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Critical current in PLD-YBCO coated conductors investigated by high-resolution Hall scan measurements

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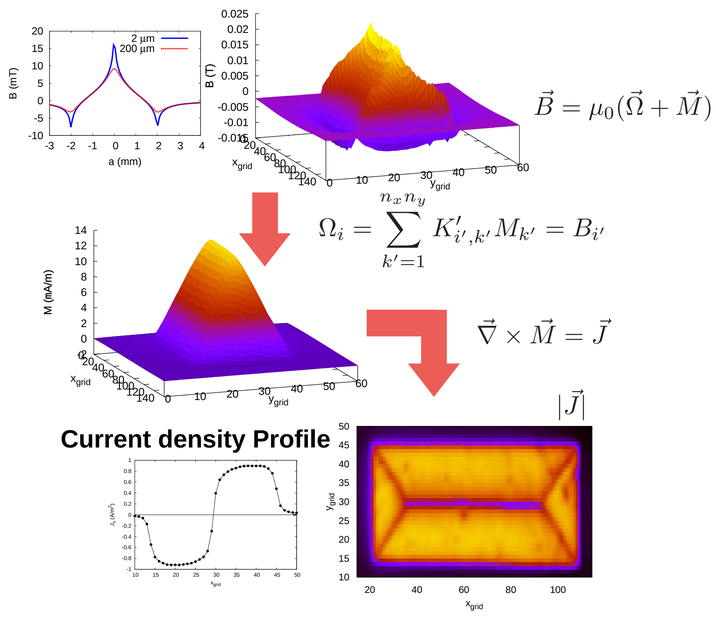
Introduction

- Grain boundaries (GB) in coated conductors (CC) are an inevitable limiting factor in the critical current density, J_c, especially at low temperatures.
- YBCO layers grown on RABiTS substrates are found to have large grains (>10μm) both in the Ni5%W and in the new non-magnetic Ni9%W templates.
- It is the aim of this work to provide insights on the extent of the grain boundary limitation to J_c compared to enhancement caused by pinning especially at low temperatures.
- Scanning Hall probe microscopy (SHPM) is a straightforward method to investigate the effect of GBs because it can directly probe the local magnetic properties in the material.

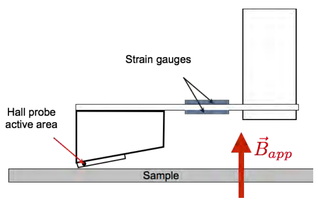
The critical current density is evaluated from the measured magnetic field profile by an algorithm that inverts the Biot-Savart Law:



Hengstberger F., et al., SUST, **22** 025011, 2009.

The SHP device

Schematic diagram of the scanning Hall probe devices

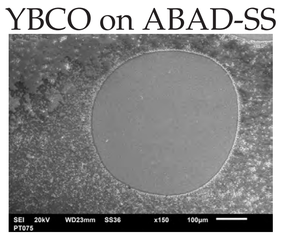


1. LN_2 bath (77 K): min. stepwidth = 50 μm
2. He gas flow cryostat (down to 4.2 K): min stepwidth = 1 μm
- Distance control: cantilever with strain gauges.

Samples

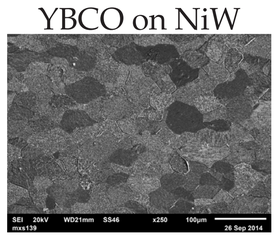
- Thick YBCO layers (> 1μm) are deposited by pulsed laser deposition (IFW)

YBCO on ABAD-SS



Grain size: 0.7-1.1 μm

YBCO on NiW



Grain size: 20-80 μm

Acknowledgements

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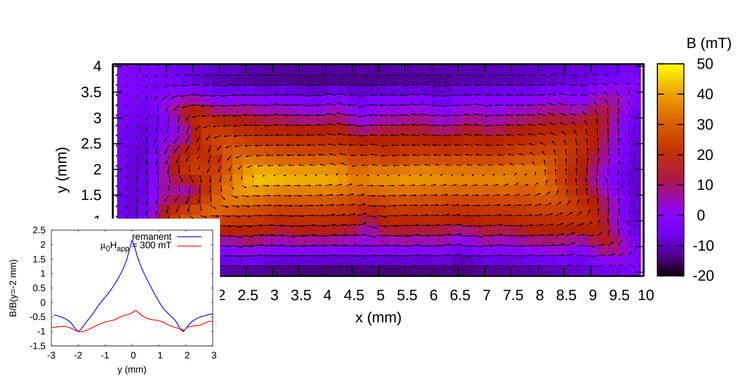
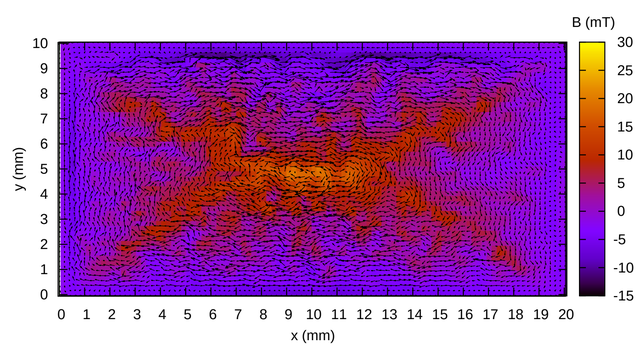
Results

Remanent field profile at 77 K (LN_2 bath)

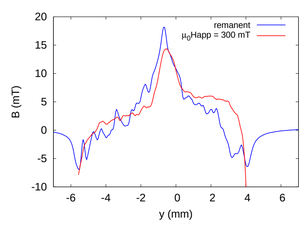
YBCO ABAD-SS

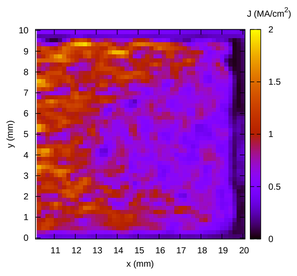


YBCO Ni5%W

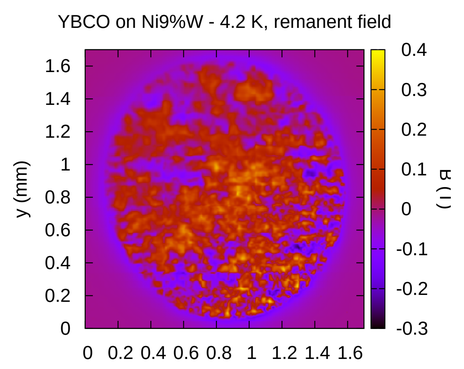


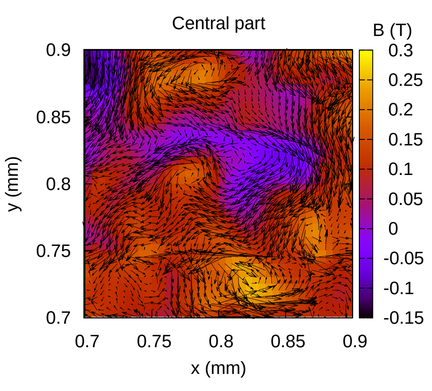
- YBCO on Ni5%W was found to have a granular texture in the trapped field profile compared to YBCO on ABAD-SS.
- Local areas in the YBCO on Ni5%W have J_c of up to 2 MA/cm^2 while transport J_c at 77 K and self field is 0.5 MA/cm^2.

