Nanocomposites and nanomaterials

Critical current in superconductors with extended linear defects

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Extended linear defects with a diameter of few nanometers, which is comparable with the coherence length value in high-Tc superconductors (HTS), are known to be strong pinning sites for Abrikosov vortices, preventing their motion and related energy dissipation [1]. In the present work some theoretical aspects of vortex pinning and dynamics in HTS materials with extended *c*-oriented linear defects are explored. We consider Abrikosov vortices as an elastic vortex strings, settled in the pinning potential well of linear defects and additionally exerted to the Lorentz force action, caused by the transport current flow. The latter is considered as a surface Meissner current with density $j(z)$, which is inhomogeneously distributed over the superconductor plate thickness d ($d > \lambda$; λ- is the Meissner penetration deprh).

The explored model is based on the classical mechanics approach for behavior of an elastic vortex string which is settled in the potential well of linear defect $U_p(s)$ ($s = s(z)$ - is the vortex line displacement from the defect axis) and being also under the action of the Lorentz force $F_L(z) = \phi_0 j(z)$ ($\phi_0 = hc/2e$ - is the flux quanta). $F_L(z)$ is maximal near the film surfaces at $z = \pm d/2$. Numerical calculation of stability threshold for the pinned vortex line state and its subsequent escape from linear defect is performed for the model potential well $U_p(s)$, taken in the Lorentz form: $U_p(s) = -U_{p0}\, r_p^2/(r_p^2 + s^2)$. Solution of the stability problem gives conditions for the onset of vortex escape from the linear defect (which approximately can be written as: $\phi_0 j(z = \pm d/2) = j_{c0} \cong \max\,(dU_p/ds)$) and thus determines the averaged (over the thickness) depinning critical current density $\langle j_c(d)\rangle$ at low magnetic fields and temperatures.

1. *Civale L.*Vortex pinning and creep in high-temperature superconductors with columnar defects // Supercond. Sci. Technol. -1997.- **10**, N 7A .–P. A11–A28.