Master and PhD Thesis Projects 2016

spintec
SPIN IN ELECTRONICS

SPINTRONIQUE et TECHNOLOGIE des COMPOSANTS

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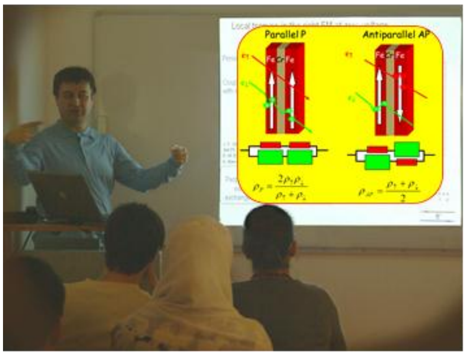
Université Joseph Fourier GRENOBLE

Grenoble INP

SPINTEC - WHO WE ARE

Centred between nanosciences and nanotechnologies and between very basic research and technological applications, the research activity of SPINTEC laboratory focuses on the emerging field of spintroncis that is today recognized as one of the major innovation routes for future microlectronics industries.

Located on the research site of MINATEC in Grenoble France, SPINTEC regroups, in an open structure organized around well focused research topics, researchers and engineers from the academic and the industrial world. The research activity of SPINTEC covers the whole spectrum from theory to demonstrators, passing from the study of innovative functional materials, experimental validation of novel physics concepts to the realization of test structures. The major application oriented research topics are: magnetic random access memories, hard disc drives, non-volatile logic circuits, microwave components and magnetic sensors. Most of these activities are performed in collaboration with academic and industrial partners from around the world.




SPINTEC FOR YOUR MASTER OR PHD PROJECT !

With the objective to train tomorrow's researchers in an active and growing research field, SPINTEC proposes every year several (paid) Master projects. The majority of the Master projects will lead over to a PhD thesis project with financial support that comes from a large variety of funding sources, including funding via research institutions (bourse ministère, bourse CFR CEA…), via ongoing contracts or via industrial partners (bourse CIFRE).

At SPINTEC, you will find a dynamic and multicultural environment that provides all facilities to advance your research project and the possibility to get your project and yourself known in the academic world via participation at international conferences. All our students have found a position several years after their thesis, be it in academics or in industry.

Come and join us and be part of those who like to revolutionize microelectronics research and applications! For more information please contact the scientists in charge for the different topics or check out our webpage.

