Imaging antiferromagnetic domains and interfaces

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Interface and surface effects play an increasingly important role in modern magnetic devices, because of the continuing reduction of the device dimension and the thickness of the magnetic layers. Spin injection across the boundary between magnetic and non-magnetic layers, the surface and interface anisotropy in multilayers, and magnetic exchange coupling and bias are important examples of interface phenomena that are utilized in magneto-electronic devices. In particular, the microscopic origin of exchange bias at ferromagnet/antiferromagnet interfaces is still unclear despite of intense research, driven by the important application of exchange bias in hard disk read-heads and magnetic RAM.

X-ray magnetic circular and linear dichroism spectroscopy and microscopy allows determining the magnetic structure of both ferromagnets and antiferromagnets in coupled structures directly at their interface, which is of crucial importance for achieving a microscopic understanding of coupling phenomena. The high magnetic sensitivity of x-ray photoemission electron microscopy (X-PEEM) utilizing x-ray dichroism contrast and its elemental specificity make PEEM an excellent tool for the investigation of such complex, layered magnetic structures, as they are typical in modern magnetic devices. We will give an overview over recent experiments on antiferromagnetic oxide and ferro- and antiferromagnetic metal layers, revealing their magnetic domain structure. We will show that XMLD is sensitive to the orientation of the magnetization axis in collinear magnetic system, which can be either ferromagnetic or antiferromagnetic. XMCD can then used for determining the direction of the magnetization. We observe a 1:1 correlation of the domain structure in exchange coupled antiferromagnet (e.g. NiO) and ferromagnet (e.g. Co) structures and also detect uncompensated interfacial spins in the antiferromagnet, which have been discussed as a possible cause for exchange bias. High sensitivity spectroscopy reveals that actually only a small fraction of these uncompensated spins is pinned and results in bias. A simple numerical estimate leads to realistic bias fields.

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