AP1-1-INV

Portable high-field magnet systems using bulk high-temperature superconductors

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Bulk high-temperature superconductors can be used, when cooled to cryogenic temperatures, as super-strength, stable permanent magnets capable of generating fields of several Tesla. This makes them attractive for a number of engineering applications that rely on high magnetic fields, including compact and energy-efficient motors/generators with unprecedented power densities, magnetic separation and compact and portable magnetic resonance imaging (MRI) and nuclear magnetic resonance (NMR) systems.
In this presentation, we report our recent developments in portable high-field magnet systems using bulk high-temperature superconductors, including: 1) cryogenic system design that emphasises flexibility and portability, but with operating temperatures down to around 50 K or lower, 2) a compact pulsed field magnetisation (PFM) system, including pulse waveform control and the exploitation of flux jumps during the PFM process, and 3) solenoid- and split-type magnetising coil options.

Keywords: Bulk high-temperature superconductors, Portable magnet system, Large scale applications

AP1-2-INV

A Hybrid Trapped Field Magnet Lens (HTFML): concept and experimental realization

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The concept of a Hybrid Trapped Field Magnet Lens (HTFML) is described, which exploits two different characteristics of type-II superconductors: the “vortex pinning effect” of an outer superconducting bulk cylinder, which acts as a trapped field magnet (TFM) using field-cooled magnetization (FCM), combined with the “diamagnetic shielding effect” of an inner bulk magnetic lens using zero-field cooled magnetization (ZFCM) [1]. The HTFML can reliably generate a concentrated magnetic field in the center of the lens that is higher than the trapped field from both the cylindrical bulk TFM and the external magnetizing field, even after the externally applied field decreases to zero. We predicted numerically a concentrated field of B_c= 4.73 T under an external magnetizing field of B_{app}= 3.0 T using an MgB_2TFM cylinder and GdBaCuO lens design with a single cooling stage, and a B_c= 13.5 T under an external magnetizing field of B_{app}= 10 T using an all-GdBaCuO cylinder and lens design using independent temperature control of each part [1]. In this presentation, we report the experimental verification of the HTFML using the MgB_2TFM cylinder and GdBaCuO lens design. Using an optimised lens design [2], a maximum concentrated magnetic field of B_c= 3.55 T was achieved experimentally at the central bore of the HTFML after removing an applied field of B_{app}= 2.0 T at T_s= 20 K. The HTFML effect is also reported using the all-GdBaCuO cylinder and lens design at 77 K. The HTFML device could prove useful to enhance the magnetic field for bulk NMR/MRI systems and to achieve a locally higher magnetic gradient for magnetic separation applications.

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Acknowledgements
This research is supported by Adaptable and Seamless Technology transfer Program through Target-driven R&D (A-STEP) from Japan Science and Technology Agency (JST), Grant No. VP30218088419 and by JSPS KAKENHI Grant No. 19K05240. M. D. Ainslie would like to acknowledge financial support from an Engineering and Physical Sciences Research Council (EPSRC) Early Career Fellowship, EP/P020313/1.

Keywords: A Hybrid Trapped Field Magnet Lens , experimental realization, vortex pinning effect, diamagnetic shielding effect

AP1-3

Upgrade of 25T cryogen-free superconducting magnet to 30T at HFLSM

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The 25T cryogen-free superconducting magnet (CSM) with high strength Bi2223 insert and CuNb/Nb_3Sn Rutherford cable coils is operated as a user magnet at High Field Laboratory for Superconducting materials (HFLSM) sine 2016 [1]. Now we plan an upgrade of the 25T-CSM with replacing the Bi2223 insert coil with the REBCO one. Thanks for good mechanical and in-field J_c properties of REBCO tapes, we can design the 16T REBCO insert under the background field of 14 T, in spite of some limitations such as coil space, operation current and cooling capacity. We propose two bundle (two-ply) REBCO tape winding in order to increase the space current density with a good reliability of REBCO coil. The design study is performed based on the REBCO tapes with the artificial pinning center (APC). In addition, the effects of two REBCO tape coupling on the AC losses and magnetic field should be investigated. We performed some R&D studies with the two-ply REBCO pancake coils under the electro-magnetic stress. The R&D studies and the primitive design of REBCO insert will be presented.

This work was supported by JSPS KAKENHI Grant Number 18H05248.

[1] S. Awaji *et al.*, *Supercond. Sci. Technol.* **30** (2017) 065001.

Keywords: REBCO, Cryogen-free superconducting magnet, electromagnetic force

AP1-4

Field and Voltage transient behavior in REBCO HTS coils using single tape or two bundled tapes: Comparison between Experiment and Modelling

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The development of practical REBCO HTS coils (Rare-EarthBiCaCuO High Temperature Superconductor) for very high field face two issues. The first is destructive thermal runaway induced by local dissipative zones, and the second is dynamic field homogeneity. These two problems are due to the specificities of REBCO Coated Conductors. They have significant critical current variations along the length which engender local dissipative zones with slow propagation, and their wide and thin tape structure enable the development of large shielding current loops. The first issue, thermal runaway, may be solved by using a non-insulation or partial insulation technique. These techniques however affect negatively the second issue as shielding current loops may appear both in the tape surface and across coil turns. We observed, as other groups, that an early detection of dissipating voltages makes it possible to discharge isolated coils before a dangerous thermal runaway can occur. However, the dissipating voltage that must be detected is very low, comparable in amplitude to the transient voltage due to magneto-electric effects. These must thus be understood and considered in the detection scheme.
We report results obtained on pancakes wound with single 12 mm tape, in terms of transient voltages and magnetic field evolution. They are compared with simulation results obtained using a recently developed model. It shows that these transient behaviors can be accurately predicted by the model and that transient voltage measurement can be a good tool to study shielding current variations.
Even though early detection makes the practical use of isolated REBCO coils possible, the maximum operating current remains limited by the weakest conductor defect. We investigated the possibility of using two co-wound tapes to average the tapes properties. Results obtained on pancakes wound with such conductors are reported both in terms of transient voltages and field evolution. The behavior is qualitatively similar to single tape pancakes, with comparatively weaker hysteresis.
Simulation results obtained using various simplifying assumptions for the conductor structure are presented for comparison, showing the interest of the two bundled concept and the need for further model refinement to represent accurately such conductors.

Keywords: REBCO coil, Field homogeneity, Very high field