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[Invited] Lessons Learned in No-insulation HTS Magnet Technology

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Firstly reported by MIT in 2010, the no-insulation (NI) high temperature superconductor (HTS) winding technique introduced a new philosophy of HTS magnet protection: "current sharing"with adjacent turns upon a quench. The protection mechanism of the NI HTS technique was later explained by RIKEN: the multi-turn-to-single-turn transition. To mitigate the charging delay, a major drawback of NI HTS magnets, variations of the NI HTS technique such as partial and metal insulations have been proposed. Most of "NI-class"HTS magnets were essentially immune to local burn-out from overheating upon a quench. Consequently, some NI HTS magnets were operated at substantially higher engineering current densities than those of insulated ones, e.g., the well-known "Little Big Coil (LBC)"by NHMFL, a 14.4 T NI-REBCO insert operating at 1260 A/mm2 in a 31.1 T resistive background magnet to reach a record high DC magnetic field of 45.5 T. Although the NI-class HTS magnets have been widely studied in various applications nowadays, multiple groups have reported failures of NI HTS magnets, mostly due to mechanical issues. Moreover, as some NI HTS magnets experienced long-term operation over years, operational issues such as characteristic resistance change and joint degradation have been also raised. Recently, the so-called "one-side-edge plastic deformation"of REBCO tapes of LBC due to the screening current induced stress (SCS) was reported by NHMFL. Yet, to date our community has been unsuccessful to quantitatively explain SCS with the conventional numerical approaches. This paper intends to summarize those lessons learned over the last decade on NI HTS magnets, identify key technical challenges, and introduce potential solutions for ultimate success of HTS magnet technology, if not limited to NI or its variations.

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