Key microstructural features of Bi2212 and Bi2223 wires


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Sibling materials, but different architectures are needed for high $J_c$

- **Bi$_2$Sr$_2$Ca$_2$Cu$_3$O$_x$$^*$ (Bi2223) conductors
  - Flat tape

- **Bi$_2$Sr$_2$Ca$_1$Cu$_2$O$_x$$^*$ (Bi2212) conductors
  - Round wire

- **Bi2223**: Uni-axial texture

- **Bi2212**: No macroscopic texture
Generally high angle GBs should be avoided

Typically the $J_c$ of highly textured HTS is better than that of untextured

- Planar bi-crystal studies have shown strong $J_c$ decay at HTS GBs


J. Mannhart and H. Hilgenkamp, APL 73, 265 (1998)
Elimination of Bubbles is the key for high $J_c$ Bi2212 RWs

- High angle GBs were not the primary current limiting mechanism in Bi2212 RWs

Fully dense Bi2212 RWs now show higher \( J_c \) than highly textured Bi2223 tapes

- Why do the macroscopically untextured RWs show higher \( J_c \)?
- Are HAGBs more transparent in Bi2212?
- Or any mechanisms that compensate the RW architecture?
Comparison of $I_c$ in fields between Bi2223 flat and Bi2212 round wires

- $I_c$ hysteresis in fields is caused by granularity of superconductors
  - Transport current passes through weak links in Bi2223
  - Weak links may be absent in Bi2212

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Electron Backscatter Diffraction (EBSD) was used to visualize and analyze the microstructure of BSCCO.

The sample surface must be very clean – otherwise the diffraction signals will be blocked.

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Uniaxial [001] texture is clearly seen in a Bi2223 tape conductor

- Transport current mostly passes across HAGBs with >20° misorientation
Grain/GB structure in a Bi2212 filament

10 µm

*Animation made by P. J. Lee
Typical grain structure in a Bi2212 RW

- Grain dimensions (ab vs c-axis) are more anisotropic
- Larger area of GBs//ab-plane due to the more anisotropic grain shape
- There are regions close to [001] (red), forming the colony structure
Typical GB structure in Bi2212

- Most of GBs appeared here have <20° misorientation
- There are more current paths that consists of just <20° GBs.

Magenta: <20°
Dark Blue: >20°
GB fraction as a function of misorientation angle

- In the Bi2223 flat filament, the GB misorientation angles are broadly distributed from <5° to 45°
- The distribution of Bi2212 misorientation angles shows a sharp peak around 10-15°
Anisotropic BSCCO crystal defines in-plane and out-of-plane misorientation

- **In-plane rotation**: rotation axis // c-axis
- **Out-of-plane**: rotation axis // ab-plane
Bi2212 grain orientations in the filament

- The orientations parallel to the ND are plotted in IPF.
- Dotted lines represent 15° in- and out-of-plane misorientation from [100].
Bi2212 grain orientations in the filament

- The orientations parallel to the RD are plotted in IPF.
- Dotted lines represent 15° in- and out-of-plane misorientation from [100].

Along the filament direction, both in- and out-of-plane misorientation is \(~15°\) or less.
The Bi2212 filament has greater out-of-plane misorientation along the radial direction.
The Bi2212 has fewer in-plane misorientation

- The in-plane misorientation in Bi2212 is almost \( \sim \pm 15^\circ \) or less
- Meanwhile, almost random in-plane orientation in Bi2223
Conclusion

- Two BSCCO sibling materials require two different architectures for high $J_c$ wires
  - Bi2223 needs high uniaxial texture
  - Bi2212 does not need macroscopic texture
- The Bi2212 RWs show no $J_c(H)$ hysteresis
  - Strong indication that the Bi2212 grains are strongly coupled
  - There must be HAGBs, but they don’t dominate transport $J_c$
- Bi2212 has the unique grain structure
  - There is a huge amount of local texture, although prior deformation (wire drawing) can play no role in the grain growth
  - The out-of-plane misorientation along the filament direction is $\sim 15^\circ$
  - Surprisingly in-plane misorientation is $\sim 15^\circ$ too