Tutorial 01

X-rays and Magnetism – A Perfect Match

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Today's fundamental and applied magnetism research is particularly focused on magnetic materials that are suitable as magnetic sensors, spin valves, spin transistors or magnetic media consisting of complex magnetic multilayer structures. Scientific investigations in this area are concerned with the origin of magnetic coupling, spin transport across interfaces, magnetic properties of magnetic oxides and the complex magnetic structures which evolve when different kind of magnets for example antiferromagnets (AF) and ferromagnets (FM) are brought into contact. Dichroism x-ray absorption spectroscopy (XAS) represents a unique tool to understand complex nanomagnetic samples. The power of XAS is that it provides a possibility to address individual magnetic properties of different elements in a sample and a way to distinguish between different magnetic order like AF and FM order at the same time. It can furthermore be used to study the magnetism of buried interfaces, diluted magnetic systems like FM semiconductors or other exotic new magnets. To perform these studies a source of tunable soft x rays with high brilliance and full polarization control is required which is available at today's state of the art synchrotron radiation sources. The pulsed nature of the synchrotron asx-ray source allows for studying the time dependent behavior of a sample with a temporal resolution of a few tens of picoseconds. Dichroism soft x-ray absorption spectroscopy can furthermore be used to obtain spatially resolved informationwith less than 50nm lateral resolution in a modern full field or scanning x-ray microscopes.

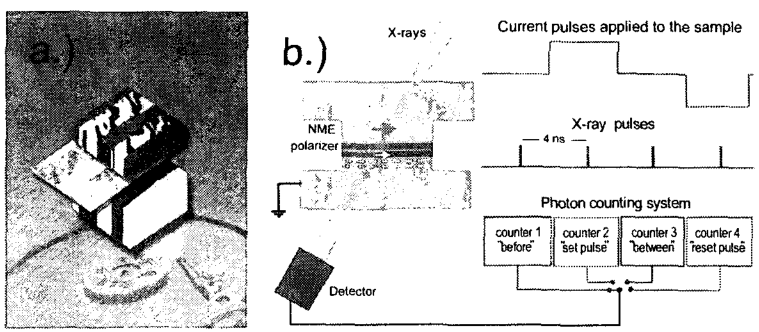

Fig. 1. a) Correlation between ferromagnetic (blue), antiferromagnetic (green) and interfacial domains (yellow) in an Co/NiO AF/FM bilayer, b) Photon counting scheme in a x-ray transmission microscope that allows for time resolved imaging of non-uniform switching modes in nanoscale spin transfer devices.

REFERENCES

[1] J. Stöhr and H. C. Siegmann, Magnetism, From Fundamentals to Nanoscale Dynamics (Springer, Berlin Heidelberg, 2006)

Tutorial 02

Basics of Current-induced Magnetic Excitation

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The spins of conduction electrons are filtered when an electrical current passes through a structure consisting of non-magnet / ferromagnet (FM1) / non-magnet because the reflection probabilities at the interface are spin-dependent. The filtered spin-flow, spin-polarized current, exerts a torque to the magnetization of the second FM which has a non-collinear magnetization to FM1, i.e. the spin-transfer torque [1, 2].

The spin-transfer torque attracts a considerable interest because of its new physics and potential for the important applications such as the current-induced magnetization switching, microwave oscillation and domain wall motion.

This talk will cover from the quantum mechanical origin of the spin-transfer torque to the consequent magnetization dynamics. It will overview landmarks of theories, experiments, and modelling studies in the research field of the spin-transfer torque. This talkwill also introduce unresolved questions about the fundamental physics and challenging issues for the application of the spin-transfer torque.

REFERENCES

[1] J. C. Slonczewski, J. Magn. Magn. Mater. **159**, L1 (1996).
[2] L. Berger, Phys. Rev. B **54**, 9353 (1996).