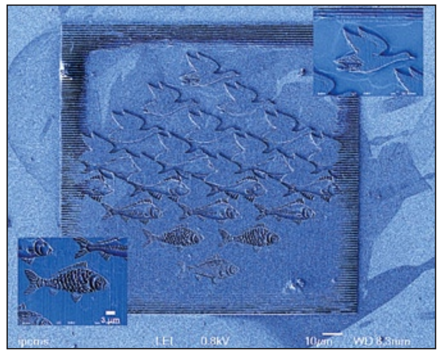
• The RBnano project

The **RBnano company** is a spin-off of the IPCMS, prize winner of the French national contest on innovating technology companies in 2004. RBnano develops a new process for the fabrication of nano structures. In its present state, the company gathers five individuals still involved in the academic research community sharing complementary skills (microfabrication, chemistry, optics...). Being located in the institute the company takes advantage of a favorable environment and of the access to high-level characterization and preparation equipments. The innovative contribution of the **RBnano** process is based on an original chemical precursor that can be patterned on a nanometric scale when irradiated with a focused electron beam. The process allows the deposition of a large variety of materials (metals, oxides, semiconductors...) on a large variety of substrates (glass, metal, silicon...) under soft hygrometric and temperature constraints. The process is achieved without any further chemical additive with water as a solvent; the toxicity of the precursor only depends on the toxicity of the final material. Therefore the process is totally compatible with the new European directive on the Restriction of Hazardous Substances (RoHS). For the present times, **RBnano** explores the ways to produce diffractive optical elements that could be useful in the field of property protection as well as the possibility to produce customised electronic microcircuits. The access to the in-situ available nanofabrication plateau will undoubtedly accelerate the development of the **RBnano company** by shortening the manufacturing delay. ■



Nanopicture obtained by RBnano maskless engraving process (based on Escher original).

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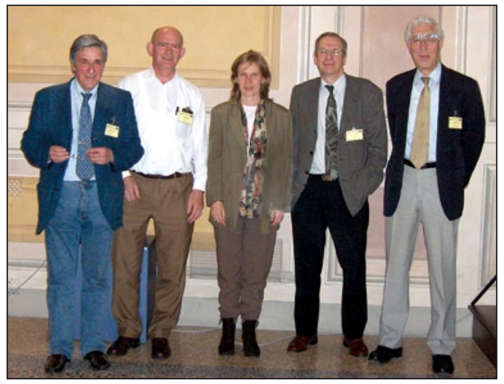
➜ *RBnano is the winner of the Raith Technology company special price 2004.*

MAGMANet http://www.magmanet-eu.net/

European network of Excellence

Research onto novel molecule-based magnets is taking a big step forward as fifteen groups of chemists and physicists in Europe combine their efforts in a Network of centres of Excellence (NoE), named MAGMANet (Molecular Approach to Nanomagnets and Multifunctional Materials). The aim is to generate the knowledge and technology of tomorrow in diverse fields – information science (nano- and molecular-scale data storage, quantum computing), healthcare/biomedecine (biodegradable microspheres, drug delivery systems, biocompatible magnets, hyperthermic cancer treatment, biomagnetic separation, smart imaging probes), optoelectronics and displays, magneto-optical switches, safety and security devices, magnetic nanocomposites, refrigeration, etc.

MAGMANet will focus on new kinds of magnetic materials, built up from atoms or individual molecules through bottom-up approaches, priority being stressed on switchable magnetic materials, conducting magnets, molecular nanomagnets and nanostructured molecular materials.



Kick-off meeting: D. Gatteschi, J. Reedijk, A. de Baas, M. Drillon, P. Day (from left to right).

European Commission is providing a 10.7 M€ funding through the Sixth Framework Programme to this network coordinated by INSTM (National Institute for Science and Technology of Materials) in Florence. The task of the IPCMS will be to develop integration, namely a virtual laboratory to share world-class instrumentation, a joint training and education programme and the partnership with industrial groups.

Ultimately the aim is to create a new organisation, the 'European Institute of Molecular Magnetism', which will provide lasting integration of research and technological capabilities in this field, crossing national and disciplinary boundaries. This Institute will offer world-class resources through a Virtual Laboratory of excellence and selected instrumentation platforms.