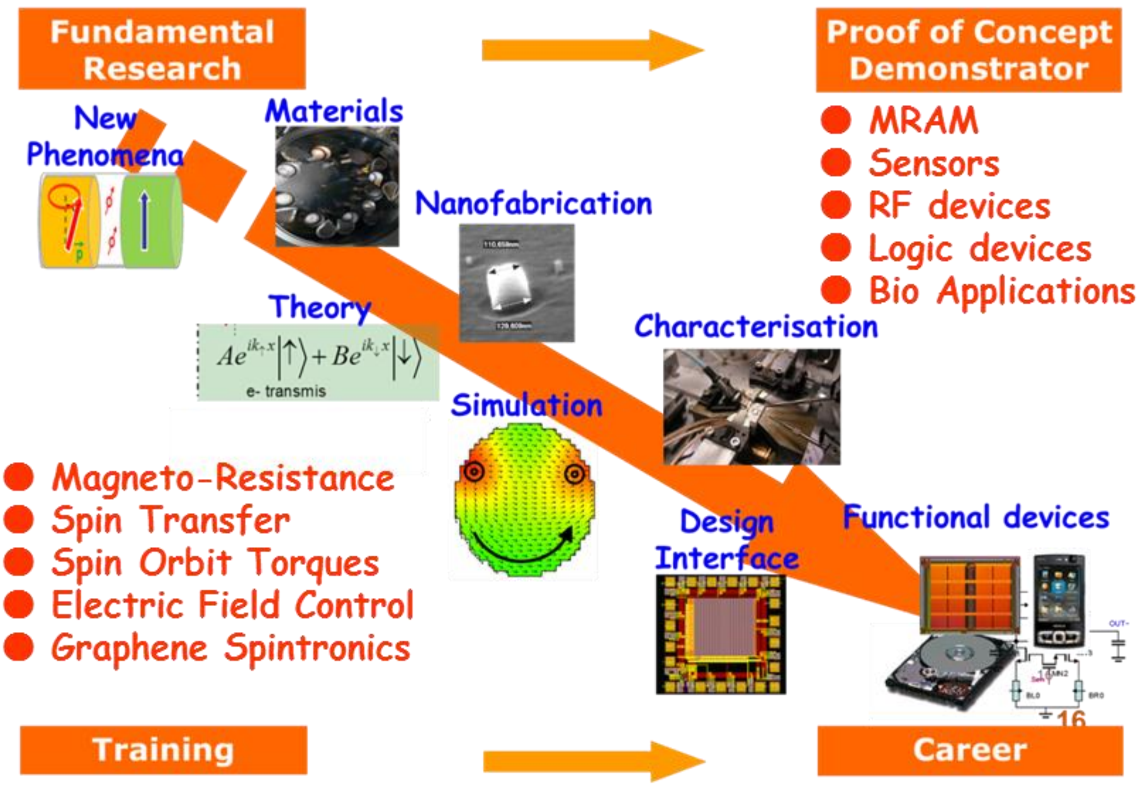
Hoping to see you seen,

Directeur : Jean-Pierre Nozières
Tel : 33 (0) 4 38 78 31 62
Mail : jean-pierre.nozieres@cea.fr

SPINTEC – IN BRIEF

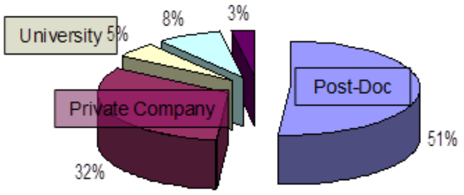
1 SPINTRONICS : **Rich and dynamic research field**, ranging from studies of basic phenomena to development of applications.

2 SPINTEC : Well established and open infrastructure for Master and PhD research providing **diversified training**: materials development – nanofabrication – diverse experimental tools for static & dynamic, magnetic & transport studies – theory and numerical modelling; application oriented projects within international collaborations.



3 FINANCIAL SUPPORT: All master projects are paid. Variety of **PHD funding schemes** (bourse CFR, bourse MNRT, CIFRE, CNES, ANR and EC projects……)

4 TRAINING : Awareness for necessity to provide at the same time specialized and broad training leading to **publications in recognized journals, participation at international conferences**, exposure and interaction with industrial and academic collaborating partners.



5 CARREER : 3 years after their PhD 90% of the students have found a position in academia or industry.

6 SOCIAL ACTIVITIES : **hiking, skiing, BBQ…..**

MASTER AND PHD PROJECTS FOR THE FOLLOWING SUBJECTS

MAGNETIC RANDOM ACCESS MEMORIES (MRAM)

● Ricardo Sousa (ricardo.sousa@cea.fr), Lucian Prejbeanu (ioan-lucian.prejbeanu@cea.fr), Bernard Dieny (bernard.dieny@cea.fr)

MICROWAVE MAGNETIZATION DYNAMICS AND RF DEVICES

● Ursula Ebels (ursula.ebels@cea.fr), Olivier Klein (olivier.klein@cea.fr))

NON VOLATILE LOGIC

● Guillaume Prenat(guillaume.prenat@cea.fr), Gregory DiPendina (gregory.dipendina@cea.fr), Christophe Layer (christophe.layer@cea.fr)

ADVANCED CONCEPTS

● Spin orbit torques and domain wall dynamics

Gilles Gaudin (gilles.gaudin@cea.fr), Mihai Miron (mihai.miron@cea.fr), Olivier Boulle (olivier.boulle@cea.fr)

