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Microscopic studies of the Magnetic Structure at the Ferromagnet - Antiferromagnet Interface.

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The current interest in magnetism is largely based on atomically engineered thin film structures, owing to the interesting physics of these materials and their technological use in the magnetic storage industry, e.g. as magnetic sensors in hard drive heads, or as magnetic RAM elements. Antiferromagnetic layers are a scientifically challenging component in these devices. The antiferromagnet magnetically pins or "exchange biases" the magnetization of a ferromagnetic layer to serve as a magnetic reference. This technologically important effect is still poorly understood because of the inability of traditional techniques to spatially determine the microscopic magnetic structure at the ferromagnet – antiferromagnet interface. We will present results, showing that photo-electron emission microscopy (PEEM) is capable of determining the surface magnetic structure of ferromagnets and antiferromagnets with high spatial resolution (<50 nm). Dichroism effects at the L edges of the magnetic 3d transition metals, using circularly or linearly polarized soft x-rays from a synchrotron source, give rise to a magnetic image contrast. Images, acquired with the PEEM2 experiment at the Advanced Light Source, show magnetic contrast on antiferromagnetic $LaFeO_3$, for the first time resolving the magnetic domain structure in an antiferromagnetically ordered thin film. Angle and temperature dependence were used to illuminate the magnetic properties of the material. Magnetic coupling between $LaFeO_3$ and an adjacent Co layer results in a complete correlation of their magnetic domain structures. From field dependent measurements a unidirectional anisotropy resulting in a local exchange bias of up to 30 Oe in single domains could be deduced. The elemental specificity and the quantitative magnetic sensitivity render PEEM a perfect tool to study magnetic coupling effects in multi-layered thin film samples.