Les détecteurs à transfert de spin pour la communication sans fil intrachip

Contact : Ursula EBELS DRF//INAC/SPINTEC ursula.ebels@cea.fr 0438785344

Stage pouvant se poursuivre en thèse : Oui

Résumé :

Spin electronics is a merging between electronics and magnetism. It aims at using the spin of the electrons to reveal new phenomena and try to use them in devices showing new functionalities or improved performances. Magnetic memories called MRAM using spintronic materials and phenomena are about to be launched in volume production. Besides, a phenomenon called spin transfer torque (STT) can be used to conceive radiofrequency oscillators as well as microwave detectors called spin-diodes. These devices are based on magnetic tunnel junctions or spin-valves in which steady precession of magnetization are excited by a spin-polarized current flowing through them due to STT. This internship which covers fundamental and applied aspects, is part of a larger effort funded by an ERC Advanced grant aiming at exploring the possibility of using these devices for short distance wireless communication (intrachip distance of the order of 1mm). The internship will particularly focus on the detection part using spin-diodes. It will comprise numerical simulations and experiments.

Sujet détaillé :

Spin electronics is an extremely vivid field of research and development which merges microelectronics with magnetism. Lot of new phenomena were discovered in this field in the past 20 years, each of them opening new perspectives of applications. Spin-electronics is about to become a mainstream technology in microelectronics with the forthcoming launching of volume production of magnetic memories called Magnetic Random Access Memories (MRAM). Besides memory, another very important field of research and development in spin-electronics concerns radiofrequency components for wireless communication. These components use the phenomenon of spin transfer torque (STT). STT

occurs when a spin-polarized current is injected in a magnetic nanostructure. Due to the exchange interaction between the spin of the injected electrons and those responsible for the local magnetization, a magnetic torque is exerted on the magnetization of the nanostructure. Under certain circumstances, it can drive the magnetization of the nanostructure into a steady precessional motion. By using this phenomenon in spin-valves or magnetic tunnel junctions, nanometer scale radiofrequency (RF) oscillators can be conceived. SPINTEC has already been working on such RF oscillators for more than 10 years. The goal was so far to produce RF voltages across magnetic tunnel junctions.

In this study which is part of an ERC advanced grant, we want to use these RF oscillators in a different way. The idea is to use the microwaves that they emit in the free space around them to achieve short distance wireless communication. For that, several such oscillators will be synchronized to increase the power of the microwave and its propagation range up to several hundreds of microns. Then microwave detector will be developed called spin-diodes. The internship will actually focus on this detection part. These spin diodes which consist of magnetic tunnel junctions convert the RF stray field received by the device into a DC voltage as diodes do. By modulating the emitted RF signal, an information can be transmitted to the spin diode. The internship will comprise simulations and experiments. Simulations will be used to evaluate the amplitude of the signal detected by the spin-diode depending on the composition of the MTJ stack constituting the spin-diode and on the amplitude of the RF field to which it is submitted. The simulations will allow to find the optimal operation conditions for the foreseen communication application.

Next, benefiting from the expertise of the lab in the field, the optimal magnetic stacks identified by simulations will be deposited by sputtering and magnetically and electrically characterized at wafer level.

If time allows during the internship, the wafers will then be patterned in our clean room in the form of electrically contacted nanopillars constituting the spin-diodes of interest. The rectification properties of the spin-diodes will then be electrically characterized.

The work will be performed in collaboration with the permanent staff of the magnetization dynamics team at SPINTEC as well as with a postdoctoral

fellow hired on the ERC Advanced grant to work on this RF intrachip communication.
We hope that the internship will be pursued in a thesis. This would allow a thorough optimization of the stacks, spin-diode configuration and complete test of the short distance communication.

Compétences requises :
Connaissances de base de la programmation, magnétisme