Study of skyrmions in ultrathin magnetic multilayers

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PhD may follow: Yes

Summary :

The recent discovery of novel magnetic structure with nm size, named magnetic skyrmions, is currently attracting considerable attention. These structures are topologically protected and poorly sensitive to local defects in the material. Their stability, very small size (of the order of tens of nm) and the fact they can be moved by very small current densities makes these structures very attractive as information carriers in high density memory technology. In this internship, we propose to study the formation of magnetic skyrmions in ultrathin magnetic multilayers deposited by sputtering in heavy metal/ferromagnetic multilayers, such as Pt/Co/AlOx, whose magnetic properties seem compatible with the formation of magnetic skyrmions. The internship will be based on the use of a whole set of experimental techniques for the development and characterization of spintronics devices: deposition by sputtering, magnetic characterization, nanofabrication, characterization by magneto-transport and magnetic microscopy (MFM)

Full description :

The recent discovery of novel magnetic structure with nm size, named magnetic skyrmions, is currently attracting considerable attention. Magnetic skyrmions are magnetization textures which cannot be continuously transformed into the uniform magnetic state without causing a singularity. They are topologically protected and poorly sensitive to local defects in the material. Their stability, their small size (of the order of tens of nm) and the fact they can be moved by very small current density makes these structure very attractive as information carriers in high density memory technology. The first experimental observation of magnetic skyrmions where carried out in relatively thick magnetic materials(>50 nm) in which the crystalline structure is characterized by the absence of inversion symmetry. This leads to an additional term in the exchange interaction, namely the
Dzyaloshinskii-Moriya (DM) interaction which tends to make magnetization rotate around a characteristic vector D and leads to the formation of magnetic skyrmions. However, these skyrmions have been observed only in organized superstructure in these materials which prevents their individual manipulation and only under particular magnetic field and temperature conditions.

Recently, first observation of isolated magnetic skyrmions and their manipulation by a current has been reported in ultrathin epitaxial magnetic bilayers Ir/FePd in the presence of a magnetic field and at low temperature. In this case, the DM interaction arise from the the inversion symmetry breaking at the interface. Howeever, these experimental conditions are poorly compatible with industrial constrain in the outlook of memory devices. In this internship, we propose to study the formation of magnetic skyrmion in ultrathin magnetic multilayers deposited by sputtering in ultrathin heavy metal/ferromagnetic metal structure, such as Pt/Co/AlOx. These structures have the advantage of being very versatile as their magnetic properties can be tuned by playing on the materials, their thickness and deposition conditions. Recent results have in addition demonstrated that a high DM interaction is present in this class of material. The sputtering deposition method has in addition the advantage of being fully compatible with industrial constrain.

The internship will be based on the use of a whole set of experimental techniques for the development and characterization of spintronics devices : deposition by sputtering of the ultrathin magnetic multilayers, characterization of their magnetic properties by magnetometry, nanofabrication of nanostructures cut in these layers by electron beam lithography and ion beam etching. The nanofabrication will be carried out at the nanofabrication platform PTA. The nanostructure will then be characterized by magneto-transport measurement and magnetic microscopy (MFM), in order to demonstrate the nucleation of isolated skyrmions and characterize the magnetic structure.

Requested skills :

Basic knowledge in magnetism and solid state physics;