université de BORDEAUX

LAPHIA international symposium
2nd edition

September 8 -12, 2014
Institut d'Optique d'Aquitaine - Talence

Welcome to the second annual symposium of the Cluster of Excellence LAPHIA (Excellence Initiative – University of Bordeaux).

The LAPHIA symposium, which unites researchers, industrials, institutional and international academic partners offers the opportunity **to enrich and broaden scientific debate** in the three principal LAPHIA axes:

- Laser and high energy physics
- Emerging photonics and materials
- Innovative imaging

This event is not only the opportunity to present the research projects already funded by LAPHIA, but also to stimulate scientific discussions, and to give an overview of new trends in photonics, laser and imaging. All week, there will have abundant learning opportunities at plenary sessions.

Industrials participate

For this second edition, we give the industrial, researcher and student participants the opportunity to attend **three courses** on September 8^{th} **:**

- **Artificial optical materials** by Philippe Lalanne (LP2N)
- **High resolution optical microscopy** by Laurent Cognet (LP2N)
- **Specialty optical fibers: an overview** by Sylvain Danto (ICMCB)

All attendees especially industrial partners are welcome to attend the « **table ronde** », or round table discussion, which will be the opportunity to discuss about research, innovation, partnerships and education, planned on the 9^{th} September.

Students are also involved

This year, a **junior committee** has been created in order to organise events for students, a **« Pint of LAPHIA »** will take place to present scientific applications, accessible for a broad audience, notablyfor all University of Bordeaux masters students. **Two poster sessions** will also be organised by this committee in order to highlight the research work of Ph.D. and post-doctoral fellows, but also to reinforce the network between the members of the community. The best poster prize will be attributed during the gala.

Apart from this exciting scientific program, we welcome you to the 2nd annual Symposium to embrace and enjoy what Bordeaux has to offer – its unique blend of contemporary and traditional ways of life as well as its cultural landmarks, attractions, and entertainment.

We wish you all a most interesting, rewarding and stimulating symposium.

The Direction
Lionel Canioni, Evelyne Fargin, Philippe Balcou, Philippe Bouyer

General Index program

Program of the week

Program_SYMPOSIUM LAPHIA _September 8-12, 2014_Institut d'Optique d'Aquitaine_Talence

	Monday 8 September	Tuesday 9 September	Wednesday 10 September	Thursday 11 September	Friday 12 September
9:00 - 9:30 am		**9:00_9:10 : Welcome address** - LAPHIA steering committee	**Véronique JUBERA** - ICMCB - Univ. of Bordeaux/CNRS	**Thomas FERHAT** - NKT Photonics	
9:30 - 10:00 am		**9:10_9:50 : Costel SUBRAN** - Steering Committee of 2015 (France) - International Year of Light	**Joël BELESSA** - ILM - Univ. of Lyon1/ CNRS	**Benjamin CANUEL** - LP2N - Univ. of Bordeaux/IOGS/CNRS	**Scientific council**
10:00 - 10:30 am		**9:50_10:30 : Stephen G. ANDERSON** - SPIE	**Laurent GROC** - IINS - Univ. of Bordeaux/CNRS	**Fabien GUILLEMOT** - BioTis - Univ. of Bordeaux/INSERM	
10:30 - 10:50 am		*Coffee Break*	*Coffee Break*	*Coffee Break*	
10:50 - 11:20 am		**10:50_11:30 : Alexis CASNER** - CEA	**Senthil GANAPATHY** - Univ. of Southampton	**Brahim LOUNIS** - LP2N - Univ. of Bordeaux/IOGS/CNRS	
11:20 - 11:50 am		**11:30_12:10 : Thomas DEKORSY** - Univ. Konstanz	**Pierre-François BREVET** - ILM - Univ. of Lyon1/CNRS	**Cyril AYMONIER** - ICMCB - Univ. of Bordeaux/CNRS	
11:50 - 12:20 pm			**Vincent RODRIGUEZ** - ISM - Univ. of Bordeaux/CNRS	**Jérôme DEGERT** - LOMA - Univ. of Bordeaux/CNRS	
12:20 - 1:00 pm		*Lunch*	*Lunch*	*Lunch*	
1:00 - 1:30 pm					
1:30 - 2:00 pm				**Visit of the Mega Joule Laser or the City of Photonics** (with registration)	
2:00 - 2:30 pm	**Course** - High resolution optical microscopy - **Laurent COGNET** - LP2N	**Table ronde** - Industriels	**Jean-Luc BARDON** - THALES		
2:30 - 3:00 pm			**Vladimir TIKHONCHUK** - CELIA - Univ. of Bordeaux/CNRS/CEA		
3:00 - 3:30 pm	**Course** - Artificial optical materials - **Philippe LALANNE** - LP2N		**David PUREUR** - QUANTEL		
3:30 - 4:00 pm		**LAPHIA laboratory tour** (with registration)	**Strategic council**		
4:00 - 5:00 pm	**Course** - Specialty Optical Fibers: an overview - **Sylvain DANTO** - ICMCB				
5:00 - 5:30 pm	**Flash presentation - Posters** - Auditorium				
5:30-6:00 pm	**Poster session** *(Group A)* **& networking reception**	**Flash presentation - Posters** - Auditorium			
6:00 - 7:00 pm		**Poster session** *(Group B)* **& networking reception**	**Pint of LAPHIA** *(for master students, PhD and Post doc)*		
7:00 - 7:30 pm					
7:30 - 8:00 pm					
From 8:00 pm		**Evening reception and Awards** - Palais de la Bourse - (with invitation)			

Courses

- **2 :00 pm – 3 :00 pm – auditorium**

High resolution optical microscopy

Laurent COGNET – LP2N – University of Bordeaux – CNRS – IOGS
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Over the last years, high-resolution optical microscopy techniques have revolutionized imaging capabilities offered by far-field optical microscopy in complex environments. The development of these newly developed techniques was mainly driven by the need for improved resolutions to study biological processes in live samples. In particular, several super-resolution microscopy techniques were invented to surpass the diffraction limit, thus allowing to push optical resolutions down to the scale of individual biomolecules in order to give access to nanoscale molecular organizations. In this introductory course I will present the main state-of-the-art optical methods that allow achieving such improved resolutions in the far-field. They are based on controlling fluorescence emission volumes to highly localized regions, on using structured illumination schemes or on stochastic detection of single emitters. These techniques will be described and compare in terms of instrumentation and capabilities.

- **3 :00 pm – 4 :00 pm - auditorium**

Artificial optical materials

Philippe LALANNE – LP2N – University of Bordeaux – CNRS – IOGS
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In most optical materials the atomic or molecular structure is so fine that the propagation of light within them may be characterized by their refractive indices. When an object has structure which is larger than the wavelength of light, its influence on the propagation of light may be described by the laws of diffraction, refraction and reflection. Between these two extremes is a region in which there is structure that is too fine to give rise to diffraction in the usual sense but is too coarse for the medium to be considered as homogenous. For this, a full description can only be achieved through a rigorous solution of Maxwell's electromagnetic equations and resonance phenomena are often observed. Recent developments in micro-lithography have extended the possibility of generating sub-wavelength structures and it is now possible to produce materials with remarkable new optical properties.

We shall review the optical properties of subwavelength “artificial materials”.

Keywords : subwavelength optics, homogeneization, diffractive optics, electromagnetic metamaterials.

Courses

- **4:00 pm – 5:00 pm – auditorium**

Specialty optical fibers: an overview

Sylvain Danto – ICMCB – CNRS – University of Bordeaux
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In widespread popular outlook, fiber optic remains as a long thin stretch of silica glass constituting the backbone for long-haul modern telecommunication systems. Yet, beyond its more preeminent success, fiber optic technology has found numerous other applications ranging fiber lasers, dispersion tailoring, monitoring and so on. In the meantime, new fiber paradigms have emerged, improving or even expanding functionalities beyond the scope of optic. Multi-material fibers are now routinely fabricated, with functionalities spanning photo-thermal detection, electronics or acoustics. The fiber drawing itself has become a promising alternative for producing large-area, scalable micro-structured devices. Here we will review recent achievements in the field of "Specialty optical fibers"; fundamentals, fabrication processes, applications and perspectives will be presented.

Poster session – Group A

- **5 :00 pm - 5 :30 pm - auditorium**
  Flash presentation

- **5 :30 pm - 7 :00 pm - hall**
  Poster session & networking

1	Evaluation of led-to-led system performances for smart lighting applications	Diez	Miguel
2	Towards a new experiment for studying degenerated quantum gases in optical lattices	Vasquez Bullon	Hugo Salvador
3	Control of surface reactivity and non-linear optical properties in borosilicate glasses using thermal poling	Lepicard	Antoine
4	Refraction Index of Shock Compressed Water in the Megabar Pressure Range	Jakubowska	Katarzyna
5	Influence of organic contamination on laser induced damage of PVD mirrors by subpicosecond laser pulses	Favrat	Olivier
6	Modal q-plates	Rafayelyan	Mushegh
7	High-NA optical vortex coronagraphy	Aleksanyan	Artur
8	Polarization Modulation Microscopy.	Baida	Hatim
9	Magneto-Optical Imaging of Thermal Depinning of Abrikosov Vortices in Nb film	Veshchunov	Ivan
10	Femtosecond surface plasmon polariton pulse tracking with pump-probe thermoreflectance	Lozan	Olga
11	Spectroscopic signature of the entire band-edge exciton fine structure in single CdSe nanocrystals	Sinito	Chiara
12	Synthetic Approach for the Experimental Investigation of Plasmonic Dicke Effect in Au-Fluorophore Nanohybrids	Comesana-Hermo	Miguel
13	Synthesis of plasmonic nanostructures for nanopolaritonics	Ivaskovic	Petra
14	Interest of Spark Plasma Sintering to obtain Optoceramics versus Crystals	Prakasam	Mythili
15	3D-photopatterning: photochemistry of a •±-diketone anthracene derivative	de Vet	Christiaan
16	Experimental Investigation of Plasmonic Superradiance in Au-Fluorophore Nanohybrids	Pierre	Fauché

Abstracts : Ref. Appendices

Tuesday sessions

- 9 :00 am – 9 :10 am – auditorium - **Welcome address – LAPHIA Direction**

- 9 :10 am – 9 :50 am - auditorium

Photonics perspectives & 2015, International Year of Light

Costel SUBRAN - Steering Committee of 2015 (France) - International Year of Light
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Photonics is a key technology based on multidisciplinary and interdisciplinary fields, a synthesis of optical engineering, material science, physics, chemistry, nanotechnology, electrical engineering. Photonics has been defined very well by the French scientist Pierre Aigrain:

"Photonics is the science of harnessing the light, encompasses the generation of light, detection of light, management of light trough guidance, manipulation, amplification, for the benefit of mankind."

What can be the key segments for the photonics, the major trends and opportunities? The "green" photonics: lightning, solar/photovoltaics, sensing & monitoring, displays and biophotonics. An overview on markets, investments and perspectives is presented.

The 20th century was the the century of electronics and micro-electronics.
The 21st century will be the century of photonics!

United Nations (UN) General Assembly 68th Session has proclaimed 2015 as the **International Year of Light and Light-based Technologies (IYL 2015).** This International Year has been the initiative of a large consortium of scientific bodies together with UNESCO, and will bring together many different stakeholders including scientific societies and unions, educational institutions, technology platforms, non-profit organizations and private sector partners.
In proclaiming an International Year focusing on the topic of light science and its applications, the United Nations has recognized the importance of raising global awareness of the importance of how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture and health. An International Year of Light is a tremendous opportunity to ensure that international policymakers and stakeholders are made aware of the problem-solving potential of light technology. Photonics provides practical and cost-effective solutions to challenges in so many different areas: energy, sustainable development, climate change, health and agriculture."

Tuesday sessions

- **9 :50 am – 10 :30 am - auditorium**

Photonics industry update: Measuring the market

Stephen G. ANDERSON – SPIE
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A new look at the worldwide marketplace for core photonics components is based on an in-depth year-long evaluation by a team of SPIE analysts of more than 3,000 companies that are active in the global optics and photonics industry. This presentation will showcase the results of this novel approach to assessing the photonics industry, which has yielded a unique ranking of the firms that serve the optics and photonics marketplace and their impact on the global economy.

* * *

Stephen G. Anderson

Stephen Anderson is a photonics industry expert with an international background and has been actively involved in the lasers and photonics technology marketplace for more than 30 years. He joined SPIE – The international society for optics and photonics – in 2011 as Industry & Market Strategist and is responsible for tracking the photonics industry markets and technology to help define long-term strategy, while also facilitating development of SPIE's industrial engagement activities. Before joining SPIE, Anderson was Associate Publisher and Editor-in-Chief of PennWell's "Laser Focus World," where he directed the editorial strategy for all media and platforms. During his 18 year tenure at PennWell, Anderson supervised the Annual Review and Forecast of the Laser Marketplace and led the highly regarded Lasers & Photonics Marketplace Seminar, held annually at SPIE's Photonics West. He also co-founded the "BioOptics World" brand. Since 2006 Anderson has served as a member of the jury panel for the Berthold Leibinger Innovationspreis in Germany. He is a regular presenter of market and industry commentary at many US and international forums. Anderson holds a chemistry degree from the University of York, (England), and an Executive MBA from Golden Gate University in San Francisco, CA.

Tuesday sessions

- **10 :50 am – 11 :30 am - auditorium**

LMJ + PETAL Laser Facility: commissioning and opportunities for academic collaborations

Alexis CASNER – CEA, DAM, DIF, F-91297 Arpajon, France
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The Laser Megajoule (LMJ), keystone of the French Simulation Program, is under commissioning at CEA/CESTA and will deliver 1.3 MJ with 176 beam lines [1]. The first physics experiments on LMJ will be performed at the end of 2014 with 2 quadruplets (8 beams). The operational capabilities (number of beams and plasma diagnostics) will increase gradually during the following years. I will describe the current status of the LMJ facility and the first set of x-ray diagnostics to be used during the commissioning phase and the first experiments.

The PETAL project [2], part of the CEA opening policy and financed by the Conseil Régional d'Aquitaine, the French ministry of Research and the European Union, consists in the addition of one short-pulse (500 fs to 10 ps) ultra-high-power, high-energy beam (a few kJ compressed energy) to the LMJ facility. PETAL will offer a combination of a very high intensity multi-petawatt beam, synchronized with the nanosecond beams of the LMJ. PETAL will extend the LMJ diagnostic capabilities and will be devoted to academic research. Specific diagnostics adapted to PETAL capacities are being fabricated in order to characterize particles and radiation yields that can be created by PETAL. A first set [3] will measure the particles (protons/ions/electrons) spectrum (0.1 to 200 MeV range) and will also provide point projection proton-radiography capability.

