Interface-induced magnetic anisotropy in Co/MoS_2

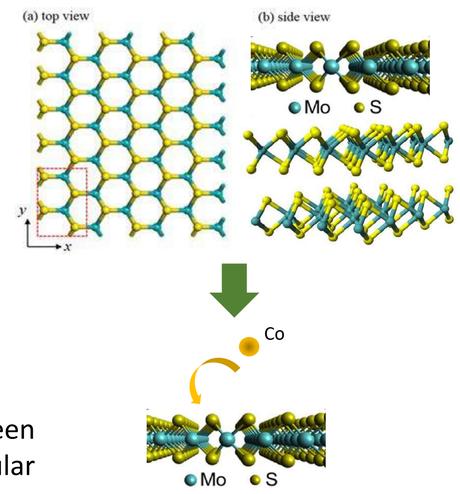
A. González-García[1], J. Obando-Guevara[1], D. Wilgocka-Ślęzak[2], E. Madej[2], A. Mandziak[3], A. Mascaraque[1], M.A. González-Barrio[1]

[1]Dept. de Física de Materiales, Universidad Complutense de Madrid, 28040 Madrid, Spain
[2]Jerzy Haber Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, 30-239 Kraków, Poland
[3]SOLARIS Synchrotron, ul. Czerwone Maki 98, 30-392 Kraków

Email: alvaroag@ucm.es

Motivation

• Interfacial engineering represents a vital strategy not only to manipulate the properties of materials but also to unlock hidden physical phenomena absent in single-phase materials. Ferromagnet/2D materials interfaces provide an attractive playground for exploring novel and tunable magnetic systems that could be applied in electronics [1], information storage technology and spintronics [2, 3].

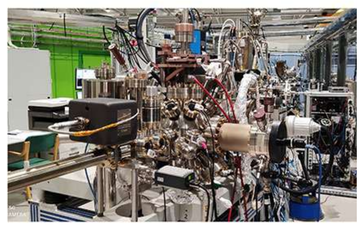


• An interface-driven spin reorientation has been observed in CoFeB/MoS_2, leading to perpendicular magnetic anisotropy (PMA) in a broader thickness range than in common systems [4].

• We have analyzed the spin textures of different thicknesses of Co deposited on MoS_2(0001) samples to investigate the appearance of magnetic anisotropies in the neighboring ferromagnet.

Experiment

• The experiment was done at the PEEM end-station of the DEMETER beamline at SOLARIS synchrotron source. The set up consists of an Elmitec LEEM/PEEM III.

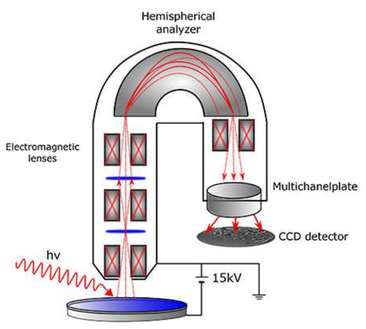


• The data were taken at room temperature.

• Samples were exfoliated in air and introduced quickly in the load-lock chamber. Later the surface was prepared in UHV (mild annealing).

• We studied the pristine MoS_2(0001) sample and Co/MoS_2(0001) for different cobalt coverages: from 2ML up to 14 ML.

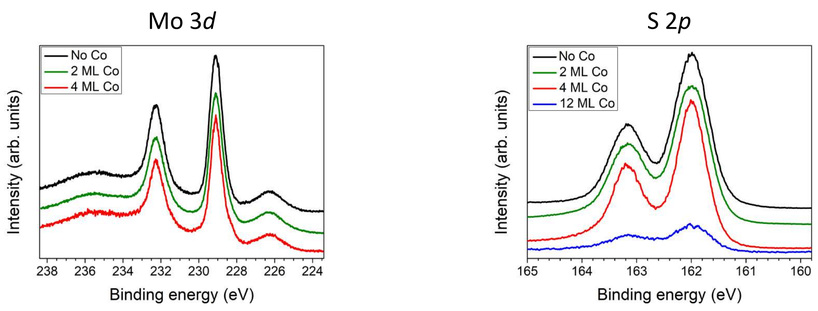
• PEEM (*), X-ray absorption spectroscopy (XAS) at the Co $L_{2,3}$-edge and XMCD images were taken for increasing Co thicknesses.



