ESRF	**Experiment title:** **XMCD studies of the interface magnetism responsible for magnetic patterning of thin Co film by Au and Mo buffers**	**Experiment number**: **SI 2538**
Beamline: ID-12	**Date of experiment**: from: 5th Dec. 2012 to: 10th Dec. 2012	**Date of report**: 23rd Sept.2013
Shifts: 15	**Local contact(s)**: Andrei Rogalev, Katharina Ollefs	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Andrzej Wawro[1] , Ewelina Sieczkowska[1] , Piotr Mazalski[2]

[1] Institute of Physics, Polish Academy of Sciences, Al. Lotników 32/46 street, 02-668 Warsaw, Poland.

[2] Faculty of Physics, University of Bialystok, Lipowa 41 street, 15-424 Bialystok, Poland.

Report:

The aim of the performed experiment was to investigate magnetic properties of the elements forming the Mo/Co and Au/Co interfaces. The measurements were inspired by a role which a structured buffer in the form of self-assembled Au(111) islands on a Mo(110) layer surface [1] plays as a template for magnetic patterning of deposited Co ultrathin films. As a result we have obtained an array of magnetic dots, hundred nanometers in lateral size, magnetized in perpendicular direction [2-4]. Acquired magnetic patterning is a consequence of spatially varied buffer / Co layer interface affecting either the surface anisotropy as well as a growth mode of the Co layer and – in consequence – its magnetocrystalline anisotropy. A particular attention was paid to magnetic properties at the Mo/Co interface which are practically unknown.

A number of the samples investigated in this experiment was a compromise between the number of granted shifts and long lasting data acquisition time for XMCD at the Mo $L_{2,3}$-edges. Finally, we studied the following samples (substrate: sapphire (11-20) wafer, layer thicknesses given in Å):

1309: V200/(Mo9/Co50)*3/Mo9/V50
1310: V200/(Mo22/Co50)*3/Mo22/V50
1311: V200/(Mo22/Co11)*3/Mo22/V50
1334: V200/(Mo_4Co_{96})1100/V50

The idea of the above listed sample selection was the following: (i) comparison of the magnetic moment strength induced at the Mo site as a function of the Mo spacer thickness (1309 and 1310); (ii) sample 1334 (alloy) served as a reference one (for the samples 1309 and 1310) in which every Mo atom was statistically surrounded by Co atoms (different symmetry from that at Co/Mo interface); (iii) comparison of the Co layer growth mode (samples 1310 and 1311) in a function of Co layer thickness (the crystalline structure affects magnetocrystalline anisotropy).

Due to electronic configuration of Mo atom $[Kr]4d^5 5s^1$, the *d* band is supposed to be half-filled and to exhibit the largest spin moment among *4d* elements, according to Hund's rules. The intensity of XANES white lines is related to the number of *4d* holes. These XANES spectra were normalized taking into account the statistical branching ratio of 2. Due to well-defined white lines, the continuum was subtracted using a step function.

In order to extract the magnetic moment at Mo site the XMCD spectra were obtained at L_2 and L_3 edges of Mo both in the layered samples and in the alloy film. Fig. 1 depicts XANES and XMCD signals recorded at Mo $L_{2,3}$ edges for the samples 1309 and 1334. The raw XMCD signal is rather weak: below 2% with respect to the edge jump. This is, in part, due to poor polarization transfer by Si<111> monochromator

at these photon energies where the monochromator is close to the Brewster angle. The circular polarization rate of the monochromatic beam is about 12% at the Mo L_3-edge and only 4% at the Mo L_2-edge. Thus a correction has to be applied for incomplete circular polarization rate of the beam before applying the sum rules to XMCD spectra.

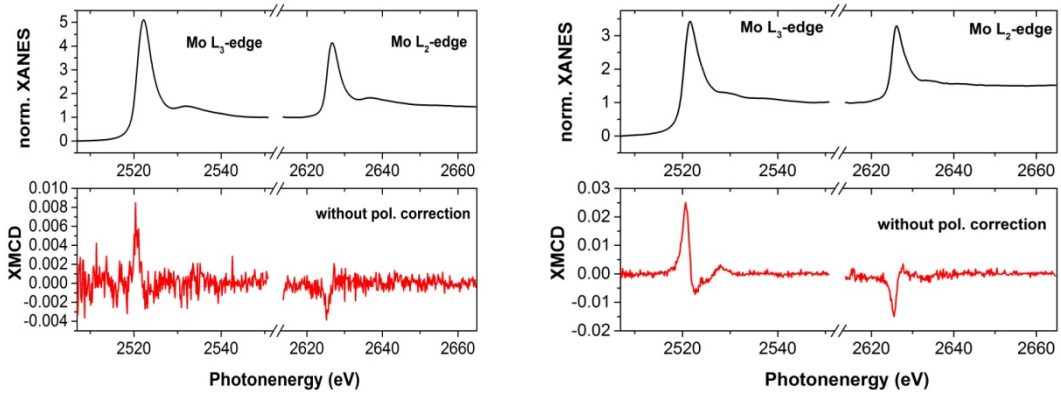

Fig.1 XANES and XMCD spectra for the samples 1309 (left) and 1334 (right) measured at Mo $L_{3,2}$-edges.

The sum rules analysis of the XMCD spectra reveals an induced magnetic moment of m_s=-0.03(4)μ_B and m_l=0.005(6)μ_B for the multilayer and m_s=-0.21(7)μ_B and m_l=0.01(4)μ_B for the alloy. Negative sign indicates that the moment at Mo site is antiparallel to the applied magnetic field and therefore to the Co magnetization. Unfortunately, the XMCD signal for the layered sample 1310 with much thicker Mo spacer (not shown in this report) is below the detection limit.

A possible interpretation is that the magnetic moment is mainly induced at the first Mo atomic layer forming the interface with the Co layer. As the magnetic moment is determined as an average value per every Mo atom, it could be hardly detectable. Another interpretation would be antiparallel alignment of the moments in individual atomic layers in the Mo spacer due to RKKY interaction. Indeed, it may correlate with the observed antiparallel coupling of the Co layers in Co/Mo multilayered structures. The issue of moment alignment inside the Mo spacer can be judged in X-ray resonant magnetic scattering (XMRS) measurements [5]. This is precisely the aim of our planned next proposal for ID12 beamline.

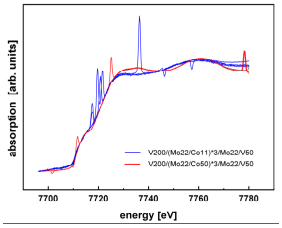

Fig. 2 Raw XANES absorption profiles recorded at the Co K edge for the 1310 (red) and 1311 (blue) samples. Visible diffraction peaks originate from the sapphire (11-20) substrate wafer.

Different, thickness dependent growth mode of the Co layer was deduced from the XANES spectra (Fig. 2) recorded at the Co K-edge. They are similar to the shapes typical of fcc and hcp structures [6] for the samples 1311 and 1310, respectively. This technique is much more sensitive than XRD for investigations of thin layer systems. We believe that at the initial stage of growth the fcc structure of the Co layer is forced by the Mo spacer. The thicker Co layers adopt a stable bulk-like hcp structure. Thus, not only surface anisotropy but also magnetocrystalline anisotropy should be taken into account to understand the effect of the Co layer thickness on magnetic anisotropy in the Co/Mo multilayers.

References

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