Steady states of current carrying layered superconducting film

A.N. Artemov, Yu.V. Medvedev

Donetsk Physics & Thechnology Institute, Donetsk 83114, Ukraine

Layered superconductor under transport current is a rather complicated object. It may be in superconducting, resistive or normal state. Moreover its state may be homogeneous or heterogeneous, steady or unsteady one. The state is stipulated by conditions of heat producing and removing. Peculiar features of the heating of the layered superconductors are conditioned by its nonlinear conductivity in the resistive state. This nonlinearity is connected with the properties of the system of 2D magnetic vortices (pancakes) which can exists in a layered superconductor. It reveals themselves in nonlinear IVCs which have the form of $V \propto (I - I_c(T))^{a+1}$. Taking into account these features of layered superconductors the model expression for heat prodousing rate was proposed $\dot{Q}(T) = \rho(j,T) j^2$ where effective resistivity in the resistive state has the form

$$\rho(j.T) = \rho_n \left(j - j_c(T) / j_{GL}(T) - j_c(T) \right)^{a(j,T)}$$

Here $j_{GL}(T)$ is the de–pairing current, $a(j,T) = K(T_c / T - 1)[1 - (j / j_{GL})^2]$, and K is the parameter of nonlinearity. The heat transfer processes, which take place mainly in a substrate, we describe by the one–dimensional equation

$$D_s C_s \frac{\partial T}{\partial t} = D_s \frac{\partial}{\partial x} k_s \frac{\partial T}{\partial x} + d_f \dot{Q}(T) - W(T),$$

where d_f and D_s are the film and substrate thikneeses, C_s and k_s are heat capacity and conduction of the substrate material, $W(T) = h(T - T_0)$, $h = k_s / D_s$, T_0 is the thermostate temperature. In dependence of number and kind of specific points defined by the equality $d_f \dot{Q}(T) - W(T) = 0$ model proposed may has one or three stationary solutions. In the first case the homogeneous states is stabil only. In second one the both homogeneous and heterogeneous states are possible. The diagams of steady states of the superconductor which depend on the nonlinearity parameter K or the effective coefficient of heat removing h and transport current j is builded. The velocities of the heterogeneous temperature distribution as function of current under different values of K was calculated.