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AND
MICRO/NANO OPTICS
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PARIS

BOOK OF ABSTRACTS

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Nanophotonics with nanomembrane materials and architectures

Wednesday, 7th December - 09:05 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 437

Prof. Oliver G Schmidt [1]

1. *Leibniz Institute for Solid State and Materials Research Dresden*

Nanomembranes are thin, flexible, transferable and can be assembled into 3D micro- and nanoarchitectures. In case optically active nanomembrane materials are selected many new research paths and exciting future application scenarios open up in nanophotonics. For instance, if semiconductor nanomembrane materials including high quality quantum emitters are transferred onto piezoelectric substrates, high speed and wavelength tunable entangled photon sources can be produced, which could lie at the heart of future quantum communication technologies.

If nanomembranes are differentially strained they deform themselves and roll-up into microtubular structures upon release from their mother substrate. Photonic rolled-up microtubes can be exploited as 3D microcavities to study spin orbit coupling of light or selective opto-plasmonic coupling in vertical ring resonators. Fully on-chip integrated systems offer interesting options for 3D photonic integration and lab-in-a-tube concepts.

Merging micro- and nano-optics

Wednesday, 7th December - 09:40 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 438

Prof. Harald Giessen [1]

1. *University of Stuttgart*

Microoptics has a plethora of applications, ranging from miniature endoscopes in hospitals to beam shaping or imaging. 3D printing with a femtosecond laser and two-photon polymerization allows for manufacturing optical elements directly after their design with an optical CAD program on a computer, with a resolution better than 100 nm and a high accuracy and reproducibility.
The talk is showing first experimental results and discusses the different possibilities and perspectives. Triplett microscope objectives of only 100 µm diameter with excellent imaging properties, fitting into the inside of a syringe, are becoming available with this technology and can be useful for medical applications as well as for novel sensors or inspection methods.
Merging this technology with metasurfaces and plasmonics will be discussed.
[1] T. Gissibl et al., Optica 3, 448 (2016).
[2] T. Gissibl et al., Nature Communications 7, 11763 (2016).
[3] T. Gissibl et al., Nature Photonics 10, 554 (2016).
[4] S. Thiele et al., Opt. Lett. 41, 3029 (2016).

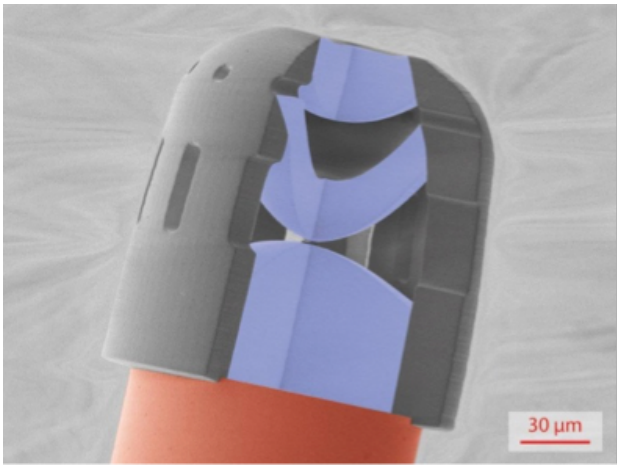


Fig1.png

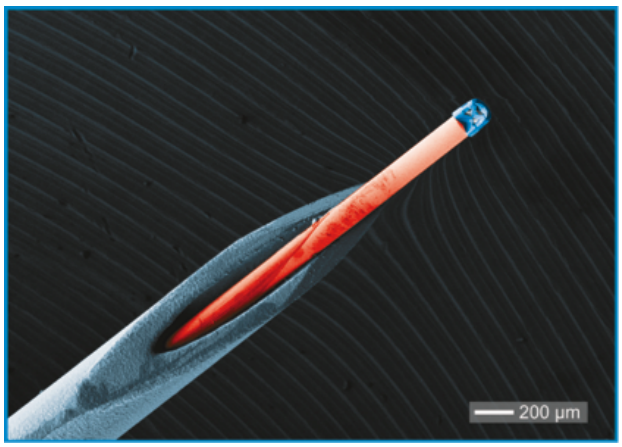


Fig2.png

X-ray Free Electron Lasers: the New frontier of Spectromicroscopy

Wednesday, 7th December - 10:45 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 439

Prof. Giorgio Margaritondo [1]

1. *Ecole Polytechnique Fédérale de Lausanne (EPFL)*

Many decades after the theoretical proposal of x-ray free electron lasers (X-FELs) and after solving formidable technical problems, the first machines of this class were commissioned, first in Stanford and then in several other places. These sources already have a major impact on microscopy for materials science, the life sciences and technology thanks to their fantastic performances. The peak brightness is larger than that of synchrotron sources by many orders of magnitude, the pulse length points to the femtosecond range and the lateral coherence is unprecedented. Recently, the theoretical notion of seeding also became a reality, delivering excellent time coherence and opening the door to sophisticated time-dependent experiments. We will illustrate these exciting developments by first introducing the basic concepts of the X-FEL operation in very simple terms. Then, we will present a selection of recent microscopy results and briefly discuss the possible future developments.

Fermiaerial.jpg

Plasmonic Raman microscopy for nano, 3D, and deep UV imaging

Wednesday, 7th December - 11:20 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 332

Prof. Satoshi Kawata [1]

1. *Osaka University*

Raman microscopy has been getting popular in nanomaterials and biosciences, and industry of advanced materials and devices, as it provides richer information than other imaging techniques without any process to damage samples. However, Raman scattering is a weak phenomenon and the spatial resolution is usually limited by the diffraction of probing light. Both these problems can be overcome with use of a metallic tip, which provides local enhancement of light in the focused light spot [1]. The spatial resolution is limited by the diameter of metallic tip (typically 10nm) to excite collective electron oscillation as localized mode of surface plasmons at the tip [2]. The factor of Raman scattering is enhanced by the tip due to the plasmon resonance similarly to the mechanism of surface enhanced Raman scattering. The effective spectral range is typically between near UV to near infrared for silver and gold. In this presentation, I will show our research progress in plasmonic Raman microscopy or TERS (tip-enhanced Raman scattering) microscopy beyond the limitations. The spatial resolution has been drastically improved by applying pressure on to the sample with a tip to introduce the localized structural deformation in sample [3]. The broadband enhancement by cascading the probe antennae [4], the deep UV resonant Raman TERS [5], and 3D Raman imaging with a gold nano-particle inside a living cell [6] will be discussed.

[1]Y. Inouye and S. Kawata, Opt. Lett. 19, 159, 1994.
[2] S. Kawata, Y. Inouye, P. Verma, Nature Photonics. 3, 388 (2009).
[3]T. Yano et al., Nature Photonics, 3, 473 (2009).
[4]S. Kawata, A. Ono, P. Verma, Nature Photonics, 3, 473, (2009).
[5]A. Taguchi, et. al., J. Raman Spectrosc. 40, 1324, (2009).
[6] J. Ando, et. al, Nano Lett. 11, 5344 (2011).

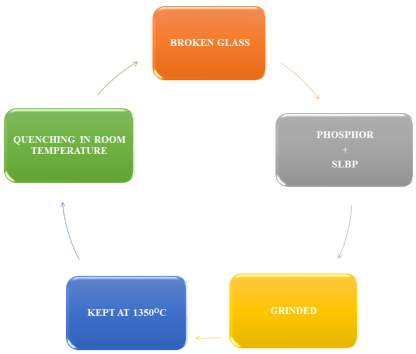
Development of Nanoceramics by Uniform Distribution of Phosphor in Broken Glass Materials Through Recycling Routes for WLED applications

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 8

Mr. Nimmakayala Prudhvi Raju [1], ***Dr. Gurram Giridhar*** [2], ***Prof. Man Singh*** [1]

1. *CENTRAL UNIVERSITY OF GUJARAT,* ***2.*** *Acharya Nagarjuna University*

The process of transmuting waste materials in to the useful products is possible through recycling process. Therefore, this research work has been planned to achieve high efficiency White Light Emitting Diodes (WLED'S) using the broken glass materials. The demand for the high efficiency LED's is increasing due to current scenario of energy crisis across the globe. The earlier LED's had limited performance and less life span. These limitations can be overcome by fabricating the luminescent based nanophosphor materials in high range temperature. In recent times, innovation in advance research focused on phosphor in glass (PIG) materials. This can be achieved by dispersing phosphor in 10-30% glass matrix. However, it is quite expensive to fabricate. Considering all these peculiarities, the objective of the work is to achieve high efficiency, low cost, long life span LED's to meet and the energy demands. A novel nanoceramic material, by the combination of nanophosphor in broken glass (PIBG) material has been developed. The nanophosphor materials has been synthesized by Dy3+ doped with Strontium Aluminium Oxide ($SrAl_2O_4$) through solid state reaction which is fabricated at 1350°C. The average crystal size of pure nanoparticles are found to be 35nm which is characterized by X-Ray Diffraction technique. By dispersing the certain amount of phosphor in broken glass materials, the average crystal size of the PIBG materials was found to be 13, 14, and 45 nm. The SEM & HRTEM reveals that, the surface morphologies of the pure nanoparticles are spherical in shape. The PIBG materials was found to have uniform distribution of particles at 2:9 ratio. The results of HRTEM studies reveals the particle size of Dy3+:$SrAl_2O_4$ nano particles of 27-42 nm which corroborates approximately to the average crystal size calculated from XRD. Besides, our approach had achieved the remarkably transparent optical properties at 2:9 ratio from the data obtained from luminescence spectra. The CIE co-ordinates acclaimed that the broken glass matrix with combination of Dy3+:$SrAl_2O_4$ nanoparticles is suitable for white emission.



Process of recling.png

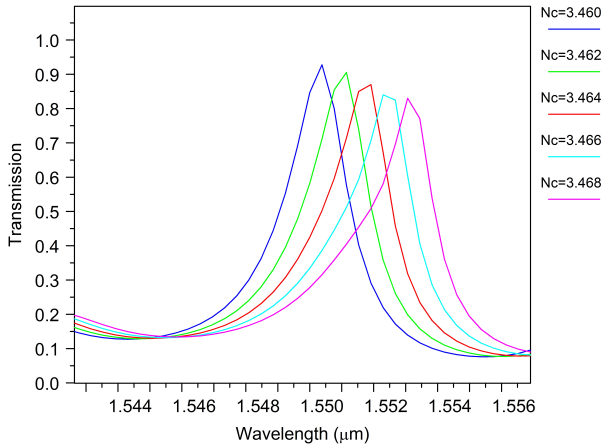
Narrowband Photonic Crystal THz Compact Filter Based on Microring Resonators

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 76

Dr. Hamed Alipour-Banaei [1], ***Mrs. Mahsa Jahanara*** [2], ***Mr. Farhad Mehdizadeh*** [2], ***Mrs. Behnaz Amini*** [1]

1. *Department of Electronics, Tabriz Branch, Islamic Azad University, Tabriz, Iran,* ***2.*** *Young Researchers and Elite Club, Urmia Branch, Islamic Azad University, Urmia, Iran*

Photonic crystal microring resonators are promising candidates for realizing all optical filters with acceptable transmission efficiency and quality factor values. In this paper, by putting a hexagon-shaped structure at the middle of on 7*7 square cavity, we created a microring resonator structure and designed a narrowband channel drop compact filter. The drop wavelength of the proposed filter is at 1550.4 nm, with transmission efficiency and quality factor equal to 94% and 707. Our structure is composed of dielectric rods immersed in air. Because in this kind of structures the dominant band gap is in TM mode, all of our simulations have been done in TM mode. The total footprint of the proposed THz filter is 199.4 □m2, which makes it suitable for all optical integrated circuits. The parameters of the proposed structure proving that this block is suitable for optical communication systems and the frequency ranges are in the communication application window.



Narrowband photonic crystal.jpg

Unified Scattering Parameters formalism in terms of Coupled-Mode Theory for investigating hybrid single-mode/two-mode photonic interconnects

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 247

Dr. Yann BOUCHER [1], ***Dr. Alberto PARINI*** [1], ***Prof. Patrice FERON*** [1]

1. *CNRS Foton (UMR 6082)*

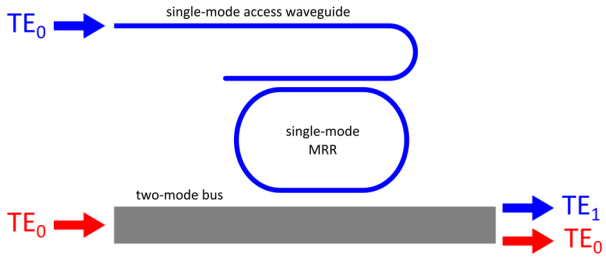
Hybrid single-mode/multimode optical interconnects tend to become all-pervading in Photonic Integrated Circuits (PIC) involving Modal Division Multiplexing (MDM), where information is distributed over different spatial modes sharing the same wavelength. Mode add-drop multiplexing is typically achieved by means of asymmetric directional couplers between single and multimode waveguides, whose dimensions are designed in order to enable an index-matching condition between the modes to be coupled.

In terms of Coupled-Mode Theory (CMT), each mode-to-mode coupling is described by two quantities: a detuning (or mismatch between the propagation constants in the k-space) and a coupling constant (whose physical origin lies in evanescent tunneling), both rendered dimensionless by way of spatial integration over the total interaction length.

We apply this formalism to characterize a typical ring-based mode multiplexer (see Figure). For the sake of clarity, we consider only the TE state of polarization. This structure consists of a narrow access waveguide and a micro-ring racetrack resonator, both designed to guide only the fundamental TE0 mode. A second coupled waveguide (bus) is dimensioned to support both its TE0 and TE1 modes. Waveguide widths can be arranged so that the effective index of the TE0 mode of the narrow waveguide matches that of the TE1 mode of the wide (bus) one, thus ensuring a high coupling efficiency. Importantly, the presence of the micro-ring limits the modal power conversion only to signal tuned on its resonant wavelengths.

The key feature of our approach is the way we treat the two-mode output waveguide as formally equivalent to a set of two identical, mutually coupled single-mode waveguides (which amounts to a mere change of basis, as far as the even/odd modes of the two-mode waveguide are concerned). The simultaneous co-directional interaction between the three scalar waves is solved analytically as a function of the mismatch and the coupling constants. As a result, we obtain a closed-form expression of the scattering parameters relating the single-mode input to the even- or odd-mode output.

This approach can prove of interest for the systematic investigation of short-range optical interconnects, notably in terms of tolerances to technological or geometrical parameters.



Add-drop resonant modal converter for mdm optical interconnect.png

Structural and optical properties of ZnTe thin films growth by PLD

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 255

Prof. francisco ochoa [1], Dr. Israel Mejia [2], Dr. Ana Lilia Leal-Cruz [1], Dr. Alicia Vera [1], Dr. Manuel Quevedo [2]

1. *Universidad de Sonora,* ***2.*** *University of Texas at Dallas*

F.J. Ochoa-Estrella1, I. Mejia2, A. Vera-Marquina1, A.L. Leal-Cruz1, and M. Quevedo-López2.
1Departamento de Investigación en Física, Universidad de Sonora, Rosales y Luis Encinas, Hermosillo, Sonora, 83000, México
2Department of Materials Science and Engineering, University of Texas at Dallas, USA.

Abstract
Thin films of ZnTe have been prepared by pulsed laser deposition technique. Several experiments were performed considering stoichiometric condition at 559 K and pressure was varied as follows: 1, 10, 20, 50, and 100 mT. Deposited films were characterized by using X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman spectroscopy, and UV-Vis spectroscopy. Structural investigations performed by X-ray diffraction technique showed that studied samples are all polycrystalline, belonging to the cubic phase of zinc-blende with a preferential orientation in the plane (111). Also, XRD patterns were used to determine the microstructural parameters, such as: crystallite sizes and lattice constants. Surface morphology studies by SEM shows grain clusters in a circular pattern distributed over the entire surface of the substrate. Film thicknesses and grain size behaviors show an increase as function of pressure increasing. Optical properties of ZnTe films were extensively studied in the range of incident light wavelength (400 to 1000 nm), exhibiting band gap values between 2.51 and 2.58 eV.

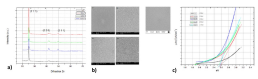


Figure 1. Characterization results of ZnTe thin films deposited by PLD (a) XRD Patterns, (b) SEM morphology, and (c) optical behavior.

Figures znte.png

Effect of graphene oxide concentration on structural, optical and photocatalytic performance of RGO/CeO2 nanocomposites

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 261

Ms. JASMEET KAUR [1], ***Mrs. Kanica Anand*** [1], ***Prof. Ravi Chand Singh*** [1]

1. *Guru Nanak Dev University, Amritsar*

The decoration of metal oxide nanoparticles on reduced graphene oxide (RGO) has sparked research interest in scientific community as they holds promise for various applications such as photocatalysis, chemical sensors and supercapacitors etc [1-3]. In present work, CeO2 nanoparticles were decorated on RGO by in-situ reduction of different concentration of graphene oxide (GO) in the presence of cerium nitrate and hydrazine hydrate through hydrothermal method. The as-synthesized RGO/CeO2 nanocomposites with 0.0, 2.0 and 4.0 wt. % of GO were labelled as CeO2, RG1 and RG2, respectively. All the samples were characterized by x- ray diffraction (XRD), Raman spectroscopy, diffuse reflectance spectroscopy (DRS), photoluminescence spectroscopy (PL) and transmission electron microscopy (TEM). The XRD patterns and Raman Spectra confirmed the cubic fluorite structure for all the samples. A blue shift for F2g mode of CeO2 was observed in Raman spectra of RGO/ CeO2 nanocomposite (Fig.1) as compared to pure CeO2. TEM micrographs showed that CeO2 nanoparticles were decorated uniformly on the RGO sheets. The size of CeO2 nanoparticles formed in the presence of GO were larger as compared to pure CeO2. DRS spectra showed significant bandgap narrowing for nanocomposites. Photoluminescence quenching was also observed for nanocomposites. Further, we investigated the photocatalytic performance of nanocomposites for the degradation of methylene blue (MB) and found that optimum amount of GO was crucial for enhancing the photocatalytic performance of nanocomposites.

References

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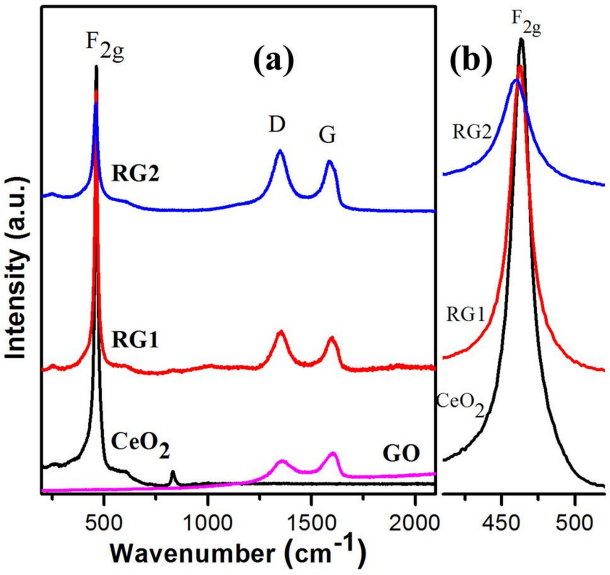
2.Kaur, J., Anand, K., Anand, K., Thangaraj, R., Singh, R.C., Indian J Phys,10 1183–1194 (2016)

3.M. Srivastava, A.K Das, P. Khanra, M.E. Uddin, N.H. Kim and J.H. Lee, J. Mater. Chem. A 1, 9792-9801 (2013).



Raman final.jpg

Exploration of new surface patterns for nanophotonics

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 322

Ms. shahla Golghasemi sorkhabi [1], ***Prof. Regis Barille*** [2], ***Dr. Sohrab Ahmadi-kandjani*** [3]

1. *University of Angers/University of Tabriz,* ***2.*** *University of Angers,* ***3.*** *University of Tabriz*

Nano-science is an interdisciplinary field for the future development in technologies. Progress toward smaller features is of great importance in nanofabrication in order to explore unique functionalities for nanophotonics and nano-biotechnology. We are currently facing an explosion of novel ideas and strategies with fusion of bottom-up and top-down strategies[1]. In this regard, thin films of polymers containing azobenzene chromophores have received much attention due to their potential in the emerging field of controlled nanostructure formation[2]. Here, we experimentally show a simple bottom-up approach to produce cavity shaped nanostructures on the surface of azopolymer thin films by the choice of solvent-droplet-induced-dewetting method and incoherent unpolarized light illumination. We use the special properties of azopolymer with illumination of these nanostructures by a polarized laser light showing the possibility of further growth and reshaping of structures (Figs.1-3). Cavity shaped nano-structures will give a point of interest owing to their applications in nano-plasmonics, photochemistry, nano-rectors and sensors. Smart nano-cavities with controllable volumes and shapes can be investigated as plasmonic traps for photo-catalytic and enzyme reactions. Also, these patterns present the possibility of creating controllable nano-structures as a nano-environment for trapping nanoparticles[3]. We will show examples exploiting these possibilities.

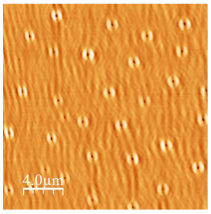


Fig. 1 - Topographical images of the azopolymer film after laser illumination

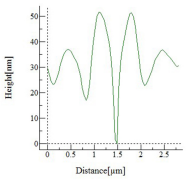


Fig.2 - corresponding height cross-section of a cavity shape structure

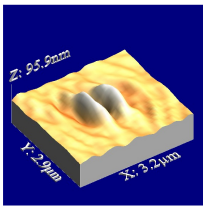


Fig.3 - Three-dimensional AFM image of nano-structures formed on surface of Azopolymer film under laser radiation

3 in one.jpg

Photo-Induced Enhanced Raman spectroscopy (PIERS) for detection of ultra-trace levels of Explosives.

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 114

Mr. Sultan Ben Jaber [1], ***Prof. Ivan Parkin*** [1]

1. *University College London*

Surface enhanced Raman spectroscopy SERS is a powerful technique for highly sensitive and selective detection and identification of trace levels of a wide range of important molecules. Strong SERS enhancement even for low Raman cross-section materials, i.e. explosives can be achieved when their molecules adsorb on a roughened noble metal nano structures. There are two mechanisms contribute to the SERS enhancement, one is the electromagnetic enhancement (EM) where the electric filed modified due to the physisorpotion interaction between incident photons and nobel metal nanoparticles. The other mechanism is the chemical enhancement via polarizability and electron charge transfer as a chemisorption interaction occurs where there is a resonant charge transfer between adsorbent molecules and the metal particles [1, 2].

In this work, we propose a new Raman enhancement method titled 'Photo-Induced Enhanced Raman Spectroscopy' (PIERS), where photoactivited semiconducting metal oxide substrates (TiO2 or ZnO) combined with plasmonic nanoparticles (NPs) provide strong Raman signal enhancement and increase the sensitivity beyond normal SERS [3]. In PIERS, the substrate (TiO2 or ZnO) coated by either gold NPs or silver NPs were irradiated with 254 nm light, followed by deposition of an analyte and Raman measurement. We have observed strong enhancement for PIERS over typical SERS with no pre-irradiation. We propose a mechanism for PIERS whereby electrons migrate from the photo-excited semiconductor substrate to the metallic NPs, leading to increase electron density on the NPs, and as a consequence provide further enhancement, via increased chemical enhancement over and above the SERS enhancement. Increasing the electron density on the metallic particle was demonstrated by measures of localised surface plasmon resonance shifting and time dependant measures of PIERS enhancement.

References:

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3.Ben-Jaber, S., et al., Photo-induced enhanced Raman spectroscopy for universal ultra-trace detection of explosives, pollutants and biomolecules. Nat Commun, 2016. 7.

Photoluminescence quenching and negative diamagnetic shift in GaP-InP lateral nanowires

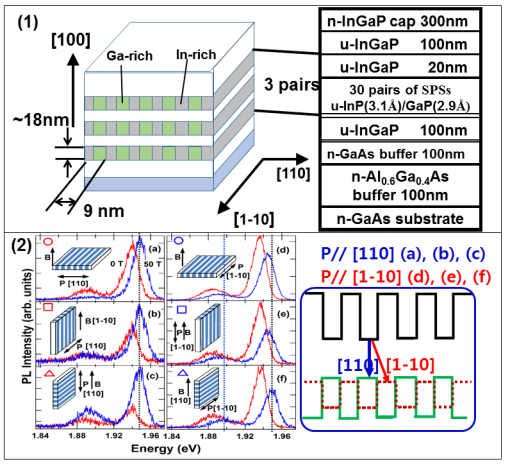
Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 156

Prof. Yongmin Kim [1], ***Dr. Jindong Song*** [2], ***Dr. Yongho Shin*** [1], ***Dr. Daisuke Nakamura*** [3], ***Prof. Yasuhiro Matsuda*** [3], ***Prof. Shojiro Takeyama*** [3]

1. *Department of Physics, Dankook University,* ***2.*** *Korea Institute of Science and Technology,* ***3.*** *University of Tokyo*

The general behavior of the exciton diamagnetic shift is quadratic in low magnetic fields (ΔEdia□B2) and linear in high magnetic fields (ΔEl□B). A negative energy shift is difficult to imagine when using the features of the normal diamagnetic shift. In this work, we report the magneto-exciton transitions of an InP/GaP lateral nanowire structure that was grown using a lateral composition modulation (LCM) growth technique. Linearly polarized photoluminescence (PL) measurements were made under pulsed magnetic fields to 50 T. We observed the normal diamagnetic shift from the direct InP nanowire transition and PL intensity quenching below 60 K at B=0T. However, the indirect InP-GaP transition exhibits no energy shift or negative energy shift depending on the magnetic field directions.

Fig. (1) depicts a schematic of the sample structure wherein three layers of lateral nanowires are aligned along the [1-10] direction. Fig. (2) shows the band alignments of the lateral nanowires (direct and indirect) and their PL transitions in different magnetic and polarization directions. Figure (c) alignment (indirect transition) shows strong negative diamagnetic shift. The direct transition exhibits PL intensity quenching behavior below 60 K. We will discuss negative diamagnetic shift and PL quenching by exciton center of motion and mobility enhancement, respectively



2016 nanop.png

Excitonic optical response of Carbon nanotubes

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 187

Mr. Farzad Bonabi [1], ***Prof. Thomas Garm Pedersen*** [1]

1. *Aalborg university*

In this work, we provide the calculation of optical response of single wall carbon nanotubes (CNT) with and without excitonic effects. We implement the excitonic effects using two methods, first Bether-Salpeter and second the Wannier model and focus on semiconductor CNT. We show that electron hole potential has a huge effect in the optical absorption, so there is a considerable exciton binding energy. We also compare the results of these methods and show the results are very similar.

Thermal bistability control with four-wave mixing in microcavities

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 279

Mr. Luigi Di Lauro [1], ***Mr. Li Jin*** [2], ***Prof. Sai T. Chu*** [2], ***Dr. Marco Peccianti*** [1], ***Dr. Alessia Pasquazi*** [1]

1. *University of Sussex,* ***2.*** *City University of Hong Kong*

Doped silica glass optical microcavities with high refractive index and silicon nitride integrated platforms have been widely studied to produce and enhance nonlinear optical microcomponents. Bistability and multistability have been observed in these devices offering an improvement for ultrafast optical applications. Numerical approaches to describe bistability in semiconductor nanocavities have been investigated [1], while experimental evidence of bistability and multistability in high-index silica micro-ring resonators has been shown experimentally [2].

In this work we present a numerical model to study bi-stable response in a single micro-ring resonator and to predict nonlinear dynamics, using the coupled mode theory (CMT). Stable oscillations appear when the system is perturbed from its initial steady state (stable or unstable), coupling a further optical field (probe) as input. By increasing the intensity of the probe above a power threshold of a few mW, self pulsing (SP) regime is achieved through a bifurcation mechanism. This behaviour is mainly due to the opposite contributions of Kerr and thermal detuning effects. The phase matching condition considered excludes the possibility to reach the parametric gain regime. In this scenario, one of the interesting applications is the realisation of integrated optical components for all-optical switching exploiting SP triggered by a week probe signal.

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Lithographically patterned silicon nanostructures for optical gas sensing

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 312

Ms. Agnieszka Gwiazda [1], ***Dr. Anna Rumyantseva*** [1], ***Dr. Anisha Gokarna*** [1], ***Dr. Bijal Kottukkal Bahuleyan*** [2], ***Dr. Françoise Chuburu*** [2], ***Dr. Cyril Cadiou*** [2], ***Dr. Jérémy Mallet*** [2], ***Prof. Gilles Lerondel*** [3]

1. *University of Technology of Troyes,* ***2.*** *University of Reims Champagne-Ardenne,* ***3.*** *Univesity of Technology of Troyes*

Silicon offers excellent electronic and mechanical properties and can be easily engineered at the nanometer scale which is useful for a large amount of applications such as in electronic devices, self-cleaning, MEMS and solar cells. Silicon which is an indirect band gap semiconductor cannot be used as an efficient light source. On the other hand large scale, well-ordered, periodically patterned silicon structures with a high aspect ratio such as nanowires (NWs), can be used for optical sensing. Synthesis of silicon NWs using a simple and an inexpensive technique, however, still maintaining the advantages of conventional techniques, is now the major challenge. The aim of this work is to present a new approach of obtaining NWs and nanostructures from crystalline silicon by using a top-down technique which is a combination of laser interference lithography and reactive-ion etching (RIE). As in the case of conventional dry etching technique, where one uses metal as a mask, in our study we use zinc oxide as a hard mask for etching. The advantage of using ZnO is that it is easy to structure it using acidic solutions. Moreover, we avoid the various lift-off steps which are necessary for metallic mask structuring. The main goal is to obtain photoluminescent silicon structures for optical gas sensing applications. The surface of silicon structures having a high aspect ratio (as shown in figure 1(a) below), is functionalized using lanthanide complexes (fig.1(b)) which are photoluminescent. Detection of gas molecules using these functionalized silicon surfaces is based on a selective "quenching of luminescence ", which can be induced in the presence of an analyte (gas molecules).

Fig.1: luminescent silicon nanowires: a) Example of silicon nanostructures, b) Silicon surface modified with the terbium complex, c) Photoluminescence from terbium functionalized silicon structures.

Widely tunable near-IR monolithic coherent source

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 327

Ms. Alice Bernard [1], Mr. Valerio Flavio Gili [1], Dr. Marco Ravaro [1], Dr. Ivan Favero [1], Dr. Michel Krakowski [2], Dr. Michel Garcia [2], Dr. Vincent Parrillaud [2], Dr. Bruno Gérard [2], Dr. Jean-Michel Gerard [3], Prof. Giuseppe Leo [1]

1. *Université Paris Diderot,* ***2.*** *III-V Lab,* ***3.*** *INAC-CEA*

The InP and GaAs platforms, well known for their mature laser-diode technology, allow for efficient optical frequency conversion on chip thanks to their strong quadratic nonlinearity and broad transparency range. Based on these features, we report on the design and preliminary characterization of a monolithic widely tunable near-IR parametric source.

Two spontaneous-parametric-down-conversion (SPDC) sources are studied. The first one relies either on a GaAs/AlGaAs laser diode operating as a pump at 1 µm or on an InGaAsP/InP diode with laser emission at 1.55 µm, with intracavity SPDC from 1.8 to 2.3 µm or around 3 µm, respectively. In the second one, two superposed cavities for laser emission and SPDC are coupled through a vertical tapered coupler. These designs are accompanied by a characterization of GaxIn1-xAsyP1-y refractive index in the near-IR range up to 3 µm, where this alloy has never been studied despite its common use in the telecom range. The material index is determined with a precision of 0.001 in m-line measurements, extending the wavelength range where it was known and significantly improving the experimental accuracy. Three alloy compositions (y = 0.6, 0.7, 0.75) and three wavelengths (0.55, 2.1 and 3.1 µm) are spanned.

This work is promising for a continuous-wave parametric source on chip, with wavelength tunability up to 500 nm and a peak power of a few milliwatts, enough for out-of-the-lab spectroscopy applications.

NANO-BIOADHESIVE OPTICAL EYE LENS FOR CORNEAL PERFORATION

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 395

Dr. Danial Khorsandi [1], ***Ms. Zahra Madadi*** [2]

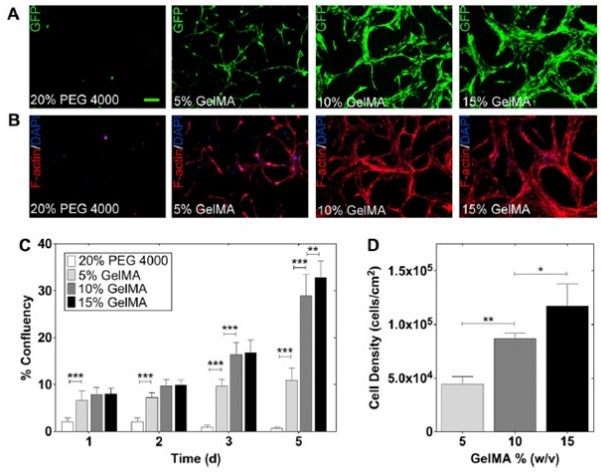
1. *Harvard-MIT's Division of health science and technology,* ***2.*** *Azad University of North Tehran*

Reliable closure of the cornea wounds after trauma or disease as well as incisions for cataract, LASIK, corneal transplant, and other ophthalmic surgeries needs special care and immediate treatment, yet remains one of the key challenges of the clinical medicine. This originates from the crucial role of the corneal structure and curvature in the eye's overall function, as the improper adjusting of the wound edges during the healing causes astigmatism. Moreover, the inflammation of the cornea can lead to vascularization and reduce the transparency of the tissues and patient's visual acuity.

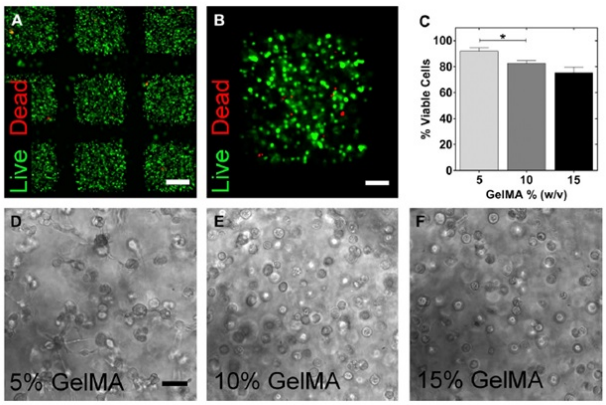
Herein, we synthesized a Nano-bioadhesive lens which not only circumvents such shortcomings, but also (i) rapidly and strongly adheres to the moist corneal surface, and seals the wound; (ii) have biomechanical properties (rigidity and elasticity) similar to the cornea; (iii) be bioabsorbed in the wound on a time scale proportional to the tissues regeneration and (iv) provide a microbial barrier.

Inspired by the gelatin-based hydrogels which have been successfully used in many biomedical applications, we synthesized and systematically optimized a gelatin-based bioadhesive, which can meet mechanical and adhesion properties of the corneal wound adhesive; assessed its degradation, retention and biocompatibility both in vitro and in vivo (using the corneal injury model in rabbits); evaluated the capacity of the corneal cells to integrate into produced gel to permit tissue regeneration; and covalently integrated antibacterial and antifungal drugs into the gel, and subsequently assessed their antimicrobial effects both in vitro and in vivo.

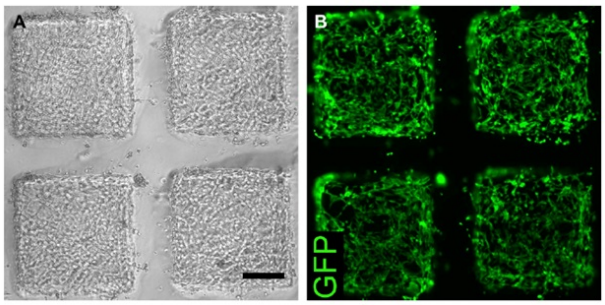
These data suggest that NANO-BIOADHESIVE lenses could be useful for creating complex, cell-responsive microtissues, such as endothelialized microvasculature, or for other applications that require cell-responsive microengineered hydrogels.



Cell adhesion proliferation and migration on gelma surfaces.jpg



Characterization of embedded cell behavior in micropatterned gelma.jpg



Selective binding to gelma micropatterns.jpg

Fabrication and characterization of Au dimer antennas on glass pillars with enhanced plasmonic response

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 415

Mr. Pedram Sadeghi [1], ***Dr. Kaiyu Wu*** [2], ***Dr. Tomas Rindzevicius*** [2], ***Prof. Anja Boisen*** [2], ***Prof. Silvan Schmid*** [1]

1. *TU Wien,* ***2.*** *Technical University of Denmark*

Introduction

Localized surface plasmon resonance (LSPR) in strongly coupled subwavelength metal nanoparticles has been studied extensively due to the potential applications in plasmonic sensing and surface-enhanced Raman spectroscopy (SERS). Recent studies have shown that “elevating” the nanoparticles results in even larger field enhancements, due to less screening of fields by the substrate. However, as the pillar height is increased, new plasmonic modes arise, which can change measured spectra significantly. Here, we present dark-field measurements of round Au dimer antennas on top of transparent SiO2 pillars. Placing the nanoparticles on 240 nm tall pillars results in an enhanced plasmonic response compared to the case without pillars. At 480 nm pillar height, a pronounced dip in the scattering spectrum is observed, which can be understood through a analysis of the measurement geometry.

Methods

Nanodisk dimer arrays are defined using electron-beam lithography with well-defined gaps from 15-30 nm. This is then followed by gold deposition and liftoff. Finally, nanopillars are defined using reactive-ion etching (RIE) with the nanoparticles functioning as an etch mask. A schematic of the fabrication process is given in figure 1a and an SEM image of a single dimer is shown in figure 1b. A high-density array of nanopillar dimers is shown in figure 1c.

Optical scattering spectra are measured with an optical dark-field microscope (Nikon Ti-U, NA = 0.9-1.0) in transmission mode. Light scattered by the sample is collected by a dark-field objective (Nikon, NA = 0.7, 60x) and sent to a high-sensitivity spectrometer (Andor, SR-303i) equipped with an EMCCD (Andor Newton) detector. A schematic of the setup is given in figure 2a. All measured spectra are averages of 10 nanopillar dimers separated by 5 um, with dark-field images of arrays with pillar heights of 240 nm and 480 nm given in figure 2b and 2c, respectively.

Results and Discussion

Figure 3a shows measured scattering spectra with (blue) and without (red) nanopillars, with the pillar height being 240 nm. A clear enhancement of the plasmonic response is observed, attributed to reduced substrate interaction. FDTD simulations of the reponse reproduce this trend very well, as shown in figure 3b.

Figure 3c and 3d show measured and simulated (FEM) scattering spectra, respectively, of dimer nanoantennas with 240 nm (blue) and 480 nm (red) pillars. The spectrum for the 240 nm pillars is dominated by a single peak at x nm, which is the expected coupled LSPR mode of the dimer. However, the 480 nm spectrum displays a pronounced dip at 680 nm. The simulations reproduce the data for the 240 nm qualitatively, while the 480 nm simulation only shows a single peak at x nm, as would be expected for the coupled mode.

The FEM simulations were performed with the incoming light perpendicular to the substrate surface. However,

the actual measurements are done with a 64 degrees angle. Furthermore, the finite opening angle of the objective means that only some of the light is captured. By adjusting the simulations so that only light scattered from the top and bottom surface of the nanoparticle is detected, the spectra appear very similar to the measured ones.

From field distribution plots, it appear that a secondary mode forms at around x nm, which scatters the light in directions parallel to the substrate. Since only forward scattered light is captured in the experiments, a dip is formed in the spectra at the given wavelength.

Conclusion

The findings presented here shows that, even though the response of nanoantennas are enhanced using nanopillars, the results are not always intuitive and calculations have to be adjusted accordingly.

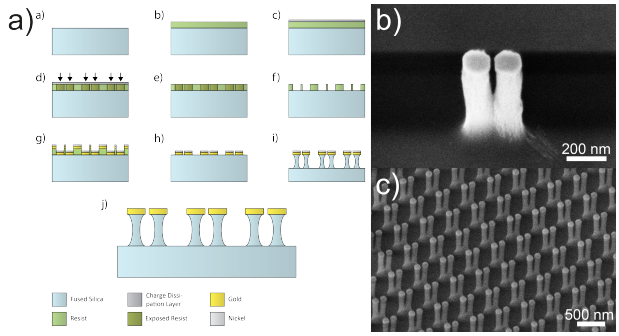


Figure1.png

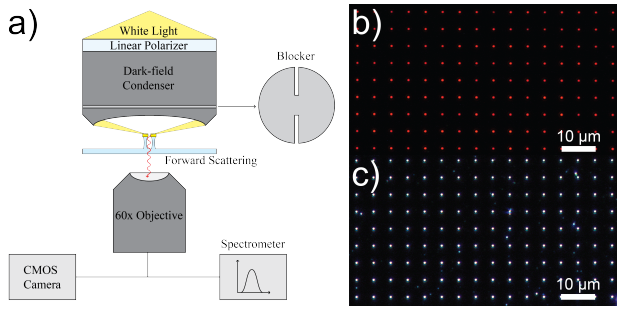


Figure2.png

How Plasmonic excitation influences the LIPSS formation on diamond during multipulse femtosecond laser irradiation ?

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 432

Dr. Bedrane Zeyneb [1], ***Mr. Abdelmalek Ahmed*** [2], ***Dr. El-Hachemi Amara*** [3], ***Dr. Shane Eaton*** [4], ***Prof. Ramponi Roberta*** [4]

1. *Tlemcen University,* ***2.*** *Tlemcen,* ***3.*** *CDTA,* ***4.*** *Politecnico di Milano*

Laser Induced Periodic Surface Structure, also called "ripples or nanograting" are part of morphologies that have focused the interest of several researchers and have been on the heart of a lot of studies since the first experiment done by Birnbaum in 1965 where two types of training LIPSS formation were observed during the irradiation of dielectric, semiconductor and metals by multipulse femtosecond laser linearly polarized, called low spatial frequency LIPSS (LSFL) and high spatial frequency LIPSS (HSFL).

