Journées J3N Nationales en Nanosciences et en Nanotechnologies

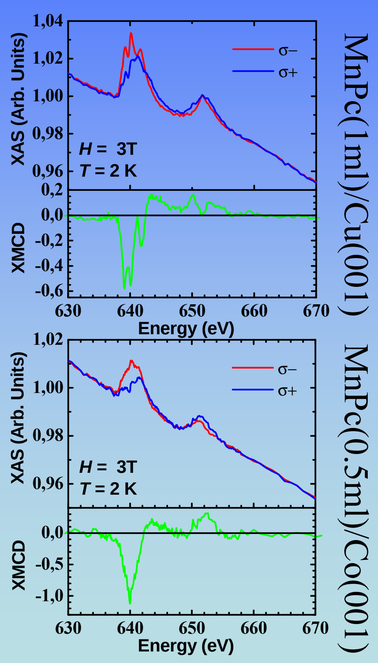
SPIN POLARIZED TRANSPORT IN FERROMAGNETIC METAL /METAL-ORGANIC HETEROSTRUCTURES (SPINORGA)

Objectives

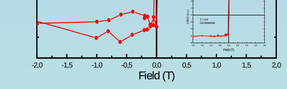
Our project is at the interface between the two emerging fields of spintronics and molecular electronics. This interface has been an area of considerable interest over the past two years . In this project, we aim to study the spintronic properties of a novel type of hybrid nanostructures that integrate insulating or semiconducting metal-organic layers sandwiched between ferromagnetic layers. Growth studies of such heterostructures will be combined to spin-dependent transport experiments. We will perform transport studies from the molecular scale (near-field spectroscopies) to the nanometric (nano-indented junctions) and micronic (UV lithographic & shadow-mask junctions) scales. As a testbed system, we will study FM/MPc/FM (MPc = metal phthalocyanine, FM=Ferromagnet) and determine the incidence of the metal element M in the organic molecule MPc on spin-dependent transport properties such as the spin diffusion length or tunneling. We will then replace the MPc spacer in such heterostructures by a spacer consisting of exotic self-assembled spin transition molecules. The magnetic properties of these molecular systems may be externally controlled by optical or thermal means. We will integrate such materials into solid-state devices with the goal of understanding, tailoring and then addressing the spin transport properties of the junctions envisioning innovative perspectives.

Magnetic, electronic and structural properties of MnPc/Cu(001) and Co(001): experiment (synchrotron) and theory

XMCD at Mn L2, 3 edges

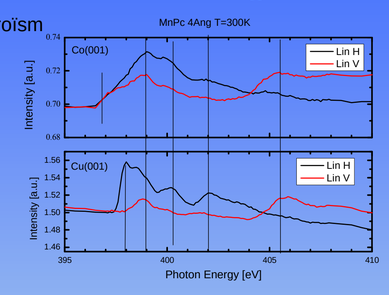


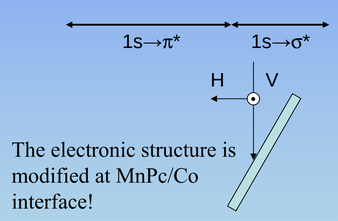
Experiments preformed at SLS, samples prepared in situ (UHV).
Multiplet features get blurred for MnPc(1ml)/ Co(001), this results from the interaction with the substrate.
Element selective selective hysteresis loops show the strong Co-Mn magnetic coupling.



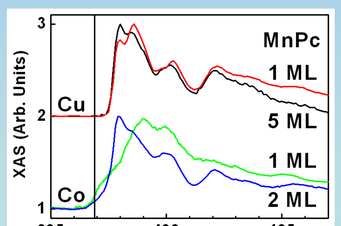
XAS at N K-edge

Linear dichroïsm





The electronic structure is modified at MnPc/Co interface!



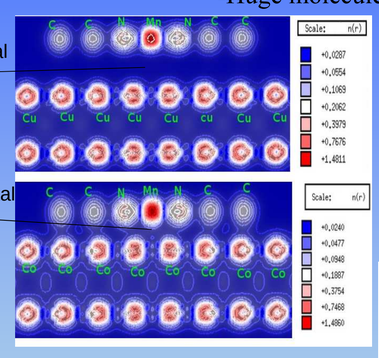
DFT calculation

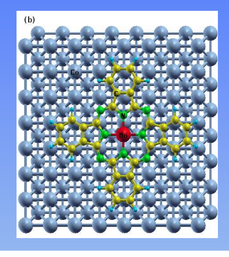
See Abinitio-nanospin

Structure:
-Hollow site is preferred (vs bridge and ontop)
-Huge molecule-substrate distance effect

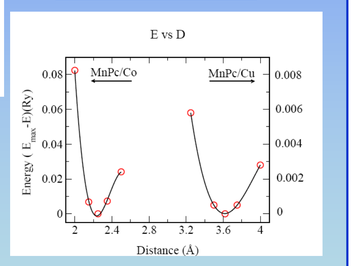
Weak molecule/metal bond

Strong molecule/metal bond





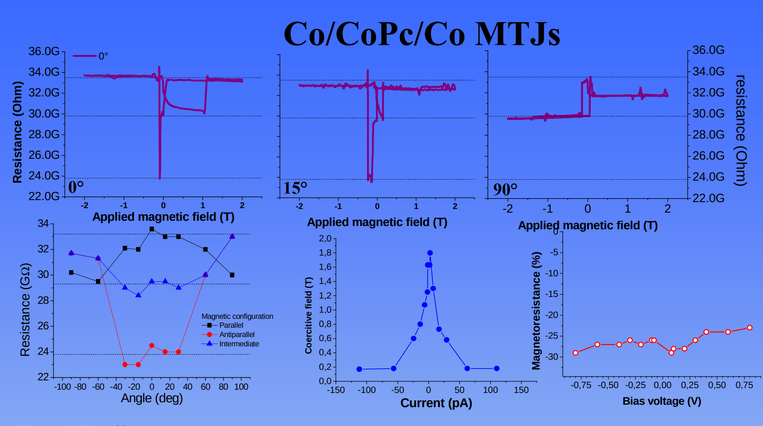
Charge density maps MnPc/Cu, Co(001)



MnPc is "physisorbed" on Cu with weak hybridization at the interface and large molecule-substrate distance. The molecule is quasi-semiconducting and paramagnetic.
MnPc is "chemisorbed" on Co with strong chemical binding at the interface, short molecule substrate distance. The molecule is quasi-metallic and magnetically coupled.

