Effects of oxygen doping in Bi-2212 wires and bulk samples

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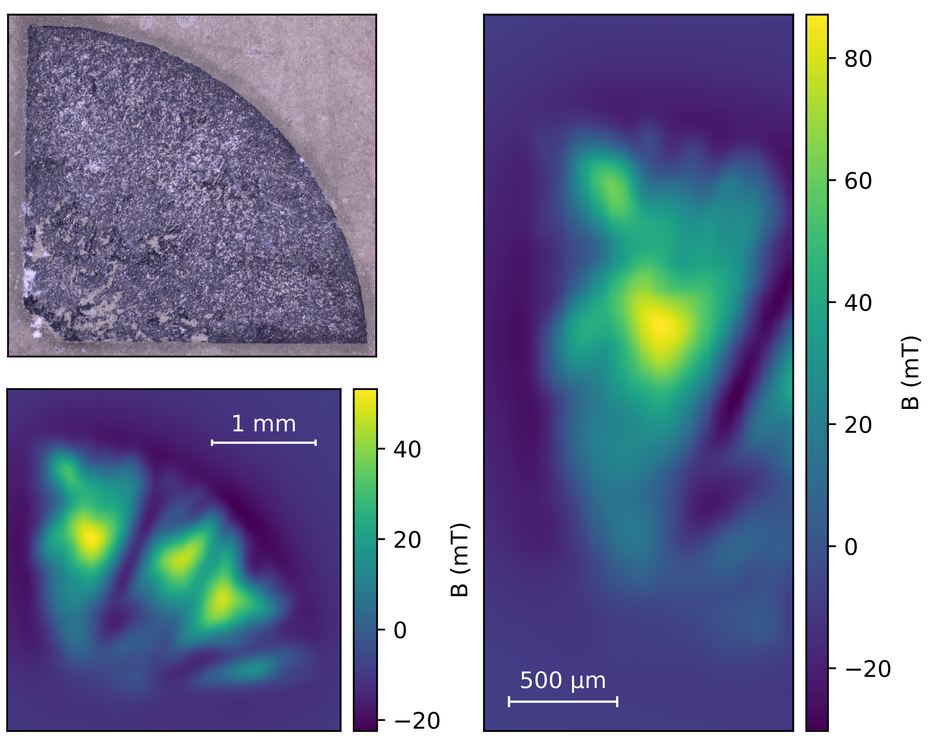
Introduction

The high achievable engineering current density in $Bi_2Sr_2Ca_1Cu_2O_{8+\delta}$ (Bi-2212) wires makes them a promising candidate for high field magnets to be used for example in fusion reactors. In this work, the superconducting properties of multifilamentary Bi-2212 wires, produced by the powder-in-tube process, and melt cast processed bulk rods were analyzed with respect to the oxygen doping of the samples. Magnetic measurements with a SQUID magnetometer as well as resistivity measurements were conducted in order to determine the superconducting properties. Scanning Hall Probe Microscopy imaging was performed to assess the global homogeneity of the samples and compared with remanent magnetization data from SQUID measurements.

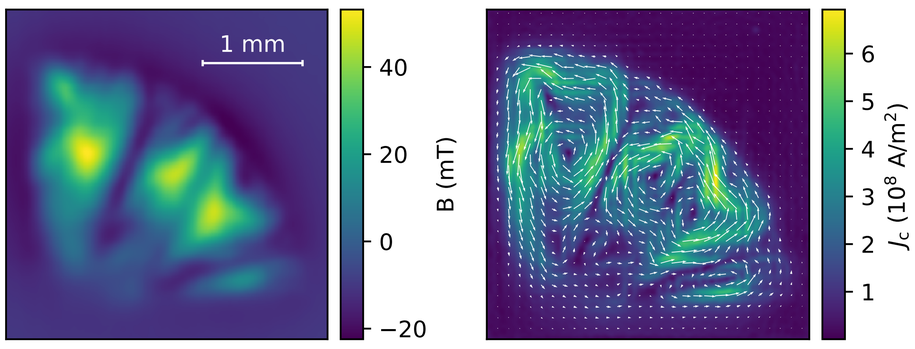
SHPM scan of bulk sample

- $Bi_{1.95}Sr_{2.01}Ca_{0.92}Cu_{2.02}O_{8+\delta}$ where $\delta = 0.175$ [1]
- Cylindrical MCP bulk sample with ⌀ 5 mm
- Quarter disc with a thickness of 200 µm cut out of bulk rod
- Remnant magnetic field at 5 K mapped by Scanning Hall Probe Microscopy (SHPM) with H parallel to the sample axis (out of the picture plane)
- Resolution of full scan: 25 µm
- Resolution of the detailed scan: 10 µm



