Characterization of improved SuperPower REBCO tapes up to 31 tesla field

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Funding Grants: K.M. Amm (NSF DMR-2128556); D. Abraimov (DE-SC0023177, DMR-2131790);

MagLab's development of world-record superconducting magnets shares a key connection with start-up industries seeking to produce electricity by nuclear fusion: the need for improved high-temperature superconducting REBCO tapes to build magnets. In this Highlight, funds from the US Dept. of Energy's INFUSE program supported an extension of characterizations presently used in MagLab's 40T all-superconducting magnet project and MagLab's core grant to understand REBCO tape limits. Measuring the transport critical current (I_c) of 4 mm wide conductors is difficult due to high currents and strong nonlinearity of current-voltage curves, which is why MagLab has developed special protocols for these characterizations. By combining I_c data with structural characterization, our partner and supplier, SuperPower, gains insight about their processes to improve their REBCO product.

The data at right has been taken for REBCO wires with different Zr doping levels from 15% to 25%, which boosts in-field performance not only at liquid helium temperature but also for fusion applications at 20K, 20T. We measure I_c for magnetic field B perpendicular to the tape orientation, acquire SEM images to assess REBCO layer uniformity and thickness, and correlate I_c with the structure to find the origins of variability. To adjust MagLab's measurements for temperature T = 20K, we redesigned[1] a variable-temperature probe to measure $I_c(B, T)$ in He gas using a 31T resistive magnet. At 20K, 20T, a tape with 20% Zr appears to have optimal parameters, achieving I_c of 242A, critical current density of 3.65 MA/cm^2, and pinning force 730GN/m^3 (about 50 times stronger than the typical conductor in a medical imaging magnet attains). The full range of observations gave critical feed back to SuperPower. Moreover, we demonstrated the ability to measure transport I_c of **full-width** tape at 20K, 20T, perpendicular field, which uniquely positions MagLab to assist the fusion community.

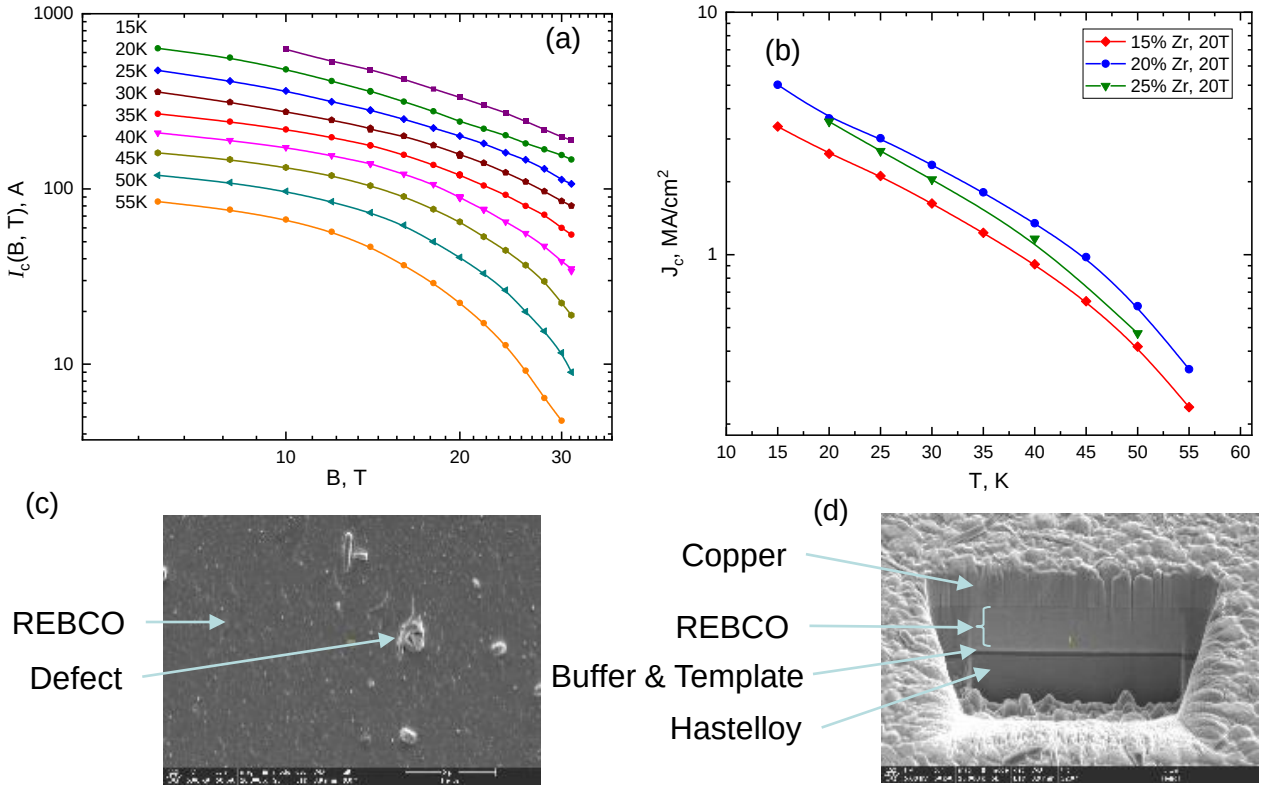

Figure (a) $I_c(B, T)$ for a 4mm wide sample with 20% Zr over 15-55K. (b) Set of critical current density dependencies J_c(T) for tapes with different Zr doping. (c) SEM top-view image shows a mostly defect-free sample for 20% Zr. (d) SEM view of the conductor cross-section for the sample with 20% Zr.

Facilities and instrumentation used: DC Field Facility 31 Tesla, 50 mm Bore Magnet (Cell 7); power: 18 MW; bore diameter: 50 mm.

Citation: [1] Francis, A.; Abraimov, D.V.; Viouchkov, Y.L.; Su, Y.; Kametani, F.; Larbalestier, D.C., *Development of general expressions for the temperature and magnetic field dependence of the critical current density in coated conductors with variable properties,* **Superconductor Science and Technology**, **33** (4), 044011 (2020) **doi.org/10.1088/1361-6668/ab73ee**