LMJ/PETAL like previously the LIL will be open to the academic community. In particular the advent of high-power lasers facilities such as NIF and LMJ opens a new era in the fields of High Energy Density Laboratory Astrophysics [4], Warm Dense Matter or laser-driven direct-drive fusion. The academic access to LMJ/PETAL and the selection of the first proposals will be done by Institut Laser Plasma (ILP) through the PETAL international Scientific Advisory Committee. The LMJ Users guide will be release soon.

[1] C. Lion, Journal of Physics: Conference Series 244, 012003 (2010). [2] N. Blanchot et al., EPJ Web of Conferences 59, 07001 (2013). [3] J.E. Ducret et al., Nuclear Instrum. Methods in Physics Research A 720,141 (2013). [4] A. Casner et al., HEDLA 2014 proceedins, to appear in High Energy Density Physics.

Tuesday sessions

- **11:30 am - 12:10 am - auditorium**

Femtosecond Spectroscopy of Coherent Acoustic Excitations in Multilayers and Nanostructures

Thomas DEKORSY - Department of Physics and Center for Applied Photonics, Konstanz University, Germany
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Acoustic phonons in the Terahertz frequency range correspond to wavelengths in the nm regime. Spectroscopy of acoustic phonons with femtosecond laser pulses enables the access to the dynamics of coherent acoustic excitations in nanostructures and multilayers. The spectroscopy of these excitations hence opens a pathway for metrology with sub-nanometer resolution and the investigation of heat transfer at the nanoscale. We realized a femtosecond pump-probe scheme based on two femtosecond lasers (two Ti:sapphire ring lasers with 1 to 10 GHz repetition rates) which operates without mechanical delay lines and has the functionality of an all optical oscilloscope with THz bandwidth and GHz frequency resolution [1,2]. Results on the coherent excitation of single nanostructures [3] and technologically important membranes and multilayers are presented [4-7].

[1] Bartels et al., Rev. Sci. Instr. 78, 035107 (2007) [2] Gebs et al., Opt. Express **18**, 5974 (2010) [3] Ristow et al., Appl. Phys. Lett. **103** 233114 (2013) [4] Bruchhausen et al. PRL **106** 077401 (2011)

[5] Cuffe et al., PRL **110**, 095503 (2013) [6] Grossmann et al. Physical Review B 88, 205202 (2013) [7] Hettich et al., Appl. Phys. Lett. **98**, 261908 (2011)

Table ronde - industriels

- **2 : 00 pm – 3 :30 pm - auditorium**

  Language : french

« Partager une vision en recherche, innovation et formation : témoignages »

Marie Bénédicte VIEULES – Chargée de projet Plateforme de formation optique/photonique/lasers (Mission Investissement d'avenir)

Rodolphe GOUIN – Directeur – Fondation Bordeaux Université

Philippe BOUYER – Directeur laboratoire LP2N / Directeur adjoint - valorisation LAPHIA

Eric MOTTAY – Chef d'entreprise **–** Amplitude Systemes

Christophe RANGER – Chef d'entreprise – Explora Nova

Nicolas CESAR – Journaliste

Laboratory tour

- 3:30 pm - 5:30 pm

List of the laboratories *(registrations online) :*

LOMA / LP2N / CELIA / ICMCB / ISM / IMS / CRPP / CENBG / I2M

All the information will be in the reception desk in the symposium hall.

Poster session – Group B

- 5 :30 pm to 6 :00 pm – auditorium : **Flash presentation**
- 6 :00 pm to 7 :30 pm – hall – **Poster session and networking**

17	Intermediate field measurement to characterize the wavefront of large optics	Audo	Frederic
18	Modeling of Electro-Magnetic Pulses generated by high intensity lasers	Poyé	Alexandre
19	Macroscopic and microscopic color-tuning of self-assembled dialkoxy-diphenylanthracene nano-ribbons	Schafer	Philip
20	Terahertz Imaging And Spectroscopy: Applications To Defense And Security	Bou Sleiman	Joyce
21	Microstructuration by Direct Laser Writing in silver doped glasses : Structure-property relationships	Desmoulin	Jean-Charles
22	TeraHertz field-induced Second Harmonic Generation through Pockels Effect in a zinc telluride crystal	Cornet	Marion
23	Realization of a high speed atomic force and optical microscope	Ferreyrol	Franck
24	Magneto-photoluminescence of individual semiconducting single-walled carbon nanotubes	Gandil	Morgane
25	Weak measurements and feedback on coherent atomic states	Cantin	Etienne
26	Protein Crystal Multimodal Imaging	Kuntzel	Thomas
27	Reversible emission switch: luminescent elpasolite matrix as new generation of opto-thermo chemical sensor.	Cornu	Lucile

28	Plasmonic nanostructured materials by bottom up self assembly of colloids	Zheng	Hanbin
29	Single and collective mechanosensing and mechanotransduction	Strehle	Dan
30	Modification of space – charge embedded surfaces by photoactive molecules	Bouriga	Meriem
31	Top-hat beam output with 100 µJ pulses from a linearly polarized all-fiber system	Calvet	Pierre
32	Novel metal ions sensor using uncoated polymer optical mMicroring resonator for environmental applications	Meziane	Farida
33	Second harmonic generation in germano-tellurite glass ceramics	Lo	Nhat-Truong
34	Engineering Nanocrystalline Microstructures in GeS2-Sb2S3-PbS Glasses	Buff	Andrew
35	Numerical modeling of injection of a relativistic electron bunch into a high intensity optical lattice	Hadj-Bachir	Mokrane
36	Optical Characterization of Amplifier Media	Gebremichael	Wendwesen

Abstracts : Ref. Appendices

Wednesday sessions

- **9 :00 am – 9 :30 am – auditorium**

Presentation of the EXOLAS (EXOtic LASers and optical materials) collaborative project

Véronique JUBERA – ICMCB – CNRS – University of Bordeaux
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State of the art laser technology is based on the use of different materials which have limits in compactness, emission spectrum, lifetime or damage threshold just to mention a few. Nowadays, needs are huge in term of exotic wavelength generation (visible, mid-IR), compactness, robustness and mechanical or thermal stability. The EXOLAS project is based a double entry to work on a new generation of laser systems and emitting materials. On the one hand, a top down approach will be focused on the laser architecture construction and the response of the laser cavity component under high power conditions. On the other hand, a bottom up route will allow developing new materials to generate visible, IR and mid-IR emission. Crystals, as well as glasses, glass ceramic or optical ceramics will be produced within the LaPhIA consortium. In the EXOLAS project, we will mainly focus the activities around crystalline materials (crystals and transparent ceramics). Structural, chemical, optical and laser properties will be characterized. Finally, one key point of this project is also to understand the behavior of the whole system under stresses. Then to prevent the ageing and to improve the cycling of the materials represent a real challenge.

- **9 :30 am – 10:00 am - auditorium**

Tamm plasmon lasers

Joël BELLESSA, Lheureux.G , Symonds.C , Azzini.S

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Plasmonic Tamm states are interface modes formed at the boundary between a distributed Bragg mirror and a metallic layer. Their optical properties lie in between surface plasmons and microcavity photonic modes and make them very promising for an new type of laser. We will describe some features of semiconductor quantum wells coupled to extended Tamm modes, like strong coupling with the excitons and lasing. The main advantage of the Tamm modes lies in the easy confinement of the mode which can be obtained only by structuring the metallic part of the structure. The reduction of the mode volume leads to an efficient control of the spontaneous emission (increased beta factor), making Tamm confined structures well suited for single photon emitters and lasers. We demonstrate that confined Tamm plasmon modes can be advantageously exploited for the realization of new kind of metal/semiconductor lasers. Laser emission is studied for Tamm structures with various diameters of the metallic disks which provide the confinement. A reduction of the threshold with the size is observed. The competition between the acceleration of the spontaneous emission and the increase of the losses leads to an optimal size, which is in good agreement with calculations. Polarization effects in asymmetrical Tamm structures will also be discussed.

- **10 :00 am – 10 :30 am - auditorium**

Exploring the intimacy of brain cell communication: the single molecule revolution

Laurent GROC - Interdisciplinary Institute for Neuroscience, University of Bordeaux, CNRS UMR 5297
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Understanding the molecular and cellular mechanisms that shape and regulate the communication between neurons is one of the key challenge in neuroscience, particularly since dysfunctions in the neuronal communication is increasingly associated with the major neuropsychiatric disorders. Neurons communicate at the level of the synapse, in which neurotransmitter are released on one side and activate receptors on the other side. Thanks to development and application of the single molecule/nanoparticle tracking in live cells decades ago, our comprehension of the neuronal communication organization has simply been revolutionized. I will discuss this major discovery, emphasizing on the essential role in fostering interdisciplinary actions between labs in Bordeaux (optics, biophysics, cellular neurosciences). Current innovative interdisciplinary project, between labs from Brain and Laphia Labex, will likely open new avenues in our understanding of the brain physiology and potential new therapeutic strategies, emphasizing on the huge benefit from fruitful transdisciplinary dialogue.

Wednesday sessions

- **11:50 am – 11:20 am - auditorium**

Glass Based Optical Microresonators: New Configurations and Novel Fabrication Techniques

Senthil Murugan GANAPATHY - Optoelectronics Research Centre, University of Southampton, Southampton SO17 1BJ, UK
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Optical passive and active microresonators are versatile optical devices and show the potential to become compact building blocks in larger integrated systems performing

key optical signal processing functions such as wavelength filtering, switching, regeneration, and buffering. Some of these functions find already widespread use in novel optical sensor arrangements and can be potentially employed in future advanced telecom systems. Various microresonator geometries have been studied recently each with associated unique characteristics. We have recently demonstrated first integrated microsphere laser and fabricated novel optical microresonators, namely the "microdiscus", the "microbottle" and the "microstub", and studied their performance. Detailed results, analysis and applications of these microresonators will be presented at the symposium, followed by a brief introduction to our group's very recent activity and capability at the Mid-IR wavelengths for waveguide- based biomedical sensing.

- **11 :20 am – 11 :50 am - auditorium**

Quadratic Nonlinear Optics of Liquids : from Bulk to Surfaces and Interfaces

Pierre-François BREVET - Institut Lumière Matière, UMR CNRS 5306, Université Claude Bernard Lyon 1, F-69622 Villeurbanne, France
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Quadratic nonlinear optical processes entailing the conversion of two photons at a fundamental energy into one photon with the sum energy are gaining a wide interest over the years. These processes obey strict parity rules in order to occur. For instance, they are forbidden in media possessing inversion symmetry like liquids. This rule can however be of a fundamental importance to investigate the special cases where it is broken by a small amount. Second harmonic generation, the degenerate processes of photon addition, can thus be used to investigate the bulk of liquid phases as well as liquid interfaces.

I will show in a first part how hyper Rayleigh scattering, the incoherent second harmonic generation process, can be used to investigate molecular interactions at the nanoscale in bulk liquids. Then, in a second part, I will describe the use of coherent second harmonic generation to investigate these molecular interactions at liquid interfaces and I will close the presentation in addressing the problem of transfer processes at liquid-liquid interfaces.

Wednesday sessions

- **11 :50 am – 12 :20 am - auditorium**

Integrated Photonic Achitectures

Vincent RODRIGUEZ - Université de Bordeaux - Institut des Sciences Moléculaires, UMR 5255 CNRS - 351 cours de la Libération, 33405 Talence Cedex, France.
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The aim of the project Integrated Photonic Architectures (InPhotArch) funded by Laphia (2013-2016) is the development of a new generation of hybrid (organic/inorganic) photonic structures, using molecular and supramolecular photonic engineering, colloidal particle assembling techniques, laser and electric field structuring at different scales that will be compatible with their integration into functional devices. The main strength of this interdisciplinary collaborative project is to combine Photonics, Molecular and Materials Science gathering numerous researchers from the physics and the chemistry departments. This project involves strong collaboration with international partners of recognized expertise in the field, notably the Photonic Centers CREOL in UCF Florida, USA and COPL in University LAVAL, Québec, Canada as well as a connection with emerging photonics clusters.
The project is divided into two different workpackages (1) Laser structuring and electric field structuring as efficient top-down tools to pattern and design surfaces and volumes of glass-based materials; (2) Addressable Photonic Molecular Structures on unconventional designed interfaces (notably next generation patterned glasses) as elementary functional hybrid toolbox.
A summary of recent advances of the InPhotArch project launched in 2013 will be presented.

Wednesday sessions

- **2 :00 pm – 2 :30 pm – auditorium**

Optics in Head-Up Displays and Helmet Mounted Displays

Jean-Luc BARDON – THALES Avionics Bordeaux Le Haillan
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Thales Avionics has been developing and manufacturing Head-Up Displays (HUDs) in Bordeaux for nearly 40 years, and started working on Helmet Mounted Displays (HMDs) in the 1990s. Initially mostly used for military applications, where they often are the aircraft Primary Flight Display, the HUDs have now demonstrated their interest in commercial applications, for instance by enabling lower altitude decision point when landing in adverse weather conditions. HMDs, with concepts starting as miniature HUDs attached to a helmet, have now evolved, associated with cockpit head tracking and sensors, as a family of equipments of its own, allowing the pilot a complete assessment of the 3D space situation surrounding the aircraft.

HUDs and HMDs incorporate many different technologies and know-hows, from electronics to imagers, or graphic generation to ergonomy, etc ... In this presentation, I will focus on optics and particularly on optical systems enabling a signal generated on the surface of an imager to be projected towards the pilot's eyes. Optics for HUDs and HMDs is a small part of the general optics domain, with some quite specific properties, hopefully worthy of your interest. After a review of the higher level functions and requirements, we will briefly discuss the different tools developed to control the performances in all the domaine of use. We will then go through the different challenges and constraints facing the optical designer and how the technical and technological evolution in concepts and capabilities, including in optical manufacturing, will enable more globally efficient designs.

