Dynamics of a domain wall in a sub-micron tunnel junction

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PhD may follow: Yes

Summary :

Promising applications have been recently proposed based on the manipulation of DWs by a magnetic field or a current such as magnetic sensors, mass storage devices, logics devices or neuronal network architecture. In these devices, the position of the DW must be controlled and detected on the nm scale. This can be done using a magnetic tunnel junction (MTJ) composed of two magnetic layers separated by a thin insulating layer. We have recently obtained high magnetoresistive signal (50 %) in MTJs with high magnetic anisotropy characterized by very thin Bloch DW (5 nm). This result should make possible the characterization of the dynamics of a DW with a very spatial resolution (a few nm). This experimental internship proposes to study the dynamics of a DW in a sub-micron MTJ induced by a magnetic field and then, if time allows, by a current. The internship will include a nanofabrication step of a submicronic step using standard techniques then the characterization of the DW dynamics using magneto-transport techniques.

Full description :

The manipulation of magnetic domain walls (DW) in magnetic nanostructures is currently attracting a lot of interest. Domain walls, whose thickness typically ranges between 1 and 100 nm, can be manipulated using a local magnetic field or a spin polarized current through the spin transfer effect: when going through a domain wall, the spin polarized current transfers its angular momentum to the magnetisation which leads to a motion of the DW in the direction of the electron flow. We have recently shown that very fast DW motion (up to 400 m/s) can be obtained using this effect when injecting current pulses in a magnetic nanotrack in optimized materials [1,2]. Promising applications have been proposed recently based on the manipulation of DWs by a magnetic field or a current such as magnetic sensors [3], mass storage devices[4], logics devices [5] or neuronal network architecture where the synapse is replaced by a memristive element [6]. In these devices, the position of the DW must be controlled and detected on the nm scale. This can be done using a magnetic tunnel junction (MTJ) composed of two magnetic layers separated by a thin insulating layer : the displacement of the DW in one of the layer leads to a large change in the resistance of the MTJ due to the tunnel magnetoresistance effect which allows one to detect the position of the DW (Fig1(b)). We have recently obtained high magnetoresistive signal (50 %) in MTJs with high magnetic anisotropy characterized by very thin Bloch DW (5 nm). This result should make possible the characterization of the dynamics of a DW with a very spatial resolution (a few nm).

This experimental internship proposes to study the dynamics of a DW in a sub-micron MTJ induced by a magnetic field and then, if time allows, by a current. In particular, the role of the natural defects in the materials, that can locally pin the DW, will be studied and solutions will considered. Several deposition and characterization techniques will be used, as well as the nanofabrication facilities of the PTA clean room located in the same building. The internship will include a nanofabrication step of a submicronic step using standard techniques (e-beam, RIE, IBE, UV lithography, evaporation), then the characterization of the DW dynamics using magneto-transport techniques.

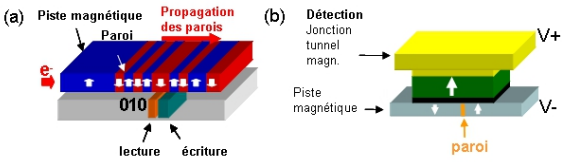
[1] Miron et al., Phys. Rev. Lett., 102, 137202 (2009). Miron et al. , Nature Physics, submitted, (2010). Moore et al. Appl. Phys. Lett. 93, 262504 (2008).

[2] O. Boulle et al., Phys. Rev. Lett. 101, 216601 (2008).

[3] G. A. Wang et al., J. Appl. Phys. 107, (2010).

[4] S.S. P. Parkin, , et al., Science 320, 190 (2008).

[5] D. A. Allwood, et al., Science 309, 1688 (2005).
[6] D. B. Strukov et al., Nature 453, 80 (2008).



Requested skills :

Basic knowledge of magnetism and solid state physics