Development of superconducting joints between Bi-2212/Ag wires

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Introduction

Bi-2212 superconducting wires are being considered as key components for the development of high field magnets (up to 25 T), but it is recognised that a reliable joining process between these wires is a critical challenge for most high-field applications. This work focuses on the design and testing of jointing processes between Bi-2212 wires using different practically applicable techniques, including soldering and melt-processing, to make persistent mode joints. In the soldered joints, superconducting alloys from the PbBi, SnBi and SnInBi systems have been investigated. Several architectures of melt-processed joints have also been studied, with cold-pressing stages and the use of additional BSCCO powder to form superconducting paths between the filaments after a local melting process.

Soldered joints

- Ag matrix needs to be removed from reacted wires to produce direct bond between Bi-2212 filaments and superconducting solder.
- Bi-2212/Ag wires were dipped in various molten superconducting solder alloys (SnBi and PbBi) at 400°C to investigate how effectively they remove the Ag matrix.
- Joints have also been fabricated using a two-stage process involving molten Sn followed by molten PbBi solder, as this is commonly used for soldering NbTi wires [1].

Melt-processed joints

Lap joints have been made between unreacted Bi-2212 wires by:
- Etching the outer silver layer using dilute nitric acid.
- Uniaxial pressing to flatten each wire.
- Assembling lap joint (with or without additional Bi-2212 powder in between) and cold pressing to fuse silver.
- Heating current flowing O2 at melt temperatures $T_m = 880-889°C$.

Before heat treatment

X-ray tomography cross section through a joint with extra Bi-2212 between the wires before heat treatment showing the BSCCO (dark grey) and Ag matrix (light grey).

After heat treatment

(Left): BSE micrograph of cross-section through a melt-processed joint made with extra Bi-2212 powder. (Below): Higher magnification image and EDX chemical maps showing an interconnected path between adjacent Bi-2212 filaments.

Transport measurements

(Left): 4 terminal transport $T_c$ measurements from joints fabricated at a series of melting temperatures, $T_m$. Values of joints are consistent with the in-house reacted wire.

- Preliminary critical currents measurements have been performed on some joints. The highest $J_c = 13$ A at 4.2 K in self field was found for a joint melt-processed at 883°C (estimated from transport data using 100 µV m⁻¹ criterion).
- EDX mapping at high resolution shows that the BSCCO filaments contain a significant fraction of a non-superconducting, Cu-free oxide, which may be responsible for the poor current critical values.
- Further optimisation of the heat treatment is required to promote formation of the superconducting Bi-2212 phase.

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