Wednesday sessions

- **2 :30 pm – 3 :00 pm - auditorium**

Preparation of the high power laser system PETAL for studies of high energy density states of matter

LAPHIA collaborative project PETAphys

Vladimir TIKHONCHUK - CELIA, University of Bordeaux – CNRS – CEA
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The high power laser system PETAL will be delivered in 2015 and will be operated together with the Laser MegaJoule (LMJ) as an open access academic facility starting from 2017. The project PETAphys aims at coordinating the ensemble of theoretical, numerical, experimental and technical work during the final period of PETAL construction and the starting phase of its operation. The project brings together the scientists and engineers of two partners – CELIA and CEA/CESTA, in order to coordinate the actions related to planning and realization of the first stage of the PETAL operation so that it will be compatible with all safety requirements, with the characteristics of the diagnostic equipment and with the planned regular operation of PETAL together with the LMJ as an international user facility.

In this presentation I will describe the results obtained during the first year of this project concerning two following issues: (i) control of the electromagnetic emissions from the laser-target interaction and (ii) development of the plasma metrology. We developed a theoretical model and conducted a series of specially designed experiments providing a possibility to evaluate quantitatively the amplitude and the spectral contain of the electromagnetic signal generated in the PETAL pulse interaction with the target. This will allow us to develop methods of reduction of the electromagnetic threat and use of electromagnetic pulses for new applications. For the initial stage of PETAL operation we are developing a system of robust diagnostics that will provide information on the plasma characteristics using the radiation emission in the optical and hard x-ray domains. The basic characteristics of the diagnostic system will be presented. The plan of future work will be also discussed.

Wednesday sessions

- **3 :00 pm – 3 :30 pm - auditorium**

Fiber lasers in the visible range

David PUREUR - QUANTEL, rue L. de Broglie, Lannion – France
david.pureur@quantel-laser.com

We will first introduce the company Quantel and its main laser technologies and markets. We will then focus our presentation on continuous wave fiber lasers emitting in the visible range. Due to their silica matrix, fiber lasers can indeed directly emit a laser beam in a very wide range of infrared wavelengths which can then be frequency converted in the visible range (SHG, SFG) [1], [2]. Advantages of this technology is inherent to all fiber laser products meaning a high reliability, a low maintenance, a perfect output beam quality associated with watt level power and the ability to generate a single frequency linewidth laser.

References : [1] M. Jacquemet et al., "Small linewidth CW high power PM Yb-fiber laser around 1150 nm and yellow

generation", SPIE Photonics West (Lase), paper [7195-15], 2009.

[2] A. Mugnier et al., "Spectral characterization of a narrow linewidth, single-frequency 780 nm fiber laser source for atom cooling applications", CLEO/Europe, paper CJ7_2, 2011.

PINT of LAPHIA

- **6 :00 pm - 8 :00 pm – cafeteria**

  Language : french

L'évènement où tous les étudiants, doctorants et post-doctorants de l'Université de Bordeaux pourront plonger dans le monde des lasers et de la photonique avec :

Joyce BOU SLEIMAN – doctorante – LOMA
Jean-Baptiste PERRAUD– ingénieur – LOMA

Les ondes TeraHertz : voir au travers de la matière

Marcin KRASNODEBSKI – doctorant – SPH

Le LASER MegaJoule

Amélie FERRE – doctorante – CELIA

LASERS ultra-courts et phénomènes ultra-rapides

Olga LOZAN – doctorante – LOMA

Les plasmons dans les nanomatériaux

Thursday sessions

- **9:00 am – 9:30 am - auditorium**

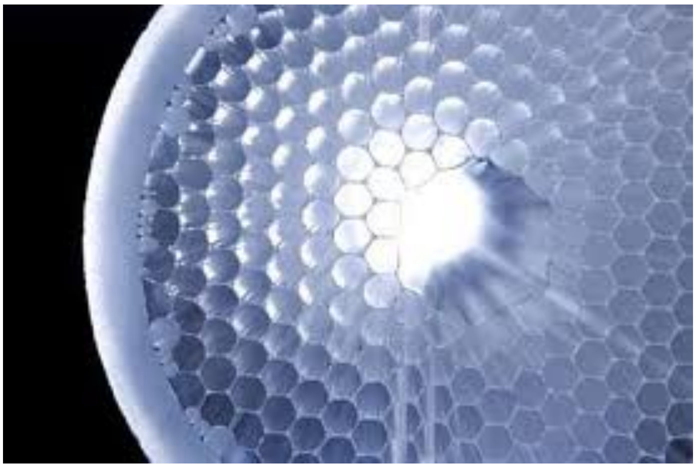
From ultra narrow linewidth to ultra broad band spectrum, technologies and applications of Photonic Crystal Fibers.

Thomas FERHAT - NKT Photonics
thf@nktphotonics.com

Photonic crystal fibers (PCFs) were first demonstrated in 1996 and have generated much attention since then. PCFs are optical fibers that employ a microstructured arrangement of material in a background material of different refractive index. The background material is often undoped silica and a low index region is typically provided by air voids running along the length of the fiber.

Based on fiber technologies we developed two systems: Bragg grating DFB Fiber and SuperContinuum Laser. They are respectively ultra narrow linewidth and ultra broad band and allow applications as various as atom trapping or bio imagery.

In this talk we will present the state of the art of Photonics Crystal fiber and discuss two technologies (Bragg **grating DFB Fiber and SuperContinuum Laser**) built around this platform and their applications.



Hollow core fiber

Thursday sessions

- **9:30 am – 10:00 am – auditorium**

MIGA: an hybrid atom-optical interferometer for fundamental physics and geosciences

B. Canuel for the MIGA consortium

Benjamin CANUEL - LP2N – University of Bordeaux – CNRS – IOGS
benjamin.canuel@institutoptique.fr

We are building a new, hybrid detector that couples laser and matter-wave interferometry to study sub Hertz variations of the strain tensor of space-time and gravitation. Using a novel approach exploiting a set of atomic interferometers simultaneously manipulated by the resonant optical field of a 200m cavity, this instrument will allow at the same time a better understanding of the evolution of the gravitational field and a new tool for gravitational waves (GW) detection. Indeed, each atomic ensemble of the antenna will be manipulated by cavity enhanced Bragg pulses to create an atom interferometer that will simultaneously read out motion of the cavity, GW and inertial effects.

The MIGA project is funded in the frame of the “Equipement d’Excellence” initiative and is carried out by 15 research institutes and 3 companies. This new infrastructure will be embedded into the LSBB underground laboratory in Rustrel, ideally located away from major anthropogenic disturbances and benefitting from very low background noise.

Thursday sessions

- **10 :00 am – 10 :30 am - auditorium**

Laser-Assisted Bioprinting

Fabien GUILLEMOT - INSERM U1026, University of Bordeaux
fabien.guillemot@inserm.fr

The development of strategies to reproduce the functional anisotropy of living tissue remains a puzzling challenge for tissue engineers. Biological tissues are composed of multiple components in close interactions with each other: different cell types, each embedded in their specific extracellular matrix and with blood capillaries nearby. Cells are often in physical contact with each other, which allows complex interactions which support homeostasis. The winning tissue engineering strategy may address precise organization of different cell types embedded in cell type specific ECM with specific growth factors, cell adhesion proteins and specific mechanical properties.

Parallel to scaffold-based approaches, technological advances in the fields of automation, miniaturization and computer-aided design and machining have led to the development of Bioprinting. This later concept has been defined recently as the “the use of computer-aided transfer processes for patterning and assembling living and non-living materials with a prescribed 2D or 3D organization in order to produce bio-engineered structures serving in regenerative medicine, pharmacokinetic and basic cell biology studies”. As compared to traditional approaches in Tissue Engineering, bioprinting represents a paradigm shift. Indeed, its principle is not more to seed cells onto a biodegradable scaffold but rather to organize the individual elements of the tissue during its fabrication step (before its maturation) through the layer-by-layer deposit (bottom-up) of biologically relevant components.

Besides ink-jet printing and bioplotting by means of pressure-operated mechanical extruders, the Laser-Assisted Bioprinting (LAB) technology has emerged as an alternative method, thereby overcoming some of the limitations of ink-jet and micropen printing devices, namely, the clogging (viscosity, cell agglomeration, ink drying, etc...) of print heads or capillaries used by these printers to achieve micron-scale resolution.
In this context, after describing physical parameters involved in Laser-Assisted Bioprinting, we present applications for printing biomaterials and cells (3,4), both *in vitro* and *in vivo* (5) and we discuss on how this high-throughput, high resolution technique may help in reproducing local cell micro-environment and dealing with tissue complexity.

Thursday sessions

- 10:50 am – 11:20 am - auditorium

Collaborative project TAINEPEC : Tailored Nanostructures for Efficient Plasmons-Emitters Coupling

Brahim LOUNIS - LP2N – University of Bordeaux – CNRS – IOGS
blounis@u-bordeaux1.fr

In this talk I will present the collaborative project TAINEPEC launched and financed by the LAPHIA cluster. This project aims at designing, manufacturing and characterizing the new optimized optical nanoantennas and photonic structures. These nanostructures will be used to achieve strong coupling regime with quantum emitters and to perform fundamental quantum information experiments. Progress accomplished towards the achievement of these goals will be presented

- 11:20 am – 11:50 am - auditorium

Design of advanced nanostructured materials using supercritical fluids – Application to materials for optics

Cyril AYMONIER - ICMCB – CNRS - University of Bordeaux
aymonier@icmcb-bordeaux.cnrs.fr

Supercritical fluids offer continuous, scalable, fast and facile routes towards well-crystallized tailor-made nanoparticles. This method has already been used to synthesize various inorganic materials (metals, semiconductors, nitrides, oxides, etc.) with controlled size, complex shapes and compositions. In the last 20 years, the use of sc-water as solvent was extended to other fluids to synthesize nanostructures (alcohols, NH_3, alkanes,... and mixture of them). This variety of solvents opens avenue towards the use of numerous precursors for the investigation of a very rich chemistry; this means the use of more complex systems with an increasing number of parameters. In order to have a better insight into these complex systems, supercritical microfluidics was introduced few years ago to propose to improve the understanding and develop chemistries and processes for the design of advanced nanostructured materials through an access to in situ investigation and high screening capability. As soon as the process is developed and the chemistry understood, the synthesis is made in millifluidic reactors to produce more materials for its characterization and its application. In this lecture, we propose to present the interest of this original and efficient approach in Materials Science. This will be, in particular, illustrated with the formation of exciton luminescent ZnO NCs, CdS/CdSe based-materials with different morphologies or still nitrides.

Thursday sessions

- **11 :50 am – 12 :20 am - auditorium**

THz nonlinear optics

Jérôme DEGERT – LOMA - University of Bordeaux - CNRS
jerome.degert@u-bordeaux.fr

For a while, nonlinear optics experiments were ‘‘limited’’ to the visible and infrared ranges due to the lack of appropriate intense sources in other spectral ranges. However, thanks to recent developments of intense pulsed terahertz (THz) sources, it is now possible to study the nonlinear optical properties of materials in this spectral range. First, we will present Kerr effect measurements induced by an intense THz pulse performed in a gallium phosphide crystal. The temporal and angular behaviors of the phase retardation have been measured and agree well with theoretical predictions. From these measurements, we extracted the two nonzero tensor elements of the third-order response function of the crystal in the terahertz range. Then, we will report on the second harmonic generation of a near-infrared pulse in a zinc telluride crystal through

the Pockels effect induced by an intense terahertz pulse. The temporal and angular behaviors of the second harmonic generation have been measured and agree well with theoretical predictions. This phenomenon, so far overlooked, makes it possible to generate second harmonic through cascading of two second-order nonlinear phenomena in the near-infrared and terahertz range. We will also show how this cascading process can be used to sample terahertz pulses.

Visits

- **1 :30 pm - 6 :00 pm**

1. Visit of the Mega Joule Laser – registration mandatory

Meeting point : **1 :30 pm** in front of the Institut d'Optique d'Aquitaine

Important : please do no forget your passport or identity card (CNI)

More details will be on the reception desk in the hall of the Institut d'Optique d'Aquitaine.

2. Visit of the City of Photonics or visit of Alphanov Center & starts up (Institut d'Optique d'Aquitaine) – registration mandatory

Meeting point : **1 :30 pm** in the hall of the Institut d'Optique d'Aquitaine.

More details will be at the reception desk in the hall of the Institut d'Optique d'Aquitaine.

General information

Committees

Local organizing committee

- Lionel CANIONI: lionel.canioni@u-bordeaux.fr
- Thierry CARDINAL : thierry.cardinal@u-bordeaux.fr
- Jean-Christophe DELAGNES : jean-christophe.delagnes@u-bordeaux.fr
- Yannick PETIT : yannick.petit@u-bordeaux.fr
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- Marc DUSSAUZE : marc.dussauze@u-bordeaux.fr
- Nathan Mc CLENAGHAN: nathan.mcclenaghan@u-bordeaux.fr
- Anne-Lise BUE: anne-lise.bue@u-bordeaux.fr

Junior committee

- Nadezda VARKENTINA: nadezda.varkentina@institutoptique.fr
- Chiara SINITO: chiara.sinito@institutoptique.fr
- Mokrane HADJ-BACHIR : hadjbachir@celia.u-bordeaux1.fr
- Quentin D'ACREMONT: quentin.dacremont@etu.u-bordeaux.fr

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Anne-Lise BUE – Manager : anne-lise.bue@u-bordeaux.fr
06.77.59.66.45

Website LAPHIA : http://laphia.labex.u-bordeaux.fr/

General information

Lunch

Near Institut d'Optique d'Aquitaine :

- CNRS restaurant from 11:30 am to 2:00 pm, price is around 12€.
- Restaurant Universitaire from 11:30 am to 1:30pm, price: 5,90€.
- Au nouveau monde : the price is about 4€ for a sandwich.
- Le Carpe Diem: the price is about 8€.

In the city center : please refer to the website : [bit.ly/1n39xQC](bit.ly/1n39xQC)

Evening reception – invitation

Planned on September 9, 2014 at 8:00 pm. Palais de la Bourse / Salle Tourny – 17 place Palais de la Bourse – 33000 Bordeaux.

Tramway : Stop « Quinquonces » (then tramway C – Direction Bègles Terres Neuves – stop at « Place de la Bourse).