Magneto-transport properties on nanojunctions

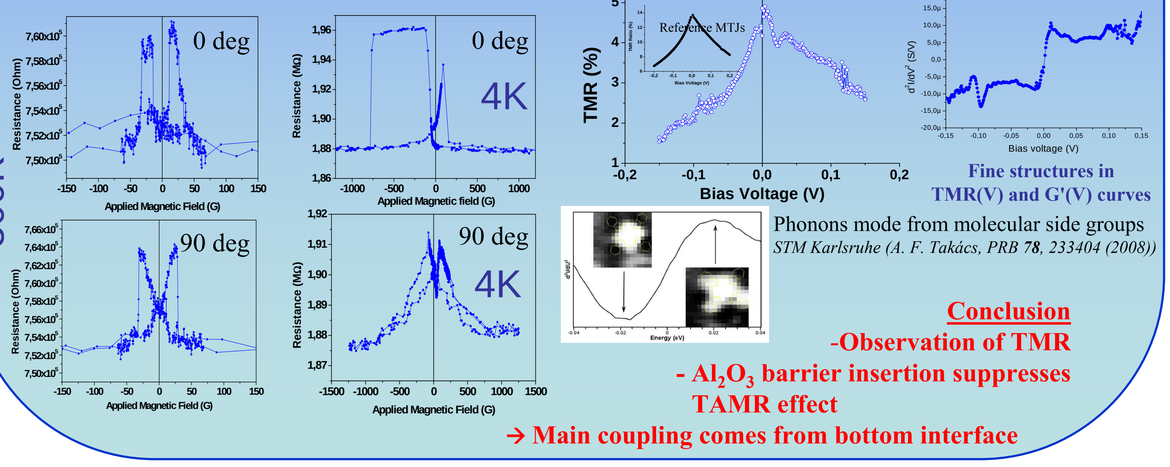
Co/CoPc/Co MTJs



Two MR effects:
✓ Anisotropic effect (TAMR)
✓ Spin valve effect (TMR)

Coupling at Co/CoPc interfaces.
Top and/or bottom interface ?

Co/AlOx/CoPc/Co/CoO: supressing Co/CoPc coupling



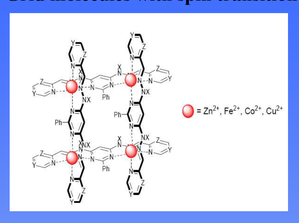
Fine structures in TMR(V) and G'(V) curves

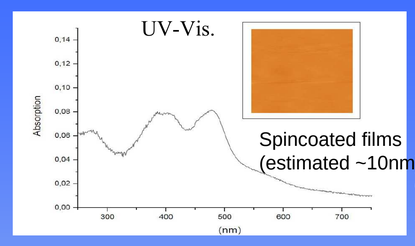
Phonons mode from molecular side groups
*STM Karlsruhe (A. F. Takács, PRB **78**, 233404 (2008))*

Conclusion
-Observation of TMR
- Al_2O_3 barrier insertion suppresses TAMR effect
→ Main coupling comes from bottom interface

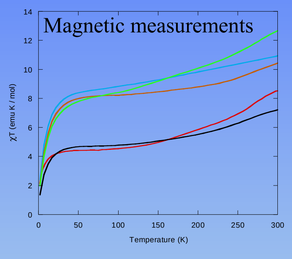
Devices based on metallo-grids (spincoating)

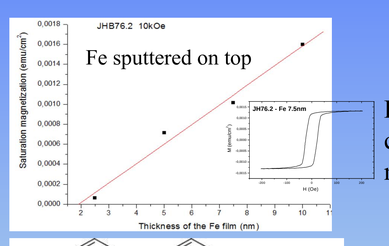
Grid molecules with spin transition



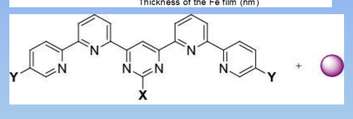


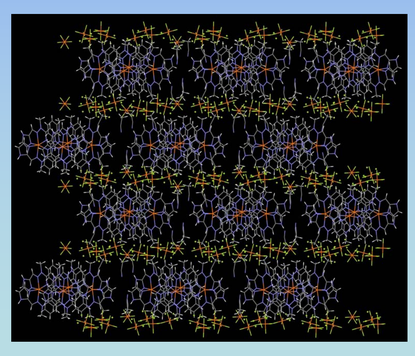
The morphology of the films obtained by spincoating is ligand dependent (AFM image 50x50µm)





Fe films obtained on the spin coated organic present good magnetic properties.





Cristallographic structure in presence of counter-ions (obtained on single crystals). A. Stefankiewicz, thèse UdS 2009

Results :
- Determination of ligand/ solvent combination allowing to obtain ultrathin layers with low roughness by spincoating.
-Deposition on the organic layer of Fe films ferromagnetic (RT) above
Under progress:
- Realization of trilayers Co/grid/Fe (coupling)
- Bilayers Co/Grids for nano-indentation and magneto-transport.

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