Atomically Sharp Domain Walls in an Antiferromagnet

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Introduction
Efficient manipulation of antiferromagnetic (AF) domains and domain walls has opened up new avenues of research towards ultrafast, high-density spintronic devices [1,2]. AF domain structures are known to be sensitive to magnetoelastic effects, but the microscopic interplay of crystalline defects, strain and magnetic ordering remained largely unknown. Recently, we have explored antiferromagnetic CuMnAs thin films in which imaging by x-ray photoemission electron microscopy (XPEEM) revealed that its AF domain structure is dominated by nanoscale crystalline defects [3]. However, even smaller magnetic objects were indirectly observed in the material, but they remained below the detection limit of the used established XPEEM methods.

Materials and Methods
Scanning transmission electron microscopy (STEM), differential phase-contrast (DPC) and 4D-STEM techniques are utilized CuMnAs epilayers grown by molecular beam epytaxy.

Results
Here, we achieve atomic resolution imaging of abrupt AF magnetic domain walls in CuMnAs epilayers [4]. The identification of the magnetic domain DPC signal is based on the specific symmetry of the CuMnAs crystal, where the opposite magnetic Mn sublattices occupy crystallographically distinct noncentrosymmetric sites, Fig. 1A. With focus on small field-of-view high-resolution imaging, we could associate the DPC-STEM signals with two types of abrupt Néel vector reversals, schematically illustrated in Fig. 1C and D: The first type occurs at a crystallographic antiphase boundary defect (Fig. 1C), while the second type forms in a part of the epilayer with no crystallographic perturbation detectable by STEM (Fig. 1D).

Conclusions
The results emphasized the crucial role of these defects in determining the AF domains and domain walls, and provided a route to optimizing device performance in term of scaling limits for the data density in the bulk of the antiferromagnet.
**Graphic:**

Fig. 1: (A) CuMnAs unit cell. (B) HAADF-STEM of [100] CuMnAs epilayer on GaP. (C, D) Atomically sharp domain walls at antiphase boundary defect and in unperturbed area of the CuMnAs single crystal, respectively. Black arrows represent Lorentz force direction at individual sublattices. (E) DPC-STEM overview of atomically sharp domain walls in CuMnAs.

**Keywords:**

DPC, 4D-STEM, Antiferromagnets

**Reference:**

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