Superconductor Bi-2212 Wire for Very High Magnetic Field Magnets

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Introduction

Bi-2212 round wire is highly desirable for high field magnets due to its long length and high engineering current density up to at least 45 T at 4.2K. But the vital materials issues and the current limiting mechanisms of the Bi-2212 conductor are still poorly understood. The key materials issues for the Bi2212 conductor are the narrow reaction heat treatment window, the frequent leakage of Bi-2212 conductor through the silver matrix, and the reaction of Bi-2212 with the conductor insulation and magnet construction materials. In 2007, we have studied the leakage, the microstructure, the irreversibility field, the connectivity, and the effects of composition and post reaction anneal of the Bi2212 round wires and tapes on J_c and T_c.

Experimental

We made 12 test coils from the Bi-2212 round wire in 2007. Eleven of them leaked. The surface and the cross sections of the leaked and unleaked sections of test coils were examined extensively by SEM and EDS. The critical state irreversibility field H_K for a variety of Bi-2212 samples (tapes and round wires), was measured by using a 14T Oxford VSM. Transport measurements of irreversibility field H_{irr} using small currents were performed with a Quantum Design PPMS and the NHMFL 33T user magnet. We started the connectivity analysis for Bi-2212 conductor with A. Yamamoto of University of Tokyo by measuring the remnant fields at different temperatures with a Quantum Design SQUID.

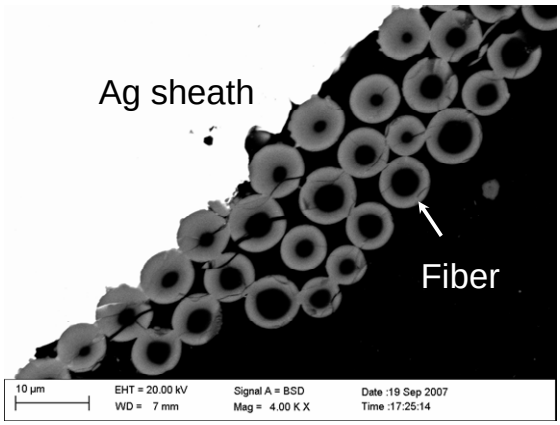

Figure 1: Backscattered electron image of a partial cross section of Bi-2212 round wire from NHMFL test coil 20007-012 showing the reacted insulation Al_2O_3-SiO_2 fiber. Silver reacted with the fiber, forming a bright ring surrounding the fiber. Fibers close to Ag showed stronger reaction. The reacted fibers bonded together, which may form a barrier to oxygen flow, resulting in an inbalance in the oxygen pressure during the reaction.

Results and Discussion

We found the Bi2212 test coil with Inconel coil form performed better than coils with Macor forms. Our leakage analysis showed the leak holes normally aligned longitudinally along the Bi-2212 wire. We found the insulation material Al_2O_3-SiO_2 reacted with the silver matrix (Fig.1). This kind of erosion reaction may promote the formation of the observed holes near the edges of the round wires. Understanding the leakage mechanism is in progress. Extensive measurements of the critical-state irreversibility field H_K revealed that H_K values are the same for wires with J_c (4.2K, 5T) ranging from 1084 to 2880 A/mm^2. We conclude that connectivity is a key issue for improving the J_c. Porosity, 2201 intergrowth and 2212 phase are still key issues for Bi2212 wire, but we do not have a clear correlation between the microstructure and the conductor performance. Further work is needed to understand the current flow in Bi-2212 conductor.

Conclusions

It was found that the Al_2O_3-SiO_2 insulation fiber reacted with silver in Bi2212 wire. A better insulation is needed. Connectivity is a key issue for improving the J_c.

Acknowledgements

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