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XAFS study on the ultrathin Pt/Co/Pt trilayers modified with short light pulses

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Ultrathin film systems containing magnetic component, like Co, sandwiched between nonmagnetic metals, with tunable magnetization anisotropy (in-plane and out-of-plane) are of particular importance for spintronics as well as for technology of magneto-optical memory devices. The perpendicular easy axis of magnetization is considered in these systems to be related to the structural features of magnetic film and interfaces. The Co/Pt systems are particularly interesting due to the strong magnetic anisotropy and high magneto-optical response in ultra violet range [1]. In case of a Pt/Co/Pt trilayers irradiated with different type of light pulses [2], an out-of-plane from in-plane spin reorientation transition (SRT) was evidenced. While earlier out-of-plane to in-plane SRT was observed and characterized as irradiation-driven intermixing and disordering at the Co–Pt interfaces. These processes lead to a reduction of the anisotropy, coercivity, magnetization and Curie temperature. This way a new possibility to induce the perpendicular magnetization becomes available. In particular, in comparison with conventional thermal annealing of the sample [3], the ultrafast laser annealing provides possibility to create structural and magnetic changes at the interfaces while substrate temperature is almost unchanged which is important for technological applications.

The investigations were performed for the series of the Pt (5 nm)/Co (3.5 nm)/Pt (5 nm) trilayers grown by the MBE method on the sapphire single crystal substrate. In part of the samples the lower Pt layer was grown at 750 °C, in others whole process was carried out at room temperature. Afterward selected samples were irradiated with light – either ns XUV pulses using laser produced plasma source or by fs optical laser pulses. The whole sample surfaces were exposed point by point in order to achieve quasi-uniform irradiated area. The light irradiation fluencies were adjusted to correspond to appearance of the out-of-plane magnetization state. Magnetic studies were carried out after irradiations by means of magnetooptical techniques exploiting Kerr effect. The X-ray absorption fine structure (XAFS) experiment was performed at the BM08 beamline in ESRF. Both regions X-ray Absorption Near Edge Structure (XANES) and Extended X-ray Absorption Fine Structure (EXAFS) were investigated. The signal was gathered in a fluorescence mode at 77 K in a normal (out-of-plane) and grazing (in-plane) incidence configurations. The measurements were carried out at the Co K-edge for the as-grown reference and modified samples.

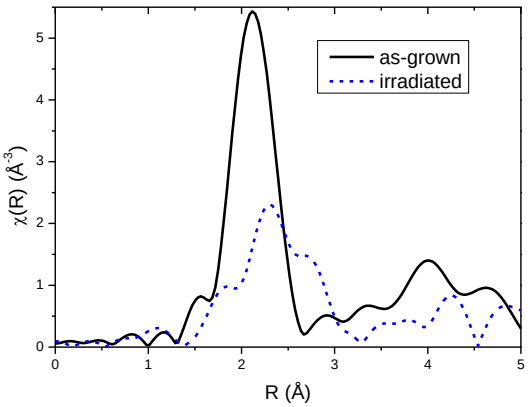

Figure 1. FT EXAFS: comparison between spectra of reference and irradiated sample, both in grazing incidence.

In case of the as-grown samples only the Co neighbors were found in the first shells. The bond lengths and local disorder are the same independently from the preparation method.

The irradiation causes significant changes in the local structure around Co atoms (Fig. 1). Mixing between Co and Pt atoms occurs. The bond lengths and local disorder increase. Moreover, detailed EXAFS analysis revealed that for all irradiated samples the bond lengths in the direction parallel to the layer surface are longer than in the perpendicular one. It suggests that after light irradiation tensile stress appeared in the Co layer.

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