

Direct imaging of out-of-plane spin canting in α -Fe₂O₃: effects of a Co overlayer.

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Precise control of the spin structure in antiferromagnetic (AFM) oxide materials is essential for functional spintronic devices. In this study, we investigate the magnetic structure of epitaxial Co/ α -Fe₂O₃(0001) heterostructures consisting of a 10 nm hematite film capped with an ultrathin (1 nm) cobalt overlayer. Element-specific synchrotron methods, such as x-ray magnetic circular and linear dichroism photoemission electron microscopy (XMCD and XMLD-PEEM), are combined with complementary laboratory measurements, including conversion electron Mössbauer spectroscopy (CEMS), magneto-optical Kerr effect (MOKE) magnetometry, and magnetic force microscopy (MFM).

XMLD-PEEM imaging as a function of azimuthal angle reveals symmetry breaking relative to the behavior expected for a Néel vector strictly confined to the (0001) surface plane. A 3D reconstruction of orientation maps shows a pronounced out-of-plane component of the Néel vector in α -Fe₂O₃ already at room temperature, with an average canting angle of $\sim 15^\circ$. CEMS indicates that the observed canting is not a property of the entire 10 nm-thick film but is concentrated in a near-surface region of about 1.5 nm thickness, which can explain why the effect may remain unnoticed in less surface-sensitive techniques. At the same time, the Co overlayer forms a complex, non-collinear domain structure with both Néel and Bloch domain walls and a measurable out-of-plane tilt of the Co magnetization (on average $\sim 11^\circ$), consistent with the competition between thin film anisotropy and interfacial exchange coupling. Strong FM/AFM coupling is confirmed by the spatial correlation between the Co and hematite domain patterns and by the reorientation of the Néel vector in magnetic fields as low as ~ 0.14 T.

These results challenge the common assumption of a strictly planar Néel vector orientation in α -Fe₂O₃(0001) above the Morin transition and provide insights into interface engineering and spin-orientation control in oxide antiferromagnets for memory and logic applications.