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Quench detection and protection for high-temperature superconducting magnets: lessons from Bi-2212

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High temperature superconducting magnets may enable applications ranging from high field magnets generating magnetic fields of >20 T and highly efficient electric power devices such as superconducting magnetic energy storage systems and wind generators. A critical roadblock, however, is to detect a normal zone propagating only at a speed of 1-10 cm/s, while the maximum temperature of the normal zone rises quickly at 10-200 K/s, depending on the stabilizer current density, operating temperature and magnetic field. This presentation will report on the quench characteristics of a round wire Bi-2212 as well as small-scale Bi-2212 coils at 4.2 K and in a background field up to 14 T. Conductors and coils tested included those made using both 1 atmosphere melt processing, which yield an engineering current density Je of 300 A/mm2 at 20 T, 4.2 K, and an overpressure process, which was recently used to achieve Je above 700 A/mm2 at 20 T, 4.2 K in short-length round wires of Bi-2212. Based on the experimental and modeling results of quench propagation in Bi-2212, this talk will also discuss the feasibility and trial tests of using various strategies to detect quenches, including traditional voltage based method, fiber optics, acoustic emission sensors, and an innovative quench detection sensor being developed at Fermilab.

Primary author: SHEN, Tengming (Fermilab)

Co-authors: Mr TURRIONI, Daniele (Fermi National Accelerator Laboratory); Mr ORRIS, Darryl (Fermi National Accelerator Laboratory); Dr TOMPKINS, John (Fermi National Accelerator Laboratory); Dr COOLEY, Lance (Fermi National Accelerator Laboratory); Mr YE, Liyang (Fermi National Accelerator Laboratory); Dr LI, Pei (Fermi National Accelerator Laboratory); Mr SCHAPPERT, Warren (Fermi National Accelerator Laboratory)

Presenter: SHEN, Tengming (Fermilab)

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