Pulsed Current-induced Magnetization Dynamics in Spin-Valve Nanostructures studied by XMCD-PEEM

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Moving magnetic domain walls using electric currents via spin-torque effects rather than using a magnetic field is one of the recent exciting developments in spintronics. Besides fundamental investigations, the use of domain walls in logic and memory [1] devices has already been proposed. Low current densities and high domain wall (DW) velocities at zero magnetic field are required for future applications. Using XMCD-PEEM, we have recently shown that spin-valve-like (NiFe/Cu/Co) nanostructures allow high domain wall velocities (up to 200 m/s) to be obtained for current densities as low as 5×10^{11} A/m^2, showing that with this system part of the requirements needed for applications of spin torque can be reached [2].

The size of the spin-transfer-torque (STT) in magnetic nanostripes critically depends on the angle between the conduction electron spin polarization and the local magnetic moments, and thus on the magnetization configuration inside the domain wall [3]. In narrow, thin stripes of soft ferromagnetic materials like NiFe and CoFeB, the domain walls are of Néel-type (magnetization in the plane of the layers) and can be transverse or vortex-like. In general, it is supposed that the domain wall internal structure during current pulses is modified only by the STT effect itself. We have recently performed time-resolved XMCD-PEEM measurements at SOLEIL with 50 psec temporal resolution *during* the application of nanosecond current pulses, directly showing that the magnetic (Oersted) field generated by the electric current also has to be taken into account. This Oersted field tends to align the magnetization in the direction perpendicular to the stripes and strongly modifies the direction of both the conduction electron spins and the domain wall internal magnetic structure. The fast magnetic pulses associated to the Oersted field induce precessional motion of the magnetization around the effective field at GHz frequencies.

References

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