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Reentrant superconductivity in superconductor/ferromagnetic-alloy bilayers

Zdravkov V., Kehrle J., Obermeier G., Gsell S., Schreck M., Müller C., Krug Von Nidda H., Lindner J., Moosburger-Will J., Nold E., Morari R., Ryazanov V., Sidorenko A., Horn S., Tidecks R., Tagirov L.
Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

We studied the Fulde-Ferrell-Larkin-Ovchinnikov-type state established due to the proximity effect in superconducting Nb/ Cu41 Ni59 bilayers. Using a special wedge-type deposition technique, series of 20-35 samples could be fabricated by magnetron sputtering during one run. The layer thickness of only a few nanometers, the composition of the alloy, and the quality of interfaces were controlled by Rutherford backscattering spectrometry, high-resolution transmission electron microscopy, and Auger spectroscopy. The magnetic properties of the ferromagnetic alloy layer were characterized with superconducting quantum interference device magnetometry. These studies yield precise information about the thickness and demonstrate the homogeneity of the alloy composition and magnetic properties along the sample series. The dependencies of the critical temperature on the Nb and Cu41 Ni 59 layer thickness, Tc (dS) and Tc (dF), were investigated for constant thickness dF of the magnetic alloy layer and dS of the superconducting layer, respectively. All types of nonmonotonic behaviors of Tc versus d F predicted by the theory could be realized experimentally, from reentrant superconducting behavior with a broad extinction region to a slight suppression of superconductivity with a shallow minimum. Even a double extinction of superconductivity was observed, giving evidence for the multiple reentrant behavior predicted by theory. All critical temperature curves were fitted with suitable sets of parameters. Then, Tc (dF) diagrams of a hypothetical ferromagnet/superconductor/ferromagnet spin-switch core structure were calculated using these parameters. Finally, superconducting spin-switch fabrication issues are discussed in detail in view of the achieved results. © 2010 The American Physical Society.

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