TT 12: Symposium "Coated HTS Conductors"

Time: Tuesday 9:30–13:00 Location: H20

Invited Talk TT 12.1 Tue 9:30 H20

Improvement of the Critical Current Density in YBCO Coated Conductors — •Bernhard Holzapfel — IFW Dresden, Helmholtzstr. 20, 01069 Dresden

The Jc limitation mechanism in coated conductors based on biaxially textured metal substrates depends strongly on the applied magnetic field. Up to a texture dependent crossover field, the network of small angle grain boundaries limits Jc. Below this crossover field Jc can be improved by optimizing the grain boundary network. At higher magnetic fields above the crossover field, Jc is limited by the intragrain pinning properties. Here we report on different material aspects connected to the Coated Conductor to improve the overall critical current density. Based on optimized cube textures in recrystallized metal tapes and appropriate buffer layer architectures, Jc of coated conductors at lower magnetic fields can be improved by geometrically tailoring the grain boundary network using cube textured substrates with high aspect ratio grains. For higher magnetic fields, where the intragrain pinning properties limit Jc, our experiments to introduce artificial pinning centres by preparation of quasi-multilayers where sub unit cell thin metal layers were incorporated in Y123 films will be discussed. Due to the oxidizing deposition atmosphere and solid state reaction with the Y123 phase nanometre sized perovskite precipitates, which are epitaxially incorporated into the Y123 lattice, are formed. Pinning properties and Jc anisotropy at various fields and temperatures were analyzed. At 77K irreversibility fields up to 10.3T were observed in Y123 quasi-multilayers containing nano-sized BaHfO3 precipitates.

TT 12.2 Tue 10:00 H20

A Reel to Reel MOCVD process for Coated Conductors — •Oliver Stadel[1], Ruslan Muydinov[1], Jürgen Schmidt[1], Hartmut Keune[1], Georg Wahl[1], Sergej Samoilenkov[2], Andrej Blednov[2], Georgy Dosovitskiy[2], Oleg Gorbenko[2], and Andrey Kaul[2] — [1]Institut für Oberflächentechnik, TU Braunschweig, Bienroder Weg 53, 38108 Braunschweig — [2]Moscow Department of Chemistry, State University V 234, Moscow,119 899, Russia

A MOCVD process for contiuous deposition of YBCO and oxide buffer layers on long metal tapes was developed. Texured Ni alloyed tapes were coated with oxide buffer layers at low oxygen partial pressure without oxidation of the metal tape. 350-1000 nm thick YBCO films were deposited at a tape velocity of 4 m/h. MOCVD buffer layers and additional samples, which were delivered from partners of the Virtual Institute, were used. The YBCO films on chemically coated buffer layers exhibit 0.3-7 MA/cm2 at 77 K. On PVD coated buffer layers the critical current density was 1-2 MA/cm2. The excellent in plane texture (FWHM = 5-6°) and out of plane texture (FWHM = 1.4-3°) of the YBCO films on chemically coated buffer layers may enable to increase further the critical current density.

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TT 12.3 Tue 10:15 H20

The potential of Roebel assembled coated conductor cables — •Curt Schmidt — Forschungszentrum Karlsruhe, Institut für Technische Physik, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

Low ac-loss HTS cables for transport currents well above 1 kA are required for application in transformers and generators and are taken into consideration for future generations of fusion reactor coils. Coated conductors (CC) are suitable candidates for high field application at an operation temperature in the range 50-77 K, which is a crucial precondition for economical cooling costs. We prepared a short lengths of Roebel bar cables made from industrial DyBCO-CC (Theva Company, Germany) and YBCO-CC (Superpower). Meander shaped tapes of 4 (5) mm width with twist pitches of 122 (180) mm were cut from the 10 (12) mm wide CC tapes using a specially designed tool. Eleven or sixteen of these strands were assembled to a cable. The electrical and mechanical connection of the tapes was achieved using a silver powder filled conductive epoxy resin. Ac losses of a short sample in an external ac field were measured as a function of frequency and field amplitude in transverse and parallel field orientations as well as the coupling current time constant in transverse field. The potential of this cable type for ac-use is discussed with respect to ac-losses and current carrying capability.