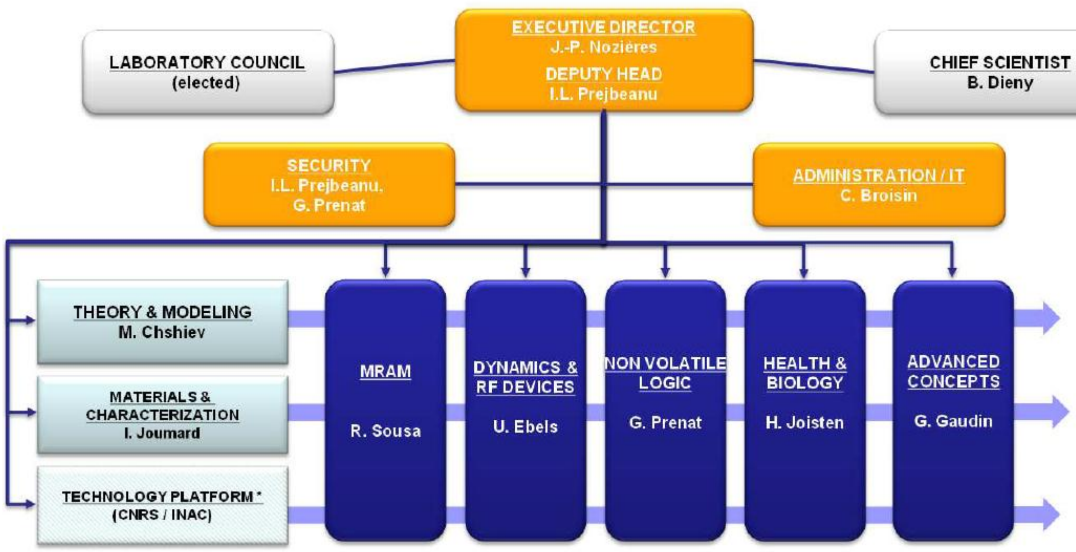
MAGNETIC SENSORS

● Claire Baraduc (Claire.baraduc@cea.fr), Gilles Gaudin (gilles.gaudin@cea.fr), Lucian Prejbeanu (ioan-lucian.prejbeanu@cea.fr)

THEORY and MODELLING

Mairbek Chshiev (mair.chshiev@cea.fr), Liliana Buda-Prejbeanu (liliana.buda@cea.fr), Daria Gusakova (daria.gusakova@cea.fr), Claire Baraduc (Claire.baraduc@cea.fr)

Further information on www.spintec.fr



Ecriture de cellule mémoire magnétique (MRAM) par courant polarisé en spin assisté thermiquement

Contact : Ricardo SOUSA DSM/INAC/SPINTEC ricardo.sousa@cea.fr 0438784895

Résumé :

Les mémoires magnétiques MRAM associent la non-volatilité à une écriture de quelques nanosecondes. Les concepts MRAM les plus avancés utilisent des impulsions de courant pour réaliser la commutation entre deux états de résistance Une approche brevetée d'écriture assistée thermiquement, permet la réalisation de cellules mémoire à plus grande stabilité. La stabilité de la cellule est temporairement réduite pendant l'écriture par le chauffage électrique produit par le courant d'écriture, ce qui permet l'obtention d'un meilleur rapport stabilité/consommation.

Le travail de stage consistera à caractériser et évaluer l'utilisation simultanée d'un courant polarisé en spin et d'un chauffage contrôlé pour orienter l'aimantation de la couche de stockage d'un élément mémoire MRAM. L'objectif est d'obtenir une variation thermique de l'anisotropie magnétique la plus abrupte possible vers la température d'écriture. En même temps, il faut assurer que lors de l'écriture, la configuration magnétique est stable pendant et après l'impulsion d'écriture pendant la phase de refroidissement du point mémoire. Le travail consistera dans l'identification des conditions évitant d'avoir des erreurs d'écriture pendant le refroidissement de la jonction. Cette analyse pourra être faite à l'aide de mesures électriques des dispositifs, et aussi par une modélisation macrospin prenant en compte les variations thermiques des paramètres matériaux. Ce stage pourra être poursuivi en thèse (CIFRE).

Sujet détaillé :

Les mémoires magnétiques MRAM non-volatiles sont une technologie en développement à Spintec en partenariat avec la start-up Crocus Technology. Ce type de mémoire a comme caractéristique d'associer la non-volatilité à des commutations rapides de l'ordre de la ns. La commutation de la direction de l'aimantation de la couche de stockage résulte en une variation de résistance de la cellule qui peut être supérieure à 100%, à des densités de courant de 106A/cm² par effet de transfert de spin. Ceci permet d'écrire un bit '1' ou '0' en fonction de la polarité du courant appliqué. Une approche brevetée d'écriture assistée thermiquement, permet la réalisation de cellules mémoire à plus grande stabilité. La stabilité de la cellule est temporairement réduite lors de l'écriture par le chauffage électrique produit par le courant d'écriture, ce qui permet l'obtention d'un meilleur rapport stabilité/consommation.