General information

Transport - Tramway B

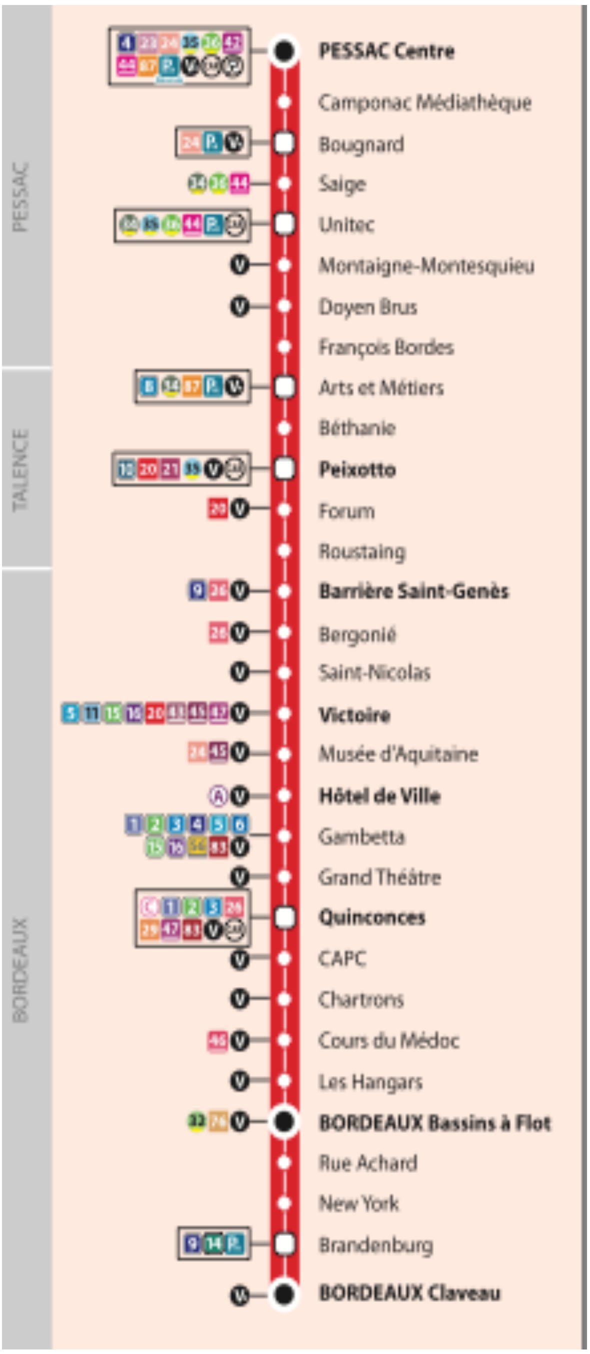
Institut d'Optique d'Aquitaine – Stop « **Arts et Métiers »**

Teneo Hotel – Stop « **Forum** »

Evening reception – Stop « **Quinquonces** » (then tramway C – Direction Bègles Terres Neuves – stop at « **Place de la Bourse** »).

Station Train Bordeaux St Jean – Stop « **La victoire** » and then bus n° 10 or 16.

TBC Website : http://www.infotbc.com/



Appendices

Abstracts – Posters

1. Miguel DIEZ

EVALUATION OF LED-to-LED SYSTEM PERFORMANCES FOR SMART LIGHTING APPLICATIONS

Díez Garcia Miguel[1], Demba Ly, Bechou Laurent[1],Deshayes Yannick[1]
Laboratoire IMS, Université de Bordeaux, CNRS UMR 5218
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Smart lighting systems usually require RF devices to communicate. An excellent alternative consists in using visible light communication by means of light emitters and receivers. By using the same LED as transceiver and photodetector it could be possible to greatly reduce fabrication and maintenance costs. This study aims to show the efficiency of GaN based LEDs as photodetectors. First an optoelectronic characterization was performed. Then the bandwidth of the photoreceptor LED versus a frequency modulated optical signal is studied in a bidirectional LED-to-LED visible light communication system. The objective is to produce a very low cost visible light communication system with enough bandwidth to compute basic instructions betwen the intelligent lamps.

2. Hugo Salvador VASQUEZ BULLON

Towards a new experiment for studying degenerated quantum gases in optical lattices
Research axis: Lasers and materials

Hugo Vásquez Bullón,[1,*] Simon Bernon,[1] and Philippe Bouyer[1]

[1] *Laboratoire Photonique, Numérique, Nanoscience (LP2N), Institut d'Optique d'Aquitaine (IOA) - Université Bordeaux 1 Rue Francois Mitterrand, 33400, Talence, France*

For some time now, theoretical physicists in condensed matter face a major problem: the computing power needed to numerically simulate and study some interacting many-body systems is insufficient. As the use of ultracold atomic systems has experimented a significant grown, an alternative might be to use optical lattices and atoms cooled to quantum degeneracy to simulate the properties of materials. Indeed, an analogy can be made between the behavior of electrons in the crystalline structure of a solid, and trapped atoms in optical lattices, thus reproducing the electrical properties such as conductivity or insulating behavior, and the magnetic ones, as antiferromagnetism. Additionally, the big advantage of using cold atoms is that the parameters of the simulated solid, such as the geometry of the lattice, the intensity and the sign of the interactions between atoms, their bosonic of fermionic nature (while the electrons are always fermions!), the number of atoms per site, etc, can be well controled, which would allow us to "create" artificial quantum matter. My PhD thesis focuses on the construction of a new experiment, which will aim at reproducing these properties. In order to do so, we will use a fermionic gas of potassium (40 K). Quantum degeneracy regime will be achieved by sympathetic cooling with a bosonic rubidium gas (87 Rb), and the gas will then be loaded into an optical lattice of variable geometry.

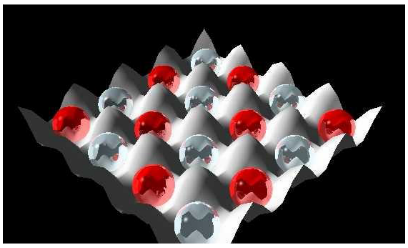

FIG. 1. Two species of atoms trapped in an optical lattice.

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* hugo.vasquez-bullon@institutoptique.fr; http://www.lp2n.institutoptique.fr/

3. Antoine LEPICARD

Control of surface reactivity and non-linear optical properties in borosilicate glasses using thermal poling

A. Lepicard[1,2], M.Dussauze[1], V.Rodriguez[1], K.Richardson[2], T.Cardinal[3]

[1]*Institut des Sciences Moléculaires (ISM), Université de Bordeaux, 351 Cours de la Libération, 33405 Talence*

[2]*Glass Processing and Characterization Laboratory / College of Optics and Photonics, CREOL - University of Central Florida, Orlando, FL 32816*

[3]*Institut de Chimie de la Matière Condensée de Bordeaux (ICMB), Université de Bordeaux, 87 Avenue du Docteur Albert Schweitzer, 33600 Pessac*

Abstract

The control glass substrates surface reactivity at different scales is of a great interest in order to master the properties of future "smart substrates". Within this objective, we aim to design a surface with tailored properties at a submicronic scale using a thermal poling treatment on borosilicate glasses with selected chemical compositions. The chosen glassy systems have a high level of alkali elements which diffuse in the glass during the polarization treatment creating structural changes and the formation of a frozen electric field in the glass. Such an electric field is also responsible for non-linear optical properties, usually forbidden in a centrosymmetric medium. The structural modifications were investigated using Raman, infrared and micro-infrared spectroscopy. Second harmonic generation was evaluated with the Maker fringes technique. Structural changes were linked to the creation of BO_3 units replacing $[BO_4]^-$ entities in the glass after the migration of alkali ions. This leads to a tendency of the glass to attract water at the surface where the poling procedure was performed. Second harmonic generation was also observed which indicates that the centrosymmetry of the glass was broken allowing for the creation of non-linear optical interactions.

4. Katarzyna JAKUBOWSKA

Refraction Index of Shock Compressed Water in the Megabar Pressure Range

D. Batani[1], M. Kimpel[1], M. Koenig[2], A. Benuzzi-Mounaix[2], B. Telaro[2], M. Rabec Le Gloahec[2], T. Hall[3], C. Cavazzoni[4], I. Masclet[5], B. Marchet[5], Ch. Reverdin[5], R. Jeanloz[5], J. Pasley[6], D. Neely[7], C. Danson[7], K. Jakubowska[1,8]

[1]*Université Bordeaux, CNRS, CEA, CELIA (Centre Lasers Intenses et Applications), UMR 5107, F-33405 Talence, France*
[2]*Laboratoire pour l'Utilisation des Lasers Intenses (LULI), UMR. 7605, CNRS-CEA-X-UPMC, 91128 Palaiseau, France*
[3]*University of Essex, Colchester, U.K*
[4]*C.I.N.E.C.A., Bologna, Italy*
[5]*CEA/ DAM, Ile de France, 91680 Bruyeres-le-Chatel, France*
[6]*University of York, York, UK*
[7]*Central Laser Facility, Rutherford Appleton Laboratory, Oxfordshire OX11 0QX, UK*
[8]*Institute of Plasma Physcis and Laser Microfusion, Hery Street 2301-497 Warsaw, Poland*

The interest related to behavior of water is largely justified by planetological research and it has been the subject of several works [1, 2]. Together with ammonia and methane, water is one of the main elements of the mantles of giant planets like Uranus and Neptune. The observation of a large and asymmetric magnetic field in those planets [3, 4] has prompted the idea that the field is originated in the mantle. Since the dynamo effect requires the presence of a conductive material, a phase transition to the metallic state has been suggested [5]. Such phase transition has been evidenced in molecular dynamics simulations.

The study of the optical properties of compressed water, of its refraction index n and its reflectivity R can allow getting information related to the microscopic structure of water and its transition towards a metallic state (i.e. how the energy gap is approaching closure).

Experimentally by increasing the pressure we observed an increase in water absorption (driven by larger value of n_i, the imaginary part of the refraction index) followed by a large increase of R when a conductive state is achieved.

In this contribution, we present the results of experiments performed at the LULI and RAL laboratories. A water sample was compressed to Mbar pressure by a laser-driven shock. We used shock chronometry and VISAR diagnostics to measure the shock and fluid velocities. This allowed obtaining experimental points on the equation of state (EOS) of water, which were in fair agreements with the SESAME tables. Also, VISAR allows to measure water reflectivity or, in a regime of pressures for which water is still transparent or weakly absorbing, its refraction index n (indeed in this case the probe beam crosses the layer of compressed water before being reflected from an Al pusher layer).

[1] T.R. Mattsson and M.P. Desjarlais, *PRL* **97**, 017801 (2006)
[2] N. Goldman, E.J. Reed, I.-F. William Kuo, et al., *J. Chem. Phys.* **130**, 124517 (2009)
[3] N.F. Ness, M.H. Acuña, L.F. Burlaga, J.E.P. Connerney, et al., *Science* **246**, 1473 (1989)
[4] N.F. Ness, M.H. Acuña, K.W. Behannon, L.F. Burlaga, et al., *Science* **233**, 85 (1986)
[5] C. Cavazzoni, G. L. Chiarotti, S. Scandolo, E. Tosatti, et al., *Science* **283**, 44 (1999)

5. Olivier FAVRAT

Influence of organic contamination on laser induced damage of PVD mirrors by subpicosecond laser pulses

Commissariat à l'énergie atomique et aux énergies alternatives, centre d'études scientifiques et techniques d'aquitaine, 15 avenue des sablières, CS 60001, 33116 Le Barp cedex, France

Olivier Favrat, Martin Sozet, Laurent Lamaignère, Isabelle Tovena-Pécault, Jérôme Néauport

Laser induced damage of optical components is often a limiting factor for the development of high power lasers. Indeed, for many years organic contamination is identified as a factor decreasing the Laser Induced Damage Threshold of optical surfaces, limiting the use of high fluences. Also, for the development of its laser facilities, Laser MégaJoule and PETAL, the Commissariat à l'énergie atomique et aux énergies altenatives investigates the influence of organic contamination on the optical performances of its components. Actually, although a great care is provided on the cleanliness of the optics, organic volatile compounds outgassed from surrounding materials may be adsorbed on the sensitive surfaces during their timelife. Thus, for this study, multilayer dielectric mirrors are intentionally contaminated by qualified protocols to compare their performances with clean components. Identification and quantification of the organic contamination is realized by automated thermal desorption and gas chromatography coupled with mass spectrometry. Laser induced damage threshold of clean and contaminated mirrors are then investigated by a 670 fs laser pulses at 1053 nm.

6. Mushegh RAFAYELYAN

Modal q-plates

Authors Mushegh Rafayelyan, Etienne Brasselet

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In our work we show that the optical medium which possesses certain type of phase mask can work as a modal q-plate. This modal q-plate transforms the incident plane wave to a Laguerre-Gaussian mode with radial index *p* and azimuthal index *l* ($LG_{p,l}$). Experimental and theoretical results of transmitted $LG_{0.2}$ like beam through common q-plate was compared with modal q-plate transmitted beam which retardation possesses *l*=2 and *p*=0 characteristics. The correlation method was used for numerical comparison and it was shown that LG02 mode generated by modal q-plate is better compared with the output of the simple q-plate. Moreover, unlike common q-plate, which generates this certain mode in the case of the impinging Gaussian beam, modal q-plate works in the case of incident plane waves, i.e. there is no need to focus the beam on the sample.

Area: Emerging photonics and materials

Keywords: modal q-plate, Laguerre-Gaussian beam, correlation, phase mask, retardation.

7. Artur ALEKSANYAN

High-NA optical vortex coronagraphy

Artur Aleksanyan, Etienne Brasselet

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In the current study we prove that umbilic-like defects can be used for high NA coronagraphy. Modern q-plates are good in the case of low-NA coronagraphy but they don't cover the range of high-NA due to the limits coming from their process of fabrication. In contrast, umbilic-like defects which are created in liquid crystal (LC) cells under the applied voltage don't have such limitations and their defect size can be tens or hundreds of nanometers depending on the cell and LC characteristics and the applied voltage as well. 'Natural' umbilic-like defect coronagraphy have been compared with the q-plate coronagraphy and it was proven that the umbilics are effective in both low and high NA cases, meanwhile, q-plates are only showing good results in the case of low NA. 10um liquid crystal cell has been used to generate the defects under 7.5-25V applied voltage and l = 1 q-plate with the 3um defect size has been used for q-plate coronagraphy. Ring of fire (ROF) and star and planet images in the regime of low NA for the q-plate sample have been taken. In the case of high NA (beam waist size is bigger than the q-plate defect size), ring of fire of q-plate disappears, thus, coronagraphy effectiveness drops drastically. Meanwhile, umbilics ROF is undistorted, because its defect size for 25V voltage is a few hundred of nanometers. In the regime of high NA both ROFs and star and planet images for both samples have been compared. Measurements also include dependence of the azimuthal average of the ROF intensity on the first objective NA for both samples and umbilics ROF dependence on the applied voltage.

