Molecular switches for spintronics

Spin-based molecular electronics (molecular spintronics) offers a unique opportunity to combine the established advantages of the non-volatility of magnetism with molecular concepts like molecular switches, memristors, and interaction with light, in which the basic building block of a single molecule can have a multitude of degrees of freedom.
The aim of this PhD study is to tackle this step by validating a new set of tailored multi-functional magnetic-organic materials for the next generation of molecular spintronic devices. The thesis will be developed in collaboration between groups in Strasbourg (IPCMS) and Karlsruhe (KIT) resp. led by E. Beaurepaire and W. Wulfhekel, that collaborate on this topic[1,2] and are members of the French-German doctoral school on "Molecular Electronics and Hybrid Systems". This multidisciplinary consortium includes chemists and physicists from both University of Strasbourg (Unistra) and KIT. The molecular materials needed for the present work is available through collaborations with chemistry groups. For the present work, multifunctional magnetic molecular objects are deposited in ultra-high vacuum on noble metal or ferromagnetic surfaces as isolated molecules and ultrathin films. The magnetic and electronic interactions between a molecule and the surface can be then studied and switched on and off, or at least modulated under light irradiation or by interaction with the STM tip.
Switching properties of adsorbed molecules and films will be studied using synchrotron techniques (allowing chemical and submonolayer sensitivity) and scanning probe techniques (allowing atomic resolution and electron induced switching), including for single or isolated molecules. Particular emphasis will be put on the control of the magnetization connected with the optical switching of the molecules, related to interface anisotropy or magnetoelastic effects.

A PhD grant is available for this project and funded by the IdEx of Unistra after selective competition. We look for strongly motivated candidates with master degree in solid state physics, nanoscience, material science or equivalent. The candidate will have in charge the preparation and study of metallic thin films and molecular overlayers. Co-tutelle between Unistra and KIT is encouraged. The work in Strasbourg will include the study of the molecules in ultra-high vacuum, using a variable temperature scanning probe microscope compatible with illumination with LEDs. Macroscopic magnetic measurements will be performed ex situ by magneto-optical Kerr effect. They will be completed by x-ray magnetic circular dichroism at Synchrotron Soleil allowing the determination of magnetic properties and mechanisms of magnetic anisotropy at the level of atomic species. In addition, detailed low temperature STM measurements will be performed at KIT. The setup allows topographic, magnetic and spectroscopic measurements of single molecules, with atomic resolution. Costs related to missions or relocation to Karlsruhe are taken in charge by the French-German University.

References

1) Toshio Miyamachi, et al., *Spin Crossover-induced Robust Memristance across a Single Molecule*, Nature Communication 3, 938 (2012).

2) M. Gruber, et al., *Exchange bias and room-temperature magnetic order in molecular layers*, Nature Materials, 14, 981 (2015), DOI: 10.1038/NMAT4361.

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