LSFL formation for the majority of materials is well explained by the interference between the incident laser wave and the plasmon polaritons SPP surface. But HSFL formation remain a misunderstood phenomenon and it is still under discussion.

There are several models proposed and many studies were done to identify the origin of formation of this such type of LIPSS on dielectric and semiconductor, induced by multipulse laser femtosecond at low fluency. In such cases, the non-thermal interaction and plasmon excitation play a very important role, where the HSFL's period is very lower to the incident laser wavelength.

A recent explanation of HSFL formation was proposed by Miyazaki et al [1] and Miyaji et al [2] where they proposed that by increasing the number of low fluence pulses, the periodic nanostructures HSFL can be developed through the non-thermal structure change of the treated surface. The nanoscale ablation due to strong near-fields appears around of sweeling followed by a plasmonic excitation (SPP) to improve the nano-periodicity of irradiated area.

In this work, we illustate the plasmon excitation advantage to training HSFL formation through a general plasmon model that can follow the evolution of training LIPSS formation and changing diamond optical parameters in function of electron plasma excitation. We also proposed an hypothesis that can visualize the importance of plasmonic excitation in the dynamic change of non-thermal fusion like an origin of HSFL nanograting periodic training formation.

[1] K. Miyazaki and G. Miyaji, Physics Procedia 39, 674 – 682 (2012).

[2] G. Miyaji and K. Miyazaki, App. Phys. Lett. 103, 071910 (2013).

A hybrid Ag-CdSe NC based plasmonic metamaterials

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 370

Ms. SooJung Kim [1], Ms. MIHYUN KIM [2], Prof. Heon Lee [1], Dr. SUNGHOON HONG [2]

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Metamaterials are artificial, engineered materials with composited materials and arrangements of nanostructured building blocks. Silver and gold are the most conventional metals for plasmonic metamaterials due to their negative-refractive-index in visible and near-infrared (NIR) ranges, and in addition, relatively low loss than other metals. However, the optical properties of silver and gold cannot be tuned for various metamaterial applications. Many research groups have been studying the controlling of the optical properties of silver and gold by alloying two or more elements for applying to plasmonics and metamaterial applications. And the alternative plasmonic materials with improved optical properties over the traditional materials have been studied.

In this study, we discussed the optical and electrical properties of the coupled Ag NCs and the hybrid Ag-CdSe coupled NPs with various factor such as concentrations. We manufactured the hybrid Ag NCs with CdSe NCs that were covalently linked via short ligand on surface of each NC. And the NCs metamaterial was fabricated by direct nanoimprint process in other to control optical, electronic or magnetic properties based on interaction of the constituent NCs. Experimentally, we used spectroscopic ellipsometry to determine the refractive index of coupled Ag NCs and Ag-CdSe coupled NPs. In case of the coupled Ag NPs, the real part of permittivity is considerably lower than bulk Ag as the near zero negative value. Ag-CdSe coupled NPs showed the different optical properties from Ag NCs and the tunable properties with ratio.

This work was supported by Institute for Information & communications Technology Promotion(IITP) grant funded by the Korea government(MSIP) and the Pioneer Research Center Program through the National Research

Foundation of Korea funded by the Ministry of Science, ICT & Future Planning (NRF-2013M3C1A3063046)

Nanocrystal based metamaterials fabrication by direct nanoimprinting

Wednesday, 7th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 404

Ms. MIHYUN KIM [1], ***Ms. SooJung Kim*** [2], ***Dr. Sung-Hoon Hong*** [1]

1. *3D novel Device Research Section, ETRI,* ***2.*** *Korea University*

In this study, we present the direct nanoimprinting of colloidal nanocrystals for the functional metamaterials nanostructures fabrication. The coupled silver colloidal nanocrystal dispersion are used as a direct nanoimprinting resin, and the PDMS soft mold is used as a imprinting stamp. [1] Using the direct nanoimpring process, the Ag nanocrystal-based nanostructures were fabricated over large areas of up to a few centimeters of nano-pillars, nano-rods, and nano-holes. The direct nanoimprinting with room temperature process allows for the demonstration of these plasmonic nanoscale nanostructures on the rigid substrates as well as, on the various flexible polymers substrates. The optical plasmonic resonances of the nanostructures were tuned by the choice of nanocrystal building block (Ag), the dielectric function of the nanocrystal nanostructure, and the nanostructure geometry and periodicity.

This work was supported by Institute for Information & communications
Technology Promotion(IITP) grant funded by the Korea government(MSIP) (B0117-16-1004) and by the Pioneer Research Center Program through the National Research Foundation of Korea funded by the Ministry of Science, ICT & Future Planning (NRF-2013M3C1A3063046).

Reference

[1] S-H Hong et al, “Chemically Tailored Dielectric-to-Metal Transition for the Design of Metamaterials from Nanoimprinted Colloidal Nanocrystals”, Nanolett. 13(2) 350-357 (2013)

From localized to delocalized plasmonic modes, first observation of superradiant mode in silver random film.

Wednesday, 7th December - 14:30 - Photonic & plasmonic nanomaterials - Optical properties of nanostructures - Tower 24 - Room 101 - Oral presentation - Abstract ID: 224

Dr. Alice Berthelot [1], ***Dr. Jean-michel Benoit*** [1], ***Mr. Ruben Mascart*** [1], ***Dr. Julien Laverdant*** [1]

1. *Institut Lumière Matière CNRS-Université Lyon1*

Semicontinous Plasmonic films, such as random silver films obtained by evaporation on a glass substrate, are very attractive due to the confinement of Electromagnetic (EM) field in sub-wavelength area. When the thickness of the film is reduced down to few nanometers, the samples present discontinuities: silver Nanoparticles (NPs) appear. For a specific metallic surface coverage, the film presents very strong EM fields localized in hot-spots near the percolation threshold. Such concentration of field is already used for enhancing the Surface Enhanced Raman Scattering of single molecule [1]. This singular behaviour results from coexistence of localized and delocalized plasmonic modes. In this contribution, the nature and structure of these modes are investigated by measuring the reflectivity of the film.

Following the transition of plasmonics modes from localized to delocalized resonance, our work has revealed a remarkable intermediate behaviour before the percolation: for 6nm film we observe the coexistence of an absorbing (dark) and reflecting (bright) collective modes that can be addressed by changing incident angle. Theses collective plasmonic modes [2] results from the hybridization of localized plasmon resonance. With similar elliptical polarizations, this dark mode seems to be precursor of Surface Plasmon Polariton, observed for higher silver coverage. “Bright” mode with out-of-plane polarization corresponds to a transverse collective plasmonic resonance, usually with uncoupled oscillation [2]. By increasing the density of metallic nanoparticles in a wavelength scale, we observe an angular squeezing and a spectral broadening of this mode. This behaviour can be explained considering that transverse LSPR of each nanoparticle, all resonant, interact in a collective and coherent way via a common confined light mode: the evanescent wave. Such phenomenom has been described as superadiance in atomic physic [3]. In this regime, radiation rate of superradiant mode increases with the numbers of tied dipoles. This could explain spectral broadening observed in our work and constitutes the first observation of plasmonic superradiance effect in silver random film.

References:

[1] Walter et al. Phys. Rev. Lett., 98, 137401 (2007).

[2] Willingham et al Opt. Exp, 19, 6450 (2011).

[3] R. H. Dicke, Phys. Rev. 93, 99 (1954).

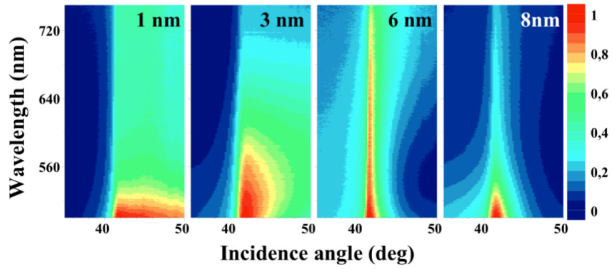


Fig 1: Evolution of Normalized Reflectivity of the sample with incidence angle and wavelength in TM polarization for silver film thickness varying between 1nm and 8nm. Measurements have been realized using Attenuated Total Reflection Experiment.

Evolpt.jpg

Blue emission of Cerium doped Aluminum (oxy)-nitride thin film prepared by reactive sputtering technique

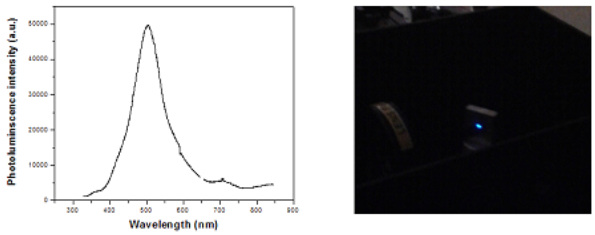
Wednesday, 7th December - 14:47 - Photonic & plasmonic nanomaterials - Optical properties of nanostructures - Tower 24 - Room 101 - Oral presentation - Abstract ID: 102

Mr. Alaa eldin Giba [1], ***Mr. Philippe Pigeat*** [2], ***Dr. Stéphanie Bruyere*** [2], ***Prof. Hervé Rinnert*** [2], ***Dr. Flavio Soldera*** [3], ***Prof. Frank Mücklich*** [3], ***Prof. Raul GAGO-FERNANDEZ*** [4], ***Prof. David Horwat*** [2]

1. *Université de Lorraine and Saarland University,* ***2.*** *Université de Lorraine,* ***3.*** *Saarland University,* ***4.*** *Instituto de Ciencia de Materiales de Madrid*

Recently, blue light emitting solid-state materials received high attention for use in white LEDs and other luminescent applications.In this direction, phosphors doped nitrides and oxy-nitrides composites exhibit strong potential due to their thermal, chemical stability and the possibility to tune their electronic structure to adapt to the required applications. In particular, the III-nitrides (e.g. AlN, GaN) have been considered as suitable host materials for phosphors that emit in UV-visible range due to their large bandgap energy. Thus, the purpose of this study is to induce blue emission from AlN wide bandgap semiconductor using Cerium as a rare earth luminescent dopant.

In the present work, Cerium-doped aluminum nitride (Ce-AlN) thin films were prepared at room temperature using radio frequency (RF) reactive magnetron sputtering. X-ray diffraction and high resolution transmission electron microscopy (HRTEM) revealed a well crystalline textured microstructure with single (002) out-of-plane orientation. Strong blue emission (eye-visible) from the prepared samples was detected when excited by 325 nm laser. Electron energy loss spectroscopy (EELS) has been used to reveal the dominant oxidation state of Ce atoms, which undergoes a change from of Ce4+ to Ce3+ ions after annealing.The chemical composition was analyzed by simulation of Rutherford backscattering spectrometry (RBS). A clear correlation between microstructure, composition and sample photoluminescence (PL) was established. It was found that surface oxidation during the post-deposition annealing plays an important role in the PL response of the samples. We believe that the strong blue emission in this new (oxy)-nitride materials has great potentials for solid state lighting applications due to its thermal and chemical stability as well as the luminescence efficiency. Moreover, the comprehensive approach conducted within this study could serve as a guideline for better understanding and design of the luminescence behavior in rare earth-doped (oxy)-nitride thin films.



Photoluminscence of Ce doped AlN excited by 325 nm laser (on left). Photo reveals the blue emission that can be seen by the naked-eye (on right).

Figure.png

Optical activity in graphene-based cylindrical plasmonic waveguides

Wednesday, 7th December - 15:04 - Photonic & plasmonic nanomaterials - Optical properties of nanostructures - Tower 24 - Room 101 - Oral presentation - Abstract ID: 234

Dr. Dmitry Kuzmin [1], ***Prof. Igor Bychkov*** [1], ***Mr. Valentin Tolkachev*** [1], ***Mr. Ivan Biryukov*** [1], ***Prof. Vladimir Shavrov*** [2], ***Prof. Vasily TEMNOV*** [3]

1. *Chelyabinsk state university,* ***2.*** *Kotel'nikov Institute of Radio-engineering and Electronics of Russian Academy of Sciences,* ***3.*** *Institut des Molécules et Matériaux du Mans*

Nowadays, graphene plasmonics shows a great number of features unusual for conventional (metal-based) plasmonics: from the strong energy localization and the large propagation distance of surface plasmon-polaritons (SPPs) due to the existence of both TE- and TM- polarized modes to the possibility of control SPPs by tuning the graphene chemical potential (or, equivalently, the applied gate voltage or chemical doping) [1, 2]. Cylindrical graphene-based plasmonic structures have some advantages as compared to the planar geometry: reduced edge losses, existence of high-order azimuthal modes, etc [3, 4].

In this work, we discuss novel ways to obtain an optical activity in cylindrical graphene-based plasmonic structures and their possible applications in plasmonics. Recently, we have shown that the magneto-optical activity (or gyrotropy) of a dielectric nanowire covered with graphene leads to the giant Faraday rotation of the electric field distribution of high-order plasmonic modes propagating along the wire [5]. This effect is mediated by the magneto-optical activity in the bulk of the dielectric wire. An alternative way to create an optical activity at the surface arises from engineering of chiral graphene-based plasmonic waveguides. The spiral graphene-based nanostructures demonstrate a strong surface-induced optical activity, where the rotation of high-order plasmonic modes is comparable or even larger than in gyrotropic graphene-covered nanowires. The sensitivity of the chirality to the applied strain suggests an application of graphene-based waveguides as strain sensors.

Moreover, the control of the electromagnetic field intensity at the nanoscale in graphene-based plasmonic structures may open the door to novel applications in quantum plasmonics.

This work was supported in part by RFBR (grants ## 16-37-00023, 16-07-00751, 16-29-14045) and RScF (grant # 14-22-00279).

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5. D. A. Kuzmin, et al. Nano Lett. 16, 4391–4395 (2016)

Plasmonic Nanostructured Cellular Automata

Wednesday, 7th December - 15:21 - Photonic & plasmonic nanomaterials - Optical properties of nanostructures - Tower 24 - Room 101 - Oral presentation - Abstract ID: 366

Mr. Emad Alkhazraji [1], ***Mr. Assim Ghalib*** [2], ***Mr. Khawer Manzoor*** [2], ***Dr. Mohammad Alsunaidi*** [2]

1. *Jubail Industrial College,* ***2.*** *King Fahd University of Petroluem and Minerals*

Introduction:

A one-dimensional cellular automaton (CA) consists of a sequence of consecutive cells where each cell can take a value between 0 and k-1 which then is updated in generation-by-generation. CA's can be found in universal dynamic models that govern several naturally existing phenomena from DNA sequences to galactic formations. We believe that employing these nature-complying rules as models in different artificial systems and structures, such as sensing, imaging, and energy harvesting applications, can introduce positive enhancements to their capabilities, efficiency, and energy utilization. We investigated the scattering plasmonic resonance profiles of silver spherical nano-particles when CA33 is used as a model of their configurations where 1's and 0's indicate either their presence or absence.

Methods:

The analysis model is based on the numerical time-domain solution of Maxwell's equations. The scattering of light waves off the nanoshperes is simulated by implementing the Finite-Difference-in-Time-Domain method in a 3D Yee's staggerd mesh. Moreover, the plasmonic resonance modes are obtained through the Total-Field-Scattered-Field method. Finally, the dispersive nature of the silver nanospheres was simulated following the Lorentz–Drude model.

Results&Discussion

CA33 is an elementary one-dimensional CA rule whose cells can occupy one of two states. This rule is used in RNG's and models few natural phenomena.

Firstly, a single nanosphere was put at the top middle the total region whose scattering profile matched that of a typical silver nanoshpere, i.e. 2 modes. The Figure shows a side and a top view of the configuration resonance after eight generations. For the first 3 generations, the scattering profile only witnessed red-shift in both peaks as shown in the Figure by the dotted curve.

However, after introducing the fourth generation, peculiarly, two new peaks emerge as shown in the Figure by the solid curve. Moreover, the newly added nanospheres in the fourth generation were isolated and their scattering profile was found and is represented in the Figure by the dashed curve.

It is clear that the scattering profile after four generations is not merely a superposition of the preceding generations and the newly added particles, but rather, it introduces its unique profile that keeps evolving with generations.

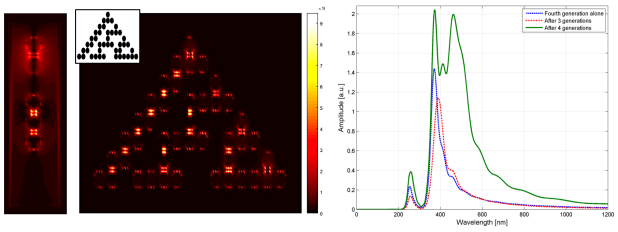

Fourth generation alone
After 3 generations
After 4 generations
Amplitude [a.u.]
Wavelength [nm]

Figure.png

Near-field dichroism of azo-polymers for optical switching and image storage

Wednesday, 7th December - 15:38 - Photonic & plasmonic nanomaterials - Optical properties of nanostructures - Tower 24 - Room 101 - Oral presentation - Abstract ID: 191

Dr. Sergey Kharintsev [1], ***Prof. Alexandr Fishman*** [1], ***Dr. Semion Saikin*** [2], ***Prof. Sergei Kazarian*** [3], ***Prof. Myakzyum Salakhov*** [1]

1. *Kazan Federal University,* ***2.*** *Harvard University,* ***3.*** *Imperial College London*

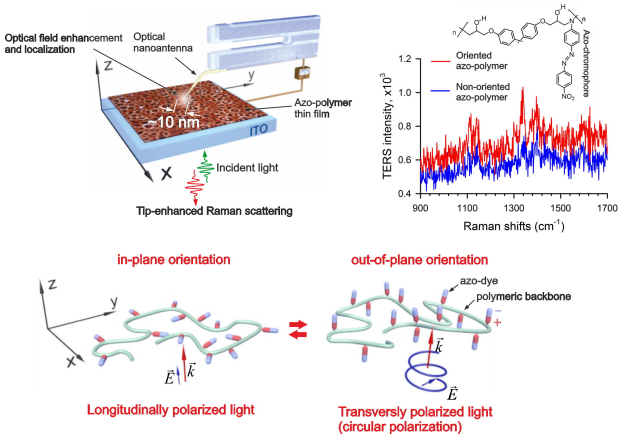
Recent advances in improving information storage performance are inseparably linked with circumvention of fundamental constraints such as the supermagnetic limit in heat assisted magnetic recording, charge loss tolerance in solid-state memory and the Abbe's diffraction limit in optical storage. A substantial breakthrough in the development of nonvolatile storage devices with dimensional scaling has been achieved due to phase-change chalcogenide memory, which nowadays, meets the market needs to the greatest advantage. A further progress is aimed at the development of versatile nonvolatile high-speed memory combining potentials of random access memory and archive storage.

The well-established properties of light at the nanoscale empower us to use them for recording optical information with ultrahigh density scaled down to a single molecule, which is the size of a pit. Indeed, diffraction-limited optics is able to record as much information as 1 Gb/in2. Nonlinear optical effects, for example, two-photon fluorescence recording, allows one to decrease the extent of the pit even more, which results in the recording density up to 100 Gb/in2. Going beyond the diffraction limit, due to the sub-wavelength confinement of light, pushes the pit size down to a single chromophore, which is, on average, of 1 nm in length. Thus, the memory capacity can be increased up to the theoretical limit of 1 Pb/in2. Moreover, the field confinement provides faster recording and readout operations due to the enhanced light-matter interaction. This, in turn, leads to the miniaturization of optical devices and the decrease of energy supply. Intrinsic features of light such as multimode, mixed polarization and angular momentum in addition to the underlying optical and holographic tools for writing/reading, enriches the storage and encryption of optical information. In particular, the finite extent of the near-field penetration, falling into a range of 50-100 nm, gives the possibility to perform 3D volume (layer-to-layer) recording/readout of optical information.

Controlling transverse and longitudinal optical anisotropy in photo-responsive organic solid materials, beyond the diffraction limit, is an ongoing challenge. Considerable progress in polarization-controlled diffraction-limited optical microscopy has been achieved due to the z-polarization of focused laser beams. Evaluation and control of the near-field polarization state are directly linked to the properties of optical nanoantennas such as their shapes, sizes and orientations in relative to the polarization direction. A defocused imaging technique and polarization-dependent analysis give the possibility to explicitly determine the direction of dipole oscillation at the tip apex. They contribute to the further development of polarization-controlled tip-enhanced Raman scattering (PC-TERS) method.

In the paper, we focus on the study of near-field dichroism of a sub 10-nm thick azo-polymer film, which is handled with a biased plasmonic nanoantenna, as shown in the figure. The in-plane and out-plane arrangement of chromophores in the glassy polymer, assigned to transverse and longitudinal optical anisotropy, are

mapped with the polarization-controlled TERS microscopy when a radially polarized and azimuthally polarized laser light are used. Changing the near-field polarization allows us to optically align the azo-chromophores at arbitrary direction. Thus, the determination of a polarization state of the near-field is a task of high priority. The figure shows a light illuminated bent gold tip with a point dipole at its apex. The dipole orientation can be found from polarization-dependent Rayleigh scattering patterns. Amorphous-to-liquid crystal (nematic phase) transition effect on the sub-10 nm azo-polymer film is demonstrated with a biased plasmonic nanoantenna. Orientation polarization and birefringence of the azo-polymer is visualized with differential scanning capacity microscopy. We are confident that this study paves the way to apertureless optical technology for further increasing information recording density and electro-optical switching speed on amorphous and liquid crystal azo-polymers.



Pic.jpg

Nanostructured InGaAs Photodetectors for Infrared Imaging

Wednesday, 7th December - 14:30 - Enhanced devices: lasers, nano antennas, solar cells, LEDs, photonic crystal fibers... - Tower 24 - Room 103 - Oral presentation - Abstract ID: 292

Dr. michael verdun [1], ***Dr. Benjamin Portier*** [2], ***Dr. Katarzyna Jaworowicz*** [3], ***Dr. Julien Jaeck*** [4], ***Dr. François Lelarge*** [5], ***Dr. Stéphane Guilet*** [3], ***Mr. Christophe Dupuis*** [3], ***Dr. Riad Haïdar*** [4], ***Dr. Fabrice Pardo*** [3], ***Dr. Jean-Luc Pelouard*** [3]

1. *CNRS, C2N,* ***2.*** *REOSC,* ***3.*** *CNRS - C2N,* ***4.*** *Onera,* ***5.*** *3-5lab*

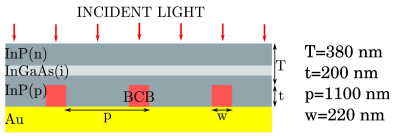
Despite the outstanding performances reached by today's infrared quantum photo-detectors, progresses have been stagnating for years. Their detectivity is mainly limited by the noise generated by the dark current requiring cooling down the devices at cryogenic temperatures. To go beyond this last limit we combine a P-i-N semiconductor structure with a nano-antenna based on a guide mode resonance (GMR) effect. The optical and electronic properties of devices are significantly modified by reducing by more than one order of magnitude the active area dimensions, paving the way for a new generation of photo-detector [1].

The device is a resonant photodiode transferred onto a gold mirror. It comprises a sub-wavelength dielectric grating inserted between the gold mirror and the detector (see Figure attached). The structural parameters were optimized to maximize a main resonance around λ= 1,55 µm for both polarizations. The thickness of the InGaAs absorbing layer was reduced to 90 nm in order to improve the signal-to-noise ratio. As InP and InGaAs have similar refractive indices, the whole semiconductor heterostructure acts as a waveguide. The modal analysis shows that under normal incidence, propagation inside the semiconductor cavity involves some modes coming from the combinations of diffracted orders and the non-diffracted wave [2]. At resonances the electric field intensity maps show that the path of the photo-carriers is reduced to about 100 nm, and is localized in a high static electric field area that maximizes their collection efficiency.

Clean room processes were developed in order to fabricate individual GMR pixels of various sizes. They were opto-electrically characterized over the 1,2-1,8 µm range for an unpolarized focused beam. The spectral EQE measurement showed a main resonant response around λ= 1,55 µm with a maximum value of 71% and an averaged value of 50% over a 450 nm bandwidth. The good agreement between experimental and calculated EQE indicates a near perfect collection of the photo-carriers. Compared to the state-of-the-art InGaAs resonator detector, we showed a broader spectral response compatible with SWIR imaging.

[1] M. Verdun et al., JAP 120(8), 2016.

[2] M. Verdun et al. APL 108(5), 2016.



Schematic cross-section showing three periods of the device. InP(p)/InGaAs(i)/InP(n) photodiode of total thickness T=380 nm (90 nm InGaAs absorbing layer, 90 nm InP p-type layer, and 200 nm InP n-type layer) on top of a backside semiconductor/dielectric grating of period p=1100 nm, width w= 220 nm and thickness t=200 nm on a gold mirror.

Nanop2016 gmr figure.jpg

Emission Properties of Optically-Injected Semiconductor Lasers at the Nanoscale

Wednesday, 7th December - 14:47 - Enhanced devices: lasers, nano antennas, solar cells, LEDs, photonic crystal fibers... - Tower 24 - Room 103 - Oral presentation - Abstract ID: 281

Mr. jean-maxime sarraute [1], ***Dr. Kevin Schires*** [1], ***Prof. Frédéric Grillot*** [1], ***Prof. Sophie Larochelle*** [2]

1. *Télécom-ParisTech,* ***2.*** *Université Laval*

Introduction

Semiconductor nanolasers are envisioned to be attractive candidates for future energy-saving optical communication networks. Their attractiveness relies in the dimensions of the optical cavity, well below the diffraction limit. First, this offers promises for a tighter integration of optoelectronic devices on a microchip. Then, optical cavities of subwavelength dimensions exhibit enhanced spontaneous emission, quantified by the beta- and Purcell factors. The Beta-factor quantifies the ratio of spontaneous emission coupled into the cavity mode. The Purcell factor (Fp) is proportional to the ratio between the cubed lasing wavelength and the cavity volume. Physically, the Purcell effect decreases the carrier lifetime and enhances by a factor Fp the rate of spontaneous emission that is coupled into the cavity mode. The increased spontaneous emission of nanolasers allows reaching much lower threshold currents, with stimulated emission being achieved without requiring population inversion.

Methods

The emission properties of optically-injected nanolasers are discussed with a novel rate equation model taking into account the zero point energy. When injecting light into the laser, the frequency of the slave laser will be pulled towards that of the master laser. In the particular case when the frequency of the master laser is close enough to the slave laser frequency and the master laser power is high enough, the slave laser will operate at the master laser frequency. This phenomenon, called injection locking, is known in various physical systems.

Results and discussion

In this work, we will show that the cavity's volume widely impacts the injection-locking area. In particular, working below the diffraction limit leads to an enlargement of the locking area meaning that nanolasers theoretically need very low injected power to be locked. Impact of the spontaneous emission rate on the locking map will be presented. Under optical-injection, simulations point out that a stably-locked nanolaser can exhibit large modulation dynamics at injection rates that are by far much smaller than those used in edge-emitting macrolasers. These results will pave the way for the development of energy-saving directly-modulated optical sources in future high-speed optical networks.

Enhancement of Radiative Plasmon Decay by Hot Electron Tunneling

Wednesday, 7th December - 15:04 - Enhanced devices: lasers, nano antennas, solar cells, LEDs, photonic crystal fibers... - Tower 24 - Room 103 - Oral presentation - Abstract ID: 69

Prof. Alfred J. Meixner [1], *Dr. Xiao Wang* [1], *Dr. Kai Braun* [1], *Dr. Dai Zhang* [1]

1. University of Tübingen

We demonstrate that photon emission induced by inelastic tunneling through a nanometer single gap between a sharp Au tip and an Au substrate can be significantly enhanced by the illumination of the junction with 634 nm laser light with an electric field component oriented parallel to the tip-axis, i.e., perpendicular to the sample. Analyzing photoluminescence (PL) spectra recorded as a function of bias voltage allows us to distinguish between PL from (1) the decay of electron–hole pairs created by the laser excited sp/d interband transition with a characteristic band at 690 nm and (2) the red-shifted radiative decay of characteristic plasmon modes formed by the gap. Since the electroluminescence spectra (without laser) already show the plasmonic gap modes, we conclude that the enhanced intensity induced by laser illumination originates from the radiative decay of hot electrons closely above the Fermi level via inelastic tunneling and photon emission into the plasmon modes. Since these processes can be independently controlled by laser illumination and the amplitude of the bias voltage, it is of great interest for designing new switchable photon emission plasmonic devices.

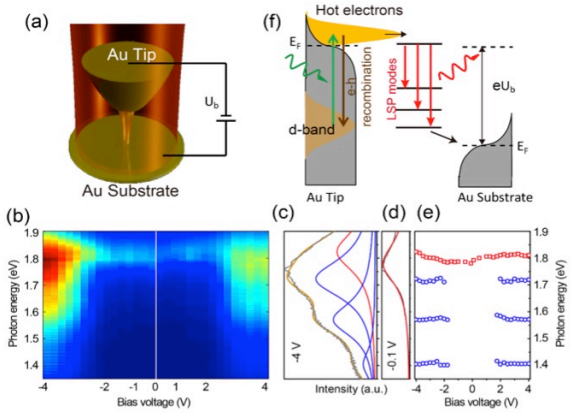


Figure.jpg

Optical properties of TiO2 nanostructures and recent developments in their use for photoluminescence-based oxygen sensing

Wednesday, 7th December - 15:21 - Enhanced devices: lasers, nano antennas, solar cells, LEDs, photonic crystal fibers... - Tower 24 - Room 103 - Oral presentation - Abstract ID: 212

Dr. Deborah Katia Pallotti [1]***, Dr. Stefano Lettieri*** [1]***, Dr. Felice Gesuele*** [2]***, Dr. Luca Passoni*** [3]***, Dr. Fabio Di Fonzo*** [3]***, Prof. Pasqualino Maddalena*** [2]

1. *Institute of Applied Science and Intelligent Systems (CNR-ISASI),* ***2.*** *Università degli Studi di Napoli "Federico II",* ***3.*** *IIT – Center for Nanoscience and Technology*

Titanium dioxide (TiO2) nanoparticles are at the basis of different important applications including solar energy conversion, heterogeneous photocatalysis, environmental remediation and many others. Understanding and control of TiO2 properties is, thus, extremely important in view of development of new technological devices or improvement of existing ones. Ambient-controlled photoluminescence (PL) analysis is a tool that provides important information on TiO2 photo-physical characteristics, while also representing a possible multi-parametric route to chemical sensing. Towards this direction are addressed our recent researches, mainly focused on optical oxygen sensing in TiO2 through static and excitation resolved photoluminescence spectroscopy and high-performance oxygen optical sensors, also finalized to detection of dissolved oxygen.

In this contribution some recent findings on the feasibility of the use of TiO2 for efficient and multi-parametric oxygen sensing are shown. First are discussed different effects induced by oxygen (O2) on the PL activity of anatase and rutile TiO2 and a physical model for the recombination processes at the origin of the two polymorphs PL properties. Then, we show some of our recent findings in the optimization of optical oxygen sensors performances, through:

a)ratiometric approach by means of mixed-phase TiO2 and the simultaneous detection of well separated-PL emissions of the two crystalline phases;

b)quasi 1-D hierarchical nanostructures of TiO2, for which we obtained unconventional sensitivities in the field of PL-based oxygen sensing.

Our findings pointed out the potentialities of optical sensing for future double-parametric optical sensing by titania thanks to multiple response obtained toward a same analyte and possibly paved the way for selective detection towards chemical species carried in air.

INVITED TALK -> Semiconductor-Superconductor Optoelectronic Devices

Wednesday, 7th December - 15:38 - Enhanced devices: lasers, nano antennas, solar cells, LEDs, photonic crystal fibers... - Tower 24 - Room 103 - Oral presentation - Abstract ID: 174

Mr. Dmitry Panna [1], Mr. Shlomi Bouscher [1], Dr. Leonid Rybak [1], Prof. Alex Hayat [1]

1. *Technion*

We demonstrated experimentally superconducting proximity in semiconductor light-emitting structures proposed by us for enhanced two-photon gain, electrically-driven entangled-photon generation and Bell state analyzers. We produced high-temperature superconductivity in topological insulators Bi2Se3 and Bi2Te3 and high-temperature superconductor-semiconductor tunnel diodes.

We proposed an efficient approach for generation of entangled photons, based on Cooper-pair luminescence in semiconductors, which does not require isolated emitters. Semiconductor quantum wells, remove the light-heavy-hole degeneracy, allowing efficient photon entanglement generation in simple electrically-driven structures, taking advantage of the superconducting macroscopic coherence [1]. We analyzed a new effect of enhanced light amplification in electrically-driven semiconductor-superconductor structures, including Cooper-pair based two-photon gain [2]. We also proposed a compact and highly-efficient scheme for a complete Bell-state analysis using two-photon absorption in a superconducting proximity region of a semiconductor avalanche photodiode. This Cooper-pair based two-photon absorption results in a strong detection preference of a specified entangled state.

We demonstrated experimentally hybrid high-Tc-superconductor-semiconductor tunnel junctions [3]. The devices were fabricated by the newly-developed mechanical bonding technique, resulting in high-Tc-semiconductor planar junctions acting as superconducting tunnel diodes. Tunneling-spectra characterization of the hybrid junctions of BSCCO combined with bulk GaAs, or a GaAs/AlGaAs quantum well, exhibits excess voltage and nonlinearity.

We produced high-temperature superconductivity in topological insulators Bi2Se3 and Bi2Te3 via proximity to BSCCO [4], persisting up to at least 80K – a temperature an order of magnitude higher than any previous observations. Moreover, the induced superconducting gap in these devices reaches values of 10mV, significantly enhancing the relevant energy scales. Andreev reflection is observed as an excess current and an increase in differential conductance.

These results open new directions for fundamental studies in condensed matter physics and light-matter interaction and enable a wide range of applications in optoelectronics and quantum information processing.

[1] A. Hayat, et al, Phys. Rev. B 89, 094508 (2014).

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[3] A. Hayat et al. Phys. Rev. X 2, 041019 (2012).

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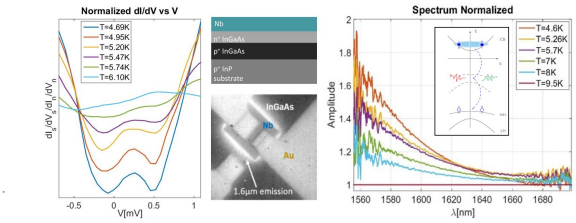
Normalized dI/dV vs V
T=4.69K
T=4.95K
T=5.20K
T=5.47K
T=5.74K
T=6.10K
dI_s/dV_s/dI_n/dV_n
V[mV]
Nb
p+ InGaAs
p+ InP
substrate
InGaAs
Nb
Au
1.6μm emission
Spectrum Normalized
T=4.6K
T=5.26K
T=5.7K
T=7K
T=8K
T=9.5K
Amplitude
λ[nm]

Fig1.jpg

Light from plasmonic lenses stimulated by tunnel electrons

Wednesday, 7th December - 16:30 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 22

Dr. Eric Le Moal [1]***, Ms. Shuiyan Cao*** [2]***, Dr. Aurélien Drezet*** [3]***, Dr. Serge Huant*** [3]***, Dr. Jean-Paul Hugonin*** [4]***, Prof. Jean-Jacques Greffet*** [4]***, Dr. Gérald Dujardin*** [1]***, Dr. Elizabeth Boer-Duchemin*** [2]

1. *CNRS, Institut des Sciences Moléculaires d'Orsay (ISMO),* ***2.*** *Université Paris-Sud, Institut des Sciences Moléculaires d'Orsay (ISMO),* ***3.*** *Université Grenoble Alpes, CNRS, Institut Néel,* ***4.*** *Laboratoire Charles Fabry, Institut d'Optique*

A plasmonic lens is a metallic nano- or microstructure designed to control the propagation of surface plasmon polaritons (SPPs), i.e., electromagnetic waves that are coupled to electronic density oscillations at a metal-dielectric interface. Plasmonic lenses are among the most versatile optical microcomponents since they may be used to (i) convert light into SPPs and vice versa, (ii) focus and collimate SPPs or light, and (iii) couple the optical nearfield of a nanoscale emitter to farfield radiation. The integration of plasmonic lenses with nanoelectronics on a chip is desired, e.g., for applications in optical communications. Such integration requires that electrically driven nanosources of light or SPPs be incorporated into the design of plasmonic lenses, thus raising a number of fundamental and technical issues. In particular, the generation of light and SPPs from electrical current generally yields a broad power spectrum, whereas plasmonic lenses are often designed for specific energies or wavelengths. Their optical response to an electrical, spectrally broad, excitation has rarely been addressed.
Here we report on the emission properties of a plasmonic lens driven by low-energy electrons. The plasmonic lens consists of concentric circular slits etched in a thick gold film on a glass substrate. A local, broadband, electrical excitation is applied using the inelastic effects of the tunnel current from the tip of a scanning tunneling microscope (STM). The excited SPPs scatter at the circular slits. This yields light that we collect below the substrate using the objective lens of an optical microscope. The angular and spectral distributions of the emitted light are measured using optical imaging in Fourier space and optical spectroscopy. As well, we use numerical methods to simulate the electrical excitation of a plasmonic lens with tunnel electrons and the resulting far-field radiation in the substrate. The geometry of the plasmonic lens (diameter, period and number of slits) and the excitation site strongly influence both the angular emission pattern and the emission spectrum. By optimizing these parameters, we can obtain a broadband, electrical microsource of cylindrical vector beams, whose angular divergence is < 4 degrees.

Nanoparticles mediated chiral interactions of pharmaceutical compounds: a combined SERS and DFT study

Wednesday, 7th December - 16:47 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 313

Prof. Rares Stiufiuc [1]***, Dr. Cristian Iacovita*** [2]***, Dr. Gabriela Stiufiuc*** [3]***, Prof. Vasile Chis*** [3]***, Prof. Constantin Lucaciu*** [2]

1. *University of Medicine and Pharmacy, Cluj-Napoca,* ***2.*** *Univ. Medicine and Pharmacy, Cluj-Napoca,* ***3.*** *"Babes-Bolyai" University Cluj-Napoca*

The investigation of pharmaceutical compounds by means of Raman spectroscopy has attracted much interest in the last years. The method allows getting information about structural properties of different molecules based on their specific vibrational structure. Nowadays Raman spectroscopy is gaining popularity in different areas of the pharmaceutical industry mainly due to its ability to provide information on the fundamental vibrational bands (the fingerprint region), offering a high degree of specificity in analysis1. It also forms an ideal complement for existing methods of analysis such as nuclear magnetic resonance, mass spectrometry and elemental analysis.

On the other hand chiral recognition and differentiation in living organisms represents one of the most intriguing natural phenomena, which assures in the organism a high fidelity transfer of the molecular information. This phenomenon has a significant role in the pharmaceutical industry, since chirality plays a key role in the development of target drug candidates, being a structural variable parameter that needs elucidation. In this context, the subject of chiral purity gained a particular importance in the pharmaceutical industry.

In this paper we will show that by taking advantage of the unique plasmonic properties of noble metal nanoparticles, the chiral separation of propranolol enantiomers was successfully studied and proved by Surface-Enhanced Raman Spectroscopy (SERS)2. The quantum chemistry calculations of native cyclodextrin - propranolol enantiomers complexes have been used as a further proof of the proposed interaction mechanism. It has been observed (experimentally and theoretically) that β-cyclodextrin (compared with the other two classes of native α and γ cyclodextrins) had the best chiral recognition ability for propranolol enantiomers, hence producing the largest difference in the SERS spectra of propranolol enantiomers - native cyclodextrin complexes.

Effective medium approximation for hybrid plasmonic multilayers

Wednesday, 7th December - 17:04 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 351

Dr. Ilya Razdolski [1]***, Dr. Alexey Melnikov*** [2]***, Dr. Denys Makarov*** [3]***, Prof. Vasily TEMNOV*** [4]

1. *Fritz-Haber Institute of the Max-Planck Society, Berlin,* ***2.*** *University of Halle,* ***3.*** *Helmholtz-Zentrum Dresden-Rossendorf,* ***4.*** *Institut des Molécules et Matériaux du Mans*

Hybrid metallic multilayer structures consisting of functionally different materials represent the building blocks for linear and nonlinear plasmonic devices, which are often coupled to acoustic [1,2] and magnetic [3-6] phenomena. Despite of the nano-scale plasmonic confinement, optical fields inside metallic nanostructures overlap with several materials characterized by different optical properties, including anisotropy. Straightforward transfer-matrix calculations are often bulky, particularly for optically anisotropic materials [5], and a simple effective medium approximation (EMA) would be helpful. The complexity of the rigorous microscopic treatment becomes even more crucial in the nonlinear optics, where, for example, the generation of optical second harmonic at each surface/interface is characterized by multiple components of chi(2)-tensor [6].

In case of multiple interfaces intrinsic to the hybrid multilayer structures an effective interface approximation (EIA) would be highly desirable as well.

Here we present an EMA for the magneto-plasmonic metal-ferromagnet multilayers [4]. Whereas EMA for the diagonal components of the (linear) dielectric succeptibility tensor can be used to predict the propagation length of surface plasmon polaritons (SPPs), the EMA for its non-diagonal components accurately describes the magnetic modulation of SPP wave vector [1,2]. The EMA displays a good agreement with transfer-matrix calculations. In the nonlinear magneto-plasmonics the phenomenological nonlinear EIA is applied to quantitatively model the angular dependence of second harmonic generation in Kretschmann configuration.

In addition to static multilayer structures we can also generate “transient multilayer structures”. Here, the nano-scaled (a few picoseconds long) acoustic pulse creates a layer with a modified electron density propagating at the speed of sound through the layer of a noble metal. The linear EMA can be applied to characterize ultrashort acoustic pulses from the dynamic modulation of SPP wave vector, which is measured by femtosecond time-resolved plasmonic interferometry [2].