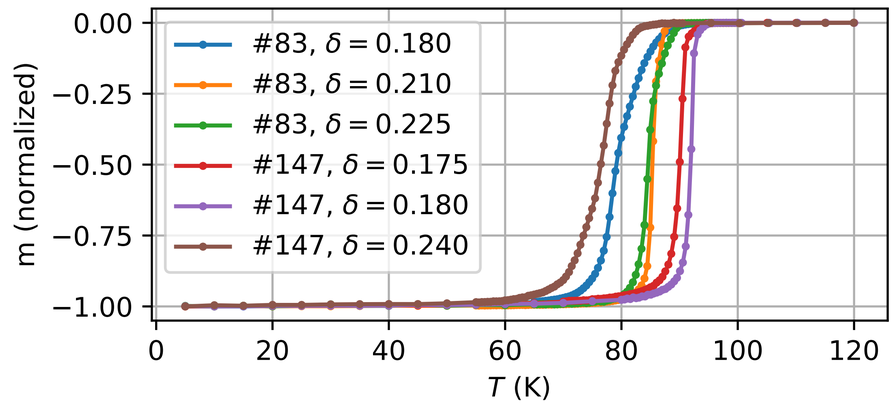
Inversion of the remnant magnetic field

- The critical current density at 5 K is calculated by inversion of the remnant field and reaches about $J_c = 6 \times 10^8\,\mathrm{A/m^2}$



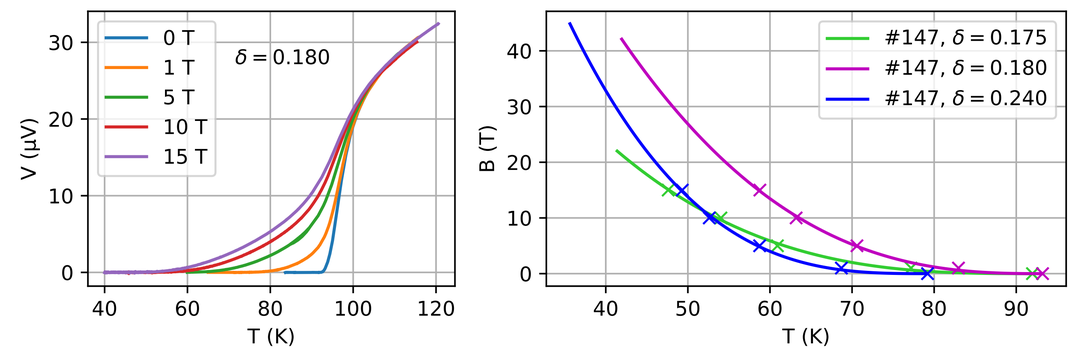
T_c measurements of bulk samples

- T_c measurements in SQUID magnetometer for different oxygen doping and two different cation-compositions: $Bi_{2.15}Sr_{2.02}Ca_{0.83}Cu_2O_{8+\delta}$ (#83) and $Bi_{1.95}Sr_{2.01}Ca_{0.92}Cu_{2.02}O_{8+\delta}$ (#147) [1]
- $T_{c,\mathrm{onset}}$ in a range from 85 to 95 K, depending on the oxygen doping and the cation composition



