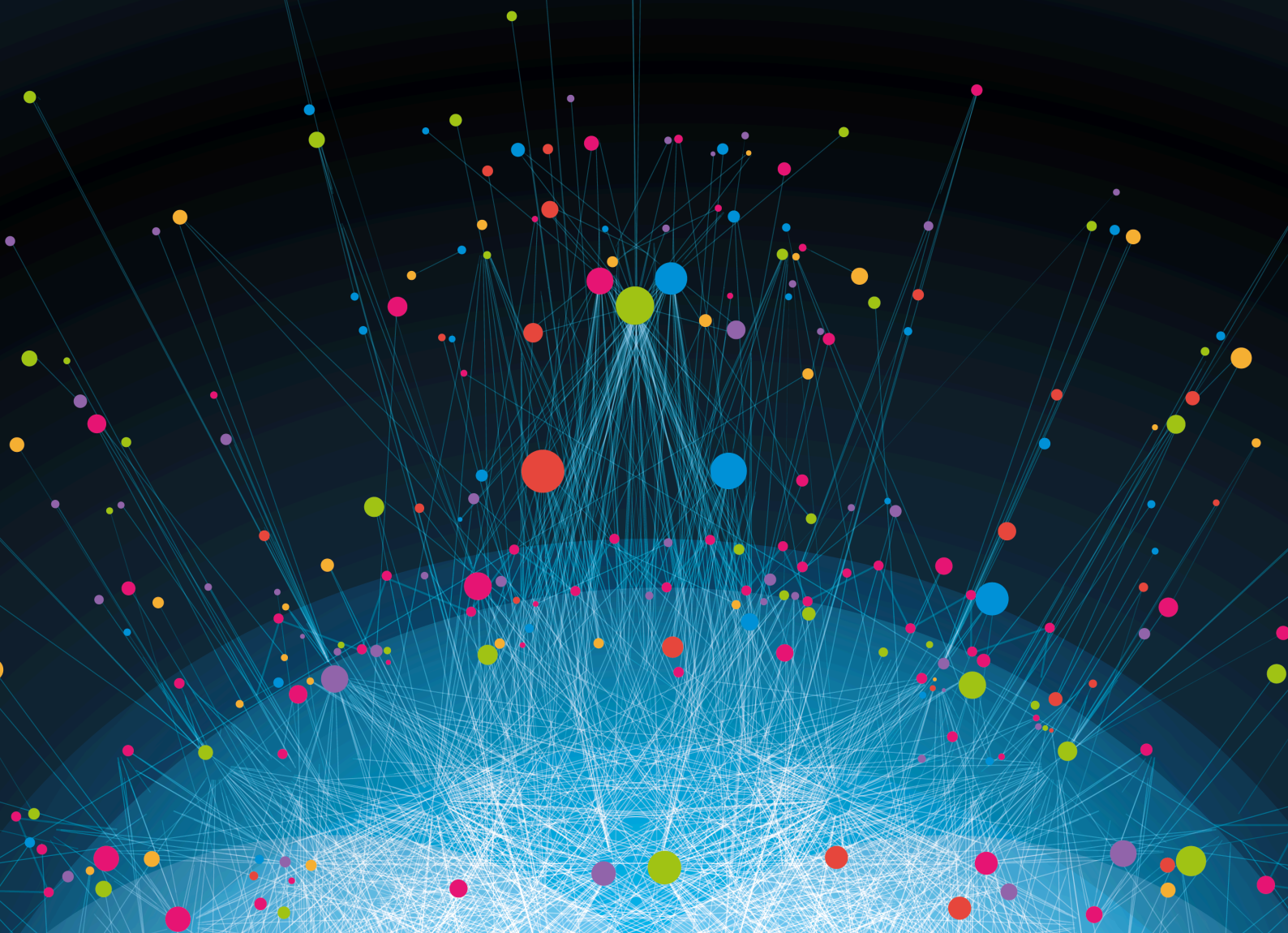
BOOK OF ABSTRACTS

Nanophotonics & Nanooptics



Nanophotonics & Nanooptics

Tuesday March 18th

3:15 P.M. - 6:30 P.M.