Le travail de stage est de caractériser et évaluer l'utilisation simultanée d'un courant polarisé en spin et d'un chauffage contrôlé pour orienter l'aimantation de la couche de stockage d'un élément mémoire MRAM. La structure de l'élément mémoire, une jonction tunnel magnétique, peut être optimisée par le choix des matériaux magnétiques, et aussi par la conductivité des barrières tunnel utilisées. L'objectif est d'obtenir une variation thermique de l'anisotropie magnétique la plus abrupte possible vers la température d'écriture. Au même temps, il faut assurer que la configuration magnétique pendant l'écriture est stable pendant et après l'impulsion d'écriture. Le travail consistera dans l'identification des conditions évitant d'avoir des erreurs d'écriture pendant le refroidissement de la jonction. Cette analyse pourra être faite à l'aide de mesures électriques des dispositifs, et aussi par une modélisation macrospin prenant en compte les variations thermiques des paramètres matériaux. La caractérisation électrique se fera sur des testeurs automatiques existants à Spintec. Il s'agira aussi de créer des procédures de test, permettant l'observation des commutations de résistance. Ces mesures permettent ensuite de calculer la probabilité de retournement associée à une condition d'écriture.

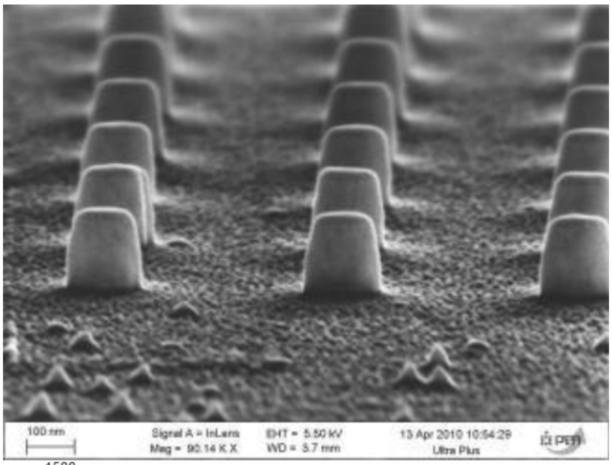
La mise en place des tests électriques sera réalisée en utilisant des programmes codés en MATLAB. Il est souhaitable que le(a) candidat(e) possède des connaissances élémentaires d'informatique et/ou instrumentation électrique. L'analyse des résultats nécessitera ensuite une compréhension des phénomènes physiques mis en jeux et une confrontation des résultats électriques avec les modèles.

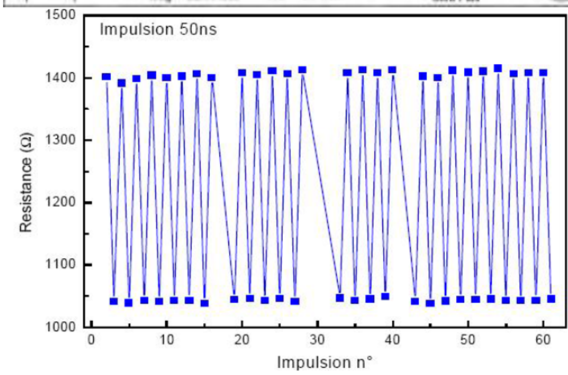
Le stage sera réalisé en utilisant les moyens de test du laboratoire sur des échantillons réalisés par Spintec ou CROCUS Technology. Ce stage pourra être poursuivi en thèse (CIFRE)

Pour plus d'informations sur nos récents résultats :

[1] S. Bandiera, R.C. Sousa et al., Appl. Phys. Lett., 99, 202507 (2011)

[2] A. A. Timopheev, R. Sousa, M. Chshiev, L. D. Buda-Prejbeanu, and B. Dieny, Phys. Rev. B 92, 104430 (2015)





Compétences requises :

Connaissances élémentaires d'informatique et/ou instrumentation électrique

Stage pouvant se poursuivre en thèse : Oui

Non-volatile gigital integrated circuit test and characterization

Contact : Gregory DI PENDINA DSM/INAC/SPINTEC GREGORY.DIPENDINA@cea.fr 04 38 78 47 46

Summary :

Several version of a digital integrated circuit have been designed and fabricated. The objective of the training is to understand the circuit's behavior and then to test and characterize it.

Full description :

In the framework of a collaboration between 2 CEA's laboratories LCM (Memory Device Lab) and Spintec (mixed research unit between CEA/CNRS/Univ. Grenoble), an hybrid CMOS/MRAM (Magnetic Random Access Memory) circuit has been designed and fabricated. The MRAM is an emergent non-volatile technology, based on the single device called MTJ (Magnetic Tunnel Junction). The objective of this training is first of all to understand the MRAM technology,to control the behavior of this circuit and then to test and characterize it. This circuit is composed of simple test structures (! transistor / 1 MTJ) and several versions of a digital filter. The required skills are good knowledge in integrated circuit design and some knowledges in programming. Indeed, tests will be performed using an industrial tester controlled by a graphical interface.