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High-Resolution Cathodoluminescence (CL) for Characterization of Nanophotonic Structures

Wednesday, 7th December - 17:21 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 286

Dr. David Gachet [1], ***Dr. Marcin Zielinski*** [1], ***Dr. Jean Berney*** [1], ***Dr. Samuel Sonderegger*** [1]

1. *Attolight AG*

The emergence of nanophotonic devices appeal for sub-wavelength optical characterization techniques. Various techniques such as scanning near-field optical microscopy (SNOM) or stimulated emission depletion (STED) microscopy are now currently used in the field of nano-optics. Here, we introduce cathodoluminescence CL as a powerful and versatile technique for optical and structural characterization of nanoscale structures. CL can be performed in a scanning electron microscope (SEM or STEM) to study nanostructures made of semiconductors, metals or insulators. It offers several advantages over usual optical spectroscopy techniques. The multimode imaging capabilities of the SEM enable the correlation of optical properties (via CL) with surface morphology (secondary electron – SE – mode) at the nanometer scale [1].

In semiconductors and insulators, the CL signal gives local information on the electronic bandgap and defect states. In nanoresonators such as photonic crystals or metal nano-antennas, CL directly maps local density of optical states (LDOS) [2]. In addition, CL has been recently used in nano quantum optics experiments [3].

We intend to show a selection of results obtained with SEM-CL on various semiconductor and metal nanostructures, such as nanowires [4], microdisks [5] or nanoapertures in metal films [6]. These structures find applications for single photon emission, nanolasing or color generation at the nanoscale. Finally, we will show how the introduction of pulsed electron excitation and time resolved detection of the CL signal (TRCL) allows carrier dynamic probing at the nanoscale [7].

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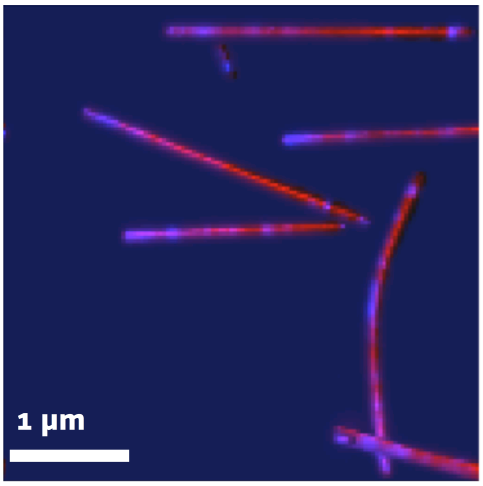


Fig. 1. Application of CL for imaging quantum dots in nanowires (courtesy of Prof. A. Fontcuberta, EPFL).

Nw-qds - image.png

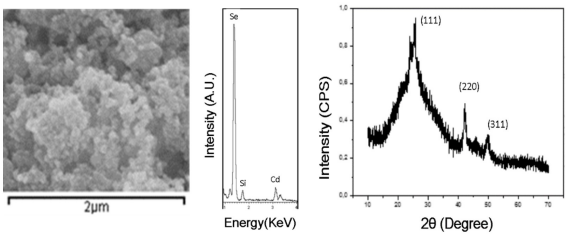
A Novel Approach for CdSe Nanospheres Synthesis and Their Optical Behavior

Wednesday, 7th December - 17:38 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 138

Dr. Ana Lilia Leal-Cruz [1], ***Dr. Alicia Vera*** [1], ***Dr. Armando Rojas-Hernández*** [1], ***Dr. Josué Aguilar-Martínez*** [2], ***Dr. Alejandro García-Juárez*** [1], ***Dr. Ignacio Zaldivar-Huerta*** [3]

1. *Universidad de Sonora,* ***2.*** *Universidad Autónoma de Nuevo León,* ***3.*** *Instituto Nacional de Astrofísica Óptica y Electrónica*

Cadmiun selenide (CdSe) is an attractive semiconductor material from technical and scientific standpoints thanks to their versatility and capability to be obtained as nanostructured film and powder with particle sizes at micro and nanoscale. CdSe nanostructures have been recognized as very interesting materials given their excellent optical and electrical properties, arising from the reduction of their size. In addition, it is considered a promising semiconductor material by their potential applications in biological, biomedical, electronic and optoelectronic fields, ranging from bioassays, bioprobes, biosensors, sensors, solar cells, and others optoelectronic devices. CdSe is an inorganic compound exhibiting a band gap of 1.74 eV and it has a similar behavior to the n-type semiconductors, density of 5.816 g/cm3, melting point of 1268 °C, and refractive index (nD) of 2.5. Moreover, CdSe exhibits high crystallinity degree, adopts micro and nanostructured morphologies, and presents three different polymorphic forms, denominated wurtzite (hexagonal), sphalerite (cubic) and rock-salt (cubic). CdSe crystalline characteristics have an influence on their optical and electrical performance, strongly linked to the processing conditions used to synthesize it. Consequently, the study of novel, innovative, cheap, and sustainable synthesis methods and materials must be a priority in semiconductor field for the discovery of material with superior optical and electrical properties and behaviors, because, it allows the design and the development of novel electronics and optoelectronics devices with higher efficiency, better behavior, and superior stability in the operation conditions. In the present work, an approach for the synthesis of CdSe nanospheres by solution growth using nitrite tetrahydrate (Cd(NO3)2.4H2O), selenourea [SeC(NH2)2], glycine, and pH buffer (borate) is proposed. In summary, microstructural, chemical, and optical characterizations of synthesized CdSe by FE-SEM/EDS, DRX, and UV-Vis spectroscopy techniques are reported. Characterization results confirm the formation of CdSe nanospheres (a) containing Cd and Se (b) with an average atomic composition of 48.62 and 51.38 %, respectively. Lastly, synthesized CdSe nanospheres correspond to cubic crystalline structure commonly named sphalerite (c) and they present an optical band gap of 1.70 eV.



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Highly doped semiconductor plasmonic resonators for surface enhanced infrared absorption spectroscopy

Wednesday, 7th December - 16:30 - Enhanced sensing (SERS, SEIRA) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 298

Ms. Franziska Barho [1], ***Dr. Fernando Gonzalez-Posada Flores*** [1], ***Mr. Mario Bomers*** [1], ***Dr. Maria-Jose Milla Rodrigo*** [1], ***Dr. Laurent Cerutti*** [1], ***Prof. Eric Tournié*** [1], ***Prof. Thierry Taliercio*** [1]

1. *Université de Montpellier, Institut d'Electronique et des Systèmes*

Introduction

Infrared spectroscopy is an efficient technique for the selective detection of molecules by their vibrational spectra. The electric field enhancement effect from plasmonic nanostructures in resonance with vibrational modes of molecules increases the signal strength. Surface enhanced infrared absorption (SEIRA) spectroscopy facilitates therefore the detection of vibrational active molecules using adequately designed plasmonic resonator substrates. We propose highly doped semiconductor material as an alternative to gold or silver for plasmonic resonators. A plasma frequency in the mid-infrared can be reached with highly n-doped InAs(Sb), allowing for higher electric field enhancement compared to gold, considering the respective dielectric functions [1, 2]. We demonstrate SEIRA with a 1-dimensional periodic grating made of InAsSb on GaSb substrate. Furthermore, we investigate 2-dimensional periodic arrays of rectangular resonators. They offer an additional degree of freedom to tailor their optical response.

Methods

Plasmonic resonators were fabricated from epitaxial, highly doped InAs_0.91Sb_0.09 films grown on GaSb substrate by large-area surface patterning methods as interferential or UV lithography and chemical etching with C_6H_8O_7 : H_2O_2. Reflection spectra were obtained with an IR-microscope coupled to an FTIR interferometer.

Results and Discussion

The 1-dimensional periodic gratings feature a dominant spectral signature linked to a localized surface plasmon resonance (LSPR) at the resonator-substrate interface, when excited with light perpendicularly polarized with respect to the ribbons' long axis. We observe the enhancement of an originally rather weak absorption feature of polymethylmethacrylate deposited on the plasmonic resonators displaying their resonance around the spectral range of the absorption line.

In 2-dimensional periodic arrays, transverse and longitudinal LSPR modes can be distinguished when the polarization direction is oriented along the short respectively the long axis of the rectangular-shaped structures. This gives access to two spectral bands of interest within the mid-infrared with one SEIRA substrate by adjustment of resonator size and aspect ratio. When working with light polarized along the diagonal of resonators or with unpolarized light, we simultaneously excite both modes covering consequently a large range of the mid-infrared spectrum.

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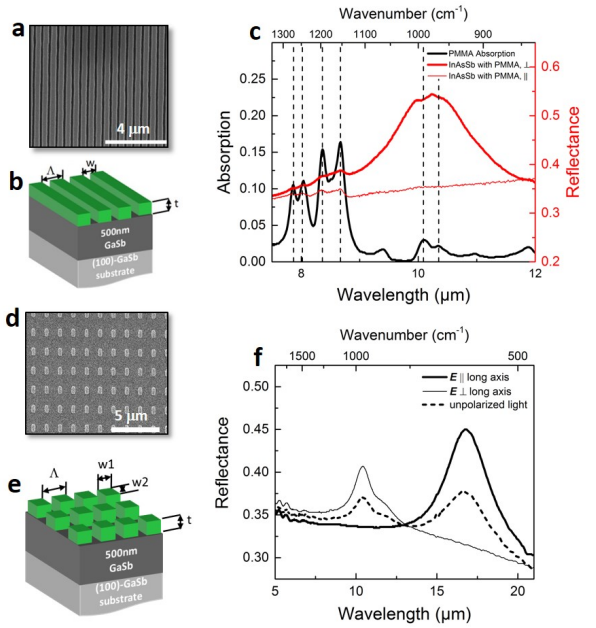

Figure 1: a. SEM image of a 1-dimensional periodic grating structure. b. Schematic diagram of the grating structure. c. PMMA absorption spectrum obtained in grazing incidence on a mirror surface and reflectance spectra of the plasmonic resonator with PMMA layer. Weak absorption features are enhanced when in resonance with the plasmonic mode. d. SEM image of a 2-dimensional periodic array of rectangular shaped resonators. e. Schematic diagram of the array. f. Reflectance spectra of the 2-dimensional periodic array with light polarization parallel respectively perpendicular to the long resonator axis and with unpolarized light. Longitudinal and transverse plasmonic modes are excited.

Inassb-plasmonic-resonators.jpg

Shifting plasmonics towards the infrared: the quest for alternative materials

Wednesday, 7th December - 16:47 - Enhanced sensing (SERS, SEIRA) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 284

Mr. Eugenio Calandrini [1], ***Dr. Denis Garoli*** [2], ***Dr. Francesco De Angelis*** [1], ***Dr. Andrea Toma*** [2], ***Dr. Angelo Bozzola*** [2], ***Dr. Sandro Cattarin*** [3], ***Dr. Simona Barison*** [3], ***Dr. Francesco Tantussi*** [2], ***Prof. Paolo Biagioni*** [4], ***Dr. Michele Ortolani*** [5], ***Dr. Leonetta Baldassarre*** [5], ***Dr. Valeria Giliberti*** [1], ***Dr. Giordano Scappucci*** [6], ***Mr. Tommaso Venanzi*** [5], ***Mr. Felice Appugliere*** [5], ***Dr. Wolfgang Matthias Klesse*** [7]

1. *Italian Institute of Technology,* ***2.*** *Italian Institute of Technology Genoa,* ***3.*** *Istituto di Chimica della Materia Condensata e di Tecnologie per l'Energia (CNR-ICMATE),* ***4.*** *Politecnico di Milano,* ***5.*** *Università Sapienza Roma,* ***6.*** *university of technology delft,* ***7.*** *university new south wales*

One of the key features of plasmonics is the confinement of the optical energy into very small volumes (the so called hot-spots) that can be further engineered by means of nanoantennas. In the small modal volume of the hot spots, plasmons can boost energy transfer, trigger chemico-physical process, provide field enhancement for nonlinear and second-order phenomena that are often difficult or even impossible to generate. These features depend on the nanoantenna geometry and on the dielectric function of the metal. Due to the intrinsic optical properties of noble metals these concepts are mostly exploited in the visible/near-infrared range. Therefore, finding valuable materials and device concepts for mid-infrared plasmonics is still an open issue. Here we show that the introduction of unconventional mid-IR materials, such as nanoporous gold and heavily-doped germanium (doping concentration of 10ˆ20 cmˆ-3), can pave the way to overcome the aforementioned limitations. Indeed the dielectric function can be tuned and optimized for the infrared range, acting on the physical parameters of the material development process. To this aim, we measure the optical response of both materials by means of Fourier Transform Infrared Spectroscopy and retrieve their dielectric function. In the case of nanoporous gold, array of 3D vertical nanoantennas have been fabricated (fig. 1a). The resonance wavelength has been properly tuned in order to further promote the coupling between surface plasmons and 7 nm of SiO2, used as probing layer (fig. 1b). In a standard surface-enhanced infrared absorption experiment, we demonstrate a 3-fold enhancement with respect to bulk gold. In the case of doped germanium, bow-tie antennas are designed, fabricated (fig. 2a), and embedded in a polymer. Nanoantennas were investigated with a near-field mid-IR nanoimaging technique in which the absorbed electromagnetic energy is measured locally with a scanning probe tip coupled to a quantum cascade laser in pulsed operation at Lambda = 5.8 um. We demonstrate the existence of an electromagnetic energy density hotspot in the antenna gap of diameter below 100 nm and confinement volume 105 times smaller than Lambdaˆ3 (fig.2 b and 2c).

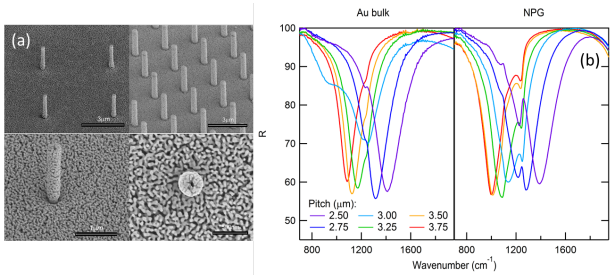

Fig1.png

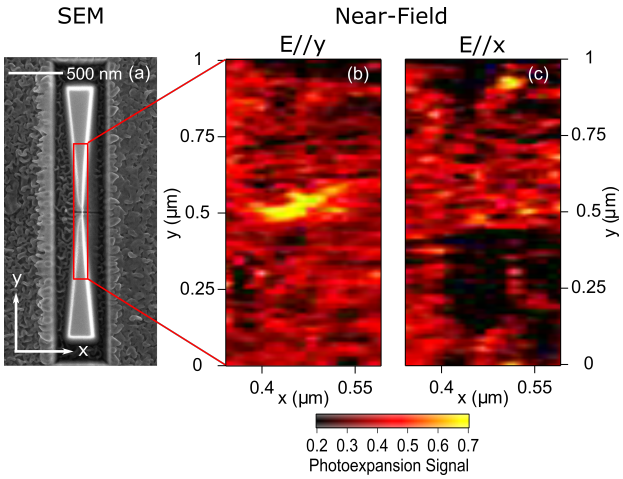

Fig2.png

Single-molecule biosensing using plasmonic nanoparticles

Wednesday, 7th December - 17:04 - Enhanced sensing (SERS, SEIRA) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 288

Mr. Michael Beuwer [1], ***Prof. Menno Prins*** [1], ***Dr. Peter Zijlstra*** [1]

1. *Eindhoven University of Technology*

Optical detection of single molecules mostly relies on their fluorescence because of the high contrast of this technique against the background. Since their invention in the early 1990s, single-molecule fluorescence microscopy and spectroscopy have spread to many fields in chemistry, physics, and biology, and have provided unique access to nanometer scales. However, the majority of native bioorganic molecules such as proteins hardly fluoresce at all. Therefore, their detection in native and unmodified state requires a different approach. We demonstrate the label-free detection of single proteins using plasmonic nanoparticles. We monitor the scattering signal of hundreds of particles simultaneously in a total-internal-reflection microscope. This approach allows for the statistical analysis of single-molecule interactions without requiring any labeling of the analyte. Single-protein binding events are resolved as step-wise changes in the scattered intensity, see Fig. 1. We study an antibody–antigen interaction and find that the waiting time distribution is concentration-dependent and obeys Poisson statistics. The ability to probe hundreds of nanoparticles simultaneously will provide a sensor with a dynamic range of 7 decades in concentration and will enable the study of heterogeneity in molecular interactions.

We foresee that this approach will be particularly attractive to monitor biomarker concentrations directly in a complex matrix in which labeling is not possible. Moreover, our approach will provide a means to improve the sensor's specificity by distinguishing populations of specific interactions from non-specific ones by statistical analysis of single-molecule kinetic parameters. These advantages will benefit future point-of-care biosensors and may allow for the real-time monitoring of biomarker concentrations on- or in-the-body.

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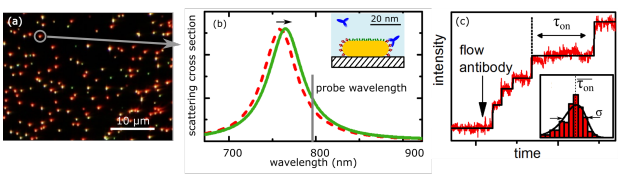


Fig1.png

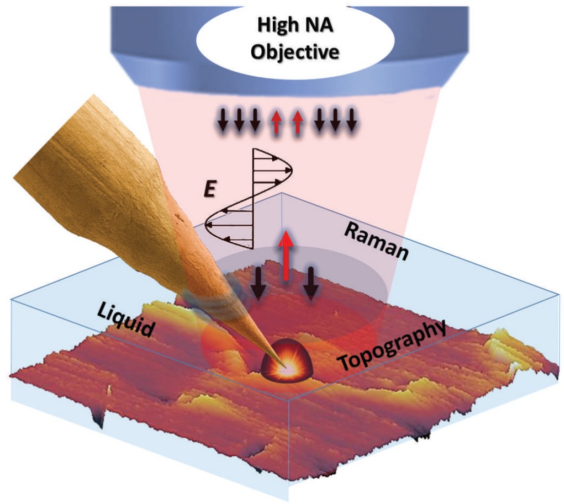
Tip enhanced Raman spectroscopy imaging of opaque samples in organic liquid

Wednesday, 7th December - 17:21 - Enhanced sensing (SERS, SEIRA) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 250

Dr. Ivan T. LUCAS [1], ***Prof. Emmanuel Maisonhaute*** [1], ***Mr. Thomas Touzalin*** [1], ***Ms. Alice Dauphin*** [1], ***Dr. Suzanne Joiret*** [1]

1. *Sorbonne Universités - UPMC*

Near-field scanning optical microscopies (NSOM) associating vibrational spectroscopies (Raman, infrared: IR) and Scanning Probe Microscopies (SPMs) stand as powerful techniques to provide unambiguous and precise chemical identification with high sensibility and high spatial resolution. The specific development of Raman-SNOM, i.e. Tip Enhanced Raman Spectroscopy (TERS), has necessitated to tailor specific probes which support localized surface plasmon resonance close to the apex of the tip, at the so-called "hot spot". When a gold or silver tip is shinned with a visible laser light of suitable wavelength, the electric field at the hot spot is considerably amplified and translates into a strong near field Raman scattering signal enhancement at the tip/sample interface. Low laser excitation power can be therefore applied, minimizing considerably the far-field contribution to the scattered signal. The strong signal enhancement compensates for the low efficiency of the inelastic scattering process of many compounds, enabling detection and imaging of single molecules. While silver provides the largest enhancement, gold is less prone to oxidation and therefore more adapted to liquids. Implementation of Tip Enhanced Raman Spectroscopy in liquid is still a challenge. We demonstrate herein its feasibility in an upright illumination/collection configuration. Through a thin layer of organic solvent covering the sample, laser focusing on the tip is possible, enabling TERS imaging in liquid.



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TERS characterization of 2D materials: from graphene to TMDCs

Wednesday, 7th December - 17:38 - Enhanced sensing (SERS, SEIRA) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 325

Dr. Marc Chaigneau [1]***, Dr. Andrey Krayez*** [2]

1. *HORIBA Scientific,* ***2.*** *AIST-NT*

We report results of TERS (Tip Enhanced Raman Spectroscopy) characterization of graphene oxide and the 2D semiconductors, MoS2 and WS2. The gap mode TERS signal of these 2D materials becomes dramatically enhanced over wrinkles and creases, as well as over nanopatterns imprinted into flakes using a sharp diamond probe. The resonant Raman signal of MoS2 contains additional peaks normally forbidden by selection rules. TERS maps of few-layer-flakes of this 2D semiconductor show that the spatial distribution of Raman intensity across the flake varies for different peaks, providing interesting insights into the structure of such 2D semiconductors with 10-20 nm spatial resolution.

Single molecule plasmonics, strong coupling, and nanochemistry

Thursday, 8th December - 09:00 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 434

Prof. Jeremy Baumberg [1]

1. *university of Cambridge*

Coupling between plasmonic nano-components generates strongly red-shifted resonances combined with intense local field amplification on the nanoscale. This allows directly seeing molecules as well as excitations in semiconductors. We have recently explored plasmonic coupling which can be tuned dynamically, through reliable bottom-up self-assembly using the nanoparticle-on-mirror geometry (NPoM) [1-14]. We recently demonstrated how individual molecules can be strongly coupled to these ultralow volume plasmonic cavities [13] as well as how they act as optomechanical constructs with enormously enhanced couploing.[14]

We also demonstrate the possibility to track few molecules using the extreme enhancements. We find that changing just a single atom on each molecule of a self-assembled monolayer can shift the plasmon by over 50nm, and produce surprising vibrational signatures.[4-7] These have encouraging prospective applications in (bio)molecular sensing as well as fundamental science.[8-14] The ability to track and watch molecules interact and react opens up the ability to study chemistry molecule-by-molecule.

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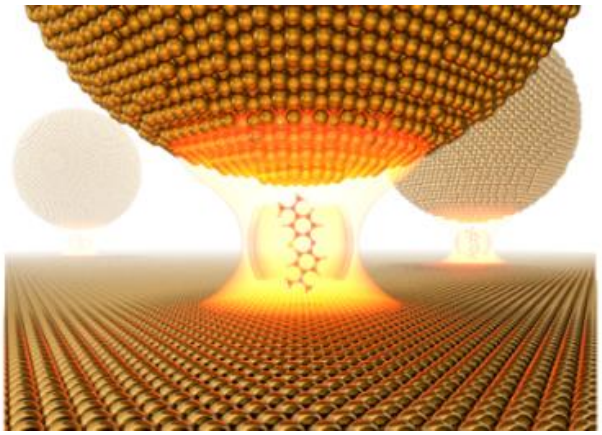

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Classical and Quantum Light Generation with Nitride-based Semiconductor Nanostructures

Thursday, 8th December - 09:35 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 440

Prof. Yong-Hoon Cho [1]

1. *Korea Advanced Institute of Science and Technology*

We present various types of group III-nitride micro- and nano-structures for novel classical and quantum photonic applications. We demonstrate phosphor-less white-color light generation, unidirectional light propagation, ultrafast single photon generation, and room temperature exciton-polariton generation using these group III-nitride based photonic structures. First, multi-color and broadband visible light emitting diodes based on GaN hexagonal truncated pyramid and columnar structures were demonstrated [1, 2]. Second, by using GaN/InGaN core–shell QW semiconductors grown on tapered GaN rods, which have a large gradient in their bandgap energy along their growth direction, highly asymmetric photonic diode behavior was observed [3]. Third, we utilized a novel approach of the self-aligned deterministic coupling of single quantum dots (QDs) to nanofocused plasmonic modes, which enhances spontaneous emission rate of QDs as high as 22 over a wide spectral range [4]. We also discuss about effective method for enhancing collection efficiency of the QDs formed in these photonic structures [5]. Finally, we developed a novel exciton-polariton system working at room temperature resulting from strong coupling between a two-dimensional exciton and whispering gallery mode photon using a core–shell hexagonal wire with GaN/InGaN multiple quantum wells [6]. An overview and comparison of the characteristics of the above nanostructures will be given.

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Progress in printing and imaging with optical fibers

Thursday, 8th December - 10:45 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 441

Prof. Christophe Moser [1]

1. *Ecole Polytechnique Fédérale de Lausanne (EPFL)*

In the last 5 years, there has been rapid progress by many groups in endoscopic imaging with multimode fibers. Imaging modalities such as fluorescence, confocal, photoacoustic and two-photon with sub-micrometer resolution have been shown through several tens of centimeter long fibers of diameter less than a human hair. I will review this body of work and introduce a new use for this fiber technology, namely for advanced manufacturing that we coin endo-fabrication.

The concept is to do micro-fabrication by additive and subtractive means in areas that are difficult to reach with conventional optics.

In one demonstration, the fiber is used as a thin objective lens for the micro fabrication of arbitrary shapes 3D objects at the distal end of the fiber. The objects are manufactured by two photon polymerization by digitally scanning a temporally and spatially focused ultrafast pulse. A replica of the Chichen Itza pyramid with a base length of 60 um was manufactured through a 5 cm long, 560 um diameter fiber.

In another demonstration, a thin fiber capillary is filled with a liquid. Light is then used to eject micro droplets with a velocity suitable to print functional or biological materials. The laser-induced shockwaves overcome conventional problems in inkjet printing methods, such as aggregation and clogging issues when viscous material is printed. The range of printable liquids with our device was significantly extended compared to conventional inkjet printers performances. In addition, the laser-induced flow focusing phenomenon allowed to controllably generate viscous micro-droplets up to 210 mPa s with a diameter smaller than the nozzle from which they originated (200 μm). Inks containing proteins were printed without altering their functional properties thus demonstrating that this jetting technique is potentially suitable for bio-printing.

We expect to combine 3D structuring and precise biological material delivery in the structure as a mean to build functional biological structures.

Photonic wires and trumpets : an attractive novel platform for quantum optoelectronic devices

Thursday, 8th December - 11:20 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 442

Dr. Jean-Michel Gerard [1]

1. *INAC-CEA*

Over the last 20 years, major efforts have been devoted to the tailoring of the optical properties of semiconductor emitters using optical microcavities and photonic crystals. We have recently introduced photonic wires as a novel platform for quantum optics. I will review recent studies which demonstrate an excellent control over the spontaneous emission of InAs quantum dots (QDs) embedded in vertical single-mode GaAs photonic wires and first applications in the field of quantum optoelectronic devices.

On the basic side, we have demonstrated a strong inhibition (x 1/16 [1]) of QD SpE in thin wires (d<λ/2n) and a nearly perfect coupling of the SpE to the guided mode (β>0.95 for d λ/n) in circular photonic wires [2]. The polarization of QD SpE can also be tailored by playing with the shape of the cross section of the photonic wire. For elliptical cross sections, a strong (>90%) linear polarization oriented along the long axis of the ellipse is observed [3].

In view of practical applications, a proper engineering of the radiation pattern of the photonic wire is required. We have therefore developed novel hybrid (metal+dielectric) mirrors displaying a high modal reflectivity, as well as integrated tip-shaped or trumpet-like adiabatic tapers, in order to reduce the divergence of the emitted beam. The recently developed photonic trumpet (see fig.1) exhibits superior performances in this context, since it ensures a perfectly Gaussian and low NA far-field emission [4].

As a first application of SpE control in photonic wires, we have developed single mode QD single-photon sources (SPS). Unlike microcavity-based devices, such SPS display an excellent purity (g(2) (0) < 0.01) under non-resonant excitation, over the whole range of excitation powers. Furthermore, efficiencies exceeding 0.7 photon per pulse (within NA=0.75) have been obtained for tip-shaped [5] as well as trumpet-like [4] SPS. Beyond these first results, photonic wires are also very attractive for developing high efficiency sources of entangled photon pairs or wavelength tuneable SPS, thanks to the broadband SpE control they provide.

More generally, photonic trumpets appear as a very promising template to explore and exploit in a solid-state system the unique optical properties of “one-dimensional atoms”. Possible long term applications in the field of quantum information processing will be discussed, including the optimal quantum cloning of single photons, using the amplification by stimulated emission provided by a single 1D atom [6].

Finally, photonic trumpets containing a single QD constitute a hybrid optomechanical system, whose remarkably large coupling between the two-level system and the mechanical degree of freedom, mediated by the strain, opens promising novel perspectives [7].

This work has been done in collaboration with J Claudon, J Bleuse, M Munsch, P. Stepanov, NS Malik (CEA Grenoble), N Gregersen, J Moerk (DTU Fotonik, Copenhagen), P Lalanne (Institut d’Optique, Palaiseau), A. Auffèves, J.P. Poizat, M Richard and coworkers at CNRS/Néel; it has been supported by the IST FET European project “HANAS”.

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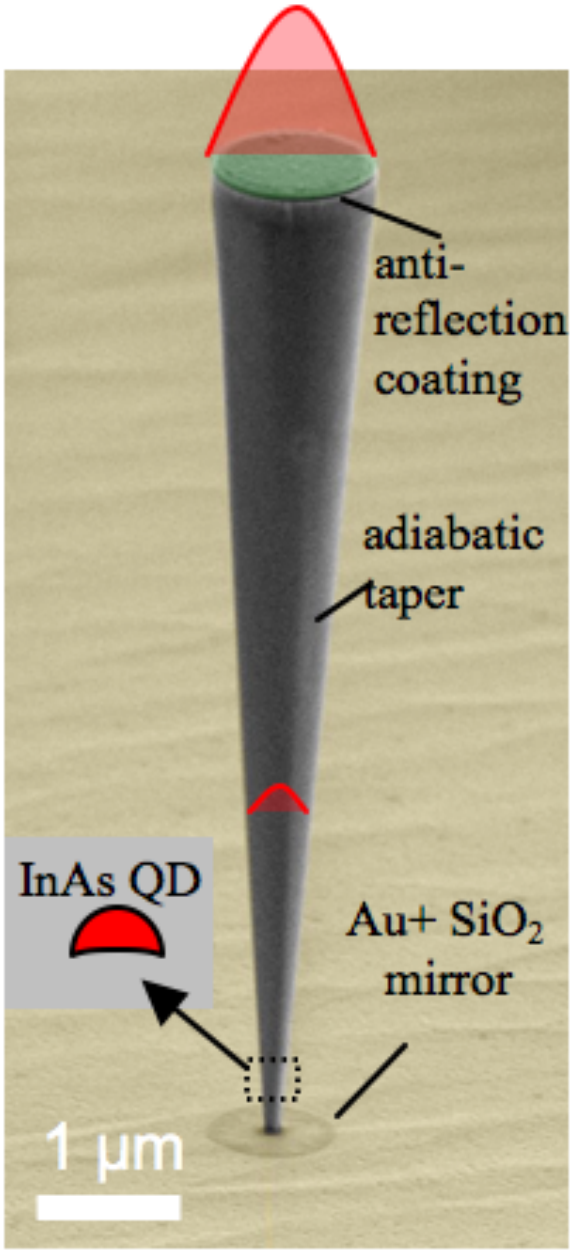

Figure 1 - colorized scanning electron micrograph of a gaas photonic trumpet.png

Surface plasmon – polaritons in structure of dielectric – graphene – antiferromagnetic

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 218

Prof. Igor Bychkov [1], ***Dr. Dmitry Kuzmin*** [1], ***Mr. Ivan Biryukov*** [1], ***Prof. Vladimir Shavrov*** [2], ***Mr. Valentin Tolkachev*** [1]

1. *Chelyabinsk state university,* ***2.*** *Kotel'nikov Institute of Radio-engineering and Electronics of Russian Academy of Sciences*

Nowadays, in plasmonics great researchers attention is paid to investigation of graphene-based nanostructures and perspectives of its applications in data processing and storage devices [1]. In our recent works we have considered some graphene-containing structures. Some interesting results on speckle-pattern rotation in graphene-coated optical fibers [2], surface plasmon manipulation by magnetic field in the planar gyrotropic waveguide formed by two graphene layers [3], plasmonically induced magnetic field and Faraday rotation of high order modes in graphene-covered nanowires [4, 5] have been obtained.

In this work surface plasmon-polaritons in dielectric – graphene – antiferromagnet structure is investigated. We assume that dielectric is non-dispersive one, antiferromagnet is centrosymmetric few-sublattice magnet (of rhombic symmetry) with exchange spin excitations of electroactive type. Eigen frequencies of exchange modes correspond to infrared and visible spectrum ranges (for example, $YBa_2Cu_3O_{6+x}$, α-Fe_2O_3). Frequency-dependence of graphene conductivity is taken into account.

Calculations are carried out in assumption of decaying length of surface electromagnetic wave is much greater than the lattice constant and phenomenological method may be used. Properties of the structure are depending on dielectric permittivity tensor of antiferromagnet and graphene conductivity.

Different propagation directions of electromagnetic wave with respect to antiferromagnet crystal orientation are considered. Dispersion equations and conditions of excitation of TM- and TE- waves and components of electromagnetic field are obtained. It is shown, that TE- waves, which are non-existing without graphene, may propagates in the structure when some relations between parameters of mediums are satisfied in frequency ranges of exchange modes of antiferromagnet.

This work was supported in part by RFBR (grants ## 16-37-00023, 16-07-00751, 16-29-14045) and RScF (grant # 14-22-00279).

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TM surface plasmon – polaritons in structure of vacuum - graphene – dielectric - metal

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 235

Mr. Valentin Tolkachev [1], ***Mr. Pavel Plaksin*** [1], ***Prof. Igor Bychkov*** [1], ***Dr. Dmitry Kuzmin*** [1], ***Prof. Vladimir Shavrov*** [2]

1. *Chelyabinsk state university,* ***2.*** *Kotel'nikov Institute of Radio-engineering and Electronics of Russian Academy of Sciences*

It takes a keen interest in nanostructures based on graphene now. Graphene properties are very attractive in terms of its possible use application as the basis for new nanomaterials with improved electrical, thermal and mechanical characteristics, as well as an element of nanoelectronic information processing devices [1].
We present the results of simulation of the propagation of surface plasmon polaritons in structure of vacuum - graphene - dielectric - metal. SiO2 was selected as dielectric, gold (Au) was selected as the metal. Structure properties are defined by dielectric constant, its thickness and conductivity of graphene. Theoretical methods of macroscopic electrodynamics is used. The calculations were performed in the terahertz range from 0.1 to 1 THz.
Dispersion equations and conditions of existence of the TM wave of the structure were obtained on the basis of Maxwell's equations solutions. The behavior of the propagation constants and attenuation for different thicknesses of the dielectric layer and at different chemical potentials of graphene is investigated. Distinction of plasmon propagation modes depending on the chemical potential of graphene dielectric layer thickness at different frequencies is shown. Energy and magnetic moment distributions (inverse Faraday effect) generated by plasmon modes of the structure is obtained. It is shown that the maximum value of the magnetic moment is observed at the boundary vacuum - graphene - dielectric and decreases exponentially to a minimum in the dielectric and vacuum.
This work was supported in part by RFBR (grants ## 16-37-00023, 16-07-00751, 16-29-14045) and RScF (grant # 14-22-00279).
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Linear and quadratic magnetooptic spectroscopy of bcc Fe

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 267

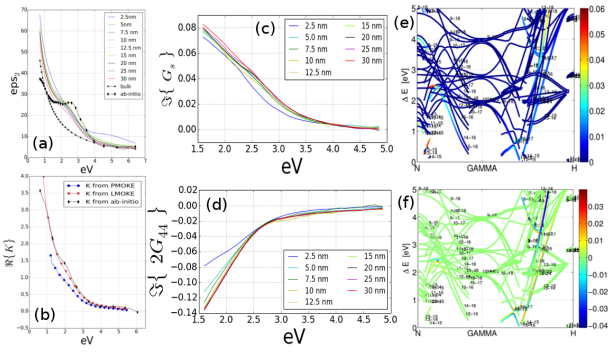
Mr. Robin Silber [1], Mr. Ondřej Stejskal [1], Mr. Jan Dušek [2], Mr. Lukáš Beran [2], Prof. Jaromír Pištora [1], Prof. Guenter Reiss [3], Dr. Martin Veis [2], Dr. Timo Kuschel [3], Dr. Jaroslav Hamrle [2]

1. *Nanotechnology Centre and IT4 Innovations, VSB - TU Ostrava,* ***2.*** *Institute of Physics, Charles University, Prague,* ***3.*** *Department of Physics, Bielefeld University*

The magnetooptic Kerr effect (MOKE) is a widely used tool for both basic research and applications. Despite well-known linear MOKE (LinMOKE) being linear in magnetization, there is also a MOKE being quadratic in magnetization (QMOKE). Both LinMOKE and QMOKE are described by change of permittivity tensor upon magnetization direction. In case of cubic crystal owning point symmetry, linear combination of four spectra (so called principal spectra) are enough to describe permittivity tensor for any magnetization orientation. Namely, those spectra consists of one optical spectra ε, one spectra linear in magnetization K and two quadratic spectra, Gs=G11-G12 and G44. Here, we will present both experimental and ab-initio technique to determine all four principal spectra in bcc Fe. This approach is applied to thin films of Fe(5-30nm)/MgO(001). The absorption part of all principal spectra of bcc Fe is shown in Figure (a-d).

In general, optic and magneto-optic properties of crystals are determined by the well-known Kubo formula for direct inter-band transitions. It states that the absorption of a photon followed by the excitation of electron in solids is governed by electric dipole element <i|p|f>, where |i>, |f> are initial and final electron states and p is the momentum operator. In order to understand in detail the electric dipole elements, we visualize them in the reciprocal space by two different means: on surfaces of constant energy difference between initial and final states and by joint spaghetti diagram (Figure (e), (f) for ε and K, respectively). It allows us to identify hot-spots contributing to the magneto-optic response, and conditions of those hot-spots in topology of the band structure.

The work was supported by Czech Science Foundations (grant no. 13-30397S).



Abstract figure hamrle.png

Type II microcomb generation in a filter-driven four wave mixing laser

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 287

Mr. Andrew Cooper [1], ***Dr. Alessia Pasquazi*** [1]

1. *University of Sussex*

Andrew Cooper1, Hualong Bao1, Sai T Chu2, Dave J Moss3, Roberto Morandotti4, Brent Little5, Marco Peccianti1 and Alessia Pasquazi1

1 University of Sussex, UK, 2 City University of Hong Kong, Hong Kong, China, 3 RMIT University, Melboune, Australia, 4 INRS - Énergie, Matériaux et Télécommunications, France,

5 Xi'an Institute of Optics and Precision Mechanics of CAS, China

We report experimental results of generation of a type-II microcomb in a filter-driven four wave mixing laser based on a CMOS compatible microring resonator. These results represent steps toward a miniature and robust source of optical frequency combs. These combs consist of precisely spaced spectral lines, with potential to create ultra-fast and stable optical clocks that can be easily fabricated [1] and used for integrated optics applications.

In this work we present the behaviour of our laser in a variety of regimes producing stable frequency combs using a doped silica glass microring with a FSR of 50GHz. The system consists of an outer fibre loop cavity with a fibre amplifier as the gain medium. Combs form through passive mode-locking of the laser through filter-driven four wave mixing [2] and the four wave mixing process inside the high-Q, highly nonlinear microring. The system can be controlled by varying the polarization, main cavity path length and intra-cavity power.

We observe overtone oscillation and for higher powers the lines fill the comb at the free spectral range of the system. This behaviour is recalls the behaviour of type-II microcombs [3] excited with a coherent laser lines, but in stark contrast with these results we observe coherent oscillation.

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Snake-shaped waveguides for quasi-phase-matched second harmonic generation

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 326

Ms. Natália Morais [1], Mr. Valerio Flavio Gili [1], Dr. Marco Ravaro [1], Dr. Fares Chouchane [1], Dr. Maurizio De Rosa [2], Dr. Iolanda Ricciardi [2], Dr. Aristide Lemaitre [3], Dr. Ivan Favero [1], Prof. Giuseppe Leo [1]

1. *Université Paris Diderot,* ***2.*** *Istituto Nazionale di Ottica,* ***3.*** *C2N-CNRS*

Phase-matched three-wave mixing is possible in optically isotropic zinc-blende materials, thanks to quasi-phase matching occurring when the interacting fields propagate along a curved path about a principal dielectric axis [1]. Following this scheme, efficient second harmonic generation (SHG) was recently demonstrated in GaAs [2] and AlGaAs microdisks [3], and it was predicted in curved waveguides [4].

In order to obtain this type of SHG with monolithic low-loss photonic wires in the optical telecom range, we designed and fabricated snake-shaped semiconductor waveguides of two different kinds: 1) air-suspended waveguides; and 2) waveguides on a thick aluminium-oxide (AlOx) substrate. In the first case, a 123nm Al0.18Ga0.82As layer was MBE grown over an Al0.80Ga0.20As sacrificial layer, while in the second case a 100nm Al0.18Ga0.82As layer was grown on an Al0.98Ga0.02As that was wet-oxidized after lithography and dry etching.

Losses in ideal bent waveguides are of two distinct types: radiation losses at the bent semiconductor-air interface, and overlap mismatch losses stemming from the incomplete mode coupling at the waveguide sections with a sudden change of curvature radius. Finite-element simulations predict them to be < 1dB/cm both for 0.75μm wide air-suspended waveguides with 20μm radius of curvature, and for 1μm wide waveguides on AlOx with 50μm radius of curvature. In order to assess the additional guided-mode losses due to scattering at the non-ideal interfaces of the fabricated nanowires, systematic transmission measurements are under way, the light injection and collection being made with micro-lensed-fiber end-fire coupling into inverted tapers.

Our preliminary results show the good potential of such snake-shaped waveguides for SHG.

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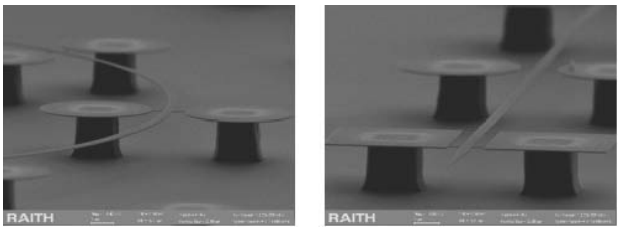

Fig.jpg

Synthesis of nanoporous gold nano-shell structure by simple plasma treatment

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 353

Mr. Jongho Hwang [1], ***Mr. Jung Su Park*** [1], ***Dr. Joon Heon Kim*** [1]

1. *Advanced Photonics Research Institute, Gwangju Institute of Science and Technology*

A nanoporous gold nanoparticle can have an advantage of plasmonic nanoporous structure, such as a large surface area and multiple hot-spots, together with a benefit of a small overall size in nanoscale. Its plasmonic property can be determined by a size of an overall structure as well as its ligaments. Therefore, its size tunability can be critical for the desired optical property. Here, a simple way to synthesize a nanoporous gold nano-shell (NPGNS) structure having a near-IR localized surface plasmon resonance (LSPR) peak will be provided.

