Nanocomposites and nanomaterials

Magnetic properties, anisotropic coercivity and in-plane anisotropy in nanogranular Co/Al_2O_3 films above the percolation limit

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Magnetic properties of nanogranular ferromagnetic Co/Al_2O_3 films with 74.5 at. % Co, which is above the percolation limit, were investigated. It was established that the films have perpendicular magnetic anisotropy and a weaker in-plane anisotropy. The analysis of the magnetization curves show that the film consists of two magnetic components: a dominating contribution from magneto-anisotropic isolated grains with the anisotropy axis perpendicular to the film plane and a weaker contribution from the percolated part of the film. This two-component magnetic composition of the films, with the dominating contribution from the nanograins, is confirmed by transmission electron microscopy as well as by ferromagnetic resonance spectroscopy. It is further established that the coercive field of the film is almost entirely determined by the percolated part of the film. In this, the angular dependence of the coercive force, $H_c(\theta_H)$, is essentially proportional to $\sin^{-1}\theta_H$, where θ_H is the angle between the applied field and the film's normal. However, for $\theta_H \to 0$, $H_c(\theta_H)$ has a narrow minimum with H_c approaching zero. Such non-linear dependence agrees well with our modeling results for a two-component magnetic system of the film, where the non-percolated nanograins have distinct perpendicular anisotropy. Furthermore, it was shown that the presence of in-plane anisotropy affects the critical field for an ensemble of superparamagnetic nanogranules. The reported results should be important for in-depth characterization and understanding the magnetism and anisotropy in inhomogeneous systems as well as for applications, specifically in perpendicular magnetic recording.