Keywords: coronagraphy, high-NA, defects, umbilics, q-plate

Area: ***Innovative imaging***

8. Hatim BAIDA

Polarization Modulation Microscopy.

Hatim. Baida and Brahim. Lounis.

Laboratoire Photonique Numérique et Nanosciences. Institut d'Optique graduate School, CNRS & Université de Bordeaux

We present an experimental technique for measuring the extinction cross-section of anisotropic nanomaterials. The experiments are performed by focusing a laser beam to a diffraction-limited spot under an optical microscope, and rotate the polarization of the light beam. Monitoring the transmitted beam with a lock-in amplifier yields the difference in extinction for light polarized parallel and perpendicular to the optical axis of the nanostructure. Experimental results for gold nanorods are presented that demonstrate the sensitivity and properties of this technique. In particular, we show that by collecting images at many laser polarizations it is possible to construct an extinction cross-section image. The advantages and disadvantages of the PMM technique compared to existing ways of measuring the extinction of nanoparticles (photothermal heterodyne imaging and spatial modulation spectroscopy) are discussed.

(a) (b)

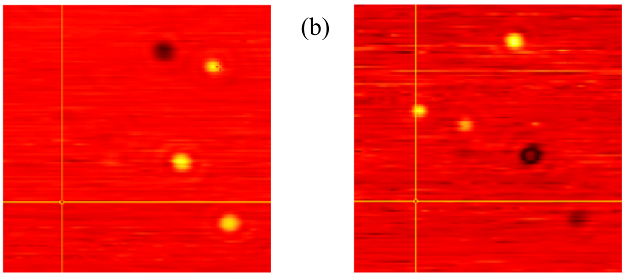

Fig: (a and b) Images of a gold nanorods recorded with a wavelength of 750 nm (4.5 × 4.5 µm image size; 0.1 step size) for two different polarization angles. Note the change in sign of the signal with angle.

9. Ivan VESHCHUNOV

Magneto-Optical Imaging of Thermal Depinning of Abrikosov Vortices in Nb film

I.S. Veshchunov[1,2], W. Magrini[1,2], S. Mironov[3], A. Godin[1,2], J.-B. Trebbia[1,2], Ph. Tamarat[1,2], A. Buzdin[3] and B. Lounis[1,2]

[1] *Université de Bordeaux, LP2N, 351 cours de la Libération, F-33405 Talence, France*
[2] *Institut d'Optique Graduate School and CNRS, LP2N, F-33405 Talence, France*
[3] *LOMA, Université de Bordeaux and CNRS - UMR 5798, France*

Abstract

We report the magneto-optical (MO) imaging of vortices on the surface of a 450 nm-thick layer of Nb grown on SiO_2/Si substrate. High-resolution MO imaging was applied for direct observation of vortex motion under the influence of a temperature gradient, produced by heating with a tightly focused laser beam. For different initial flux density the radius of the thermally depinned area associated with the critical temperature gradient, and its dependence on the power of the laser beam P, initial temperature T_{in} and the size of the focused spot $2r_0$ was measured (Fig.1). The critical temperature gradient to unpin trapped vortices is proportional to the critical current density $J_c(T)$. We compared the data on the critical current density $J_c(T)$ deduced from experiments on thermal depinning with local heating by the focused laser beam with $J_c(T)$ obtained from transport measurements.

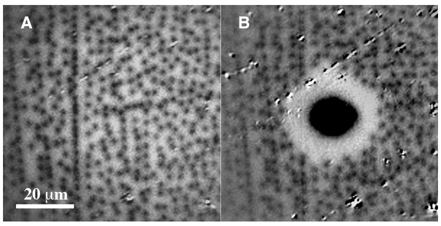

Figure 1: (A) Magneto-optical imaging of vortices FC (field cooling) in ~ 2 Oe at $T_{in} = 6.5\ K$ and (B) the result of heating with the focused laser beam with $\lambda = 532$ nm, absorbed power $P_{abs} = 326\ \mu$W duration of heating 0.5 sec. For chosen magnification 4 pixels/μm: area of view ~ 75 x 75 μm^2. The radius of the focused spot $r_0 \sim 0.5\ \mu m$.

10. Olga LOZAN

Femtosecond surface plasmon polariton pulse tracking with pump-probe thermoreflectance

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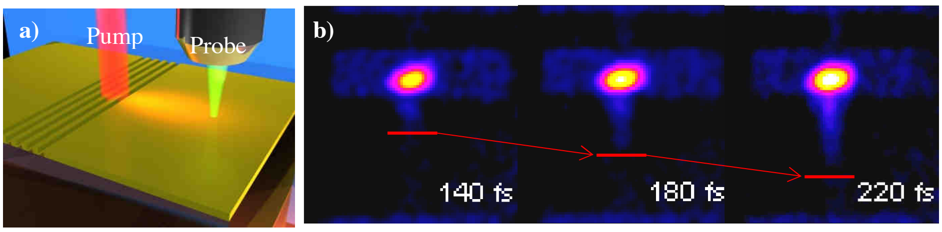
Research axis: *innovative imaging*

Semiconductor electronics and dielectric photonics have reached their critical limits in terms of device dimensions and operating speed. The further evolution in this direction is possible through *plasmonics*, which offers the opportunity to combine the size of nanoelectronics and the speed of dielectric photonic. Plasmons can be excited by electrons or photons at a metal/dielectric interface and consist of electrons oscillating en masse and have wavelengths measured in nanometers. These oscillations are called *surface plasmons*. The key property of plasmonic metallic structures is that they exhibit an unparallel ability to concentrate ligh and once they are set in motion, these 'surface plasmons'(SP), can pick up more light and carry it along the metal surface for comparatively vast distances.

The commonly used technique to study SP is near-field microscopy (NFM). However, when applied to nanoscale, the NFM is considered to be perturbative. In our experiment (fig.1.a) we apply, for the first time to our knowledge, femtosecond thermoreflectance [1] to detect indirectly SPs by imaging the heat dissipated by plasmons while they propagate. This represents a *far-field*, *noninvasive* way to detect the temperature increase due to energy deposited by the SP in the metal. Combined with the femtosecond temporal resolution of the experimental set-up, we study also the dynamics of SPPs (Fig.1b.), thus being capable to record phenomena which occurs at the speed of light. This work opens also new insight in the field of thermal energy transfer which has not yet been experimentally studied at time scales comparable with light propagation.



Filming Plasmon propagation at the rate of 25 Tera images per second

Fig.1 (a) Sketch of the experiment: a first laser incident on a nanoslit excites SPs, a second laser detects the plasmon dissipation (b) Thermoreflectance images of SPs taken at different delays after excitation: the bright spot is the excitation beam, the weak tail starting from the spot is the propagating SP.

11. Chiara SINITO

LAPHIA axis : Emerging photonics and Materials

Spectroscopic signature of the entire band-edge exciton fine structure in single CdSe nanocrystals

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The understanding of the optical and electronic properties of semiconductor nanocrystals (NCs) is of extreme importance for the development of their applications in the fields of laser technology, biological labeling, nano-electronics and quantum information. Single nanocrystal spectroscopy and the theoretical model developed by Efros, Rosen et al. [1] have provided a deeper understanding of the size dependent emission properties of the band-edge exciton in CdSe NCs ranging from spherical to ellipsoidal shape.

Effects of shape anisotropy in colloidal CdSe nanocrystals have recently been observed, consisting in orthogonal linearly polarized bright state spectral doublets [2]. Two effective mass models were developed to explain the source of the anisotropy-induced lift of bright states degeneracy, including respectively anisotropic exchange interaction [2] and valence band mixing, which is the effect of shape anisotropy on the valence band energies [3]. The two models differ in the predictions of the spectroscopic characteristics of the lower and upper bright states, ($\pm1^{L,U}$). Since the $\pm1^{U}$ state is not observable in photoluminescence, due to its fast relaxation to the lower states manifold, these models have not been fully tested yet.

We study single spheroidal CdSe nanocrystals having a zinc blende crystal structure. Since there is no crystal field, the heavy hole and light hole bands are degenerate for spherical shape, making the band-edge exciton fine structure very sensitive to shape deformations. The study of photoluminescence at low temperature and under magnetic field enables us to establish a relationship between the spectroscopic fingerprint of the band-edge exciton fine structure and nanocrystal morphology according to the existing models [4].

In particular, we find that nanocrystals exhibiting anisotropy-induced bright state splittings have a prolate shape. These splittings, which spread up to ~ 1 meV, can be tailored by applying a magnetic field oriented in the plane perpendicular to the axis of the main deformation, eventually restoring the bright state degeneracy. This fine-tuning of individual quantum states energies can be helpful for quantum technological applications, such as the generation of polarization entangled photon pairs.

Furthermore, we develop a photoluminescence excitation technique (PLE) to probe the entire band-edge exciton fine structure. We observe an upper bright state splitting comparable to that of the lower bright state and anticorrelated polarizations between the split components of

12. Miguel COMESANA-HERMO

Synthetic Approach for the Experimental Investigation of Plasmonic Dicke Effect in Au-Fluorophore Nanohybrids

Axe: Matériaux photoniques

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It has been postulated that for an ensemble of dipoles situated at the surface of a plasmonic nanoparticle (NP) the interaction between emitters is of plasmonic character, rather than radiative, leading to the formation of collective states known as "superradiant modes".[i] These results are an extension of the previous work by Dicke, in which he postulated the existence of such states for an ensemble of dipoles confined in a volume smaller than the radiation wavelength.[ii] To the best of our knowledge, there has been no experimental demonstration of the plasmon-mediated superradiance near metal nanoparticles, this being a consequence of the difficulty to create a system in which the number of dipoles per plasmonic core and the distance between them are precisely controlled.

In our work, Au NPs functionalized with fluorophores (organic molecules or quantum dots) have been used as model systems. In both cases a homogeneous silica shell has been used as spacer between the plasmonic core and the fluorophores as a way to control the physical interaction between them. Time-resolved fluorescence spectroscopy has been used to study the light-matter interactions within the system, both in solution and in single particle measurements. This allows us to determine the collective emission rates as a function of wavelength, concentration of fluorophores and distance to finally compare the experimental data with the theoretical predictions.

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13. Petra IVASKOVIC

Synthesis of Plasmonic Nanostructures for Nanopolaritonics

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Abstract

Gold nanorods have received a great attention in recent years due to their unique optical properties which depend on their shape, size and aspect ratio.
They offer two absorption bands corresponding to their width and length, transverse at shorter wavelength and the longitudinal at a longer [1]. Longitudinal plasmon absorption can be modulated through their linear assembly, leading to the new properties which arise from the coupling of the optical and electronic properties between the individual nanorods. Tuning the optoelectronic properties has a wide range of applications, especially in plasmonics [2].

In order to produce these plasmonic nanostructures, we used a seed-mediated growth method, a highly controlled redox reaction performed in the room temperature in the aqueous solution. The method was optimized by the use of various aromatic additives, which led to the improvements in monodispersity and spectral tunability [3]. Obtained nanorods were characterized by transmission electron microscopy and UV-visible spectroscopy.

Moreover, we assembled gold nanorods using different thiol-terminated molecules. Preferential binding of surfactant on the longitudinal side of NR allowed the binding of thiol groups to the ends of nanorods, leading to their assembly in the longitudinal direction.

In the end, we are presenting the main goal of a project – synthesis of Y-shape nanoplasmonic assemblies comprising nanorods and the linker molecules, an architecture which should be able to selectively route the plasmonic current, serve as plasmonic switch and finally enable the nanoscale light manipulation.

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14. Mythili PRAKASAM

Interest of Spark Plasma Sintering to obtain Optoceramics versus Crystals

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Conventional transparent materials have a strong absorption in the infrared region making them unsuitable in this spectral range. Transparent ceramics with nanograins is one of the widely studied topics by the ceramics society, could be an alternative. In order to obtain the transparent ceramics, it is important to obtain maximum density and porosity in the orders of 100 ppm < 0.01 vol % and $\varnothing_m < \lambda/10$. Various sintering parameters interplay to obtain the desired result, where the prime factors being sintering temperature (T_s), dwell time (t) and Pressure (P_s) and the point of pressure application (A_P). With the help of the aforesaid sintering parameters, it is necessary to optimize the conditions to obtain optimal grain size, density and porosity. Other than the grain boundaries, porosity is one of the main scattering centers of light. In order to obtain the minimal porosity, it is necessary to stay at high sintering temperatures for long time, but at the risk of grain growth, which will impede the transparency of the ceramics. Conventionally optically transparent ceramics are often fabricated by either hot-isostatic pressing (HIP), or hot pressing (HP) or vacuum sintering at very high temperatures using ultrapure ultrafine powders. Rapid sintering techniques such as Spark Plasma Sintering (SPS) helps in obtaining maximum densification in short duration of time at comparatively lesser sintering temperatures in comparison to other classical sintering. Simultaneous application of pressure and the help of Joules heating aids in avoiding Ostwald's ripening [1]. Most of the current transparent ceramics are limited only to cubic materials, currently extended to non-cubic materials as well though in early stages. At ICMCB, we have demonstrated successfully the fabrication of transparent ceramics of both cubic and non-cubic crystal structured materials by combining the high sinterability of nanocrystalline (nc) powders with the rapid densification rates characteristic of spark plasma sintering (SPS) [2]. Few examples of transparent ceramics fabricated at ICMCB [3, 4] by SPS are Yb^{3+}:Lu_2O_3, Yb^{3+}:Gd_2O_3, Yb^{3+}:Sc_2O_3, Yb^{3+}: Y_2O_3, ZnO, YAG, Yb^{3+}: YAG, $MgAl_2O_4$, ZrO_2 and ZnSe. The fabrication methodology and results will be discussed in detail.

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15. Christiaan DE VET

3D-PHOTOPATTERNING: PHOTOCHEMISTRY OF A α-DIKETONE ANTHRACENE DERIVATIVE

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Control over the growth of organic nanostructures is a developing field of research due to increasing needs in optoelectronics and tissue engineering. A rising approach consists in triggering and controlling the self-assembly of low molecular weight gelators using external stimuli.[1] Light and focused laser irradiation presents many advantages, such as contactless, spatial, temporal and energetic control of the stimulus.

In this study, we present a novel photoreactive precursor (dKDDOA) of 2,3-didecyloxyanthracene (DDOA).[2] DDOA is a fluorescent "super gelator" and forms fibers upon cooling a supersaturated solution to room temperature. The entanglement of fibers traps the solvent and leads to the formation of an organogel. In the case of dKDDOA, the formation of an organogel is obtained by irradiation with blue light. The irradiation of the precursor with blue light prevents the possible photobleaching of the UV-absorbing photoproduct DDOA. The gelation also occurs without change in temperature or volume of the initial solution, using concentrations of dKDDOA as low as 0.5 mM in DMSO.

