Do Columnar Defects Produce Bulk Pinning?

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Abstract

Using the magneto-optical imaging technique we observe a surprisingly homogeneous perpendicular flux penetration into $YBa_2Cu_3O_{7-\delta}$ single crystals with big surface steps, and irradiated with 6 GeV Pb ions. Contrary to what is normally observed for bulk pinning, the penetration depth is equal in the thick and thin parts of the crystals. This observation supports the idea (Th. Schuster et al. *et al.*, Phys.Rev. **50**, 9499 (1994); **51**, 16358 (1995)) that the vortex depinning from parallel columnar defects created by the irradiation occurs only at the crystal surface and the further easy sliding of the vortex kinks along the columns does not produce a considerable bulk critical current. The situation resembles surface pinning wich can only support a surface critical current. Local magnetic measurements using miniature Hall probes indicate the restoration at higher fields of the ordinary sample magnetization proportional to its thickness, the latter is discussed in terms of appearance of "free" vortices well below the matchnig field.