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Domain wall narrowing in ferromagnetic bilayers

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Abstract – This work deals with domain-wall narrowing in thin-film nanoestructures. Some parameters like wall width, q, and the density energy wall values were calculated for a bilayer composed of two ferromagnetic materials. We observed an effect of the position of the center of the domain wall relative to the interface, which yields a spring-like jump when domain wall is driven from a soft into the hard region. An asymmetric narro-wing similar to that in the present paper is known from domain wall pinning.

This work deals with domain-wall narrowing in thin film nanoestructures. Some parameters like wall width, q, and the density energy wall, γ, values were calculated for a bilayer composed of two ferromagnetic materials, A and B, with different anisotropy, $K_{A,B}$, and exchange, $C_{A,B}$, constants. We observed an effect of the position of the center of the domain wall relative to the interfase, which yields a spring-like jump when domain wall is driven from a soft into the hard region. An asymmetric narrowing similar to that in the present paper is known from domain wall pinning. We solved the case for two bilayer thicknesses of Fe-Co with Bloch-type walls, *b*: 150 nm and 2 μm. The p parameter was incorporated into the integration limits in the energy densities:

$$\gamma(p,q) = \int_{-\infty}^{p} w(K_A, C_A)dx + \int_{p}^{\infty} w(K_B, C_B)dx$$

As expected, in the limits p→± ∞, the energy density values lead to the case of a single material. Solving transcendent equations, involved as the total energy is minimized, requires the use of numerical methods. The only cases where analytical solutions can be obtained are with the Bloch-type walls in very thick films or with the Néel-type walls in ultra thin films, because the magnetostatic energy term is not significant. In both cases, analytical expressions are obtained for the wall width $q = \sqrt{2(\sqrt{2}-1)C/K}$ and wall energy $\gamma = \pi\sqrt{2(\sqrt{2}-1)CK}$, which will apply solely within the limits p→ ±∞ and p = 0. In this paper, we solved the case for two bilayer thicknesses of Fe-Co with Bloch-type walls: 150 nm and 2 μm. In Figures 1 and 2, q and γ are shown as functions of position on the wall regarding the interface of the materials. For a film thickness of 150 nm, the q and γ values range from 5.3 nm < q < 8.9 nm and 3.9 erg/cm2 < γ< 9.9 erg/cm^2, respectively. For a film thickness of 15 μm, the value ranges are: 6 nm<q <9.5 nm and 2.57 erg/ cm^2 < γ< 9.5 erg/cm^2. Additionally, the conductivity through the interface was calculated by using micromagnetic modeling conductance calculations. The asymmetrical domain wall narrowing described in this paper is especially suitable to study transport properties in nanodevices.

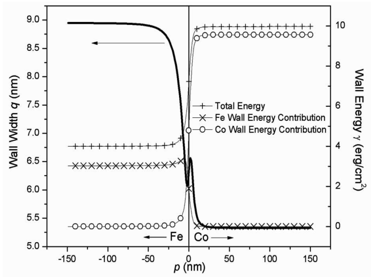

Figure 1: Wall Width and wall energy for a bilayer of 150 nm thicknesses of Fe-Co

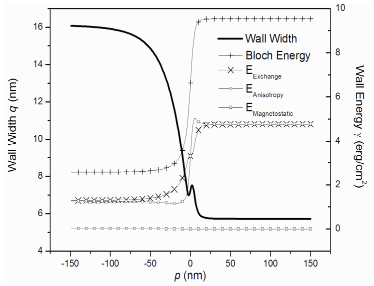

Figure 2: Wall width, total energy and partial energies for a bilayer of 2 μm thicknesses of Fe-Co