Characterization of the spin-orbit torques in magnetic layers with large spin-orbit coupling

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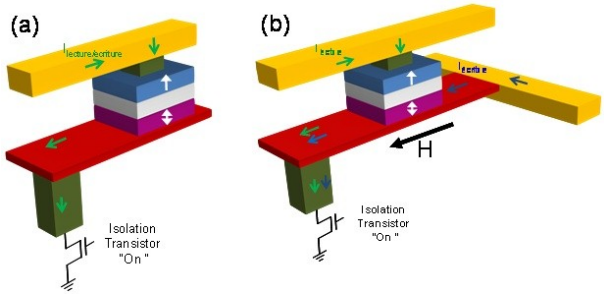
PhD may follow: Yes

Summary :

DRAM and SRAM memories are currently facing unsolvable issues as the size of the transistors shrinks due to their growing static and dynamical consumptions. We have recently proposed a new concept of non-volatile magnetic memories, named SOT-RAM which appears as a serious alternative to DRAM and SRAM. The writing of the magnetic bit is based on the discovery that a current flowing in a heavy metal, such as Pt or Ta in contact with a magnetic layer, can exert a “spin-orbit torque” (SOT) on the magnetization and switch its direction. We have recently fabricated a memory cell of a SOT-RAM and demonstrated its basic writing and reading functionality. The objective of this internship is a better understanding of the physical origin of the SOT, in order to optimize devices, in particular decrease the magnetization switching current densities. The internship will be based on thin layers of magnetic materials characterized by a large spin-orbit coupling and in which one can expect a large SOT.

Full description :

The discovery that a spin polarized current can switch the magnetization of a nanomagnet has opened a new path to manipulate the magnetization at the nanometer scale. This effect is based on the spin transfer effect where the spin current going through the nanomagnet is transferred to the magnetization leading to spin torque and switching. The spin transfer is the basis of the non-volatile STT-RAM magnetic memory, whose memory element is composed of a magnetic tunnel junction (cf Fig.1(a)). This memory combines non-volatility, high density and fast writing and reading and is considered today as a serious candidate to the non-volatile replacement of DRAM and SRAM cache memory at advanced technological nodes. These memories are indeed facing huge issues as the size of the transistors shrink due to their growing static and dynamic consumptions. However, one current issue of the STT-RAM is that a large current density is needed for writing, which leads to reliability problems due to a faster aging of the tunnelling barrier. We have recently submitted three patents to protect a novel concept of magnetic memory, named SOT-RAM, which allows to get ride of the limitations of STT-RAM. Contrary to the STT-RAM, the current is injected in the MTJ’s bottom electrode, composed of a heavy material, such as Pt or Ta. When injecting a current, the high spin-orbit coupling leads to a deviation of the conduction electrons upwards or downwards depending on the orientation of their spin (cf Fig.1(b)). This leads to a perpendicular spin current that will exert a torque on the magnetization and switch its orientation. As current does not goes through the tunnel barrier, reliability issues are naturally solved. In addition, much lower critical currents and faster switching (



Requested skills :

master 2 in physics; basic knowledge of magnetism and solid state physics