Our identity and **missions**

The internal organization of IPCMS ("Institut de Physique et Chimie des Matériaux de Strasbourg, UMR 7504 CNRS - Université de Strasbourg") is based on five strongly interacting departments : **Magnetics Objects on the Nanoscale** (DMONS), **Inorganic Materials Chemistry** (DCMI), **Organic Materials** (DMO), **Ultrafast optics and Nanophotonics** (DON), **Surfaces and Interfaces** (DSI). The institute is an internationally well established research center in the area of nanomaterials and nanoscience. About 240 people work at IPCMS, among them ~ 80 are researchers and university professors/lecturers while 60 belong to the technical and administrative staff.

IPCMS belongs to a regional network of laboratories active in material science, the "Alsace research federation in materials and nanosciences". Along the same lines, IPCMS plays an important role in several inter-laboratory networks active in France, such as the C'Nano (competences center in nanosciences), METSA (national electron microscopy network) and Synchrotron facilities.

International collaborations

IPCMS is very much open and active on the international scene, through a range of informal and institutional contacts with international partners. We are strongly engaged with China, Japan, India and Korea, through the establishment of mutual agreements managed by the University of Strasbourg.

In particular, IPCMS is the french leader of an institutional partnership with South Korea (Ewha Womans University, Seoul) that has taken the form of a joint international laboratory (LIA, "laboratoire international associé").

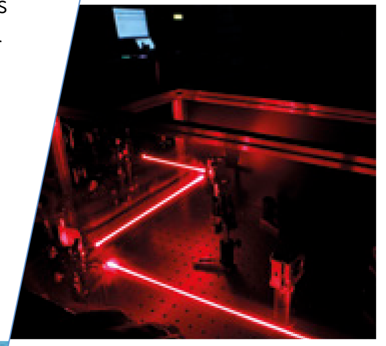
IPCMS is deeply involved in the establishment of an european campus associating the University of Strasbourg to the neighboring leading Universities in Germany and Switzerland.

2014 Winter School IPCMS / Ewha Womans University, Seoul

National projects of investment for the future

IPCMS is a driving force promoting **Equipex** (dedicated excellence equipments) and **Labex** (excellence network laboratories) initiatives.

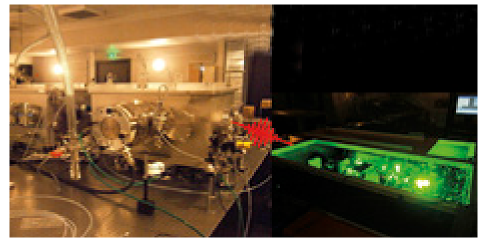
The **UTEM** (Ultrafast Transmission Electron Microscopy) project combines the spatial resolution of transmission electron microscopy (subnanometric scale) with a pump-probe laser apparatus with picosecond temporal resolution. This allows studying the functional dynamics of nano-materials with both high temporal and spatial resolution.

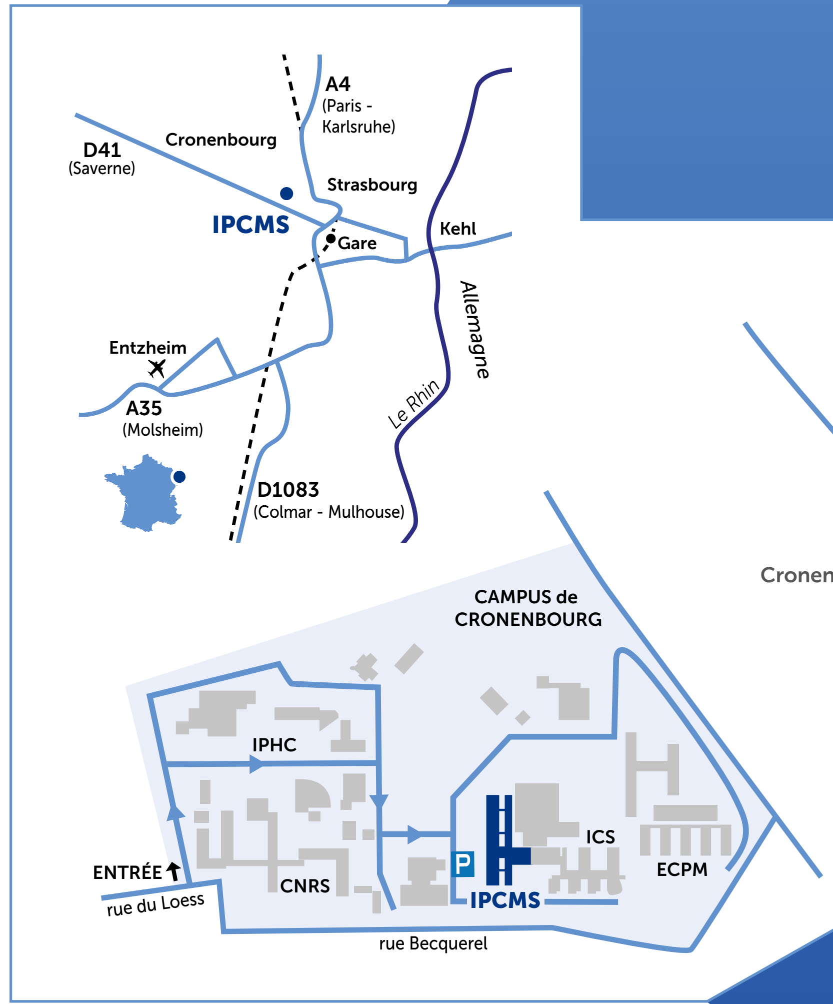


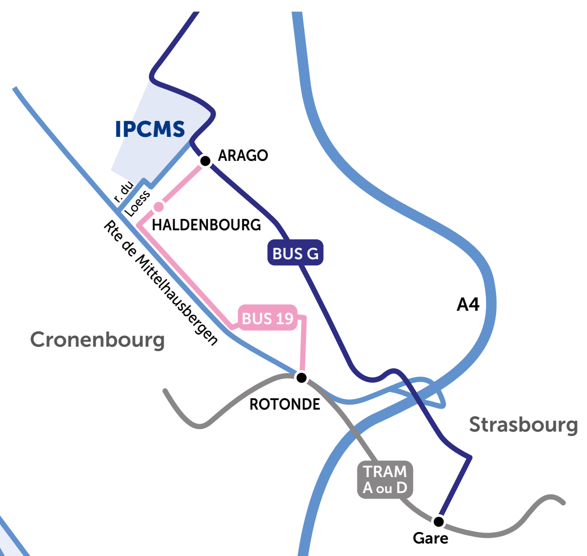
UNION is an experimental platform devoted to investigations of magnetic and plasmonic nanostructures on very short time scales. It relies on ultra-fast magnetization dynamics induced by very short laser pulses and on nano-photonics. The goals are to explore new phenomena and physical mechanisms as well as to develop methods and instrumentation for characterizing nano-materials and nanostructures.

LabEx NIE aims at achieving a better understanding of nanostructure properties as resulting from the interaction with their environment. NIE is issued from the efforts of three research institutes of Strasbourg (IPCMS, ICS, and ISIS). The strategy of NIE can be made explicit as follows:

- Bridge the gap between nano-objects and the real world (nanotechnology)
- Unravel the fundamental mechanisms of the interactions, by using photonics, magnetism, electronics, acoustic, mechanical probes having optimal spatial and temporal resolution
- Investigate the origins of quantum decoherence
- Exploit the environment for modifying nano-materials.