Citrate-stabilized gold nanoparticles (AuNP) with a size of 15 nm were mixed with positively functionalized polystyrene (PS) microspheres with a size of 1 μm in aqueous solution. AuNP were attached to the surface of microspheres by the electrostatic interaction. A monolayer of microspheres with attached AuNPs was formed on the glass substrate, and then it was treated by oxygen plasma. A plasma treatment reduces the size of PS microspheres, which makes inter-particle distance between attached AuNPs to be reduced. Finally, AuNPs contact each other on the microsphere surface to make a nanoporous gold frame. Further plasma treatment completely removes a polystyrene core part to leave only a NPGNS structure.

A fabricated NPGNS structure has a diameter of approximately 300 nm and ligaments of a size similar to used AuNPs. It shows a LSPR peak in the near-IR range. By using different sizes of AuNPs and microspheres, a diameter and a ligament size of a NPGNS can be controlled and the corresponding LSPR peak can be shifted quite well. Because a connection point between AuNPs in a NPGNS is not very smooth and there are many pores with rough ligaments, there can exist many hot-spots in a NPGNS. A simple post plasma treatment combined with the well-established chemical synthesis of colloid AuNP and polymer microsphere can provide a new synthetic route for nanoporous gold nanoparticle structure with a tunable LSPR peak in the near-IR range.

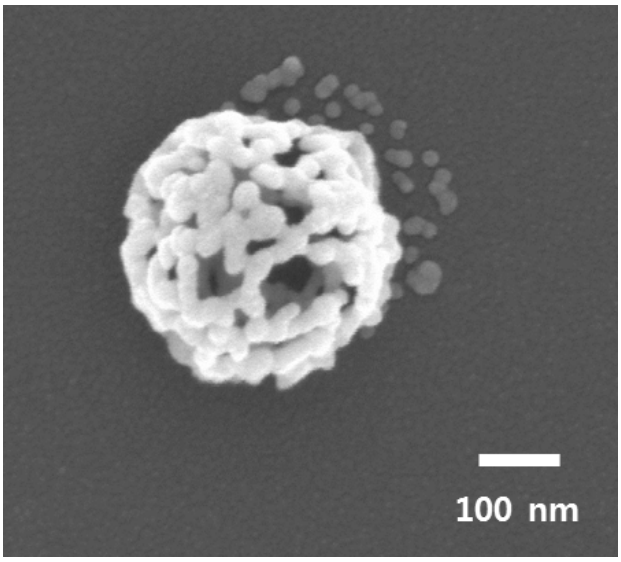

Figure nanoporous gold nano-shell.png

Investigation on Optical and Structural Properties of Photon Induced Chemically Deposited Nanocrystalline CdSe Thin Films

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 67

Mr. Sanjay Pawar [1], ***Dr. Archana Meshram*** [2], ***Prof. Vilas Tabhane*** [1]

1. *Savitribai Phule Pune University, Pune,* ***2.*** *Dr. Ambedkar College, Dikshabhoomi, Nagpur*

Introduction

In recent years, the cost of inorganic nanocrystalline semiconductor thin film solar cell has significantly reduced, however to make it viable, its efficiency needs to be enhanced. For this the thin film nanostructure geometry would be very useful for fundamental studies and technical applications. Electrical, optical and mechanical properties which depend on structure, size and dimension need to be investigated. This has great potential to generate structures of suitable properties under control parameters which is the dire need of today's many fields of modern science and technology.

In nature, biological reactions are influenced more or less under the sun light photon energy and resulting in nature's beauty of different colors, shapes and sizes. So photon energy might become the important vital parameter to manipulate and control chemical reaction.

Methods:

In the present work, the influence of different single color light illumination on the chemical bath deposition of CdSe thin films was investigated by means of X-ray diffraction, Scanning electron microscopy, Energy Dispersive Spectroscopy (EDS), photoluminescence spectroscopy(PL) and UV-Vis-NIR spectrophotometer respectively. Films are deposited on glass, stainless steel and conducting glass substrates at room temperature for various time periods of Cd and Se ion source solutions for suitable Cd/Se source solutions ratio under darkness, red, green and blue color Light Emiting Diodes(LEDs) illuminations condition with constant stirring speed.

Results:

The study reveals change in film color appearance and band gap change. Solution color changed from colorless, pale yellow, orange and finally turned into reddish dark brown. This reveals the growth of grain size from nano scale to micro scale. Attempt has been made to study the structural, physical and optical properties by the influence of single color light illumination on the growth of CdSe nanocrystallite.

Discussion:

1.under the different single color light illumination conditions, remarkable changes in surface morphology, band gap, % Transmittance and absorption were observed.

2.Extra shoulder peak in XRD pattern was observed under green and blue color illumination conditions.

Keywords: Nanocrystalline CdSe, Chemical bath deposition, XRD, SEM

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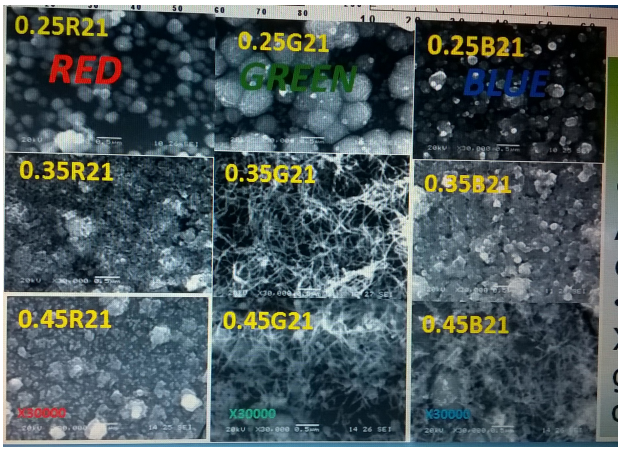
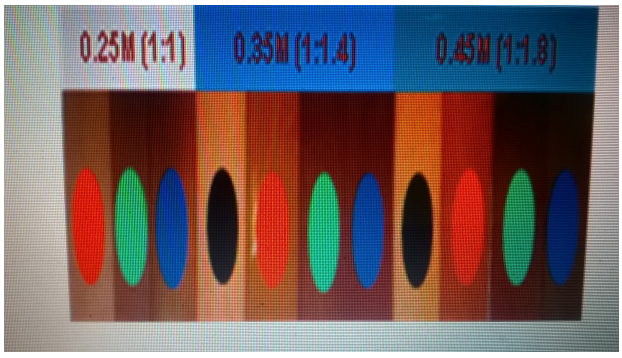


Sem of photochemically deposited cdse.jpg



Cdse thin film under dark red green blue color.jpg

Photochemical cbd setup.jpg

Facile Bioinspired SERS Substrates for Real Life Applications

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 151

Mr. Vipul Sharma [1], ***Dr. Venkata Krishnan*** [1]

1. *Indian Institute of Technology Mandi*

For the first time, fabrication of bioinspired, eco-friendly, low cost and reproducible surface enhanced Raman scattering (SERS) substrates based on plant leaf substrates has been done. The naturally occurring roughness (microstructures) on the surface of the plant leaves were replicated using the soft lithography technique. The replica of the leaf surfaces mimicked the surface roughness of the real leaves which influenced the deposition of Au NPs and leading to the formation of electromagnetic hot spots. The surface morphologies of different biomimetic surfaces tend to influence the SERS performance of the substrates which was demonstrated using MB as analyte molecule. Upon comparison of the enhancement factors obtained from the different substrates, one can correlate the effect of surface morphology of the leaf surface with SERS performance which is directly due to the different arrangement of the microstructures within the surfaces. Furthermore the fabricated biomimetic SERS substrate was found to be equally efficient in the real life application which was demonstrated by the sensing/detection of the common pesticides carbendazim and thiabendazole upto 10 nanomolar concentrations.

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NEW METHODS OF DEFINING MOLECULES ELECTRONIC STRUCTURE FOR NANOELECTRONICS AND NANOPHOTONICS

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 165

Prof. Michael Dolomatov [1], ***Mr. Kamil Latypov*** [2], ***Dr. Ella Kovaleva*** [3], ***Ms. Natalia Paimuzina*** [3], ***Mrs. Milana Dolomatova*** [2]

1. *Bashkir State University, department of physical electronic and nanophysics, Ufa, Russia,* ***2.*** *Bashkir State University, department of physical electronics and nanophysics, Ufa, Russia,* ***3.*** *Ufa State Petroleum Technical University, Ufa, Russia*

In the last decade polycyclic aromatic hydrocarbons (PAHs) attracted great interest in the diverse applied fields. PAHs became an alternative to existing nanophotonic and optoelectronic materials. The optical properties of PAHs depend on charge transfer properties and consequently electron structure of molecules. The aim of this research is to generalize our new and previous works[1,2] on defining electronic structure of molecules and materials. In particular, these methods can be applied to define the first ionization potential (IP) and the electron affinity (EA) of molecules and organic semiconductors. In our methods, unlike other conventional spectroscopic methods, substances are considered as a quantum continuum without dividing the spectrum into characteristic spectral bands of certain frequencies or wavelengths of individual functional groups and components. This approach we called Electron phenomenological spectroscopy (EPS)[1]. Unlike our previous works[1,2] within EPS we present new methods for identifying the electronic structure that based on new physical effects – the correlation of the molecular levels energy with the autocorrelation function.

$Ei=\gamma 0i+ \gamma iK(\nu)$(1)

where $K(\nu)=\int\square(\nu)\ \square(\nu+\Delta\ \nu)$ – the autocorrelation function of the electron spectrum (ACFS) in visible and UF spectrum, $\varepsilon(\nu)$ – the frequency distribution function of the electron spectrum

$IP=\alpha 0 + \alpha\ K(\nu)$ (2)

$EA=\beta 0 + \beta\ K(\nu)$(3)

We suggest that phenomen (1) is explained by strong electron interactions (i.e. each electron interact with the whole electron system)

where $\gamma 0i$, γi, $\alpha 0$, α, $\beta 0$, β – empirically determined coefficients characterize quantum interaction degree.

Thus, the new methods are performed to define characteristics of electronic structure can be applied for studying multi electron systems in optoelectronics and nanophotonics.

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Two-photon excited ultrafast spin dynamics in monolayer MoS2

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 213

Dr. Jayakrishna Khatei [1], Mr. Dmitry Panna [1], Mr. Amit Bendel [1], Mr. Barak Lavy [1], Dr. Leonid Rybak [1], Prof. Alex Hayat [1]

1. *Technion*

Monolayers of transition-metal dichalcogenides (TMDCs) such as MoS2 have drawn great interest because of the direct band gap nature in monolayers to explore 2D valley excitons. So, far there have been various spectroscopic efforts to study exciton dynamics in MoS2 such as reflectance, photoluminescence excitation spectroscopy and pump-probe spectroscopy. However, little is known related to exciton relaxation dynamics under two-photon excitation, where a thorough knowledge of the valley selective selection rules for optically inactive dark excitons in monolayer MoS2 is needed.

In this work, we have studied two-photon excited ultrafast spin dynamics in monolayer MoS2, by performing two-photon excited pump-probe differential reflection and photoluminescence (PL) studies near 1200 nm excitation wavelength. By exploiting the interplay between same and opposite pump-probe circular polarizations the differential reflection signal (Fig. a) associated with the exciton dynamics of optically inactive dark excitons (mj+-2) (Fig. b) created under circularly polarized two-photon excitation are probed using broadband white light supercontinuum via optically active bright excitons (625 nm and 695 nm). The pump-probe signal is attributed to transformation of dark exciton into bright exciton via phonon-assisted inter-valley scattering. In our two-photon excited PL studies, a two-photon absorption (TPA) saturation effect (with high unsaturated TPA co-efficient 10ˆ4 cm/GW) is observed at higher excitation intensity (>1 MW/cm2) possible because the pulse duration is shorter than the thermalization time of the generated carriers and with high intense laser pulse. Moreover, the enhanced PL intensity for linearly polarized emission as compared to circularly polarized emission at different polarization angle suggests that the linearly polarized excitation at 1250 nm (Fig. c) creates exciton valley coherence, where phonon assisted inter-valley scattering is prevented due to insufficient excitation energy. Our results provide important experimental information for exciton-valley coupling in monolayer MoS2 - for valleytronics, quantum optics and photonic devices.

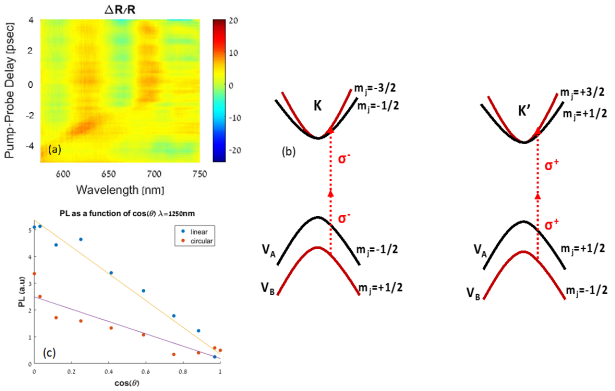

ΔR/R
Pump-Probe Delay (psec)
Wavelength (nm)
(a)
(b)
K
K'
m_j=-3/2
m_j=-1/2
m_j=+3/2
m_j=+1/2
σ-
σ+
V_A
V_B
PL as a function of cos(θ) λ=1250nm
linear
circular
PL (a.u)
cos(θ)
(c)

Fig1.png

An experimentally founded rate equation model for NIR-photon upconversion

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 225

Mr. Jeppe Christiansen [1], ***Prof. Brian Julsgaard*** [1]

1. *Aarhus University, department of physics and astronomy*

The efficiency of modern photovoltaic units are getting close to the SQ-limit [http://dx.doi.org/10.1063/1.1736034], that is, the maximum obtainable efficiency of a standard photovoltaic unit. Thus, new methods, are in demand, to increase this limit in the process towards a renewable energy-system. Upconversion of sub-band-gap photons has proven to be a fruitful way of achieving this goal [http://dx.doi.org/10.1002/adom.201500024]. Upconversion is the process of creating a higher energy photon out of two or more low energy photons. A standard silicon solar cell cannot absorb photons with energy below 1.11 eV. This amounts to 20% of the light from the sun witch reaches the surface of the earth. Moreover -- as silicon is transparent to the sub-band-gab photons -- the upconverting unit can beneficially be attached to the rear side of a photovoltaic unit and hereby improving existing as well as future developed units.

Trivalent rare earth ions, and especially erbium ions, have proven to be a promising candidate for upconversion [http://dx.doi.org/10.1063/1.1844592]. The erbium ions are doped into a host matrix -- in our case TiO_2. The aim of this work is to construct a model for the upconversion dynamics based on rate equations. The parameters of the model will be measured and cross-related through different experiments. The main parameters of the model are the absorption cross-section of the erbium ions, and the different transition rates governing population decay and increase. The absorption cross-section will be determined through absorption spectra using a spectrophotometer cross-related to measurements of the complex index-of-refraction obtained with an ellipsometer. From the ground-state-absorption cross-section combined with the theories of McCumber [http://dx.doi.org/10.1103/PhysRev.136.A954], and Judd & Ofelt [http://dx.doi.org/10.1103/PhysRev.127.750] it is possible to compute the exited-state cross-sections as well. The transition rates will be determined through the exited-state life-time of the erbium ions, measured from time-resolved-luminescence experiments. The accuracy of the model will be demonstrated via comparison of the model output with quantum-efficiency measurements of the upconversion yield.

Besides enabling investigation of the upconversion dynamics the model paves the way for a direct investigation of transition rates such as multi-phonon relaxation and Förster-resonance energy-transfer.

Structural, Optical and electrical properties of CdS annealed thin films

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 256

Dr. Alicia Vera [1], Dr. Ana Lilia Leal-Cruz [1], Dr. Alejandro García-Juárez [1], Dr. Carlos Zuñiga [2], Dr. Ignacio Zaldivar-Huerta [2], Dr. Josué Aguilar-Martínez [3]

1. *Universidad de Sonora,* ***2.*** *Instituto Nacional de Astrofísica Óptica y Electrónica,* ***3.*** *Universidad Autónoma de Nuevo León*

Recent advances in soft solution processing of inorganic materials offer an exciting opportunity to develop large area manufacturing technologies for solar cells. In the present work, cadmium sulphide (CdS) thin films were prepared by chemical bath deposition technique under optimal conditions, and annealed in nitrogen atmosphere at 100, 150, 200, and 250°C. Structural properties of CdS semiconductor were characterized by X-ray diffraction and the XRD patterns indicated the presence of single-phase of hexagonal CdS. Annealing samples at 200°C exhibit compact and well-defined granular structures, containing 56 and 44 At. % of Cd and S, respectively. According to the optical characterization, films without annealing exhibit a band gap of 2.35 eV and after annealing treatment, the band gap of the films changes from 2.3 to 2.4 eV, when annealing temperature increase from 100 to 250 °C. Based on the obtained results through measurements in a 4 points equipment, CdS resistivity varies from 7E8 (annealed films) to the 2.6E9 Ωm2 (as deposited films), those values shows a good agreement with other experimental studies of CdS thin films

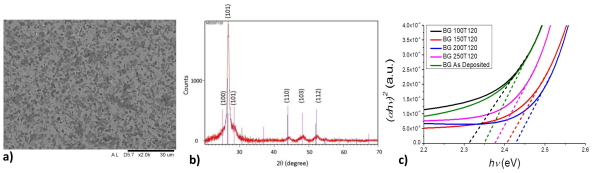


Figure abstract vera.jpg

Gold nanoparticle-doped silica fiber for a new generation of optical amplifiers

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 273

Mrs. Aurélie Demol [1], ***Mr. Rémi Habert*** [2], ***Dr. Monika Bouet*** [3], ***Dr. Odile Cristini Robbe*** [1], ***Ms. Mathilde Bruge*** [2], ***Ms. Bénédicte Calimet*** [2], ***Dr. Laurent Bigot*** [2], ***Dr. Rémy Bernard*** [2]

1. *IRCICA, CNRS (USR 3380), Université Lille 1,* ***2.*** *University of Lille Sciences and technologies,* ***3.*** *IRCICA,*

Owing to their plasmonic properties as efficient scatterers or absorbers of light in the visible and near-infrared (NIR) range, noble metal nanoparticles (NPs) have been widely investigated in recent years for a variety of applications in different fields such as sensing, nonlinear optics and fluorescence enhancement. Indeed, Maurizio et al. show that gold nanoparticles can act as very efficient nanoantennae for the luminescent enhancement of photoemitting systems like Er ions [1]. Erbium Doped Fiber Amplifiers (EDFAs) are clearly a key technology in present optical communication systems because of their high gain, low noise and high-speed response. Many research efforts are being made in these years to increase the small cross-section for Er excitation and enhance the Er3+ luminescent emission at 1.54 mm to improve the efficiency of EDFAs.

The aim of our ANR project AMPEROR was to realize silica fibers co-doped with gold nanoparticles (Au-NPs) and Er ions for a new generation of EDFAs. The preparation of optical fibers required high temperature process (> 1800°C for pure silica fibers, elaborated by Modified Chemical Vapor Deposition process(MCVD)). This temperature is higher than the gold nanoparticle melting point (300°C). A technological obstacle is to maintain the gold nanoparticles in the manufacturing process. In this project, we developed a new doping concept involving a zirconia sol co-doped with gold nanoparticles and Er ions in a MCVD-compatible process. Preservation of Au-NPs all along the fiber manufacturing process is demonstrated. Surface Plasmon Resonance (SPR) is clearly observed at 500 nm and remain unchanged during the process fabrication (fig. 1). First attenuation value measurement by conventional cut-back technique is about 120 dB/m showing a high incorporation of Au-Nps into the glass fiber.

This promising method for the manufacture of gold nanoparticle-doped fibers was also used for the realization of an EDFA incorporating erbium to the doping solution. The characterization of the co-doped fiber is under progress.

[1] C. Maurizio, E. Trave, G. Perotto, V. Bello, D. Pasqualini, P. Mazzoldi, G. Battaglin, T. Cesca, C. Scian and G. Mattei, Phys. Rev. B: Condens. Matter Mater. Phys., 2011, 83, 195430.

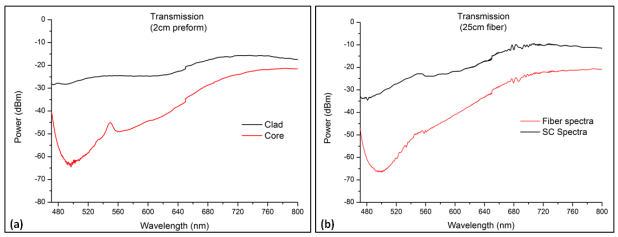


Figure 1: Transmission sprectra of (a) the MCVD preform, and (b) the obtained fiber

Transmission sprectra of a the mcvd preform and b the obtained fiber.png

Plasmons in 2D materials

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 274

Mr. René Petersen [1], ***Prof. Thomas Garm Pedersen*** [1], ***Prof. Javier Garcia De Abajo*** [2]

1. *Aalborg university,* ***2.*** *Institute of Photonics Sciences (ICFO)*

We study plasmons in the 2D materials graphene, MoS2 and black phosphorous using the local and the non-local RPA conductivity. These three materials are respectively zero-gap, large gap and anistropic 2D materials, thus representing a broad variety of 2D materials. Non-local effects are known to be important in applications involving large in-plane wavevector components, such as the enhancement of the dipole radiation rate (Purcell factor) in the vicinity of a lossy material, and in calculations of the lifetime of excited electrons. We investigate the importance of non-local effects and the importance of resonant plasmon modes for the Purcell factor. Furthermore we present calculations of plasmon dispersions in a pump-probe setup where the local electron temperature can easily reach several thousands Kelvin. In this setup plasmons are activated by locally increasing the temperature using an intense laser beam and subsequently the response is measured using a second laser. We provide calculations of Purcell factors for the three materials in this scenario, as well as calculations of the electron lifetime, a measure which is highly relevant in a pump-probe experiment. Finally, we calculate for all materials the equivalent temperature for a given Fermi level, to study the difference between thermal doping and electron doping.

Passive mode-locking in quantum-well semiconductor laser based on InGaAs/InGaAlAs/InP heterostructure

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 324

Mr. Ivan Polukhin [1], ***Mr. Grigoriy Mikhailovskiy*** [1], ***Mr. Dmitrii Rybalko*** [1], ***Dr. Yurii Solov ev*** [1], ***Prof. Maxim Odnoblyudov*** [1], ***Ms. Natalia Sorokina*** [1], ***Mr. Evgeniy Petukhov*** [1], ***Dr. Maxim Vinnichenko*** [1], ***Dr. Vladislav Bougrov*** [2], ***Prof. Boris Ermakov*** [1]

1. *Peter the Great St. Petersburg Polytechnic University,* ***2.*** *ITMO university*

We propose a model of passive mod-locking (ML) laser diode based on quantum wells. This model is a comprehensive numerical study of the operation regimes of semiconductor laser and can estimate main characteristics of ML pulses such as the repetition rate, width and shape of the pulse depending on different parameters of laser structure such as the absorber length and relaxation rate, pumping current, number and width of quantum wells. Our model is based on travelling wave equations which shall be completed with boundary conditions, which link amplitudes at the boundaries of different laser sections and initial conditions responsible for the first pulse of laser radiation. Here we accompany the wave equation with a spontaneous noise function that is responsible for the initial generation of laser radiation. The spontaneous noise function is complex, random both in space and time while having no correlation between the real and imaginary parts. The distribution density of such parts is described by a Gaussian distribution. Numerical results for InGaAlAs/InGaAs/InP laser heterostructure emitting at 1.55 um wavelength with 5 quantum wells in active region are presented. It has been shown that two modes are possible in the given structure - fundamental and second harmonic. The appearance of the second harmonic radiation in the laser cavity is due to insufficient absorber relaxation rate. We have demonstrated that it is possible to achieve the most effective transition to the passive ML by varying the length of the absorber. For the structure under study the optimal length was equal to 637 μm. The pulse duration was amounted to 2 ps, repetition rate to 10 GHz and average output power - to 9.4 mW. Figure 1 shows the distribution of radiation intensity along the laser resonator in fundamental mode-locking.

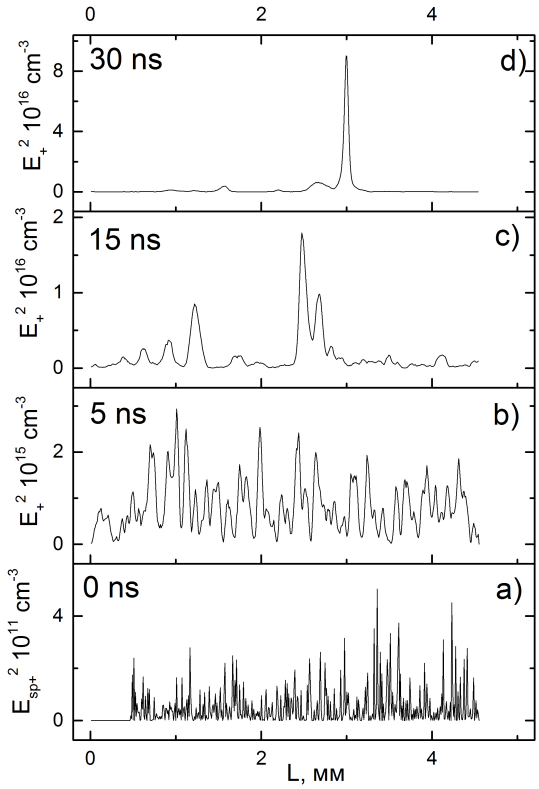


Figure 1.jpg

Evolutionnary optimization of nanophotonic multilayered structures

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 424

Mr. Mamadou Aliou Barry [1], ***Dr. Antoine Moreau*** [1]

1. *Université Blaise Pascal*

Bragg mirrors have now been manufactured for decades, and we are nowadays pretty aware that such a structure is ubiquitous in nature. Although there are strong clues that this is the case, it has never been proved that such regular structures are optimal.

We have used evolutionary algorithms to optimize multilayered structures and we have found that, using a simple objective function, the algorithms are actually able to retrieve Bragg mirrors as the best structure to reflect light at a given wavelength.

This give a very convincing argument suggesting that Bragg mirror are actually optimal, and gives an opportunity to define more precisely to which sense.

Finally, Bragg mirrors can be considered as a valid test-case to assess the efficiency of a given optimisation algorithm. We thus expect this fundamental work to be useful to the community.

Light Emission from Al0.08Ga0.92As Gunn Device

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 277

Mr. Caglar Cetinkaya [1], ***Mr. Selman Mutlu*** [1], ***Dr. Omer Donmez*** [1], ***Prof. Ayşe Erol*** [1]

1. *istanbul university*

We report light emission characteristic of a waveguided Al0.08Ga0.92As Gunn Device, which consists of an n =4.6x1017 cm-3 doped Al0.08Ga0.92As active layer sandwiched between the undoped Al0.32Ga0.68As waveguiding layers grown on a semi-insulating GaAs. The device is fabricated in simple bar geometry with a length of 300 m. The device emits light from both edge and surface when it is biased at an applied electric field of onset of the negative differential resistance (NDR) region via recombination of electrons and holes, generated by impact-ionization process within the traveling high-electric fielddomain, that is, Gunn domains. 1,2. Our results show that, because of impact ionization within the travelling space charge, the intensity of the edge- and surface- emitted light is dependent on applied electric field. At low electric fields, light intensity increases linearly then, as applied electric field reaches threshold of NDR process, increases exponentially. Besides, as applied field is increased, full width at half maximum (FWHM) of emitted light decreases and the FWHM of the edge emission is observed to be narrower.

Impact of Earth's magnetic field intensity on forest vegetation

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 447

Dr. Aigars Indriksons [1]

1. *Latvia University of Agriculture, Forest Faculty*

Research of the Earth's magnetism is one of the oldest in the history of science. However, till up to now, there is not completely elaborated quantitative theory of geomagnetic field existing.
So called, Earth's dipole field is generated by circulating electric currents in the planet's metal core. The hemi-fluid Earth's core consists of fusion of iron (Fe), nickel (Ni) and silicon (Si). The local variations in the field (few hundreds of nT) are due to changes in magnetic properties of the crustal rocks themselves.
Still there are few studies of Earth's magnetism impact on living organisms, particularly, to green plants and trees. The forests are covering 25% of the total terrestrial area of planet. In some countries this coverage is even bigger, e.g., in Latvia covering 52% of total land area.
The research is carried out by comparison of magnetic field anomaly map with forest data basis of Latvia. The strength of magnetic field in Latvia varies between -1200 nT and +7590 nT, but the average strength is about +400 nT. These data are obtained based on remote sensing by distinguishing of various visible and invisible bands of the electromagnetic spectrum, such as infrared, gamma, or ultraviolet from the satellite imagery technologies. Although both the qualitative and quantitative nature of that radiation is not sufficiently known, there are some significant correlations found between Earth's magnetism and forest properties. Thus, most forested in Latvia are the regions with higher intensity of the magnetic field. Also the forests of broad-leaved trees (Quercus robur L., Fraxinus excelsior L., Tilia cordata Mill., Acer platanoides L., Ulmus sp. etc.) are more located in regions with enhanced intensity of magnetic field.

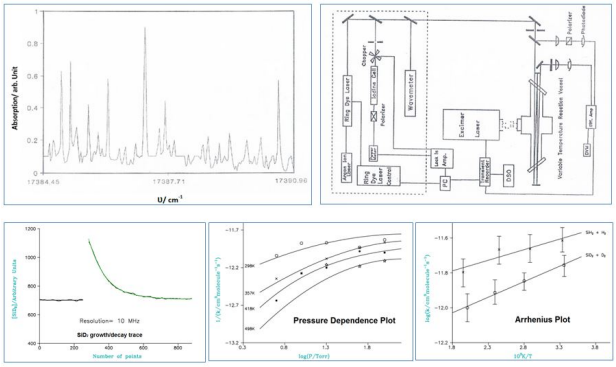
Time resolved spectroscopic investigation of SiD2 + D2: kinetic study

Thursday, 8th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 363

Prof. Najm Al-Rubaye [1], ***Prof. Robin Walsh*** [2]

1. *University of Technology, Baghdad,* ***2.*** *University of Reading*

Silylenes (silanediyls) have made an important impact on organosilicon chemistry even if it is of more recent foundation than carbenes in organic chemistry and much less complete. These species are highly reactive intermediates. They play a central role in the chemical vapor deposition (CVD) of various silicon-containing thin films which have a technological importance in microelectronics as well as in the dry etching processes of silicon wafers. Spectroscopic methods have been developed to observe these species, a necessary pre-requisite to their direct monitoring. In this work, PhSiD3 precursor was chosen for SiD2 because its analogue phenylsilane, PhSiH3 proved to be a good precursor for SiH2 and the high quality decay signals observed revealed that SiD2 be readily detected from PhSiD3 and that if other decomposition pathways (e.g. PhSiD + D2) are occurring, they do not effect measurements of the rate constants for SiD2. The absorption spectrum of SiD2 formed from the flash photolysis of a mixture of PhSiD3 and SF6 at 193nm were found in the region 17384-17391 1/cm (the laser linewidth was approximately 3×10-5 1/cm) with strong band at 17387.07 1/cm. This single rotational line of pQ1 was chosen to monitor SiD2 removal. Time-resolved studies of SiD2 have been carried out to obtain rate constants for its bimolecular reactions with D2. The reactions were studied over the pressure range 5-100 Torr (in SF6 bath gas) at four temperatures in the range 298-498K. Single decay from 10 photolysis laser shots were averaged and found to give good first-order kinetics fits. Second order kinetics were confirmed by linear pressure dependence of the pseudo first order decay constants and substance D2 pressures within experimental error. The reaction was found to be pressure dependent at all temperatures, consistent with a third-body mediated association process and approximately has the same reactivity to that of SiH2+ H2. Theoretical extrapolations (using Lindemann-Hinshelwood model and Rice, Ramsperger, Kassel and Marcus (RRKM) theory) were also carried out and obtained data were fitted the Arrhenius equations.



Summary results.jpg

Topographically induced mode-coupling: Beyond FIB-milled single open microcavities

Thursday, 8th December - 14:30 - Lithography and nanofabrication (large scale nanostructuring) - Tower 24 - Room 101 - Oral presentation - Abstract ID: 227

Dr. Aurélien Trichet [1], ***Mr. Lucas Flatten*** [2], ***Dr. Philip Dolan*** [1], ***Prof. Jason Smith*** [2]

1. *Department of Materials - University of Oxford,* ***2.*** *University of Oxford*

Open-access optical microcavities, depicted in figure 1 a), are emerging as an original tool for light-matter studies thanks to their intrinsic tunability and the direct access to the maximum of the electric field along with their small mode volume. They have been attracting a lot of attention recently, especially in Europe with a total of 10 groups now working with open microcavities configuration producing high-profile Science including QED experiments, strong coupling with quantum wells and 2D materials, micro-lasing, nano-sensing and nano-tweezing.

The fabrication challenge of these devices lies in making the concave mirror substrate as small and smooth as possible while avoiding cracks in the Dielectric Bragg Reflector (DBR). Both, CO2 laser ablation and Focused Ion Beam (FIB) milling have produced low mode volume (≈ $\lambda\hat{}3$) with high Finesse (> $10\hat{}4$) single microcavity. However, the FIB milling strategy is the only one providing nanometric topographic control [1] of the photonic potential with a high degree of reproducibility (see figure 1 b)). This feature opens the possibility to investigate high quality extended structures (> 100 µm x 100 µm) beyond the single microcavity.

I will firstly discuss our optical study of two coupled microcavities for which the coupling strength depends on the barrier height in between the two microcavities [2]. As a second example, I will show that the mirror topography can induce an anti-crossing and an hybridization in between the microcavity localized modes and the surrounding planar modes. Then, I will show our latest effort in fabrication and surface characterization to extend these devices towards super-structures such as photonic squared and hexagonal crystals, photonic graphene structures and circuitry as shown in figure 1 c).

The FIB strategy offer the unique possibility to manipulate the flow of light on-a-chip while maintaining high finesse and low mode volume and therefore, brings open-microcavities into the realm of photonic circuits and superstructures with a wide range of applications in nanophotonics.

[1] A. A. P. Trichet, et al., Optics Express, 23, 13, 17205-17216 (2015)

[2] L. C. Flatten, et al., Laser & Photonics Reviews, 10, n°2, 257-263 (2016)

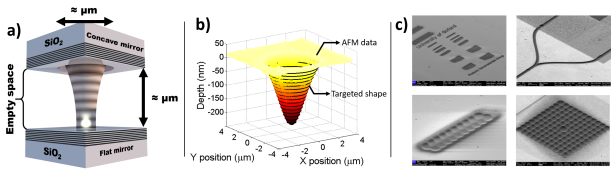


Fig1.png

Cavity Enhanced Light Emission from Electrically Driven Carbon Nanotubes

Thursday, 8th December - 14:47 - Lithography and nanofabrication (large scale nanostructuring) - Tower 24 - Room 101 - Oral presentation - Abstract ID: 280

Mr. Felix Pyatkov [1], ***Mr. Valentin Fütterling*** [1], ***Dr. Svetlana Khasminskaya*** [1], ***Dr. Benjamin Flavel*** [1], ***Dr. Frank Hennrich*** [1], ***Prof. Manfred Kappes*** [1], ***Prof. Wolfram Pernice*** [2], ***Prof. Ralph Krupke*** [1]

1. *Karlsruhe Institute of Technology,* ***2.*** *University of Münster*

Nanoscale photonic emitters are essential elements for on-chip networks and optical interconnects. Carbon nanotubes (CNTs) can be envisioned as electrically driven waveguide-integrated light sources for future on-chip data communication due to their unique structural, electrical and optical properties. The challenge thereby is to integrate and electrically contact solution processed CNTs across CMOS compatible waveguide structures and to enforce efficient coupling of light from the CNT into the waveguide. Recently, we realized wafer scale, broadband CNT-based emitters integrated with nanophotonic circuits allowing for propagation of light over centimeter distances [1]. Moreover, we have shown that semiconducting CNTs can act as electroluminescent single photon sources, embedded in fully electrically triggered quantum photonic circuits [2]. Here we demonstrate ultrafast light emitters with exceptionally narrow linewidths based on cavity-coupled CNTs [3].

Hundreds of nanophotonic circuits with integrated CNTs were fabricated using a number of large scale nanostructuring techniques. Electrodes, waveguides and photonic crystal nanobeam cavities were defined by means of electron beam lithography and subsequently formed using metal evaporation, reactive ion and wet etching, respectively. Finally, dielectrophoresis allowed for scalable and site-selective placement of individual CNTs from pre-sorted suspensions into photonic cavities between metal electrodes (Fig. 1).

In combination with a nanobeam cavity CNTs transform into exceptionally narrowline light sources emitting at arbitrary designed wavelength (Fig. 2a). Enhanced emission couples into the underlying photonic network with high reproducibility for both dc and ac biased CNTs. Waveguide-integrated CNTs emerged as high-speed transducers for light pulse generation in the GHz range (Fig. 2b). Our approach holds promise for active photonic networks and localized sensing applications in a chip-scale framework.

[1] S. Khasminskaya, F. Pyatkov et. al., Adv. Mater. 26, 3465–3472 (2014).

[2] S. Khasminskaya, F. Pyatkov et. al., Nat. Photon. 10, 727-732 (2016).

[3] F. Pyatkov, V. Fütterling et. al., Nat. Photon. 10, 420-427 (2016).

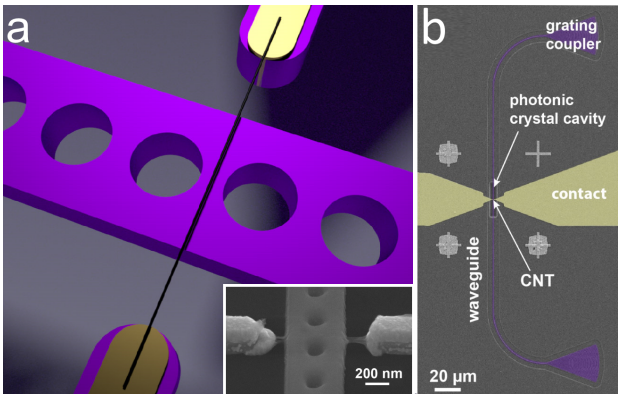


Fig. 1. cavity-integrated electrically driven nanotube..png

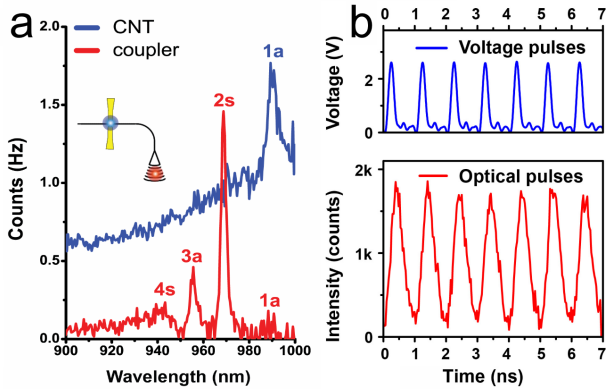


Fig. 2. narrow-line and ultra-fast light source..png

Single step optical realization of 3D photonic bandgap submicrometer periodic structures for thermophotovolatics

Thursday, 8th December - 15:04 - Lithography and nanofabrication (large scale nanostructuring) - Tower 24 - Room 101 - Oral presentation - Abstract ID: 195

Ms. Saraswati Behera [1], ***Prof. Joby Joseph*** [1]

1. *Indian Institute of Technology Delhi*

3D photonic structures show photonic bandgap in all three directions and for all polarizations of the electromagnetic modes due to the presence of wavelength scale periodic features in three dimensions. Basically woodpile and inverse opal kind of structures show complete photonic bandgap and can be used in thermo-photovoltaic (TPV) as frequency selective absorbers that can increase the conversion efficiency without using a concentrator [1]. We report a single step optical fabrication approach to realize a 3D woodpile submicrometer periodic photonic structure with nano-scale features over large area. The fabricated structure can be used as frequency absorbers for long wavelength photons. The band gap properties of such a structure is studied using Lumerical solution's FDTD on a suitable material to suggest the application. We use a phase SLM assisted technique to avoid the generation of multiple beams and to manipulate the phase of the side beams to realize woodpile photonic structure [2]. We have used a multi-mirror (four mirrors) custom made assembly that is housed in a 3D printed mount to allow large angle interference of the generated phase engineered beams. The umbrella geometry and experimental setup to realize the woodpile photonic structure is presented in the attached Fig. 1. Spatial periodicity of the realized woodpile structure is approximately 600 nm.

Fig. 1. caption: Realizaton of woodpile phootnic structure (a) Umbrella geometry of 4+1 beams (b) experimental setup; LCOS: Liquid crystal on silicon; SLM: Spatial Light Modulator.

Reference

[1] M. Florescu, H. Lee, I. Puscasu, M. Pralle L. Florescu, D.Z Ting and J. P. Dowling , "Improving solar cell efficiency using photonic band-gap materials", Solar Energy Materials and Solar Cells 91, 1599-610 (2007).

[2] S. Behera, M. Kumar and J. Joseph, "Submicrometer photonic structure fabrication by phase spatial-light-modulator-based interference lithography", Opt. Lett. 41, 1893-6 (2016).

