Effects of Neutron Irradiation and Co-Doping on Polycrystalline Copper Oxide Superconductors

The magnetic field dependence of the transport critical current density has been investigated at temperatures of 65K and 77K in bulk polycrystalline samples of the high temperature superconductor $HoBa_2Cu_3O_{7-x}$, and $YBa_2Cu_{3-y}(Co)_yO_{7-x}$ (y = 0, 0.003, 0.006, 0.009), (where the cobalt molar percentage was 0.1%, 0.2% and 0.3%). Samples were sintered in ¼ inch pellet form using conventional ceramic processing techniques, and mechanical pressure contacts were used for these four-probe measurements. A 1.4 Tesla magnet was used to provide the magnetic field, and a 500 W current supply was used to provide steady sample currents as high as 2 A.

The use of neutron irradiation to induce structural defects in the crystalline lattice led to enhanced behavior of the transport critical current density in the presence of a magnetic field in the cuprate oxide superconductor, $HoBa_2Cu_3O_{7-x}$, at 77K. However, the in-field behavior of the critical current density degraded at 65K. Several investigations have been completed using a large flux of neutrons, such as from a reactor; this study utilizes a 1 Ci Am-Be neutron source for the sample irradiation. This has the added advantage of decreased residual radioactivity of the sample.

For the cobalt (Co) substitutions for copper (Cu) atoms in the crystalline lattice of the $YBa_2Cu_3O_{7-x}$superconductor, the 0.2% dopant level demonstrated the most pronounced weakening of the magnetic field dependence of the critical current density of any of the three dopant levels. This effect was most pronounced at 65K, indicating its increased effect at lower temperatures. Resistivity versus temperature curves taken for all four samples indicated a severe reduction in the critical temperature of the sample as the cobalt fraction increased to 0.3% dopant level and beyond.