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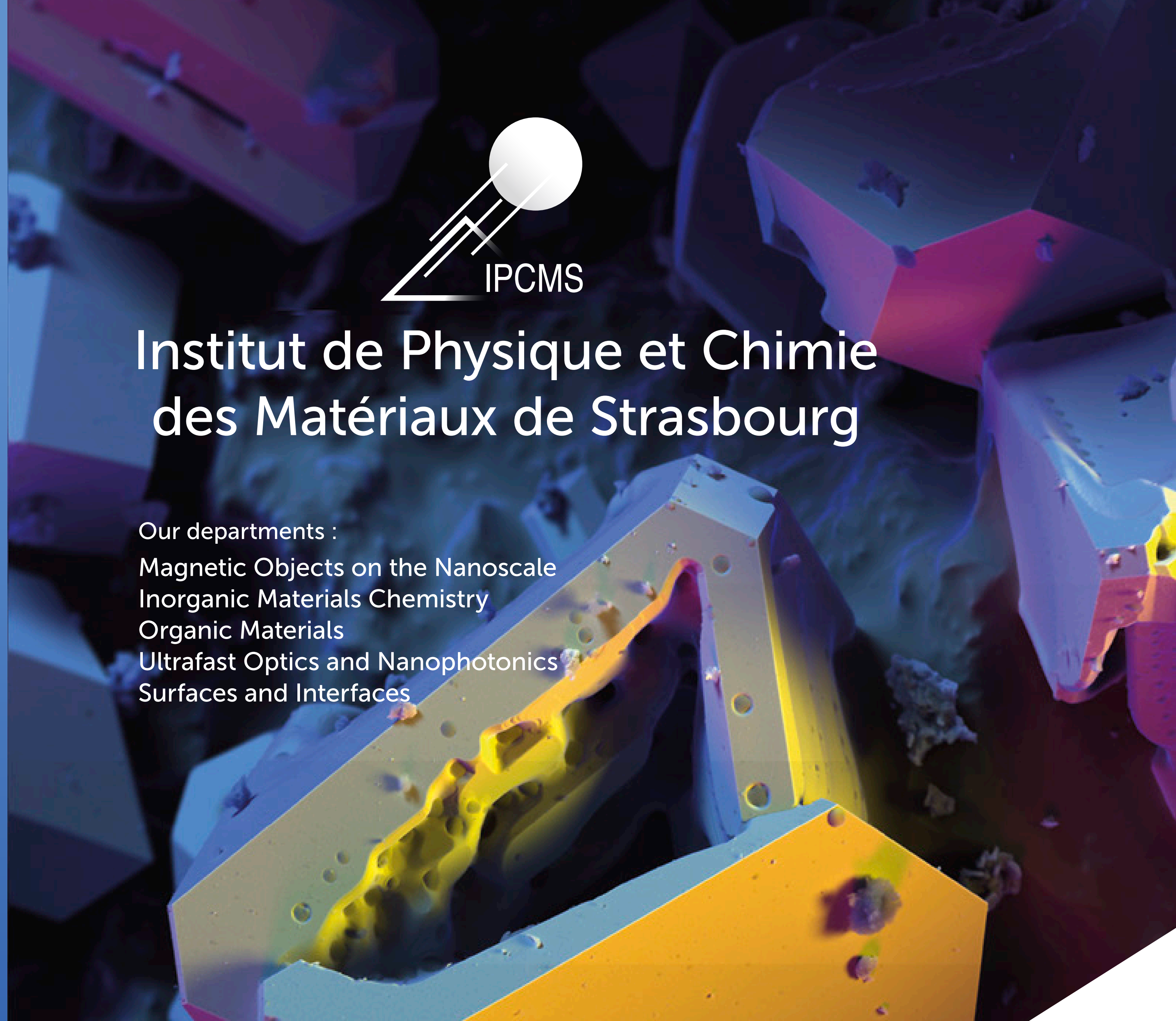
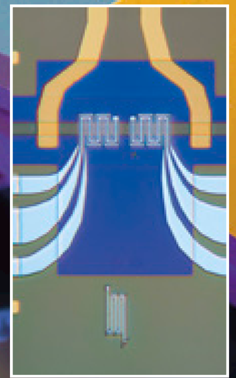


