Double barrier magnetic tunnel junctions

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PhD may follow: Yes

Summary :

Nowadays magnetic tunnel junctions are widely used as spintronic basic structure. They are composed of two ferromagnetic electrodes spaced by a tunnel barrier. Their resistance varies as a function of the relative orientation of the electrode magnetizations. Magnetic tunnel junctions could gain new properties if the tunnel barrier would be replaced by two tunnel barriers around an intermediate layer, ferromagnetic or not. Double barrier junctions could pave the way towards new devices such as spin diode or spin transistor. Therefore a clear understanding of spin dependent transport properties in these double barrier junctions is necessary. We propose an experimental study of these systems based on the microfabrication of such systems and on conductivity and electrical noise measurements, in close connexion with theoreticians. Our aim is to understand the influence of the intermediate layer thickness (diffusive or ballistic transport) on magnetoresistance

Full description :

By contrast to conventional electronics, spintronics takes advantage of both electron charge and spin to create various devices as field sensors, magnetic memories or logic devices. Nowadays magnetic tunnel junctions are widely used as spintronic basic structure. They are composed of two ferromagnetic layers separated by a thin insulating layer that electrons cross by tunnel effect. The interesting property of these structures is that their electrical resistance depends on the relative orientation of the magnetizations of the ferromagnetic layers: the resistance is low when magnetizations are parallel and resistance is high when magnetizations are antiparallel. Magnetic tunnel junctions could gain new properties if the tunnel barrier would be replaced by two tunnel barriers around an intermediate layer, ferromagnetic or not. Double barrier junctions could pave the way towards new devices such as spin diode [1] or spin transistor [2]. Therefore a clear understanding of spin dependent transport properties in these double barrier junctions is necessary. In fact these structures behave differently from single barrier junctions. At Spintec laboratory, we have shown that double junctions may present a specific signature when current flows in the plane of the layers [3]. Moreover we have just observed an amplification of spin transfer torque in these double junctions. Our aim is to continue and study transport in these devices, and in particular the occurrence of quantum well states in the central layer when it is very thin. Therefore we propose an experimental study of these systems by conductivity and electrical noise measurements, in close connexion with theoreticians.

Studies will be performed on double magnetic tunnel junctions with magnesium oxide barrier deposited by sputtering. Deposition will be performed on a state-of-the-art tool at the start-up Crocus Technology which is a spin-off from our laboratory. The central layer thickness will vary from 1 to 10 nm and it could be ferromagnetic or not. Microfabrication will be performed in the PTA clean room, located in the same building, using a process developed in the laboratory for single junction. The process is based on e-beam lithography, dry etching and metal deposition. Static measurements will be performed on an already existing set-up. Low frequency noise measurements will require installing a new set-up relying on the laboratory expertise in this field.

[1] Nano Letters 8(3), 805 (2008)
[2] J. Phys.: Condens. Matter 20, 423202 (2008)
[3] Appl. Phys. Lett. 100, 262404 (2012)

Requested skills :

experimental skills ; solid state physics ; basics of quantum mechanics