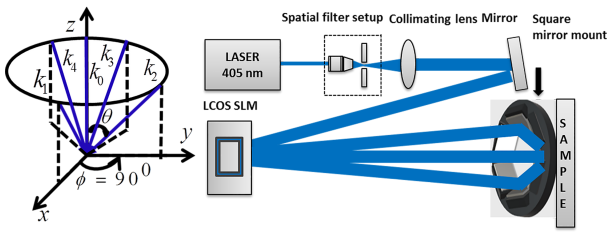


Fig. 1.png

Amplitude mask for generating 2D periodic nano-structures

Thursday, 8th December - 15:21 - Lithography and nanofabrication (large scale nanostructuring) - Tower 24 - Room 101 - Oral presentation - Abstract ID: 153

Ms. Kavya Mohan [1]***, Prof. Partha P. Mondal*** [2]

1. *Indian Institute of Science Banglore,* ***2.*** *Indian Institute of Science*

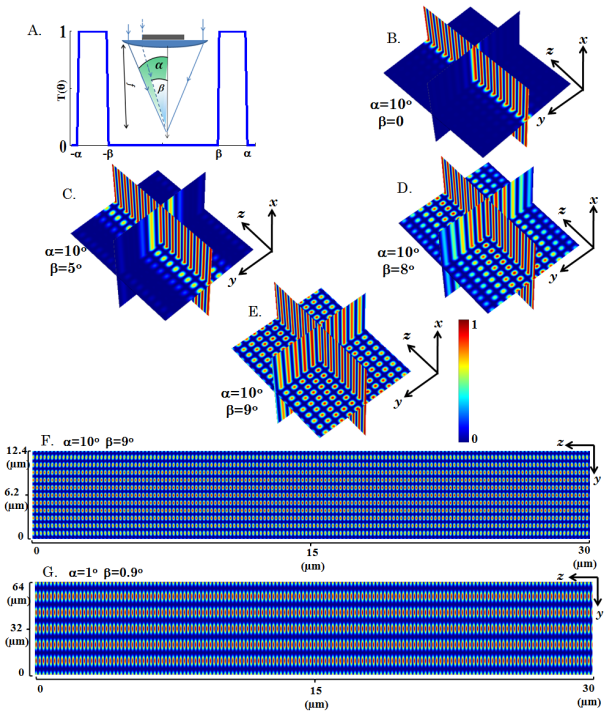
Introduction:
Periodic nanostructures have gained lot of significance because of its wide range of applications ranging from nano-electronics to nano-fluidics. Laser interference lithography has emerged as a powerful, cost effective and simpler tool to generate periodic patterns over a large area. In Multi-beam interference lithography, amplitude and polarization angle of the individual beam and the angle between the beams control the interference pattern [1] [2]. Choosing the right set of parameters for the individual beam is highly challenging. Phase mask holography involves a 2D or 3D mask. Using a single laser source, phase mask creates beams with required properties but designing a proper mask and its fabrication processes are exigent.
We propose a new technique to generate 2D periodic nano structures. We have integrated light-sheet illumination technique with a spatial filtering technique in a 2π system to enable the generation of 2D periodic nanostructures. Selective plane illumination property of light sheets can be exploited to produce nanostructures with fewer defects.
Methods:
The schematic diagram of the proposed optical setup is as shown in Image 1. The electric field distribution at and near the focal region of the two opposing cylindrical lens C1 and C2 having semi-aperture angle alpha , are given in Image 2.,
So the intensity of the field distribution at and near the common focal region is given by
I=|E_x |ˆ2+|E_y |ˆ2+|E_z |ˆ2 ----------(2)
Results:
Computational techniques are adopted to study the nature of the intensity of the field distribution over a predefined 3D grid. A monochromatic wavelength of 364nm is chosen to evaluate equation (2). Image 3 shows the intensity cross sections for different values of stop angle β. Periodicity along z axis is found to be 180nm where as feature size is 80nm. Image 3 also shows the possibility of uniform patterning over a large area.
Conclusions:
The proposed technique is hoped to find immediate applications in the field of nano-waveguides and optical microscopy.
Reference:
1.J.-H. Jang, C. K.Ullal, M. Maldovan, T.Gorishnyy, S.Kooi, C.Koh, and E. L. Thomas, Adv. Funct. Mater.17, 30273041,2007.
2.G.v.Freymann, A.Ledermann, M.Thie,I.Staude,S. Essig, K.Busch, M. Wegener, Adv.Funct.Mater . 20, 1038, 2010.

$$\begin{bmatrix} E_x(\rho,\phi,z) \\ E_y(\rho,\phi,z) \\ E_z(\rho,\phi,z) \end{bmatrix} = 2AE_0 \int_{-\alpha}^{+\alpha} T(\theta) \begin{bmatrix} cos\theta_p \\ sin\theta_p cos\theta \\ sin\theta_p sin\theta \end{bmatrix} \sqrt{cos\theta}\ \exp(ipk\ sin\theta sin\phi)\ \cos(\rho k\ cos\theta\ cos\phi)\ d\theta \quad (1)$$

Where, T(θ) is the transmission characteristics of the amplitude mask

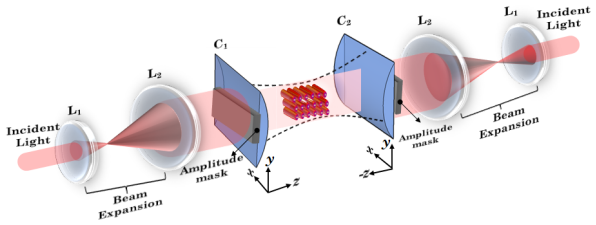
$$T(\theta) \begin{cases} 1, if\ \beta < |\theta| \le \alpha \\ 0, \quad if\ |\theta| \le \beta \end{cases}$$

Field components .png



A. Transmission characteristics of the Amplitude mask. (B-E) Intensity cross sections of the filed distribution at and near the focus of the two opposing cylindrical lens obtained by simulation. (F-G) shows possibility of patterning over a large area.

Intensity of the filed distribution.png



Schematic diagram.png

The manufacture of complex micro-optical elements on the ends of optical fibres, using a Focused Ion Beam Microscope

Thursday, 8th December - 15:38 - Lithography and nanofabrication (large scale nanostructuring) - Tower 24 - Room 101 - Oral presentation - Abstract ID: 289

Dr. Vlad Stolojan [1], ***Dr. David Cox*** [1], ***Dr. Mark Langridge*** [1], ***Dr. Irshaad Fatadin*** [2], ***Dr. Robert Ferguson*** [2]

1. *Advanced Technology Institute, University of Surrey,* ***2.*** *National Physical Laboratory*

Coupling optical fibres to the new generation of silicon photonic devices typically involves direct contact of the cleaved fibre to the chip or contacting it through diffracting or lensing optics fabricated on chips, but with large signal losses. The fabrication of optics directly onto the fibres can direct and focus light into waveguides and increase the transmitted signal. In particular, axicon lenses, which are common in light-sheet microscopy, can be fabricated onto the end of optical fibres to produce long and narrow Bessel-Gaussian beam profiles that are ideal for coupling to waveguides. As some of the cores of the single-mode fibres are only of the order of a few microns, optical elements that are larger than the core are likely to affect the total internal reflection within the optical fibres, resulting in intensity losses. We show a method for using a Focused Ion Beam microscope (FIB) to manufacture an axicon lens on the 3 micron core of a single-mode optical fibre (Figure 1a-c); we discuss a method to find the centre of the fibre and align the milled feature with it. Although we use charged particles in the milling process, we show that this method can be used effectively with insulators. We demonstrate the milling of parabolic and spherical lenses, axicons and concentric ring lenses, as well as Fresnel lenses in optical fibres. We also show other test structure, with complex footprints and 3D morphologies manufactured in a glass slide. We further measure the mode field diameter of a single-mode fibre with an axicon microlens. The manufacturing method leads to Ga ion implantation, and we discuss the effect of ion implantation on the optical properties of the fibre and ways to restrict the implant damage to the core of the optical fibre. This manufacturing method is applicable to all optical fibres and offers significant opportunities for fibre-optic coupling to chips and single fibre-optic sensing, such as for medical applications.

The work reported in this paper was partially funded by project EMPIR 14IND13 PhotInd at NPL, co-financed by the Participating States and from the European Union's Horizon 2020 programme.

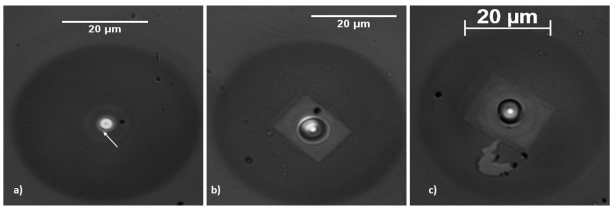


Figure 1. Transmission optical images of optical fibres prepared from the same initial fibre: a) an 'as is' optical fibre, with a circular fiducial marker used for FIB alignment indicate by the arrow. This image is very sensitive to the microscope defocus, the centre spot blurring very rapidly when moving away from focus; b) a mis-aligned axicon lens, with the rectangular scan area of the ion beam exposed during alignment visible. It is brighter than its surrounding, suggesting an increased light transmission may result from Ga implantation; c) an axicon lens aligned with the centre of the fibre core by using the fiducial marker in a), showing a narrow spot that contains ~80% of the intensity of a) in less than half-diameter of a beam, and is non-diffracting.

Axicononfibrefigure.png

Four-wave Mixing in Quantum Dot Semiconductor Optical Amplifiers: Hierarchy and Significance of the Effects Involved

Thursday, 8th December - 14:30 - Quantum dots - Tower 24 - Room 103 - Oral presentation - Abstract ID: 262

Dr. Marina Zajnulina [1], ***Dr. Benjamin Lingnau*** [1], ***Prof. Kathy Lüdge*** [1]

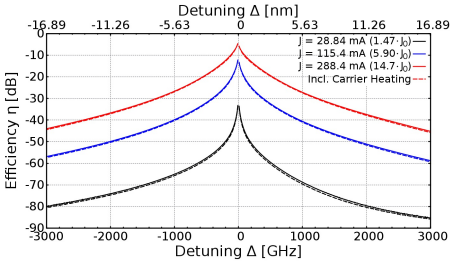
1. *Technische Universität Berlin*

To effectively deploy Quantum Dot Semiconductor Optical Amplifiers (QD-SOAs) for the wavelength conversion for wavelength division multiplexing within Telecommunication, four-wave mixing (FWM), a nonlinear parametric process driven by such third-order medium susceptibility effects as the charge-carrier-density pulsation, spectral hole-burning, and charge-carrier heating, needs to be thoroughly understood.

So far, the theoretical treatment of FWM in QD-SOAs was done by modelling the optical field by means of nonlinear Schrödinger-like equations or by analytic evaluation of the optical field at the amplifier facets. [Uskov et al. (1994), Nielsen et al. (2010)] These methods usually involve only a spatially averaged gain and a constant linewidth-enhancement factor and neglect the inhomogeneous spectral line broadening due to the inhomogeneous energy distribution of the active quantum dots in a QD-SOA device. Moreover, they allow only for a limited discussion of the hierarchy and significance of spectral hole-burning, carrier-density pulsation, and carrier heating in the FWM process in QD-SOAs.

We propose a microscopocally motivated model featuring the evolution of the optical gain along the amplifying medium, including a dynamic linewidth-enhancement factor, and allowing separate consideration of the nonlinear effects responsible for FWM in the quantum dots and the surrounding quantum well reservoir. It is based on a travelling-wave equation implemented as a delayed differential equation for the spatially resolved optical field. The charge-carrier dynamics in the quantum dots and the surrounding quantum well are modelled by means of balance equations using microscopically calculated Auger scattering rates. The inhomogeneous spectral line broadening is taken into account by inclusion of the light-matter interaction of all active quantum dots within the ensemble. [Lingnau, Springer (2015)]

Using this model, we numerically study the FWM wavelength conversion efficiency as a function of the pump current using the characteristics of a 3mm long InAs/InGaAs QD-SOA device. The results (cf. Figure) show a very good agreement with the experimental data in terms of efficiency curves range and shapes (cf. [Meuer et al. (2010)]). We found out that spectral hole-burning is the most important effect for FWM in QD-SOAs, whereas the charge-carrier heating is negligible. The carrier-density pulsations are decisive for the efficiency curves shapes.



Efficiency withch vs current.jpg

Energy transfer in QD dendrite-type fractal superstructures

Thursday, 8th December - 14:47 - Quantum dots - Tower 24 - Room 103 - Oral presentation - Abstract ID: 341

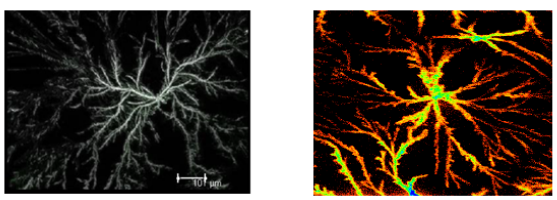
Mr. Cesar Bernardo [1], ***Dr. Peter Schellenberg*** [2], ***Prof. Michael Belsley*** [1], ***Prof. Mikhail Vasilevskiy*** [1]

1. *Center of Physics of the University of Minho (CFUM),* ***2.*** *MackGraphe – Graphene and Nanomaterials Research Center, S.Paulo*

The unique luminescent properties of colloidal quantum dots (QDs), tunable via precise control of their size, shape and composition, allow for a broad range of applications including energy harvesting. Self-assembly and Langmuir–Blodgett fabrication of QDs into superstructures ranging from layer-by-layer configurations with a pre-determined band-gap progression, to fractal clusters, dendrites and nanowires, constitute powerful approaches to engineering systems with directed energy flow via exciton transport without charge transfer. Furthermore, interactions between elements within these structures can lead to new interesting properties of the superstructure.

Here we present the investigation of excitonic energy transfer in self-assembled dendrite-type fractal-dimension structures (DFST) composed of (nominally) monosize CdTe QDs by mapping their fluorescence spectra and lifetimes. Our results indicate the Förster-type energy transfer in these superstructures, caused by the near-field (non-radiative) dipole-dipole coupling between the individual QDs within a dendrite. The measured emission lifetime is higher in the central (and denser) part of the dendrite. The experimental findings were supported by theoretical modeling results obtained by using master equations for exciton migration/decay kinetics in diffusion-limited fractal aggregates composed of identical particles. We find that the fractal geometry of the dendrite, with the QD density decreasing from its core towards the periphery, leads to the energy concentration in the core. The asymmetry between the inward and outward exciton fluxes leads to the more intense and longer lived emission from the central part of the dendrite structure.

Figure1. (left) Microscopy image of DFST; (right) Lifetime map for representative DFST.



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Effect of ligand-exchange on CdSe/CdS dot-in-rods based light emitting diodes

Thursday, 8th December - 15:04 - Quantum dots - Tower 24 - Room 103 - Oral presentation - Abstract ID: 71

Ms. Prachi Rastogi [1]***, Dr. Francesco Di Stasio*** [2]***, Prof. Roman Krahne*** [2]

1. *Istituto Italiano di Tecnologia, Genoa,* ***2.*** *Istituto Italiano di Tecnologia, Genova*

Among colloidal semiconductor nanocrystals (NCs), CdSe/CdS dot-in-rods (DiRs) [1] are very promising candidates for light emitting application such as lasers [2] and light emitting diodes (LEDs)[3] due to their unique optical properties such as high quantum yield and low Auger recombination. In this work, we investigate the effect of the ligands present on the nanorod surface on the LED performance. In addition to the native octadecylphosphonic (ODPA) ligands we tested shorter molecules such as 3-mercaptopropionic acid (MPA), 2-Aminoethanethiol hydrochloride (AET), and ammonium thiocyanate (SCN). Here ligand exchange was performed after film deposition. Figure 1a shows the structure of the LED where poly (3, 4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) and Poly [(9,9- dioctylfluorenyl- 2,7- diyl)-co- (4,4'- N- (4- sec- Butylphenyl) diphenylamine)] (TFB) together serve as a hole injecting/transport layer and ZnO nanoparticles as an electron injecting layer. The ligands affect the position of the energy bands (Fig. 1b) and thus provide a means to tune the band offsets in the LED structure. Furthermore, exchanging the long chain ligands to shorter ones has been shown to improve significantly charge injection and transport. However, the LED performance will also depend on a compromise between charge injection enhancement and the possible decrease of photoluminescence quantum yield caused by the formation of surface traps following the ligand modification. We elucidate in detail the impact of surface ligands on luminance, current density and external quantum efficiency (Fig. 1c,d), which gives valuable insight for the development of high performance LEDs.

Keywords: Dot-in-rods, LEDs, ligand-exchange

References:

1) L. Carbone et al., Nano Lett. 2007, 7, 2942.

2) F. Di Stasio et al., Small 2015, 11, 1328.

3) A. Castelli et al., Nano Lett. 2015, 15, 5455.

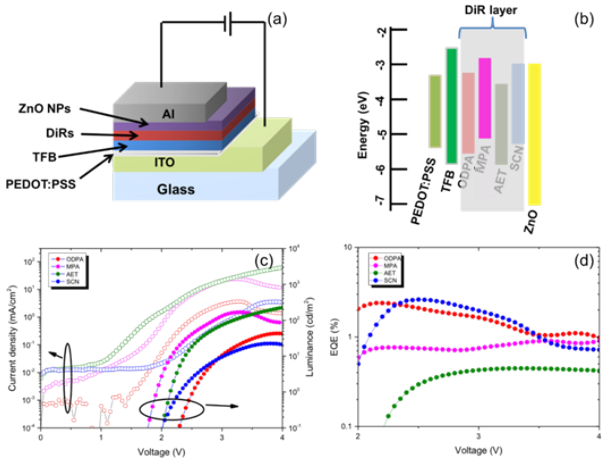

(a)
ZnO NPs
Al
DiRs
TFB
ITO
PEDOT:PSS
Glass
(b)
DiR layer
Energy (eV)
PEDOT:PSS
TFB
ODPA
MPA
AET
SCN
ZnO
(c)
Current density (mA/cm²)
Luminance (cd/m²)
Voltage (V)
(d)
EQE (%)
Voltage (V)

Figure 1.png

Light emission from silicon containing tin nanocrystals

Thursday, 8th December - 15:21 - Quantum dots - Tower 24 - Room 103 - Oral presentation - Abstract ID: 245

Mr. Søren Roesgaard [1], Prof. Etienne Talbot [2], Dr. Jacques Chevaller [1], Prof. Peter Gaiduk [3], Mr. John Lundsgaard Hansen [1], Prof. Brian Julsgaard [1]

1. *Aarhus University,* ***2.*** *University of Rouen,* ***3.*** *Belarusian State University*

Nanocrystals of diamond-structured tin (alpha-Sn) are very interesting due to their potential use as light emitters and their chemical compatibility with silicon. Here we present our studies on tin nanocrystals embedded in silicon. Initially, a layer of tin-rich silicon was grown by molecular beam epitaxy on a silicon substrate and covered by a capping layer of silicon. A subsequent heat treatment at various temperatures, ranging from 650 to 900 degrees, formed the nanocrystals embedded in silicon by segregation of the tin.
Time-resolved photoluminescence spectroscopy revealed that the samples emit light in a broad spectrum around 0.8 eV and that the strength of light emission is particularly strong for one of the samples heat treated at 725 degrees. In order to investigate the reasons for this observation, a number of structural characterization techniques were employed. First, scanning transmission electron microscopy showed that the nanocrystal diameters were distributed around a mean diameter of approximately 3 nm - rather independent of the temperature of the heat treatment. Next, Rutherford backscattering spectrometry showed, after comparing random and channeling directions, that the sample heat treated at 725 degrees had its tin atoms placed most coherent with the surrounding silicon lattice. This suggested that the nanocrystals consist of tin in the alpha phase in the sample emitting most light; however, it could not be determined with certainty that no silicon was included in the nanocrystals. For this reason, the samples have also been studied by atom probe tomography, which preliminarily has shown that the nanocrystals are indeed made from pure tin.
We conclude that the sample showing the strongest light emission is the sample with the highest crystalline quality of alpha-tin nanocrystals. It is too early to claim that the tin nanocrystals are the direct source of light emission, but they seem to play a positive role. For more information, see Roesgaard, et al., AIP Advances 5, 077114 (2015)].

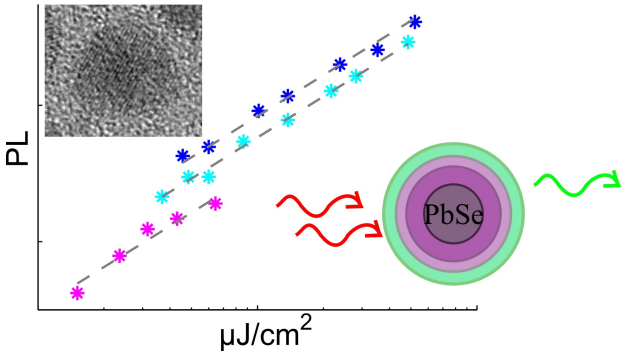
Broadband near-infrared to visible upconversion in quantum dot-quantum well heterostructures

Thursday, 8th December - 15:38 - Quantum dots - Tower 24 - Room 103 - Oral presentation - Abstract ID: 314

Ms. Ayelet Teitelboim [1], ***Prof. Dan Oron*** [1]

1. *Weizmann institute of science*

Ayelet Teitelboim, Dan Oron.
Department of Physics of Complex Systems, Weizmann Institute of Science, Rehovot, Israel, 7610001
Abstract:
Upconversion (UC) is a nonlinear process in which two, or more, long wavelength photons are converted to a shorter wavelength photon. This process is based on sequential absorption of two or more photons, involving metastable, long lived intermediate energy states, thus it is not restricted to UC of coherent laser radiation as a non-coherent process. Hence, requirements for UC processes are long lived excited states, a ladder like arrangement of energy levels and a mechanism inhibiting cooling of the hot charge carrier. UC holds great promise for bioimaging, enabling spatially resolved imaging in a scattering specimen and for photovoltaic devices as a mean to surpass the Shockley-Queisser efficiency limit. Here, we present a novel luminescence UC nano-system based on colloidal semiconductor double quantum dots, consisting of a NIR-emitting component and a visible emitting component separated by a tunneling barrier in a spherical onion-like geometry. These dual NIR and visible emitting core/shell/shell PbSe/CdSe/CdS nanocrystals are shown to upconvert a broad range of NIR wavelengths to visible emission at room temperature, covering a spectral range where there are practically no alternative UC systems. The synthesis is a three-step process, which enables versatility and tunability of both the visible emission color and the NIR absorption edge. Using this method one can achieve a range of desired upconverted emission peak positions with a suitable NIR band gap. The physical mechanism for upconversion in this structure, as well as possible extensions and improvements will be discussed. (1)
(1) Teitelboim, A.; Oron, D. ACS Nano 2016, 10, 446-452.



Toc image.jpg

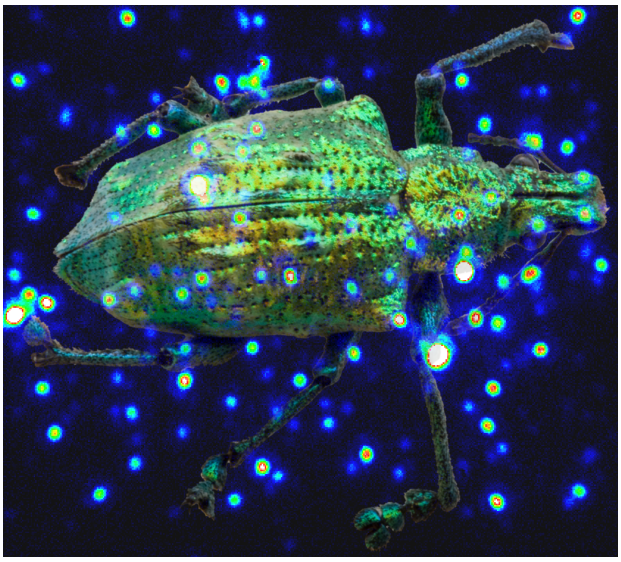
Supercontinuum generation from metal nanostructures

Thursday, 8th December - 14:30 - Optical properties of nanostructures - Tower 24 - Room 105 - Oral presentation - Abstract ID: 54

Prof. John Lupton [1]

1. *Regensburg University*

150 years after the invention of the incandescent bulb the generation of light by metals remains intriguing. Silver nanoparticle aggregates offer extraordinary fidelity in single-molecule Raman spectroscopy provided that the photophysics of the analyte is adequately controlled [1]. Under irradiation with femtosecond infrared laser pulses, non-linear luminescence is observed from hot spots, which spatially anti-correlate with SERS [2]. In contrast to surface-enhanced SHG, which exhibits pronounced intermittency [3], these hot spots display ultrafast white-light emission [4] from sub-diffraction volumes. Hot spots can even be used as an alternative to conventional SNOM in broad-band superresolution transmission microscopy of photonic crystals [5] (see Figure).
Single continuum hot spots can be characterized both in time and frequency domain, by autocorrelation spectroscopy of the emission intensity [6] or recording time-integrated emission as a function of excitation wavelength [7]. Both approaches reveal hybridization of bright localized nanoparticle plasmons with propagating surface-plasmon polaritons, which can traverse in excess of 100 microns in the rough silver film, leading to pronounced interference phenomena which are manifested in the frequency and time response.
Wet-chemical growth provides a simple metric to control interparticle coupling, which is examined directly using correlated electron and optical microscopy [8]. While being heterogeneous between single hot spots, continuum generation exhibits a universal excitation power dependency, extending to the Stokes regime, which demonstrates that emission originates from thermal radiation of the electron gas that is heated by the nanoparticle plasmon [9]. The generality of these radiative intraband transitions is readily extended to other metals such as gold, copper and aluminium, and provides an extended framework to examine electrically excited hot spots in percolation films.
[1] Walter et al., PRL 98, 137401 (2007). [2] Walter et al., JACS 130, 16830 (2008). [3] Borys et al., PRB 80, 161407(R) (2009). [4] Borys et al., JPCC 115, 13645 (2011). [5] Chaudhuri et al., Nano Lett. 9, 952 (2009). [6] Klemm et al., PRL 113, 266805 (2014). [7] Borys et al., Sci. Rep. 3, 2090 (2013). [8] Borys et al., Science 330, 1371 (2010). [9] Haug et al., PRL 115, 067403 (2015).



Lupton beetle micro v1.png

Either Electric or Magnetic Field Hugely Enhanced by Coupling to Optical Energy Focusing Structure

Thursday, 8th December - 14:47 - Optical properties of nanostructures - Tower 24 - Room 105 - Oral presentation - Abstract ID: 346

Prof. Yumin Hou [1], ***Dr. Wei Li*** [1]

1. *Peking University*

We introduce a new optical energy focusing structure consisting of a circular dielectric Bragg nanocavity and a circular metallic plasmonic lens. Via the hybridization of Bragg cavity modes and surface plasmon modes, optical energy is highly confined in the central region of the Bragg nanocavity under linearly polarized illumination. When either a Bowtie Nano-antenna (BNA) or a Magnetic Resonator (MR) is placed on this focusing structure, the energy can be high-efficiency coupled and focused into the BNA or MR. Simulations show that the electric field enhancement (|E|/|E0|) in the BNA and magnetic field enhancement (|H|/|H0|) in the MR can be more than 3000 and 200, respectively, which are both currently the highest as far as we know. This proposed hybrid dielectric-metallic structure opens a new avenue in energy focusing and transferring and provides opportunities for various applications, including single-molecule SERS, optical trapping, photolithography, fluorescent microscopy, magnetic sensors, etc.

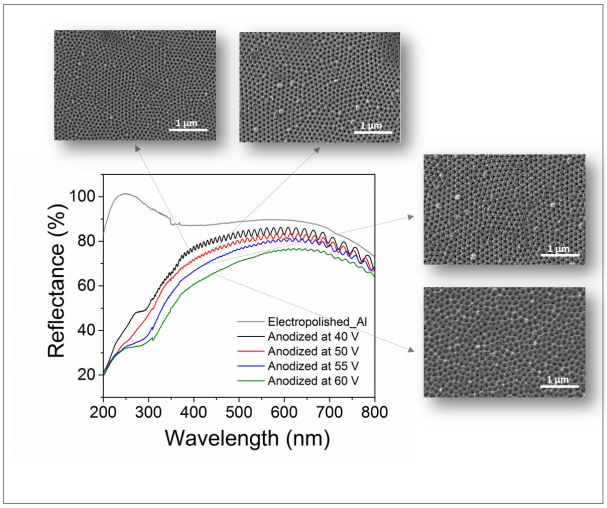
Influence of Pore and Cell Sizes on Aluminum/Nanoporous Alumina Optical Properties

Thursday, 8th December - 15:04 - Optical properties of nanostructures - Tower 24 - Room 105 - Oral presentation - Abstract ID: 253

Ms. Sara María Aguilar Sierra [1], ***Dr. Felix Echeverria Echeverria*** [1]

1. *Universidad de Antioquia*

Considerable attention has been paid to nanoporous anodic alumina (NAA) due to its excellent electronic and optical properties. A wide range of self-organized honeycomb structures is formed by controlling the aluminum anodization parameters (potential, time, temperature, and electrolyte solution). The optical properties of bi-layer systems composed by Al/NAA are strongly influenced by the thickness, porosity and refractive index of the NAA. A deep knowledge of the influence of morphological characteristics of NAA on its optical performance is necessary to enlarge the film applications in optics. In the literature, the effect of film thickness and porosity on optical properties is well known. Herein, in this study, the influence of pore and cell sizes on reflectance was studied. Highly ordered structures with similar thicknesses but different cell and pore sizes were obtained at 40 V, 50 V, 55 V and 60 V by two-step anodization in oxalic acid. The pore and cell sizes increased with anodizing voltage as SEM images showed. The porosity percentages were between 10 to 12 % assessed by image analysis (Image J software). Ordered hexagonal structures grouped into domains were showed by fast Fourier transform for all samples. The reflectance curves revealed that electropolished aluminum is highly reflective near 250 nm in the UV zone. While, the anodized samples worked as UV filters and showed a maximum reflectance percentage ranging from 77 to 86 % near 600 nm being the lower for 60 V condition and the higher for 40 V. As density and diameter of pores change with voltage, about the same porosity percentages were obtained at all anodizing conditions. It was found that reflectance decreases as cell and pore sizes increases, despite both porosity and thickness are still about constant. Therefore, these two characteristics of the NAA films must be considered in order produce the looked-for optical properties of the multilayer systems.



Uv vis reflectance spectra of electropolished aluminum and anodized samples also showing the structure for all conditions.jpg

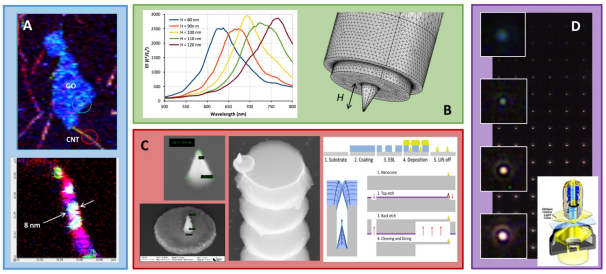
High performance micro/nanofabricated AFM-TERS probes based on a metallic nanocone/nanodisk integrated on silicon cantilever

Thursday, 8th December - 15:21 - Optical properties of nanostructures - Tower 24 - Room 105 - Oral presentation - Abstract ID: 336

Mr. Damien ESCHIMESE [1]

1. *Lille 1 University*

We present modelling, fabrication and characterization of atomic force microscopy-tip enhancement Raman spectroscopy (AFM–TERS) probes which demonstrate a very high electromagnetic (EM) enhancement due to a novel metallic nanocone/nanodisk combination at the tip apex. Calculations of the EM enhancement are obtained by finite element methods to improve the understanding of underlying physical phenomena and processes in the near-field and far-field optics. In addition, to the known 'lightning rod effect' and plasmonic resonance properties of a bulk metal tip, we study the cavity resonance modes of surface plasmons related to the dimensions and nature of the metal part of the tip. We demonstrate advantages an isolate metallic nanoparticule at the apex rather than a full metallic system, with an original shape as a nano-antenna . We also highlight the importance of the radiative losses at the metal-dielectric interface that has motivated us to propose a particular shape of the apex which greatly improves the EM enhancement with a precise control of the spectral position of the optical response as a function of the nano-antenna dimensions, shape and material composition. The cantilever-based probes were fabricated using top-down micro/nanotechnology to enable many probes to be fabricated on single silicon wafers. Dark-field microscopy combined with a total internal reflexion excitation is used to characterize the optical properties of the localized EM enhancement in order to compare with the predictions of the numerical calculations. Compatible with a standard AFM cantilever mounting, the microfabricated AFM-TERS probes are novel high-performance optical near-field elements that will enable a powerful optical analysis and imaging technique for high resolution Raman microscopy.



A_Application : TERS map (2x3 µm & 100x100 nm) of graphene oxide flake and carbon nanotubes (HORIBA_2015)
B_Modelling : Spectrum of electromagnetic exaltation 1 nm below of silver nanocones (with height variation) by finite element method
C_Fabrication : SEM image of gold nanocone/nanodisk on silicon substrate and silicon pillar _ Schema of the fabrication process of the probes
D_Characterization : Dark-field image (transmission mode) of silver nanodisks (thickness 50nm – diameter variation from 70 to 210 nm)

Nanop16.jpg

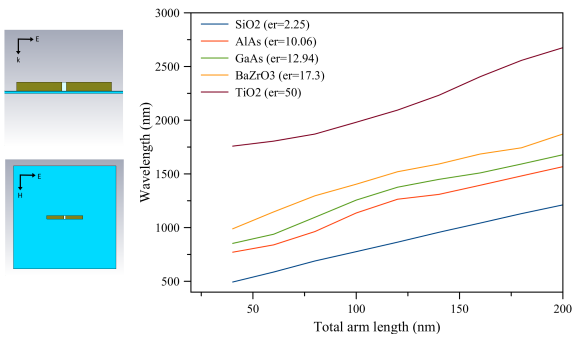
Mapping Resonant Wavelengths of Au Optical Nanoantennas at Multiple Substrate Permittivities

Thursday, 8th December - 15:38 - Optical properties of nanostructures - Tower 24 - Room 105 - Oral presentation - Abstract ID: 413

Mr. Lutfi Torla [1]

1. *University of Sheffield*

Au (gold) nanorods behaving as dipole nanoantennas (DNAs) do not resonate at the typical half-wavelength when subjected to optical frequencies. Scholars have found these DNAs to have an optical resonance which are linearly dependent upon both thickness and aspect ratio as shown by Novotny. Bryant et al have also plotted the linear response of DNAs based on thickness and absolute length. The effect of substrates are often ignored during the theoretical study of optical resonant antenna (ORA) behaviour even though they are required for most practical applications. This work studies the effect of substrate permittivity on the resonant length of ORAs using the simulation software CST Microwave Studios. Coupled gold strips are simulated and first verified against previously published experimental results. A 250nm x 40nm x 40nm gold strip with a 20nm gap cut in the middle (effectively having a 115nm arm on each side) is simulated on a SiO2 substrate and excited with a planewave perpendicular to the substrate. This yields a resonance at 825.92nm in the gap where experimental results by Mühlschlegel et. al. showed resonance at 826.45nm. The Brendel-Bormann model for gold is used, fitted to experimental data for higher accuracy based on data by Rakić et. al. The gold strip with 40nm thickness and 20nm gap is maintained and placed on a substrate of 1500nm x 1500nm x 10nm while both the arm lengths and substrates permittivities are varied. The resonant wavelength is measured across the central gap. It is found that the substrate permittivity has a measurable effect on the resonant length of the ORA. At a permittivity of 2.25 the ORA resonates from 600 THz to 250 THz based on aspect ratio, while at permittivity of 17.3 the ORA resonates between 300 THz to 160 THz for the same aspect ratios. This shows a strong effect caused by the dielectric permittivity of the substrate that is a significant factor during fabrication of such optical antennae while the expected linear response is maintained. We provide a reference map for the resonant wavelengths of a typical gold dipole optically resonant antenna on various substrates.



Nanop2016.png

Towards nano-sensing using the acoustic vibrations of nano-objects

Thursday, 8th December - 16:30 - Strong light-matter interaction at the nanoscale - Tower 24 - Room 101 - Oral presentation - Abstract ID: 65

Dr. Jérémie Margueritat [1], ***Dr. Adrien Girard*** [1], ***Dr. Hélène Gehan*** [1], ***Dr. Aurélien Crut*** [1], ***Dr. Lucien Saviot*** [2], ***Dr. Benoît Dubertret*** [3], ***Dr. Alain Mermet*** [1]

1. *Institut Lumière Matière CNRS-Université Lyon1,* ***2.*** *Laboratoire Interdisciplinaire Carnot de Bourgogne CNRS-Université de Bourgogne,* ***3.*** *Laboratoire de Physique et d'Etudes de Matériaux CNRS-Université Pierre er Marie Curie-ESPCI*

One of the technological challenges of these last years is the development highly efficient nano-sensing device, to determine for example the size, the mass, or even the presence or not of a given molecule. An interesting route to develop such sensors is to use the mechanical properties of mechanical nano-resonators, whose high frequencies of vibration (GHz to THz) are ideal to develop nano-clocks or nano-balances. The simplest nano-resonator, and maybe the easiest to produce, is the nanoparticle in which the vibration frequency is directly proportional to its reciprocal dimensions (inverse diameter for a sphere, inverse length for a wire, or inverse thickness for a nanoplatelet).

In this paper we show, with two specific cases, that these simple nano-objects have promising potential to develop nano-sensing devices.

The first system studied is a dimer of gold nanoparticles whose ultra low frequency vibration modes (<5GHz 0.15 cm-1) arising from the hybridization of the individual vibration modes of each nanoparticle, is highly sensitive to the elastic properties of the surrounding medium.[1]

The second system consists of nano-platelets of semi-conductor whose thicknesses can be controlled from 2 to 14 monolayers. Detecting the resonant breathing frequency across the thickness of the nano-platelets reveals a significant sensitivity to mass loads attached the free surfaces of the nano-platelets.[2]

Both systems, dimer and nano-platelets, are optically addressed thanks to their specific optical properties (plasmon and exciton), which makes them good candidates to be integrated into high density detectors for sensing applications.

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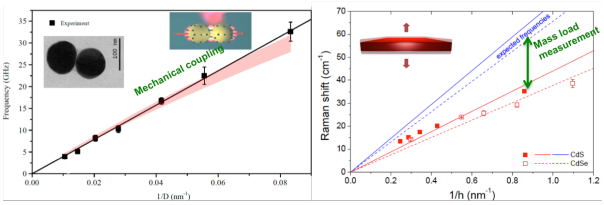

Abstractnanop.png

Colloidal Gold Nanostructures for Plasmonics

Thursday, 8th December - 16:47 - Strong light-matter interaction at the nanoscale - Tower 24 - Room 101 - Oral presentation - Abstract ID: 282

Dr. Sylvie Marguet [1], ***Dr. Mohammad Khaywah*** [1], ***Mr. Jérôme Caron*** [1]

1. *NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay 91191 Gif-sur-Yvette*

Our research activities concentrate on the synthesis and assembly of gold nanoparticles (NPs) with tunable sizes and shapes, to provide original materials for research in plasmonics through collaborations (1,2,3,4).
We synthesize non-commercial Au-NPs: nanospheres (perfectly spherical and very large), nanocubes, prisms, nanooctahedra and micro-plates of various size and thicknesses. Perfect spheres and cubes on top of Au-film are very attractive for spectroscopies within the gap; Prisms are promising for ultrasensitive sensing; Plates can spontaneously self-assemble in ordered 1D-columnar aggregates (fig) or 2D-metasurfaces; their large atomically flat facets are promising for F.I.B. fabrication of monocrystalline structures.
Assembly of such NPs leads to the appearance of new properties, still relatively poorly explored, apart from SERS experiments. Here, we report the spontaneous self-assembly of gold NPs by simply evaporating concentrated solutions on non-patterned substrates. The degree of reproducibility of this method, the maximum size of the perfectly organized area and the key parameters related to a controlled-deposition are presented We are looking for collaborations to study the optical properties of these unusual assemblies and the plasmon-driven chemical reactions that should occur as a result of strong light-matter interation within the hot-spots.
References:
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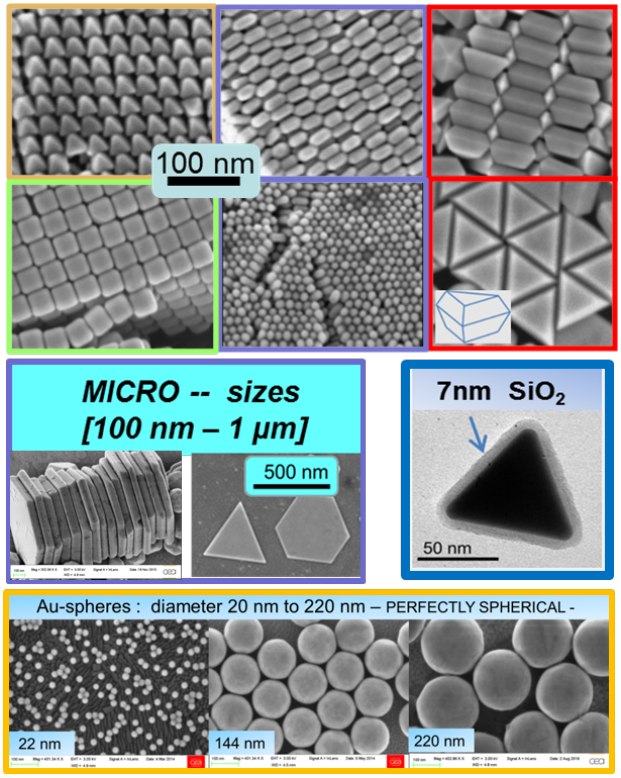
(2) E. Le Moal et al. Phys.Rev.B-2016 ; Nano-Lett-2013
(3) M. Haggui et al. ACSnano-2012
(4) C. Deeb et al. J. Phys. Chem. C-2012


100 nm
MICRO -- sizes
[100 nm – 1 µm]
500 nm
7nm SiO2
50 nm
Au-spheres : diameter 20 nm to 220 nm – PERFECTLY SPHERICAL -
22 nm
144 nm
220 nm

Aunps.png

Control of Energy Flow within nano metallic Gratings

Thursday, 8th December - 17:04 - Strong light-matter interaction at the nanoscale - Tower 24 - Room 101 - Oral presentation - Abstract ID: 304

Dr. Guoguo Kang [1]

1. *Beijing Institute of Technology*

Surface plasmon polariton (SPP) and cavity modes supported by the plasmonic gratings are often of hybrid nature in ruling light-nanostructure interactions. The coupling of incident light to SPP waves through the excitation of SPP modes usually traps the light at the air-metal interface, while the coupling to standing waves through cavity modes confines the light within the grating grooves. However, in a specific application, the highly selective coupling of incident light to either SPP or cavity mode is always required. To control the energy flow, the periodicity was introduced to the metal-insulator-metal (MIM) grooves: When the period approaches (deviates from) the wavelength of SPPs, the incident light highly couples to SPP (cavity) mode, due to the constructive (destructive) interference between the propogating SPPs at metal-air interfaces. Two types of metallic gratings1, aluminum grating with its period approaching the λSPP and iridium grating with its period far away deviating from the λSPP, were fabricated and measured. The almost null TM transmission through aluminum grating and detection of surface enhanced Raman scattering (SERS) signal from iridium grating solidly guarantee the validity of the proposed method in manipulating the modes, through which the energy flow can be guided to its supposed-to-appear regions.