This training is suppose to lead to a Ph. D in the domains of non-volatiles integrated circuit design and micromagnetic simulations that would enable to anticipate and analyze the MTJ behavior according to several fabrication criteria.

Requested skills :

Integrated circuit design

Programming

Test

PhD may follow: Yes

Ultra-sensitive magnetic field sensor for space applications

Contact : Claire BARADUC DSM/INAC/SPINTEC claire.baraduc@cea.fr 0438784235

Summary :

Magnetic sensors for space flight are highly sensitive inductive sensors but they are cumbersome and heavy (150g/axis) which impacts the launching cost. Since many years, research has been performed in order to reduce the sensor size and mass. However no further progress is expected on this line without a definite change of paradigm. The solution could be spintronic devices provided they could present the proper sensitivity. Our aim is therefore to develop a magnetic sensor which will combine an innovative architecture with a low-noise magnetoresistive element based on a phenomenon we recently discovered. The experimental work will be : i)the microfabrication of the device; ii) measurement of the electrical noise. The device composition will be optimized depending on the obtained results.

Full description :

The aim of this project is to manufacture a magnetic sensor that could be a serious competitor, in term of sensitivity, to those currently shipped onboard the space missions, with a weight reduction of at least two orders of magnitude. Up to now, magnetic field sensor used for space missions are inductive magnetic sensors that have a very high sensitivity, up to few tenths of fT. Nevertheless, this very good sensitivity is achieved at the cost of large size and mass (150g per axis), markedly increasing the launching cost. Solutions to reduce the sensor mass has been systematically tested for years but no further improvement can now be obtained without a change of paradigm. Using nano-devices from spin electronics integrated on silicon would allow a significant progress in the size and mass reduction of vectorial magnetic sensors provided they could have the required sensitivity.

Our aim is to develop an ultra-sensitive magnetic sensor that combines an innovative architecture and a low noise magnetoresistive element. It will include a magnetic circuit, a biasing coil and a tunnel junction, made with thin film technology, an electronic circuit in ASIC technology and a feed back coil made with a micro winding process, the latter responsible for the sensor high performance in terms of linearity and stability. The sensor high sensitivity is obtained by a strong amplification (>300) of the measured magnetic field thanks to a magnetic circuit acting as a flux concentrator, and by using magnetic tunnel junctions with high magnetoresistive ratio.

The originality of the proposed sensor lies in a differential and heterodyne detection combined with a feed-back.

In fact, none of the nano-devices sensitive to the magnetic field (from the Hall sensors to the magneto-resistances or magneto-impedances) exhibits today the expected sensitivity, due to a large 1/f noise that spreads up to 100kHz. Therefore the magnetic field to be measured is modulated by an ac biasing field, so that the measurement is translated in the vicinity of the biasing frequency where the noise is low.

The innovative and ambitious features of the proposed solution should allow to develop a sensor able to detect

magnetic fields as low as 100fT/Hz1/2 in the frequency range below 10kHz, which corresponds to a sensitivity three orders of magnitude larger than the best magnetoresistive sensors currently available. Furthermore, a large reduction in size increases the sensor spatial resolution which extends the scope of applications towards the medical sector, biotechnologies or non destructive control for example.

Requested skills :

solid state physics

PhD may follow: Yes

Study of the dynamic coupling via spin currents

Contact : Olivier KLEIN DSM/INAC/SPINTEC olivier.klein@cea.fr 0438785802

Summary :

The purpose of this training is to measure the spin pumping emitted by a magnetic insulator.

Full description :

One of the potential field of application of nano-magnetism is communication technology where magnetism is used here for its non-reciprocal properties, combined with a wide tunability very high selectivity. The expected properties depend greatly upon the choice of the material. So far the best results were obtained with yttrium iron garnet (YIG) that is found in high-end microwave components. France has in this area a unique expertise in the growth of thin film of high quality YIG. Very recently, the first YIG-based nano-devices have emerged opening a very large field of potential applications for the communications industry. The purpose of this training will be to study the dynamical properties of these nano-objects. The student will have access to YIG nano-structure. The objetive will be to measure the dynamical behavior of these nano-objects when inserted into a device. In particular we will focus on spin pumping flowing in an adjacent normal metal. The goal will be to understand the basic physical phenomena that control electronically the dynamics of these nano-objects.

