Magnetic structures in ultrathin films revealed by resonant soft X-ray diffraction

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X-ray diffraction using photon energies corresponding to core-level dipole transitions in 3d and 4f transition metals provide particular sensitivity to electronic and magnetic ordering phenomena in thin films and heterostructures. This permits to study the influence of surfaces, interfaces as well as dimensionality effects in magnetic materials.
Applied to a thin epitaxial film of the simple antiferromagnet EuTe, the method yields magnetic diffraction peaks that exhibit detailed finite-size Laue oscillations (Fig. 1). The temperature dependence of these profiles can be analyzed to observe layer-resolved magnetization profiles, revealing modified temperature dependences of the magnetization in the surface layers [1].
Nickelate superlattices composed of layers of $LaNiO_3$ (LNO) and $LaAlO_3$ (LAO) or $DyScO_3$ (DSO) can be grown with excellent structural quality with varying substrate-induced strain. While LNO is nonmagnetic as bulk material, dimensionality-driven magnetic order was observed to appear in these superlattices, when the thickness of the nickelate layers is 2 unit cells [2]. Resonant x-ray diffraction at the Ni-L_3 resonance was able to identify the recurrence of the antiferromagnetic order found in the bulk of other rare-earth nickelates in the two unit cells of LNO (Fig.2). In addition, by exploiting the polarization dependence of resonant magnetic scattering, strain-dependent spin-moment directions could be determined, paving a way for controlling magnetic order by orbital polarization [3].

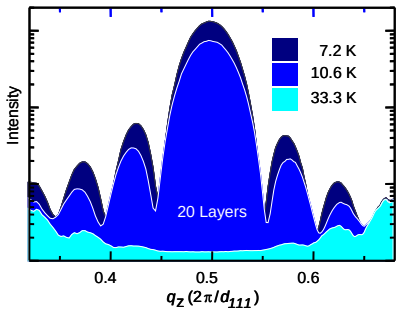

Fig. 1. (½ ½ ½) magnetic diffraction peak recorded from 20 layers of EuTe at the Eu-M_5 resonance. The temperature-dependent Laue oscillations can be analyzed to provide the layer-resolved magnetizations of the film.

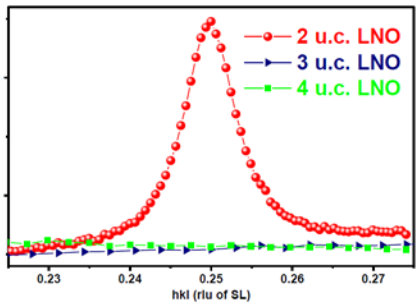

Fig. 2. Reciprocal space scans across the (¼ ¼ ¼) magnetic diffraction peak of LNO/LAO superlattices recorded at the Ni-L_3 resonance. The number of unit cells (u.c.) per LNO layer is indicated.

References

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