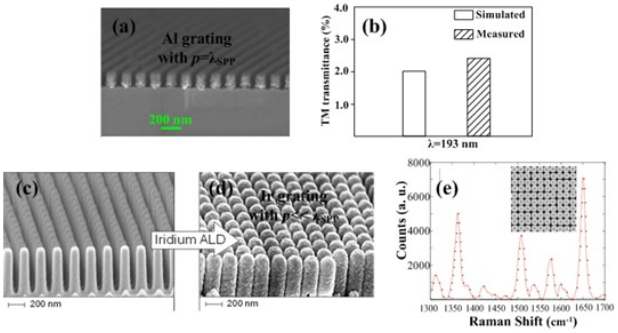


Fig.jpg

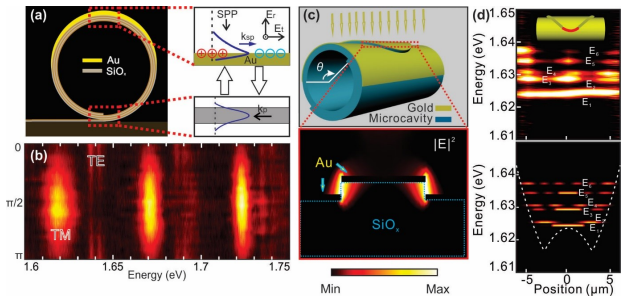
Photon-plasmon coupling in metal coated microtubular cavities

Thursday, 8th December - 17:21 - Strong light-matter interaction at the nanoscale - Tower 24 - Room 101 - Oral presentation - Abstract ID: 38

Mr. Yin Yin [1], ***Dr. Shilong Li*** [1], ***Dr. Libo Ma*** [1], ***Prof. Oliver G Schmidt*** [1]

1. *Leibniz Institute for Solid State and Materials Research Dresden*

Noble metal nanostructures are known to be able to support plasmonic modes which are highly confined at the metal surfaces, exhibiting many novel phenomena. In particular, metal-coated optical cavities have been investigated to study surface plasmon polaritons (SPPs) in combination with optical whispering-gallery-mode (WGM) resonances, which result in SPP resonant and/or hybrid plasmon-photon modes localized at the metal surface. These kinds of plasmonic resonant cavities are capable to accommodate intense resonant EM fields on the metal layer surfaces suitable for various applications such as enhanced light-matter interactions or plasmonic microcavity lasers. In the recent study of thin-walled microtube cavity coated with a gold nano-cap, we reveal that the transverse magnetic (TM) polarized light predominantly excites the hybrid resonant modes in these opto-plasmonic microcavities. Remarkably, the exterior field of the hybrid mode is enhanced by more than an order of magnitude over previously reported designs and is caused by the light confinement in a narrow potential well. In addition, vertical gold nanogap is fabricated on microtube cavities to support localized surface plasmons (LSPs). By tuning the position of the gold nanogap on the tube surface, selective coupling between resonant light and LSPs are observed, and is explained by a modified quasi-potential model based on perturbation theory. These investigations interface surface plasmons and optical modes in hybrid opto-plasmonic microcavities towards promising applications such as enhanced light-matter interactions.



1.jpg

Electrically tunable organic–inorganic hybrid polaritons with monolayer WS2

Thursday, 8th December - 17:38 - Strong light-matter interaction at the nanoscale - Tower 24 - Room 101 - Oral presentation - Abstract ID: 183

Mr. Lucas Flatten [1], ***Mr. Zhengyu He*** [1], ***Dr. David Coles*** [2], ***Prof. Robert Taylor*** [1], ***Prof. Jamie Warner*** [3], ***Prof. Jason Smith*** [1]

1. *University of Oxford,* ***2.*** *University of Sheffield,* ***3.*** *University of Oxfo*

We demonstrate the formation of hybrid organic-inorganic polaritons created through the simultaneous coupling ofa J-aggregate dye and a CVD grown tungsten-disulphide monolayer to a confined optical microcavity mode. Electricaltuning of the tungsten-disulphide exciton energy results in a controllable change in the relative mixing of Frenkel andWannier-Mott excitons within the polariton states.Transition metal dichalcogenides (TMDs), such as MoSe 2 and WS 2 , have received increased attention due to theability to produce large, atomically flat monolayer domains with intriguing optical properties [1] (see Fig. 1a). Whilstexfoliated material has generally shown lower defect densities, the level of control achieved in CVD offers strongpotential for the fabrication of device structures. The large exciton-binding energy and direct band gap typical forthese monolayers leads to stable exciton formation at room temperature, narrow absorption and emission peaks.These properties make TMDs strong candidates for a wide range of optoelectronic devices.Here we present a study in which WS 2 and the organic J-aggregated dye TDBC are implemented in a microcavityfacilitating hybrid polariton formation at room temperature. TDBC has been shown to enable the strong couplingregime in microcavities before. By embedding the monolayers of WS 2 within a grid of silver electrodes we canelectrically control the photon mediated hybridisation of Frenkel and Wannier-Mott excitons between maximal mixingcoefficients of 17% and 26% in the middle polariton branch [2].Polariton-polariton interactions give rise to non-linear effects, which make polaritonic systems attractive to observea multitude of fascinating phenomena such as inversionless lasing, polariton condensation and superfluidity. Theseinteractions are much weaker for localised Frenkel excitons than for Wannier-Mott excitons typical in a crystallinelattice. Our results show how the hybridisation between such distinct excitons could be controlled electrically at roomtemperature. These findings could open pathways to novel photonic devices with engineered optical properties.

[1] Y. Rong et al. Nanoscale, vol. 6, no. 20, pp. 12096–12103, 2014.

[2] L. C. Flatten et al. arXiv:1608.05274 [cond-mat, physics:physics], 2016. arXiv: 1608.05274.

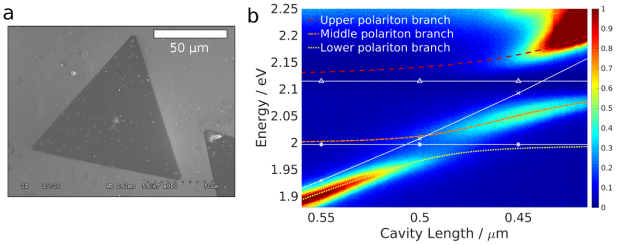

a
50 μm
b
Upper polariton branch
Middle polariton branch
Lower polariton branch
Energy / eV
2.25
2.2
2.15
2.1
2.05
2
1.95
1.9
0.55
0.5
0.45
Cavity Length / μm
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

Fig2.png

What can we learn from the Two-Photon Luminescence properties of Single Colloidal Gold NanoParticles ?

Thursday, 8th December - 16:30 - Nonlinear nano-optics - Tower 24 - Room 103 - Oral presentation - Abstract ID: 285

Dr. Céline FIORINI-DEBUISSCHERT [1]

1. SPEC, CEA, CNRS, Université Paris-Saclay, CEA Saclay

Although bulk gold is known to present very low luminescence quantum yield, a huge luminescence is observed from gold nanostructures, the two-photon brightness of a single gold nanorods (GNR) being a few millions higher than the two-photon brightness of fluorescein molecules ! Although directly correlated to the excitation of the rods longitudinal surface plasmon modes, the detailed origin of the important luminescence in GNRs is still a matter of debates : are the particles plasmon modes determining their luminescence spectra or, inversely is the spectral shape of luminescence directly determined from the gold band structure and thus the crystalline properties of particles ?

The two-photon luminescence (TPL) of small 10 nm x 40 nm colloidal gold nanorods (GNR) was investigated at the single object level, combining polarization resolved TPL and simultaneously acquired topography. A very high dependence of the TPL signal with both the nanorods longitudinal axis and the incident wavelength is observed confirming the plasmonic origin of the signal. The spectral analysis of the TPL evidences two emission bands peaks: in the visible and in the infrared (IR) ; the signal emitted in either the visible or the IR exhibiting however different polarization properties.

We show that the important TPL observed in these GNRs results from resonance effects both at the excitation and emission level : local field enhancement at the longitudinal surface plasmon resonances (LSPR) first results in an increase of the electron-hole generation. Further relaxation of electron-hole pairs then mostly leads to the excitation of the GNR transverse plasmon mode and its subsequent radiative relaxation (see figure). This conclusion was confirmed by the results obtained in the case of nanobipyramids. A deeper insight in this model was further developed after investigating the properties of gold nanorods having close aspect ratio and plasmonic resonances but increasing volume. Experimental data were correlated with BEM (Boundary Elements Method) simulations. It is evidenced that the TPL signal directly depends on field enhancements effects at both the exciting and emission wavelengthes, the efficiency of the transverse plasmonic mode excitation by hot plasmons playing a key role.

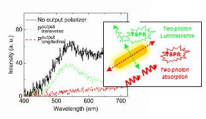


Figure nanop.jpg

Ultrafast cavity switching : a novel ressource for solid-state CQED

Thursday, 8th December - 16:47 - Nonlinear nano-optics - Tower 24 - Room 103 - Oral presentation - Abstract ID: 410

Mr. Tobias Sattler [1], ***Dr. Emanuel Peinke*** [1], ***Dr. Joël Bleuse*** [1], ***Dr. Julien Claudon*** [1], ***Mr. Gaston Hornecker*** [2], ***Dr. Alexia Auffèves*** [2], ***Dr. Henri Thyrrestrup*** [3], ***Prof. Willem L. Vos*** [3], ***Dr. Jean-Michel Gerard*** [1]

1. *CEA Grenoble-INAC,* ***2.*** *CNRS-Institut Néel,* ***3.*** *Twente University-COPS*

It has been known since the 80's that the optical modes and optical response of semiconductor microcavities can be changed in a transient and reversible way through a modification of the refractive index of the semiconductor matrix. Initially developed in view of all-optical data processing and computing, "cavity switching" induced by the electrical injection of free carriers is nowadays widely used for the reconfiguration of photonic circuits.
In the context of CQED, cavity switching appears as a very powerful tool enabling to tailor the spontaneous emission properties of embedded emitters, through a dynamic control of the emitter-cavity mode detuning [1]. As a first example, we present recent switching experiments performed on micropillars containing collections of QDs. We observe large switching amplitudes (by as much as 20 linewidth), as well as differential switching of the pillar modes [2], using ultrafast optical carrier injection. By filtering the micropillar emission within a narrow spectral window, we observe ultrashort spontaneous emission pulses (down to 4ps!), which are generated by the QDs during their transient coupling with the cavity mode. Cavity switching acts here as a way to switch on and off the QD spontaneous emission into the cavity channel. In clear contrast to Fourier-transform laser pulses of similar duration, such pulses display a much shorter coherence time, as highlighted e.g. by transmission experiments through scattering media.
Recent theoretical advances also highlight the huge interest of cavity switching for CQED. For instance, single photons with a tailored time-envelope can be generated by a single quantum dot (QD) in a state-of-the-art microcavity, with a high efficiency and fidelity, by adjusting in real-time the magnitude of the Purcell effect [1,3]. This is noticeably the case for Gaussian time-envelopes and time reversed-exponential envelopes, both important resources for photonic quantum information processing.

[1] H. Thyrrestrup et al, Opt. Exp. 21, 23130 (2013).
[2] H. Thyrrestrup et al, Appl. Phys. Lett. 105, 111115 (2014).
[3] G. Hornecker et al, SPIE Optics and Optoelectronics 2015, Prag, doi:10.1117/12.2178991; E Peinke et al, under review

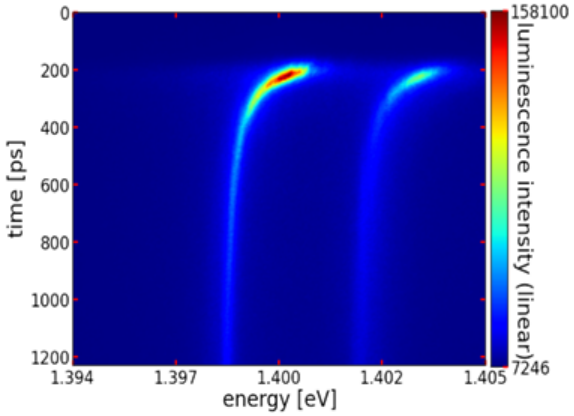


Fig : Multimode switching events in a QD-micropillar, as observed by a streak-camera.

Image sattler.png

A macroscopic enhancement of surface second harmonic generation in polymer nanofibers with embedded para-nitroaniline nanocrystals

Thursday, 8th December - 17:04 - Nonlinear nano-optics - Tower 24 - Room 103 - Oral presentation - Abstract ID: 340

Mr. Hugo Gonçalves [1], ***Ms. Inês Saavedra*** [1], ***Prof. Etelvina Matos Gomes*** [1], ***Prof. Michael Belsley*** [1]

1. *Center of Physics of the University of Minho (CFUM)*

Assembling nanomaterials with a strong nonlinear optical (NLO) response is the key to many photonic applications. Currently the majority of the nonlinear photonic components are based on inorganic optical materials. However, problems persist with these materials such as the magnitude of their optical nonlinearities together with the cost of fabrication. Organic systems are an attractive alternative because of their low cost, fast and intense nonlinear response over a broad frequency range and the wide scope for molecular tunability.

The challenge for organic NLO materials has been to transfer the strong individual molecular NLO response into a macroscopic material that is stable and resistant to intense laser irradiation. For molecules like para-nitroaniline (pNA) that have a large molecular first hyperpolarizability quadratic nonlinear optical phenomena are forbidden in bulk, due to the crystalline centrosymmetric structure.The strong interaction between the large dipole moments, typical of these molecules, favours a pairwise antiparallel configuration that cancels out the second order NLO response. However, a medium that is centrosymmetric in the bulk necessarily loses that symmetry at the surface.

The particular case of SHG generated at surface of pNA has been described, theoretically, by Munn and his co-workers. To promote the enhancement of the surface second order NLO effects, polymeric nanofibers are used as scaffolds where the organic molecules are arranged into suitable organizations. These hybrid organic nanofibers created by electrospinning are extremely promising in terms of amount of produced nanomaterials, low cost, and operational convenience. These supramolecular systems are fabricated on a 1D sub-wavelength scale, where the strong electric field, used in the deposition, and the rapid solidification forces the alignment of the organic material to add up constructively. Polarimetry analysis (Figure 1) demonstrates well-oriented dipole moments inside the nanostructure, while the spectrum of the SHG is wide-band indicating the extreme thinness of the active sections. X-Ray analysis and the analytical data fit, according to Munn approach, were used as tools to reveal the molecular arrangement within the symmetry plane which induces a strong macroscopic surface SHG response.

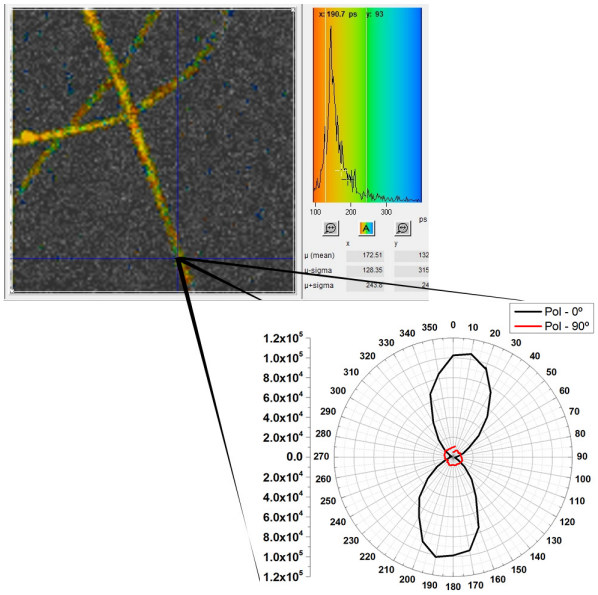


Figure 1 shg microscope image of the nanofibers with embedded p na and the respective polarimetry profile of the shg .jpg

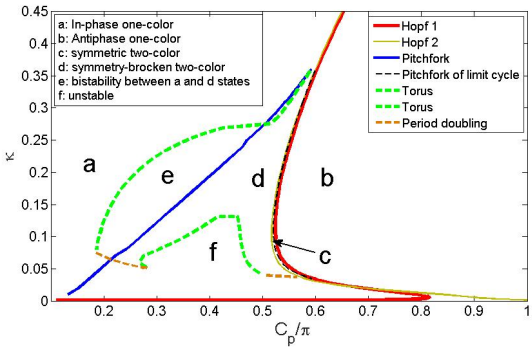
Emergence of stable two-color states in mutually coupled lasers

Thursday, 8th December - 17:21 - Nonlinear nano-optics - Tower 24 - Room 103 - Oral presentation - Abstract ID: 144

Dr. Masoud Seifikar [1], ***Prof. Frank H. Peters*** [1], ***Dr. Andreas Amann*** [2]

1. *Tyndall National Institute and Department of Physics, University College Cork, Cork,* ***2.*** *School of Mathematical Sciences and Tyndall National Institute, University College Cork, Cork*

We theoretically investigate a setup of two mutually delay-coupled semiconductor lasers in a face to face configuration, and study the multi-stabilities and symmetry-broken 1-colour and 2-colour states for this system, for the development of mutually coupled lasers for integration in a Photonic Integrated Circuit (PIC).
The lasers are coherently coupled via their optical fields, where the time delay τ arises from the finite propagation time of the light from one laser to the other. This system is well described by single mode rate equations, which are a system of delay differential equations (DDEs) with one fixed delay. Yanchuk et al. 2004 predicted 1-color symmetric states for very small delays. In Erzgräber et al. 2006 the bifurcations of 1-color states were studied for large delay. Moreover, for zero delay, stable symmetric and symmetry-broken 1-color and 2-color states have been predicted recently by Clerkin et al. 2014.
In particular, symmetry-broken 2-color states are highly interesting from an application point of view, for example in the context of all-optical switching. Here we show that these states continue to exist for finite delays. We performed a detailed study of the relevant bifurcations of the system with finite delay in the range of τ from 0 to 1 (in units of photon lifetime), by means of the continuation Matlab package DDE-BIFTOOL.
Bifurcations and stability regions with the two bifurcation parameters, coupling strength κ and coupling phase Cp are shown in the figure for τ=1. In regions a and b, in-phase and antiphase 1-color states are stable, respectively. For very high coupling strength κ, these two regions are separated by two supercritical Hopf bifurcations. The very small area between these two Hopf lines contains region c with stable symmetric 2-color states. More importantly, the model predicts that symmetry-broken 2-color states are stable in the two large regions d and e, which are bounded by torus, period-doubling and pitchfork of limit cycle bifurcations.
Acknowledgements: We thank Bernd Krauskopf and Hartmut Erzgräber for helpful discussions and for help with the DDE-BIFTOOL implementation. This work was supported by the Science Foundation Ireland under grant SFI 13/IA/1960 .



Stability regions and bifurcations for time dely 1.jpg

INVITED TALK -> Frequency mixing phenomena in acousto-magneto-plasmonics

Thursday, 8th December - 17:38 - Nonlinear nano-optics - Tower 24 - Room 103 - Oral presentation - Abstract ID: 347

Prof. Vasily TEMNOV [1], ***Dr. Ilya Razdolski*** [2], ***Dr. Denys Makarov*** [3], ***Dr. Alexey Lomonosov*** [4], ***Dr. Vladimir Vlasov*** [5], ***Mr. Julius Janusonis*** [6], ***Mr. Chia-Lin Chang*** [6], ***Prof. Raanan Tobey*** [6]

1. *Institut des Molécules et Matériaux du Mans,* ***2.*** *Fritz-Haber Institute of the Max-Planck Society, Berlin,* ***3.*** *Helmholtz-Zentrum Dresden-Rossendorf,* ***4.*** *LAUM CNRS 6613 Universite du Maine,* ***5.*** *IMMM CNRS 6283, Universite du Maine,* ***6.*** *University of Groningen*

Frequency conversion in periodically driven systems lies at the heart of nonlinear physics. While the second harmonic generation (SHG), sum- and different frequency mixing in the optical frequency range originate from the chi(2)-nonlinearities, in acoustics and magnetism they are often dominated by parametric resonances, where system parameters are modulated at frequencies comparable to the natural oscillation frequencies, typically in the MHz-GHz range.

Keeping in mind the intrinsic differences in the physical nature and frequency range of these phenomena, here we discuss, in a comparative manner, two examples of frequency mixing in magneto-plasmonics [1,2] and magneto-acoustics [3,4]. The ability to experimentally tune both systems through Surface Plasmon Resonance (SPR) and Ferromagnetic Resonance (FMR) as well as to theoretically describe these resonant interactions within the framework of phenomenological models based on the Lorentz oscillator, represent the key idea behind this presentation.

In nonlinear magneto-plasmonic experiments, the Kretschmann configuration SPR resonances for different optical wavelengths occur at different angles (Fig. 1a,b), offering the unique possibility to match the fundamental and SHG resonances. In magneto-plasmonic Au/Co/Ag/glass samples, the plasmonically assisted SHG also depends on the direction of magnetization M in ferromagnetic cobalt, which can be reversed with a weak external magnetic field. A simple model utilizing the resonant plasmonic enhancement of the chi(2)-susceptibility confirms the experimental observation that magnetization-induced effects are most pronounced between the SHG and fundamental SPR resonances [1,2].

In the second experiment [3,4], the magnetization in a Ni/glass sample is excited by two distinct transient surface acoustic waves (SAW and SSLW). Magnetic tuning the FMR frequency in resonance to the their SHG, sum- and difference frequencies demonstrates the full variety of frequency mixing phenomena (Fig. 1c). In contrast to nonlinear optics, the frequency mixing is dominated by the parametric effect in the externally driven FMR oscillator. An analytical model based on the resonant enhancement of frequency-mixed signals explains the experimental observations [4].

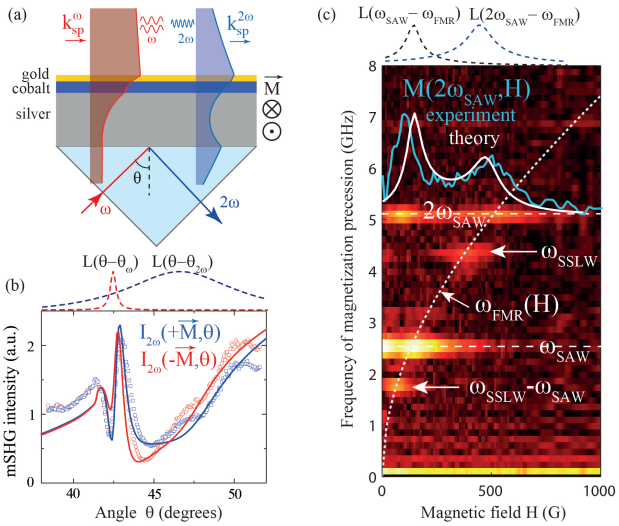
References:

[1] I. Razdolski et al., ACS Photonics 3, 179 (2016)

[2] V.V. Temnov et al., J. Opt. 18, 093002 (2016)

[3] J. Janusonis et al., Phys. Rev. B 94, 024415(2016)

[4] C.L. Chang et al., arxiv1610.02926 (2016)



Frequencymixing figure.jpg

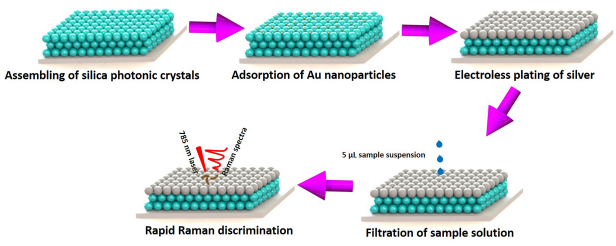
Label-free, sensitive Streptomycete spore detection by silver-plated photonic crystals biosensor

Thursday, 8th December - 16:30 - Photonic & plasmonic nanomaterials - Tower 24 - Room 105 - Oral presentation - Abstract ID: 124

Dr. Delong Wang [1], *Prof. Xiangwei Zhao* [1], *Prof. Zhongze Gu* [1]

1. *Southeast University*

Highly sensitive bacteria identification plays an important role in the field of clinical diagnosis, food industry, and environmental monitoring. Common techniques for identification of Streptomyces include polymerase chain reaction (PCR) and staining method, which have been developed for decades. However, PCR method is time-consuming and needs following procedures like electrophoresis, gene sequencing and sequence alignment. Staining method based on Gram staining is highly dependent on the concentration and purity of samples. In this paper, a label-free, sensitive biosensor based on silver-plated photonic crystal (PC) was developed both for the filtration and identification of spores from nosiheptide prepared with Streptomycete fermentation through Surface-enhanced Raman Scattering (SERS). The Finite difference time domain (FDTD) results indicated that this biosensor exhibited good electric field enhancement which contributes to the Raman intensity. A “drop and measure” manner was adopted for the spore identification with only 5 μl sample and 5 minutes. The Raman results showed that this label-free biosensor could be not only utilized for the highly sensitive spore identification from nosiheptide prepared with Streptomycete fermentation, but also applied to the discrimination of nosiheptide prepared with chemical and biological methods. The label-free, sensitive silver-plated PC biosensor will be a promising tool for the highly sensitive bacteria and chemical molecule detection in food safety, environmental and pharmaceutical applications.



Abstract image.jpg

Optical properties of all-dielectric Fabry-Perot filter with Si-pillar-filled cavity

Thursday, 8th December - 16:47 - Photonic & plasmonic nanomaterials - Tower 24 - Room 105 - Oral presentation - Abstract ID: 396

Mr. Yingjie Chai [1], ***Dr. Anna Sytchkova*** [2]

1. *Shanghai Institute of Optics & Fine Mechanics (SIOM), Chinese Academy of Sciences,* ***2.*** *ENEA Optical Coatings Group, DTE-PCI-IPSE*

Employment of metasurfaces in interference optical filters yields additional flexibility to its design. Optical properties of such hybrid structures are ruled by the double nature of the interference effects occurring within the multilayer. While the planar layers may be described by conventional formalism of Fresnel coefficients, the included 3D nanostructures require application of full-wave Maxwell equation calculation, accounting for Mie scattering and/or possible plasmonic resonances induced in meta-atoms.

Single-cavity Fabry-Perot filter is one of the most known and widely used all-dielectric multilayer structures. Here we analytically investigate modification of this structure by inclusion of a metasurface of silicon pillars at the bottom of its cavity. We show how the geometry of the metasurface influences the optical properties of the device on terms of the transmission peak spectral position, the transmittance-at-peak value and the peak bandwidth value. The dependence of these parameters on the angle of incidence is also examined. Electric field profiles in the multilayers with different pillar geometries are drawn here as well.

We infer that the metasurface inclusion may serve as an instrument for fine tuning of the filter spectral characteristics. Their employment provides an important tool for micro-optics designers through enabling spatially local control of the optical performance of the filter. Additionally, some applications may gain from such hybrid structures thanks to dramatically lower concentration of light energy in the filter, and in particular in its cavity.

Electric file profiles in the multilayers with different pillar geometries are drawn here as well.

We infer that the metasurface inclusion may serve as an instrument for fine tuning of the filter spectral characteristics. Their employment provides an important tool for micro-optics designers through enabling spatially local control of the optical performance of the filter. Additionally, some applications may gain from such hybrid structures thanks to dramatically lower concentration of light energy in the filter, and in particular in its cavity.

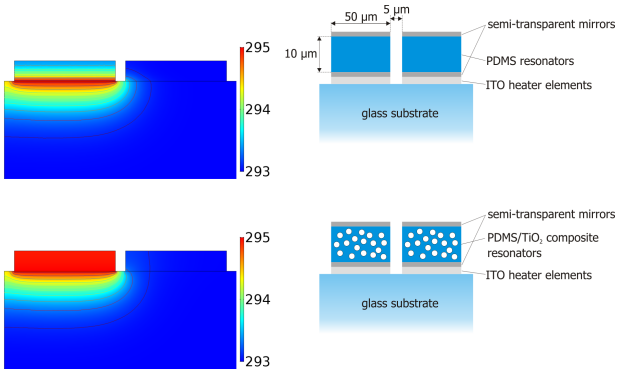
Polymer-nanoparticle composites for thermally-tunable optical resonator devices

Thursday, 8th December - 17:04 - Photonic & plasmonic nanomaterials - Tower 24 - Room 105 - Oral presentation - Abstract ID: 414

Mr. Hendrik Block [1], ***Prof. Martina Gerken*** [1]

1. *Kiel University*

Progressing miniaturization and integration of optical systems requires optical devices that can be fabricated in a wafer-level process. Previously, we experimentally demonstrated a tunable optical aperture based on segmented thin-film resonators [1]. Aperture opening and closing is achieved by thermally tuning polymer resonator segments from on-resonance to off-resonance. Using standard lithography for defining the Joule heating elements, arbitrarily-shaped tunable segments can be achieved. Due to the small thermal conductivity of polydimethylsiloxane (PDMS) of 0.15(W/m/K) tuning speeds are limited. We chose PDMS for its high thermal expansion coefficient of 340e-6(1/K). Here, we propose the use of polymer-nanoparticle composite layers for the resonators combining materials with a high thermal conductivity and a high thermal expansion coefficient.
Titanium dioxide (TiO2) offers a much higher thermal conductivity of around 8.5(W/m/K) compared to PDMS. In previous experiments we demonstrated that blending of a polymer with TiO2 nanoparticles (diameter 35nm) allows for refractive index tuning with negligible scattering losses in the 500nm to 700nm wavelength range [2]. Here, we present a theoretical study of the performance of tunable apertures incorporating PDMS blended with TiO2 nanoparticles. In finite-element-method (FEM) simulations a 10-µm composite layer with 30%vol TiO2 nanoparticles and 70%vol PDMS on a glass substrate is evaluated. The effective medium is modelled with a thermal conductivity of 3.1(W/m/K) and a thermal expansion coefficient of 240e-6(1/K). The attached figure presents a schematic of the simulated device section. Simulation results are given of the temperature distribution 200µs after setting a 2K temperature increase at the left-resonator bottom interface. Clearly, the resonator device with the nanoparticle-polymer composite layer is fully actuated. The PDMS-only device on the other hand shows a temperature gradient across the cavity layer. As the composite layer combines a high thermal conductivity with a high thermal expansion coefficient ten times faster response times are predicted.
[1] H. Block, P. Metz, J. Adam, M. Gerken, “Thermally tunable optical aperture based on a segmented thin-film resonator,” Proc. SPIE 9130, Micro-Optics 2014, 913002 (2014).
[2] A. Pradana, C. Kluge, M. Gerken, “Tailoring the refractive index of nanoimprint resist by blending with TiO2 nanoparticles,” Opt. Mater. Express 4(2), 329-337 (2014).



Thermal tuning with composite resonator material.png

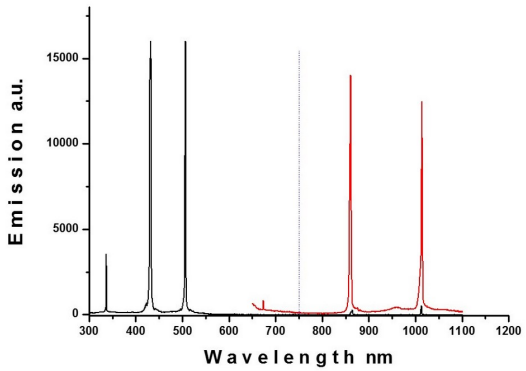
Infrared and visible lasing in cholesteric liquid crystals

Thursday, 8th December - 17:21 - Photonic & plasmonic nanomaterials - Tower 24 - Room 105 - Oral presentation - Abstract ID: 217

Mr. saadaoui lotfi [1], ***Dr. Ridha Hamdi*** [1], ***Dr. Gia Petriashvili*** [2], ***Dr. Maria Desanto*** [3], ***Prof. Riccardo Barberi*** [3], ***Prof. Tahar Othman*** [1]

1. *University of Tunis-El Manar,* ***2.*** *Institute of Cybernetics,of the Georgian Technical University, Euli str. 5, 0175, Tbilisi, Georgia,* ***3.*** *University of Calabria, Ponte P. Bucci 31C, 87036 Rende (CS), Italy*

Cholesteric liquid crystal (CLC) resembles nematic liquid crystal except that the molecules tend to align themselves into a helical structure with the helical axis perpendicular to the director. Due to their periodical orientation of molecular helix, CLC can be regarded as one-dimensional photonic crystal. In this work, lasing based on dyes-doped cholesteric liquid crystal (DD-CLC) is proposed. We present a strategy to obtain the lasing emission in the visible and Near Infrared (NIR) ranges for DD-CLC. In fact, we fabricate a novel structure composed of a DD-CLCs sandwiched in a multilayered cell. The system is irradiated with nanosecond laser pulses. As result, lasing emission is observed at different wavelengths in the visible and the infrared ranges as shown in the following figure.



Lasing spectra of the uv pump 337nm the first the second the third and the fourth laser lines were in 430 nm 506nm 860nm and 1012nm respectively.jpg

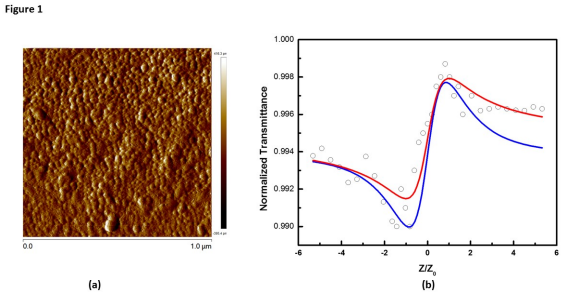
Third-order nonlinear optical properties of ultra-thin e-beam evaporated silver films

Thursday, 8th December - 17:38 - Photonic & plasmonic nanomaterials - Tower 24 - Room 105 - Oral presentation - Abstract ID: 408

Dr. Husam Abu-Safe [1], ***Dr. Radwan Al-Faouri*** [2], ***Ms. Thekrayat Hasan*** [2], ***Prof. Hameed Naseem*** [2]

1. *German-Jordanian University,* ***2.*** *University of Arkansas*

Ag ultra-thin films with thickness of 3 nm was prepared by e-beam evaporation under ultra-high vacuum at room temperature on glass substrates. The third-order nonlinear optical response of the fabricated films was investigated by single beam z-scan technique using cw 457 nm. To reduce the thermal nonlinear response, an optical chopper at 1kHz was used. The Atomic Force Microscopy (AFM) images showed granular surface with an average 30 nm for the grain size. However, the roughness measurements resulted in Ra value of 0.08 nm only. The films' linear absorption showed a peak at 459 nm indicated a surface Plasmon behavior as expected. In the closed aperture z-scan measurements the distance between the peak and the valley (ΔTp-v) in the transmission curves was about 1.67 z0 indicating that the nonlinear response in these films was a third-order nonlinear optical response. The computed nonlinear refractive index (n2) and the two photon absorption (β) coefficient were 5.98×10-6 m2/W and 2.92 m/W, respectively. The calculated value of χ(3) was 5.2×10-10esu. This a very large value for such a continuous thin film. We believe that such strong response is most properly due to surface Plasmon resonance enhancements in the films.



Figures.jpg

Recent advances in silicon photonics

Friday, 9th December - 09:00 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 443

Prof. Laurent Vivien [1]

1. *University of Paris-Sud*

Silicon is the mainstream material in the electronic industry and it is rapidly expanding its dominance into the field of photonics. Indeed, silicon photonics has been the subject of intense research activities in both industry and academia as a compelling technology paving the way for next generation of energy-efficient high-speed computing, information processing and communications systems. The trend is to use optics in intimate proximity to the electronic circuit, which implies a high level of optoelectronic integration. Over the last decade, the field of silicon photonics has advanced at a remarkable pace. Most applicative sectors have now included silicon photonics in their roadmaps as a key technology to be deployed over short, medium or long-term horizons. This evolution towards silicon-based technologies is largely based on the vision that silicon provides a mature integration platform supported by the enormous existing CMOS manufacturing infrastructure which can be used to cost-effectively produce integrated optoelectronic circuits for a wide range of applications, including telecommunications, optical interconnects, medical screening, spectroscopy, and biological and chemical sensing… Recent advances and new trends in the development of silicon photonic devices will be presented.

Quantum light generation with semiconductor nanostructures

Friday, 9th December - 09:35 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 444

Prof. Elisabeth Giacobino [1]

1. *Laboratoire Kastler Brossel, UPMC-Sorbonne Universités, CNRS, ENS-PSL Research University, Collège de France, 4 place Jussieu, 75005 Paris*

In a semiconductor system, optical excitations can create excitons, which are bound electron-hole pairs. In semiconductor nanostructures the excitonic energy levels are quantized, leading to a strong size dependence of their optical properties and allowing engineering of classical and non-classical light generation. Two cases will be described, one involving quantum wells with 1D quantization, the other one involving quantum dots, with 3D quantization.

When a quantum well is placed in a high finesse microcavity, the strong coupling regime between 2D excitons and light is reached, forming exciton-photon mixed quasi-particles called polaritons. Polaritons combine the coherent properties of photons with the highly interacting features of electronic states. These properties have allowed us to demonstrate nonlinear and quantum optical effects in the microcavity emission, as well as quantum fluid properties in the propagation of polaritons in the system.

Quantum optical properties of quantum dots, or semiconductor nanocrystals, made of a few thousand atoms will also be described. Here, the strong confinement of electron-hole pairs leads to very interesting properties such as photon antibunching, opening the way to on-demand single photons sources at room temperature.

Quantum light sources using InAs quantum dots

Friday, 9th December - 10:45 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 445

Prof. David Ritchie [1]

1. *university of Cambridge*

I will describe work undertaken in collaboration between the Cavendish Laboratory and the Toshiba Research Europe Laboratory, based in Cambridge. In this research we have fabricated and demonstrated triggered sources of single-photons and entangled-photon pairs using self-assembled InAs quantum dots embedded in GaAs/AlGaAs heterostructures.

Single-photon sources operating in the wavelength range 0.8 – 1.5 μm have been developed where the probability of multi-photon emission is as low as 2%. We are able to electrically tune the emission energy by up to 25meV allowing observation of two-photon interference between photons emitted from different quantum dots.

Our sources of polarization entangled-photon pairs rely on the radiative decay of an InAs quantum dot from a biexciton state to the ground state via an intermediate exciton state. We have developed several techniques to tune the splitting of the exciton state to less than 0.5 μeV and allow entangled-photon emission.

We have increased the fidelity of the entangled state to over 70% by control of the growth process and to over 90% by time gating as well as demonstrating the operation of a high-fidelity entangled-photon light emitting diode. Recent use of these sources to demonstrate quantum teleportation and a quantum relay will be described

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Two dimensional transition metal dichalcogenides for photonics and electronics

Friday, 9th December - 11:20 - Plenary Speeches - Amphitheatre 25 - Oral presentation - Abstract ID: 446

Prof. Manish Chhowalla [1]

1. *State University of New Jersey*

Manish Chhowalla is a Professor, Associate Chair of the Materials Science and Engineering Department, and the Director of the Institute for Advanced Materials, Devices and Nanotechnology at Rutgers University. His current research interests are in the fundamental studies of 2D transition metal dichalcogenides (TMDs). In particular, his group studies the optical and electronic properties of different phases of 2D TMDs. They have demonstrated that it is possible to induce phase transformations in atomically thin materials and utilize phases with disparate properties as electrodes for field effect transistors, catalysis, and energy storage. Prof. Chhowalla has authored over 220 refereed articles, he held the Jacobs Chair in Applied Physics from 2009 – 2012 at Rutgers University, and was awarded the Institute of Physics – Ireland Lectureship in 2013.

Synthesis, Characterization and Optical Constants of Silicon Oxycarbide Thin Films

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 103

Mr. Faisal Ahmed Memon [1], ***Dr. Francesco Morichetti*** [1], ***Mr. Giosue Iseni*** [2], ***Dr. Claudio Somaschini*** [2], ***Prof. Andrea Melloni*** [3]

1. *Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB) Politecnico di Milano,* ***2.*** *PoliFAB Politecnico di Milano,* ***3.*** *Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB)*

High refractive index glasses are preferred in integrated optics applications to realize higher integration scale in passive devices. With a refractive index that can be tuned between silica (1.46) and amorphous silicon carbide (3.2), silicon oxycarbide SiOC offers this flexibility. However, current methods in use to produce SiOC such as PECVD, ion-beam-synthesis, and sol-gel-pyrolysis introduce large volumes of hydrogen that elevates the amount of transmission loss. In this work, SiOC thin films have been deposited using RF-reactive-magnetron-sputtering system by a pure SiC target in a controlled environment of argon-and-oxygen gases at room temperature. Quantitative characterization of the SiOC thin films was performed extensively by profilometry, ellipsometry, prism-coupling, XPS, SEM, and AFM. The optical constants, index-of-refraction n and extinction-coefficient k, of the prepared silicon oxycarbide films were derived from the ellipsometric measured data with JA-Woollam-VASE-ellipsometer in the UV-VIS-NIR wavelength regions (300-1600nm) and at multiple angles-of-incidence. A four-layer optical model including: surface roughness/SiOC/SiO2/c-Si was created in WVASE32TM software to perform numerical fitting to the experimental data. A Kramers-Kroning consistent Tauc-Lorentz oscillator was used to describe SiOC films, hence the obtained optical functions were Kramers-Kroning consistent. Controlling the deposition parameters, the refractive index of the SiOC films was tuned from 1.39 to 1.86 as measured by ellipsometer and prism-coupler at 1550 nm. The dispersion curves of n and k of the deposited SiOC films are shown in figure 1. The SiOC films thickness was determined to be between 200 nm and 2000 nm using P-15 profilometer. The deposition rate followed an increasing trend with RF power as shown in figure 2 and significantly large rate of 150 nm/min was achieved. XPS analysis confirmed the presence of silicon, oxygen and carbon in SiOC films that exist in mixed bonding structure as given in Si2p peak (inset a). RMS roughness of SiOC films as low as 0.5 nm were obtained from AFM imaging (inset b). In this work, we demonstrated synthesis of silicon oxycarbide with good transparency in VIS-NIR regions, index tunability, large rate of deposition, and low roughness which suggest sputtered silicon oxycarbide a promising candidate for waveguides (inset c) in integrated optics.