Contact Olivier Klein (olivier.klein@cea.fr) and Ursula Ebels (ursula.ebels@cea.fr)

Requested skills :

Sound knowledge in solid state physics

PhD may follow: Yes

Spin transfer torque oscillators for Phase locked loop operation

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

Summary :

One of the basic concepts of spintronics is the spin momentum transfer where spin polarized conduction electrons can transfer a magnetic moment to the local magnetization of a thin ferromagnetic film. This magnetic momentum transfer is responsible for the excitation of high frequency (Gigahertz range) magnetization oscillations when a DC current is injected into a magneto-resistive device.

This concept opens novel possibilities for the development of integrated microwave components. SPINTEC studies these effects of spin momentum transfer from a fundamental point of view to better understand the non-linear magnetization dynamics of nansocale devices, but also in context of potential applications. In particular, the generation of microwave signals will be the object of the study of this internship, followed by a thesis.

Full description :

The non-linear dynamics of a spin transfer torque oscillator and its microwave signal generation have been studied in the past by our group as well as by numerous others. Good results in terms of output power and spectral purity have been obtained for oscillators emitting in the 0.2-1GHz range. Operation at higher frequency ranges (1-10GHz) of interest for applications, still suffers from too high a phase noise, making implementation for instance into a phase locked loop (PLL) difficult. The aim of the present internship project, followed by a PhD, is to explore different magnetic stack configurations (magnetization in-plane and/or out of plane for polarizer and/or free layer), allowing for more stable and robust oscillations. The final aim is the operation and characterization of a PLL for the frequency range of 1-10GHz.

As a first task, the student will evaluate the dynamic response of different magnetic stack configurations by numerical simulations. Subsequently the student will realize the device (materials and nanofabrication) and characterize the high frequency emission properties. Successful devices will be tested within PLL operation. This work will be realized in collaboration with other group members of the microwave component group of Spintec, as well as in collaboration with TU Dresden (for PLL testing) and in collaboration (or joint supervision) with a group of the « International Iberian Nanotechnology » center in Portugal for materials development and nanofabrication.

Contact: Ursula Ebels (ursula.ebels@cea.fr)

Requested skills :

Motivated student with a sound background in solid state physics and/or nanosciences and keen to explore new concepts and ideas that are at the interface between physics (spintronics) and applications (microwave oscillators).

PhD may follow: Yes

Spintronic based wireless communication

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

Summary :

One of the basic concepts of spintronics is the spin momentum transfer where spin polarized conduction electrons can transfer an agular spin-moment to the local magnetization of a thin ferromagnetic film. This magnetic momentum transfer is responsible for the excitation of high frequency (Gigahertz range) magnetization oscillations when a DC current is injected into a magneto-resistive device. Spintec is studying the spin momentum transfer concept from a fundamental point of view to better understand the non-linear magnetization dynamics of nanoscale devices, but also in context of applications. Namely, the effect can be used to generate microwave signals as well as to detect microwave signals. The combination of the two could lead to a novel concept for a wireless communication system, which is the object of study of this internship, followed by a PhD thesis.

Full description :

In the frame of an EC project MAGICAL (2015-2019), a wireless short range communication concept will be explored, that is based on the emission of electromagnetic waves via spin torque oscillators and the detection of this wave by a second spin transfer oscillator. In the first part of the project, the student will explore several detection schemes in context of the proposed application and will be carrying out numerical simulations. This will be followed by the realization of the devices (materials deposition and nanofabrication) and the characterization of the high frequency response of the devices. This work will be carried out in collaboration with the microwave components team of Spintec.

Contact: Ursula Ebels (ursula.ebels@cea.fr) and Bernard Dieny (bernard.dieny@cea.fr)

Requested skills :

Motivated student with a sound background in solid state physics and/or nanosciences and keen to explore new concepts and ideas that are at the interface between physics (spintronics) and applications (microwave oscillators).

