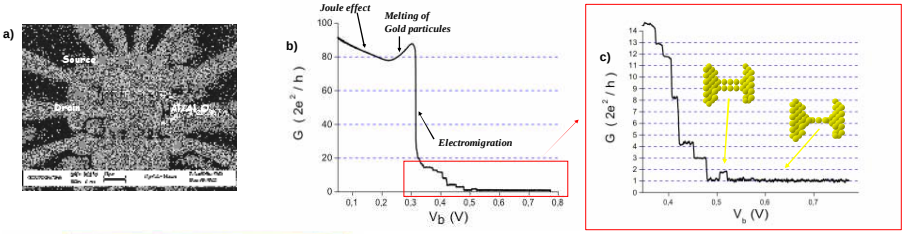
MolSpintronics

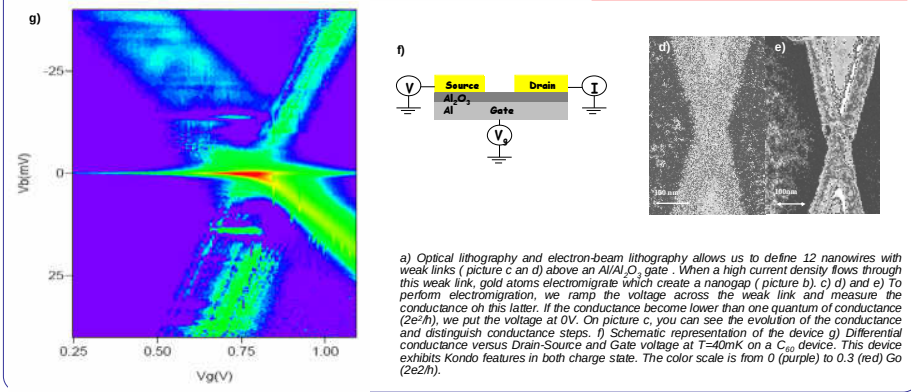
At the border between molecular electronics and spintronics one, this project deals with the realization and the fundamental study of single magnetic molecules devices. To take up the challenge of the connection of a singlemolecule, we develop a process of self-assembly on junctions obtained by electromigration thanks to a close and direct collaboration between the chemists and the physicists. Several molecules with well characterized magneticbehavior will be studied, like molecular magnets based on transition metallic atoms or lanthanides, or fullerenescages encapsulating a single magnetic atom. It was theoretically predicted that the magneto-resistance of such a molecular junction makes it possible to highlight the tunnel effect of magnetization. Such observations would open the way to the control of the spin state at atomic scale opening the way to molecular spintronics. In parallel withthese experiments, the theoretical team will contribute to the modeling of electronic transport through the molecular systems having a spin, connected to normal or ferromagnetic metal electrodes. We will interpret our experimental measurements of magneto-transport in different regimes, basing these results on effective models resulting frommesoscopic physics.

Institut Néel, Département Nano, CNRS, UJF, Grenoble

F. Balestro(MdC), V. Bouchiat(CR), E. Bonet(CR), N. Roch(Ph.D.), W. Wernsdorfer(DR), C. Winkelmann(Post. Doc)

Electronic lithography does not allow to pattern gap between electrodes of the order of molecule diameter which is of the order of 1 nm. An alternative and reproducible method to realize such gaps is to control the electromigration process of atoms.
Fabrication of nanogaps is achieved by passing a large electrical current through a gold nanowire having a weak link. The current flow causes the electromigration of gold atoms and a control of the breakage of the weak link yields two stable electrodes separated by ~ 1nm.
Our devices combine optical and electronic lithography. The first one is used to realized an Al/Al_2O_3 gate, and the large ohmic pattern. The second one is used to realize the nanowires with weak links.



