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Depth profiling of interfacial spin complexities in magnetic heterostructures[1]

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Attentively restrained interfaces or superlattices between two materials can lead to emergent functionalities not shown by either constituents in their bulk form. Direct quantitative investigation of spatio-temporal correlations of magnetic and electronic properties of such interfaces is crucial in controlling and tailoring the close proximity of competing energy landscape that naturally exist in these systems. Due to the smallness and buried nature of the magnetization, characterizing these materials at the appropriate length scale is of considerable challenge. In this talk I will give examples from a variety of systems where the unique sensitivity of soft x-ray beams in reflection geometry have been exploited to obtain a quantitative description of the complex magneto-chemical depth profile across the interface between ferromagnetic (F) and antiferromagnetic (AF) thin films. In exchanges bias Co/FeF_2 heterostructures we have found antiferromagnetic coupling across the interface with the net magnetization having a twisted "fan-like" structure near the F/AF interface. For Py/CoO we observed a redox reaction driven novel interfacial layer that has magnetic properties very different from bulk. We found that 10% of the net spins in this layer get pinned antiparallel to the cooling magnetic field at low temperatures. In complex oxide $BiFeO_3$-$La_{0.7}Sr_{0.3}MnO_3$ we have obtained direct experimental evidence of transitory layers, ionic rearrangements and depleted magnetism at the $BiFeO_3$-$La_{0.7}Sr_{0.3}MnO_3$ interface. Our examples show that interface-selective probing of magnetism in thin film heterostructures can provide vital understanding needed for rational design of future nanoelectronic devices.

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