P-09

Structural and magnetization changes induced in Pt/Co/Pt trilayers irradiated by femtosecond XUV FEL pulses

R. Sobierajski[1]*, D. Klinger[1], I. Jacyna[1], P. Dłużewski[1], M. M. Klepka[1], Z. Kurant[2], J. B. Pełka[1], I. Sveklo[2], A. Wawro[1], J.Chalupsky[3], V.Hajkova[3] and A. Maziewski[2]

[1]*Institute of Physics, Polish Academy of Sciences, 02- 668 Al. Lotników 32/46, Warsaw.*
[2]*Laboratory of Magnetism, Faculty of Physics, University of Bialystok, K. Ciolkowskiego 1L, 15-245, Bialystok, Poland*
[3]*Institute of Physics, ASCR, Na Slovance 2, Prague 8, 182 21, Czech Republic*

Keywords: FLASH, FEL ultrathin films, Pt/Co/Pt, structure modification, magnetic reorientation

*e-mail:ryszard.sobierajski@ifpan.edu.pl

We have studied threshold energy density for structural and magnetic modifications (spin reorientation between out-of-plane and in-plane magnetization) in the Pt/Co/Pt trilayer systems modified with femtosecond XUV light pulses. Ultrathin film systems containing magnetic component, like Co, sandwiched between noble metals, with tunable magnetization direction (in-plane and out-of-plane) are of particular importance for spintronics as well as for technology of magneto-optical memory devices. In case of a Pt/Co/Pt trilayers irradiated with different light impulses [1-3], an out-of-plane to in-plane magnetization reorientation phase transition was evidenced, with an irradiation-driven intermixing and disordering at the Co–Pt interfaces. In comparison with conventional thermal annealing of the sample, the fast laser annealing provides possibility to create structural and magnetic changes at the interfaces without substrate overheating which is important for technological applications.

In general sample irradiation may lead to such phenomena as blurring of originally sharp interfaces and - as a result of atomic interdiffusion - formation of a PtCo disordered/ordered alloys and appearance of defects and strains. Such structural modifications change the basic parameters characterizing magnetic properties of multilayer structures – specifically magnetic anisotropy. In particular the interface blurring may reduce the surface anisotropy, while atomic interdiffusion leads to formation of alloys with specific magnetocrystalline anisotropy. In case of lattice deformation – magnetoelastic anisotropy contribution may become significant, as well.

We have investigated Pt(5 nm)/Co(3.5 nm)/Pt(5 nm) trilayers grown by the MBE method on the sapphire (0001) single crystal substrate. We have studied two series of samples – the Pt buffer layer was grown either at 750 ^{0}C, or at room temperature. Selected samples were irradiated with fs XUV pulses using Free Electron LASer in Hamburg (FLASH). Samples were exposed to single pulses, each at a pristine position, at two incidence angles (normal and grazing angle of 20 degree). The irradiation fluences were in the range appropriate to switch the system between in-plane and out-of-plane magnetization states. Magnetic tests were carried out after irradiations by means of magnetooptical Kerr effect (MOKE) based techniques. We have performed morphological and structural characterization of Pt/Co/Pt trilayers by means of optical microscopy, AFM, SEM and TEM. The structural properties were correlated with the magnetic features and radiation fluence (see Figure 1). Thus it was possible to associate the magnetic modifications with the required radiation dose and their structural context.

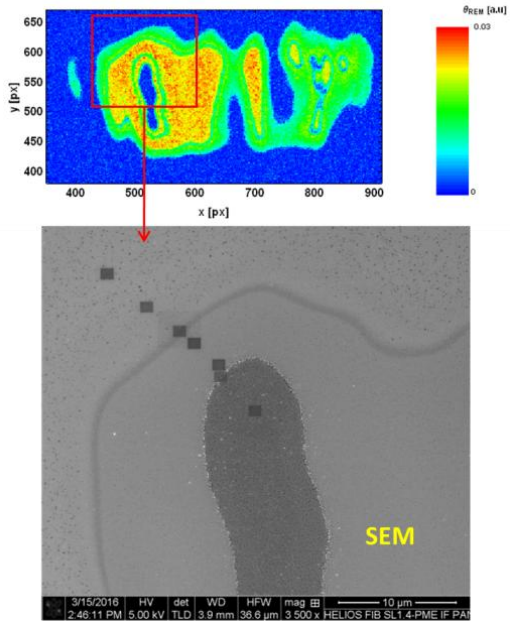

Figure 1. Magnetization (top) and surface morphology (bottom) images of an irradiated spot measured by means of MOKE and SEM techniques, respectively. Black squares at the SEM images correspond to positions of previous SEM detailed studies (carbon contamination of the surface).

Acknowledgments: This work has been supported by the Polish National Science Center (Grant No. DEC-2012/06/M/ST3/00475).

[1] J. Kisielewski, *et al., J. Appl. Phys* **115** (2014) 053906.
[2] E. Dynowska, *et al., Nucl. Instrum. Methods Phys. Res., Sect. B* **364** (2016) 33.
[3] W. Szuszkiewicz, *et al., Phase Transitions* **89** (2016) 328.