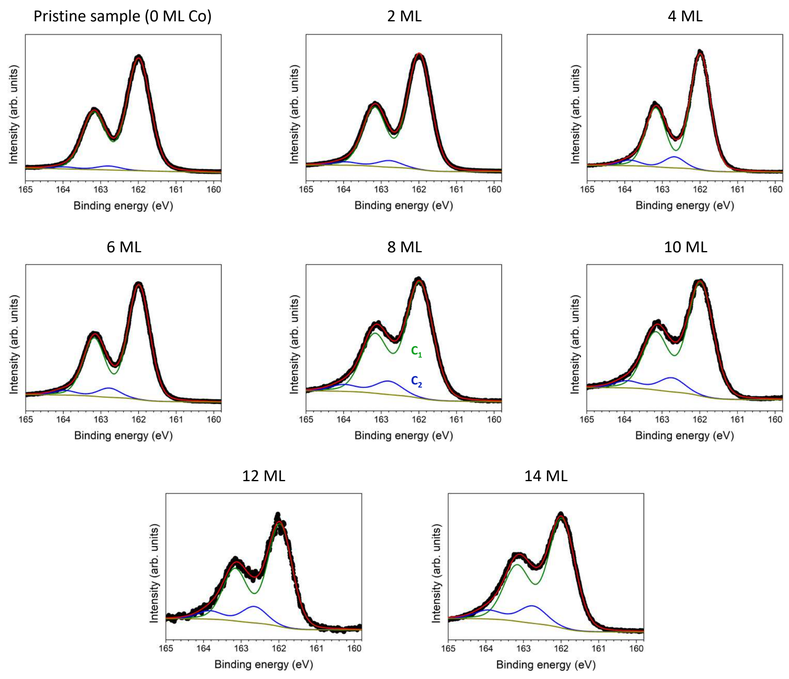
(*) LEEM set up was developed after we performed the experiment.

XPS measurements

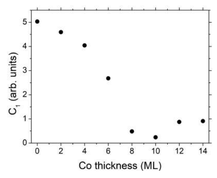
• We measured the Mo 3*d* level for Co thickness up to 4 ML and S 2*p* level for Co thickness up to 14 ML.



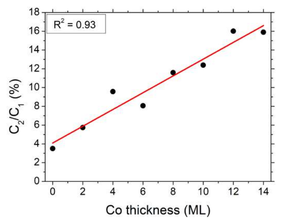
• The S 2*p* level fit of all samples shows that the level is made up of two components (C_1 and C_2).



• The intensity of the main component exhibits a strong initial attenuation. When the Co thickness is about 8 ML, the level appears to stabilize.