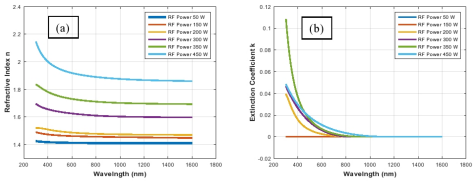

Figure (1): Index of refraction (a) and extinction coefficient (b) dispersion curves of deposited silicon oxycarbide films at different RF power of sputtering system

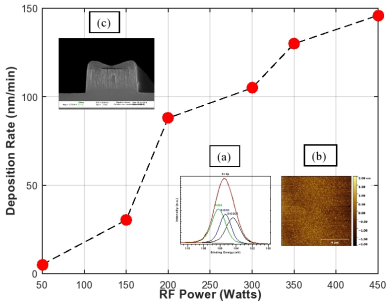

Figure (2): Deposition rate in (nm/min) of deposited silicon oxycarbide films as a function of RF Power of sputtering system

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The one-dimensional photonic band gap materials for gas sensing

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 146

Ms. Tayssir Gahef [1], ***Ms. Oumayma Habli*** [1], ***Dr. Yassine Bouazzi*** [1], ***Prof. Mounir Kanzari*** [1]

1. *Laboratory of Photovoltaic and Semiconductor Materials, National Engineering School of Tunis, University of Tunis-El Manar*

In recent years, there has been more research on the use of the Photonic Band Gap (PBG) materials in the detection area. The application of these materials as gas sensors, seems to be very promising because of their miniaturization and high spectral sensitivity.
The aim of this work is arranged around the contribution to the design and study of a resonant microsystem based on PBG materials for applications as optical sensors to measure the gases presence and concentration in the air. Where we proposed an gas monitoring structure for detecting the gas in ambient air. This sensor is based on a 1D PBG material formed by alternating layers of Silicon (Si) and Silica (SiO2) with an high Q-factor air cavity in the middle. The numerical results show that the transmission peak, which appears in the gap, is caused by the infiltration of impure air into the cavity middle layer. This transmission peak can be used for detection purposes in real-time environmental monitoring. Also, we theoretically study the relevance of these photonic systems, we analyze the effect of intrinsic and extrinsic parameters of this device on the detection performance.

Coupled-Mode Theory derivation of the formal equivalence between a three-mode waveguide and a set of three mutually coupled single-mode waveguides

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 226

Dr. Yann BOUCHER [1]

1. CNRS Foton (UMR 6082)

In the frame of Coupled-Mode Theory (CMT), for a given eigen-state of polarization, a two-mode waveguide can be formally interpreted as a set of two identical, mutually coupled single-mode waveguides, where the even/odd supermodes play the roles of the symmetric (slow) and antisymmetric (fast) modes of the two-mode waveguide. Within this formalism, the relevant parameters are the phase mismatch and the coupling constant: symmetry ensures that the former is zero, whereas the latter is defined by the half-difference between the propagation constants of the supermodes.

In a ternary system made of three identical, phase-matched, mutually coupled single-mode waveguides, the propagation constants of the supermodes are equidistant in the k-space. In a three-mode waveguide, however, the three modes (slow, “neutral” and fast) are not equidistant. It is therefore impossible to proceed to the same identification, with one coupling constant as the sole modelling parameter.

Nevertheless, a formal equivalence is still relevant, provided we also take into account the “diagonal perturbation” exerted on the central waveguide by its two neighbours. As it happens, the three-mode waveguide can be interpreted as a set of three mutually coupled single-mode waveguides, where the middle one appears slightly detuned. We propose to show how to derive the equivalent mismatch and the equivalent coupling constant from the three propagation constants.

Alternatively, another picture is possible, with three identical, phase-matched, mutually coupled single-mode waveguides, where this time the coupling is not limited to the nearest neighbours. Once again, two distinct parameters are required (two coupling constants). Both approaches lead to similar results in terms of mode indices. This means that, if a formal identification is actually possible in the frame of CMT, the solution is not unique.

We’ll illustrate our findings on planar waveguides, where exact calculations are readily available, not only for the propagation constants but also for the transverse distribution of the optical fields on each mode (see Figure). This approach can prove of interest for the analytic investigation of photonic integrated structures involving Modal Division Multiplexing (MDM), notably in terms of design and tolerances.

Ince-Gaussian beam-excited surface plasmon polaritons with Ag surface structure

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 272

Prof. Shu-Chun Chu [1], ***Mr. Yi-Hua Chen*** [1], ***Mr. Chun-Fu Kuo*** [1]

1. *National Cheng-Kung University*

Owing to the capability of achieving tighter spatial confinement and higher local field intensity, surface plasmon polaritons (SPPs) have been investigated extensively. To excite SPPs with plane wave and conventional Gaussian beam have been well-discussed previously. Recently, researchers have great interests in studying the properties of the SPPs that excited by structure lights, such as cogwheel-like structured light beams, optical vortex beams, and etc.. This study made subwavelength-scale Ag structure on the ITO glass with e-beam lithography, and investigated the resulting SPPs that excited by normally incident focusing Ince-Gaussian Beams (IGBs) [Opt. Express 29, 144] of several different modes. Where the IGBs is a third complete family of exact and orthogonal solutions of the paraxial wave equation. The Ag structure this study adopted is composed of two groups of thin periodic Ag bars. The wavelength of the IGB this study used is 1064 nm. Several different widths and periods of the Ag structures have been made and tested in this study. The SPPs that excited by several different IGBs have been measured by scanning near-field optical microscope (SNOM). The figure shows a measured near-field images (|E|ˆ2) detected by SNOM, while the incident IGB is even IGB with mode number: order p=2 and degree m=2. Two yellow dotted lines in the figure indicate the boundaries of two groups of Ag bars. The distance between two boundaries (two yellow dotted lines) is 14 micrometer. In this experiment, the two bright spots of the incident IGB is just hitting on the boundaries of two groups of Ag bars. Several experimental results of this study reveal that while the edge of the IGBs hitting on both boundaries of two group of the Ag bars, the resulting SPPs propagating from the Ag bar along the metal–dielectric interface forms sable subwavelength-scale slit-like interference patterns. The phenomenon is interesting, and the relation between the slit-like interference patterns and Ag structure is worth to be further investigated. Suitable arrangements of the periodic thin Ag bar might achieve more different subwavelength-scale spatial localized interference patterns, which might be useful to nanoimaging, as well as to nanolithography and nanomanipulation.

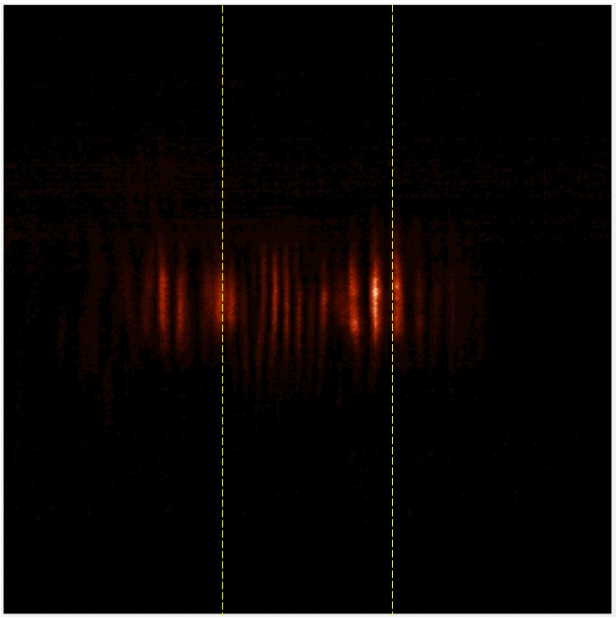

Figure1.jpg

Design Issues and Characterization of a GaInNAs-based Resonance Cavity Enhanced Photodetector

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 275

Mr. Fahrettin SARCAN [1], ***Mr. M. Syahmi Nordin*** [2], ***Mr. Furkan Kuruoğlu*** [1], ***Prof. Ayşe Erol*** [1], ***Dr. Anthony Vickers*** [2]

1. *istanbul university,* ***2.*** *University of Essex*

We report a resonant-cavity-enhanced novel GaInNAs-based photodetector, designed to be operated at optical communication window of 1.3 μm. Transfer-matrix method was used to design the structure of the device. 7 nm-thick nine (Sb) / quantum wells were used as the absorption layers and 15 and 10-pairs GaAs/AlAs-distributed Bragg reflectors were grown as the bottom and top mirrors, respectively. All measurements were carried out at a temperature range from 5 to 40 oC in order to investigate characteristic of cavity resonance. The quantum efficiency is determined to be in the range of 10% (at 5 oC) to 32% (at 40 oC). An excellent wavelength selectivity is observed and changed from 3.4 nm (at 5 oC) to 6 nm (at 40 oC). Our results reveal that properties of RCEPD is quite sensitive to temperature changes due to the difference in the temperature dependence of DBRs and bandgap of absorption layer.

Selective Synthesis and Thermoluminescence Response of One Dimension Nanostructures of Eu2+ doped TiO2 obtained by HYSYCVD

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 276

Dr. Ana Lilia Leal-Cruz [1], ***Prof. Jesús Alán Pérez-aguirre*** [1], ***Dr. Alicia Vera*** [1], ***Dr. Rodrigo Melendrez-amavizca*** [1], ***Dr. Josué Aguilar-Martínez*** [2], ***Dr. Marcelino Barboza-Flores*** [1]

1. *Universidad de Sonora,* ***2.*** *Universidad Autónoma de Nuevo León*

Titania (TiO2) has attracted interest owing its potential applications as semiconductor and dosimetry materials given its excellent properties. Optical, electrical, and thermal properties of TiO2 are closely linked to microstructure, and at the same time, to processing condition and synthesis methods. TiO2 can be synthesized by sol-gel, solution growth, and chemical vapor deposition starting from gas or metalorganic compounds. An alternative synthesis method to produce undoped and doped TiO2 nanostructures, for dosimetry applications, is the hybrid precursor systems chemical vapor deposition (HYSYCVD) technique, starting from solid precursors with low decomposition temperature. In this work, a systematic study to know the magnitude of processing parameters influence on thermoluminescent response of TiO2:Eu2+ nanomaterials obtained by HYSYCVD is presented. Synthesis of one dimension nanostructures of TiO2:Eu2+ was carried out using K2TiF6, as titanium solid precursor, EuCl2 was added as europium dopant at 0.5, 1, 2.5, and 5 at. %. HYSYCVD processing conditions were temperature of 923.15 K, processing time of 2.5 h, atmospheric pressure, and two different heating rate of 5 K/min (thermal treatment 1 or TT1), and 10 K/min (thermal treatment 2 or TT2). Obtained materials were irradiated with beta rays in the range of doses from 0.083 to 3000 Gy. Field emission scanning electron microscope photomicrographs shown evident changes in microstructure at different heating rates. Thermoluminescence analysis shown 3 main peaks: the first one around to 373.15 K, the second one (main peak) nearby 473.15 K, and the third at 573.15 K. Also, according to heating rates, samples exhibit a marked difference in the thermoluminescence response.

Plasmonic solar cell with randomly distributed Ag nanopaticles

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 323

Ms. shahla Golghasemi sorkhabi [1], ***Mrs. Mina Piralaee*** [2], ***Prof. Asghar Asgari*** [2]

1. *University of Angers/University of Tabriz,* ***2.*** *University of Tabriz*

Random metal-dielectric nanocomposites are excellence choices for efficient light absorption. In this work, an Ag-Si random nanocomposite is used as the active layer of solar cell. Solar cell applications request to achieve the maximum absorbance of light in the active layer and since silicon is a weak absorber at long wavelength, we have used metal nanoparticles into the active layer of the thin film solar cell [1]. Moreover we have used a random distribution of nanoparticles in order to provide a broad spectrum of Light absorption [2]. In addition, we have used the effective medium theory to describe the dielectric function of such nanocomposite system, using the Maxwell-Garnet theory along with Percus-Yevick approximation that is an appropriate model for almost all values of filling fraction of nanoparticles [3]. We have used this effective dielectric function directly related with transmittance, Absorbance and Reflectance of the nanocomposite. The effect of changing the radius and filling fraction of nanoparticles on short current density of solar cell have been investigated and we have comprehended that there is an optimum value for nanoparticles radius and filling fractions giving higher values of the reflectance. We have increased these values. We have also shown that lower values of the transmittance increases led to reduce the absorbance. However, in the obtained optimum values of radius and filling fraction, the highest values are for short current density. The results are compared with ordinary thin film silicon solar cell and the results show an increasing in the values of short current density up to 30 percent.

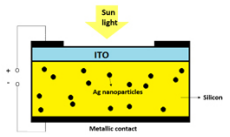

Fig. 1. Schematic structure of random plasmonic solar cell

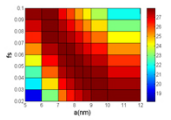

Fig. 2 –Short current density of solar cell as a function of nanoparticles radius and filling fraction (m A/cm^2)

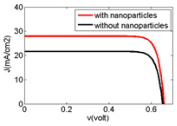

Fig. 3 – I-V curve of solar cell, with and without nanoparticles

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Application of ultrafast femtosecond lasers exposure to solids: time- and angle-resolved photoemission spectroscopy

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 426

Dr. Haiyun Liu [1]

1. *Beijing University of Technology*

Angle-resolved photoemission spectroscopy (ARPES) is a powerful tool of probing electronic structures in solids, however static ARPES fails to visualize ultrafast dynamic processes and interactions, which contain rich physical information, for example, light-matter interaction and electron coupling with various coherent collective modes, which survive in few picoseconds or even tens of femtoseconds. To directly study such interesting phenomena, it is critical to develop time-resolved ARPES (TR-ARPES), by implementing ultrafast pump-probe laser beams: a first low energy infrared (IR) pulse as pump to stimulate/drive the system, and then a second high energy ultraviolet (UV) or extreme ultraviolet (XUV) pulse as probe to detect transient electronic states from femtosecond to picosecond time-scales.

Here I will first briefly introduce the development of a high resolution TR-ARPES, based on NIR/MIR pump and XUV probe. Then I will talk about its applications with two different hot topics: Photon-driven insulator-to-metal electronic transition and detection of collective modes in charge-density-wave (CDW) materials.

[1] J. C. Peterson, et al., Clocking the Melting Transition of Charge and Lattice Order in1T-TaS2 with Ultrafast Extreme-Ultraviolet Angle-Resolved Photoemission Spectroscopy, Phys. Rev. Lett. 107, 117402 (2011).

[2] H. Y. Liu*, et al., Possible observation of parametrically amplified coherent phasons in K0.3MoO3 using time-resolved extreme-ultraviolet angle-resolved photoemission spectroscopy, Phys. Rev. B 88, 045104 (2013).

[3] D. Fausti, et al., Light-Induced Superconductivity in a Stripe-Ordered Cuprate, Science 331, 189 (2011).

[4] S. Kaiser, et al., Optically induced coherent transport far above Tc in underdoped YBa2Cu3O6+δ, Phys. Rev. B 89, 184516 (2016).

Efficient TE/TM mode conversion in a hybrid structure made with a SiO2/ZrO2 layer coated on an ion-exchanged glass waveguide

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 10

Dr. bouras mounir [1], ***Prof. Hocini Abdessalem*** [1]

1. *university of mohamed boudiaf msila*

The integration of magneto-optical materials with classical technologies being still a difficult problem, Many novel materials and device designs have been proposed as photonic analogs to electrical diodes over the last four decades. This study explores the possibility to realize a mode converter TE-TM based on a hybrid structure. This hybrid device is made by coating a SiO2/ZrO2 layer doped with magnetic nanoparticles on an ion-exchanged glass waveguide. We have used the finite difference beam propagation method for numerical solution of the Full-wave vector equation. We have also used the transparent boundary condition. The mode converter TE-TM and the modal birefringence, depend on the amount of nanoparticles in the composite on the spatial distribution of the field in the guide of hybrid structure. Accordingly, the possibility to achieve a TE-TM mode conversion in a magneto-optical hybrid waveguide operating at $\lambda = 1550$ nm, to nine of degrees.

High sensitive photonic crystal multiplexed biosensor array using sandwiched H1 cavities

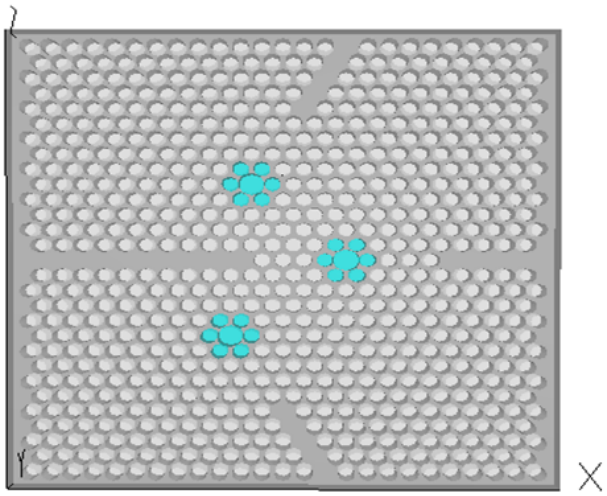
Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 40

Dr. ARAFA Safia [1], ***Prof. Mohamed Bouchemat*** [2], ***Prof. Touraya Bouchemat*** [1], ***Dr. Ahlem Benmerkhi*** [1]

1. *Département d'électronique, Université des frères Mentouri, Constantine,* ***2.*** *Department d'électronique Université des frères Mentouri, constantine*

Integrated optical sensors based photonic crystal (PhC) structures have emerged as a field of great interest due to their promising characteristics in terms of cost, compactness, flexibility in structural design and easy extension to the sensor arrays. In addition to these characteristics, they provide a large light-matter interaction due to their photonic band-gap effect. This phenomenon makes the sensors highly sensitive to small refractive index (RI) variations. However, most of studied and experimentally realized PhC sensors operate as a single or a point sensor. Therefore, to overcome the single purpose performance of the sensor and to make the detection of different analyte simultaneously on a single platform possible, photonic crystal sensor array is a better choice. In this context, we demonstrate a high sensitive photonic crystal integrated biosensor array, considering the multiple sensing performance and label-free Biomolecular detection. In order to further improve the detection level and simultaneously restrain the crosstalk value between the adjacent biosensors, the well-known technique of wavelength division multiplexing to spatially separate the integrated biosensor has been used. The device platform consists of an array of three sandwiched H-1 cavities patterned above silicon on insulator (SOI) substrate (Figure 1). Each cavity has been designed for different resonance wavelength and different cavity spacing. Results obtained by performing finite-difference time-domain (FDTD) simulations, indicate that the response of each sensor unit to the RI variation is completely independent and the resonance spacing between the adjacent sensors is wide enough to ensure high multiplexed detection. Considering water absorption at telecom wavelength range, a RI sensitivity of 530nm/RIU and a quality factor over 104 are both achieved with an average accompanied crosstalk of -26.12 dB. These features make the designed device a promising element for performing label-free multiplexed detection in monolithic substrate for medical diagnostics and environmental monitoring.

Figure.1. 3D schematic diagram of the integrated PhC biosensor array based on H-1 sandwiched microcavities. The blue holes refer to the sensing filled initially filled with water



Demux sensor.png

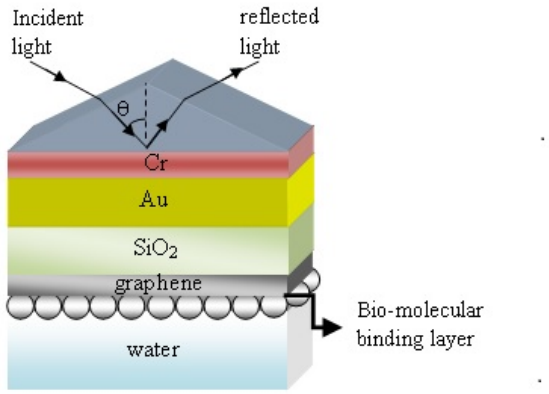
A Graphene based self-referenced Plasmon Waveguide Resonance biosensor for high imaging sensitivity

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 70

Dr. Chikhi Malika [1], ***Prof. Fatima Benkabou*** [1], ***Prof. Habib Hamam*** [2]

1. *Université Djillali LIABES Sidi-Bel-Abbès,Laboratoire d'étude des matériaux et instrumentations optiques,* ***2.*** *Université de Moncton, Campus de Moncton*

By taking advantages of the interesting and distinguished optical and chemical properties of graphene we numerically investigate the effect of a graphene as an additional layer on the top of a Plasmon Waveguide Resonance (PWR) sensor for self-referenced measurements. The figure of merit as well as the field distribution of the proposed self-referenced PWR sensor Cr/Au/SiO2 /graphene are then discussed. Typical applications are then presented.



Pwg.jpg

Density of states in finite graphene superlattices

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 198

Prof. Carlos Duque [1], ***Prof. Melquiades De Dios*** [2]

1. *Universidad de Antioquia,* ***2.*** *Universidad de la Habana*

We have derived a formula for the density of states of a N-period graphene superlattice (SL), which is given as an integral over the inverse of the absolute value of the group delay velocity along the SL-axis. Using that formula, it was shown that density of states exhibits essentially the same structure for all values of N> 5. It was found that for E<0, the effects of finite crystal size modify dramatically the density of states of the corresponding infinite SL, whereas for E>0 and N> 5, it is only slightly modified. According to our results, the inverse of the group delay velocity is proportional to the transmission coefficient, which allows us to establish a certain correlation between the properties of the density of states and those of the Landauer conductance of the N-period SL. Certainly, the Landauer conductance exhibits a peak structure as a function of E, with local dips located at the same energies as those of the density of states. The same behavior was observed for the group delay velocity-dependence of the Landauer conductance with E=0, which is very similar to that of the density of states. When N increases, the peak positions of both the Landauer conductance and the density of states tend to be located at those values of group delay velocity where new Dirac points appear.

TM and TE surface electromagnetic waves in the dielectric – inhomogeneous dielectric structure

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 233

Mr. Ivan Biryukov [1], ***Prof. Igor Bychkov*** [1], ***Dr. Dmitry Kuzmin*** [1], ***Prof. Vladimir Shavrov*** [2]

1. *Chelyabinsk state university,* ***2.*** *Kotel'nikov Institute of Radio-engineering and Electronics of Russian Academy of Sciences*

Dependence of dielectric permeability on coordinates defines existence domain of nonlocal dispersion. At certain values of characteristic scales of spatial inhomogeneity, this domain can be formed in a range of frequencies that are far from natural resonances and absorption bands of material. The use of materials with strong artificial dispersion opens new opportunities for synthesis of optoelectronic and radio systems, development of optimal communication modes and energy transfer through layered medium.

In the present work, we study surface polaritons in structure of the dielectric – inhomogeneous dielectric with dielectric permeability depending on z-coordinate. Inhomogeneity can be created by acoustic wave's propagation in the medium, which results in compression and extension. Frequency of surface polaritons has been considered in infrared and visible spectral regions.

TE- and TM-waves were studied. For TE-wave, which cannot exist in structure of two homogeneous dielectrics, existence condition in inhomogeneous medium was derived. Also, we obtain dispersion equations, distribution of induced magnetic moment (the inverse Faraday effect), energy flux density vector (Poynting vector) and field components of each wave. All calculations were performed analytically and numerically using the methods of classical electrodynamic.

This work was supported in part by RFBR (grants ## 16-37-00023, 16-07-00751, 16-29-14045) and RScF (grant # 14-22-00279).

Microstructure-mediated optical effects in southern African snakes

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 243

Mr. Ishan Singh [1], ***Prof. Graham Alexander*** [1]

1. *University of Witwatersrand*

Optical effects are found to enhance the appearance of various botanical structures, insects, birds, and snakes. These effects are often due to structural colours which result from the manipulation of incident light by micro-structures present on the surface.

The optical effects which result from microstructures on the snake epidermis may offer the animal ecological and physiological benefits. For example, Spinner et al. (2013) showed that Bitis rhinoceros (West African Gaboon Adder) has micro-structures with complex nanoscopic detail on dark scales that produces structural velvet blackness. As a result, black regions have a lower reflectance than pale regions when controlled for pigmentary effects.

Using electron microscopy, we examined two southern African species for microstructure-mediated optical effects. In Bitis arietans (Puff Adder) we found significant differences ($U = 184.00$; $p < 0.0001$) in the height of microstructures between black (40 μm) and pale (17 μm) scale regions, but no differences ($t_{8,0.8} = 0.26$; $p = 0.80$) in the density of microstructures on each region. These results show that the colour of B. arietans scales is primarily a product of optical effects which result from the height of micro-structures. The optical effects likely improve the camouflage of B. arietans on which it relies extensively as an ambush forager.

Hemachatus haemachatus (Rinkhals) bears hierarchically arranged microscopic ridges across its scales in three distinct orders (figure 1): primary (30 um), secondary (5 um), and tertiary (0.4 um). The orders span both the visible and infra-red spectra of the electromagnetic range and may explain the species ability to thermoregulate successfully in even cold climates with a thermal uptake at almost 1 degree Celsius per minute during basking.

This is the first study to report microstructure-mediated optical effects in southern African snakes. Micro-optics may have far-reaching biological significance with respect to animal ecology and physiology. Further, the natural designs of such surfaces provide inspiration for man-made designs in bio-mechanics, hydrophobicity, camouflage, and thermal uptake.

Direct Structuring of multifunctional Zinc Oxide using holography

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 295

Dr. Clotaire Chevalier Cesar [1], ***Dr. Anna Rumyantseva*** [2], ***Ms. Agnieszka Gwiazda*** [2], ***Dr. Komla Nomenyo*** [2], ***Prof. Gilles Lerondel*** [1]

1. *Université de Technologie de Troyes,* ***2.*** *Université de Technologie de Troyes*

Reliable, sustainable and easy to implement large scale patterning techniques are nowadays of great need. Indeed controlling location, size, shape and orientation are key points to achieve desired properties. Few complementary techniques such as electron beam lithography, nano-imprint or laser interference lithography, exist for controlled patterning down to the nanoscale. Full control at the large scale of a multifunctional material like Zinc Oxide (ZnO) is of great interest for the research community, it is considered for many applications due to its unique properties. It is a wide electronic bandgap semiconductor (3.4 eV) [1] which possesses a large exciton binding energy (60 meV) [2] and demonstrates a high optical gain [3]. Hence, ZnO appears as a good candidate for short wavelength optoelectronic devices such as LEDs [4] lasers or photodetectors [5]. His sensitivity to its environment makes ZnO suitable as sensor [6]. Electron beam lithography has shown well controlled structuring properties but is limited regarding to the size of the pattern area and requires huge amount of time to achieve few square millimeters. On the other hand, laser interference lithography needs the deposition of a photoresist mask which is first patterned before the etching of ZnO. In this study we will present a new technique on direct patterning of ZnO using holography [7]. The parametric study of the photodissolution process allowed kinetics to achieve up to 30 nm/sec for 1 cm² patterned area making the technique compatible with large scale and fast direct patterning.

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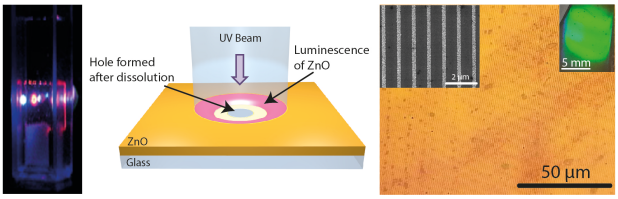

Abstract image.jpg

Synthesis, Characterization and antibacterial activity of nano metal oxide : ZnO and CuO

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 406

Dr. Bouledroua Samia [1], ***Prof. Merah Abdelali*** [2]

1. *Faculté de Médecine. Université Badji-Mokhtar. Annaba.,* ***2.*** *Faculté de Médecine*

Metal oxides nanostructures have shown great potential in biomedical sector due to their tremendous properties at nanoscale; such as optical, catalytical and antibacterial properties. Metal oxides nanomaterials, such as ZnO and CuO have shown significant antibacterial properties. Among these metal oxides nanomaterials, ZnO is special interest due to its established use in healthcare products, UV blocking capability, biocompatibility and modest cost. ZnO is an attractive semiconductor with wide band gap (3.37 eV), large exciton binding energy (60 meV) and high chemical and thermal stability. Recent studies demonstrate that ZnO nanostructures can effectively be used both against Gram-positive and Gram negative bacteria .Copper oxide (CuO) nanoparticles have attracted huge attention due to catalytic, electric, optical, photonic, textile, nanofluid, and antibacterial activity The nanoparticles of metal oxides (ZnO,CuO) Were prepared by the sol-gel method using zinc acetate (Merck) Oxalic acid (Fluka) copper nitrate (Chemopharma) and Citric acid (Fluka) as starting materials the synthesized sample was calcined at temperature of 600°.

The samples were characterized by X ray diffraction (DRX), Fourier transform infrared spectroscopy (FTIR) and UV-visible spectroscopy .The average crystallite sizes of the samples were calculated from the full width at half maximum of XRD peaks by using the Scherer's formula equation .

Antimicrobial activities of the synthesized metal oxide nanoparticles were performed against both gram-negative bacteria (Escherichia coli, Shigella, Klepsiella pneumoniae and Pseudomonas aeruginosa) and Gram-positive bacteria (Staphylococcus aureus, Staphylococcus hominis, Staphylococcus haemolyticus, Enterococcus feacalis) the antibacterial activity of ZnO and CuO nanoparticles was tested by the disk diffusion method. The presence of an inhibition zone clearly indicated the antibacterial effect of ZnO and CuO nanoparticles

Nanoparticles of metal oxides ZnO and CuO show a bactericidal effect on both gram-positive strains as Gram-negative strains. The bactericidal effect seems to extend also on strains of Pseudomonas aeuroginosa and Staphylococcus aureus particularly known for their multidrug resistance. This effect is more pronounced in nanoparticle zinc oxide. The nanoparticle zinc oxide has an antibacterial effect more pronounced against Gram-positive strains while copper oxide shows greater effectiveness against Gram-negative strains.

Plasmonic metasurfaces modeled for phase control of electromagnetic radiation

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 64

Dr. Roxana Tomescu [1], ***Dr. Cristian Kusko*** [2]

1. *National Research and Developement Institute in Microtechnology - IMT Bucharest,* ***2.*** *National Research and Developement Institute in Microtechnology*

Plasmonic structures are an advantageous alternative to photonic structures due to their capabilities to operate at dimensions bellow the diffractive limit and strong radiation confinement. Moreover, plasmonic metasurface are the perfect option for beam shaping at nanoscale and are presently used for flat optical components [1,2], biosensors [3], solar cells and photodetectors [4,5]. This type of structures are composed of an array of metallic nano-antennas patterned on a dielectric substrate [6] and offers the possibility of beam shaping due to the plasmonic nano-antennas exceptional advantages to sustain magnetic and electric resonances [7].
We present a method for modeling the plasmonic metasurfaces to obtain a phase shift of electromagnetic radiation that propagates through a plasmonic metasurface from 0 to π rad or 2π rad. Therefore, by dividing the nano-antennas that form the array in tow periodic successions of a various number of elements with different sizes we can achieve the desired results. Furthermore, the phase manipulation can be achieved also by modeling the configuration of the nano-antennas on the selected substrate. Due to the importance of a proper defined geometry for the metallic (gold) structures in this type of study, we present an ample 3D numerical investigation using finite differential time domain (FDTD) method of both cylindrical and rectangular resonators patterned on glass or silicon. Fig.1 presents the phase behavior when the electromagnetic radiation propagates through described plasmonic metasurface.
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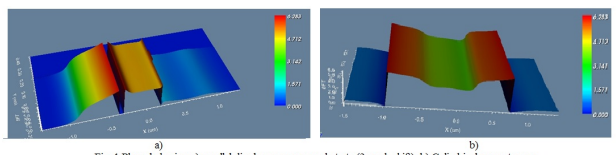

Fig. 1 Phase behavior: a) parallel dipoles on opaque substrate (2π rad. shift); b) Cylindrical resonators on transparent substrate (π rad. shift).

Fig 1.jpg

FLOWS IN COMPOSITE LIQUID CRYTAL MATERIALS: NEW APPROACH FOR THZ APPLICATIONS

Friday, 9th December - 13:30 - Poster Session - Tippie - Poster presentation - Abstract ID: 421

Dr. Dina Shmeliova [1], ***Prof. Sergey Pasechnik*** [1], ***Ms. Olga Semina*** [1], ***Mr. Arseniy Girgidov*** [1]

1. *Moscow Technological University*

THz waves are of a wide usage in different modern applications like biomedicine telecommunications and security. The further progress in an elaboration of corresponding technical devices can be achieved due to usage of the units, like shutters, phase retarders, beam splitters, with tunable parameters. Liquid crystals are considered now as suitable materials for elaboration of such devices. Nevertheless, some new problems like low operating speed in relatively thick (about 1 mm) and restrictions in usage of an electric control due to high losses in electrodes have to be solved in this case.

In this report we propose the new approach to an elaboration of liquid crystals (LC) tuned THz devices, based on usage of shear flows. Flows are considered as more universal tool of LC orientation, which can be effective for both thin and thick samples. We consider the possibility of flow induced changes of optical properties for two types of composite LC materials: layered structures and porous polymer films filled with liquid crystals. The results of combined action of flows and magnetic (electric) fields are analyzed from the point of view of perspectives for THz applications. The special attention is paid on the electro-osmotic flows of liquid crystals throw the porous membranes, which can be effectively used in THz units of different types.

This work was supported by the Ministry of Education and Science of the Russian Federation [project no. 14.583.21.0058]

Carbon nanotubes for hybrid silicon photonics

Friday, 9th December - 14:30 - Advanced integrated optics - Tower 24 - Room 101 - Oral presentation - Abstract ID: 407

Ms. Elena Durán-valdeiglesias [1], ***Mr. Weiwei Zhang*** [1], ***Dr. Carlos Ramos*** [1], ***Ms. Thi Hong Cam Hoang*** [1], ***Mr. Samuel Felipe SERNA OTALVARO*** [1], ***Dr. Francesco Sarti*** [2], ***Dr. Francesco Biccari*** [2], ***Dr. Niccolò Caselli*** [2], ***Prof. Anna Vinattieri*** [2], ***Mr. Xavier Le Roux*** [1], ***Dr. Matteo Balestrieri*** [3], ***Dr. Al-saleh Keita*** [4], ***Dr. Hongliu Yang*** [5], ***Prof. Eric Cassan*** [1], ***Prof. Delphine Marris-Morini*** [1], ***Prof. Arianna Filoramo*** [3], ***Dr. Viktor Bezugly*** [5], ***Prof. Massimo Gurioli*** [2], ***Prof. Laurent Vivien*** [1]

1. *Université Paris Sud / C2N,* ***2.*** *University of Florence,* ***3.*** *CEA Saclay, IRAMIS, NIMBE (UMR 3685),* ***4.*** *CEA Saclay, IRAMIS, NIMBE (UMR 3685),,* ***5.*** *Technische Universität Dresden*

Demanding applications such as video streaming, social networking, or web search relay on a large network of data centres, interconnected through optical links. The ever-growing data rates and power consumption inside these data centres are pushing copper links close to their fundamental limits. Optical interconnects are being extensively investigated, aiming to solve these limitations. Silicon photonics, due to its compatibility with the Si platform, has become one of the preferred solutions for the development of the future generation photonic interconnects. However, the current strategy for on-chip integration of all photonic and optoelectronic building blocks (sources, modulators and detectors…) relies on very different materials. For instance, Ge for detection, doped Si for modulators and III-V for lasing. This multi-material approach results in a complex fabrication process that offsets the cost-effectiveness of using silicon photonics.

Carbon nanotubes (CNTs) are being considered for the realization of next generation nanoelectronic systems, due to their exceptional transport capabilities, chemical stability and potential CMOS compatibility. On the other hand, CNTs are nanomaterials that exhibit very interesting properties for the photonics field. Specifically, they show strong room-temperature photo-luminescence and electro- luminescence in the near-infrared wavelength range, Stark effect, Kerr effect and absorption. Hence, they are considered a particularly promising alternative solution for the implementation of optoelectronic functionalities in silicon photonics, including light generation, modulation and detection.

Here, we report on the development of new integration schemes to couple the light emission from CNTs into optical resonators implemented on the silicon-on-insulator platforms. We obviated unwanted absorption effects resulting in a substantial improvement of the resonant light enhancement. We have optimized and experimentally validated different resonant structures, including ring resonators, microdisks, 1D photonic crystal cavities and 2D slot photonic crystal cavities as an effective means of on-chip resonant enhancement of CNTs emission. At the same time, this integration approach allowed coupling the generated photoluminescence from CNTs to integrated Si photonic waveguides with enhanced signal to noise ratios.

Magneto-optical isolator for silicon photonics

Friday, 9th December - 14:47 - Advanced integrated optics - Tower 24 - Room 101 - Oral presentation - Abstract ID: 383

Prof. Tetsuya Mizumoto [1], ***Prof. Yuya Shoji*** [1]

1. *Tokyo Institute of Technology*

An optical isolator is one of developing devices in silicon photonic integrated circuits. The magneto-optical polarization rotation, which is used in conventional isolators and circulators, cannot be applied in Silicon-On-Insulator (SOI) waveguide platforms because of the phase matching issue between TE and TM modes. We have realized isolators in SOI Mach-Zehnder interferometer (MZI) waveguides based on the magneto-optical phase shift as shown in the figure. The magneto-optical phase shifters are installed in the MZI waveguide arms where a magneto-optical garnet (CeY)3Fe5O12 (Ce:YIG) is directly bonded on a silicon waveguide by using a surface activated bonding technique. A magnetostatic field is applied transverse to the light propagation direction in the film plane of Ce:YIG to saturate its magnetization. The first-order magneto-optical effect gives a different propagation constant for TM modes propagating in the waveguide depending on the propagation direction as well as the direction of the applied magnetostatic field. The phase difference is provided between two arms due to anti-parallel magnetostatic fields, which is set to be -90 and +90 deg in the forward and backward propagation, respectively. The magneto-optical phase difference is cancelled by the 90 deg phase bias installed in one of the arms in the forward propagation, whereas 180 deg phase difference is introduced in the backward propagation. Hence, constructive and destructive interferences occur in the forward and backward propagations, respectively, which result in the transmission and isolation in respective directions. A magneto-optical phase shift of 3.65 mm-1 is generated in a 450-nm-wide and 220-nm-thick SOI waveguide at a wavelength of 1550 nm using a saturation Faraday rotation of -4500 deg/cm for Ce:YIG. By virtue of the direct bonding technique, we can make full use of the large Faraday rotation of single-crystalline Ce:YIG. A maximum optical isolation of 30 dB is demonstrated together with a bandwidth of 8 nm for >20 dB isolation in a 1550 nm wavelength range. Also, a temperature insensitive isolation has been demonstrated in a temperature range of 20-60 degC by properly adjusting a phase bias. Reducing an insertion loss of 13 dB is under investigation.

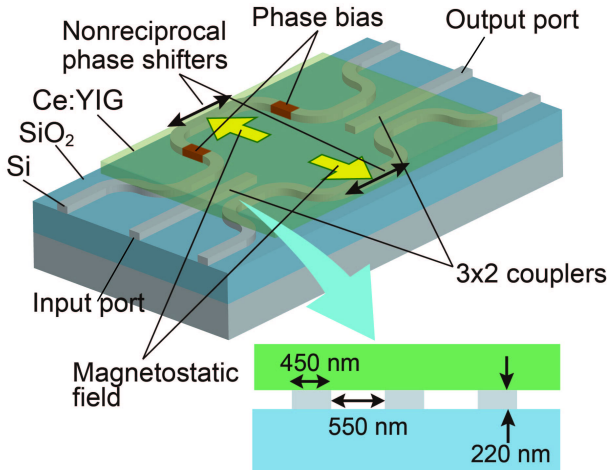
Nonreciprocal
phase shifters
Phase bias
Output port
Ce:YIG
SiO2
Si
3x2 couplers
Input port
Magnetostatic
field
450 nm
550 nm
220 nm

Figure.jpg

Fully integrated quantum photonic circuit with an electrically driven light source based on carbon nanotubes

Friday, 9th December - 15:04 - Advanced integrated optics - Tower 24 - Room 101 - Oral presentation - Abstract ID: 265

Dr. Svetlana Khasminskaya [1], ***Mr. Felix Pyatkov*** [1], ***Dr. Karolina Słowik*** [2], ***Mr. Simone Ferrari*** [3], ***Dr. Oliver Kahl*** [1], ***Mr. Vadim Kovalyuk*** [4], ***Dr. Patrik Rath*** [1], ***Mr. Andreas Vetter*** [1], ***Dr. Frank Hennrich*** [1], ***Prof. Manfred Kappes*** [1], ***Prof. Gregory Gol'tsman*** [4], ***Dr. Aleksander Korneev*** [4], ***Prof. Carsten Rockstuhl*** [1], ***Prof. Ralph Krupke*** [1], ***Prof. Wolfram Pernice*** [3]

1. *Karlsruhe Institute of Technology,* ***2.*** *Nicolaus Copernicus University,* ***3.*** *University of Münster,* ***4.*** *Moscow State Pedagogical University*

The scalable integration of single photon sources, detectors and linear optical elements in a common platform is essential for many applications in quantum cryptography, simulation, and computation. Nanophotonic circuits combined with on-chip superconducting nanowire provide a suitable solution for the detection side. Integratable and reproducible single photon emitters, however, still have to be developed. Optically excited semiconducting carbon nanotubes (CNTs) can serve as quantum emitters operating in the telecommunication wavelength range. As recently reported, dielectrophoretically deposited CNTs can also be used as waveguide-integrated electrically driven light sources [1] with narrow-line emission profile [2]. The optical properties of such emitters were tuned by pre-sorting of CNT suspensions before the deposition and can be additionally narrowed by photonic circuit design [2]. Here we show that CNTs can act as electroluminescent non-classical emitters [3]. The nanophotonic device (Fig.1) consists of CNT-based emitter in the center (E) and two equidistant detectors (D), embedded within the same photonic integrated circuit. The electrically generated light efficiently couples into and propagates inside the waveguides, and is recorded with integrated traveling-wave single photon detectors (D) at cryogenic conditions. Correlation function recorded in Hanbary-Brown and Twiss-like configuration demonstrates pronounced antibunching (Fig.2), which is a clear signature of non-classical nature of light. Therefore, we realized a fully integrated photonic quantum circuit with purely electrical drive and semiconducting CNT as non-classical source.