AMPHITHEATRE LOUIS ARMAND OUEST

Program of the session :

Chairs: Maria TCHERNYCHEVA & Erik DUJARDIN

HOUR	NAME	TITLE
15:15	**Hai-Son NGUYEN** **INL - Ecole CentraLe de Lyon**	**Engineering on-demand Band Structures and Non-Hermitian State of Light in Photonic Crystal**
15:45	Nordin FELIDJ ITODYS - Université Paris Cité	Aluminum Plasmonics : Overcoming Strong Damping for High-Performance Applications in the Near-Infrared
16:00	Pascale NASR, INSP - CNRS	Harvesting the Magnetic Field of Light at the Nanoscale
16:15	Benedict S. MORRIS LuMIn, Université Paris-Saclay	Strong coupling in plasmonic-photonic hybrid microcavities
17:00	Benoît REYNIER INSP - Sorbonne Université	Photon-avalanche manipulation of Tm^{3+} doped nanoparticles using a gold nanomirror
17:15	Alban GASSENQ ILM - UCBL	Rare Earth doped microstructures made by pulse laser deposition
17:30	Kevin KIM L2n - Univ. Reims Champagne Ardenne	Surface functional group and contaminant mapping in MXene materials via photo-induced force microscopy
17:45	Chang ZHOU institut Langevin - CNRS	Single-molecule fluorescence lifetime imaging nanoscopy to study plasmonic and biomimetic materials
18:00	Simon VASSANT SPEC - CEA	Optical characterization of a single molecule complete spatial orientation using intra-molecular triplet–triplet absorption
18:15	Vadim ZAKOMIRNYI L2n - UTT	Surprisingly large fluorescence enhancement via all-dielectric spherical mesoparticles

Hai Son NGUYEN (École Centrale de Lyon – INL, Lyon)

Short biography

Hai Son Nguyen holds a degree in Physics (2009) from the École Normale Supérieure de Paris and a PhD in Physics (2011) from the Laboratoire Pierre Aigrain (ENS Paris), where he studied single-photon emission from semiconductor quantum dots.
From 2011 to 2014, he was a CNRS postdoctoral researcher at the Laboratoire de Photonique et de Nanostructures, focusing on light-matter coupling in nanophotonics.
Since 2014, he has been an Associate Professor at École Centrale de Lyon and a junior member of the Institut Universitaire de France (2020–2025).
In 2024, he received the Fabry de Gramont Prize for his contributions to non-Hermitian photonics and optoelectronic devices.
His research at the Institut des Nanotechnologies de Lyon focuses on light-matter interactions in three key areas: optical lattices and metasurfaces, perovskite-based emitting devices, and single-photon emitters for telecom wavelengths.

Two-level system in graphene double quantum dots and Tamm resonators for THz quantum technology

Quantum technologies are experiencing considerable growth in the microwave and optical domains, while their development in the THz spectral range is still in its infancy, but promises significant technological impact1. In this context, developing a novel technology to realize two-level quantum systems at THz frequencies compatible with direct on-chip integration would represent a major breakthrough.
To this aim, graphene quantum dots are very attractive due to their high flexibility in engineering electronic states through their size, shape, and edges2. Here, we present a two-level system based on a hBN-encapsulated graphene double quantum dot (DQD) exhibiting a tunable transition frequency within the THz spectral range. Using low temperature transport measurements, we demonstrate a two-level system with resonance frequency of up to 0.14 THz. We further show that a single graphene QD exhibits a large THz electric dipole with a length of ≈230 nm, revealed by transport measurements under coherent THz illumination and the photon-assisted tunnelling phenomenon3. We also present original hybrid THz resonators4,5 that combine relatively high quality factors (Q~37) with a deep subwavelength mode volume (V~3.2x10−4λ3). Coupling graphene DQDs to these Tamm resonators opens new avenues for generating and detecting non-classical THz light states, essential building blocks of quantum technologies.

