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The Enhanced Magneto-Optical Kerr Effect in Co/TiO_2 Multilayer Films

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Abstract—Spectral dependences of the polarization plane rotation angle (θ_k) in the polar Kerr effect in Co/TiO_2 multilayer nanocomposite films have been studied in the 400–1000 nm wavelength range. It is established that the sign, magnitude, and shape of the magneto-optical spectrum depend on the dielectric spacer thickness and the number of layers in the structure. The Kerr rotation angle in Co/TiO_2 multilayers is significantly greater than that in homogeneous Co films of the same thickness. The angle of rotation of the polarization plane reaches a record high value of $2\theta_k = 7.3°$ in the Co(5 nm)/TiO_2(17 nm) multilayer structure with number of layers $n = 8$ at a wavelength of 540 nm.

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The considerable interest in nanocomposite materials—in particular, nanocomposite films—is related to their numerous unusual and practically important properties, which are inherent in these materials and make them promising objects for both basic and applied research. There are two main types of nanocomposite film systems, representing (i) nanogranular films that consist of ferromagnetic (FM) nanoclusters distributed in a nonconducting matrix and (ii) periodic nanodimensional structures (multilayers) of the FM metal/nonmagnetic metal (or dielectric) types. The magneto-optical properties of nanocomposite films are extensively studied in view of their use as magnetically active media for various magneto-optical devices.

In particular, the enhancement of magneto-optical effects observed in periodic film structures of magnetic metal/dielectric type offers a new class of promising magneto-optical materials [1, 2]. The dielectric spacers in these systems have been most frequently represented by SiO_2 and Al_2O_3 layers. As is known, the magneto-optical properties of these heterogeneous structures are determined by the dielectric and optical parameters of both magnetic and nonmagnetic layers [1–4]. In this context, it was of interest to study the magneto-optical properties of Co/TiO_2 multilayers, since TiO_2 spacers possess higher optical characteristics than those of SiO_2 and Al_2O_3.

Previously, we have studied the magneto-optical properties of nanogranular Co–Ti–O films [5]. It was found that the spectral dependences of the angle of polarization plane rotation in the polar Kerr effect in this system exhibited a resonant character with significantly enhanced magneto-optical response. The observed effect depended on the magnetic phase concentration and exceeded the analogous value reported for a nanogranular $Co–SiO_2$ film [6].

This Letter presents the results of an investigation of the magneto-optical properties of Co/TiO_2 nanocomposite films. The composite represented a Co/TiO_2 multilayer periodic structure with the maximum number of bilayers $n = 12$, which were synthesized in vacuum in a single technological cycle by sequentially depositing Co and TiO_2 layers onto coverglass substrates using the ion-plasma sputtering and reactive sputtering techniques, respectively. All layers were deposited onto a relatively cold substrate (T = 320 K). The angle of polarization plane rotation (θ_k) in the polar Kerr effect and its spectral dependences were measured using the null-analyzer technique with double modulation of the plane of incident light polarization with respect to azimuth. The measurements were performed at room temperature on a magneto-optical setup operating in a wavelength range of λ = 350–1000 nm in magnetic fields up to 14 kOe. The accuracy of angle measurements was 0.2 arc min. The spectral dependences of the angle of polarization plane rotation in the polar Kerr effect were studied for nanocomposite samples with different thicknesses of the dielectric spacers and various numbers of Co/TiO_2 bilayers.

The influence of the thickness of TiO_2 spacers on the spectral dependences of the Kerr rotation angle was studied using a series of four-bilayer structures with spacer thicknesses x = 10, 14, 17, 20, 25, and 30 nm. Samples with 10-nm-thick spacers exhibited an almost monotonic spectral dependence of the angle of polarization plane rotation. Figure 1 shows the

tude, and shape of the magneto-optical spectrum of Co/TiO_2 multilayer films depend on the dielectric spacer thickness and the number of layers in the structure. The spectral dependences of the Kerr rotation angle in Co/TiO_2 multilayers with number of bilayers $n = 4$ and above exhibit a resonant character, whereby the Kerr effect at the resonance is significantly enhanced as compared to that in homogeneous Co films. The angle of polarization plane rotation in the polar Kerr effect reaches a record-high value of $2\theta_k = 7.3°$ in the Co(5 nm)/TiO_2(17 nm) multilayer structure with number of bilayers $n = 8$ at a wavelength of 540 nm.

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