Dynamical magnetic imaging of nanostructures

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Magnetization reversal is important in the fields of basic and applied ferromagnetism. The magnetic storage bit reversal dynamics is one of the limitations of magnetic disk write speed. To study magnetization reversal dynamics and magnetic domain wall motion in ferromagnetic thin films and nanostructures, imaging techniques are essential.

This thesis will concern the implementation at IPCMS of the Lorentz imaging (see figure 1 and references [1] or [2]) under static and dynamic conditions. The dynamic behaviour of magnetic processes (magnetization reversal phenomena, domain walls motion, etc.) will be studied at the nanometre scale by using the stroboscopic acquisition method. The system recovery of the initial magnetic configuration will be achieved through a laser or a magnetic field pulse.

The project will be carried out on the Electron Microscopy facilities from IPCMS. The Lorentz imaging will be first developed in the static (or quasistatic) mode on the Jeol 2100 (with LaB_6 gun) and then in a dynamic mode on the Ultrafast Transmission Electron Microscope (electron pulse extracted from a thermo-ionic gun by a fs laser pulse [3]) at a temporal scale between 0.1s and 1 ps (10^{-12}s).

Different nano-systems will be explored, synthesized either in the laboratory and/or by living organisms [4]. Nanostructures with different materials and morphologies will be prepared using sputtering, electronic or/and optic lithography on electron transparent membranes. Using adapted geometries, it is possible to create domain walls in a reproducible way through appropriate magnetic history [5]. The dynamics of motion of domain walls will be correlated to the intrinsic properties of the material as well as to the shape and defects in the nanostructures.

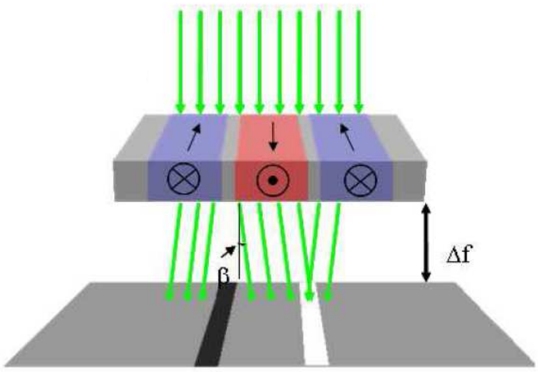

FIGURE 1 :
Deflection of electrons due to the Lorentz force when passing through a thin magnetic film and principle of defocused Fresnel imaging (the microscope makes the image of a plane below the sample). The domain walls parallel to the magnetization appear either white or black, lines with respectively excess and default of electrons, depending on the relative orientation of magnetizations in adjacent domains.

[1] M. E. Hale, H. W. Fuller, and H. Rubinstein, *J. Appl. Phys.* 30 (1959) 789.
[2] J. N. Chapman, *J. Phys. D: Appl. Phys.* 17 (1984) 623.
[3] http://utem.u-strasbg.fr/?p=22
[4] S.H.K. Eder, H. Cadiou et al, *Proc. Natl. Acad. Sci. U. S. A.* 109 (2012) 12022.
[5] M. Kläui et al, *Appl. Phys. Lett.* **87** (2005) 102509.