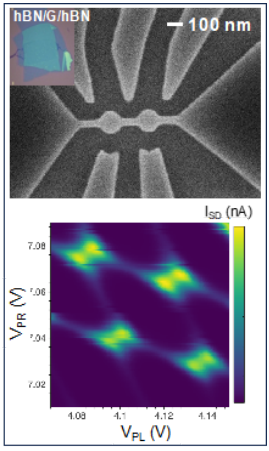


Figure 1 : Top) SEM image of the graphene DQD. Bottom) Measured charge stability diagram of a graphene DQD based device.

Keywords

Graphene, Quantum Dots, Terahertz, Resonators

Acknowledgement

We would like to thank Rebeca Ribeiro for her fruitful assistance in the fabrication of hBN/graphene/hBN heterostructures.

References

[1] Y. Todorov, S. Dhillon, J. Mangeney, Nanophotonics 13, 1681 (2024).
[2] E. Riccardi, et al. Nano Letters 20, 5408 (2020).
[3] S. Messelot et al. Phys. Rev. Res. 4, L012018 (2022).
[4] Simon Messelot et al. ACS Photonics, 7, 2906 (2020).
[5] S. Messelot, S. Coeymans, J. Tignon, S. Dhillon, J. Mangeney. Photon. Res. 11, 1203 (2023).

Abstract

Thematic Session: Nanophotonics & nano-optics

Disciplinary fields involved: Plasmonics

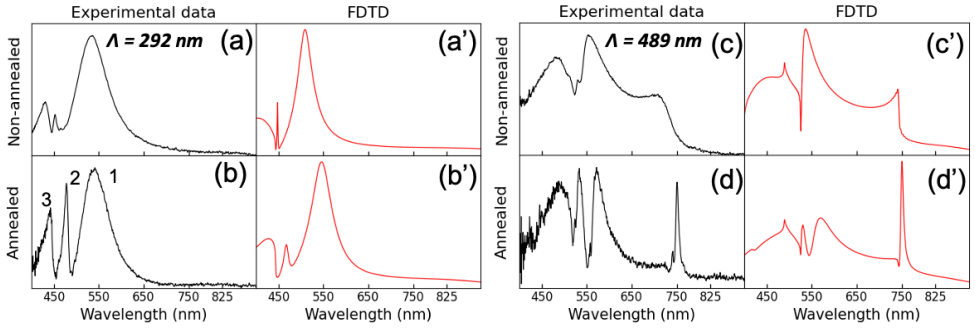
Keywords (max. 4-5)**: Aluminum, Plasmonics, Near IR, surface lattice resonance**

Aluminum Plasmonics : Overcoming Strong Damping for High-Performance Applications in the Near-Infrared

Pascal Cheng[1], Stéphanie Lau-Truong[1], Sarra-Gam Derouich[1], Roméo Bonnet[1], Alexandre Chevillot-Biraud[1], Macilia Braïk[2], Abdelaziz Mezeghrane[2], Abderrahmane Belkhir[2], Claire Mangeney[1], Manon Dewynter[3], Renaud Bachelot[3], Anne-Laure Baudrion[3], and Nordin Félidj[1]

1. Université Paris Cité, F-75006 Paris,
2. Université Mouloud Mammeri de Tizi-Ouzou, BP 17 RP, 15000 Tizi-Ouzou, Algeria
3. Université de Technologie de Troyes (UTT), France

Aluminum is an attractive material for plasmonics due to its low cost and abundance. However, its optical performance in the near-infrared (NIR) has been limited by interband transitions (IBTs) around 800 nm and significant damping of localized surface plasmon (LSP) excitations, leading to high absorption losses. To overcome this, we propose to take advantage of surface lattice resonances (SLRs) in regular arrays of aluminum nanoparticles on a high-refractive-index indium tin oxide (ITO) waveguide. These SLRs result from long-range coupling between LSPs and diffracted modes, producing a pronounced Fano-type resonance in the NIR. This approach significantly enhances the quality factor, reaching up to 100, with peak performance starting from the IBT region [1]. Experimental results closely match finite-difference time-domain (FDTD) simulations, offering a path for high-performance, cost-effective plasmonic devices in applications like optical sensing and photovoltaics.



