INTRODUCTION

Bi2212 is a superconducting material that is of high interest, but needs improvement in its filament structure to increase its critical current. Standard OP heat treatment to improve $I_c$ uses heat and pressure simultaneously to densify the wire and reduce bubbles in the superconducting filaments formed in the process. To demonstrate the need for this simultaneous process, we are testing the densification process by applying heat first, then pressure – essentially densifying after melting (DAM) the 2212 powder. What is the effect on filament shape, microstructure and critical current density of DAM?

To improve $I_c$, the conditions need to support growth of long crystal grains in the filaments to conduct maximum current. The Bi2212 growth process, bubbles are formed causing voids which block $I_c$. The standard OP heat treatment has reduced these bubbles. It was believed that DAM would cause even greater deformation of the filaments due to pressure on the bubbles (sausaging).

After DAM, wire diameter and cross section analysis indicate a larger variation in filament size for the 37x18 wire – but not for the 27x7 suggesting filament deformation. There was no visible evidence of sausaging, however there were large sized secondary phases and bubbles that resulted in 69.3% reduction in $I_c$ on 37x18 wires, and preliminary tests show 79.8% reduction on 27x7 wire.

PROCEDURE

Sample preparation
- Two types of wire were used: 37x18 and 27x7
- Measure and cut 8 mm samples
- Wrap ends with 4 mm silver wire
- Melt silver to seal ends of samples
- Prepare labels for samples, copy, place in boat
- Place in furnace
- Setup heat and pressure profiles
- Measure diameter of samples using microscope to verify densification occurred.
- Puck
  - Drill holes to match order
  - Insert 5 mm samples (carefully)
  - Complete puck structure
  - Grind 1 mm of conductive puck material and level
  - Polish with increasing grit sandpaper
  - Monitor in microscope for scratch reduction
  - Place in Vibromet overnight
- Etch the samples using ammonium hydroxide and hydrogen peroxide diluted in methanol to remove the silver and expose the ceramic filaments
- Reserve time on the SMS to view and photograph samples

HEAT AND PRESSURE PROFILES FOR FILAMENT ANALYSIS

DAM shows no significant variation in wire diameter on 27x7 wires

DAM shows large variation in wire diameter on 37x18 wires

VISIBLE EVIDENCE OF LARGE SECONDARY PHASES AND FILAMENT IRREGULARITY IN DAM 37x18 CROSS SECTIONS

CONCLUSION

Though filament shape was not visibly deformed in the Densification After Melt process (expected sausaging), the critical current of the 37x18 wire was reduced by 69.3%. Wire diameter analysis indicates deformities in filaments. The variation in filament size and large secondary phases are not conducive to Bi2212 and its superconductivity capacity. Therefore, the standard overpressure heat treatment applying Densification Before Melt is more effective on the 37x18 wires.

On the 27x7 wires, the filament diameter analysis shifts filament sizes to the left – indicating a potential increased densification process. Again, there were no visible deformation in filaments. The wire diameters in quenched samples indicate similar densification in DAM and Before Melt wires.

The critical current of the 27x7 samples are ongoing. Cross section analysis of the fully processed wires should be done to show if the change in IC is caused by the filament deformation, the large secondary phases or a combination of both.

Unintentional Outcome

Sample that did not densify. Right picture is with 2 µm of top layer removed by etching to eliminate silver and expose the “missing” filaments.

The Bi2212 process is known to create bubbles which resulted in holes in our sample that were obscured by silver.

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Jianyi Jiang, Research Staff, ASC, NHMFL, Florida State University
Eric Hellstrom, Assistant Director, Center for Integrating Research & Learning, Florida State University