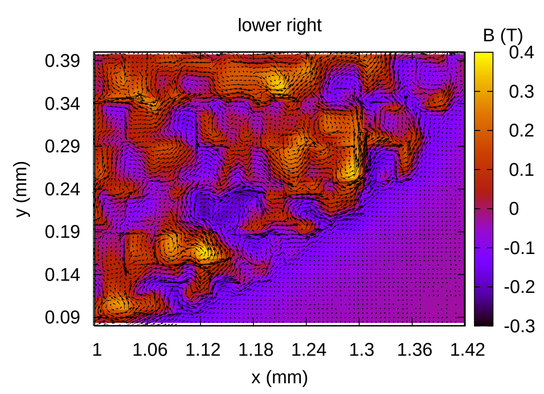




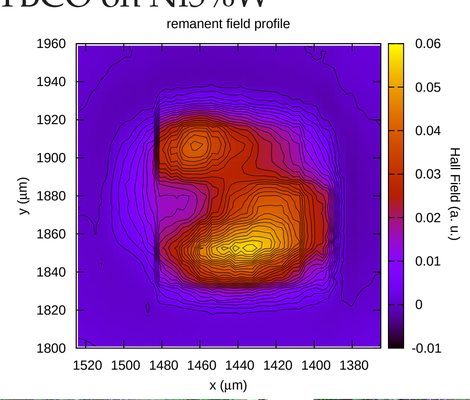
High-resolution Hall scans at 4.2 K

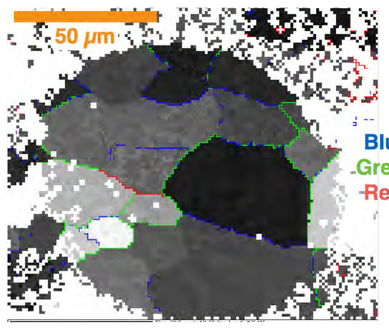




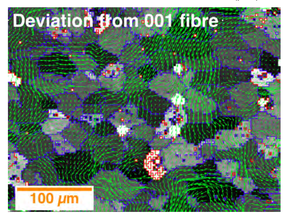


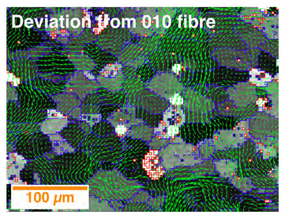
YBCO on Ni5%W

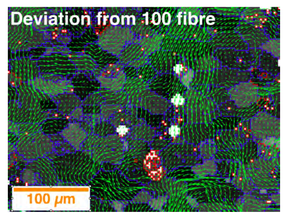




EBSD map (IFW): Deviation from 001 fibre

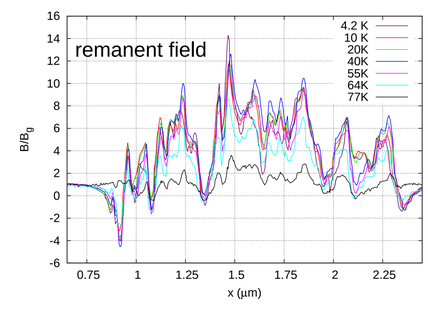


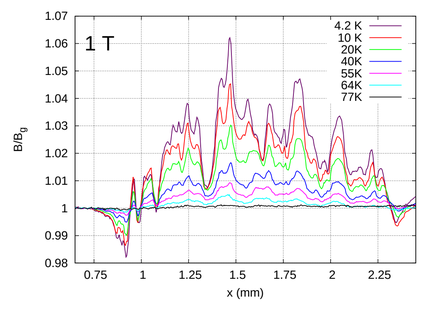


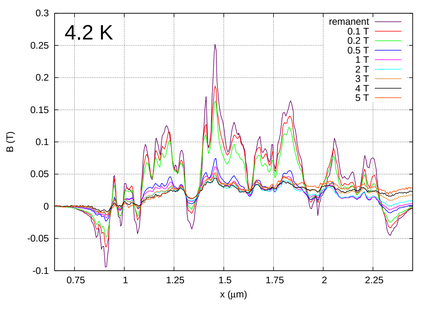


- The result of the inversion shows that the current flows locally around clusters of grains.
- By a measurement conducted on a smaller area (with ≈ 20 grains), local percolation of currents favours flow through GBs with smaller misorientation angles (i.e. < 5°).
- In a scan made on an area with small misorientation angle (i.e. < 3°), a less percolative current flow is observed.

Magnetic Field line scans of YBCO on Ni9%W







- Sharper boundaries of grains/cluster of grains at lower temperatures (stronger superconducting signal) both in remanent and in-field measurements.
- Granularity in the field profiles is present in all conditions even at large applied fields.

Conclusions

- With the high resolution Hall scan measurements on thick PLD-YBCO tapes with RABiT NiW substrate (both on magnetic Ni5%W and non-magnetic Ni9%W), the granular texture of the deposited layer was resolved in the magnetic field profile.
- The granularity of the field profiles were found to appear in all fields and temperatures. The same limiting effect may even be present for samples with smaller grains and as the clusters are formed, the boundary limitation is amplified at lower temperatures.

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