Characterization of Mechanical Properties of $Bi_2Sr_2CaCu_2O_{8-x}$ Superconductor through Scanning Electron Microscopy

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Background

What are we studying?

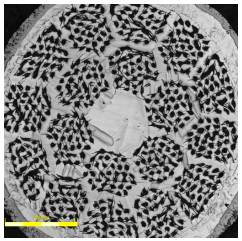
- **$Bi_2Sr_2Ca_1Cu_2O_x$ (Bi-2212)** - a high temperature superconductor

Why are we studying it?

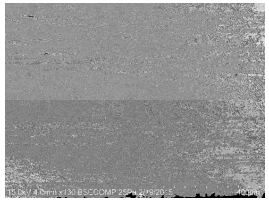
- Superconductors are used in a wide variety of high field magnetic applications.
- Bi-2212 is the only high temperature superconductor available as a round wire that is suitable for magnets.

What are we looking for?

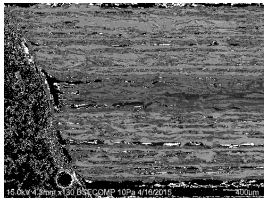
- Bi-2212 is brittle and susceptible to mechanical damage.
- Our research seeks to understand why this damage occurs, and how it propagates through the material.



Laser confocal image of transverse mounted Bi-2212 wire



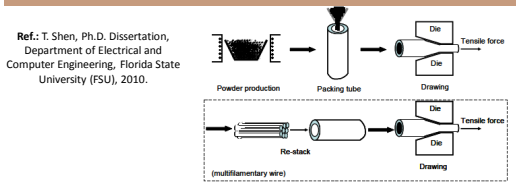
SEM image of a longitudinal mounted Bi-2212 wire



SEM image of a deep etched longitudinal Bi-2212 wire

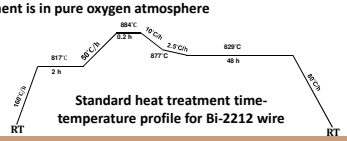
High magnification SEM image of Bi-2212 filaments

Effect of Heat Treatment



Ref.: T. Shen, Ph.D. Dissertation, Department of Electrical and Computer Engineering, Florida State University (FSU), 2010.

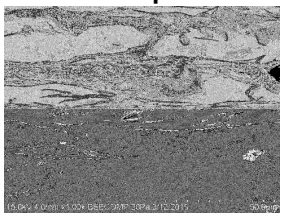
- **Bi-2212 is first created as a powder, then pulled into an Ag sheath to create a wire.**
- **In order to create superconducting phases, the Bi-2212 wire must undergo a heat treatment where we melt the superconducting powder.**
- **The heat treatment is in pure oxygen atmosphere**



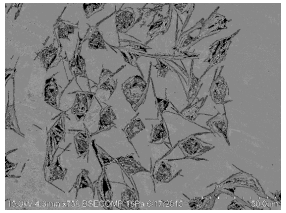
Standard heat treatment time-temperature profile for Bi-2212 wire

SEM Micrographs Showing Various Damages in the Bi-2212 Filaments

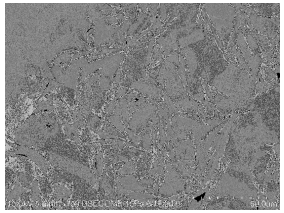
1 bar compression



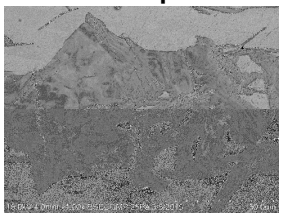
1 bar untested



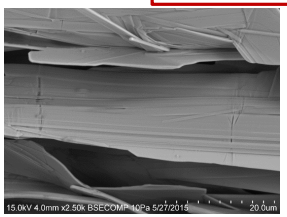
100 bar untested

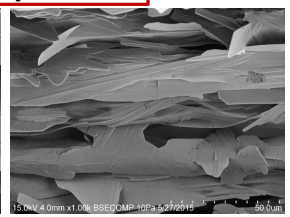


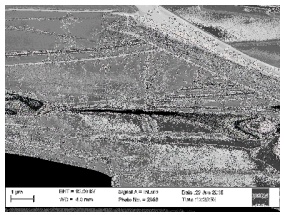
100 bar compression



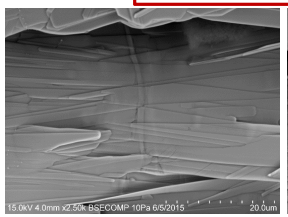
1 bar compression

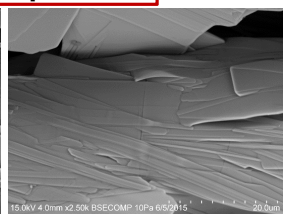


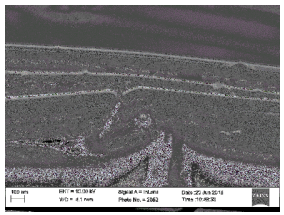


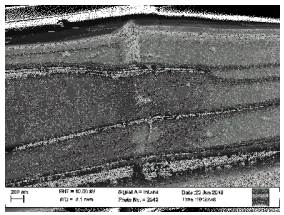


100 bar compression



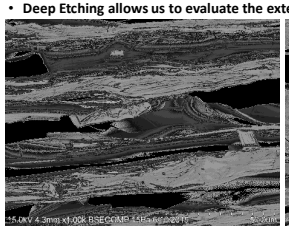






Why Deep-Etching?

- **General polishing method can create clean and scratch-free sample surfaces.**
- **Below surface level, Bi-2212 filament damage can be extensive.**
- **SiC grinding is aggressive and can break the Bi-2212 filaments.**
- **Deep Etching allows us to evaluate the extent of, and account for, this damage.**



Electro-mechanical Testing

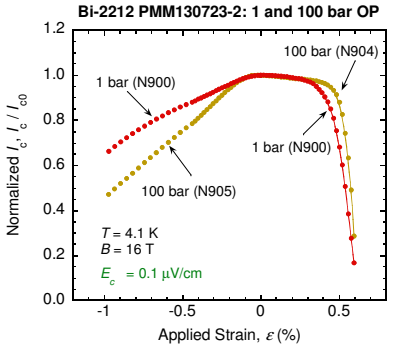


Image courtesy N. Cheggour, University of Colorado-Boulder. Data collected under UWEC sub-contract.

Summary

- **Unstrained samples, both 1 bar and 100 bar**, show very little, if any, damage. This demonstrates that our polishing technique is suitable for revealing the microstructure. 100 bar samples show significantly **less porosity** due to the applied over-pressure during heat treatment.
- **Compression samples** preferentially crack perpendicular to the growth direction of Bi-2212 grains. 1 bar wires more readily resist catastrophic damage. Cracks are arrested by the high porosity concentrations. **By contrast, 100 bar wires exhibit extensive electromechanical degradation due to a lack of crack arresting mechanisms.** Due to the high density of 100 bar Bi-2212, compressive stresses lead to buckling in the filaments. FESEM images show both outward and inward buckling events.

Acknowledgements

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