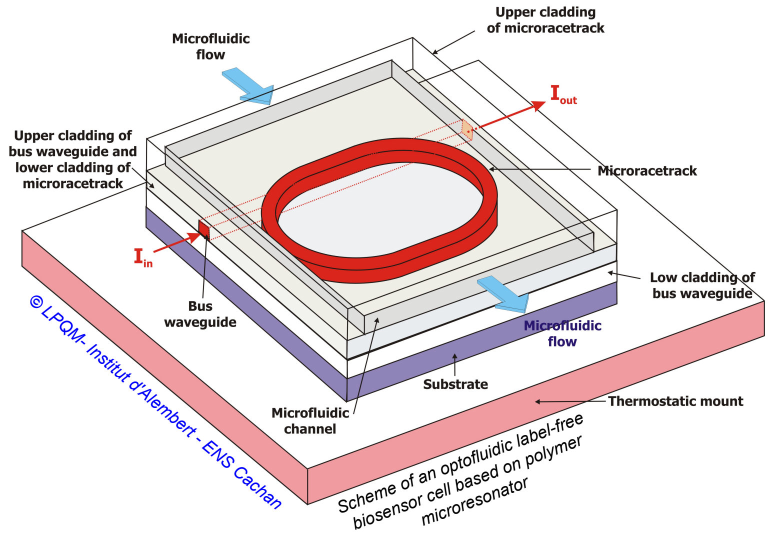
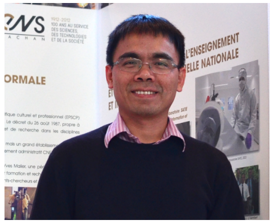
Workshop: LPQM/IMS

Material Sciences & Photonic Devices



École Normale Supérieure de Cachan
25 july 2013

Introduction



Assoc. Professor
LAI Ngoc Diep
Coordinator of the project PICS CNRS/VAST 2013-2015

Email: *nlai@lpqm.ens-cachan.fr*

Organic materials recently appeared as key components in photonic devices such as light emitting diodes, integrated lasers, photovoltaic cells, etc. Besides, polymer materials can be, by a simple way, functionalized with nonlinear optical or fluorescent materials (organic, inorganic, or metal). The ensemble can be optically structured in a desired way to obtain a polymer-based photonic nanostructure (host) containing active materials (guest). This coupling between a guest moiety and a host photonic nanostructure may lead to an exaltation of the optical response of the guest entities, leading to attractive applications.

The Quantum Photonics and Molecular Laboratory (LPQM, UMR 8537 CNRS, France) and the Institute of Material Science (IMS, VAST, Vietnam) recently decided to join force to realize a research project entitled "*Photonics crystals based on functionalized polymer materials, fabrications and applications to sensors and telecommunications*". This project aims at rapidly produce large photonic crystals, with and without defect, using organic-inorganic hybrid material as well as functionalized polymer with metallic nanoparticles. This work is supported by the CNRS and the VAST in the frame work of a PICS 2013-2015 project.

The workshop *Material Sciences & Photonic Devices* 2013 is a first meeting between researchers of two institutions, allowing to discuss about state of art of research activities in both sides and also to program the common work to make the project successfully.

