(IP013)
12nd International Conference on LEEM/PEEM (2020 online version)

Equilibrium configuration and defect-driven dynamics of the antiferromagnetic domain structure in CuMnAs films

Sonka Reimers[1,2], Oliver J. Amin[1], Filip Křížek[3], Vit Novak[3], Richard Campion[1], Francesco Maccherozzi[2], Peter Wadley[1], Kevin W. Edmonds[1], Sarnjeet Dhesi[2]
[1]*The University of Nottingham, School of Physics and Astronomy, Nottingham, NG7 2RD, UK*
[2]*Diamond Light Source, Chilton, OX11 0DE, UK*
[3]*Institute of Physics ASCR, FZU, Prague, Czechia*

Email: Sonka.Reimers@nottingham.ac.uk

The demonstration of efficient manipulation of the antiferromagnetic (AF) order parameter has highlighted its highly attractive properties for spintronics, including lack of magnetic stray fields, robustness against magnetic field perturbations and intrinsic dynamics in the THz regime [1, 2, 3]. Specific functionalities often depend sensitively on the magnetic domain structure [4]. In fully compensated AFs with no demagnetizing fields, magnetoelastic effects are expected to dominate [5,6]. CuMnAs is one of the most commonly used materials in AF spintronics research as its room-temperature AF order can be manipulated using electrical currents [1].
Here, we examine the influence of surface properties and structural defects on the AF domain structure in CuMnAs films by combining direct imaging of the AF domains using x-ray magnetic linear dichroism (XMLD)-PEEM with LEEM measurements of the structural properties on freshly prepared CuMnAs surfaces. The quality of the surface is confirmed using LEED. The LEED pattern shows a 2x1 surface reconstruction which forms surface domains of sub-micron size that can be imaged in dark-field LEEM. The surface domains are purely structural and do not correlate to the AF order. The surface topography, like atomic step edges, can provide pinning points for AF domain walls, but generally has only a minor effect on the AF domain pattern. In contrast, bulk crystalline microtwin defect lines, which can be imaged using bright field LEEM with positive sample bias, impose strict boundary conditions on the AF domain structure by locally pinning the AF spin axes parallel to the defect lines. Fig.1 shows measurements on a typical region of a CuMnAs surface at room temperature. At 30K above room temperature, we observe magneto-structural reconfigurations in which defect lines and surrounding AF domains grow together over the timescale of minutes.

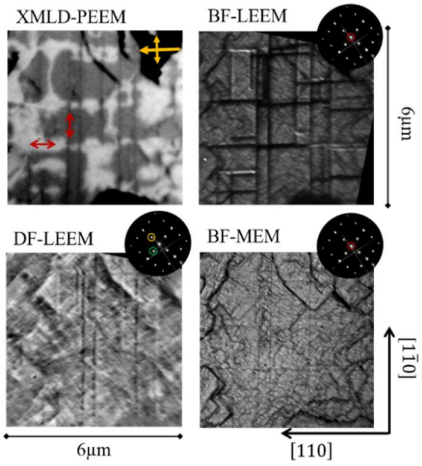

Figure 1. AF domain structure and surface structure of a typical area of a prepared CuMnAs surface. a) XMLD-PEEM image with sensitivity to the AF order. Double-headed red arrows: AF spin axes in dark and light domains; Yellow arrow: Direction and polarization of incoming x-ray beam. b) Bright field LEEM image with positive sample bias. The dark lines correspond to microtwin defects. c) Difference image of dark field LEEM images using the (0.5, 0) and (0, 0.5) reflection showing domains with different surface reconstruction. d) Surface topography measured in bright field MEM. The insets show a LEED pattern of the sample in which the reflections spots used for imaging are marked. Black arrows: CuMnAs crystalline directions.

References

[1] P. Wadley. B. Howells, J. Zelezny et al., Science **351**, 587 (2016)
[2] X.Z. Chen, R. Zarzuela, J. Zhang et al., Phys. Rev. Lett., **120**, 207204 (2018)
[3] P. Nemec, M. Fiebig, T. Kampfrath, and A.V. Kimel, Nat. Phys., **14**, 229 (2018)
[4] A.L. Ross et al., Nano Lett., **20(1)**, 306 (2020)
[5] O. Gomonay, and V. Loktev, J. Magn. Magn. Mater., **242(2)**, 1418 (2002)
[6] O. Gomonay, V. Baltz, A. Brataas, and Y. Tserkovnyak, Nat. Phys., **14**, 213 (2018)