15 min. break

TT 12.4 Tue 10:45 H20

Limitation of fault current in power grids using YBCO coated conductors — •Wolfgang Schmidt[1], Hans-Peter Krämer[1], Heinz-Werner Neumüller[1], Urs Schoop[2], Alex Malozemoff[2], and Alex Otto[2] — [1]Siemens AG, Corporate Technology, Erlangen, Deutschland — [2]American Superconductor Corporation, Westborough (MS), USA

Resistive type superconducting fault current limiters (FCL) utilize a current-driven transition from the superconducting state to the normal state to limit short circuit currents in electric power grids. The FCL needs not triggering and recovers automatically after the short circuit has been opened. The technical performance of superconducting fault current limiters has been demonstrated within numerous successful projects worldwide. Since the advent of commercial second generation (2G) high temperature superconductor wires based on YBCO thin films, also the economic feasibility comes into reach. We have investigated the fault current limiting performance of 344 superconductors stabilized with stainless steel sheets supplied by American Superconductor Corporation within a co-operation with Siemens Corporate Technology. Bifilar coils have been manufactured and tested with a typical limitation period of 50 ms under stepwise increasing voltage loads to determine the maximum temperature the wires can withstand without degradation. Several coils have been assembled into a limiter model to demonstrate uniform tripping of the individual coils and fast recovery with few seconds. Test results of single coils and of the coil assembly are presented and further developments will be discussed.

TT 12.5 Tue 11:00 H20

Switching and Quench Propagation in Coated Conductors for Fault Current Limiters — •Helmut Kinder[1], Jörg Handke[1], Werner Prusseit[1], Andrej Kudymow[2], Christian Schacherer[2], and Mathias Noe[2] — [1]THEVA Dünnschichttechnik GmbH, Ismaning — [2]ITP, Forschungszentrum Karlsruhe

We address the use of coated conductors for resistive fault current limiters. Fast quench propagation is essential to let the conductor switch on the full length within milliseconds. The ordinary thermal quench propagation mechanism, however, is too slow because of the small heat diffusivity in typical tape substrate materials. Here we present a new mechanism involving a propagating instability of the superconductor made possible by the particular conductor design. The instability is based on current bunching leading to overcritical current densities and does not rely upon thermal conductivity. It leads to a rapid spreading of the resistive state so that the conductor develops its full normal resistance in a millisecond. Thus the conductor protects itself without the need of thick normal conducting stabilizers that would reduce the current limiting efficiency. The mechanism was confirmed by numerical simulations and by experiments on samples of short and medium length. Conductor lengths of 1 m and more switched homogeneously exhibiting voltage drops of up to 2.7 V/cm.

TT 12.6 Tue 11:15 H20

Nexans Advances in all CSD Route for REBCO Coated Conductors — Joachim Bock, Juergen Ehrenberg, Bernhard Hoppe, Dirk Isfort, Marcel Klein, and •Mark Rikel — Nexans SuperConductors, Chemiepark Knapsack, Huerth 50351, Germany

Development of REBCO coated conductors (CC) at Nexans SuperConductors (NSC) is focused on all chemical solution deposition (CSD) route that promises the best performance-to-price ratio in long lengths. The feasibility of all CSD approach is shown on the lab scale: using metalorganic deposition (MOD), NSC was able to produce YBCO/CeO_2/LZO/NiW CCs with J_c(77 K, sf) = 0.5 MA/cm^2. The major advance of NSC on a semi-industrial scale is the use of MOD route for production of high-quality $La_2Zr_2O_7$ (LZO) coated NiW RA-

BITS in lengths up to 12 m. With those substrates, it is possible to produce CCs with the simplest (one-buffer) architecture by depositing REBCO using other techniques (ISD at Theva, Ismaning; MOCVD at IOT, Braunschweig; HLPE at University of Cambridge, UK). The best short sample I_c = 280, 120 and 100 A/cm-width for HLPE, ISD, and MOCVD, respectively First long-length conductors show transport I_c = 40 A (10m-long, ISD). Further work is focused on optimisation of the already established mixed (MOD+PVD) approaches, understanding optimum architecture and processing conditions for the all-CSD route and developing tools for scaling those conditions to long-length production.