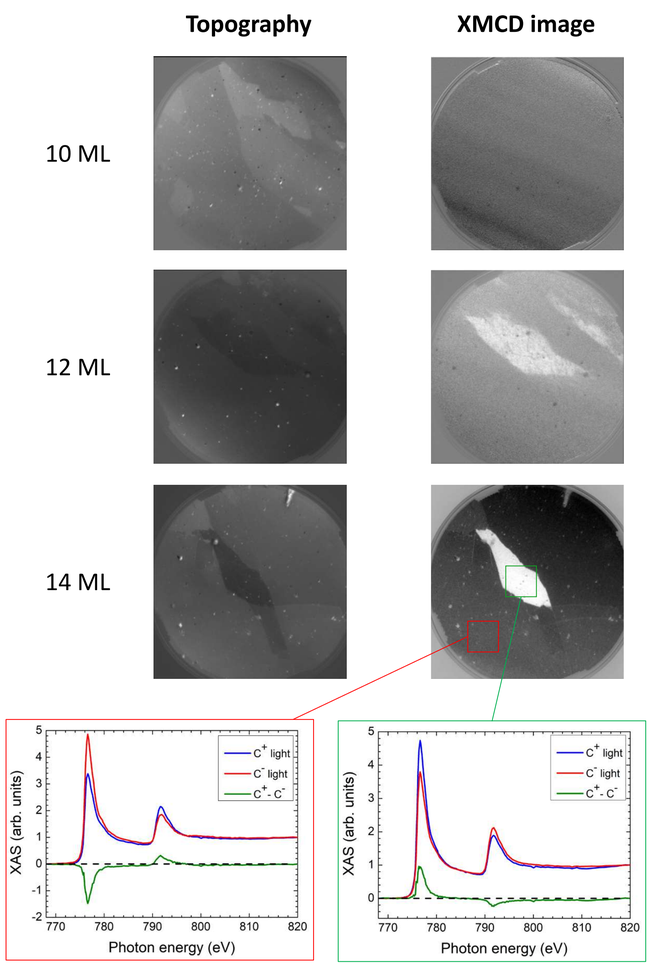


• The ratio of the area of the two components increases linearly with Co thickness.

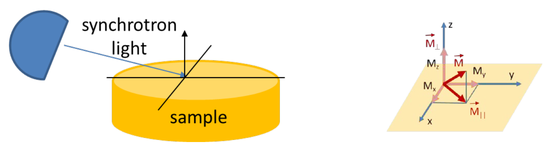


XAS measurements & XMCD Images

• XMCD images were taken for Co thicknesses ranging from 2 to 14 ML (FOV = 37.5 µm). For Co thicknesses less than 12 ML no dichroic signal was observed. For 12 ML of Co the dichroic signal is clearly visible, and for higher thicknesses a clear contrast between different domains is observed.

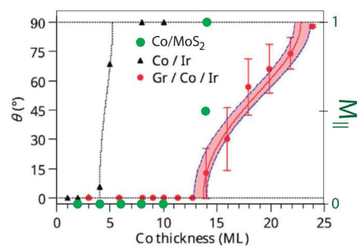


Experiment's geometry

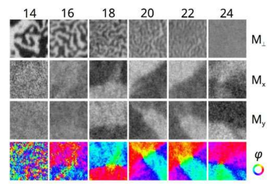


• In our experimental set up, we are mostly sensitive to the in-plane component of the simple magnetization. The incidence angle of the light beam is 16° with respect to the plane of the sample.

• The Spin Reorientation Transition takes place between 10 and 14 ML of Co. For films thinner than 10 ML of Co, the magnetization lies out of plane, while for films thicker than 14 ML the magnetization has rotated within the plane.



(Figure adapted from reference [5])



Gr/Co/Ir(111)

Conclusions

• We have studied a Co/MoS_2 interface by XPS, PEEM, XAS and XMCD.

• Analysis of the S 2*p* XPS peak allows us to estimate the Co coverage and compare it with the nominal thickness.

• The S 2*p* doublet develops a second component that increases linearly with Co thickness.

• Interface-induced anisotropy delays the Co Spin Reorientation Transition up to a thickness of ~ 10 – 12 ML.

Acknowledgments

M.A.G.B. and A.M. thank Ministerio de Ciencia e Innovación (project PID2020-117024GB-C43) and Comunidad de Madrid (project S2108-NMT4321) for financial support. A. G. G. thank Comunidad de Madrid (project S2108-NMT4321) for financial support.

References

[1] R. Ganatra, Q. Zhang, *ACS Nano* **8**, 4074 (2014).

[2] U. Krishnan *et al*., *Superlattices and Microstructures* **128**, 274 (2019).

[3] A.J. Wirth-Lima *et al*., *Appl. Phys*. **A125**, 241 (2019).

[4] W. Zhang *et al*., *ACS Nano* **13**, 2253 (2019).

[5] A. D. Vu, J. Coraux, G. Chen *et al*., *Sci Rep* **6,** 24783 (2016)