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International Newsletter
January 2006
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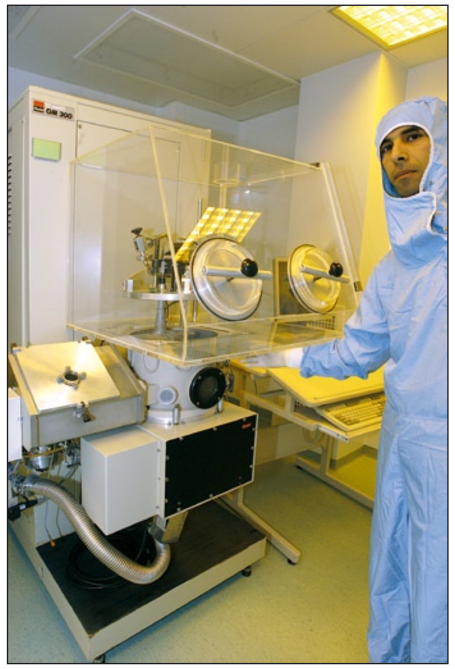
Summary

www-ipcms.u-strasbg.fr

Editorial

IPCMS International Newsletter is published twice a year, to enlighten the most recent breakthroughs of our **I**nstitute of **P**hysics and **C**hemistry of **M**aterials in **S**trasbourg in the field of materials and nanosciences, and to give an overview of the partnerships and research joint programs worldwide.
Today, IPCMS is focusing its efforts towards the fabrication and study of nanomaterials and nanostructures that can ensure the development of innovative technologies in the future, such as information science and spintronics, optoelectronics and displays, safety and security devices, etc...

The Institute is running at the forefront for the fabrication and the study of nanoscaled materials, with an emphasis on atomic and molecular level tailoring of nanomaterials to achieve desired magnetic, optical or electronic transport properties. The goal is to achieve a basic understanding of the ways in which functional materials, which display specific physical properties to external stimuli, respond when their size is limited to a few nanometers.



The facilities available include high-level capabilities in nanomaterial fabrication (molecular beam epitaxy, pulse laser deposition and electronic lithography), high resolution electron microscopy and near-field probes for imaging atomic and molecular structure, ultrafast laser sources for dynamical studies, magnetic measurement equipments, etc... together with a clean room and other support instrumentation.

The Institute develops closed collaborations both in the frame of the National Program on Nanosciences, the Sixth Framework Programme of the EC – we are member of the Network of Excellence "Magmanet" – and through the participation to synchrotron radiation experiments. This letter should contribute to strengthening our international opening and information dissemination activities.

Marc Drillon
Director

Institut de Physique et Chimie des Matériaux de Strasbourg

• Magnetization trajectory visualized by femtosecond laser pulses

The development of efficient magnetic devices is a challenge in various areas of Research and Technology. It involves several research directions like the study of spin injection, the realization of nano-scaled magnetic memories, the study of spin dynamics associated to temporary or permanent magnetic changes in various materials. In this context a research team at IPCMS has pioneered a new approach, named Ultrafast Magnetization Dynamics, to study the magnetic changes over a very broad temporal scale, ranging from a few femtoseconds up to one nanosecond. It relies on the excitation of magnetic systems with femtosecond laser pulses as well as on the all-optical detection of the corresponding induced magnetization dynamics. With such approach the magnetic properties of ferromagnetic materials can be investigated with an unprecedented temporal resolution (~10 fs) allowing to study several processes like: the thermalization of a non-equilibrium spin population, the electron-lattice and spin-lattice relaxation, the magnetization precession and damping around the effective field. These processes are of primary importance in the context of magnetic switching either by thermal or coherent pathways.

The recent investigations of this research team allow to visualize the precession of the magnetization in real time and in the three directions of space [1].

The experiments have been performed on cobalt thin films (16 nm cobalt, MBE grown on sapphire) with a time resolved magneto-optical Kerr configuration as displayed in figure 1.

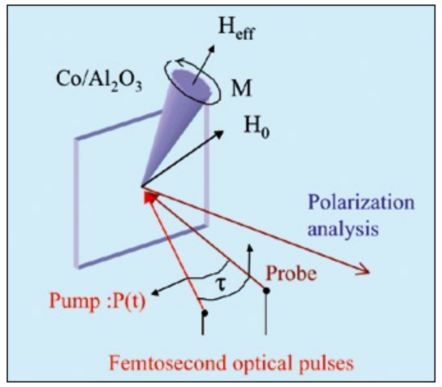


Fig. 1 : Time resolved magnetization dynamics using femtosecond optical pulses.