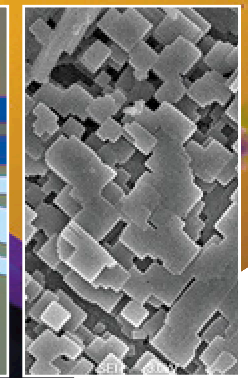
IPCMS

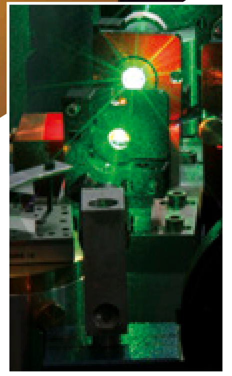
Institut de Physique et Chimie des Matériaux de Strasbourg

Our departments :

Magnetic Objects on the Nanoscale
Inorganic Materials Chemistry
Organic Materials
Ultrafast Optics and Nanophotonics
Surfaces and Interfaces





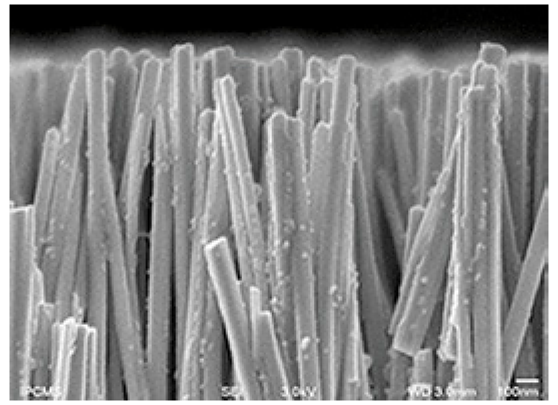


The SCIENCE of NEW MATERIALS

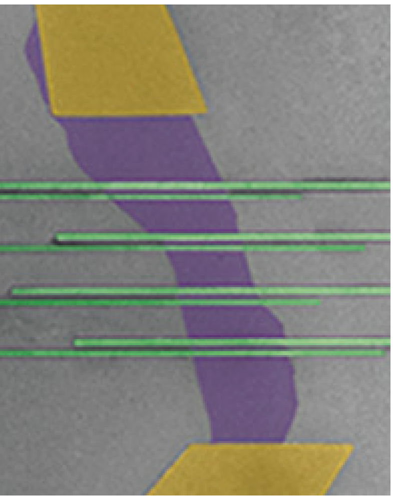
CNRS · UNIVERSITÉ DE STRASBOURG

Main **scientific** topics

Functional materials



The search for new materials with outstanding and original properties requires the development of new synthetic routes where the methods and the concepts of different disciplines (solid state chemistry, molecular or supramolecular chemistry) are combined. At IPCMS, this is particularly the case of hybrid organic/inorganic materials (designed either in the bulk state or at the nanometric scale), of self-assembled multimaterials or of functional oxides. This approach allows the elaboration of new materials that can be integrated into novel devices and that can be used for applications such as information storage, photovoltaics, electronics, detection, sensing or catalysis.

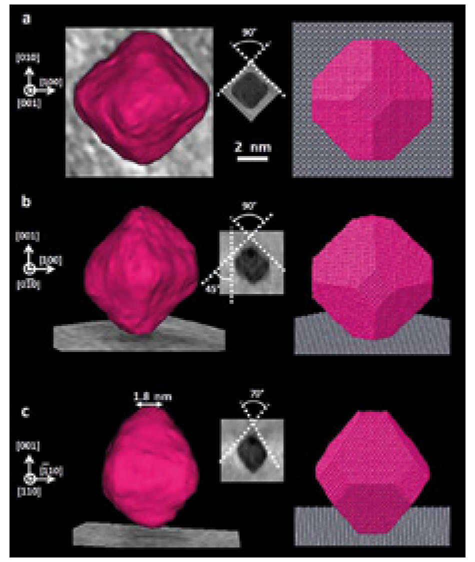


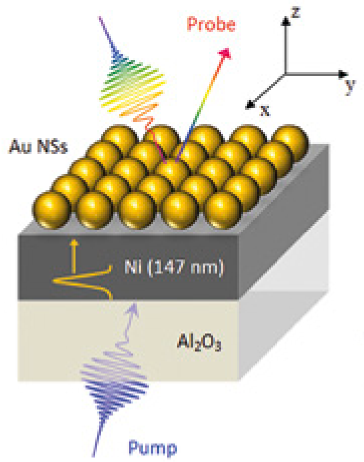
Nanoelectronics : new materials and basic properties

