Magnetic soft X-ray microscopy: Towards imaging ultrafast spin dynamics on the nanoscale

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The manipulation of spins on the nanoscale is of both fundamental and technological interest. Advances in synthesis of magnetic nanostructures and analytical tools are key to provide a fundamental insight into the physical processes involved. Magnetic microscopies are faced with the challenge to provide both spatial resolution in the nanometer regime, a time resolution on a ps to fs scale and elemental specificity to be able to study novel multicomponent and multifunctional magnetic nanostructures and their ultrafast spin dynamics.

Magnetic soft X-ray microscopy is a very promising technique since it combines X-ray magnetic circular dichroism (X-MCD) as element specific magnetic contrast mechanism with high spatial and temporal resolution. Fresnel zone plates used as X-ray optical elements provide a spatial resolution down to currently <15nm [1] thus approaching fundamental magnetic length scales such as the grain size [2] and magnetic exchange lengths. Images can be recorded in external magnetic fields giving access to study magnetization reversal phenomena on the nanoscale and its stochastic character [3] with elemental sensitivity [4]. Utilizing the inherent time structure of current synchrotron sources fast magnetization dynamics with 70ps time resolution, limited by the lengths of the electron bunches, can be performed with a stroboscopic pump-probe scheme.

I will review recent achievements with magnetic soft X-ray microscopy with focus on current induced wall [5] and vortex dynamics in ferromagnetic elements [6].

The potential of soft X-ray microscopy to push the spatial resolution into the less than 10nm regime with improved X-ray optics will be outlined and x-ray microscopy at future high brilliant fsec X-ray sources makes snapshot images of fsec spin dynamics feasible.

Many thanks to M.-Y.Im, B. Mesler, W.L. Chao, A. Sakdinawat, S. Mangin, S. Kasai, A. Thiaville, G. Meier, L. Bocklage, M. Bolte. G. Portmann,. The help of the staff of CXRO and ALS is highly appreciated. This work is supported by the Director, Office of Science, Office of Basic Energy Sciences, Materials Sciences and Engineering Division, of the U.S. Department of Energy.

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