The three components of the magnetization corresponding to the polar, longitudinal and transverse directions can be measured by applying an external magnetic static field H_0 in the various directions θ, $-\theta$ and $\neq -\theta$, where θ is the angle between H_0 and the normal to the sample. The three dimensional trajectory is displayed in figure 2. These experiments are of great interest to understand the role played by the magneto-crystalline and shape anisotropies on the precession and damping of the magnetization.

Their extension to superparamagnetic nanoparticles are under progress. ■

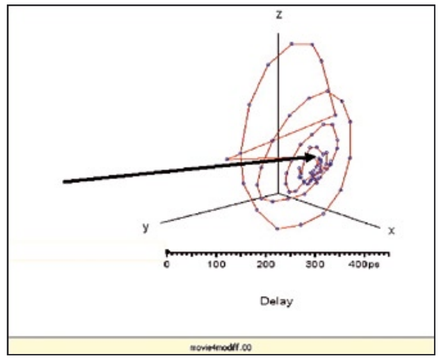


Fig. 2 : Precession dynamics visualized in 3D.

[1] M. Vomir, L.H.F. Andrade, L. Guidoni, E. Beaurepaire, J.-Y. Bigot,
«Real space trajectory of the ultrafast magnetization dynamics in ferromagnetic metals»
Phys. Rev. Lett. **94**, 237601 (2005).

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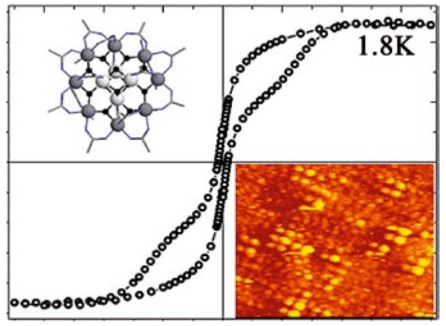
• Self organization and magnetic properties of single molecule magnets

Progress in spin electronics and magnetic data storage strongly depend on our ability to synthesize highly integrated nanostructures with sizes not exceeding a few atoms. In this size range it becomes tremendously important that all entities are identical since properties such as the magnetic anisotropy are very sensitive to the number of atoms. One way to overcome this difficulty is to use coordination chemistry to synthesize small clusters containing a limited amount of transition metal ions behaving like tiny magnets. These single molecule magnets (SMMs), show an overall classical behaviour of the magnetization, although their low temperature relaxation by quantum tunnelling suggests their use as elementary units in data storage applications or as Q-bits in quantum computers.

The deterministic organization of SMMs on a surface is a prerequisite for their individual addressing with a scanning probe tip. As an example, $Mn_{12}Piv_{16}$ molecule magnets with a moment of 20 μ_B in the ground state have been self-assembled in a two step process onto a gold surface. The substrate has been pre-functionalized with alkylthiol chains before the $Mn_{12}Piv_{16}$ are grafted by exchange reaction. That the Mn_{12} molecule magnets survive organized grafting on the Au(111) surface is shown by a magnetic study in the monolayer range.



SQUID hysteresis of the monolayer $Mn_{12}Piv_{16}$ showing a hysteresis loop, which is reminiscent of an assembly of single molecules. The first inset shows a schematic view of the $Mn_{12}Piv_{16}$ molecule. The second inset shows an STM image of the self-organized molecular layer on Au(111).

Although the magnetic features are still reminiscent of ferromagnetic SMMs, effects due to the reduced dimensionality are clearly visible. The findings are supported by the explicit identification of individual molecules by scanning tunnelling microscopy (STM), opening new opportunities in the field of addressable, high-density, molecular devices for data storage and spin electronics. ■

A. Nait Abdi, J.-P. Bucher, P. Gerbier, P. Rabu, M. Drillon
Adv. Mater., **17**, 1612-1616 (2005).

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International exchanges

An agreement for research collaboration between IPCMS and the Research Organization of Science and Engineering, RITSUMEIKAN University, Japan, has been signed on March 24, 2005. Through this agreement, researchers from both institutions will establish collaborative research projects and both institutions will promote exchanges through visits to each organization by young researchers and graduate students. This agreement will remain valid for an initial period of 3 years.