The search of peculiar properties typical of "small" objects (i.e. properties exhibited when reducing the size of the sample) has driven our interest for nanoscale materials, conceived and realized as two-dimensional templates or three dimensional organic-inorganic interfaces (ferromagnetic metal interfaces with organic molecules). The ultimate goal is to fabricate by self-organization or lithography, nanosystems in the range comprised between 10 and 100 nm behaving as multifunctional devices. In such devices, macroscopic electric transport and/or spin polarized phenomena can be tuned by the interaction with external parameters (electric and magnetic fields, temperature, light). Keeping in mind the fundamental drive of such approaches, one is willing to target potential technological counterparts, encompassing patents, applications and commercial products.

Atomic scale imaging

Microscopic features of nanomaterials are unraveled at the atomic or subatomic level by exploiting state-of-the-art imaging techniques. For instance, as part of a molecular engineering strategy, scanning probe microscopy (SPM) plays a crucial role in describing and manipulating at the scale of a single molecule by monitoring and inducing physical phenomena as a function of the chemical nature of the electrode/molecule contact. Also, synthesis, characterization and growth of new composite materials can be achieved by exploiting transmission electron microscopy (TEM) to create heterogeneous junctions (metal-carbon as an example) and understand their formation mechanism. TEM is largely used in its electron tomography mode to capture the organization of core-shell nanoparticles and the connection with the material properties.

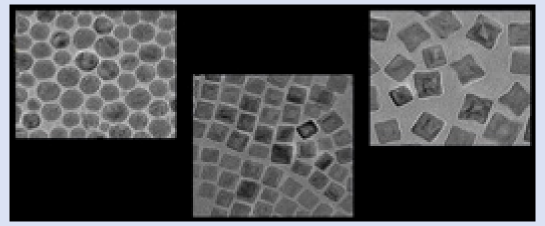




Ultrafast optics and nanophotonics

Processes based on electron relaxation dynamics are highlighted by taking advantage of ultra-fast laser pulses, allowing for investigations of correlated spin phases, collective electronic excitations, femtosecond magneto-optics; as well as non-linear optical properties of organic compounds and electro-spin dynamics. In the area of ultrafast processes, one of the underlying ideas is to use photons for storing and processing the information in magnetic media (spin photonics). Altogether, experimental and theoretical efforts in this field are boosted by technical progresses in the area of advanced optics and laser technology. (For more information, see also the section devoted to the Equipex UNION and UTEM).

Recent **research** breakthroughs



Shaping up nanoparticles for therapy and diagnostics

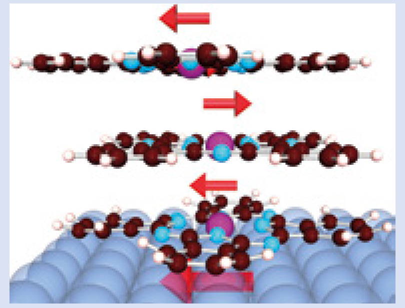
The design of nanoobjects combining therapeutic action to imaging is a breakthrough innovation for cancer treatment. Dendronized core-shell nanoparticles were shown to exhibit properties suitable for these purposes even at low concentration.

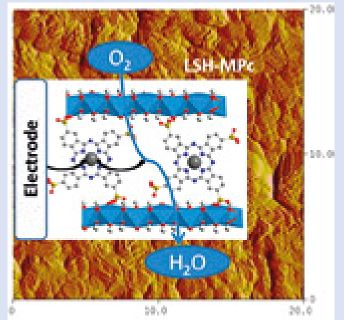
◂ *Achieving therapy and diagnostics with nanoparticles.*
➜ *Chem. Mater.* ***26**, 5252-5264 (2014)*

Spectacular magnetic effects at the molecular/metal interface

Antiferromagnetic order at room temperature is stabilized in Mn phthalocyanine (MnPc) layers in contact with a cobalt layer. In addition, the molecular layer induces an effective magnetic bias field on the inorganic ferromagnetic layer.

