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The influence of a parallel magnetic field on critical temperature and inhomogeneous current distribution of a ferromagnet/superconductor structure

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Abstract

Thin two- and three-layered ferromagnetic metal (F)/superconductor (S) structures (F/S and F/S/F) in an external constant magnetic field H parallel to the F/S interface plane are investigated in the framework of the Usadel equations for the dirty limit. The thicknesses of layers F (df) and S (ds) are supposed as being much less than the magnetic-penetration depth (λH). For the F/S and F/S/F systems the transition temperature T c is calculated as a function of df taking into account an interaction of H with the orbital motion of the conduction electrons. It is shown that magnetic field H not only suppresses the superconductivity of the S/F and F/S/F heterostructures, but it also deepens the minima of T c(df) and alters significantly the form of the function Tc(df). So the reentrant superconductivity may occur even with the magnetic field increasing, which can influence the possibility of the spin-valve regime for the F/S/F trilayer. The difference between the critical temperatures for the antiparallel (AP) and parallel (P) alignment of the F-layer magnetizations in the F/S/F trilayer essentially depends on the character of the quasi-particle motion of the F layers. This difference may strongly increase with the magnetic field growth, because superconductivity in the P alignment case may be suppressed whereas Tc AP c still does not equal zero. It is shown also that the screening current induced by the external magnetic field penetrates into the F layer through the S/F boundary. The screening current sharply decays and oscillates with distance from the boundary interface into the F layer.

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