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Temperature dependence of the higher-order magnetic anisotropies in Co/Au multilayer structures

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Uniaxial perpendicular anisotropy (PMA) can be as high as 1 MJ/m^3 in superlattices composed of Co and nonmagnetic transition metals (Pd, Pt and Au), and studies of these structures are of interest for both fundamental understanding of the magnetism and for the potential applications.

We report the detailed ferromagnetic-resonance studies of temperature dependence (100 - 600 K) of the second (K_U^2) and the fourth (K_U^4) order constants of the magnetic anisotropy in Co ultrathin (0.8 and 1.5 nm) layers. Only few measurements on the temperature dependence of the higher-order magnetic anisotropies in ultrathin films have been reported. We found that K_U^2 in an order of 1 MJ/m^3 monotonically decreases with temperature and saturates at 500 - 600 K. The magnetization direction depends on the Co thickness and changes from perpendicular to parallel to the surface at 250 - 350 K for the Co layers of 1.5-nm thick due to a contribution of the interface terms to the anisotropy energy. We estimated that the volume and the surface contributions to the PMA (K_U^2) are in the same order. The fourth order anisotropy (K_U^4) is almost temperature-independent. Additionally, a substantial increase in the surface anisotropy was observed upon a temperature cycling up to about 600 K, possibly due to an increased perfection of the Co layers.