PLENARY SPEAKERS

C'NANO 2018

Plenary speakers

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Biography

Sophie Brasselet is an optical physicist. She obtained her PhD in 1997 at University Paris-Sud, France, on nonlinear optical properties of polymers. She spent a two-year postdoc at UCSD (1998) and Stanford University (1999) in the USA, to develop single fluorescent molecules imaging in cells. After six years at ENS Cachan, France, as an assistant professor on nonlinear microscopy and optical manipulation of single molecules, she is now working as a research director at Fresnel Institute, Marseille, France. For the last fifteen years, she has developed novel nonlinear microscopy and super-resolution fluorescence tools based on polarized light, dedicated to nanomaterials and biomolecular structural imaging. Using polarized fluorescence imaging approaches down to the single molecule level, she has pioneered optical structural investigations at the nanoscale in cells. She has also extended the concept to label free nonlinear imaging, with the goal to develop tools for the understanding neuropathologies. These techniques are now applied in a large range of fields, including material sciences.

EXPLORING ULTRASTRUCTURE IN NANOMATERIALS, CELLS AND BIOLOGICAL TISSUES BY POLARIZED MICROSCOPY

Fluorescence to nonlinear coherent optical microscopy can reveal important spatial properties in nanomaterials, cells and biological tissues from fixed situations to *in vivo* dynamics. While microscopy can guide interpretation through morphological observations at the sub-micrometric scale, optical imaging cannot directly access the way molecules are organized in specific ultrastructures, occuring at the molecular scale. This property, which is important in many fields, from nanomaterials engineering to biomechanics, is today most often studied using electron microscopy or X ray diffraction, which are not compatible with real time imaging.

We will show that reporting molecular organization in protein filaments, aggregates or lipid membranes down to the nano scale is made possible using fluorescence polarization resolved optical microscopy, which takes advantage of the orientation-sensitive coupling between optical excitation fields and molecular transition dipole moments [1]. This approach, which can be extended to super resolution microscopy, has revealed ultrastructural imaging capabilities in the cell cytoskeleton [2]. Polarized imaging has also been also applied to nonlinear optical imaging in nanostructures, revealing nanoscale plasmonic vectorial properties in metal nanostructures [3] and structrural heterogeneities in dielectric nanoparticles.

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Keywords: polarization, optical microscopy, bio-imaging, nonlinear imaging, super resolution microscopy.

Plenary speakers

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Biography

Thomas W. Ebbesen received his BA from Oberlin College (USA) and his PhD from Pierre & Marie Curie University in Paris. He then did research in both the US and Japan, most notably at NEC. He is currently the head of the Center for Frontier Research in Chemistry and the University of Strasbourg Institute for Advanced Studies (www.usias.fr) where he holds the chair in physical chemistry of light-matter interactions. Prof. Ebbesen has received numerous awards for his pioneering research, including the 2014 Kavli Prize in Nanoscience for his transformative contributions to nano-optics. He is member of the Norwegian Academy of Science and Letters, and, foreign member of the French Academy of Science.

THE ALCHEMY OF VACUUM
- HYBRIDIZING LIGHT AND MATTER -

Light-matter interactions are at the heart of stability of matter and many properties we take for granted. For instance, Van der Waals forces can arise from the coupling between molecular dipoles and electromagnetic vacuum fluctuations. When such interactions become strong enough, a new regime arises characterized by the formation of hybrid light-matter states. This is the so-called strong coupling regime which leads to fundamental changes in material properties. After introducing the fundamental concepts, examples of modified material properties such as conductivity, energy transport and chemical reactivity will be presented.

Keywords: strong coupling, light-matter interactions, charge transport, energy transfer, chemical reactivity.

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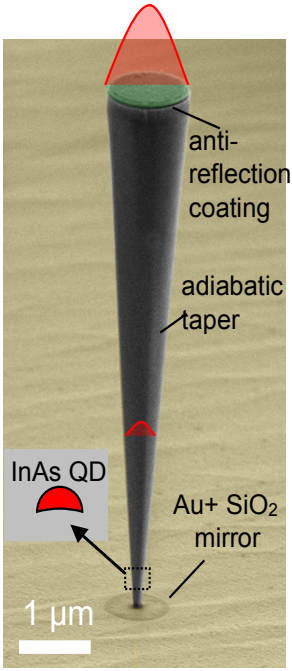
Biography

