WB2-1

Structural, mechanical and electrical characterization of long length *RE*BCO tapes for FCL applications

*Sandra Kauffmann-Weiss[1], Mayraluna Lao[1], Simon Otten[1], Veit Große[2], Markus Bauer[2], Bernhard Holzapfel[1], Jens Hänisch[1]

Institute for Technical Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany[1]
THEVA Dünnschichttechnik GmbH, Ismaning, Germany[2]

One promising solution for renewable electricity over long distances is the realization of high voltage DC super-grids, but the management of fault currents remains an issue even if DC circuit breakers have emerged. Superconducting Fault Current Limiters (SCFCLs) using *RE*BCO tapes have proved their outstanding performances for fault current limitation on medium voltage AC systems and it is already demonstrated that these tapes can be produced in the necessary length for FCL applications. However, to realize advanced cost-effective *RE*BCO tapes, first the characteristics of the tapes have to be improved further. The aim of European project FASTGRID (Cost effective FCL using advanced superconducting tapes for future HVDC grids) is the property improvement of the *RE*BCO tapes in order to significantly enhance the electric field limit that leads to economical attractiveness of SCFCL for high voltage DC applications. High critical currents will help to reduce the cost as the absolute length of the tapes is reduced for a given design and the device size will decrease. Furthermore, the metallic stabilization layer has to be suitable for good electrical contact. However, for high electric fields, the thickness of the Ag coating has to be decreased to the minimum. The process and architecture developed on short lengths has to be implemented for the long length production.
This presentation focusses on (micro-)structural and electrical characterization of THEVA tapes and shows promising results of structural and electrical homogeneity in combination with a high critical current density (> 1000 A/cm at 65K, self-field).

Acknowledgements
This project has received funding from the European Union's Horizon 2020 research and innovative program under grant agreement No 721019.

Keywords: long-length REBCO-tapes, Superconducting Fault Current Limiters

WB2-2-INV

Recent Progress on CORC® Cables and Wires

*Danko van der Laan[1], Jeremy Weiss[1], Ulf Trociewitz[2], Ernesto Bosque[2], David Larbalestier[2], Xiaorong Wang[3], Chul Kim[5], Sastry Pamidi[5], Tim Mulder[6], Herman ten Kate[6]

Advanced Conductor Technologies LLC, Boulder, CO 80301, U.S.A and the Department of Physics, University of Colorado, Boulder, CO 80309, U.S.A[1]
National High Magnetic Field Laboratory, Florida State University, Tallahassee, FL 32310, U.S.A[2]
Lawrence Berkeley National Laboratory, Berkeley, CA 94720, U.S.A.[3]
Center for Advanced Power Systems, Florida State University, Tallahassee, FL 32310, U.S.A.[5]
CERN, Geneva, Switzerland and the University of Twente, Enschede, the Netherlands[6]

Advanced Conductor Technologies has been developing Conductor on Round Core (CORC®) cables and wires wound from REBCO coated conductors for use in power transmission systems and in high-field magnets. Over the last 5 years, the in-field performance of CORC® cables and wires has been increased to the level that they've become viable candidates for high-field magnets. At the same time, low-resistance cable terminations have been developed resulting in homogeneous injection of currents that now allow CORC® power transmission cables to operate at high currents in pressurized helium gas and enable demountable fusion magnets. An overview of the current status and future plans of CORC® cables and wires is presented, including the latest results of the 80 kA-class 6-around-1 CORC®-CICC that was tested in SULTAN.

A 10-meter long 2-pole dc CORC® power transmission cable system cooled by pressurized helium gas was successfully tested, demonstrating an operating current of 8,000 A at 50 K. CORC® Fault Current Limiting (FCL) wires capable of generating a voltage of 70 V/m within several milliseconds after an overcurrent event was introduced. No degradation of the CORC® FCL wire was measured after more than 100 faults in which the wire warmed up to room temperature within milliseconds.

CORC® cables and wires have reached a point where they're viable conductors for fusion, accelerator and other high-field magnets. The next step in CORC® cable and wire development has recently been initiated where CORC®-based insert magnets are being developed. Several of these magnet programs will be discussed, including the development of canted-cosine-theta (CCT) accelerator magnets using CORC® wires and a CORC® wire insert solenoid that would generate about 3 T in a 14 T background field.

Acknowledgement

This work was in part supported by the US Navy under agreements N00024-14-C-4065 and N00024-16-P-4071, and the US Department of Energy under agreement numbers DE-SC0007891, DE-SC0007660, DE-SC0009545, DE-SC0014009 and DE-SC0015775.

WB2-3

Numerical modelling of dynamic resistance in high-temperature superconducting coated-conductor wires

*Mark D Ainslie[1], Chris W Bumby[2], Zhenan Jiang[2], Ryuki Toyomoto[3], Naoyuki Amemiya[3]

Bulk Superconductivity Group, Department of Engineering, University of Cambridge[1]
Robinson Research Institute, Victoria University of Wellington[2]
Department of Electrical Engineering, Graduate School of Engineering, Kyoto University[3]

The use of any superconducting wire within an AC power system is complicated by the dissipative interactions that occur when a superconductor is exposed to an alternating current and/or magnetic field. This gives rise to a superconducting AC loss, caused by the motion of vortices within the superconducting material. In practical applications, a cryogenic cooling system must extract the resulting heat load in order to enable constant temperature operation, and this means a comprehensive understanding of the mechanism and magnitude of AC losses is extremely important to the design and development of new superconducting magnets and rotating machines.
AC loss also arises when a superconductor is exposed to an alternating field whilst carrying a constant DC transport current. In this case, a DC electrical resistance is observed, commonly referred to as "dynamic resistance." This situation is relevant to many potential high-temperature superconducting (HTS) applications, including superconducting synchronous machines, NMR magnets and other unshielded DC magnet applications, and this dynamic resistance been identified as the underlying mechanism for HTS flux pump devices.

