# Master *Matière Condensée et Nanophysique*

**Année universitaire 2016/2017**

DIRECTEUR DE THESE : WOLFGANG WEBER
IPCMS, 23, RUE DU LOESS, 67034 STRASBOURG
TEL : 03 88 10 70 87 ; E-MAIL : WOLFGANG.WEBER@IPCMS.UNISTRA.FR

## ORGANIC SPINTERFACES BY INDIRECT EXCHANGE COUPLING

The field of spintronics has focused on combining spin injectors with organic semiconductors since this class of materials possesses long spin diffusion lengths/times of interest for encoding and transporting spin-encoded information. In this vein, recent research has shown that novel spintronic properties appear at the interface between a ferromagnetic metal and an organic semiconductor [1], a so-called spinterface [2]. In fact, due to charge transfer, strong interfacial spin polarizations could be evidenced by us for a lot of systems (Mn-phthalocyanine (Pc), $H_2$Pc, phenanthroline, amorphous carbon, pentacontane, and $C_{60}$ on Co and Fe) [3-6]. We thus found that the presence of highly polarized interface states is a property which is robust against changes to the molecule and ferromagnetic metal's electronic properties. This proves the generality of highly spin-polarized interface states at the interface between a ferromagnetic metal and an organic molecule, and augurs bright prospects toward integrating these interfaces within organic spintronic devices.

However, the study of such spin injector/molecular pairs as spinterface candidates cannot be accomplished for all molecular classes. In fact, the conditions during molecule deposition may be such that the quality of the ferromagnetic layer would be degraded without protection or in which, inversely, the direct contact between ferromagnetic layer and molecules would degrade the quality of the molecular layer. One solution to this problem is the use of a less reactive constituent in the multilayer structure, such as Cu, which separates the ferromagnetic layer from the molecules [7]. Importantly, the magnetism of the molecular layer has to couple to that of the ferromagnetic layer across the Cu interlayer. Indeed, we could show that the magnetism of Mn within MnPc molecules, for instance, is coupled to the buried ferromagnetic Co(001) layer across a separation layer of Cu [8]. Moreover, we could evidence a strong spin polarization at the molecule/Cu interface, quite similar to what we have found for molecules in direct contact with the ferromagnetic substrate [9].

It is believed that the magnetic coupling across the Cu spacer layer and thus the presence of a strongly polarized molecule/Cu interface is governed by the appearance of so-called electronic quantum-well states within the Cu layer, which possess a spin polarization induced by the ferromagnetic substrate. **The goal of this internship is to investigate the influence of the molecular top layer on the behavior of the quantum well states**. For comparison metallic top layers will be as well investigated. As experimental set-up we will use our "complete electron scattering experiment" at the IPCMS in which spin-polarized electrons are impinging the sample and the changed spin polarization of the reflected electrons is measured [10]. These studies will give us more insight why the molecule/Cu interface is so strongly polarized.

[1] C. Barraud *et al.,* Nat. Phys. **6**, 615 (2010).
[2] S. Sanvito, Nat. Phys. **6**, 562 (2010).
[3] F. Djeghloul *et al.*, Sci. Rep. **3**, 1272 (2013).
[4] F. Djeghloul *et al.*, Carbon **87**, 269 (2015).
[5] F. Djeghloul *et al.*, J. Phys. Chem. Lett. **7**, 2310 (2016).
[6] M. Bowen *et al.*, patent WO 2013156441 A1.
[7] M. Bowen *et al.*, patent WO2013156426 A1.
[8] M. Gruber *et al.*, Nano Lett. **15**, 7921 (2015).
[9] to be published.
[10] P. Dey, W. Weber, J. Phys. Cond. Mat. **23**, 473201 (2011).