Jean-Michel Gérard received his PhD at Pierre and Marie Curie University in 1989. He has been in charge of quantum dot (QD) research at France Télécom R&D in Bagneux (Paris region) from 1995 to 2001. After joining CEA in Grenoble, he has been Head of the Materials and Microstructures Lab (SP2M) until 2015, and Head of the Quantum Photonics, Electronics and Engineering Lab (PHELIQS) since 2016. J.M. Gérard has given pioneering contributions to nanophotonics (development of QD growth, single QD spectroscopy, cavity QED experiments with QDs, QD single photon sources…). His main present research topics deal with the development for advanced devices for quantum technologies, such as quantum light sources, photonic switches and high-efficiency single photon detectors. He has published around 330 papers indexed on the WoS and registered 13 patents. He is a member of French Physical Society and French Optical Society. He has received the Great Prize founded by the State of the French Academy of Sciences (2005), the Quantum Device Award founded by Fujitsu Corp, Japan (2008) and the Léon Brillouin Great Prize of the SFO (2016).

PHOTONIC TRUMPETS FOR QUANTUM TECHNOLOGIES

Over the last 20 years, quantum dots (QDs) have been fruitfully combined with optical microcavities to perform quantum optics experiments and to develop quantum light sources for quantum technologies. In this talk, I will first show that the very basic photonic wire geometry opens an attractive alternative avenue in this context [1]. I will noticeably introduce the Photonic Trumpet (PT) [2], formed by a high-index single-mode waveguide and a conical tapering. Nearly perfect single-mode emission, low-divergence Gaussian radiation pattern, linear polarization control, efficient wavelength tuning based on strain effects, and high efficiency single photon emission (> 0.75 photon per pulse) have been achieved for a single QD embedded in a PT.

In a second part, I will show that mechanical vibrations of the PT induce a time-varying strain field that modulates the QD bandgap [3]. This effect provides a remarkably large optomechanical coupling between a two level system (the QD exciton) and a mechanical mode, and opens the way to a wide range of experiments such as quantum non demolition studies of the QD state through trumpet position measurements, or the preparation of non-classical vibration states of the trumpet through a resonant optical driving of the QD. Another promising application field is quantum sensing. As first examples, I will present a high resolution (few nm) spatial mapping of QD locations in a PT [4], and will show that QD fluorescence can be exploited to probe the Brownian motion of the PT at 4K [5].



Micrograph of a GaAs photonic trumpet.

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This work has been done with J Claudon, J Bleuse, M Munsch, P Stepanov and with the groups of JP Poizat, O Arcizet, A Auffèves, M Richard (CNRS, Néel Institute in Grenoble), N Gregersen (DTU), M Munsch, M Poggio and R Warburton (U. Basel), who are gratefully acknowledged, and supported by the French National Research Agency *via* the 'QDOT' (ANR-16-CE09-0010) project.

Keywords: Nanophotonics, optomechanics, quantum dot, photonic wire, single photon source, quantum sensing.

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Biography

Elena Ishow graduated from Ecole Normale Supérieure-Paris Saclay (France) and obtained a PhD in molecular electronics in 1997 after joining the group of Nanosciences at CEMES (Toulouse), conducted by J.-P. Launay and A. Gourdon. She worked for one year as a postdoctoral fellow in the group of Prof. V. Balzani in Bologna (Italy) on light-triggered molecular machines. From 1998 to 2010, she went back to ENS Paris Saclay as an Assistant Professor in chemistry to work on the coupling between photochromic, fluorescent and nonlinear optically active molecular materials for electro- and photomodulation. She spent meanwhile a one-year research sabbatical in the group of Prof. T. Swager at MIT (Cambridge, USA) on semi-conductive polymers as chemical sensors. In 2010, she was appointed Full Professor at the University of Nantes where she currently develops hybrid multimodal nanomaterials for bio-imaging, drug delivery and optical data storage.