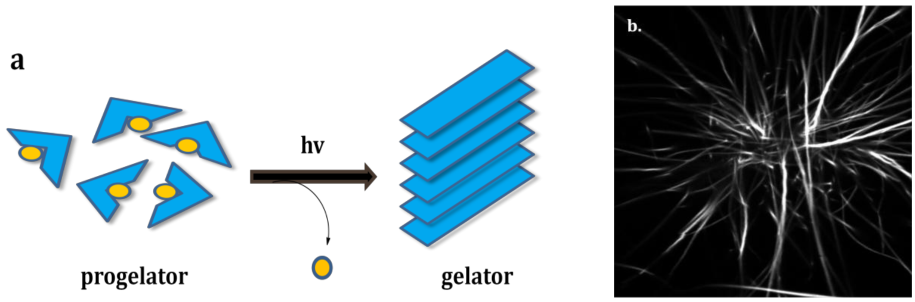

Figure 1: (a) Schematic representation of nanofiber formation upon irradiation. (b) Confocal microscopy image of the nanofibers, 80 x 80 micron.

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16. Pierre FAUCHE

Research Axis: Emerging Photonics and Materials

Experimental Investigation of Plasmonic Superradiance in Au-Fluorophore Nanohybrids

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Among the devices demonstrated during the last decade in the development of nanoplasmonics, one can notice the nanolaser proposed by Noginov *et al.* [i] in 2009 based on the surface plasmon amplification by stimulated emission of radiation (SPASER) introduced by Bergman and Stockman [ii] in 2003. This device consists in a strongly doped silica shell acting as a gain medium around a gold core. To gain insight into the way the coherent surface plasmon modes build-up in this system, it is of interest to consider the mechanism of plasmonic superradiance proposed by Pustovit and Shahbazyan to describe cooperative emission by a finite ensemble of emitters located near a metal nanoparticle [iii].

From this theoretical work we wish to study experimentally the emission of emitters (organic dyes or quantum dots) grafted onto a silica shell acting as a spacer with respect to a gold nanosphere. Using ensemble and single particle spectroscopy we estimate the fluorescence properties of the whole nano-hybrid to study the evolution of the collective light emission as a function of wavelength, amount of coupled emitters and distance to the plasmonic resonator. Here we present preliminary evidence of the plasmonic superradiance from the ensemble study of different concentrations of organic dyes grafted onto plasmonics nanoparticles.

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17. Frederic AUDO

Intermediate field measurement to characterize the wavefront of high power laser large optics

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ABSTRACT

The French Laser MégaJoule (LMJ) is a high power laser project, dedicated to fusion and plasma experiments. It will include 176 square beams involving thousands of large optical components. The wavefront performances of all those optics are critical to achieve the desired focal spot shape and limit the hot spots that could damage the components. The CEA has developed experimental methods to qualify precisely the quality of the large optical components manufactured for the project and measure the effect of various defects. For specific components (coated or parabola mirrors, lenses or gratings), classical techniques like interferometric setups may fail to measure the wavefront highest spatial frequencies (> 1 mm^{-1}). In order to improve the measurements, we have proposed characterization methods based upon a laser beam diffraction interpretation. They present limits and we need to improve the wavefront measurement for high spatial frequencies (> 1 mm^{-1}). We present in this paper the intermediate field measurement based upon the Talbot effect theory and the Fourier analysis of acquired intensity images. The technique consists in a double pass setup: a plane wave is transmitted through the component twice, to simplify the setup and improve the measurement. Then, intensity images are acquired at different distances with a CCD camera and lead to the wavefront power spectral density. We describe the experimental setup to measure the wavefront of large specific components. We show experimental results. Finally, we discuss about the advantages and the limits of such a method, and we compare it with our previous measurement methods.

18. Alexandre POYE

Modeling of Electro-Magnetic Pulses generated by high intensity lasers

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The inertial confinement fusion use high intensity laser for diagnostics and ignition scenario. Those high intensity lasers produce EMP (Electro-Magnetic Pulse) [1] which can destroy the electronic devices in the laser room. Indeed, the pulse frequency is resonant with the eigen frequency of the electronics devices and the amplitude is high enough to generate high tension and irreversible damages.

The first studies made at CELIA with the laser ECLIPSE and in collaboration with the CESTA enable us to detail the important elements of the EMP generation mechanisms. We confirmed that the EMP amplitude is linked with the quantity of electrons ejected by the laser heating [2]. After the shot, the target is charged. The charge is relative to the laser intensity : 100 nC for an intensity about 10^{18} W/cm^2 up to 100 μC for an intensity of 5.10^{19} W/cm^2. The target is settle on a support which become an antenna during the charge relaxation toward the mass. The EMP is emitted all along this relaxation.

The poster present a simple model which predicts the charge after the shot with the laser and the target parameters. The model is successfully compared to the numerical simulation and to the experience. The results have been published [3].

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19. Philip SCHAFER

MACROSCOPIC AND MICROSCOPIC COLOR-TUNING OF SELF-ASSEMBLED DIALKOXY-DIPHENYLANTHRACENE NANO-RIBBONS

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Fluorescent organogels and 1D-organic nano-objects have gained enormous interest in last decades for their potential use in optoelectronics[1]. Self-assembled nano-fibers[2] or nano-ribbons from anthracene derivatives are an interesting matrix for color-tuning of fluorescence, light-harvesting and the study of the photophysical processes involving guest tetracene derivatives.

Nano-ribbons from pure 2,3-dihexadecyloxy-9,10-diphenylanthracene (DPA-C16) emit blue light, but the emission color can be tuned and turned into green by doping with 1% 2,3-dihexadecyloxy-5,12-diphenyltetracene (DPT-C16). The optical properties of these two components provide the preconditions for two-color-writing in single nano-objects. The green-emitting DPT-C16 acts as an energy-acceptor of the DPA-C16-donor-matrix, thereby quenching nearly 100% of the blue fluorescence of the ribbons via combined exciton-hopping and Förster type energy transfer (ET). In the presence of ambient oxygen and adequate excitation power focused on a small volume of a ribbon the acceptor photo-degrades. This induces the lapse of green emission and awakens the blue emission due to the disappearance of the energy transfer, thus enabling simultaneous negative and positive writing. The robustness of the energy-donor under laser excitation guarantees the activation of fluorescence in the blue, rather than a more common laser-induced photo-bleaching of both donor and acceptor. The control of the advancement of the bleaching process also allows a control at the micrometer scale of the color of the emission on different segments of the ribbon (see CIE coordinates in Figure c).

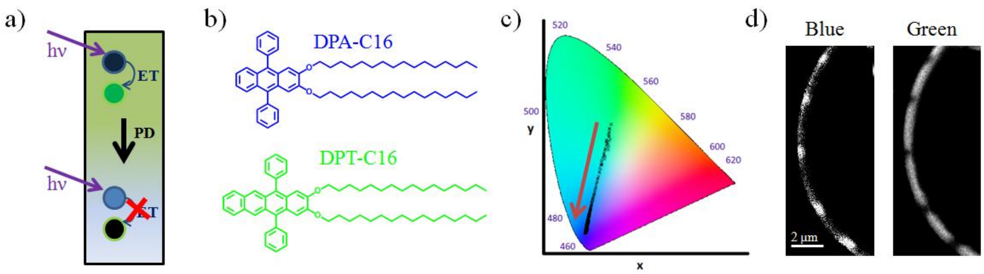

Figure: a) Schematic of two-color-patterning by amplified photo-degradation (PD) via efficient energy transfer (ET). b) Molecular structure of the donor-molecule DPA-C16 which can self-assemble forming nano-ribbons and molecular structure of the acceptor-molecule DPT-C16. c) Color change during the writing-process in the CIE-color-space. d) Blue and green emission of a photo-patterned ribbon.

Our studies reveal that indirect photo-patterning via energy transfer leads to better contrast than by direct excitation of the acceptor. Polarization microscopy shows that this selective and local photo-degradation does not alter the molecular packing in the ribbons. This study corresponds to a first example of local manipulation of optical properties to form 1D-heterostructures of *n*-acene-based nano-ribbons.

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20. Joyce BOU SLEIMAN

Terahertz Imaging And Spectroscopy: Applications To Defense And Security

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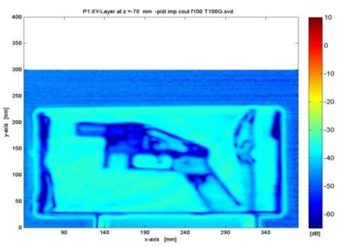
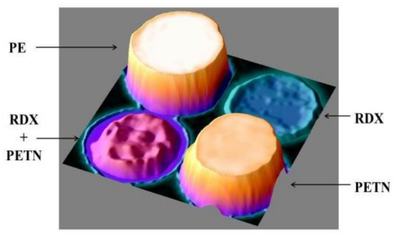
In the context of security in postal chain (Franco-German project), many fundamental concepts and techniques have been validated to lead to devices for THz imaging, THz spectroscopy and THz spectroscopic imaging. Guns, drugs, radioactive substances, liquid and solid explosives, have been transported through parcels and letters. And the fact that most of the packages are not opened through control, people think that controllers aren't able to detect those objects. But with the ability of terahertz waves to pass through plastic and paper, detecting this kind of object is now possible.

In our study, we work on two different aspects. The first is imaging of objects inside parcels. The second is spectroscopy and chemiometric analysis for different types of powder especially explosives. By mixing these two aspects, we obtain spctro-imaging method that allows us to have more information about the content of a parcel.



Nonmetallic gun and ceramic knife inside parcel at 100 GHz in transmission



Example of terahertz image at 1.6 THz in the case of four pellets: polyethylene (PE), pure RDX, pure PETN, and a mixture of RDX+PETN.

Acknowledgements: We would like to express sincere thankfulness to each of the persons who have permitted us to display some results of their work. We would also acknowledge financial support the Agence Nationale de la Recherche (ANR) for their support in the InPoSec project (www.inposec.org).

21. Jean-Charles DESMOULIN

Microstructuration by Direct Laser Writing in silver doped glasses : Structure-property relationships

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The development of integrated optical components requires miniaturizing the optical functions. Nowadays, 3D laser writing is emerging throughout the use of femtosecond lasers for designing new functionalities in glass. Then it becomes possible to avoid the use of expensive steps of multilayer process in order to build optical storage device, waveguides, etc. [1]. Indeed, the nonlinear multiphotonic absorption results in depositing energy in a confined volume leading to submicrometric material modifications.

Phosphate glasses containing d^{10} ions such as silver oxide allow the inscription of patterns owing original luminescence or nonlinear optical properties. The development of silver containing tailored glass compositions can allow obtaining a variety of photo-induced species or nano-particles. There are two main aspects: glass composition and more particularly the photosensitive ions quantity, and the laser writing parameters (wavelength and repetition rate). The use of high pulse repetition rate lasers allows a heat control via cumulative effects. Adapting the glass composition and the laser characteristics permits to benefit from the photochemical and the ionic migration mechanisms. T

Luminescence and nonlinear optical spectroscopies become a unique tool to identify the silver species and to follow the physicochemical modifications after laser irradiation. At the early of the interaction, strong embedded electric field can be implemented. Oxidation-reduction phenomena combined with the migration of mobile ions and atoms leads to localized highly light-emitting photo-induced structures in the voxel region. Migrations of silver ions have been clearly evidenced by local chemical analysis. IR and Raman spectroscopies allow establishing a link between the glass structure, the photochemical modifications and the luminescence or nonlinear optical properties

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Terahertz field-induced second harmonic generation through Pockels effect in a zinc telluride crystal

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Abstract— **We report on the second harmonic generation of a near-infrared pulse in a Zinc Telluride (ZnTe) crystal through the Pockels effect induced by an intense terahertz pulse, demonstrating cascading second-order nonlinear phenomena in the terahertz range.**

I. Introduction

The recent development of high power terahertz (THz) sources makes it possible to perform nonlinear optics in this spectral range. THz Kerr effect has been reported in liquids [1], ferroelectrics and amorpheous glasses. THz field-induced second harmonic generation (TFISH) has also been observed in a beta barium borate crystal [2] or liquids [3]. As expected for this third-order nonlinear phenomenon, the TFISH intensity is proportional to the THz intensity, I_{THz}, the square of the fundamental laser intensity, I_ω, and the third-order nonlinearity, $\chi^{(3)}$, of the material, so that:

$$I_{2\omega}^{TFISH} \propto (\chi^{(3)})^2 I_\omega^2 I_{THz}\,.$$

However, it is well-known that a cascade of two second-order nonlinear phenomena can also mimic a third-order process. We report hereafter on such a cascading phenomenon in zinc blende <110> ZnTe crystal.

II. Results

The experiment is the following: a 1.5 mJ, 800 nm linearly polarized laser beam is splitted into a pump beam used for THz generation and a probe for second harmonic generation (SHG). The pump pulse generates an intense THz radiation (E_{THz}= 20 kV/cm) through optical rectification in a $LiNbO_3$ crystal thanks to a tilted pulse front scheme [4]. Using two off-axis parabolic mirrors, the linearly-polarized THz beam is then focused into a 200 µm thick ZnTe crystal where it interacts collinearly with the IR probe pulse. Both THz and probe intensities can be adjusted by a pair of polarizers. The THz pulse polarization is set orthogonal to the c-axis of the crystal whereas a half-wave plate allows us to continuously rotate the probe polarization. The angle between the probe pulse polarization and the c-axis of the ZnTe crystal is denoted by θ hereafter. Finally, SHG is detected at 400 nm using a photomultiplier tube coupled to a lock-in amplifier.

First, performing the study with a <100> cut crystal, no SHG signal was recorded, whatever the configuration of both THz and probe polarization states. This indicates that TFISH is not visible in ZnTe under our experimental conditions. Furthermore, as expected in a <110> cut crystal, with a probe beam polarized along the c-axis of the crystal, no SHG was recorded in the absence of THz radiation. However, in its presence, a SHG signal was easily observed, whose temporal shape closely follows the evolution of $|E_{THz}(t)|^2$. In this experimental configuration (θ = 0°), it is well-known that the THz field-induced Pockels effect is maximized [5]. Actually, as the THz propagates through the crystal, it induces a Pockels effect, which rotates the probe beam polarization, enabling the latter to be frequency-doubled by the intrinsic second order susceptibility $\chi^{(2)}$ of the crystal. As a result, this Pockels-induced SHG signal can be expressed as:

$$I_{2\omega}^{Pockels} \propto (\chi^{(2)})^4 I_\omega^2 I_{THz}\,.$$

The two recorded intensity studies are displayed in the inset on Fig. 1. They clearly show the linear and quadratic dependences with respect to the THz and IR probe pulse intensities, respectively.

