Angular Critical Current of YBCO Tapes for Superconducting Magnet Technology Beyond 30 T

A. Xu, J. Jaroszynski, Y. Viouchkov, C. Tarantini, V. Griffin, Jun Lu, U. Trociewitz, D. Larbalestier (NHMFL) Y. Chen, Y.Y. Xie, V. Selvamanickam (SuperPower Inc.)

Introduction

YBCO is now the prime NHMFL choice for an all-superconducting magnet technology to go to 30T and beyond. Recent very successful test of a YBCO tape magnet to magnetic fields of almost 34 T provide the essential proof of principle that a 30 T class of all-superconducting user magnet is feasible. A key part of the coil design depends on knowing the detailed angular dependence of the critical current $I_c$ so that the coil quench design point can be predicted with confidence.

Experimental

Angular critical supercurrent $I_c(\theta, B, T)$ was measured in 15 T SC, 25 and 31 T resistive magnets. Measurements were performed with the sample tape plane rotated relative to B. A high current (up to 500 A) probe with rotating sample holder was designed and manufactured (Fig. 1a). Notably, the current leads to the rotating stage were made of 4 mm wide YBCO tape, similar to that under study. No substantial degradation of its superconductive properties was observed after several days of operation.

Results and Discussion

Our work directly develops materials for SC magnet technology, while a high current rotator develops NHMFL instrumentation capabilities. We characterized several YBCO tapes, including these from which the recent test magnets were made. Moreover, we were testing tapes with different level of nano-size BaZrO$_3$ (BZO) pinning centers, to understand valid pinning mechanisms for very high fields where vortex density exceeds pin density, at least for $H$ parallel to the c axis.

Conclusions

As shown in the inset to Fig 1b, BZO doping dramatically alters $I_c(\theta)$ at 77 K; 1 T, but these effects are washed out at low T and high field. Ginzburg-Landau model describes $I_c(\theta)$ well, except for the cusp-like, apparently strong correlated pinning dependence around the ab plane. In this region $I_c(\theta)$ is exponential (inset to Fig. 1d) for reasons still unexplained.

Acknowledgements

The work was supported by the NSF Cooperative Agreement No. DMR-0084173, by the State of Florida, and by the DOE.