PHOTO- AND MAGNETO-ACTIVE ORGANIC NANOMATERIALS AS HIGH-CONTRAST THERANOSTIC TOOLS

Nanomedicine at the crossroads between chemistry, materials science, biology and medicine nowadays represents an entire scientific area *per se*, offering disruptive alternatives to traditional medication and invasive diagnostics. Unprecedented levels of therapeutic safety and personalized care can then be reached through the smart combination of functional and biological active entities within single nano-objects. Such nanomaterials regarded as real "Swiss army knives" are thus designed to address therapeutic "dead ends", provide early diagnosis and/or decipher cellular mechanisms. Whereas inorganic nanoparticles and inert polymers have rapidly been considered as potential contrast agents and drug delivery matrices respectively, functional organic nanoparticles have appeared on the stage only recently. In particular, fluorescent organic

nanoparticles (FONs), made of self-assembled small molecules are stirring considerable interest for their biodegradability, colloidal stability in physiological media, and finally easily tunable emission energy. After a brief survey of the main emissive materials commonly used as optical labels, we will show that FONs represent very attractive systems for high-contrast optical bioimaging of various cells (cancer, bacteria, stem cells) and drug vectorization as well. Fine structural modulation of the constitutive FON units enables the introduction of complementary superparamagnetic iron oxide units, which generates photostable core-shell nanoarchitectures endowed with magnetic resonance imaging (MRI) and hyperthermia properties (Figure 1).1Emphasis will be put on the benefits of working with assembled nanoparticles over isolated ones in terms of imaging contrast2, biorecognition3 and drug release efficiency4.

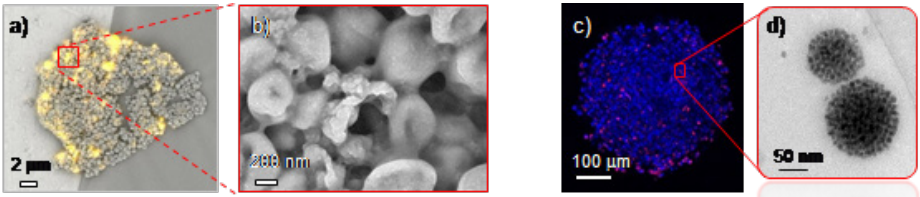

Figure 1. a-b) Correlative light-electron microscopy of bacteria interacting with FONs (zoom-out). c) Transparized multicellular cell spheroids as solid tumor models after internalization of magnetofluorescent nanoparticles (FONmag). D) TEM imaging of FONmag.

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Keywords: fluorescent organic nanoparticles, magnetism, multimodality, theranostics.

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Biography

Christian Joachim is a CNRS Research Director in the Nanoscience group at CEMES Laboratory and adjunct Professor of Quantum Physics at ISAE- SUP'AERO engineer's school (Toulouse, France). From 2005 to 2014, he was A*STAR VIP at IMRE to develop atomic scale technology in Singapore and since 2008 he has been head of the WPI MANA-NIMS satellite in Toulouse.

He coordinated the European projects «Bottom-up Nanomachines», "Pico-Inside" and more recently the European integrated project "AtMol"(2011-2014) whose objective is to construct the first ever molecular chip. He is the author of more than 300 scientific publications (h-index = 57) and 380 invited talks. His research activity mainly concerns electron transfer through a molecule, scanning tunnelling and atomic forces microscopes (STM, AFM) image calculations, tunnel transport through a molecule, single molecule logic gate, atomic scale circuits, atomic scale electronics interconnects, single molecule-mechanical machines. He wrote a book entitled "Nanosciences, the invisible revolution" (Le Seuil in 2008, WorldScientific in 2009), giving the history of nanoscience and its political drawbacks to a general public.

Christian Joachim received many Prizes: he was awarded in 1991 the IBM France Prize for his work on tunnelling through a molecule, in 1997 the Feynman Prize "Experimental" for his work on single molecule manipulation, in 1999 French Nanotechnology prize, 2001 the CNRS Silver Medal in Chemistry for his work on molecular nanoscience, in 2005 the Feynman Prize "Theoretical" for mono-molecular devices. In 2011, he entered the Guinness book for the smallest ever manipulated gear, 1.2 nm in diameter.

SINGLE MOLECULE LOGIG GATES

To explore the MKSA physical limits of machines (number of atoms (M,K), clock frequency (S), calculating power and dissipation (S,A)), molecule(s) Boolean logic gates have been

