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Structural and magnetic changes of ultrathin Pt/Co/Pt trilayers under the influence of irradiation by an excimer laser

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The Co/Pt-based ultrathin films are nowadays intensively studied due to their interesting physics and potential applications in a magnetic devices (high-density information storage devices, sensor or actuators). The initial magnetic properties of ultrathin Co-Pt system can be modified by an external factor like ion or laser irradiations. It was shown that the irradiation of Pt/Co/Pt trilayers by extreme ultraviolet (EUV) light pulses causes reorientation of the magnetic anisotropy through the creation of $Pt_{1-x}Co_x$ disordered alloy [1].

In this paper we present the results of structural studies of several Pt/Co/Pt trilayer samples irradiated by an excimer laser (homogeneous beam, profile 308 nm wavelength, 25 ns pulse duration, at two fluences: 400 and 600 mJ/cm^2). The trilayers deposited by the molecular beam epitaxy (MBE) onto (0001)-oriented Al_2O_3 substrate consisted of 5 nm thick Pt buffer, 3.5 nm thick Co layer and 5 nm thick Pt cover. As-deposited samples as well as those modified by excimer laser were studied by means of X-ray diffraction, X-ray reflectivity, polarized neutron reflectivity and magnetooptical magnetometry methods.

The diffraction studies confirmed the [111] growth direction of the Pt/Co/Pt/ Al_2O_3 structure. Due to small thickness of the layers the thickness fringes originated from Pt buffer prevent the direct observation of the diffraction peaks from the Pt and Co layers, but the position of Pt 111 peak can be found in the center between two strongest fringes as shown in the Fig.1a. The value of the 111 lattice spacing calculated from the position of the Pt peak indicates a compressive strain with strain parameter γ equal 2.50 for the Pt buffer layer (without strain: $\gamma = 2.45$ – see Ref. [1]). Irradiation at the fluence D = 400 mJ/cm^2 results only in a reduction of the strain state of Pt layer to the value of $\gamma = 2.46$ without changing the value for the relaxed lattice parameter of Pt. The further irradiation with the fluence D = 600 mJ/cm^2 results in creation of the $Pt_{0.72}Co_{0.28}$ alloy distributed in the whole structure. This layer is under tensile strain ($\gamma = 2.39$) with the relaxed lattice parameter value equal to $a_{\rm rel} = 3.851(4)$ Å what confirms creation of ordered Pt_3Co alloy with primitive cubic structure and lattice parameter $a = 3.8541$ Å [2].

Moreover, irradiation with higher fluence caused the smoothing of the surface layer as evidenced by the thickness oscillations visible in the Fig.1b.

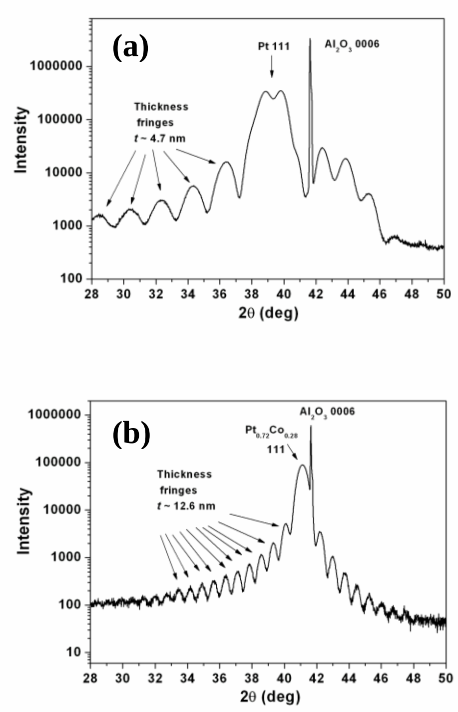

Figure 1. X-ray diffraction patterns in the vicinity of 111 Pt reflection performed for: (a) – as-deposited sample, (b) – irradiated by excimer laser with fluence D = 600 mJ/cm^2.

The X-ray reflectivity and polarized neutron reflectivity measurements confirmed the results obtained by X-ray diffraction studies.

In-plane magnetization state was observed for as-deposited samples. After the irradiation with lower fluence of 400 mJ/cm^2, the increase of magnetic anisotropy has been observed. The further increase of fluence up to 600 mJ/cm^2 results in an appearance of the out-of-plane magnetization state.

Concluding, for lower applied fluence the strain modification in trilayer is the only observed irradiation effect. Despite the lack of Pt and Co intermixing in trilayer system, the observed strain modification is sufficient for increase of magnetic anisotropy.

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[2] JCPDS, Reference code 29-0499.