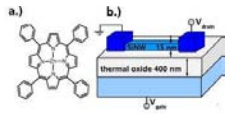


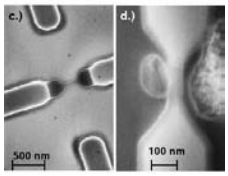
a) Optical lithography and electron-beam lithography allows us to define 12 nanowires with weak links (picture c an d) above an Al/Al$_2$O$_3$ gate . When a high current density flows through this weak link, gold atoms electromigrate which create a nanogap (picture b). c) d) and e) To perform electromigration, we ramp the voltage across the weak link and measure the conductance oh this latter. If the conductance become lower than one quantum of conductance ($2e^2/h$), we put the voltage at 0V. On picture c, you can see the evolution of the conductance and distinguish conductance steps. f) Schematic representation of the device g) Differential conductance versus Drain-Source and Gate voltage at T=40mK on a C_{60} device. This device exhibits Kondo features in both charge state. The color scale is from 0 (purple) to 0.3 (red) Go ($2e2/h$).

Laboratoire d'Electrochimie Organique et de Photochimie Redox, CNRS, UJF, Grenoble

C. Bucher(CR), X. Chevalier(Ph.D.), A Gasnier(Ph. D.), G. Royal(MdC)

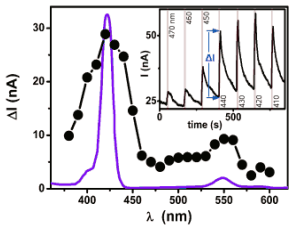
We study porphyrin derivative coated silicon nanowire field effect transistors, which display a large, stable and reproducible conductance increase upon illumination. The efficiency an the kinetics of the optical switching are studied as a function of gate voltage, illumination wavelength and temperature. The decay kinetics from the high- to the low-conductance state is governed by charge recombination via tunneling, with a rate depending on the state of the SiNW-FET. The comparison to porphyrin sensitized Carbon Nanotube FETs allows to distinguish the environment- and molecule-dependent photoconversion process from the charge-to-current transducing effect of the semiconducting channel.





Nano Letters 7, 1454 (2007)

a) Chemical structure of the zinc(II) porphyrin derivative.
b) Schematic drawing of the SiNW-FET device from silicon-on-insulator. The highly n-doped SiNW is 15 nm in height, about 70 nm in width and from 100 to 1000 nm in length.
c) Scanning electron microscopy (SEM) image of an e-beam lithographed bare SiNW before porphyrin sensitizing. The two lateral gate electrodes visible are not used.
d) SEM image of a similar SiNW after porphyrin sensitizing : porphyrin deposits are clearly visible in the SiNW vicinity, allowing for the optical gating
of the device.

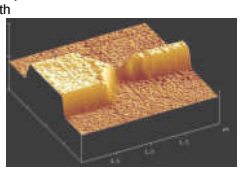


Variation of the photoinduced drain-source currentΔIds upon illumination as a function of light wavelength, at a constant illumination power of 0.5 W/m2. Light is applied for periods of 10 s, after which the sample is left to relax in the dark for 110 s; the spectrum covered extends from 380 to 600 nm, by steps of 10 nm. The measured current variations clearly exhibit the enhanced sensitivity of the device in the Soret-band (422 nm) and the main Q-band (549 nm) which are well known features of the porphyrin absorption spectrum in toluene (purple line, superimposed to the graph).

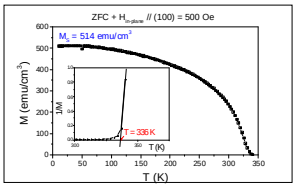
Institut d'Electronique fondamentale CNRS, U. Paris Sud

A. Aassime(IR), L. Calvet(CR), F. Gaucher(Ph. D.), A.-M. Haghiri(DR), P. Lecoeur(Pr.)

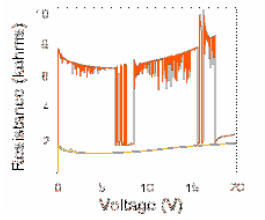
Newly functioning Pulsed laser deposition (PLD) with layer by layer growth



Nanofabrication process to realize sub-30 nm nanoconstrictions in $La_{2/3}Sr_{1/3}MnO_3$ (LSMO)



Demonstration of 10 nm LSMO films with with T_c = 336 K



LSMO-LSMO electromigration attempt unsuccessful!

