Controlling the properties of magnetic vortices in nanostructures

Flávio Garcia (1), Érico Raimundo Pereira Novais (2), Antônio Domingues dos Santos (3), Jeroen Schoenmaker (4), Antônio Carlos Seabra (5), Edson José Carvalho (6), Alberto Passos Guimarães (2)
1. LNLS, Campinas, Brazil; 2. CBPF, Rio de Janeiro, Brazil; 3. IFUSP, São Paulo, Brazil; 4. UFABC, Santo André, Brazil; 5. EPUSP, São Paulo, Brazil; UNICAMP, Campinas, Brazil.

The manipulation and control of magnetic properties in nanostructured materials have attracted a great interest in recent years. Depending on the size and shape of the structure, different magnetic domain configurations can exist, producing varied magnetic and electronic transport properties. Interestingly, a magnetic vortex represents an ordinary configuration for size-reduced structures (of the order of a micron). In general, vortices are observed in systems with in-plane magnetic anisotropy for which the lateral dimensions are comparable to the domain wall width. Two topological features characterize a magnetic vortex: polarity (up or down direction of the vortex core's magnetic flux) and circulation (curling direction). The control of these characteristics is necessary for the application of vortices to magnetic memories (VRAM's) [1, 2]. The vortex core size and the related value of its overall magnetization are very relevant for the use of such magnetic nanostructures [3].

In the present work we discuss how one can tailor the vortex core diameter, as well as extend the limits of vortex applications, by using a Co/Pt multilayer as a magnetic material. An interesting feature of Co/Pt thin films is the possibility of modifying the magnetic anisotropy (from perpendicular to in-plane anisotropy, for instance), simply by varying parameters such as the Co thickness. We show in a simple way how the vortex diameter in a film of perpendicular anisotropy characterized by K is modified.

Through micromagnetic simulation (using the code OOMMFF) we show that the variation of the vortex core diameters follow closely the theoretical expression; complex vortex structures are also observed, as a function of varying anisotropy. In our experimental study on arrays of discs produced by electronic beam lithography with different lateral sizes (250, 500, 1000 and 2000 nm diameter) and different effective anisotropies (in-plane to out-of-plane anisotropy) we observe the variation in core diameter, from images obtained by Photo-Electron Emission Microscopy, carried out at Elettra synchrotron, in Trieste, Italy. Magnetic characterization has been performed by SQUID magnetometer and MOKE. Acknowledgements: FAPESP, CNPq, FAPERJ, LNLS and Elettra for financial support.

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