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Design and fabrication of a 30 T superconducting solenoid using overpressure processed Bi2212 round wire

Cooperative Research and Development Agreement Final Report

CRADA Number: FRA-2014-0009

Fermilab Technical Contact: Tengming Shen

Summary Report
15 July 2019

NOTICE

In accordance with Requirements set forth in Article XI of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

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CRADA Title: Design and fabrication of a 30T superconducting solenoid using overpressure processed Bi2212 round wire

Parties to the Agreement: Muons, Inc. and Fermi Research Alliance, LLC

Abstract of CRADA work:

High field magnets are needed for frontier accelerator facilities and have many applications beyond high-energy physics. Of particular interest are 30-40T class (LTS/HTS hybrid) solenoids required for the final beam cooling stages of a muon collider facility. The successful design of such magnets using Bi2212 conductor depends critically on the conductor processing, stress management in the coil, and quench protection. These are the challenges addressed in the proposal and the overall objectives of the combined Phase I and Phase II projects. Bi2212 round wire conductor will be evaluated for accelerator use by concentrating on the design of a solenoid magnet that will be the enabling technology for realizing the final stages of muon beam cooling and thus a high luminosity muon collider. A full mechanical characterization of a test coil made from overpressure-processed conductor with engineering current density JE in the range of & gt;600 A/mm2 at 20-30 T will be performed. The data from the test coil will serve as input to a 30+ T magnet that will be designed, built, and tested to demonstrate the suitability of overpressure-processed Bi2212 for solenoids for final muon cooling and 6D cooling channels. Short lengths and coils wound from up to 100 m length conductor will be overpressure processed. Characterization of an overpressure processed Bi2212 round-wire based solenoid will be performed at 4.2 K in a background field of up to 14 T. The characterization will include mechanical, thermal, and quench properties. The data will be used as input to a 30+ T coil design that has suitable stress management and quench protection, to be built and tested in Phase II. Commercial applications and other benefits: The technology developed by this work will benefit high-energy physics applications. The knowledge and expertise gained from this project will enable the development of very high-field solenoids, dipoles, and quadrupoles using Bi2212 cable at low temperature for applications in future particle accelerators. The technology will also extend the range available to Nuclear Magnetic Resonance Spectroscopy, an important technique used to understand molecular structures of proteins and other materials.

Summary of Research Results:

During Phase I, an overpressure processing facility was commissioned and optimized. Three solenoids were fabricated using the overpressure processing facility. The coils were

tested in fields of up to 14 T and showed I_c in the range of 200-300 A at 4.2 K /14 T- about a factor of two higher than that expected for 1 bar processed coils. A model of an all-superconducting 30 T hybrid HTS/LTS solenoid was developed. From the model it was seen that the Bi2212 section of solenoid requires a J_E ~360 A/mm^2 at 20-30 T, which is lower than expected to achieve based on extrapolating our test coil results. Extrapolating from the test coil performance it is expected to be able to reach a J_E of 450 A/mm^2 at 20-30 T. This is a very important as it suggests that a 30 T all-superconducting solenoid is feasible.

Related Reports, Publications, and Presentations:

Reports: https://www.osti.gov/servlets/purl/1238145/

Subject Inventions listing:

None

Report Date: 15 July 2019

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