Bi$_2$Sr$_2$Ca$_1$Cu$_2$O$_x$ (Bi-2212) is the only high temperature superconductor (HTS) available as a round wire with high critical current density ($J_c$), making it a very compelling candidate for applications in high-field (>25T) magnets. New understanding of the mechanisms that create high $J_c$ in Bi-2212 round wires is important because it is breaking the long-standing belief that HTS grain boundaries are the primary mechanism that limits $J_c$ in all high-temperature superconductors. The traditional belief has been that grain boundaries limit $J_c$ by virtue of being underdoped compared to nearby grains.

Researchers studied the suppression of $J_c$ by magnetic fields for different oxygen doping levels in underdoped, optimal-doped, and overdoped Bi-2212 round wires. While underdoping severely reduced $J_c$, researchers did not observe hysteretic $J_c(H)$ curves that would be a signature of grain boundary weak-links due to underdoping. They conclude that the presently-optimized biaxial texture in Bi-2212 round wires intrinsically constitutes a strongly-coupled current path, regardless of the oxygen doping state.

Further study of Bi-2212’s unique biaxial texture will seek to understand how current flows from grain to grain by focused ion beam (FIB) surgery of single- and bi-crystals to directly measure their inter-granular current transport properties.

Facilities/instrumentation used: Helios G4 Scanning Electron Microscope, 5T SQUID, 14T Vibrating Sample Magnetometer, 15T Superconducting Magnet; MagLab’s Applied Superconductivity Center


Figure 1: $J_c(H)$ of Bi-2212 round wires with different oxygen doping levels in increasing and decreasing perpendicular magnetic fields. Despite an almost six-fold reduction in $J_c$, no field up/down hysteresis is observed, indicating a surprising lack of grain boundary weak-links.

Figure 2: Inverse pole figure maps (IPF) of a longitudinal cross section of an individual Bi-2212 filament in the highest $J_c$ sample. The dominance of green indicates a strong $a$-axis alignment.