Oxygen Doping of YBCO Grain Boundaries

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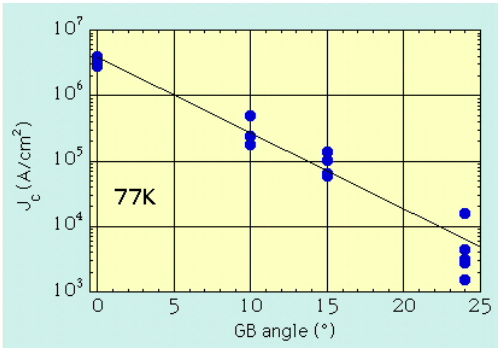
Motivation

The high T_C superconductor YBCO holds considerable promise for large-scale applications involving low loss power transmission. However, the deleterious role of grain boundaries must first be minimized. Successful YBCO wire development will probably be accomplished by eliminating high angle grain boundaries in the conductor and by minimizing losses in remaining low angle boundaries.

- Critical current J_C decreases exponentially with GB angle
- **We demonstrate that J_C can be significantly improved by oxidation.**



Grain boundary (GB) critical current decreases exponentially with GB angle

Results

We investigate how oxygenation of grain boundaries (GBs) in the high T_C superconductor $YBa_2Cu_3O_x$ (YBCO) affects supercurrent transport across them.

Critical current density J_C in YBCO is degraded when conduction occurs across grain boundaries (GB), with J_C falling exponentially as the angle increases.

It is known that superconducting bulk properties are sensitively dependent on the oxygen stoichiometry.

We performed first systematic study of how oxygen doping affects the critical current of YBCO Grain Boundaries.

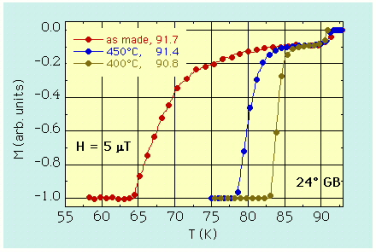
Investigated were bicrystal samples with selected [001] tilt misorientations as function of oxygen doping level.

Fabrication of samples: Thin film were produced by laser ablation onto commercial $SrTiO_3$ bicrystals. Rings were patterned by photolithography.

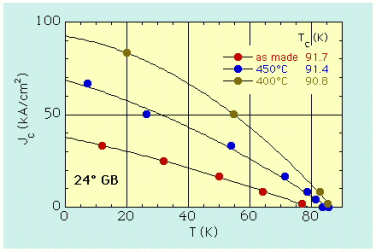
Measurement Technique: J_C was determined from magnetization measurements on ring samples bisected by a GB. This contact-free method is ideally suited for repeated secondary oxygenation treatments.

Result: GB J_C continues to increase with increased level of oxygenation (for both bulk and thin film samples) especially in the overdoped regime, where T_C decreases with increasing oxygenation.

Grain boundary oxygenation rates were also determined for both bulk and thin film samples. For best supercurrent transport, a high level of GB oxygenation is desired but a lower level of bulk oxygenation might be preferable. These oxygenation rate studies might permit independent optimization of bulk and GB properties.

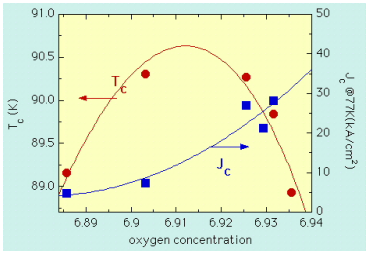


Kink in M (T) signals flux penetration into bore of ring. This kink occurs when the critical current of the grain boundary I_C (T) drops below the shielding current, I_H, induced by the applied field at low temperatures.



At the kink temperature I_C (T_{kink}) = I_H

- J_C of GBs monotonically increases with increasing oxygen concentration.

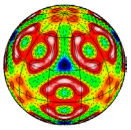


- In overdoped regime (x >6.92) T_C decreases again but J_C continues to increase with increasing oxygen doping.

Future Work

- Optimize oxygen doping of thin films GBs. Use dry etching to produce rings. At present GBs deteriorate after repeated oxygenation, most likely due to chemical reaction with residues from photolithography.
- Extend secondary oxygenation to coated conductor rings. First results show promising changes in J_C (T,H) after oxygenation of as - made coated conductors.

Claus H, Welp U, Zheng H, Chen L, Paulikas A P, Veal B W, Gray K E and Crabtree G W, Phys. Rev. B 64, 144507-1 (2001)



Work supported by the U.S. Department of Energy, Basic Energy Sciences-Materials Sciences, under Contract #W-31-109-ENG-38.

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