Physical Review B - Condensed Matter and Materials Physics 2006 vol.73 N18

Hierarchy of critical temperatures in four-layered ferromagnet/ superconductor nanostructures and control devices

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Abstract

The four-layered F/S/F′/S′ nanostructure consisting of rather dirty superconducting (S) and ferromagnetic (F) metals is studied within the theory of the proximity effect taking detailed account of the boundary conditions. The F/S structures with four F and S layers are shown to have considerably richer physics than the F/S/F trilayer (due to the interplay between the 0 and π phase superconductivity and the 0 and π phase magnetism) and even the F/S superlattices. The extra π phase superconducting states obtained for the four-layered F/S/F′/S′ system are found to be different from the known "superlattice" states. The dependence of the critical temperatures versus the F layer thicknesses is investigated. An optimal set of parameters is determined, for which the difference between the critical temperatures for different states becomes significant, and the corresponding phase diagrams are plotted. It is proven that this system can have different critical temperatures for different S and S′ layers. A conceptual scheme of a control device with superconducting and magnetic recording channels that can be controlled separately using a weak external magnetic field is proposed on the basis of the F/S/F′/S′ nanostructure. The devices with four, five, six, and seven different states are explored.

http://dx.doi.org/10.1103/PhysRevB.73.184514