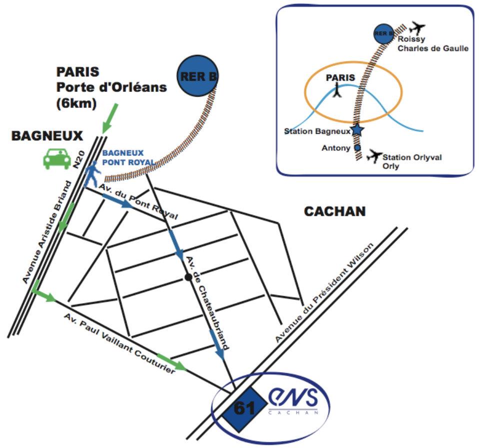
Programme

Thursday, 25 July 2013

Time	Activity/Presentation	Speaker
10:00-12:00	Visit of LPQM laboratory	Lai Ngoc Diep Bernard Journet
12:00-14:00	**Lunch**	12:00-14:00
14:00-14:05	Welcome	Lai Ngoc Diep
14:05-14:20	*ENS Cachan – Vietnam cooperation*	Bernard Journet
14:20-14:35	*Presentation of research activities of LPQM*	Isabelle Ledoux-Rak
14:35-14:50	*Presentation of research activities of IMS*	Vu Doan Mien
14:50-15:10	*Optofluidic label-free biosensors based on polymer microresonators*	Nguyen Chi Thanh
15:10-15:30	*Investigation of 780 nm high-power RW-DFB diode lasers characteristics for spectroscopic applications: laser linewidth vs. optical output power*	Tran Quoc Tien
15:30-15:50	*Optoelectronic oscillator*	Pham Toan Thang
15:50-16:10	**Coffee Break**	15:50-16:10
16:10-16:30	*Photonic packaging in Semiconductor laser laboratory of Institute of Materials Science*	Vu Doan Mien
16:30-16:50	*Material engineering for molecular photonics: from photo-active molecules to nanoplasmonics*	Isabelle Ledoux-Rak
16:40-17:00	*Fabrication and characterization of integrated nanomaterials $TbPO_4.H_2O$ and Fe_3O_4 and hybrid materials for planar waveguide*	Nguyen Thanh Huong
17:00-17:20	*Creation and optimization of polymer-based photonic crystals by two-beam interference technique*	Nguyen T. T. Ngan
17:20-17:40	*The influence of Au nanoparticles on the plasmonic effect of TiO_2/Au composite films*	Ngo Thi Hong Le
17:40-18:00	*Fabrication of multidimensional photonic crystals by one-photon absorption direct laser writing*	Do Mai Trang
18:00-18:30	**Discussions about PICS project: PHOTOCOM**	18:00-18:30

Information

Access map



By subway: Take the express subway RER B get down at "Bagneux" station. When leaving the station, make a left on the main road until the first traffic light. At this point, you can see the flag at the campus' entrance.

Address: *École Normale Supérieure de Cachan, 61 avenue du Président Wilson, 94235 Cachan, France*

Workshop place

② Institut d'Alembert
Pavillon des Jardins ⑤

Workshop:
Auditorium Chemla, D'Alembert Institute.

Accomodation:
Pavillon des Jardins guest house.

Contact:
Phone: 01 47 40 55 59
Website:
http://www.ens-cachan.fr/

Abstracts

Scientific cooperation of ENS Cachan in Viêt Nam: a long history?

Assoc. Professor
Bernard JOURNET
Coordinator of the cooperation between ENS Cachan and Vietnam

Email: *bernard.journet@ens-cachan.fr*

Abstract: Scientific cooperation of ENS Cachan in Viêt Nam started many years ago. It has followed different programs, from AUF to CNRS through ASEM or ARCUS,... and different subjects both in training and research. The number of Vietnamese students, teachers and researchers involved in this cooperation is rather great. In this presentation a general overview of the main parts of this cooperation is given, focusing on the recent activities related to Applied Physics.

The Molecular and Quantum Photonics Laboratory (LPQM) : a presentation

Professor
Isabelle LEDOUX RAK
Director of LPQM, Institute d'Alembert, ENS Cachan, France

Website:
http://www.lpqm.ens-cachan.fr/

Abstract: The main common thrust to LPQM research themes is to conceive and implement an innovative full fledged molecular photonic track all the way from targeted molecular engineering studies to optoelectronic devices for communications and sensing technologies. The broad range of molecular systems allows for a molecular engineering approach conducted in close coordination with chemistry laboratories and increasingly with biology laboratories, then enabling to derive a predictive connection between structures and properties in an effort to optimize the design of new molecules and to close the gap with applications.