Magnetic properties of the MnPc Stacking on Co. ▸
➜ *Nat. Mater.* ***14**, 981-984 (2015)*





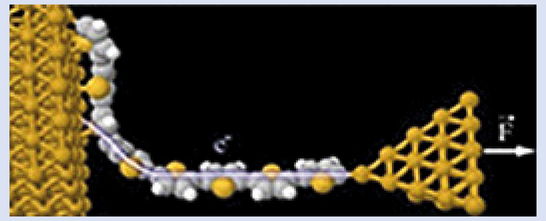
Functionalizing hybrid organic-inorganic materials with electrocatalytic properties

A Layered Copper Hydroxide functionalized using an insertion-grafting reaction was shown to be a very efficient catalyst for O_2 reduction. Electrodes modified by such hybrid materials are considered for application in the cathodic part of fuel cells.

◂ *Electrochemical behavior of Layered Simple Hydroxides. (Collaboration with ICCF)*
➜ *J. Phys. Chem C.* ***119**, 13335-13342 (2015)*

Pulling and Stretching a Molecular Wire to Tune its Conductance

A scanning tunneling microscope is used to pull a molecular wire from a Au(111) substrate. Abrupt current increases measured during the lifting procedure are associated to the release of mechanical stress paving the way to mechanically gated single-molecule electronic devices.

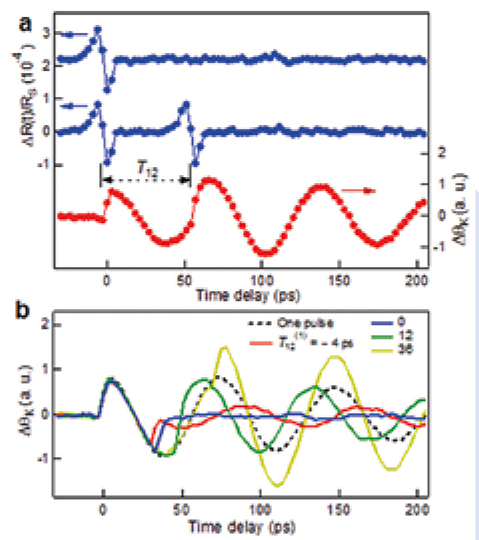


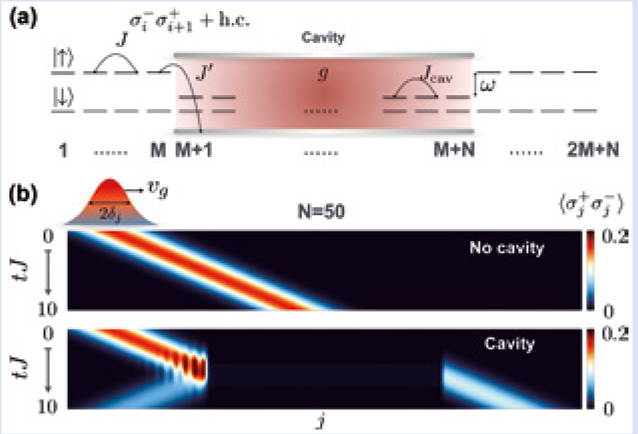
▴ *The lift of a molecular wire induces an abrupt current increase.* ➜ *J. Phys. Chem Lett.* ***6**, 2987-2992 (2015)*

Controlling the Spins Angular Momentum in Ferromagnets with Sequences of Picosecond Acoustic Pulses

We induce and manipulate at will the precession of the magnetization in ferromagnetic materials using a sequence of two or three pulses which themselves are generated by femtosecond optical pulses. The consequences are important in spintronics whenever a precise control of the magnetization dynamics is desired and for fundamental studies related to the lattice dynamics of materials.