Caption: Extinction specta in air of square arrays of aluminum disks (Diameter D=135 nm, Height H=50 nm). (a) Experimental and (a') FDTD calculation with a grating constant of Λ=292 nm for a non-annealad sample; (b) Experimental and (b') FDTD calculation with a grating constant of Λ=292 nm for an annealad sample; (c) Experimental and (c') FDTD calculation with a grating constant of Λ=489 nm for a non-annealad

Abstract

sample; (d) Experimental and (d') FDTD calculation with a grating constant of Λ=489 nm for an annealad sample.

References:
[1] P. Cheng *et al*., submitted (2025)

Abstract

Thematic Session: Nanophotonics & nano-optics

Disciplinary fields involved: Physics

Keywords: Optical magnetic response, Plasmonic nanoantennas, Magnetic dipole transitions, Magnetic local density of states (LDOS)

Harvesting the Magnetic Field of Light at the Nanoscale

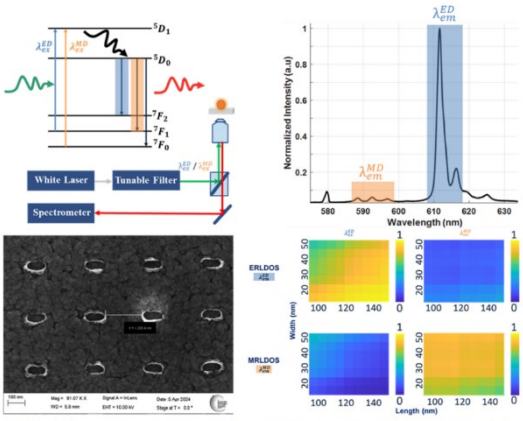
Pascale NASR [1], Benoît REYNIER [1], Wajdi Chaabani [1], Clémence Chinaud-Chaix [2], Eric CHARRON [1], Mona TREGUER DELAPIERRE [2], Sébastien BIDAULT [3], and Mathieu MIVELLE [1]

1. *Sorbonne Université, CNRS, Institut des Nanosciences de Paris, INSP, 75005 Paris, France*
2. *Institut de Chimie de la Matière Condensée de Bordeaux, 33600 Pessac, France*
3. *Institut Langevin, ESPCI Paris, Université PSL, CNRS, 75005 Paris, France*

Abstract:

While the electric field is often the primary focus in light-matter interactions, the optical magnetic response—typically overlooked in optics—also plays a vital role in various phenomena, such as circular dichroism, transitions in lanthanide ions, and chiral light-matter interactions.

In this study, we use Finite Difference Time Domain (FDTD) simulations to demonstrate that plasmonic nanoantennas in the form of nanoslits selectively enhance the magnetic component of light relative to the electric component. By embedding trivalent europium ions, which are well-known for their strong magnetic dipole transitions, within the nanostructure, we achieve a significant enhancement of their magnetic emission.



Partial band diagram, a spectrum of Europium ions representing magnetic and electric transitions, and the experimental set-up. Scanning electron microscope image of the plasmonic nanoantenna. Relative local density of state in the function of the dimensions and excitation wavelength.

Our findings reveal that this enhancement is driven by an increase in the magnetic local density of optical states (LDOS), particularly its radiative component. By tailoring the structural dimensions of the nanoantennas, we control both the Purcell factor and the relative LDOS, enabling the selective isolation of magnetic emission. Furthermore, by carefully tuning the excitation conditions, we achieve precise magnetic excitation of the emitters.

This approach provides a pathway for advanced control and manipulation of magnetic fields at the nanoscale, paving the way for novel magnetic nanosources. Potential applications include improved quantum emitters for quantum information processing, nanoscale sensing with enhanced magnetic resolution, and the development of chiral photonic devices for molecular analysis and light-driven enantioselective chemistry.