This approach rests on pioneering background in fundamental research on light-matter interactions in molecular media as well as in the development of fabrication and testing technologies with emphasis on light confining structures at the micrometer and quantum properties at the nanometer scales. LPQM research studies extend from fundamental to applied physics so as to meet the demand of future optical telecommunication systems as well as advanced bio-imaging instrumentation for life science studies. These topics rely on the laboratory's deeply rooted experience and command of a series of innovative generic technologies regarding the configuration, characterization and applications of molecular structures from laser micro-sources to optical signal processing

systems, ranging for high bit rate electro-optic devices to quantum cryptography.

These emerging technologies are targeted at scales ranging from the micrometer, for the confinement and guidance of light within polymer-based photonic devices, to the nanometer, to evidence and make use of quantum effects associated with individual molecules, and nanoparticles with nonlinear properties for bio-imaging; The laboratory develops various nonlinear microscopy tools based on multiphoton processes or electro-optic imaging and enabling to explore ordered nano- and biostructures and to manipulate molecules and nano-objects by light.

The laboratory is a medium size joint CNRS-ENS Cachan research unit lightly structured around four highly cross-linked research projects in the following areas:

• Micro- and nanostructures for optical signal processing and sensing applications: from materials to devices

• Molecular Nanophotonics: Multiphoton optical manipulation and Imaging for Biology and Nanosciences

• Ultrafast Nanohotonics and Nanothermics (in partnership with Ecole Centrale de Paris)

LPQM is an active element of Institute d'Alembert together with three other complementary CNRS-ENS de Cachan laboratories respectively in chemistry (PPSM), life sciences (LBPA) and electrical engineering (SATIE) and targeted through a dozen of ambitious cross-disciplinary projects in molecular photonics and biophotonics towards information technologies and biotechnologies.

Research activities at Institute of Materials Science, Vietnam Academy of Science and Technology (VAST)

Assoc. Professor
VU Doan Mien
Institute of Materials Science (IMS), VAST, Vietnam

Website:
http://www.ims.vast.ac.vn/

Abstract: The report is review of Institute of Materials (IMS) including IMS' staff, organization, functions, present activities and collaborations (domestic and international). IMS is the biggest institute of Vietnam Academy of Science and Technology (VAST) and multi-discipline scientific research institution but it mainly focuses on materials science and technology. The main activities can be considered as: nanomaterials and nanotechnology; optical, optoelectronic and photonic materials and devices; electronic, magnetic materials and devices; metals, alloys and specific-functional materials; composite materials and polymers; catalyst, anti-corrosion and protection materials; bio-medical- and eco-materials; renewable energy materials; mineral processing and environmental technologies; material failure analysis and science and technology services. Education and training at IMS are also mentioned in the report.

Optofluidic label-free biosensors based on polymer microresonators

Dr.
Chi Thanh NGUYEN
CNRS Research Engineer,
Molecular and Quantum Photonics Laboratory, Institute d'Alembert, ENS Cachan, France

Email: *ctnguyen@lpqm.ens-cachan.fr*

Abstract: Optofluidic label-free biochemical sensors integrating optical microresonators are highly attractive for real-time, high sensitivity detection of chemical or biochemical species. The detection principle of these sensors consists in the measurement of the resonator effective refractive index change due to the interaction, at resonator surfaces, of the guided mode evanescent field with analyte. These sensors can display highly specific and ultrasensitive detection properties if their surfaces are functionalized to detect target molecules via surface binding detection mechanisms. Optical sensors are often integrated into a microfluidic circuit, forming an optofluidic cell, in order to control the analyte solution during measurements. In the domain of optical integrated devices, polymer materials offer the advantages of low cost, easy fabrication, low scattering loss on waveguide sidewalls, and high coupling efficiency to optical fibres and waveguides. Moreover, for biochemical sensing, polymer surfaces can be easily modified to immobilize a wide choice of target molecules. Polymers are also compatible with microfluidic circuits, favoring the insertion of photonic circuits into optofluidic cells.