The work is supported in part by BMBF (SupraNanoSol, ForOxid) and EU (HiperChem, Super3C).

TT 12.7 Tue 11:30 H20

Temperature series to study the biaxial texturing of $La_2Zr_2O_7$ buffer layers on nickel-tungsten substrates — •Leopoldo Molina[1], Sebastian Engel[2], Bernhard Holzapfel[2], and Oliver Eibl[1] — [1]Institute of Applied Physics, University of Tübingen, Auf der Morgenstelle 10, D-72076, Tübingen, Germany — [2]IFW Dresden, P.O.Box 270116, D-01171 Dresden, Germany

$La_2Zr_2O_7$(LZO) buffer layers are currently of great interest for $YBa_2Cu_3O_{7-x}$(YBCO) coated conductor technology. The mechanism of biaxial texturing of the film was investigated by varying the annealing temperature. The LZO buffer layers were prepared by chemical solution deposition (CSD) and annealed at temperatures ranging from 600°C to 1000°C in order to study the growth, biaxial-texture and microstructure of the LZO thin films. Nanovoids of 10-50 nm were found to be a typical feature of the buffer layers. Samples were investigated by transmission electron microscopy (TEM) and x-ray diffraction (XRD). Diffraction contrast imaging and convergent beam electron diffraction (CBED) techniques were used to investigate the microstructure of the films in plan-view and cross-section. XRD measurements showed that LZO grain growth starts at T>800°C. The average Ni grain size of the biaxially textured nickel tungsten substrates is $40\mu m$ and the grain size of the LZO buffer layers is 100-200 nm. Thus, even though the films are highly biaxially textured, no epitaxial growth occurs.

15 min. break

TT 12.8 Tue 12:00 H20

The pyrolysis of $YBa_2Cu_3O_{7-\delta}$ thin films produced by metal-organic deposition using trifluoroacetic acid-based precursors — •Thomas Thersleff[1], Sebastian Engel[1], Martina Falter[1], Brigitte Schlobach[1], Kerstin Knoth[1], Ludwig Schultz[1,2], and Bernhard Holzapfel[1] — [1]Leibniz IFW-Dresden, Postfach 270116, 01171 Dresden, Germany — [2]Dresden University of Technology, Department of Physics, D-01062 Dresden, Germany

To assist with the optimization of the TFA-MOD process for $YBa_2Cu_3O_{7-\delta}$ coated conductor development, this work examines the pyrolysis stage - in which organic constituents are burned off - on both single crystal as well as buffered nickel substrates. Samples were dip-coated into precursor solutions prepared using metal acetates as well as $YBa_2Cu_3O_{7-\delta}$ powder dissolved in trifluoroacetic acid and placed in a flowing gas furnace with a humid O_2 atmosphere. While firing, individual samples were quenched at various temperatures, effectively freezing the pyrolysis development. These samples were then analyzed for phase formation using grazing incidence x-ray diffraction; surface morphology using AFM; decomposition reactions using TGA, DTA, and exhaust gas characterization; and stoichiometry using EDX. Additionally, cross-sectional cuts were made in the pyrolyzed layers with a FIB, facilitating a detailed discussion of the layer morphology. Results indicate that significant layer shrinkage occurs between 200 and 250 °C and reveal a large surface tension. BaF_2 crystallizes above 270 °C while CuO forms above 200 °C. FIB results suggest that HF gas evolves above 200 °C but is trapped within the layer until 270 °C.

