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Magnetic microstructure of ferromagnet and antiferromagnet interfaces studied by X-ray Photoemission Electron Microscopy (X-PEEM)

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The magnetic microstructure and the magnetic coupling to adjacent layers govern the magnetic properties of a magnetic thin film. Of particular importance in many technical applications is the interface between two magnetic layers or between a magnetic and a non-magnetic layer. Phenomena such as exchange bias, giant magneto resistance and spin injection are interface phenomena and precise knowledge of the interface spin structure and chemistry are essential for the understanding of these effects. We will show that X-ray Photoelectron Emission Microscopy (X-PEEM) offers sub-monolayer magnetic sensitivity which is sufficient to detect very small spin concentrations at surfaces and interfaces. High spatial resolution of currently down to 50 nm and theoretically down to 1 nm, elemental and chemical specificity, and sensitivity to ferromagnetic and antiferromagnetic order make PEEM an ideal tool for the study of magnetic interface phenomena. Here we will present results on the magnetic exchange coupling in ferromagnet-antiferromagnet structures, and we will show initial experiments on spin injection in all-metallic devices. In ferromagnet/antiferromagnet samples such as Co/$LaFeO_3$ and Co/NiO we were able to separate the contributions to the sample magnetism of the antiferromagnetic bulk, of its interface to the ferromagnet, and of the ferromagnetic layer itself. The relative alignment of the magnetization and its response to external magnetic fields provides important information on the origin of the exchange coupling between the layers, as we will show. Spin polarized currents provide a new method of efficiently manipulating nanoscale magnetic domains. We will present initial experiments on current induced switching, where we directly image the magnetization reversal in response to a localized current. We are currently designing a new experiment setup which will allow stroboscopic, time-resolved measurements using a synchronized sychrotron-laser setup. We expect to achieve 50 ps time resolution at the full spatial resolution of the microscope, opening new ways of studying dynamic magnetic processes.

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