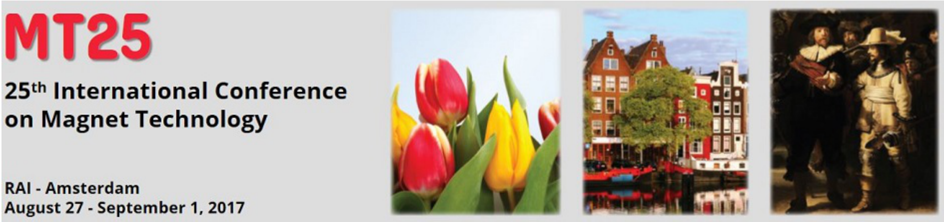

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Mechanisms to enhance stability, post-quench recovery and availability in non-insulated REBCO magnets

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Due to low turn-to-turn contact resistances, non-insulated (NI) REBCO coils possess much higher thermal stability than their insulated counterparts. Experiments even showed that NI coils are in general self-protecting, recovering from a quench without external quench protection mechanisms. Recent studies showed that an uncontained local quench can amplify itself quickly, leading to an abrupt loss of the azimuthal current and thus a sudden drop in the magnetic field. Moreover, within a NI multi-coil magnet, a quench-resulted sudden drop in magnetic field in one coil can inductively induced another quench in another coil. These phenomena result in lower thermal stability and lengthened recovery time in self-protecting NI magnets. The ultimate consequences are lower operational reliability and availability, and even catastrophic disruption in operational functionality. Here a novel graded-resistance method is proposed to tackle the mentioned problems while maintaining the superior thermal stability and self-protecting capability of NI magnets. The method is studied and designed via a network-thermo-electromagnetic NI REBCO multi-coil model. The multi-coil model is composed of multiple serially connected, spirally-wound equivalent circuit network pancake coil models coupled with an equal number of three-dimensional thermal and electromagnetic pancake models. Patterned thermally and electrically resistive-conductive layers are inserted at strategically selected turn-to-turn contacts to contain hot-spot heat propagation while maintaining the turn-wise current sharing required for self-protection. The heat containment enables the retention of useful azimuthal current responsible for magnetic field generation, resulting in faster post-quench recovery and reduced magnetic field transient. Through the proposed method, REBCO magnets with higher thermal stability, lower likelihood of quenching, and rapid, passive recovery can be built to enhance operational reliability and availability. The effectiveness of the method is assessed by comparing the recovery times, magnetic field transient rates and thermal stabilities between the modified and original NI multi-coil magnets at 4.2 K and 77 K.

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