We report on the design, fabrication and performances of these optofluidic label-free biosensors based on polymeric microresonators. Particularly, two orthogonal polarizations TE and TM guided modes of sensor response are simultaneously measured in real-time continuous monitoring. The sensor's response time is equal to 1 second. Homogeneous sensing experiments performed with the sensors displayed a limit of detection of 2.10-6 RIU, whereas surface sensing experiments performed using TAMRA-cadaverine as a test molecule, which can be quantified through fluorescence analysis, demonstrated a very low limit of detection of 0.22 attogram.

Keywords: Polymer optical microresonators, Optofluidic label-free biosensors.

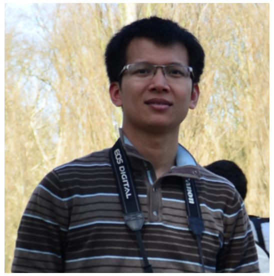
Investigation of 780 nm high-power RW-DFB diode lasers characteristics for spectroscopic applications: laser linewidth vs. optical output power

Dr.
TRAN Quoc Tien
Researcher,
Institute of Materials Science (IMS), VAST, Vietnam

Email: *tranquoctien@gmail.com*

Abstract: High-power ridge-waveguide distributed feedback diode lasers emitting at near infrared region (e.g. arround 780 nm) with narrow linewidth were realized for spectroscopic applications, e.g. for atomic clock, rubidium spectroscopy and Raman spectroscopy. The measurements of spectral linewidth can be carried out by optical heterodyne techniques (both heterodyne and self-delayed heterodyne). The spectral linewidth measurements at different optical power levels were performed for some group of laser samples that are distinguished by device parameters such as resonator length, coupling coefficient, facet reflectivity. The linewidth vs. power dependence behaviors were reported. We also discuss specific phenomena encountered at high current/high power operation, namely “linewidth floor” and “linewidth rebroadening”. The explanation for these phenomena will be given. This study can therefore provide valuable information for improving the performance of existing devices. Additionally, these devices also were implemented in the application for shifted excitation differential Raman spectroscopy measurements.

Optoelectronic oscillator



PHAM Toan Thang
PhD student,
Molecular and Quantum Photonics Laboratory, Institute d'Alembert, ENS Cachan, France

Email: *ptthang@gmail.com*

Abstract: The opto-electronic oscillator (OEO) has been introduced since more than ten years. The classical structure associates on one hand photonic devices such as a laser source, an electro-optic modulator feeding a long fiber loop and a photodetector, and on the other hand microwave devices such as an amplifier, a coupler and a filter closing the feedback loop on the modulator. By this way it is possible to create directly high frequency signal (in the domain of some tens of GHz) with very low phase noise: the fiber loop is a delay line with very low attenuation and the great propagation time is equivalent to a great storage time and then to a high quality factor. There is no need to start from low frequency (some hundreds of MHz) and obtain the higher one by multiplication process. According to the oscillation conditions there are be different modes, depending on the length of the fiber loop. As the phase noise is related to the quality factor it is necessary to use a long optical fiber, but in this case there will be a lot of very close oscillation frequencies and it is difficult to isolate only one cavity mode with the RF filter. In this presentation we will show the behavior of experimental system working at 8 GHz with fiber loops of 500 m, 1 km, or 1.5 km in term of spectrum and phase noise. The experimental results can be compared to analytical or computational models in order to estimate some of the physical characteristics.

