XV Krajowa Szkoła Nadprzewodnictwa
"Stulecie Nadprzewodnictwa"
Kazimierz Dolny, 9-13 października 2011 r.

Superconductor-ferromagnet hybrids with tunable magnetic domain patterns

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Ferromagnet(F)-superconductor(S) hybrids are important model systems to study a strong and rich interplay between two seemingly incompatible collective phenomena. The stray magnetic fields which emanate from the F layer modify both the phase diagram and the pinning of vortices in the superconductor. Exquisite control of the phase diagram and vortex dynamics can be achieved by careful tuning of the geometry of the magnetic domains.

In this talk I will review the results of recent experiments on the SF bilayers with a focus on designing a system with a versatile and reversible control of the phase diagram and vortex dynamics. In our experiments the S layer is made of niobium, the F layer is a Co/Pt multilayer with perpendicular magnetic anisotropy, and a thin insulating layer in-between eliminates proximity effect. We use various demagnetization and partial re-magnetization procedures to define different domain patterns in the F layer. As a result, the phase transition line to the superconducting state is modulated, leading to unconventional reentrant superconductivity. We show also that some domain patterns produce highly inhomogeneous flux penetration and strong vortex confinement at the sample edge, while for others there is remarkable enhancement of the critical current density in excess of 15. This is the highest value reported to date. We have measured, for the first time in a single tunable structure, the dependence of the activation energy for vortex pinning on the domain width, temperature, and magnetic field.

In collaboration with Z. Adamus and Y. Syryanyy (Polish Acad. Sci.), M. Konczykowski (Ecole Polytechnique), and L.Y. Zhu, X. M. Cheng and C. L. Chien (Johns Hopkins).

Supported by Polish MNiSW grant N202058 32/1202, by EU grant POIG.01.01.02-00-108/09, by the NSF grant DMR05-20491, and by the French-Polish Program PICS 4916.