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BOOK OF ABSTRACTS. VOLUME II

DEPENDENCE OF COERCIVE FORCE ON THICKNESS IN THREE LAYER FILMS, OBTAINED BY CHEMICAL DEPOSITION

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Magnetic hysteresis which is observed in ferromagnets during magnetization reversal can be caused by various reasons. The value of the coercive force H_C can vary in a wide range in the same compounds. The basis of its occurrence in single domain particles is irreversible processes of rotation of the magnetic moment. The coercive force is determined by the magnitude of the magnetic anisotropy, which can be caused by both crystallographic and magnetoelastic contributions, as well as the anisotropy of the sample shape.

If there are domain walls the magnitude of the magnetic hysteresis depends on the height of potential barriers that prevent the movement of domain walls. In single layer magnetic films the above mechanisms are well studied and allow to obtain both highly coercive and low coercive magnetic materials in a targeted manner. The effect of a significant reduction of the coercive force, which is observed in multilayer films with nonmagnetic layers is interesting from the physical and applied points of view. Now there is still no strict theory of this phenomenon. There is only its qualitative explanation, which is based on the fact that the total energy of the walls decreases in layered films due to the formation of Neel's quasi wall, which ultimately leads to a decrease of H_C.

This paper presents the results of studies of the coercive force of three layer films as a function of the thicknesses of non-magnetic and magnetic layers in three layer films obtained by chemical deposition.

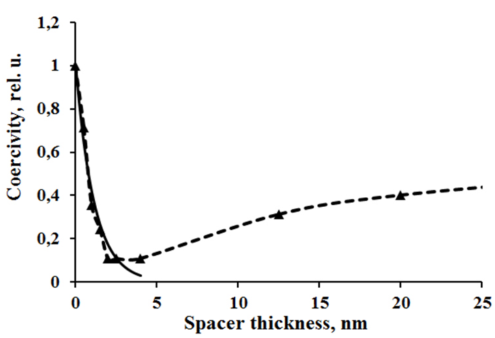

Figure 1. Coercivity of trilayers versus nonmagnetic spacer thickness. The solid line is a theoretical dependence

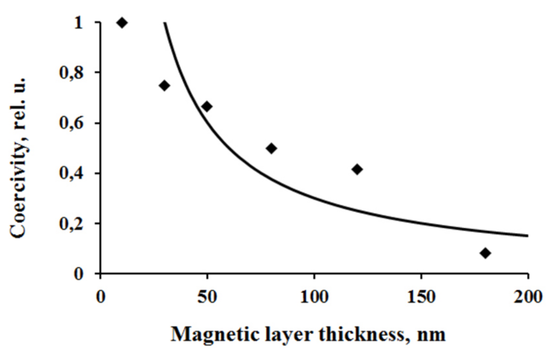

Figure 2. Coercivity of trilayers versus magnetic layer thickness. The solid line is a theoretical dependence

The magnetic layers are made of low coercive CoP alloy, the nonmagnetic interlayer is made of amorphous NiP alloy. As it was established earlier [1], the coercive force of such structure has a non monotonic dependence on the thickness of the layer t_s. At a fixed thickness of the magnetic layer, an increase of t_s from 0 to 2–4 nm leads to a sharp decrease in H_C from 7.5 to 0.5 Oe. The value of H_C monotonously increases with further growth of t_s, as shown in Fig. 1. In that case, if the thickness of the nonmagnetic interlayer is fixed, the thickness increasing of the magnetic layer t_f leads to a decrease of H_C. Its value reaches 0.05 Oe at t_f = 200 nm (Fig. 2).

Minimizing the total energy in three layer films leads to the formation of Neel quasi walls, whose energy depends on the thickness of the interlayer and magnetic layers. In the case of small thickness of the interlayer the distribution of the magnetization between the layers and hence the energy of the wall is significantly affected by the imperfections of the interface such as roughness and punctures. The presence of the first type of interface imperfections in the studied structures is confirmed by the characteristic change in the displacement field from the thickness of the interlayer in asymmetric three layer films obtained by chemical deposition.

The value of coercive force depending on the roughness parameters, as well as on the thickness of the magnetic and non magnetic layers, founded in the Neel approximation with the distribution of inhomogeneities according to the orange peel type looks like [2,3]:

$$H_C = \frac{\pi^2}{\sqrt{2}}\frac{h^2}{\lambda}\frac{1}{t_f}\exp\left(-\frac{2\sqrt{2}\pi}{\lambda}t_s\right), \qquad (1)$$

where h and λ are the amplitude and wavelength of the interface roughness.

As follows from Fig.1, the experimental dependence of the coercive force on the thickness of the interlayer in the region from 0 to 3 nm is in accordance with its theoretical variation determined from this formula. With increasing thickness of the interlayer, the influence of interface heterogeneity decreases, and the value of H_C will be determined by the energy of Neel quasi walls for a smooth interface. In accordance with the theory [4], as the thickness of the interlayer increases, the demagnetizing field energy of Neel's quasi walls will increase. This explains the growth of H_C, which is observed at $t_s >$ 4 nm.

The theoretical $H_C(t_f)$ curve, which is determined from (1) with a constant interlayer thickness, is shown in Fig. 2. It is in qualitative agreement with experimental data.

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