Photonic packaging in Semiconductor laser laboratory of Institute of Materials Science

Assoc. Professor
VU Doan Mien
Institute of Materials Science (IMS), VAST, Vietnam

Email: *mienvd@ims.vast.ac.vn*

Abstract: The photonic packaging is carrying out in the Semiconductor laser laboratory of Institute of Materials Science, VAST. We perform the laser, photodiode, semiconductor optical amplifier (SOA) and optical splitter module preparations based on the FP, DFB laser, p-i-n photodiode, SOA, planar waveguide splitter chips and 9/125 single mode optical fiber or single mode v-groove fiber arrays. The packaging of the high power laser diodes (LD) modules also is performed based on the high power LD C-mount chips and the multimode fiber with 400 μm core diameter. The characterizations of the devices show that the InGaAsP/InP FP, DFB cooled and uncooled laser modules operating in the wavelength regions of 1310 nm and 1550 nm have the threshold current from 5 to 8 mA, the output power of more than 5 dBm, the InGaAs photodiode modules have the responsibility of $\sim$1 mA/mW. The InGaAsP/InP SOA modules have the small signal fiber-to-fiber gain of more than 16 dB, large 3 dB gain bandwidth ($>$ 60 nm) at 1550 nm and low polarization sensitivity ($\sim$1 dB). The 1$\times$4 and 1$\times$8 silica PLC splitter modules have the characteristics comparable with the characteristics of the commercial ones in the wavelength regions from 1260 nm to 1600 nm (the average insertion loss is 7.4 dB and 10.5 dB for 1$\times$4 and 1$\times$8 splitters, respectively). Fiber-coupled high power laser diode modules show the optical output power of more than 500 mW and 1 W for red (670 nm) GaAsP/GaAs and infrared (940 nm) InGa(Al)As/GaAs laser modules, respectively. The prepared modules have been used in the fiber optic data communication, CATV systems and therapy equipments.

Material engineering for molecular photonics: from photo-active molecules to nanoplasmonics

Professor
Isabelle LEDOUX RAK
Director of LPQM, Institute d'Alembert, ENS Cachan, France

Email: *ledoux@lpqm.ens-cachan.fr*

Abstract: The emergence of Molecular Photonics at the cross-road of physics, chemistry and device engineering is being triggered by the increasing demands in the domain of high bit rate telecommunications and of sensor applications. The wealth of molecular structures and the exploitation of their functional and structural flexibility open-up thoroughly renewed horizons in this domain. In this talk we will present new results on photoswitchable NLO molecules.

We will focus on a recent work in the area of coordination complexes containing photochromic ligands for the photo-induced control of linear and nonlinear optical properties. Organic photochromic molecules are important for the elaboration of photo-responsive functional materials, like switches and memories. We propose here to use dithienylethene (DTE) metal complexes, which are very promising because of their good fatigue resistance, remarkable thermal stability of both isomers and rapid response time, to realize an efficient photo-induced control of molecular nonlinearities.

Hyperpolarizabilities β of the "open" (non-conjugated) and "closed" (conjugated) forms of these chromophores are determined using the Harmonic Light Scattering (HLS) method at 1.9 μm, then avoiding any multiphoton fluorescence effect and strong absorption at the harmonic wavelength. A highly efficient photo-triggered NLO enhancement (up to 50) from the "open" to the "closed" forms is re-ported, for both dipolar and octupolar complexes. The influence of the donor end group D of the photo-switchable ligands and of the nature of the central metal ion on the quadratic molecular hyperpolar.

Fabrication and characterization of integrated nanomaterials $TbPO_4.H_2O$ and Fe_3O_4 and hybrid materials for planar waveguide

Dr.
NGUYEN Thanh Huong
Researcher,
Institute of Materials Science (IMS), VAST, Vietnam

