Growth and multi-scale properties of hybrid magnetic tunnel junctions : towards the control of spinterfaces

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In the field of spintronics, there are many reasons to use organic tunnel barriers in devices: low cost, flexibility and long spin life time [1, 2]. What happens at the interfaces in these organi-inorganic hybrid systems is so relevant to the properties that a word has been proposed for it: spinterface [3]. The discrete nature of the molecular levels explains the variation of the magneto-transport properties with respect to the type of molecules and the nature of the interfaces [4]. At the UMR CNRS-Thalès the spinterface concept has been put forward and recently exciting results have been found for monolayer tunnel junction systems with a 10% magnetoresistance at room temperature. However, unexplained change in magnetoresistance sign with magnetic field orientation have been also observed [5]. The spin polarization of the molecular orbitals at the interfaces could be key explanation for that. Pioneer results have been already obtained with low interacting molecules with ferromagnetic substrates like phtalocyanines, but few results were obtained on covalently grafted molecules on such surfaces. To investigate such spinterface issues there is a need for very well defined interfaces, obtained in ultra-high vacuum conditions which is one of the major expertise of our team.

This project aims to realize hybrid hetero-structures with a molecular monolayer as tunnel barrier between two ferromagnetic layers. Modifying the way molecules are linked to the substrate, the crystallographic orientation of the substrate and the nature of the molecules, we will investigate the rules in play. Multi-scale measurements will be performed (transport measurements, synchrotron radiation measurements). We will also perform ballistic electron emission microscopy (BEEM), an STM derived technique, which is mastered by very few teams in the world [6, 7]. We will take advantage of results we have already obtained concerning metal/mol/GaAs [8] to master these new systems [9]. Obtaining such systems in a real controlled way is however one of the challenge of this project that will be addressed thanks to the very complementary experimental setups available in our laboratory (XPS, UPS, transport and magneto-transport measurements, magnetic measurement such as magneto-optical Kerr effect).

The expected results concern spin polarization of the molecular orbitals, energy alignment of the lowest unoccupied molecular orbitals and their relationship with the nature of the ferromagnetic substrate, its crystallographic orientation and the kind of molecules that are grafted to it. DFT calculations will be performed on these systems.

The PHD student will benefit from the very complete experimental setups that allow surface and interface studies (X-ray and UV photoemission spectroscopy, scanning tunneling microscopy), transport measurements (BEEM, I-V and C-V measurements and magnetic properties measurements (MOKE and BEMM). Experiments at synchrotron radiation facilities will be also possible.

The PHD student will benefit from the skills of a whole team and will be also in contact with other teams from Laboratoire de Physique du Solide-Orsay and from CNRS-Thales laboratory.

Références :

[1] J. R. Petta, S. K. Slater*, et al.*, Physical Review Letters, 93, 136601 (2004)
[2] S. Sanvito, Chemical Society Reviews, 40, 3336-3355 (2011)
[3] S. Sanvito, Nat Phys, 6, 562-564 (2010)
[4] M. Galbiati, S. Tatay*, et al.*, Applied Physics Letters, 106, 082408 (2015)
[5] Thèse Sophie Delprat (2017)
[6] Y. Zheng, A. T. S. Wee*, et al.*, Applied Physics Letters, 95, 143303 (2009)
[7] A. Bannani, C. Bobisch*, et al.*, Science, 315, 1824-1828 (2007)
[8] A. Junay, S. Guézo*, et al.*, Journal of Applied Physics, 118, 085310 (2015)

[9] A. Junay, S. Guézo*, et al.*, The Journal of Physical Chemistry C, 120, 24056-24062 (2016)

Applicant : The applicant should have a physics or physical chemistry degree with either one of these specificities: material science, surface science, condensed matter, solid state physics.

Language : written and oral French and English

To apply send a CV, a cover-letter and a support letter from the professor head of the second year of master to

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Références :

[1] J. R. Petta, S. K. Slater*, et al.*, Physical Review Letters, 93, 136601 (2004)
[2] S. Sanvito, Chemical Society Reviews, 40, 3336-3355 (2011)
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