Master 2 Experimental Research Internship

Academic Year 2024/2025

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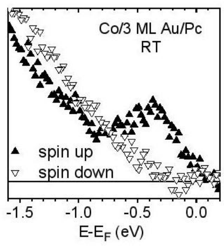
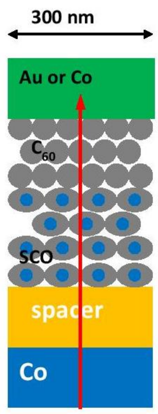
Enhancing spintronics with spin-crossover molecules

Information encoding and processing, which drives our 21st century global economy, utilizes conventional electronics by exploiting the charge of the electron. This can be enhanced by also employing the electron spin, i.e. study spintronics. The sub-field of molecular spintronics, which blends spin electronics with molecular electronics, has recently received considerable attention because of the prospect of utilizing the wide-ranging properties of molecular classes open prospects to tailor the ensuing device properties. One such property is spin crossover (SCO), i.e., the toggling between low-spin (LS) and high-spin (HS) electronic states of a molecule's transition metal site, which can occur through external stimuli such as light, electric field, temperature, or pressure [1].

So far, most SCO-based device research utilizes heavy auxiliary equipment (e.g. scanning tunneling microscope). The goal of our research track is to achieve similar molecular functionality in useful, real-world solid-state devices. A key challenge to overcome is that SCO molecules lose their toggling property when deposited onto a metal surface. We propose to solve this problem and enhance the impact of the SCO molecular property on spintronics, by utilizing the transport high spin polarization of the ferromagnetic metal/molecule interface as the device electrode in a clever way. This so-called 'spinterface', a key team expertise [2], should interact with the SCO property but not prevent toggling. To do so, we propose to utilize a customized spinterface, in which the ferromagnetic metal and SCO molecules are separated by a noble metal ultrathin layer. We have patented this approach [3] and performed preliminary spectroscopy studies. In particular, we have confirmed that the spinterface property is maintained across ultrathin Au (see left Figure) [4]. And separate studies have shown that the SCO property is maintained when $Fe^{II}((3,5-(CH_3)_2Pz)_3BH)_2$ (FePyrz) molecules (provided by collaborating chemists) are deposited onto Au [5].

Taken together, these studies indicate that it should be possible to address the HS and LS state SCO properties of FePyrz molecules using the highly spin-polarized electron flowing from the spinterface. Doing so would open multiple lines of research into SCO-driven spin qubit and energy harvesting [6] technologies. As a first step, we therefore propose in this Master 2 project to perform magneto-transport measurements on nanojunctions (see right Figure) that will have been grown and nanofabricated [7] by the team by Jan. 2025. The M2 candidate will acquire skills on how to intuitively construct experimental measurement protocols based on scientific knowledge and experimental data-driven intuition. In a possible PhD program, this research track offers solid training for academic/industrial career opportunities: UHV growth/characterization, clean-room, magneto-transport measurements.





Magneto-transport as a function of T and H

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