TT 12.9 Tue 12:15 H20

Artificial pinning centers in $YBa_2Cu_3O_{7-x}$ thin films created by nanoparticles from the gas phase — •Maria Sparing, Elke Backen, Thomas Freudenberg, Jörg Acker, Ruben Hühne, Ludwig Schultz, Bernd Rellinghaus, and Bernhard Holzapfel — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

The critical current density in $YBa_2Cu_3O_{7-x}$ (YBCO) thin films, which limits their application in high magnetic fields, can be enhanced by the introduction of artificial pinning centers as, e.g., provided by nanoparticles. An inert gas phase condensation process was used to prepare Y_2O_3 nanoparticles from an yttrium target by DC magnetron sputtering. With this method, both the size distribution and the areal density of the particles as determined from TEM investigations are independently controlled during deposition. Particles with a mean diameter of about 8 nm were deposited on $SrTiO_3$ substrates, which are terminated by TiO_2 through etching with BHF solution and subsequent annealing in 1 atm O_2 at 900°C. The behavior of the particles on the substrate at varying temperatures in an O_2 atmosphere of 0,7 mbar (YBCO deposition conditions) was studied by AFM and ICP-MS. A 300 nm thin $YBa_2Cu_3O_{7-x}$ layer was deposited onto the likewise precoated substrates by off-axis pulsed laser deposition. Both inductive and resistive transport measurements at 77K in magnetic fields of up to 9 T reveal the influence of the particles on the superconducting properties of $YBa_2Cu_3O_{7-x}$.

TT 12.10 Tue 12:30 H20

Development of conductive buffer architectures based on IBAD-TiN — •Ruben Hühne, Martin Kidszun, Konrad Güth, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany

Ion beam assisted deposition (IBAD) offers the possibility to prepare thin textured films on amorphous or non-textured substrates. It was shown within the last decade that thin cube textured MgO and TiN layers can be produced on amorphous or nanocrystalline seed layers using this technique. Especially the results on the in-plane textured growth of TiN are promising for the development of a conducting buffer layer architecture for YBCO coated conductors based on the IBAD approach. Therefore, IBAD-TiN layers have been deposited on Si/Si_3N_4 as well as on polished Hastelloy tapes using pulsed laser deposition. Different metallic buffer layers as Au or Ir were grown epitaxially on top of the TiN layer showing similar texture values as the IBAD layer. Finally, biaxially textured YBCO layers were achieved using a conductive oxide cap layer. Detailed measurements of the structural and superconducting properties will be presented.

TT 12.11 Tue 12:45 H20

Improved pinning in $YBa_2Cu_3O_{7-x}$ based quasi-multilayers prepared by off-axis pulsed laser deposition — •Elke Backen, Karolin Tscharntke, Sebastian Engel, Ruben Hühne, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Higher in-field J_c values of thin $YBa_2Cu_3O_{7-x}$ (YBCO) films due to pinning at artificial pinning centers are of great interest for the development and improvement of coated conductors. It is possible to enhance the pinning forces in YBCO by introducing nanosized particles into the films using quasi-multilayers of YBCO and a transistion metal (Hf, Zr, Ir) by on-axis pulsed laser deposition [1,2]. In order to improve reproducibility, off-axis PLD was used to prepare YBCO/Hf multilayers. Due to the oxidizing deposition atmosphere and solid state reaction with the YBCO phase, nanometre sized perovskite precipitates, that are biaxially textured with a well-defined relationship towards the YBCO lattice were formed. Pinning properties and the J_c anisotropy were characterized using magneto-transport measurements at various fields and temperatures. A significant improvement of J_c as well as irreversibility field B_{irr} could be observed in the off-axis deposited quasi-multilayers.

[1] Hänisch et al. Appl. Phys. Lett. 86 (2005) 122508.
[2] Hänisch et al. Supercond. Sci. Technol. 19 (2006) 534-540.