Magnetization reversal in nanopillars driven by spin-orbit torques

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PhD may follow: Yes

Summary :

The use of the spin orbit torques (SOT) to manipulate the magnetization of a ferromagnetic element is very attractive both for potential applications and from fundamental point of view [1]. Micromagnetic modelling is a powerful tool for exploring these multi-physical phenomena and guiding the design of future new devices.

Full description :

Experimental proofs have been reported recently showing the possibility to control the magnetization of a nanopillar by injecting current pulses of tens of ns [2]. A basic sample is consisting of a ferromagnetic nanodot (Co, CoFeB,..) placed on top of a heavy metal conducting line (Ta, Pt,..),and covered by a thin oxide layer (MgO, AlO,..). The current passing through the heavy metal line is responsible for the spin-orbit torques generation acting on the magnetization of the nanodot. However the anatomy of the spin-orbit torques in these ferromagnetic heterostructures is a complicated matter [3]. Understanding how the spin-orbit torques are involved in the reversal mechanism is a key issue for using them efficiently in spintronics devices. The intuitive analyze of the magnetization dynamics in the framework of the macrospin approximation is not anymore appropriated. The objective of this project consists in looking closely to different terms appearing in the SOT and investigating their impact on the magnetization time evolution using the micromagnetic modelling. The excitation parameters (e.g. magnetic field, injected current, pulse shape) will be varied to identify the suitable conditions for an ultra-fast magnetization switching (< 300ps).

[1] I. M. Miron et al, Nature 476, 189 (2011).

[2] M. Cubukcu et al, App. Phys. Lett. 104, 042406 (2014)

[3] K. Garello et al., Nat. Nanotec. 8, 587 (2013)

Requested skills :

master in condensed matter and magnetism ;

affinity for theory and modeling