Disorder induced transition and flux dynamics in $YBa_2Cu_3O_{7-\delta}$ (YBCO) and $Nd_{1.85}Ce_{0.15}CuO_{4-\delta}$ (NCCO) crystals

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Abstract

Measurements of the local magnetization m versus temperature T in an untwinned YBCO crystal reveal an abrupt jump in dm/dT, well below the irreversibility temperature. This jump occurs at the same field and temperature where an abrupt jump in dm/dH is observed in the magnetization curves, near the onset of the anomalous second peak. These jumps define a line $B_0(T)$ in the magnetic phase diagram of YBCO. Measurements of field profiles and magnetic relaxation suggest a disorder induced transition from a relatively ordered vortex lattice below the $B_0(T)$ line to a disordered entangled vortex solid above it. Similar measurements in a NCCO crystal reveal similar features, but the location of the anomaly in $m(T)$ do not coincide with the location of the anomaly in $m(H)$. Analysis show that the origin of the differences between the two systems is the behavior of the $B_0(T)$ line: B_0 increases with temperature in YBCO but decreases in NCCO. Vortex dynamics in these two systems was also investigated. Local magnetic measurements versus time were employed to yield the local electric field vs. current density ($E-j$) curves. Measurements in the field range corresponding to the anomalous magnetization peak reveal remarkably different $E-j$ characteristics below and above the peak, indicating a crossover in the flux creep mechanism. Similar $E-j$ behavior, as observed here in YBCO and NCCO, is expected universally in every superconductor exhibiting the anomalous peak.