Electronic properties of domain walls in La2/3Sr1/3MnO3
T. Arnal, A.V. Khvalkovskii, M. Bibes, B. Mercey, Ph. Lecoeur, and A.-M. Haghiri-Gosnet
Accepté pour publication dans Phys. Rev. B - Rapid Com , à paraître prochainement
Article en rapport avec la tâche **T2.1b**

Temperature dependence of the optical conductivity in a strained single-crystal thin La2/3Sr1/3MnO3 film.
A.M. Haghiri-Gosnet_ M. Koubaa, A. F. Santander-Syro, R. P. S. M. Lobo, Ph. Lecoeur, and B. Mercey
En soumission à Phys. Rev. B
Article en rapport avec les films minces LSMO.

Molecular Spintronics

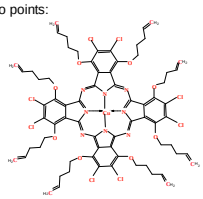
A close collaboration between Chemistry, Theoritical, and Experimental Physics

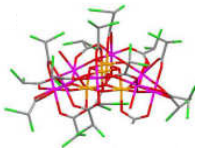
Institut de Chimie Moléculaire et des Matériaux d'Orsay, CNRS, U. Paris Sud.

R. Guillot(IR), V. Huc(CR), T. Mallah(Pr.)

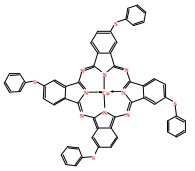
During the first half of 2007, the LCI concentrated on two points:

- Synthesis of Mn12(dichloroacétate)16, in order to carry out deposits on surfaces in conditions of ultra-high vacuum by the method of the pulsed valve; starting of the phthalocyanine synthesis adapted to the deposit between electrodes of gold and manganites
- Study of the deposit of the cluster Mn12(dichloroacétate)16 on substrates (continuous) of manganites, for their insertion within nanogaps of this same material.





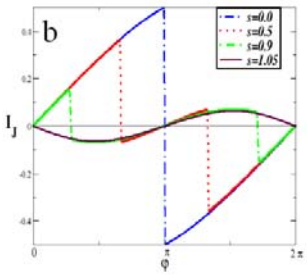
Cluster Mn_{12}(dichloroacétate)$_{16}$



Phtalocyanines de cuivre

Centre de Physique Théorique, CNRS, Luminy, Marseille

C. Benjamin(Post. Doc), A Crepieux(MdC), M Creux(Ph.D.), T. Jonckheere(CR), T. Martin(Pr.), T. Nguyen(Ph.D.), A. Popoff (Ph.D.)



Controllable π junction in a Josephson quantum-dot device with molecular spin

Quantum dot with fixed molecular spin S (*molecular magnet*)

Exchange interaction between the electronic spin on the dot and the molecular spin (s=J S)

When spin interaction is large enough, change of sign of the Josephson current (Pi-junction).

The Pi-junction behavior can be controlled with the other parameters of the system (e.g. dot level position)

C. Benjamin, T. Jonckheere, A. Zazunov and T. Martin, *Controllable pi junction in a Josephson quantum-dot device with molecular spin*, Eur. Phys. J. B **57**, 279-289 (2007)

K.-I Imura, Y. Utsumi and T. *Martin,Full counting statistics for transport through a molecular quantum dot magnet: Incoherent tunneling regime*, Phys. Rev. B **75**, 205341 (2007)

A. Zazunov, R. Egger, C. Mora, and T. Martin, *Superconducting transport through a vibrating molecule*, Phys. Rev. B **73**, 214501 (2006)

A. Zazunov, D. Feinberg, and T. Martin, *Phonon Squeezing in a Superconducting Molecular Transistor*, Phys. Rev. Lett. **97**, 196801 (2006)