Split Melt Processing of $Bi_2Sr_2CaCu_2O_x$/AgX Coils

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Introduction

$Bi_2Sr_2CaCu_2O_x$ (Bi2212) high temperature superconductor, in the form of a multifilamentary round wire, has excellent electrical performance in high magnetic field at 4.2 K, indicating significant potential for generating magnetic fields greater than 23 T [1], [2]. One of the challenges facing Bi2212 magnet development is determining a coil manufacturing approach that facilitates compatibility with insulation and results in high critical current density.

Experimental

Multifilamentary Bi2212/AgMg round wire, 0.787mm in diameter, is manufactured with a single-restack by Supercon, Inc. The wire is insulated with braided mullite (70% Al_2O_3/30%SiO_2) and wound on a 35mm diameter inconel tube. The split melt process is used to study the effects of varying the time above $T_{solidus}$ by varying T_1 and determining the effects on the transport critical current, magnetization and microstructure Bi2212 coils [2].

Results and Discussion

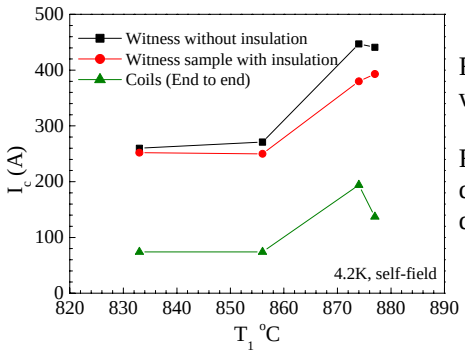

Fig.1 Effect of T_1 on I_c of coils and witness samples (left)

Fig. 2 I_c distribution of short samples deconstructed from coils heat treated at different T_1 (right)

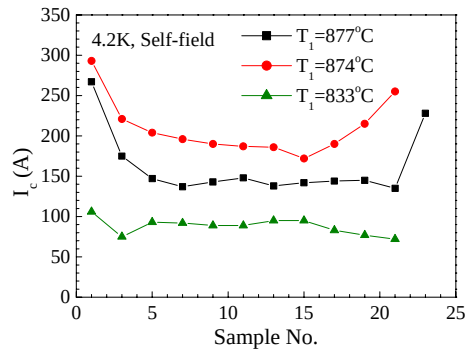

Figure 1 shows the critical current (I_c) of coils and short witness samples as a function T_1. I_c decreases with decreasing T_1 for all sample types. I_cs of witness samples with insulation are 10-15% lower than those heat treated without insulation. The ETE I_c of coils is ~50% less than that of witness samples heat treated with insulation. During heat treatment, decreasing T_1 essentially decreases the effective overall cooling rate. When T_1 is low, the coil performance becomes relatively independent of T_1 which indicates that the initial cooling rate is most significant and that the effect of T_1 on coil performance is a cooling-rate effect. It is also important to note that reduced T_1 also reduces the occurrence of leakage during coil heat treatment.

Figure 2 shows I_cs of samples cut from coils as a function of location in the coil. The short samples show the same tendency as coils, with higher I_cs at higher T_1. The difference in I_c between end and middle sections decreases from 45% to 16% as T_1 decreases from 877 °C to 833 °C. After full heat treatment, Ag and Cu have reacted with the insulation. The Cu diffuses through the Ag sheath and interacts with the insulation, resulting in a copper deficiency within the filaments and thus increased copper-free phase content in the outer filaments. Due to tight contact between the conductor and insulation on the middle section of coils, Cu diffusion from filaments through the Ag sheath is accelerated, leading to increased copper-free phase content and lost filaments. As a result, I_cs in the middle sections is decreased compared to those of the end sections.

Conclusions

Reduced T_1 is beneficial in that coil leakage is reduced, but reduced Bi2212 grain size and interfilament bridging result in reduced I_c. Cu diffuses from filaments through the Ag to the insulation, resulting in decreased Cu content in the filaments and thus increased copper-free phase and filament loss due to leakage from the outer filaments.

Acknowledgements

This work was supported by the National Institutes for Health through a Phase II STTR subcontract from Supercon, Inc.

References

[1] K.R. Marken, H. Miao, M. Meinesz, B. Czabaj, and S. Hong, "Progress in Bi-2212 wires for high magnetic field applications," *IEEE Trans. Appl. Supercond.*, vol. 16, no. 2, pp. 992-995, 2006

[2] J. Schwartz, T. Effio, X. Liu, Q. V. Le, A. L. Mbaruku, H. J. Schneider-Muntau, T. Shen, H. Song, U. P. Trociewitz, X. Wang, and H. W. Weijers, "High field superconducting solenoids via high temperature superconductors," *IEEE Trans. Appl. Supercond.*, vol. 18, no. 2, pp.70-81, 2008