Vortex Phase Diagram in Oblique Field in $Bi_2Sr_2CaCu_2O_{8+y}$

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Abstract

Vortex phase diagram in $Bi_2Sr_2CaCu_2O_{8+y}$ single crystals was studied in oblique field using micro-Hall-probes. The angular dependence of magnetization step field (H_s) and the low temperature peak field (H_p) cannot be fitted by the scaling law predicted by G. Blatter [G. Blatter *et al.*, Phys. Rev. Lett. **68**, 875 (1992)]. Instead, we obtained an empirical relation, $H_s \propto (\cos\theta + a(T)\sin\theta)^{-1}$. Here, θ is the angle between the field and c-axis. We propose two scenarios for this behavior. One is to consider the effect of in-plane field for the interplane coherence. Alternatively, the deviation from scaling law can be explained, at least qualitatively, by considering electromagnetic coupling between interlayer pancake vortices. Furthermore, a new sharp anomaly in magnetization hysteresis loop was found in the vortex solid phase only when the field is applied with a large angle from c-axis. The field, where the anomaly occurs, has been measured as functions of temperature, oxygen content, and the angle θ. As a result, we found that the behavior of this new anomaly is consistent with a prediction [A. M. Thompson and M. A. Moore, Phys. Rev. B**55**, 3856 (1997)], which indicates the uniformly tilted vortex lattice is not stable at low field when the field is tilted from c-axis. The origin of this anomaly could be structural phase transition of vortex lattice, from low field two component lattice to high field uniformly tilted lattice.