Email: *nthuong@ims.vast.ac.vn*

Abstract: In this report, we will introduce following results. First, the fabrication and properties of luminescent magnetic bifunctional nanomaterialss comprised of magnetite nanoparticles and nanowires of $TbPO_4.H_2O$ are presented. The superparamagnetic magnetite nanoparticles with size around 12 nm were synthesized by co-precipitation method under N_2 atmosphere. The $TbPO_4.H_2O$ nanowires with 200 - 300 nm in length and 5 - 10 nm in diameter were synthesized by microwave method. The grafting processing of magnetite nanoparticles on surface of $TbPO_4.H_2O$ nanowires was investigated in details. The structure, morphology, optical and magnetic properties of bifunctional nanomaterials comprised of $TbPO_4.H_2O$ nanowires and superparamagnetic magnetite nanoparticles were characterized by X-ray diffraction, scanning electron microscopy, fluorescence spectroscopy and saturation magnetization. The measuring results showed that the obtained bifunction nanomaterials can be able used as optical probe and magnetic cell separation in biomedical applications. Second, we summary some achieved results on hybrid materials for planar waveguide at 1550 nm. Polymethamethylacrylat, silica, and zirconia(ASZ)/Titania(AST) waveguide systems were fabricated by using sol-gel process. Optical properties and morphology of the films have been studied. The influence of chemical sol-gel reaction condition, film coating technique and heat treatment process on the microstructure into planar waveguide characteristics have been carefully investigated to find an optimum fabrication technique of the waveguides with low propagation loss. Based on this material system, some planar structures of optical power splitter/combiner type 1×N channels were designed and simulated by making masks using computer software.

Creation and optimization of polymer-based photonic crystals by two-beam interference technique

NGUYEN Thi Thanh Ngan
PhD student,
Molecular and Quantum Photonics Laboratory, Institute d'Alembert, ENS Cachan, France

Email: *ngan_mail@yahoo.com*

Abstract: We present our theoretical and experimental investigation of polymer based photonic crystals. In particular, we demonstrate the fabrication of 1D, 2D, 3D periodic and quasi-periodic photonic crystals by use of multiple-exposure two-beam interference technique. This method is very simple, rapid and flexible, allowing to adjust the structure period from nanometer to micrometer scales.

We show evidently the influence of the absorption effect of photoresist on the uniformity and on the thickness of fabricated structures. The quality of thick structures is then optimized by irradiating again the sample by a supplementary uniform laser beam, which propagates in opposite direction of the two interference beams. This compensation method allows to obtain uniform 2D and 3D structures with a thickness as large as 25 μm.

The influence of Au nanoparticles on the plasmonic effect of TiO_2/Au composite films

Dr.
NGO Thi Hong Le
Researcher,
Institute of Materials Science (IMS), VAST, Vietnam

Email: *hongle2009@gmail.com*

Abstract: TiO_2 is a very useful functional material for several technologically demanding applications, such as solar energy conversion, batteries and photocatalysis. TiO_2 incorporates Au nanoparticles prove to obtain interested optical and electrical behavior, such as photoluminescence, surface plasmon resonance (SPR), In this work, TiO_2/Au composite films with 0.5 wt%, 1.0 wt%, and 1.5 wt% Au prepared by the sol-gel method. Their structure, morphology, and optical properties were investigated. TEM images show that the small particle size (9–15 nm) can be obtained. From ultraviolet visible absorption and SPR was observed. It was founded that the SPR of TiO_2/Au composite films can be tuned to the near infrared region by changing the wt% Au on TiO_2.

Fabrication of multidimensional photonic crystals by one-photon absorption direct laser writing

DO Mai Trang
PhD student,
Molecular and Quantum Photonics Laboratory, Institute d'Alembert, ENS Cachan, France

Email: *domaitrang@gmail.com*

Abstract: In this work, we successfully demonstrate the fabrication of desired submicrometric structures on demand by using the low one-photon absorption direct laser writing technique (LOPA Direct Laser Writing, DLW).

In the case of strong one-photon absorption of the photosensitive material, a complex 3D structure is impossible to achieve. In LOPA DLW, we choose a laser whose wavelength is located at the ultra-low absorption range of the photoresist, which allows to let the light propagating deeply inside the material. By, using a high numerical aperture objective lens, the light is tightly focused into a submicrometric volume, where the light intensity is a million times higher than that at its vicinities. By scanning this focussing point within the photosensitive resin, the polymerization reaction occurs and sufficiently to build the structure along the desired design. The unexposed and insufficient absorbed dose regions are being removed during the development process thus leaving the fabricated structures.

This technique presents great advantages, because any kind of 2D and 3D structures can be achievable with a simple continuous laser with a modest power.