J. Ros[2], J. Farjas[3], P. Roura[3], X. Obradors[1]

Institut de Ciència de Materials de Barcelona, ICMAB-CSIC Campus de la UAB, 08193 Bellaterra, Spain[1]
Departament de Química, Universitat Autonoma de Barcelona, Campus UAB, 08193 Bellaterra, Spain[2]
GRMT, Department of Physics, University of Girona, E17071-Girona, Spain[3]

High current superconducting wires for large scale applications and magnets has been one of the most challenging achievements during all the HTS era. Coated conductors of $YBa_2Cu_3O_7$ (YBCO) have emerged as the most attractive opportunity to reach unique performances while reducing the cost/performance ratio continues to be a key objective at present. Chemical solution deposition (CSD) is a very competitive cost-effective technique which has been used to obtain nanocomposite films and CCs. In the recent years we have been able to demonstrate the unique potentiality of these CSD techniques to achieve low cost, low anisotropy and high critical current coated conductors. In my presentation, I will report on the present understanding of growth process and vortex pinning of CSD nanocomposite YBCO films, obtained from complex solutions where the nanoparticles are spontaneously segregated during growth and the novel strategy using colloidal solutions of preformed oxide nanoparticles (NPs) stabilized in the YBCO precursor solutions. A thorough investigation correlating the pinning landscape with the defect microstructure has been pursuit with detailed angular dependent in-field critical currents and HRTEM/STEM analysis. I will also report on a new approach we are investigating based on low cost nanocomposite CSD crystallization through a transient-liquid assisted growth (TLAG) enabling ultrafast growth rates in the range of 50 nm/s.

This research has been funded by EU-ERC_AdG-2014-669504ULTRASUPERTAPE project, EU-FP7 NMP-LA-2012-280432 EUROTAPES project and Excellence Program Severo Ochoa SEV2015-0496

Keywords: CSD, Nanocomposites growth, vortex pinning, films and coated conductors

WB6-5-INV

High performance $REBa_2Cu_3O_y$ coated conductors with designed artificial pinning center

*Yutaka Yoshida[1], Yusuke Ichino[1], Yuji Tsuchiya[1], Kaname Matsumoto[2], Teruo Izumi[3], Ataru Ichinose[4], Satoshi Awaji[5]

Nagoya university[1]
Kyushu Inst. Tech[2]
AIST[3]
CRIERI[4]
Tohoku university[5]

We study to determineabout optimum shapes of the artificial pinning center (APC) of $REBa_2Cu_3O_y$ (REBCO) coated conductors towards superconducting magnets operating at temperatures of 77 K or less.and lower temperature. Superconducting properties have been changedvary depending on the by different kind and addition amountquantity of $BaMO_3$ added to REBCO. Therefore, we study the changes in theof shapes of nanorods that areshape due to the difference in theof nature of additives and growth temperature. In addition, weand aim to control the APC having anwith the optimum shape that matchesing the operating temperature.

The high flux pinning performance was obtained for a 3.8vol.% $BaHfO_3$ (BHO)-doped $SmBa_2Cu_3O_y$ (SmBCO) on IBAD-MgO. At 77.3 K, the irreversibility field (B_{irr}) of 16.8 T and the maximum flux pinning force density (Fp) of 32.5 GN/m3 (B//c) were achieved. In addition, the maximum Fp values of 400 GN/m_3 and 120 GN/m^3 for B//c were realized at 40 K and 65 K.

In particular, we describe the shape control of nanorods in SmBCO coated conductors by employingusing low temperature growth (LTG) technology using seed layers. From the cross-sectional TEM observations, weit was confirmed that using the LTG technique, the BHO nanorods, which were comparatively thin in diameter and short in length, formed athe fireworks structure in the case of SmBCO coated conductors. using the LTG method. The superconducting properties in the magnetic field of the SmBCO- coated conductor on IBAD-MgO with the optimum amount of BHO showed that F_{pmax} = 1.5 TN / m ^{3} at 4.2K.

On the other hand, the high-speed growth technique for high performance SmBCO coated conductor is an important subject. In this presentation, we will describe the development of the coated conductor fabricated with a repetition rate of 100 Hz, changed from 10 Hz. We will discuss the details of microstructures and superconducting properties of BHO nanorods in SmBCO coated conductor using the laser system with high repetition rate.

This work was partly supported by a Grant-in-Aid for Scientific Research (15H04252 and 16H04512). A part of this work includes the results supported by the ALCA project of the Japan Science and Technology Agency (JST) and NU-AIST alliance project.

Keywords: flux pinning, artificial pinning center, microstructure, nanorod

WB6-6-INV

Analysis and Modeling of Current Transport Properties in Long Length Coated Conductors

*Takanobu Kiss[1], Kohei Higashikawa[1], Takumi Suzuki[1], Yuhei Nishimiya[1], Yuta Onodera[1], Masayoshi Inoue[1], Mitsunori Igarashi[2], Kazuomi Kakimoto[2], Yasuhiro Iijima[2]

Dept. of Electrical Engineering, Kyushu University, Fukuoka 819-0395, Japan[1]
Fujikura Ltd. Sakura 285-8550, Japan[2]

Current-Voltage (*I*-*V*) characteristic is one of the most fundamental properties of superconducting materials for practical applications. While the *I*-*V* characteristics are usually measured by using a short piece sample and/or a micro-bridge, practical applications require long length tapes in hundreds of meters to several kilo-meters. Spatial homogeneity becomes an important issue in such cases because the minimum I_c will limit the total performance of the full-length of the tape. Therefore, I_c in the long length tape has been studied significantly as a function of longitudinal coordinate. However, it is not yet fully understood the relationship between the local I_c variation and the global *I*-*V* characteristics. In this study, we have investigated current transport properties in long length coated conductors (CCs) based on coupled analysis using reel-to-reel high-speed scanning Hall probe microscopy and site-specified transport measurements. An analytical model to describe the relationship between the local I_c variation and the global *I*-*V* characteristics in such long length CCs have been proposed. Furthermore, we will discuss a method to increase reliability, robustness and current carrying capability of the CCs under the influence of spatial I_c variation.

Acknowledgements: This work was supported by “JSPS KAKENHI (16H02334)” and “NEDO”.

Keywords: critical current, current transport, coated conductor, modeling