The Effect of Oxygen Content and Twin Planes on the Vortex Phase Diagram of YBCO

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Abstract

We report investigations on twinned and detwinned $YBa_2Cu_3O_{7-\delta}$ crystals with δ ranging from 0.02 to 0.10. Our magnetic hysteresis studies [Phys.Rev.Lett. **79**, 2121 (1997)] revealed a well-defined peak which narrows ($\Delta B < 0.5$T) upon approaching the vortex lattice melting line. The peak position moves from relatively low field values ($B_p = 1$T) to high fields ($B_p > 12$T) with decreasing δ. This was found to correlate strongly with the dependence on oxygen content of the multi-critical point determined from our resistivity measurements. Scaling of the flux flow resistivity indicated that the intrinsic parameters of the superconducting state vary little in this range of oxygen content and we conclude that the peak effect accompanies a high field transition to a disordered (entangled) vortex phase caused by pinning by oxygen vacancies. Our findings provide strong support for the theoretical work by Giamarchi *et al.*, Phys.Rev.B **55**, 6577 (1997). The presence of extended defects such as twin boundaries was found not to effect the peak position, giving further evidence that the high field transition is caused by disordering forces on a length scale of the vortex spacing. However, our studies did reveal that these extended defects cause additional features within the vortex solid phase.