Within this framework, a delegation of six young students from the laboratory of Professor N. Nakamura have visited IPCMS during the first week of January 2006. On this occasion a joint one day Japanese-French meeting on molecular self-organization was organized where Japanese visitors and some French students from IPCMS have presented their work.

Japanese students, together with their supervisor, Professor N. Nakamura (left), and with Dr. D. Guillon (centre), leader of the Organic Materials Department at IPCMS.

• Monitoring self-assembled nanoparticles growth

Non-interacting nanoparticles with narrow size distributions are powerful tiny laboratories for investigating physical properties such as catalytic or magnetic properties, like e.g. the influence of dimensionality reduction on magnetism. Measuring a collection of identical particles allows the determination of the individual particle properties with good statistics.

Narrow size distributions of nanoparticle assemblies can be obtained by depositing adsorbates on naturally patterned surfaces. For example, nanoparticle of 3d transition metals build 2-dimensional meta-crystals over distances close to the micrometer on reconstructed Au(111) surfaces.

To characterise the degree of super-crystalline order in the obtained nanoparticle array, in situ Grazing Incidence Small Angle X-ray Scattering (GISAXS) is performed at ESRF (beamline ID32).

GISAXS is a highly surface sensitive technique because of grazing incidence, and contains information about both the particle shape and the degree of order at a nanometer scale.

The signal is recorded continuously during the particle growth at a rate of several milliseconds to several seconds per image, allowing real-time growth monitoring.

In addition to a quantitative super-crystalline order description, analysing the GISAXS signal intensity as a function of the deposited amount of metal shows that a stress-microstructure is buried in the first gold layers. ■

Science **300**, 1416 (2003)

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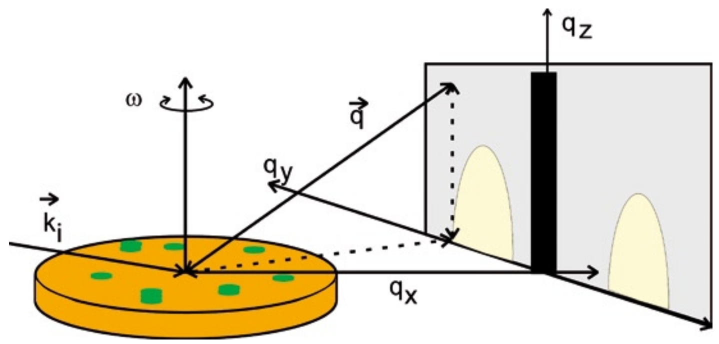
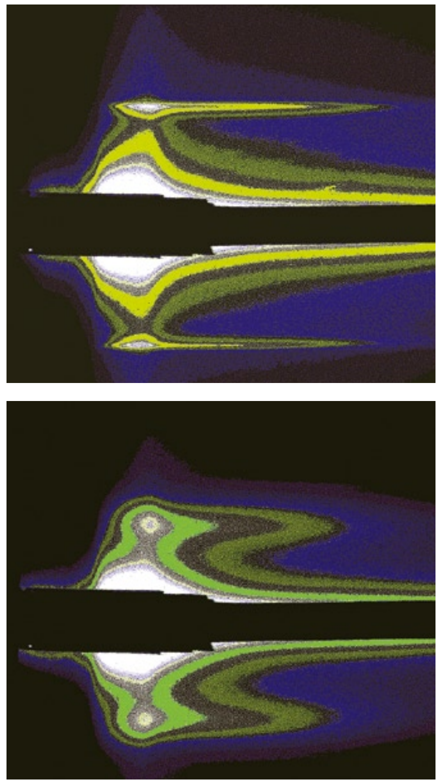


X-rays impinge on the surface with an incidence close to the total reflexion angle. The scattered intensity is recorded with a CCD camera, placed 1 meter from the sample. A tungsten beamstop (black rectangle) hides the specular beam.



GISAXS signal of a Co deposit on Au(111) for two different crystallographic directions. The top picture reveals crystalline-type order whereas the bottom one shows liquid-type order.

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