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Influence of Magnetic Domain Structure on Abrikosov Vortex Dynamics in Superconductor-Ferromagnet Hybrids[1]

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We will review the experimental and theoretical aspects of transport properties and vortex static and dynamic characteristics in magnetically coupled superconductor-ferromagnet hybrid structures. Magnetotransport characteristics and scanning tunneling microscopy (STM) images of vortex structures reveal rich superconducting phase diagram in these systems. Focusing on particular combination of a Permalloy ferromagnet with a well ordered rotatable periodic stripe-like magnetic domain structure with alternating out-of-plane component of magnetization, and a small coherence length superconductor, we find directed nucleation of superconductivity above domain wall boundaries. We show that near the superconductor-normal state phase boundary the superconductivity is localized in narrow mesoscopic channels. Changing the in-plane direction of magnetic stripe domains it is possible to re-configure the direction of the superconducting nano-channels and controllably rotate the direction of the in-plane anisotropy axis in the superconductor. Deeper into the superconducting state we observe strongly anisotropic vortex pinning effect due to the presence of the ordered magnetic domain structure. We show that the hybrid exhibits commensurability features that are related to the matching periodicities of the Abrikosov vortex lattice and the magnetic stripe domains. Using STM vortex imaging we show that the periodic magnetic induction in the superconductor creating a series of (anti)pinning channels for externally added magnetic flux quanta forcing confinement of the Abrikosov vortices and formation of quasi-1D vortex arrays. We will also discuss potential for electronic applications of ferromagnet-superconductor hybrid systems.

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