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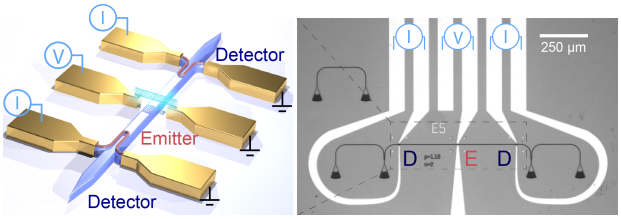


Fig1 waveguide-integrated carbon nanotube source and detectors.png

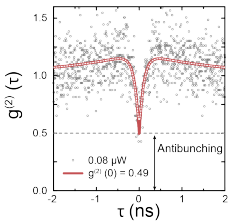


Fig2 second-order correlation function of emitted light.png

Bragg grating filter for hybrid near- and mid-infrared silicon membrane waveguides

Friday, 9th December - 15:21 - Advanced integrated optics - Tower 24 - Room 101 - Oral presentation - Abstract ID: 405

Dr. Carlos Ramos [1], ***Mr. Xavier Le Roux*** [1], ***Mr. Vladyslav Vakarin*** [1], ***Ms. Elena Durán-valdeiglesias*** [1], ***Dr. Diego Pérez-galacho*** [1], ***Prof. Eric Cassan*** [1], ***Prof. Delphine Marris-Morini*** [1], ***Prof. Pavel Cheben*** [2], ***Prof. Laurent Vivien*** [1]

1. *Université Paris Sud / C2N,* ***2.*** *National Research Council, Ottawa, K1A 0R6, Canada*

The mid-infrared (MIR) wavelength range contains the vibrational and rotational resonances of a wide number of chemical and biological substances. This enabled absorption spectrometers operating in the MIR to achieve outstanding specificity and sensitivity. The unique versatility and precision of MIR absorption spectrometers makes them an ideal solution for applications aiming multi-target detection in complex mixtures, such as non-invasive medical diagnostics, food quality control and air pollution monitoring. Unfortunately, the cost and complexity of current bulky implementations limit their use to laboratory environments. The large transparency window of silicon, covering the 1.1 - 8 μm wavelength range, makes it a promising material for the implementation of on-chip MIR photonic circuits with the potential for large-volume and low-cost production. Furthermore, such platform would open new opportunities for the realization of ultra-wideband photonic circuits that combine the near-infrared (NIR) and MIR wavelength ranges. However, the implementation of the silicon-on-insulator (SOI) platform in MIR is restricted by the absorption of buried oxide layer for wavelengths above 4 μm. A promising solution is to locally remove the buried oxide layer to form silicon membrane waveguides that can cover the full transparency window of silicon, yet benefiting from the high quality materials and mature silicon fabrication processes. Still, implementing Si membrane waveguides that exhibit single-mode operation at both NIR and MIR wavelengths is a challenge. Due to the high index contrast between Si and air cladding, conventional strip waveguides with cross-sections large enough to guide a MIR mode are multi-mode in the NIR range. Here we present, for the first time, an integrated Bragg grating waveguide filter for hybrid NIR and MIR operation. A waveguide cross- section of 0.5 μm by 1.1 μm allows single-mode propagation in the MIR, while an original waveguide corrugation approach is used to radiate out the higher order modes in the NIR infrared, yielding effective single-mode NIR operation. Exploiting this concept, we demonstrate a waveguide Bragg grating filter implemented on a single-etch suspended silicon waveguide, yielding a 4 nm wide and 40 dB deep spectral notch.

Circularly Polarized Light-Induced Homeotropic Alignment in Azo Dye Doped PMMA Polymer films

Friday, 9th December - 14:30 - Optical properties of nanostructures - Tower 24 - Room 103 - Oral presentation - Abstract ID: 13

Prof. Bendaoud SAAD [1], ***Dr. Marc-Antoine BLANCHET*** [2]

1. *National School of Applied Sciences of Safi (ENSA de Safi), Cadi Ayyad University,* ***2.*** *EXFO Inc. Québec*

Azobenzene-containing polymers have attracted much attention for the fabrication of submicrometer structures for Optical Data Storage, All-Optical Switching and nanotechnologies. The basic mechanism involves the reversible trans-cis photoisomerization reaction which can be interconvert by light and heat. Various azobenzenes have been used as dopants with transparent polymers to form guest-host films and change polymer's properties. In this communication, we present results concerning the photoinduced anisotropy of refractive index changes into initially random AZD1/PMMA guest-host films excited by linearly and circularly polarized pump beams at normal incidence. The absorption spectrum of this guest host system are depicted in Figure 1. Molecular orientation and subsequent photoinduced birefringence in azobenzene doped polymer films were investigated by pumping beams with various intensities and polarization states. A green Argon ion laser pump beam (λ=514,5 nm) at normal incidence with the light intensity and polarization as the control parameter to exposure and an He-Ne laser probe polarized beam (λ=632,8 nm) was used. The mechanism of the energy absorbed by azo-dye molecules for isomerization is known as angular hole burning. Changes in the parallel and vertical polarization components due to the photoinduced birefringence were measured simultaneously during pumping with a linearly an circularly polarized beam at 514,5 nm. To our knowledge, this is the first study of measuring the dynamic process of the refractive index dependence on circularly polarization pump. Dynamic reversible anisotropy of the exposure relaxation cycle in these azo-dye-doped polymer materials was observed (figure 2). The results recorded demonstrate that molecular orientation and anisotropy of refractive index depends on circular polarization of the probe beam. Furthermore, we showed that the direction of azo-dye molecules can be optically controlled from a plane to a line distribution along the wave vector of the pump beam. This work open a new way to azo-isomerization orientational alignment control and change in anisotropic refractive index of guest-host film of doped polymer matrix. The remaining challenge is to find good explanations to these dynamic changes in proprieties of these azopolymer films in function of polarization of the pump beam and prefereniel directional alignement subsequent to the reorientetional hole burning process.

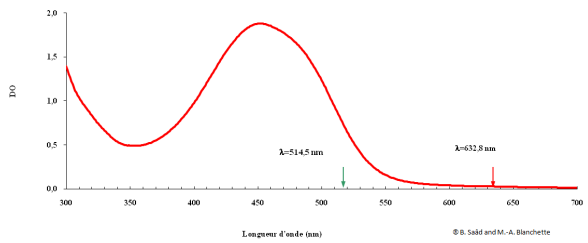


Fig1.png

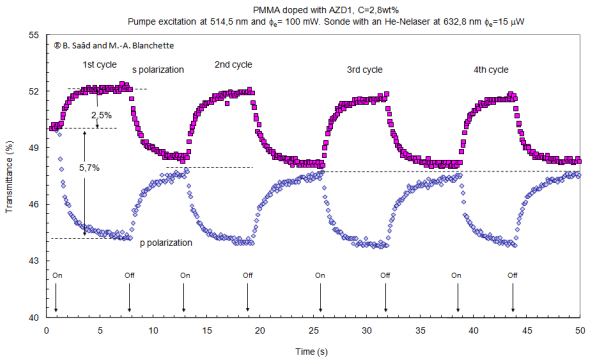


Fig2.png

New materials for Erbium Doped Fiber Amplifiers based on zirconia coated gold nanoparticles

Friday, 9th December - 14:47 - Optical properties of nanostructures - Tower 24 - Room 103 - Oral presentation - Abstract ID: 219

Dr. Monika Bouet [1], ***Ms. Mathilde Bruge*** [1], ***Mrs. Aurélie Demol*** [1], ***Dr. Odile Cristini Robbe*** [1], ***Dr. Laurent Bigot*** [2], ***Dr. Rémy Bernard*** [2]

1. *IRCICA, CNRS (USR 3380), Université Lille 1,* ***2.*** *Laboratoire PhLAM, CNRS UMR 8523, Université Lille 1*

Since the beginning of XXI century, the optical fiber became the most applied implement in the domain of information transfer. Erbium Doped Fiber Amplifiers (EDFA) are devices augmenting optical signal directly, without a need to transform it to electrical signal. They made a breakthrough in the telecommunication field in the 90th, therefore it exist a great need for new materials which should fulfilled many requirements for this technology (size minimization, the performance and the gain of signal).

The aim of our project is to create a new silica-containing porous material (a preform for optical fiber) with the organometallic erbium systems as an original EDFA. The novelty of our approach is an application of gold nanoparticles as a support for Er complexes, which should induce the exacerbation of lanthanide signal and increase optical proprieties of this material.

We have synthesized a series of organometallic bifunctional compounds which show simultaneously the affinity to gold nanopraticles (thiol group) and lanthanide chelator (DTPA or cyclen system). These compounds were introduced to the gold NP sample dispersed in ZrO2 by the mean of sol/gel method. An application of zirconia matrix permits to maintain the nanoparticle's size at elevated temperature required for the preform fabrication.[1] Spectroscopic properties of new materials revealed the intense signal at the telecommunication C-band (1.5 μm). We perform now the introduction of these systems to the porous silica by the sol/gel method and MCVD in order to obtain the preform.

The preliminary studies show encouraging results at the characterization stage: all materials give intense emission signal at 1530 nm after pumping at 980 nm regions. We managed to form first silica aerogel and xerogel samples, doped with gold NP covered by Er complexes and they revealed the same spectroscopic properties as the starting NP's model. The next step of our project is to introduce our systems to preform and manufacture Au/Er containing optical fiber amplifier.

Ref.:

[1] A. Pastre, O. Christini-Robbe, L. Bois, D. Branzea, A. Boé, C. Kinowski, K. Raulin, A. Rolland, R. Bernanrd, Matr. Res. Express, 2016, 3, 015002

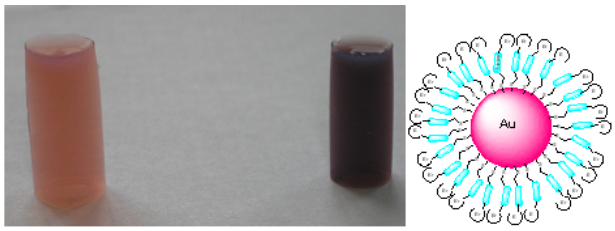


Image abstract nanop2016.png

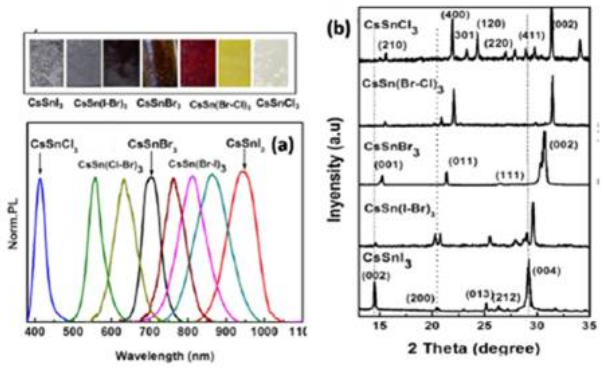
Composition Dependent Optical Properties of Cesium Tin Halide Perovskites

Friday, 9th December - 15:04 - Optical properties of nanostructures - Tower 24 - Room 103 - Oral presentation - Abstract ID: 133

Ms. Lekha Peedikkakandy [1], *Prof. Parag Bhargava* [1]

1. Indian Institute of Technology Bombay

Inorganic perovskites of the composition ABX3 (eg: CsSnX3, CsPbX3) exhibits structure dependent optical and electronic properties. There are few reports available on cesium tin halide (CsSnI3, CsSnBr3 and CsSnCl3) perovskites. These perovskites show structure dependent band gap and electrical properties. In this study, we reports the structural and optical properties of varying compositions of lead free inorganic perovskite CsSnX3. Different compositions of CsSnX3 were prepared using room-temperature solution route method under inert atmosphere. Optical band gap studies for different anion compositions show a significant (53.5%) blue shift in the absorption spectra as the composition is varied from I to Br and Cl. As the halide composition was varied from I to Cl, an intense and tunable PL emission was observed at room temperature covering a wide range from near IR to Vis region (950–420 nm). Structure variation with anion substitution was studied using X-ray diffraction, structure for different compositions were found to change from orthorhombic for CsSnI3, cubic for CsSnBr3 and monoclinic for CsSnCl3 at room temperature. Further, nanoparticles of CsSnX3 were synthesized and the quantum confinement effects studied. It was observed that nanoparticles of CsSnI3 shows size tunable PL emission. The effect of cation substitution was also investigated, a less prominent shift was observed in the optical band gap by replacing Sn (II) cation with Pb (II) (0.7eV). With its excellent composition and size dependent optical properties, tin halide perovskites are an extremely promising material which can be used either as lead free perovskites or with reduced lead content for application in opto-electronic devices.
Attached figure shows: (a) Photoluminescence spectra and (b) XRD pattern for different compositions of CsSnX3
.



Picture1.jpg

Plasmon-mediated chemical surface functionalization at the nanosocale

Friday, 9th December - 15:21 - Optical properties of nanostructures - Tower 24 - Room 103 - Oral presentation - Abstract ID: 266

Prof. Nordin Felidj [1], ***Dr. Mai Ngueyn*** [1], ***Dr. Leïla Boubekeur Lecaque*** [1], ***Mrs. Stéphanie Lau Truong*** [1], ***Dr. Georges Lévi*** [1], ***Prof. Jean Aubard*** [1], ***Dr. Johan Grand*** [1], ***Prof. Claire Mangeney*** [1]

1. *University Paris Diderot*

We performed a selective chemical surface functionalization at the nanoscale mediated by localized surface plasmon (LSP) excitation. The surface functionalization is demonstrated through aryl film grafting (derived from a diazonium salt), covalently bound at the surface of gold lithographic nanoparticles (Fig. 1). The aryl film is specifically grafted in areas of maximum near field enhancement, as confirmed by numerical calculation based on the discrete dipole approximation method - DDA (Fig. 2). This selective grafting is attributed to hot electrons generation, which escape from the plasmonic structures and reduce the diazonium salts forming aryl radicals which attach the surface through covalent bonds. Moreover, we show that the aryl film thickness can be monitored by the energy of the incident light as well as the LSP wavelength.

This robust and versatile strategy of nanoscale surface functionalization opens us the route to a controlled growth of additional species such as polymer brushes or quantum dots with high lateral resolution, which is particularly interesting in the context of molecular sensing or nanoscale color-coded devices.

Keywords: plasmonics, surface chemical functionalization, diazonium salt, lithographic structures

References:

1- M. Nguyen, A. Lamouri,C. Salameh, G. Lévi, J. Grand, L. Boubekeur-Lecaque, C. Mangeney and N.Félidj, Nanoscale, 2016,8, 8633-8640.

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3- M. Nguyen, X. Sun, E. Lacaze, P. M. Winkler, A. Hohenau, J. R. Krenn, C. Bourdillon, A. Lamouri, J. Grand, G. Lévi, L. Boubekeur-Lecaque, C. Mangeney, N. Félidj, ACS Photonics, 2015, 2, 1199–1208.

Figure 1 : Differential AFM image of a gold lithographic nano-disc, after plasmon induced grating of an aryl film. The grafting is exclusively located at areas of maximum field enhancement, confirmed by DDA simulations.

Figure 2: Mapping of the electric field on a gold disc, calculated by the DDA method.

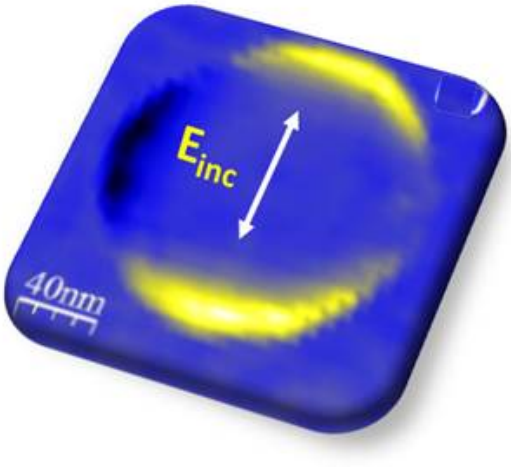

Fig1.jpg

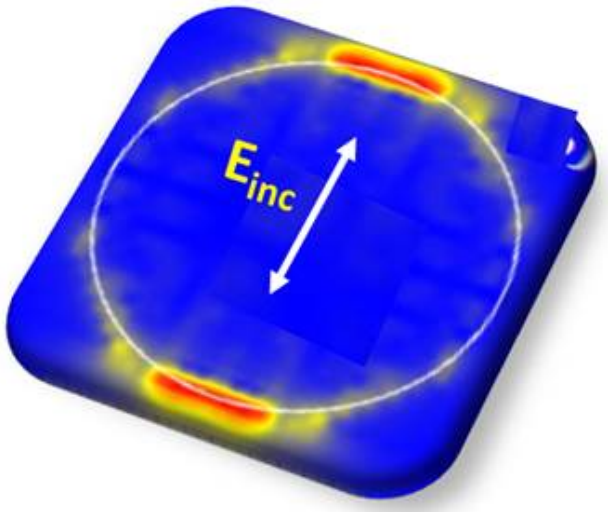

Fig2.jpg

INVITED TALK -> Chiral optical Local Density of States in a spiral plasmonic cavity

Friday, 9th December - 15:38 - Optical properties of nanostructures - Tower 24 - Room 103 - Oral presentation - Abstract ID: 196

Mrs. Aline Pham [1], ***Dr. Martin Berthel*** [1], ***Mr. Quanbo Jiang*** [1], ***Dr. Joel Bellessa*** [2], ***Dr. Serge Huant*** [1], ***Dr. Cyriaque Genet*** [3], ***Dr. Aurélien Drezet*** [1]

1. *Université Grenoble Alpes, CNRS, Institut Néel,* ***2.*** *Institut Lumière Matière CNRS-Université Lyon1,* ***3.*** *Université de Strasbourg, CNRS, Institut de Science et d'Ingénierie Supramoléculaires*

Chiral metallic nanostructures generate great interests in the study and manipulation of light-matter interactions at the nano-scale. In particular, spiral plasmonic systems have received considerable attention owing to their potential for controlling emission properties as well as for their capability to generate surface plasmons (SPs) vortices with tailored orbital angular momentum. They are expected to open new possibilities in applications ranging from biochemistry to quantum information processing. Therefore, a full characterization of system's photonic properties, provided by the optical local density of states (LDOS), is thus required. In this work, we report the observation of chiral optical LDOS in a spiral plasmonic nanostructure, in both classical and quantum regime. We demonstrate using scanning near-field optical microscopy (NSOM) in combination with spin analysis that a spiral cavity possesses spin-dependent local optical modes and features optical spin Hall effects as well as orbital angular momentum selection rule. To achieve this investigation in the classical and quantum regimen both aperture NSOM tip and quantum source based probe are considered. The later consists of a few nitrogen vacancy centers hosted in a diamond nanocrystral that is grafted at the apex of the near field probe following a method developed in our group. The orientation of the SPs dipoles induced by these probes will be discussed and characterized by leakage radiation microscopy. In addition, our theoretical model analytically describes the photonic partial LDOS maps in terms of Bessel functions whose order can be directly related to the spin and the geometrical charge of the spiral. We expect our method to bring an important contribution in future characterization and design optimization of plasmonic chiral systems.

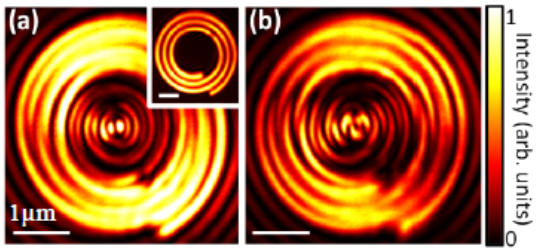

Fig. Optical LDOS maps of a spiral plasmonic cavity (inset) analyzed in the right (a) and left (b) circular polarization

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Enhancement and control of the spontaneous emission of nanoemitters in an integrated plasmonic structure on silicon

Friday, 9th December - 16:30 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 87

Ms. Avril Alicia Meza Olivo [1], ***Dr. Karina Garay Palmett*** [2], ***Dr. Rafael Salas Montiel*** [3], ***Dr. Sylvain Blaize*** [3]

1. *UTT Troyes, France / CICESE, Ensenada, México.*, ***2.*** *Centro de Investigación Científica y de Educación Superior de Ensenada, CICESE,* ***3.*** *Université de Technologie de Troyes*

Single-photon sources are essential for implementing emerging quantum technologies, focused mainly on optical-quantum information processing. One of the most straightforward methods to develop non-classical light sources, generating individual photons, is the use of individual quantum emitters.

Progress in the development of efficient single-photon sources based on quantum emitters, requires the enhancement and the effective collection of the radiation emitted by quantum emitters. Dielectric photonic structures such as waveguides or photonic crystals provide a way to enhance the emission rate as the optical modes supported by such structures present strong electric fields and low mode volumes. Metallic plasmonic waveguides supporting surface plasmon-polariton (SPP) modes provide another effective route to reduce by an order of magnitude the effective mode volume and therefore, increase the emission rate of quantum emitters.

As demonstrated in [1], an extremely low effective plasmonic mode volume was measured in a plasmonic structure integrated on a silicon photonic waveguide. This work shows that indeed, the effective volume of SPP modes is well below to that of light in free-space.

The objective of this project is to explore the configurations for an efficient coupling between quantum emitters and plasmonic modes supported by integrated plasmonic structure in order to implement highly efficient single-photon sources.

An original aspect of the research is the methodology of characterization, based on the near-field scanning optical microscopy (NSOM), which enables imaging of the light propagation along the fabricated structures. This technique allows for direct and precise measurements on the coupling mechanisms with a subwavelength spatial resolution. Additionally, photon statistics measurements involving single and coincidence detection will be carried out.

Acknowledgments: To CONACYT (scholarship No. 233924) for financial support.

[1] Luo, et. al., Nano Letters, 15(2), 849-56 (2015).

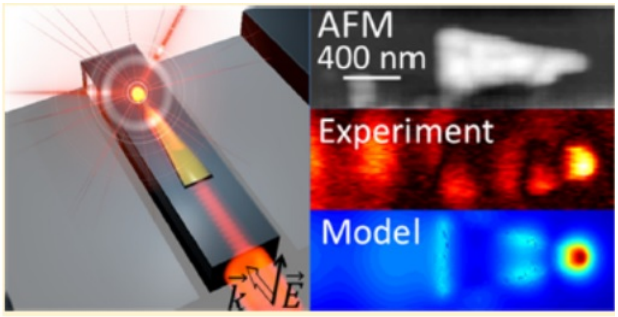

Figure 1. Schematic illustration of the hybrid nanotapered Plasmonic Light Concentrator (PLC) integrated on silicon ridge waveguide. The hybrid PLC consists of a gold isosceles triangle of 300 nm base width and 750 nm length placed on top of a 500 nm by 220 nm Si waveguide with a 20 nm thick SiO2 buffer layer. The PLC tip has radius of curvature of 20–30 nm. The fundamental TM-like mode of the Si waveguide is gradually coupled to the plasmonic modes of the PLC, which are then focused at the tip of the triangular nanotaper. Now we are using this hybrid (photonic/plasmonic) nanostructure for coupling PbS quantum dots at the tip of the gold triangle in order to achieve highly efficient production of single photons.

Paris2016.jpg

Plasmonics of Au nano-objects by photoemission electron microscopy - A polarization study.

Friday, 9th December - 16:47 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 264

Ms. Sarra Mitiche [1], ***Dr. Sylvie Marguet*** [2], ***Dr. Fabrice Charra*** [1], ***Dr. Ludovic Douillard*** [1]

1. SPEC, CEA Saclay, CNRS, University Paris-Saclay, 2. NIMBE, CEA Saclay, CNRS, University Paris-Saclay

Localised surface plasmon resonances (LSPRs) are coherent and collective oscillations of the delocalised electrons in metallic nanoparticles (NPs) under light excitation. These resonances depend on the environment, NP and illumination parameters. Here we investigate experimentally and theoretically the light polarisation effect on the low order LSPRs of Au nano- cubes and prisms.

The plasmonic response of Au nano-objects of subwavelength sizes are investigated by photoemission electron microscopy (PEEM). The LSPRs are excited by a femtosecond pulsed laser source operating in the visible and near IR wavelength ranges. The polarisation is adjusted with a half-wave plate. The experimental results are predicted and interpreted within a group theory approach. Further theoretical support is obtained by boundary element method (BEM) numerical simulations.

To illustrate our investigation, figures (a) and (b) display the experimental and numerical dipolar signatures of a subwavelength sized nanocube under grazing incidence in p polarisation. These results show a good agreement between experiment and group theory. Taking into account the object symmetry, the near-field distribution can be interpreted as a combination of two dipolar modes, one excited by an electric field component normal to the cube upper face and a second one excited by the in-plane electric field component parallel to the same face (figure (c)). Any change in the light polarisation modifies the near-field optic distribution, so we can selectively address NP plasmon modes by changing the polarisation of the incident light.

To sum up, the plasmonic response of nano-objects depends strongly to the polarisation of the incident light and the object symmetry. Near field distribution of NPs of subwavelength size can be predicted within a group theory approach. This approach can be generalized to other objects of finite dimensions (prisms, hexagons...).

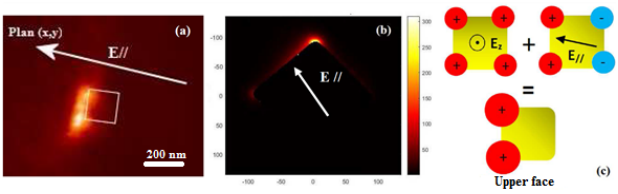

Figure.png

Isotropic Optical Magnetism in Visible Light in a Self-Assembled Bulk Metamaterial

Friday, 9th December - 17:04 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 68

Dr. Philippe Barois [1], ***Dr. Sergio Gomez-grana*** [1], ***Dr. Mona Treguer-Delapierre*** [1], ***Dr. Stéphane Mornet*** [1], ***Prof. Etienne Duguet*** [1], ***Dr. Jacques Leng*** [2], ***Dr. Jean-baptiste Salmon*** [2], ***Dr. Vasyl Kravets*** [3], ***Prof. Alexander Grigorenko*** [3], ***Mr. Naga Anirudh Peyyety*** [1], ***Dr. Virginie Ponsinet*** [1], ***Dr. Philippe Richetti*** [1], ***Dr. Alexandre Baron*** [1], ***Dr. Daniel Torrent*** [1]

1. *CNRS-Université de Bordeaux,* ***2.*** *CNRS-Université de Bordeaux-Solvay,* ***3.*** *University of Manchester*

The magnetic susceptibility of natural materials is known to be negligible in visible light, so that the generation of optical magnetism has been intensively searched in artificial nanocomposites, generally designed so as to develop loops of intense induced currents upon illumination by a light wave. Such artificial magnetism is a non local phenomenon, formally equivalent to the spatial dispersion of the dielectric permittivity. It is in general not reducible to a rank 2 tensor mu(i,j) so that the familiar notion of a bulk magnetic permeability loses a large part of its meaning, hence precluding the achievement in visible light of the extraordinary properties expected from metamaterials. Here we report on the first experimental realization of a three-dimensional isotropic metamaterial exhibiting strong artificial magnetism that satisfies the principle of effective locality across a wide range of visible wavelengths. We have used colloidal self-assembly to create artificial "nanomolecules" that generate the desired magnetic response and microfluidic self-assembly to produce a bulk metastructure. The magnetic response of the "nanomolecules" and of the bulk material are unambiguously measured by polarized light scattering and spectroscopic ellipsometry respectively. Numerical simulations confirm the experimental data. A large-scale fabrication of such magnetic metamaterials of arbitrary size and shape is made possible by our bottom-up approach that restores the hope of extending the physics of metamaterials to visible light frequencies.

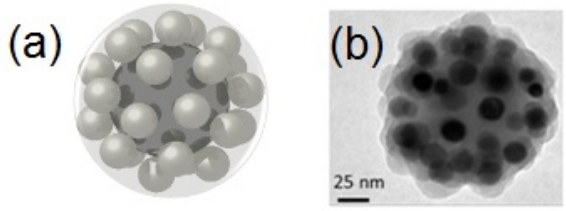

Figure:
(a) Plasmonic "raspberry" model of a magnetic nano-cluster made of siilver satellites evenly distributed around a silica core (Simovski-Tretyakov, 2009)
(b) Transmission Electron Microscopy micrograph of a real magnetic nanocluster

Figure.jpg

INVITED TALK -> Second harmonic generation in monolithic AlGaAs nanoantennas

Friday, 9th December - 17:21 - Photonic & plasmonic nanomaterials - Tower 24 - Room 101 - Oral presentation - Abstract ID: 158

Mr. Valerio Flavio Gili [1], ***Dr. Luca Carletti*** [2], ***Mr. Davide Rocco*** [2], ***Dr. Andrea Locatelli*** [2], ***Dr. Marco Ravaro*** [1], ***Dr. Ivan Favero*** [1], ***Dr. Aristide Lemaitre*** [3], ***Ms. Lavinia Gherardini*** [4], ***Prof. Marco Finazzi*** [4], ***Dr. Michele Celebrano*** [4], ***Prof. Costantino De Angelis*** [5], ***Prof. Giuseppe Leo*** [1]

1. *Université Paris Diderot,* ***2.*** *Università Brescia,* ***3.*** *LPN-CNRS,* ***4.*** *Politecnico di Milano,* ***5.*** *Università*

Metal-less nanophotonics has recently become a hot research topic because technologically available high-permittivity dielectric nanoparticles exhibit negligible dissipative losses and strong magnetic multipole resonances in the visible and near-IR [1,2]. Here we report on efficient second harmonic generation (SHG) in the optical telecom range, from monolithic AlGaAs nanocylinders that are transparent at both the pump and the SH frequency. Our samples are fabricated from a (100) GaAs wafer, with an Al0.18Ga0.82As layer (400nm) on top of an aluminum-rich substrate (1μm), and after lithography and oxidation steps we obtain high-χ(2) nanopillars on an aluminum-oxide substrate. In our experiment, we separately excite single nanopillars with an ultrafast Erbium-doped fiber laser centered at 1554 nm (150 fs pulses, 80 MHz repetition rate) and we collect the back-scattered SHG signal through the same microscope objective that we use for the pump beam. The dependence of the measured SHG on the radius of the nanocylinders (with r = 175-225 nm) shows a few resonances corresponding to distinct SH nanocavity modes, in striking agreement with our calculations. The latter, carried out with frequency-domain finite element simulations in COMSOL [3], are also in excellent agreement with the experimental SHG spectra and polarization, and with the conversion efficiency (7×10-5, measured for a 1.6 GW/cm2 pump [4]). Depending on the radius, the SHG is driven by either a magnetic-dipole (MD) or an electric-dipole (ED) resonance at the pump wavelength. We show that the pump and SH fields are co-(cross-)polarized in the MD (ED) case [5], and we explain this with the contribution of bulk χ(2).

These results show the huge potential of AlGaAs nanoantennas for nonlinear nanophotonics, in terms of both high conversion efficiency and rich polarization behavior of the SH field. The latter promise intriguing potential applications to e.g. background-free wave-shaping metasurfaces.

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[3] L. Carletti et al., Opt. Express 23, 26544 (2015).

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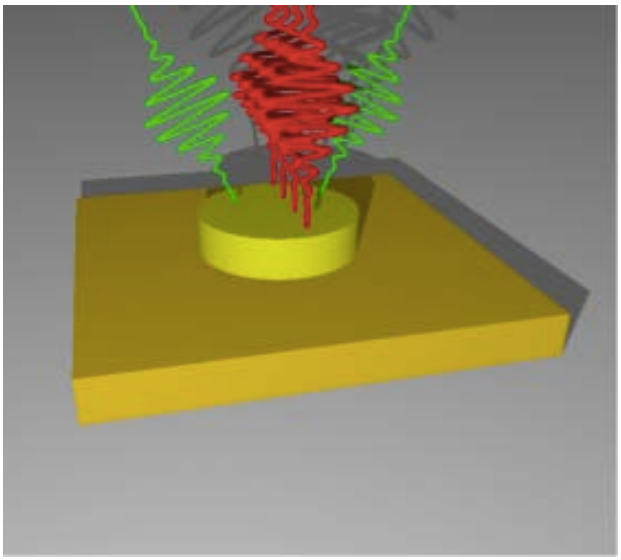


Figure.jpg

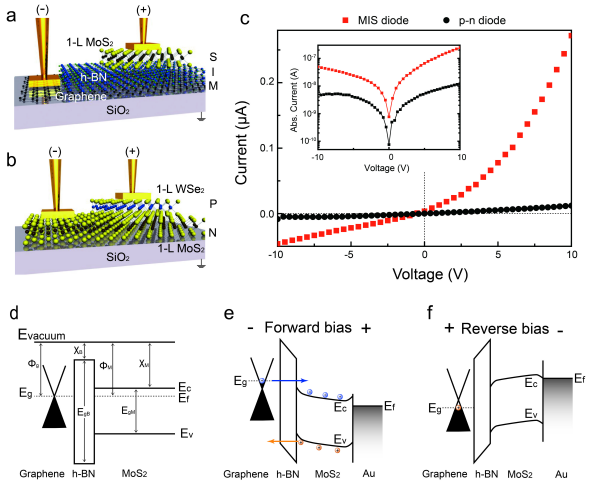
Metal-Insulator-Semiconductor Diode consisting of Two-dimensional Nanomaterials

Friday, 9th December - 16:30 - 2D luminescent materials (TMDs) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 169

Dr. Hyun Jeong [1], ***Prof. Gilles Lerondel*** [2], ***Prof. Munseok Jeong*** [3]

1. *Unervisity of Technology of Troyes,* ***2.*** *niversité de Technologie de Troyes,* ***3.*** *Sungkyunkwan University*

We present a novel metal-insulator-semiconductor (MIS) diode consisting of graphene, hexagonal BN, and monolayer MoS2 for application in ultra-thin nanoelectronics. The MIS heterojunction structure was fabricated by vertically stacking of layered materials using a simple wet chemical transfer method. The stacking of each layer was confirmed by confocal scanning Raman spectroscopy and device performance was evaluated using current versus voltage (I-V) and photocurrent measurements. We clearly observed better current rectification and much higher current flow in the MIS diode than in the p-n junction and the metal-semiconductor diodes made of layered materials. The I-V characteristic curve of the MIS diode indicates that current flows mainly across interfaces as a result of carrier tunneling. Moreover, we observed considerably high photocurrent from the MIS diode under visible light illumination.



Mis diode2-24.jpg

Enhancement of the luminescent response of 2D Indium Selenide by nanotexturing strategies

Friday, 9th December - 16:47 - 2D luminescent materials (TMDs) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 66

Mr. Mauro Brotons-Gisbert [1], Mr. Daniel Andres-Penares [1], Prof. Alfredo Segura [1], Prof. Juan P. Martínez-Pastor [1], Dr. Juan Francisco Sánchez Royo [1]

1. *ICMUV, Materials Science Institute of the University of Valencia*

Many efforts have been devoted to manipulate the morphology of two-dimensional (2D) materials to tune and improve their functionalities. It is usually believed that morphological manipulation strategies, such as nanotexturing, reduce transport abilities of 2D systems whereas introduces or enhances other functionalities. It is the case, for instance, of graphene [1,2]. Single layers (SLs) of transition-metal dichalcogenides offer unquestionable technological applications [3-6]. Nevertheless, tuning their properties for optoelectronic applications is challenging due to the intrinsically localized nature and orbital character of the d-states that dominate their valence and conduction bands. 2D forms of other layered semiconductors, as Indium Selenide, are less explored and may exhibit interesting and tunable properties [7,8]. First-principles calculations predicted that 2D InSe should produce a bandgap tuning window as large as 1.1 eV [7] and, experimentally, a blueshift of the optical bandgap of 0.2 eV has been already observed in 5 nm thick InSe nanosheets [8]. Also, devices based on few-layer InSe have shown promising applications [9,10].

In this communication, we show the ability of nanotexturing strategies to enhance the luminescent response of atomically thin Indium Selenide nanosheets. Besides, quantum-size effects make this two-dimensional semiconductor to exhibit one of the largest bandgap tunability ranges observed in a two-dimensional semiconductor: from 1.25 eV, in bulk, to 2.1 eV, in the SL. These results are relevant for the design of new optoelectronic devices, including heterostructures of two-dimensional materials with optimized band gap functionalities and in-plane heterojunctions with minimal junction defect density.

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[7] J. F. Sánchez-Royo et al., Nano Res., 7 (2014) 1556-1568.

[8] G. W. Mudd et al., Adv. Mater., 25, (2013) 5714-5718.

[9] W. Feng et al., Adv. Mater., 26 (2014) 6587-6593.

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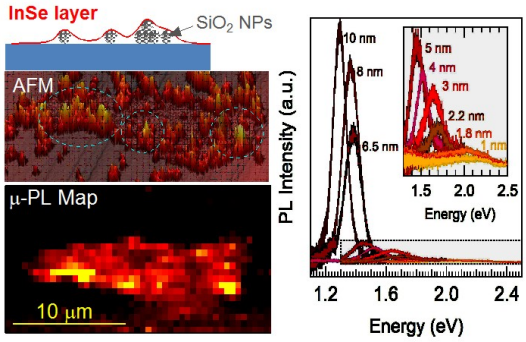

M brotons-gisbert figure.jpg

Vertically Aligned Luminescent MoS2 Nanosheets Growth and Properties

Friday, 9th December - 17:04 - 2D luminescent materials (TMDs) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 309

Dr. Geetanjali Deokar [1], ***Dr. Nitul Rajput*** [2], ***Prof. Wei Ou-yang*** [3], ***Dr. Peter Vancsó*** [1], ***Prof. Mustapha Jouiad*** [2], ***Dr. Dominique Vignaud*** [4], ***Dr. Nicolas Reckinger*** [1], ***Prof. Philippe Lambin*** [1], ***Dr. Jean-Francois Colomer*** [1]

1. *University of Namur,* ***2.*** *Masdar Institute,* ***3.*** *East china normal university,* ***4.*** *University of Lille 1*

Vertically aligned MoS2 nanosheets (NSs) with exposed edges on various substrates were successfully synthesized using a chemical vapor deposition technique. The as-grown MoS2 NSs were analyzed by using scanning and transmission electron microscopy. The obtained results along with the image analysis revealed the structural crystalline form of MoS2. The X-ray photoelectron spectroscopy and, Raman spectroscopy studies revealed the high crystallinity and quality of the synthesized NSs. The MoS2 NSs show visible light emission similar to mechanically exfoliated monolayer MoS2 NSs as confirmed by photoluminescence (PL) and UV-visible spectroscopy. The striking PL signal from the multilayered vertically aligned MoS2 NSs is explained by density functional theory calculations. The as-grown NSs can be transferred to a desired substrate employing a wet-chemical process. We have observed excellent field emission properties for the wet-transferred MoS2 sample on a conducting substrates. The vertical MoS2 NSs show a hydrophobic character with contact angle of 114°. These as-grown MoS2 NSs endowed with multiple qualities would be highly useful in the development of catalysis, nano-optoelectronic, gas-sensing and bio-sensing device applications.

INVITED TALK -> Integrated Freestanding Transition Metal Dichalcogenides

Friday, 9th December - 17:21 - 2D luminescent materials (TMDs) - Tower 24 - Room 103 - Oral presentation - Abstract ID: 168

Dr. Hyun Jeong [1], *Prof. Gilles Lerondel* [1]

1. Université de Technologie de Troyes

We report on the integration of freestanding transition metal dichalcogenides (TMDs). Monolayer (1-L) MoS2, WS2, and WSe2 as representative TMDs were transferred on ZnO nanorods (NRs), used here as nanostructured substrates. The photoluminescence (PL) spectra of 1-L TMDs on NRs showed a giant PL intensity enhancement, compared with those of 1-L TMDs on SiO2. The strong increases in Raman and PL intensities, along with the characteristic peak shifts, confirmed the absence of stress in the TMDs on NRs. In depth analysis of the PL emission also reveal that the ratio between the exiton and trion peak intensity is almost not modified after transfer. The later shows that the effect of charge transfer between the 1-L TMDs and ZnO NRs is here negligible. Furthermore, confocal PL and Raman spectroscopy revealed a fairly consistent distribution of PL and Raman intensities. These observations are in agreement with a very limited points contact between the support and the 1-L TMDs. The entire process reported here is scalable and may pave the way to the development of very efficient ultrathin optoelectronic devices.

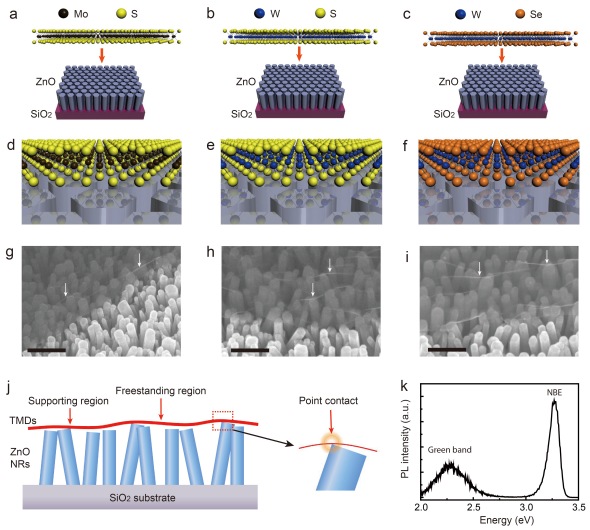

Figure 1.jpg

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Conferences, Events & Workshops