Coupling and spin transfer in magnetic tunnel junction with a MgO tunnel barrier

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PhD may follow: Yes

Summary :

Magnetic tunnel junctions consist of two ferromagnetic layers separated by an insulating layer that electrons may cross by tunnel effect. These devices are interesting since their electrical resistance depends on the relative orientation of the magnetization in the two layers. Moreover, when the tunnel junction with MgO tunnel barrier is monocrystalline, an infinite magnetoresistance ratio is theoretically expected since only a few Bloch waves that respect the crystal symmetry may contribute to the electrical transport.

Our aim is to study the spin transfer in these systems. Spin transfer is the torque that incident electron spins coming from the first ferromagnetic electrode exert on the second one. Until now, such study could not be performed since nanometric monocrystalline tunnel junctions were not available. It is now possible thanks to collaboration between LPM laboratory at Nancy University and SPINTEC. The training will be mostly experimental and will take advantage of SPINTEC expertise in spin transfer analysis from dynamic transport measurements.

Full description :

Magnetic tunnel junctions consist of two ferromagnetic layers separated by an insulating layer that electrons may cross by tunnel effect. These devices are interesting since their electrical resistance depends on whether the magnetization in the two ferromagnetic layers are aligned in the same direction (â€œparallel stateâ€•) or in opposite direction (â€œanti-parallel stateâ€•). Magnesium oxide (MgO) appeared to be a good choice as tunnel barrier material since extremely large magnetoresistance could be obtained. Moreover, when the tunnel junction is monocrystalline, an infinite magnetoresistance ratio is theoretically expected. In fact monocrystalline tunnel junctions have specific properties: only a few Bloch waves that respect the crystal symmetry may contribute to the electrical transport. The attenuation of these Bloch waves in the tunnel barrier depends on the wave symmetry and the least attenuated Bloch wave is 100% spin polarised.

Our aim is to study the spin transfer in these systems since it is expected to present specific properties. Spin transfer is the torque that incident electron spins coming from the first ferromagnetic electrode exert on the second one. Until now, such study could not be performed since nanometric monocrystalline tunnel junctions were not available. It is now possible thanks to collaboration between LPM laboratory at Nancy University that masters the material deposition and SPINTEC laboratory where a nanofabrication process has been developed.

The training will be mostly experimental and will take advantage of SPINTEC expertise in spin transfer analysis from dynamic transport measurements (spectral analysis and RF measurements). It will address the following points:

1. fabrication : nanofabrication in clean-room (in our building) of magnetic tunnel junctions starting from full sheet deposited multilayers provided by Nancy University. (e-beam and UV lithography, RIE and IBE etching, deposition).

2. static and dynamic measurements using wide-band spectrum analyser

3. result analysis as a function of the barrier thickness.

For more information :

[1] S. Petit, N. de Mestier, C. Baraduc, et al., Phys. Rev. B 78, 184420 (2008).
[2] P.-J. Zermatten, G. Gaudin et al., Phys. Rev. B 78, 033301 (2008)

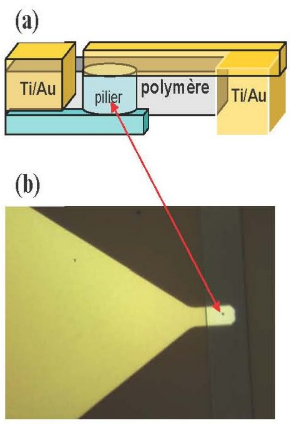

Fig. 1 : (a) Schéma de la fabrication de jonctions nanométriques. La jonction tunnel magnétique est gravée en forme de pilier nanométrique
(b) Vue au microscope de la jonction tunnel : le point noir correspond au pilier nanométrique.

Requested skills :

experimental physics, spectral analysis, quantum mechanics