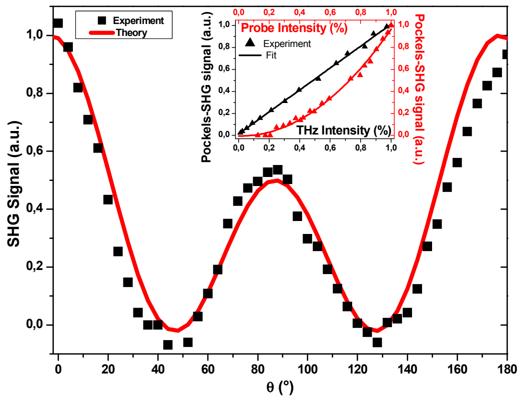

Fig. 1. Angular and intensity dependences of the Pockels-SHG signal.

We performed as well the θ angular dependence study of the Pockels-SHG signal. The experimental results (■) show a good agreement with the theoretical calculation (▬).

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23. Franck FERREYROL

Realization of a high speed atomic force and optical microscope

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Research axis: *innovative imaging*

In the recent years, super-resolution microscopy based on the super-localization of single molecules has made several advances in the field of optical microscopy. The robust localization of nano-objects at the nanometers scales requires exceptional mechanical stabilities over the time course of the experiments (minutes to hours). Such requirements are becoming highly similar to those of high speed atomic force microscopy. We can thus optimize the mechanical design of the microscope in order to use both techniques in a complementary way. We can for example use optical strategies to generate errors signals for real time microscope stabilization needed by both kind of microscopy imaging.

24. Morgane GANDIL

Magneto-photoluminescence of individual semiconducting single-walled carbon nanotubes

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Since the first experimental evidence [1] of photoluminescence (PL) of semiconducting single-walled carbon nanotubes (SWNTs), studies have been conducted to investigate the optical properties of these nanostructures, motivated by possible applications in the fields of quantum information, biological labeling, opto-electronics or laser technology.

Radiative transition energies in SWNTs are well reproduced by theoretical models which take into account Coulomb interaction within photo-created electron-hole pair, showing the excitonic nature of excited states in these one-dimensional systems [2,3]. The two lowest singlet states play a significant role in the luminescence of SWNTs. The upper one – bright state (B) – is optically active and the lower one – dark state (D) – is a parity forbidden transition. Through the Aharonov Bohm effect, B and D states can be coupled by applying a magnetic field in the direction of the SWNT, so that the lower state acquires oscillator strength and can be studied via PL signal. This opened up the field of magneto-photoluminescence spectroscopy [4,5], as a promising way to investigate the photophysical properties of these states.

We study suspended SWNTs on a lithographed silicon substrate at the individual level using a confocal optical microscopy setup, with a large numerical aperture NA=0.95, operating at cryogenic temperatures down to 2K. A magnetic field up to 7T is produced by superconductive coils. We measure PL spectrum and PL decay of SWNTs under various experimental conditions including changes of the magnetic field, temperature and optical excitation frequency. Figure 1(a) shows the spectacular magnetic brightening of the D state through the emergence of a peak ~10meV below the B state. Figure 1(b) highlights the bi-exponential behavior of the PL decay and the enhancement of the weight of the long-time component due to magnetic coupling. The magnetic brightening of D state is of particular interest because of its tunable oscillator strength.

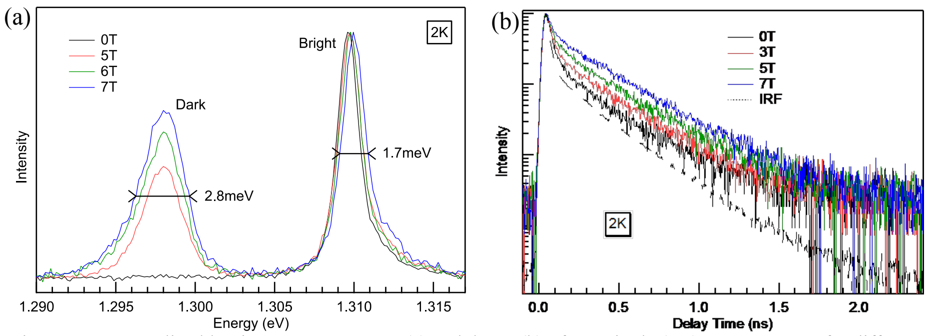

Figure 1: Renormalized luminescence spectrum (a) and decay (b) of two single (6,5) SWNTs at 2K for different magnetic field intensities under optical excitation on S22 transition.

25. Etienne CANTIN

Weak measurements and feedback on coherent atomic states

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Atom-based sensors have been used to measure fundamental constants and their time variation, as well in more applied contexts for example to realize gravity surveys for ore and oil prospecting. We investigate novel detection technique for quantum sensors using non-destructive measurements on rubidium atoms trapped in a high finesse cavity. Unlike conventionals atom interferometers based on a destructive probe, the weak measurement approach determines only a partial reduction of the atomic coherence. It is thus possible to use the measurement result to steer the atomic state using feedback. We have experimentally implemented such a scheme to recover the loss of coherence of a spin states because of random collective microwave rotations [1]. We are now trying to use coherence preserving detection techniques to increase the effective interrogation time in a Ramsey sequence, as proposed in [2]. The measurement of the phase drift between the local oscillator and the atomic reference can continue for several cycles until there is a sufficient residual coherence.

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26. Thomas KUNTZEL

Protein-Crystal Multimodal Imaging (ProXMI)

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As the crystallization behavior of a target protein is not usually known beforehand, a broad screening exercise with hundreds of different solution conditions is necessary. To facilitate the process of manually identifying crystals among so many unsuccessful experiments, automatic crystal detection algorithms have been developed[1]. Such methods usually rely on edge detection or contrast to identify crystals. However, amorphous precipitates or the drying skin of crystallization drops can also present apparent straight edges, leading to false positives. Protein-crystal identification is routinely carried out as an essential step in protein structure determination. Many high-throughput instruments are available. They are based on optical microscopy techniques at low magnification over relatively large fields of view to maximize the probability of detecting diffuse microcrystals.

ProXMI is a Passport Project, (call for research and valorization projects of LAPHIA 2014-Round 2), for one year, whose aim is to validate the potential use of multimodal imaging techniques (linear and nonlinear optic combined microscopies) to follow and detect protein crystals growth. Indeed, Second Order Nonlinear optical Imaging of Chiral Crystals (SONICC) is an emerging technique for crystals imaging, characterization and automatic detection based on the fact that Second Harmonic Generation (SHG) signals are generated only by certain ordered assemblies and only in highly intense fields. This project is based additionally on the original combination of SHG/Raman microscopies developed at the "Institut des Sciences Moléculaires" (ISM).[2] The proof of concept is performed on Hen Egg-White Lysozyme (HEWL) which is one of the most study enzyme in structural biology to date (this was the first enzyme to have its three-dimensional structure determined).

This project is a collaboration between two academic labs (ISM and IECB) and the company Explora Nova. The tasks are divided as follow between the different partners:

i. The crystallization process is fully mastered by IECB. Crystals can be obtained in a week using a crystallization conditions based on salt (NaCl) as a precipitant agent.

ii. The detection of the protein crystals thanks to the SHG/Raman microscopies will be performed at the ISM and exploited at Explora Nova. The multimodal images will be interpreted and evaluated by the three partners.

iii. Finally, if SHG/Raman multimodal imaging proves to be helpful in scoring the crystallization screening, a transfer of technology will be processed involving "Aquitaine Science Transfer" (AST). The multimodal imaging should allow Explora Nova to improve his actual system of protein crystal experiment design, imaging & analysis: ***Xtal Focus***.

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27. Lucile CORNU

Reversible emission switch: luminescent elpasolite matrix as new generation of opto-thermo chemical sensor.

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Highlights

Reversible luminescence, optical sensor, redox phenomenon.

Abstract

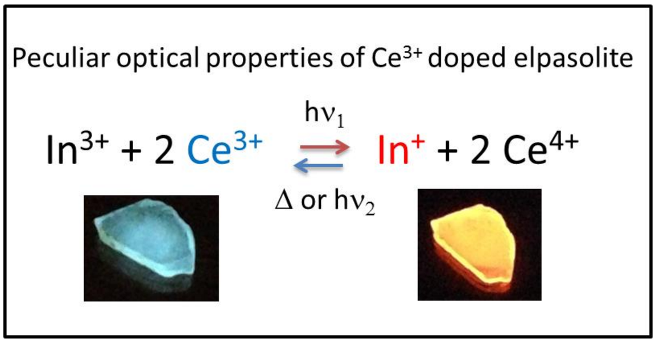

Figure 1: Reversible optical switch observed under UV irradiation

Development of selective and specific sensor has been attracted considerable attention for a decade. Optical sensing systems are compatible with distance testing keeping the excitation and detection system out of the sensing zone. They are suited to the on-board technologies and multiple light sources and detectors are now available for the obtaining of compact and robust systems. To detect an event means that a significant change of the optical properties has to occur.

We focus this work on an interesting luminescent material that presents a reversible redox phenomenon under irradiation or temperature. The ignition and the extinction of the blue and red emission are related to the oxidation and reduction processes between trivalent cerium and indium ions under UV irradiation (figure 1). Single crystals were grown using the Bridgman technic. The irradiated crystal zones are stable during at least a decade if not irradiated or heated. Understanding of these specific luminescence data [1] will be exposed and supported by structural and chemical characterizations as well as DFT calculations. The concentration dependence of luminescence properties will be shown. Finally cycling of these materials will illustrate their capability to be used as optical sensors.

Acknowledgement

The authors thank the Université de Bordeaux, the CNRS, the Région d'Aquitaine and the French National Agency of Investigation ANR (contract n° ANR-2010-BLAN-0820) for financial support.

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28. Hanbin ZHENG

Plasmonic nanostructured materials by bottom up self assembly of colloids

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Bottom up self assembly processes to fabricate large scale ordered templates made of colloidal particles are viable alternatives to the costly top down approaches that are more commonly used in lithography. One simple way is to spread a suspension of polystyrene beads onto a water surface and pack them into a closed packed structure by tuning the surface tension of water with a surfactant [1]. The structural parameters of the template can be simply adjusted by choosing particles of the appropriate size and subsequently treating the templates under different conditions [2]. Electrodeposition can then be used to deposit metals into the monolayer colloidal templates that were prepared on conductive substrates [3], [4]. Here, we present an entire bottom up fabrication route that makes use of the self assembly of colloids and electrodeposition of metals to develop plasmonic materials with tunable properties.

We demonstrate the relative ease of preparing a single monolayer of closed packed colloids on a substrate and the tunability of the pore size via a controlled sintering process. Furthermore, a plasma etching process can also be used to create non closed packed colloidal templates. By depositing the colloidal templates on conductive substrates, we show that the template prepared by self assembly can be readily used for electrodeposition of different metals to create (1) 2D arrays of gold nanoantennas with tunable geometries and (2) macroporous gold surfaces that exhibit omnidirectional total light absorption properties.

Figures

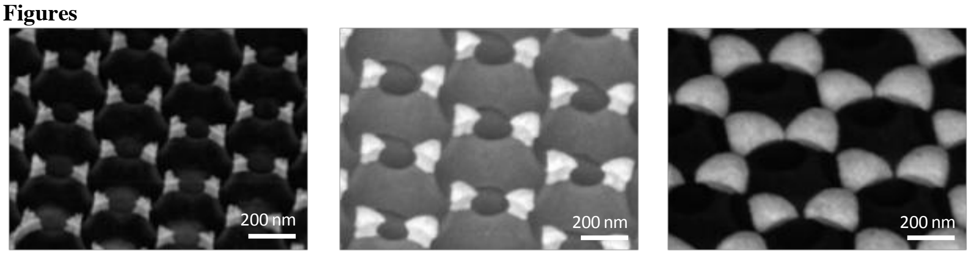

Figure 1. SEM pictures of gold nanoantenna arrays with different geometries.

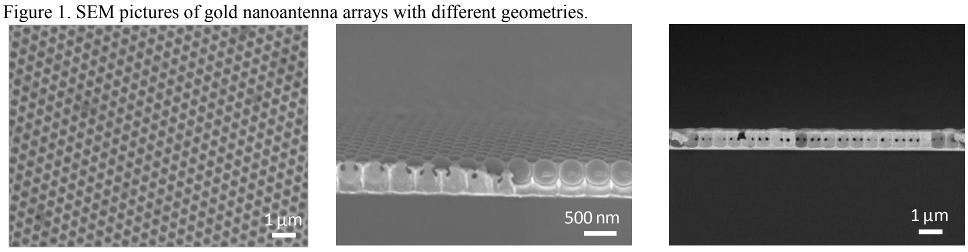

Figure 2. SEM pictures of a macroporous gold surface

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Research Axis: Emerging photonics and materials

29. Dan STREHLE

Single and collective mechanosensing and mechanotransduction

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During cancer development, tumor cells encounter various mechanical constraints. When the tumor expands, active and passive remodeling of the extracellular matrix increases the tissue's stiffness and cells experience resistance from the basement membrane surrounding the tumor. Via various mechanotransduction pathways such mechanical stimuli influence cell behavior.

Our group approaches this complex from three perspectives:

1) Tumor cell aggregates are produced via alginate microcapsules. The development of integrated lab-on-a-chip devices will allow for global observation of numerous tumor spheroids in parallel and thus screening applications.
2) Using light-sheet microscopy individual spheroids as well as individual cells at the periphery of spheroids can be observed on time scales of several weeks. Of special interest is the response to mechanical stimuli that enable some cells to leave the collective.
3) Using substrate deformation, shear flow and osmotic stress we study the individual response of cells to mechanical stress focusing on the caveolae-mediated mechanotransduction pathway.

The aim of these studies is to exploit new technologies in optical and tissue engineering as well as microfabrication to study principal physical mechanisms underlying and determining tumorigenesis.