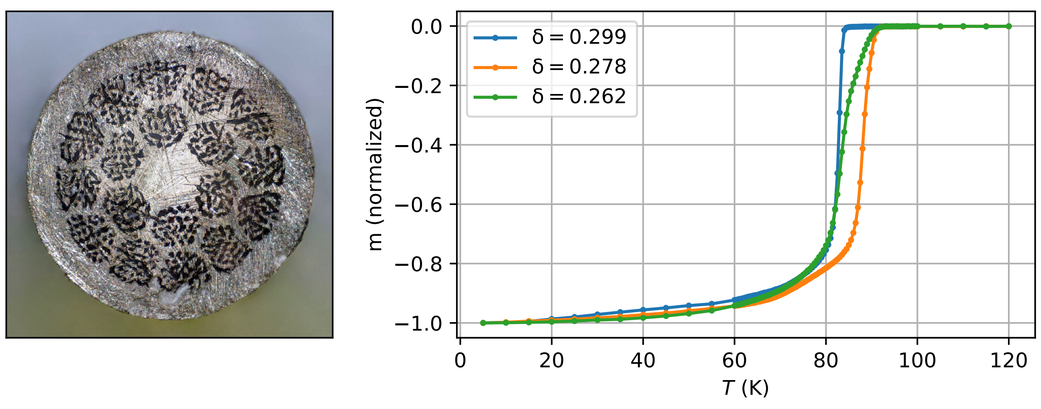
Resistive measurements of bulk samples

- $5 \times 6\,\mathrm{mm^2}$ plates cut out of cylindrical bulk samples
- Current of 2 mA applied and voltage measured using four-point-measurement while lowering the temperature
- Measure at different applied magnetic fields up to 15 T
- Fit $B_{\mathrm{irr}}(T) = B_{\mathrm{irr}}(0)(1 - \frac{T}{T_c})^n$ which gives a straight line in double-logarithmic plot
- Fitted n-values: $n_{0.175} = 2.87$, $n_{0.180} = 2.62$, $n_{0.240} = 2.95$
- Fitted irreversibility fields: $B_{\mathrm{irr},0.175}(0) = 123\,\mathrm{T}$, $B_{\mathrm{irr},0.180}(0) = 202\,\mathrm{T}$, $B_{\mathrm{irr},0.240}(0) = 262\,\mathrm{T}$



T_c measurements of wires

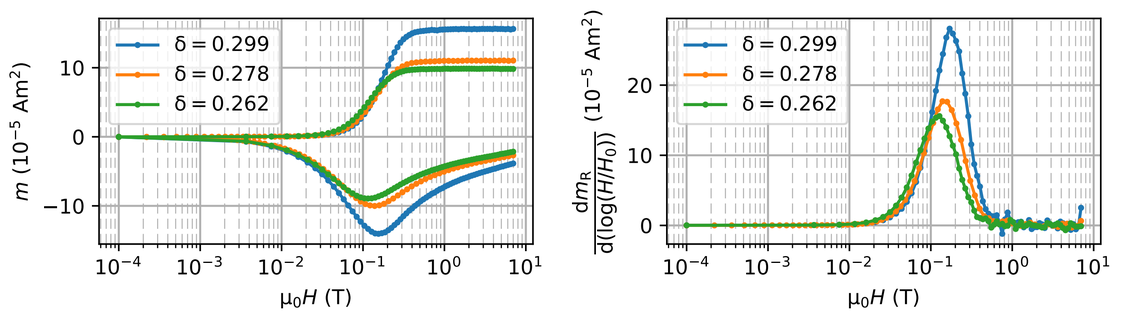
- 0.8-mm-diameter wire composed of 18×37 Bi-2212 powder filaments with a diameter of 15 µm embedded in a silver matrix [2]
- Melt process heat treatment followed by annealing at different temperatures (400 °C, 600 °C and 700 °C) resulting in a different nominal oxygen doping
- T_c measurements in SQUID magnetometer with $H \perp$ wire axis, max. $T_{c,\mathrm{onset}}$ at 91 K



Remanent magnetization measurements of wires

- Performed in SQUID magnetometer with H normal to the wire axis
- Measure the remanent magnetization after successively higher applied magnetic fields
- Calculate the derivative $\frac{\mathrm{d}m_r}{\mathrm{d}(\log(H/H_0))}$ and plot it against the applied field
- Different peaks correspond to inter- and intra-grain current densities
- Measurement (at 5 K) has only one peak, only $J_{c,\mathrm{itra}}$ is visible
- Two different estimates for J_c from H^* and m (in $10^{10}\,\mathrm{A/m^2}$)

	$\delta = 0.299$ (400 °C)	$\delta = 0.278$ (600 °C)	$\delta = 0.262$ (700 °C)
J_c from H^*	2.3	2.0	1.6
J_c from m	2.2	1.6	1.4



Summary

- Bi-2212 bulk samples and wires were analyzed
- The remnant field was mapped by means of Scanning Hall Probe Microscopy
- Magnetization measurements were done with a SQUID magnetometer

Acknowledgments

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References

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