High Field Stability Exploration of Second Generation HTS

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Introduction

2G HTS wire is based on high performance thin film YBCO superconductor. AMSC uses a bi-axially textured substrate with a thin epitaxial oxide buffer layer (RABiTS™). The YBCO layer is grown using a solution-based coating process carried out on a 4 cm wide web. After completion of all coatings the conductor is slit to multiple 4 mm widths. These are laminated on both sides to a 4.4 mm copper foil [1], resulting in a so-called 344 superconductor. For ac applications a stainless laminate can be selected [2]. Ic improvements are obtained through improved chemistry and reactor conditions [3].

The main objective of this STTR Project is the exploration of the suitability of Second Generation HTS for high heat load, high radiation environment applications. The Phase I aims at an extensive characterization of Jc (B, T, Θ) (where Θ is the angle between the field and surface of the conductor) and establishing the thermal limit in various stability experiments using small coils. The operating regime of interest is low temperatures (4.2-27 K) and fields up to 25 T. Previous measurements at the NHMFL demonstrated an engineering critical current of 225 A/mm² at 25 T, parallel field. At the onset of this Program we characterized short lengths of a new, thicker film conductor at 4.2 K and fields between 3 and 25 T.

Experimental

The 344 superconductor for this STTR Project was made using a so-called double layer geometry, resulting in a 1.4 μm thick YBCO layer with different pinning characteristics for top and bottom layer. The 4.4x0.2 mm conductor (0.88 mm² area) has 50% copper stabilizer. The conductor showed a critical current exceeding 100 A at 77 K, SF. Lengths of this conductor were used for measurements at high magnetic field, with field orientations parallel and perpendicular to the face of the tape-like conductor. In parallel fields the conductor was measured using an adapted ITER probe. Two pair of voltage taps were, at 40 and 60 cm distance, with a minimum distance of 15-20 cm between current leads and outer voltage taps. The sample was always under compression. This worked well except for very high fields when the conductor could buckle.

Results and Discussion

In parallel fields the Ic reduction with field was gradual, as anticipated form earlier work. At 10, 15, 20 and 25 tesla the critical current was 643, 557, 486 and 418 A (or 1600, 1390, 1215 and 1045 A/cm-width), resulting in an overall critical current Jc over the 344 cross section of 730, 630, 550 and 475 A/mm². These values are roughly proportional to the layer thickness compared to earlier values in 0.8 μm thick YBCO films. In a perpendicular field the critical currents were much lower, again as expected based on earlier measurements, with Jc values of 227 (5 T), 145 (10 T), 110 (15 T), 90 (20 T) and 80 A/mm² (25 T). These values too were in line of what could be expected for the increased film thickness.

Conclusions

The high demonstrated engineering critical currents (475 A/mm² at 25 T) are of interest for those high field insert applications in which the HTS magnet section is placed in a background field with field parallel to the conductor. The measurements are the first and good start in a series for a full characterization, before small pancake coils made of the same conductor will be tested for stability in a magnetic field.

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References