Title

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Exchange bias at ferromagnet-antiferromagnet interfaces resolved by Photo-Electron Emission Microscopy

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Antiferromagnetic layers are key-components in advanced magnetic devices, such as magnetization sensors used in hard disks or magnetic random-access memory. The antiferromagnet pins or “exchange biases” a thin ferromagnetic layer, which serves as a magnetic reference to a second, free ferromagnetic layer. Information is stored or magnetic fields are measured via the relative orientation of the two ferromagnetic layers, exploiting the orientation dependent resistance of the element (giant magneto-resistance, GMR effect). Despite the technological importance of exchange bias, knowledge is still lacking about the mechanism, which couples the two layers, partly because of the inability of traditional techniques to spatially determine the microscopic magnetic structure of the antiferromagnet. 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). Magnetic dichroism effects at the L edges of the magnetic 3d transition metals, using circularly or linearly polarized soft x-rays provided by a synchrotron source, give rise to magnetic image contrast. Images acquired with the PEEM2 microscope 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 [1]. Angle and temperature dependence were used to investigate the magnetic properties of the material. Magnetic exchange coupling between $LaFeO_3$ and an adjacent, ferromagnetic 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. Apparently, domain correlation and microscopic bias occurs even in samples not annealed in a magnetic field, even though no macroscopic bias was observed [2]. The elemental specificity and the quantitative magnetic sensitivity make PEEM a powerful tool in the study of magnetic coupling effects in multi-layered thin film samples with high spatial resolution.

[1] A. Scholl et al., Science 287, 1014 (2000)
[2] F. Nolting et al., Nature, to be published