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

Sonka Reimers², Oliver J. Amin¹, Filip Křížek³, Vit Novák³, Richard Campion¹, Francesco Maccherozzi⁴, Alexander Björling⁵, Dina Carbone⁶, Peter Wadley¹, Kevin W. Edmonds¹, Saranjeet S. Dhesi²

¹The University of Nottingham, ²Diamond Light Source (DLS), ³Institute of Physics ASCR, ⁴MaxIV Laboratory

Abstract:
Since the demonstration of efficient means of manipulating antiferromagnetic (AF) order [1,2], AF spintronics has become a rapidly growing research field, as AFs have highly attractive properties, including field robustness and intrinsic dynamics in the T′H regime. Specific functionalities often depend sensitively on the magnetic domain structure, which is still poorly understood. By combining AF domain imaging using XMLD-PEEM with structural imaging (LEED, SXRD, STEM) we reveal that in CuMnAs films, one of the most promising candidates for spintronic applications, both the equilibrium configuration and the kinetic response of the AF domain structure is largely dictated by a pattern of microtwin defects.

XMLD-PEEM @106, DLS - X-PEEM imaging at Mn-adsorption edge with sensitivity due to x-ray magnetic linear dichroism (XMLD). Measuring incidence - linear horizontal (in-plane) x-ray polarisation along CuMnAs [110]. Asymmetry of images taken with x-ray energy at minimum and maximum of XMLD spectrum

AF Domain Imaging
Spin axis in light/dark domains:
- 2 types of domains, respective spin axes along [101]/[110]
- "large" domains (microns)
- Even domain population

Patterned Edges
- Locally pin spin axes parallel to edge
- Significantly alter AF domain pattern over up to tens of microns

Microtwin Line Defects
- Form rectangular line pattern on surface
- Measurable in bright field (BF) LEEM - positive sample bias (max. of LEEM-IV)
- SXRD
- STEM [3]
- Inserted slabs of twinned crystal
- Intrinsic response relax strain
- Locally pin AF spin axes
- Set strict boundary conditions for AF domain structure

XMLD-PEEM at 106, DLS - X-PEEM imaging at Mn-adsorption edge with sensitivity due to x-ray magnetic linear dichroism (XMLD). Measuring incidence - linear horizontal (in-plane) x-ray polarisation along CuMnAs [110]. Asymmetry of images taken with x-ray energy at minimum and maximum of XMLD spectrum

Structural Imaging
LEED/LEEM @106, DLS - thermal removal of As cap Scanning x-ray diffraction (SXRD) @ Nanomax, MaxIV - x-ray energy 10keV - map intensity scattered away from central [003] reflection. Spotsize ~ 100nm

"Surface Domains"

"Microtwin" Line Defects
- Form rectangular line pattern on surface
- Measurable in bright field (BF) LEEM - positive sample bias (max. of LEEM-IV)
- SXRD
- STEM [3]
- Inserted slabs of twinned crystal
- Intrinsic response relax strain
- Locally pin AF spin axes
- Set strict boundary conditions for AF domain structure

Magnetostructural Correlation

References: