Enhancing Spin Orbit torques for magnetic memory applications

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PhD may follow: Yes

Summary :

A promising way to improve the energy efficiency and performance of microprocessors is the integration of non-volatile random access memories (MRAM). While many different technologies are currently developed there is only one possibility for creating non-volatile high-level SRAM. This is a type of magnetic random access memory, where the writing is achieved by a newly discovered phenomenon called Spin Orbit Torque (SOT). This relies on the electric switching of the magnetization by transferring angular momentum from the crystal lattice. While this phenomenon has been clearly evidenced, and its efficiency proven, its physical origin remains debated. We work towards understanding this phenomenon, with the goal of improving its efficiency and integrate it in MRAM applications.

Full description :

Full description of the subject (~36 lines)

The ability of ferromagnetic materials to maintain their magnetic orientation over extended periods of time is what allows using them for information storage. However, this is not the sole condition. A magnetic memory stores information but it also has to be read and written. Recent developments in spintronics have allowed to address both this problems: while reading a magnetic memory relies on the tunnel magnetoresistance effect, the writing can be achieved through different strategies. The most successful strategy so far relies on the transfer of spin angular momentum (Spin Transfer Torque - STT) by injecting an electric current from another ferromagnet .

Recently we discovered a new physical phenomenon allowing to switch the magnetization by means of in-plane electric current1. Contrasting with STT where the electric current transfers spin angular momentum from an adjacent ferromagnet, we showed that it is possible to reverse the magnetization by transferring angular momentum directly from the crystal lattice. The Spin-Orbit Torque (SOT) only occurs in magnetic materials that lack structural inversion symmetry and that have strong spin orbit coupling.

Our goal is to develop new materials with enhanced SOT efficiency, which are also compatible with industrial standards. For this purpose we design the materials, fabricate the devices and quantify the torques2. We are looking for a person genuinely interested both in the fundamental understanding of the physical phenomena as well as in using this understanding for real world applications. The successful candidate is expected to collaborate with a PhD student in all aspects of this work.

1. I.M. Miron et al. "Perpendicular switching of a single ferromagnetic layer induced by in-plane current injection." Nature 476.7359 (2011): 189.
2. K. Garello et al. "Symmetry and magnitude of spinâ€“orbit torques in ferromagnetic heterostructures." Nature nanotechnology 8.8 (2013): 587.

Requested skills :

general physics; team spirit; sense of humor;