In this presentation, a 2D numerical model implementing the H-formulation is used to calculate the dynamic resistance and total AC loss in a coated-conductor HTS wire carrying an arbitrary transport current and exposed to background AC magnetic fields up to 100 mT. The measured angular dependence of the wire, $J_c(B,\theta)$, and n value, $n(B,\theta)$, for the E-J power law representing the superconductor's electrical resistivity, are used as input data, and the model is validated using measured experimental data for magnetic fields perpendicular to the top surface of the wire, as well as at angles of 30º and 60º. The model is then used to obtain insights into the particular characteristics of such dynamic resistance, including its relationship with the applied current and field and the threshold field above which dynamic resistance is generated.

Keywords: numerical modelling, high-temperature superconductivity, dynamic resistance, coated conductor

WB2-4-INV

Progress and Status of 2G-HTS Wire Development in China

*Yue Zhao[1,2], Xiang Wu[1], Jiamin Zhu[1], Zhiwei Zhang[1,2], Wei Wu[1,2] , Zhiyong Hong[1,2], Yijie Li[12], Zhijian Jin[2], Yutaka Yamada[2]

Shanghai Superconductor Technology Co. Ltd., 200240 Shanghai, People's Republic of China[1]
Department of Electrical Engineering, Shanghai JiaoTong University, 200240 Shanghai, People's Republic of China[2]

Recently, thanks to the great supports from government and strategic investors, significant progresses on the second generation superconducting tapes (2G-HTS) have been made in China, in terms of both materials upscaling and applications. In this talk, I will first give a brief summary of the R&D of 2G HTS wire fabrication, especially focusing on three major manufactures, Shanghai Superconductor Technology Co., Ltd. (SSTC), Shanghai Creative Superconductor Technology Co. Ltd. (SCST) and Samri. All these companies are using the IBAD substrates, but different REBCO layer deposition techniques. After several years' R&D, these vendor are capable of offer high performance 2G-HTS tapes up to several hundred meters long. Some of the performance of the 2G-HTS tapes are comparable with those offered by the word-leading companies but with much lower price. In particular, SSTC co-established in 2011 with Shanghai Jiao Tong University has already commercially delivered the products to domestic and international customers, e.g., Chinese academy of science, Tsinghua University, SECRI, KIT, etc. So far, average I_c value (at 77 K, self field) of higher than 350 A/cm-width is achieved, while excellent superconducting performance of I_c exceeds 1000 A/cm-width at 4.2 K, 12 T due to the presence of instinct pinning centers. Moreover, an advanced lamination techniques have been developed in order to meet the requirements of mechanical performance for the practical applications. Additionally, in order to provide standardization procedures to characterize the superconducting performance on long-length 2G-HTS tapes for the manufactures and users in China, several efforts have also been made leading by National Standardization Committee. At the end of my talk, several ongoing and potential application cases based on 2G-HTS tapes are also mentioned, such as magnet, fault current limiters and transmission cables.

WB2-5-INV

Recent progress on the development of Bi2223 in SEI

*Tomoyuki Okada[1], Shin-ichi Kobayashi, Goro Osabe[1], Masashi Kikuchi[1], Satoru Yamade[1], Takayoshi Nakashima[1], Soichiro Takeda[1], Kenta Niki[1], Kazuhiko Hayashi[1], Takeshi Kato[1]

Sumitomo Electric Industries, Ltd., Japan[1]

Sumitomo Electric Industries, Ltd. (SEI) has been developing silver-sheathed Bi2223 multi-filamentary wires, DI-BSCCO. The wires have been improved various properties in response to growing demands from application products and projects.

For high magnetic field application, DI-BSCCO wires need to endure the intense hoop stress and maintain high engineering critical current (J_e). Lamination with Ni alloy tapes has proved to be a more feasible way to solve these challenges. Combination of the thin (30 μm-thick) Ni alloy tapes and the lamination technique with "pre-tension" has significantly enhanced the mechanical properties of the DI-BSCCO wires. For example, critical double bending diameter at room temperature ~ 35 mm, critical tensile stress at 77 K ~ 440 MPa, and critical tensile strain at 77 K ~ 0.5 %. The DI-BSCCO wires laminated with the Ni alloy tapes are commercialized as Type HT-NX (2015~). In terms of more practical use, the high resistivity of the Ni alloy results in the generation of the high Joule heat at the joint. The newly developed spliced structure successfully reduced the splice resistance without sacrificing the mechanical properties. In this presentation, the detailed performances of the currently available wires and the updated R&D activities will be shown.

Keywords: Bi-2223, reinforced wire, Type HT-NX, splice technique