explored. They can be classical, semi-classical or quantum. Classical with active devices like molecule-switches, molecule-rectifiers or molecule-transistors interconnected together with metallic nanowires. Such a hybrid molecular circuit requires power gain per logic layer. Semi-classical with molecular wires and active molecular devices forming together a single and large molecule-circuit. Here the total calculating unit is embedded in one molecule. Some logic gates have been recently designed this way using electronic intramolecular circuit rules different from the well-known G. Kirchhoff circuit rules. Going quantum is the next step in the miniaturization of a calculating unit when no qubits are used. With our new Quantum Hamiltonian Computing (QHC), the complex functionality of a Boolean logic gate is implemented inside one molecule and can be extended to surface atomic scale circuits for applications. Contrary to the standard quantum computing approach, QHC has the advantage to use decoherence and avoid the problem of the current intensity exponential decay with circuit lateral extension of the semi-classical approach. Without embedding rectifiers, switches, transistors or qubits, a QHC molecule can calculate in a quantum way. Following this approach, a first QHC NOR molecule gate have been experimentally demonstrated, an XOR gate and recently a molecule ½ adder designed with 4 graphene nano-interconnects. For demonstration, a 3 atoms AND gate had also been LT-UHV-STM constructed atom by atom on an Si(100)H surface.

Keywords: single molecule manipulation, molecule interconnects, single molecule quantum logic gate, tunnel transport, low temperature scanning tunneling microscope.

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Biography

George Malliaras is the Prince Philip Professor of Technology at the University of Cambridge. He received a PhD from the University of Groningen (1995) and did a postdoc at the IBM Almaden Research Center. Before joining Cambridge, he was a faculty member at Ecole des Mines de St. Etienne (2009-2017) and at Cornell University (1999-2009), where he also served as the Director of the Cornell NanoScale Facility (2006-2009). His research has been recognized with awards from the New York Academy of Sciences, the US National Science Foundation, and DuPont. He is a member of the Hellenic National Council for Research and Technology, a Fellow of the Materials Research Society and of the Royal Society of Chemistry.

ORGANIC ELECTRONICS FOR INTERFACING WITH THE BRAIN

One of the most important scientific and technological frontiers of our time is the interfacing of electronics with the human brain. This endeavour promises to help understand how the brain works and deliver new tools for diagnosis and treatment of pathologies including epilepsy and Parkinson's disease. Current solutions, however, are limited by the materials that are brought in contact with the tissue and transduce signals across the biotic/abiotic interface. Recent advances in organic electronics have made available materials with a unique combination of attractive properties, including mechanical flexibility, mixed ionic/electronic conduction, enhanced biocompatibility, and capability for drug delivery. I will present examples of novel devices for recording and stimulation of neurons and show that organic electronic materials offer tremendous opportunities to study the brain and treat its pathologies.

Keywords: bioelectronics, organic electronics, neuroengineering.

Plenary speakers

Clément SANCHEZ

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Biography

Clément Sanchez is Professor at the Collège de France and Chair in « Chemistry of Hybrid Materials » from 1999 to 2013. He was Head of the Condensed Matter Chemistry Lab in Paris (LCMCP). He has done a large part of his carrer at CNRS as Research Director and he also at Ecole Polytechnique as Professor.
He is specialized in the field of nanochemistry of nanostructured porous and non-porous transition metal oxide based gels and porous and non-porous hybrid organic inorganic materials shaped as monoliths, microspheres and films. He also studies the properties of hybrids and inorganic nanomaterials looking for applications in the fields of energy, environment, biomaterials and health.

SOLUTION CHEMISTRY BASED ROUTES TO NANOPARTICULES AND FUNCTIONAL NANOSTRUCTURED INORGANIC AND HYBRID SOLIDS

Nanomaterials and nanostructured materials can provide new solutions for important societal concerns such as those related to energy, environment and health. Therefore, there is an important need to amplify the set of nano-objects found in the “nanofoundries” of materials chemistry laboratories. Using innovative and integrative processing approaches and using hybrid molecular metal complex precursors or nanoparticles as precursors, we are trying to push further the limits of the nanochemistry developed with inorganic or hybrid matter. New families of nano-oxides (nanoMagnéli phases, multicationic oxides at nanoscale, core-shell mesoporous silicas and mesoporous metal-oxides), MOF, and non-oxides (metal phosphides, borides, carbides …) will be presented which might host advanced properties at the nanoscale in various fields, such as, catalysis, energy harnessing, sensors, adsorbers, and nanomedicine. This conference will describe a few of the results we have obtained in this area. We bet that some of the described strategies will open a land of opportunities to create several families of new functional nanostructured materials or even” exotic nanomaterials”.

Acknowledgement:
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Keywords: Sustainable chemistry, Designed construction of hybrid organic-inorganic materials and nanostructured materials, Hybrid Biomaterials, Bio-inspired approaches to hierarchically structured inorganic and hybrid organic-inorganic materials