Current Transport Through Low Angle Grain Boundaries and Grains in $YBa_2Cu_3O_{7-\delta}$ Thin Films, Studied Magnetometrically

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Many different phenomena affect the current-carrying capability of high temperature superconductors. Found soon after the discovery of High-Tc's, the problem of "weak links" is one of the most serious; basically, the flow of loss-free currents across a grain boundary is severely reduced, relative to the current density within a single grain. We have studied the critical current density flowing across low angle grain boundaries in $YBa_2Cu_3O_{7-\delta}$ thin films, using magnetometric methods. Films of 200 nm thickness were deposited by PLD (Pulsed Laser Deposition) on $SrTiO_3$ bicrystal substrates containing a single [001] tilt boundary, with grain boundary angles of 2, 3, 5, and 7°. The films were patterned into rings for measurement of their magnetic moment. The materials were studied in applied magnetic fields up to 30 kOe at temperatures of 5 - 95 K. We analyzed these data using a modified critical state model to obtain the current densities of rings with or without grain boundaries. For rings containing 5 and 7° boundaries, the magnetic response depends strongly on the magnetic field history, which is a consequence mainly self-field effects acting on the grain boundary.