Spin Orbitronics using Alloy Materials with Tailored Spin and Charge Dependent Properties

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Since the discovery of the giant magnetoresistance (MR) by Fert and Grünberg in 1988 and the rewarding of the importance of this effect by the Nobel Prize in 2007, spin electronics experiences a constant increasing interest from the scientific community. This is related to the potential applications of the spin dependent conduction in the field of sensors and data transfer, processing and storage. While in the classical spintronic elementary bricks [i.e. metal/oxide/metal magnetic tunnel junction (MTJ) systems] the strong spin orbit coupling (SOC) in the ferromagnetic electrodes was carefully avoided and pointed among the factors limiting the MR ratio, surprisingly, recent developments take advantage precisely on these aspects to obtain new functionalities for the “spintronic” devices or even enhance the MR effect. Recently, a magnetic switching has been obtained in a Co plot deposited on a Pt electrode through which current pulses were applied. Because most electrical lines bringing current in electronic devices are generally constituted of Cu, it was shown that the Pt electrode could be successfully replaced with Cu containing Ir impurities. More recently, it was shown that the ferromagnetic material is not necessarily a metallic conductor but can be an insulator as well. For example, in ferrimagnetic $Y_3Fe_5O_{12}$ systems, although no conduction-electron spin current is allowed due to its insulating character, a spin-wave spin current could be generated and detected using Pt electrodes. All these results rely on the direct and inverse spin-Hall effect (SHE). This new branch of spintronics which takes advantage of the SOC is called spin orbitronics. Although many studies have been recently carried out in this field, important challenges are still present both on the generation and detection of spin currents. Some of them relate to a better understanding of subjacent fundamental physics related to the generation and the control of spin currents by SOC effects in order to allow the further increase of the spin Hall (SH) angle (which is the main figure of merit characterizing the conversion ratio between the spin and charge currents). This target can be asserted by using innovative materials and experimental setups, and represents the main objective of this research project. The targeted materials are metals or semi-conductors doped with heavy and rare-earth ions providing strong spin-orbit coupling and half metallic Heusler alloys. They have tunable electrical and magnetic properties (spin dependent band gap, localized gap levels), which allows better understanding and tailoring of the key parameters controlling the spin current generation and spin torque effects in FM/non-magnetic bilayers. The final target is to fabricate novel generation spintronic devices with magnetization manipulated by spin torque due to spin currents generated by spin orbit effects in adjacent nonmagnetic alloy with tailored spin-orbitronic properties.

We look for a dynamic cadidate (master level), with strong personal motivation and solid background in physics or materials science. Good knowledge of English is desirable. He/she will be involved in the deposition of thin films, lithography processing, structural, magnetic and transport characterisation. IPCMS will actively promote the career of a successful PhD candidate within the relevant research communities through the participation in national and international conferences.