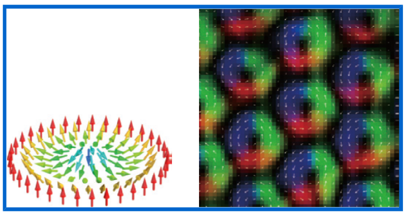
PhD may follow: Yes

Close window

Study of magnetic skyrmions in ultrathin magnetic films

Summary:
The recent discovery of novel magnetic structure with nm size, named magnetic skyrmions, is currently attracting considerable attention. These structures are topologically protected and poorly sensitive to local defects in the material. Their stability, very small size (of the order of tens of nm) and the fact they can be moved by very small current densities makes these structures very attractive as information carriers in high density memory technology. In this internship, we propose to study the formation of magnetic skyrmions in ultrathin magnetic multilayers deposited by sputtering in heavy metal/ferromagnetic multilayers, such as Pt/Co/AlOx, whose magnetic properties seem compatible with the formation of magnetic skyrmions. The internship will be based on the use of a whole set of experimental techniques for the development and characterization of spintronics devices: deposition by sputtering, magnetic characterization, nanofabrication, characterization by magneto-transport and magnetic microscopy (MFM)

Full description:
The recent discovery of novel magnetic structure with nm size, named magnetic skyrmions, is currently attracting considerable attention. Magnetic skyrmions are magnetization textures which cannot be continuously transformed into the uniform magnetic state without causing a singularity. They are topologically protected and poorly sensitive to local defects in the material. Their stability, their small size (of the order of tens of nm) and the fact they can be moved by very small current density makes these structure very attractive as information carriers in high density memory technology. The first experimental observation of magnetic skyrmions where carried out in relatively thick magnetic materials(滦 nm) in which the crystalline structure is characterized by the absence of inversion symmetry. This leads to an additional term in the exchange interaction, namely the Dzyaloshinskii-Moriya (DM) interaction which tends to make magnetization rotate around a characteristic vector D and leads to the formation of magnetic skyrmions. However, these skyrmions have been observed only in organized superstructure in these materials which prevents their individual manipulation and only under particular magnetic field and temperature conditions. Recently, first observation of isolated magnetic skyrmions and their manipulation by a current has been reported in ultrathin epitaxial magnetic bilayers Ir/FePd in the presence of a magnetic field and at low temperature. In this case, the DM interaction arise from the the inversion symmetry breaking at the interface. Howeever, these experimental conditions are poorly compatible with industrial constrain in the outlook of memory devices. In this internship, we propose to study the formation of magnetic skyrmion in ultrathin magnetic multilayers deposited by sputtering in ultrathin heavy metal/ferromagnetic metal structure, such as Pt/Co/AlOx. These structures have the advantage of being very versatile as their magnetic properties can be tuned by playing on the materials, their thickness and deposition conditions. Recent results have in addition demonstrated that a high DM interaction is present in this class of material. The sputtering deposition method has in addition the advantage of being fully compatible with industrial constrain. The internship will be based on the use of a whole set of experimental techniques for the development and characterization of spintronics devices : deposition by sputtering of the ultrathin magnetic multilayers, characterization of their magnetic properties by magnetometry, nanofabrication of nanostructures cut in these layers by electron beam lithography and ion beam etching. The nanofabrication will be carried out at the nanofabrication platform PTA. The nanostructure will then be characterized by magneto-transport measurement and magnetic microscopy (MFM), in order to demonstrate the nucleation of isolated skyrmions and characterize the magnetic structure.



Requested skills: Master 2 in nanophysics, material physics, solid state physics

PhD may follow: : Yes

Contact: Olivier BOULLE, DSM/INAC/SPINTEC/, olivier.boulle@cea.fr, 04 38 78 21 56

Modélisation des dispositifs pour l'électronique de spin: dynamique de paroi de domaine magnétique dans des nanofils à section circulaire

Contact : Daria GUSAKOVA DSM/INAC/SPINTEC daria.gusakova@cea.fr 0438786568

Résumé :

Le sujet de ce stage s'inscrit dans la continuité des études menées au laboratoire sur l'influence d'un courant polarisé en spin sur l'aimantation de structures magnétiques. Ce phénomène physique ouvre de nouveaux champs d'applications potentielles telles que les mémoires magnétiques MRAM, des processeurs à logique magnétique reprogrammable ou les dispositifs hyperfréquence pour la téléphonie mobile, GPS et les appareils sans fil. Le développement de dispositifs dans lesquels intervient l'action d'un courant polarisé en spin donne actuellement lieu à un soutien de modélisation important afin d'analyser les résultats expérimentaux et de prédire les nouvelles configurations fonctionnelles

Sujet détaillé :

Les avancés récentes dans la fabrication des nanofils magnétiques à diamètre modulable [1,2] ont permis d'envisager de créer un nouveau type de mémoire magnétique de haut densité basé sur le réseau tridimensionnelle de fils auto organisé [Fig.1 (a)-(c)]. Du point de vue de la simulation numérique ce type de dispositif combine plusieurs particularités (forts gradients d'aimantation et de courants, géométrie courbé etc) qui exigent l'utilisation de modèles appropriés et de maillages non-réguliers [Fig.1(d)]. L'expérience antérieure de l'équipe dans le domaine a permis de mettre en œuvre conjointement entre Spintec et l'Institut Néel un nouveau code numérique éléments finis permettant d'intégrer simultanément les équations de transport polarisé en spin et les équations de micromagnétisme pour des maillages non-réguliers [3].