30. Meriem BOURIGA

(Research thematic: Emerging photonics and materials)

Title: Modification of space – charge embedded surfaces by photoactive molecules

Authors: Meriem Bouriga, Vincent Rodriguez, Nathan McClenaghan, Marc Dussauze, Luc Vellutini, Frederic Adamietz, Thierry Buffeteau, Arnaud Tron

Our aim is to modify borosilicate glass surfaces to give them the potential to host photoactive molecules and to study the optical properties of the resulting novel materials. In this goal the glasses were subjected to a thermal polarization technique. The optimization of the poling atmosphere and the electrode type permits the control of the physicochemical properties of the interface by two combined actions: a) chemical activation of the surface to enable the functionalization, and b) introduction of an internal electric field.

In parallel, a grafting protocol has been established to covalently bind, harnessing a click reaction, photoactive molecules to a grafted precursor on the borosilicate surface. The chosen fluorescent molecules are pyrene and BODIPY.

Finally, the electronic properties and the arrangement of the molecular photoactive assemblies in contact with the space charge embedded substrate have been characterized by UV-Visible absorption spectroscopy and second harmonic generation.

31. Pierre CALVET

Top-hat beam output with 100 µJ pulses from a linearly polarized all-fiber system

Pierre Calvet[1,2]

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Abstract :

The compactness, long term stability, versatility and ease of use capabilities are important advantages of fiber lasers and amplifiers over bulky systems [1]. Their optical performances and ability to deliver high power or energy pulses find widespread applications in various industrial areas, for laser-biological tissues interactions, for fundamental studies of laser-matter interaction processes or for seeding large-scale laser facilities like the Laser MegaJoule (LMJ) [2]. For many of these applications, specific spatial beam shaping and more particularly a flattened profile is often a decisive requirement. Unfortunately until recently, optical fibers only deliver Gaussian-like beam, constraining the use of free-space beam shaping techniques at the output of laser systems [3]. To overcome alignment difficulties inherent to free space beam shaping, an elegant solution is to use an optical fiber directly delivering the desired spatial beam shape. Of course, an efficient solution is to use highly multimode fibers [4–6] but it leads to a low spatial coherence inducing very low depth of focus which is often detrimental for many applications, such as cutting or marking. To overcome these drawbacks, single-mode fibers supporting a flattened fundamental mode have been developed [7–10]. Despite their promising designs, these proposed fibers were still multimode. However, very recently we have developed a new strategy to obtain intrinsically single-mode fibers with very good intensity flatness by using a refractive index-depressed core [11]. Accordingly, we have realized and characterized a truly single-mode passive few-meters long fiber able to deliver a top-hat beam output [12]. We report on an all-fiber system delivering more than 100 µJ pulses with a top-hat beam output in the few nanoseconds regime at 10 kHz. The linearly polarized flattened beam is obtained thanks to a 3-mm-long single-mode microstructured fiber spliced to the amplifier's output [13].

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32. Farida MEZIANE

Novel metal ions sensor using uncoated polymer optical microring resonator for environmental applications

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Abstract:

An environmental sensor that uses planar optical microring resonator for integration in an EWOD (ElectroWetting On Dielectric) digital microfluidic chips is presented. Its operating principle is based on the measurement of optical absorption induced by color metallic complexation reactions for chemical analysis using an uncoated polymer microring resonator in the visible range. The enhancement of light by the microring resonator allows highly sensitive measurements of the fluid optical absorbance by enhancing the effective path length while the selectivity is guaranteed by the complexation reaction. The intrinsic metallic complex absorption makes the polymer ring resonator effective regarding the dielectric parameters changing namely its effective index and attenuation value at resonance. A proof of concept is presented based on a first theoretical approach and simulations in order to optimize the optical ring design and performances.

33. Nhat-Truong LO

SECOND HARMONIC GENERATION IN GERMANO-TELLURITE GLASS CERAMICS

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Abstract

Aiming the fabrication of glass ceramics with high optical nonlinearity, tellurite and germanotellurite based glasses are potential interesting glassy systems because of their high refractive index combined with low phonon energy. Nevertheless, to engineer a new optical glass ceramics, it is necessary to control first either surface or bulk crystallization and second sizes and orientation of the crystallites within the glass matrix. In this study, a glass system of composition 70TeO2 – 10 GeO2 – 10Nb2O5 – 10 K2O – x Ag2O (x=0 – 6%) has been investigated. Silver cations have been introduced in the composition to play the role of nucleating agents with the aim to control the volume crystallization. Thermal analysis and X-ray diffraction measurements have shown the precipitation of a unique crystalline phase: $K[Nb_{1/3}Te_{2/3}]_2O_{4.8}$. Second harmonic generation responses of the glass ceramics have been also investigated at the microscopic scale using µRaman/µSHG correlative technique and at the macroscopic scale with the classical Maker fringes experiments. Such a multi-scale approach has permitted to correlate symmetry, size and organization of the crystallites within the glass matrix to the macroscopic second order optical properties of the composite glass ceramics.

34. Andrew BUFF

Engineering Nanocrystalline Microstructures in GeS_2-Sb_2S_3-PbS Glasses

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Chalcogenide glasses (ChG) are known for their wide transmission range from λ=1-14 μm and for their high refractive index. However, applications for ChG are often limited by their poor thermal-mechanical properties including limited thermal shock resistance, low thermal conductivity, and modest thermo-optic coefficients. Nucleating and growing a secondary crystalline phase in the glass matrix can improve these properties, but too much crystallization and/or large or multiple phase crystallites can lead to a loss in transmission. Controlled crystallization in ChG can be quite difficult due to their low thermal conductivities. This leads to a temperature gradient across the glass in traditional furnace heat treatments, causing different rates of crystallization across the sample and leading to an uncontrolled, random microstructure. In order to control the nucleation and growth of crystals, it is necessary to fully characterize the nucleation and growth behavior of the defined glass-crystal system.

Two ChG compositions in the Sb_2S_3-GeS_2-PbS glass system, with GeS_2:Sb_2S_3 ratios of 17:3 and 11:4, were evaluated for their suitability in an application that required an optical glass-ceramic with uniform distribution of crystal nuclei in the glass matrix. Composition selection was aided by the mapped regions of crystallization stability in this glass system by Xia *et al.*[1] The glasses were characterized through Raman spectroscopy, thermal analysis, FTIR, UV-Vis spectroscopy, and microhardness. The 11:4 composition was found to be a better candidate because of its crystallization behavior and higher percent transmittance. After a down selection to the 11:4 composition, research focus shifted to creating nucleation-like and growth-like curves for the primary crystalline phase. The nucleation-like and growth-like curves were created for the primary crystal phase of the 11:4 glass-ceramic through a process adapted from the works of Marotta *et al.*[2] and Ray *et al*.[3] Points for the nucleation-like and growth-like curves were generated through DSC runs with specific isothermal holds to induce nucleation/growth at different rates. The completed nucleation-like and growth-like curves were used to identify appropriate heat treatments to nucleate and grow nanocrystals uniformly within the glass matrix. The methodology to define these material attributes and the resulting findings are discussed.

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35. Mokrane HADJ-BACHIR

Numerical modeling of injection of a relativistic electron bunch into a high intensity optical lattice

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keywords: Particle beam extraction, beam injection – Particle beam transport – X- and gamma-ray laser – Free-electron devices.

Abstract

X-rays free-electron lasers (XFEL), combine the unique properties of laser light with the atomic resolution and penetrating power of X-rays. The XFEL based on SASE (Self-Amplified Spontaneous Emission) process have a lot of new properties especially in terms of very short pulse duration (femtosecond) and focusability on very small spots, opening several new areas of research: single protein crystallography, strong field science in the X-rays, Warm Dense Matter, and even many medical applications, especially in oncology [1]. However, the current XFEL projects are so large, both in size and budget, that they are bound to remain Large Scale Infrastructures, with a real issue of beam-time availability, and will not have the possibility to disseminate in university-scale research centers, industrial laboratories, or hospitals[2].
Rapid progress in the development of high-intensity laser systems has extended our ability to study light–matter interactions far into the relativistic domain, in which electrons are driven to velocities close to the speed of light, thereby considerably reducing the size of particle accelerators[3]. Some authors have proposed applications using intense optical lattice: the emissions in the far infrared for electrons initially at rest [4], in the near infrared for non-relativistic electrons in motion [5]. We recently noted that an optical lattice in a strong laser field regime may create cases of completely original physics of laser / plasma interaction. We explore the particular case of interaction between relativistic electrons and optical lattice leading to: transverse trapping and guiding of electron beams; monochromatic betatron emission; Free Electron Laser by Raman effect [6], [7].
This poster shows how a compact XFEL can be constructed. In particular the trapping of relativistic electrons in the ponderomotive potential well of the optical lattice is studied in detail using Particle-In-Cell (PIC) simulation results of an injection code.

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36. Wendwesen GEBREMICHAEL

Optical Characterization of Amplifier Media

Yb-doped borate type-Yb:$Li_6(Y/Gd)(BO_3)_3$-monoclinic crystals

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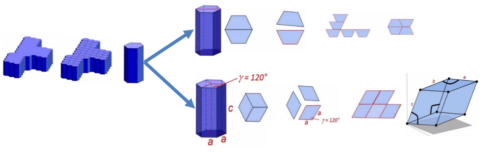
Context

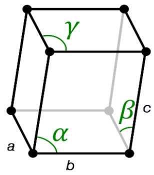
Crystals are solid materials which constitute atoms, molecules or ions with **periodic** arrangement extending in all three spatial dimensions.



The Fascination of Crystals and Symmetry (iversity.org)

Efficient use of **laser materials** requires full characterization of their **absorption** and **emission** properties. These properties can be described with **3-by-3** second rank linear **permittivity tensor**.

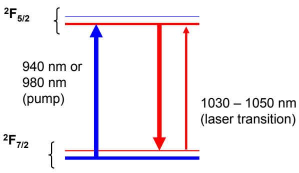
In the case of monoclinic crystals, the maximum values of absorption and fluorescence are not along the principal axes of the dielectric frame, but tilted at an angle with respect to one of the axes of dielectric frame.



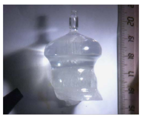
Ytterbium-doped laser materials

Why Yb-doped materials?

- Absorption spectrum ⇒ direct diode-pumping
- Low quantum defect ⇒ high power operation
- Broad gain bandwidth ⇒ (ultra)short pulses



Example: new borates of type: $Li_6(Gd_{(1-x)}Y_x)_{0.75}Yb_{0.25}(BO_3)_3$



Absorption and emission cross sections of Yb:LYB

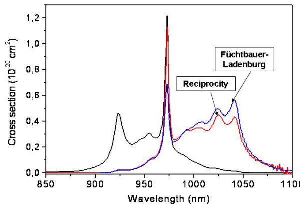
→ **Typical signature** of Yb-doped materials

However :

Quasi - 3 - level structure

→ reabsorption at lasing wavelength

→ strong pumping necessary



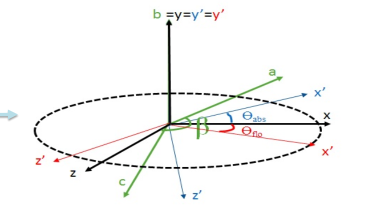
Relationship between Crystallographic Axes and Relative Dielectric Permittivity Tensor

Monoclinic crystals : considering *y//b*

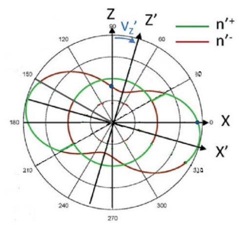
$$\bar{\bar{\varepsilon}}_r = \bar{\bar{\varepsilon}}_r'(\omega) + j\bar{\bar{\varepsilon}}_r'' = \begin{bmatrix} \varepsilon_{r_{xx}} & 0 & 0 \\ 0 & \varepsilon_{r_{yy}} & 0 \\ 0 & 0 & \varepsilon_{r_{zz}} \end{bmatrix} + j \begin{bmatrix} \varepsilon'_{r_{xx}} & 0 & \varepsilon'_{r_{xz}} \\ 0 & \varepsilon'_{r_{yy}} & 0 \\ \varepsilon'_{r_{xz}} & 0 & \varepsilon'_{r_{zz}} \end{bmatrix}$$

diagonal (light splits and propagates the principal axis of the dielectric frame)

Off diagonal (rotation in xz plane)



$(a,b,c)_{crystal} \neq (x,y,z)_{dielectric} \neq (x',y',z')_{absorption} \neq (x',y',z')_{fluorescence}$



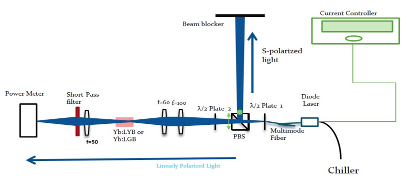
Determination of « Good » Absorption Axis

Preparation of Samples:

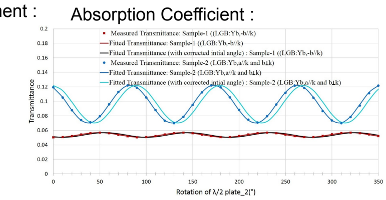
Direction of Cut	LGB:Yb 22%	LYB:Yb 26%	Properties accessed
Face ⊥ b (i.e. b // k or -k)	Sample 1	Sample 3	$\varepsilon'_{r_{xx}}, \varepsilon'_{r_{zz}}$
Face // b with a or c // k or -k	Sample 2	Sample 4	$\varepsilon'_{r_{yy}}, \varepsilon'_{r_{xz}}$

	LGB:Yb		LYB:Yb	
	Sample 1	Sample 2	Sample 3	Sample 4
Experimental Orientation				
Crystallographic Orientation				
Thickness (cms)	0.176	0.133	0.137	0.178

Setup for polarization-dependent absorption measurement :

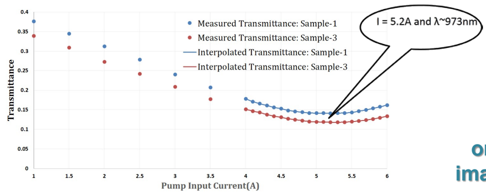


Absorption Coefficient :



$$\alpha(\theta) = -\frac{1}{L} ln \frac{\{T_{max}cos^2[2(\theta - \theta_{initial\_\lambda/2})] + T_{min}sin^2[2(\theta - \theta_{initial\_\lambda/2})]\}}{T^2}$$

Determination of Working point:



$$n'(\omega,\theta,\varphi) = \frac{\alpha(\omega,\theta,\varphi)L}{4\pi}$$

Index Surfaces for the ordinary and extraordinary imaginary refractive indices!!!

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