Control of magnetization dynamics with two acoustic pulses. ▸
➜ *Scient. Rep.* ***5**, 8511 (2015)*





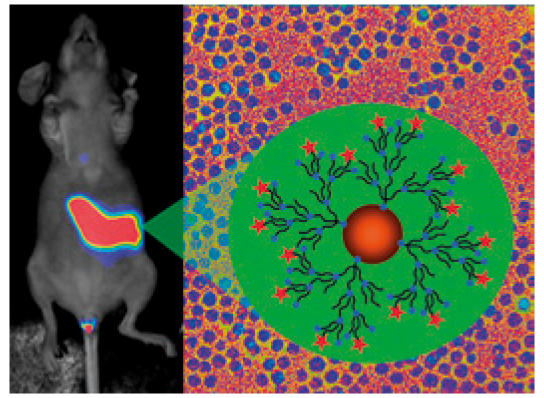
Quantum theory: Cavity-Enhanced Transport of Excitons

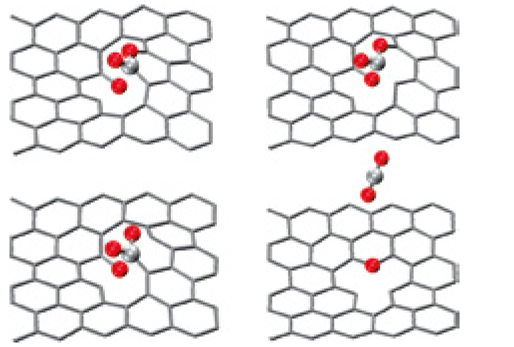
It has been shown experimentally that exciton conductivity can be increased by orders of magnitudes by coupling the excitons to the structured vacuum field of a Fabry-Perot cavity or a plasmonic structure placed transverse to the propagation direction. By providing a theoretical understanding of enhanced exciton transport, one proposes that the basic phenomena can be also observed in quantum simulators made of Rydberg atoms, cold molecules in optical lattices, as well as in experiments with trapped ion.

◂ *Exciton transmission model.* ➜ *Phys. Rev. Lett.* ***114**, 196503 (2015)*

Biomaterials for health and biophysics

At the crossroad between physics, chemistry, materials science and biology, IPCMS has pioneered the development of original and advanced nanoparticles for applications in biomedicine, with the aim of serving simultaneously for diagnostic/imaging purposes and for therapy. We are also at the forefront in the area of biophotonics (e.g. optical/magnetic tweezers) to study in vitro processes and dynamics such as cellular adhesion and growth of organs, but also the ultrafast photophysics of bio-molecules with femtosecond resolution. This methodology impacts the design of new organic materials for optoelectronic applications. The interplay between biophysics and soft matter is also exploited to investigate properties such as gene expression and regulation.





Theory and modeling

Several classes of modeling and theoretical schemes are employed to enrich and complement the experimental findings, by exploiting when needed the most powerful computational resources made available at the regional and national scale. Mesoscopic scale approaches allow to get insight into a multitude of physical phenomena in material science (as spin relaxation and molecular electronics). Ab-initio electronic structure and first-principles molecular dynamics provide knowledge of the interplay between structural, electronic and magnetic properties. The description of quantum physical processes plays an increasing role through the study of quantum dynamics of nanostructures and quantum processes at low temperatures.

Creating **knowledge** and fostering **new applications**

IPCMS is at the forefront of academic education (teaching as well as under-graduate and post-graduate training) provided within the framework of the University of Strasbourg (faculty of physics/engineering and chemistry) and its branches (as the Ecole Européenne de Chimie, Polymères et Matériaux de Strasbourg and Telecom Physique Strasbourg, IUT mesures Physique).

Facilities and Competences

- Strasbourg Nanotechnology Facility (STNano)
- Electron Microscopy (SEM and TEM)
- Scientific computing
- Mechanics Workshop
- Structural analysis

Fruitful interactions and partnerships have been undertaken with industrial partners, exemplifying the technological appeal of our competences:

- Amplitude Systèmes
- Biotech Dental
- Capsugel
- Dassault Aviation
- Infinite Vision Optics
- Inno Materials
- Siemens
- SIKA

To favor technological transfer, a strong motivation drives the establishment of partnerships with companies, this role being played by the MICA Carnot institute that ensures an effective link between academic world and industrial partnerships.