Dans le cadre de ce stage, le/la candidat/e va être amené/e à manipuler ce code afin de modéliser la dynamique de paroi de domaine magnétique sous l'action de courant polarisé en spin dans des nanofils à section circulaire modulable. Ce travail va permettre de définir les conditions de décrochage de la paroi, de définir les différents régimes dynamiques de propagation de la paroi (linaire, oscillant [Fig.1(e)] ou turbulents) et de calculer les vitesses de propagation de la paroi. Ce stage permettra à l'étudiant/e de se sensibiliser aux concepts utilisés dans la théorie du transport dépendant de spin, à l'approche micromagnetique et à la modélisation numérique basée sur la méthode des éléments finis. De plus l'étudiant/e aura l'opportunité de se familiariser avec des logiciels scientifiques tels que Comsol, MatLab, Origin etc.

[1] H. F. Liew, S. C. Low, et W. S. Lew, J. Phys.: Conf. Series 266, 012058 (2011).

[2] S. Da Col, M. Darques, O. Fruchart, et L. Cagnon S. Da Col et al., Appl. Phys. Lett. 98, 112501 (2011).

[3] M. Sturma, J.-Ch. Toussaint, and D. Gusakova, J. Appl. Phys. 117, 243901 (2015).

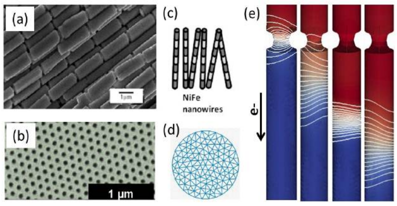


Figure 1 : (a)-(c) Nanofils magnétiques à section circulaire [1,2]. (d) Maillage non-régulier de méthode des éléments finis. (e) Déplacement de la paroi de domaine sous l'action de courant polarisé en spin dans un régime oscillant.

Compétences requises :

connaissances solides en matière condénsée

Stage pouvant se poursuivre en thèse : Oui

Theory of Spin Transport phenomena in Magnetic Tunnel Junctions

Contact : Mairbek CHSHIEV DSM/INAC/SPINTEC mair.chshiev@cea.fr 04 38 78 02 80

Summary :

Magnetic tunnel junctions (MTJ) comprising two ferromagnetic (FM) layers separated by an insulator (I) play a crucial role in current and future developments of spin electronics (spintronics), such as such as magnetic random access memories (MRAM), hard disk drives, logic devices etc. This is due to observation in MTJs of high tunnel magnetoresistance (TMR) ratios, i.e. relative change of resistance when magnetic configuration is switched from parallel to antiparallel. The discovery of a new spintronic phenomenon called spin transfer torque (STT) makes possible controlling magnetic configuration of the tunnel junction by passing spin polarized current through it instead of applying magnetic field. It makes possible thereby creation of new generations of MRAM (STT-MRAM) where both read and write operations can be performed with spin polarised current.

Full description :

The purpose of this internship is to use a tight-binding method and non-equilibrium Green function technique in order to understand deeply the quantum nature of a wide range of spin polarized transport phenomena in magnetic tunnel junctions. Among phenomena to address the priority will be given not only to quantum description of tunnel magnetoresistance (TMR), but mostly to spin transfer torque (STT) since this phenomenon's behavior defines behavior of STT-MRAM and also is crucial for signal-to-noise ratio (SNR) of magnetic sensors since its contributes to noise. Namely, a physical nature of applied voltage dependences of TMR and STT will be investigated and understood what is extremely important in a view of aforementioned spintronic devices. We expect that these dependences will be very sensitive to electronic band structure of materials involved as well as to thicknesses of the metallic and insulating layers constituting the magnetic tunnel junctions. We will also address Spin Hall Effect and interfacial magnetic anisotropy behaviour in MgO-based tunnel junctions.

Requested skills :

solid background in condensed matter theory and computational methods

PhD may follow: Yes