References:

E. C. O. M. X. Y. Benoit Reynier, "Full control of electric and magnetic light–matter interactions through a nanomirror on a near-field tip," Optica, vol. 10, no. 5, 2023.

K. e. al., "Excitation of Magnetic Dipole Transitions at Optical Frequency," 2015.

Abstract

Thematic Session: nanophotonics & nano-optics
Disciplinary fields involved: Physics
Keywords: gold nanorods, metasurface, FDTD, ultrafast

Strong coupling in plasmonic-photonic hybrid microcavities

Benedict S. Morris[1], Sergeï Kostcheev[2], Khanh-Van Do[1], Anna Rumyantseva[2], Shuwen Zeng[2], Renaud Bachelot[2], and Bruno Palpant[1]

1. *LuMIn, Université Paris-Saclay, CNRS, ENS Paris-Saclay, CentraleSupélec, Gif-sur-Yvette, France*
2. *L2n, Université de Technologie de Troyes, Troyes, France*

The strong coupling regime between two oscillators is a rich domain of electromagnetic interaction where a large diversity of fascinating physical phenomena is enabled. This regime has been shown to exist when coupling a plasmonic metasurface—a 2D array of gold nanorods (AuNRs)—to a photonic cavity. However, these hybrid cavities still pose fundamental scientific questions [1].
Here, through electron-beam lithography and evaporation, we fabricate a plasmonic metasurface placed at the anti-node of a first-order Bragg microcavity to achieve a robust, strong coupling regime (coupling strength $g \approx 0.10$) at ambient room temperature conditions. After validating the stationary FDTD simulations with experimental results, the simulations are used to investigate the effects on the coupling to the photonic resonance of the AuNR aspect ratio, the metasurface filling factor and the metasurface position in the cavity.
We then demonstrate a subpicosecond change in the coupling physics thanks to the reversible ultrafast modification of the AuNRs' complex permittivity after absorption of short laser pulses [2].

References:

[1] D. G. Baranov *et al.*, 'Ultrastrong coupling between nanoparticle plasmons and cavity photons at ambient conditions', *Nat Commun*, vol. 11, no. 1, p. 2715, Jun. 2020, doi: 10.1038/s41467-020-16524-x.
[2] X. Hou, N. Djellali, and B. Palpant, 'Absorption of Ultrashort Laser Pulses by Plasmonic Nanoparticles: Not Necessarily What You Might Think', *ACS Photonics*, vol. 5, no. 9, pp. 3856–3863, Sep. 2018, doi: 10.1021/acsphotonics.8b01012.

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics
Keywords: photon-avalanche, light-matter interactions, non-linear optics

Photon-avalanche manipulation of Tm^{3+} doped nanoparticles using a gold nanomirror

Benoît Reynier[1], Natalie Fardian-Melamed[2], Eric Charron[1], Emory Chan[3], Artiom Skripka[3], Sébastien Bidault[4], P. James Schuck[2], Mathieu Mivelle[1]

1. *Institut des Nanosciences de Paris, Sorbonne Université, CNRS, Paris 75005, France*
2. *Department of Mechanical Engineering, Columbia University, New York, New York 10027, USA*
3. *Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA*
4. *Institut Langevin, ESPCI Paris, Université PSL, CNRS, Paris 75005, France*

Mexican wave, earthquakes, landslides, forest fires, species extinctions, stock market crashes, and wars are all examples of self-organized criticality in nature, exhibiting avalanche-like behavior. In optics, this type of behavior can be observed in the photon emission of certain rare-earth-doped nanoparticles of the Tm^{3+} type. This highly non-linear phenomenon is known as the photon avalanche (PA). The emission from these Avalanching NanoParticles (ANPs) exhibits a non-linear response to the excitation source, making them promising probes for applications such as super-resolution biological imaging [1].

Building on our team's expertise in manipulating electric and magnetic light-matter interactions [2,3], we are coupling these complex optical systems (Tm^{3+}-doped nanoparticles) with a Scanning Nearfield Optical Microscope (SNOM) setup. Over the past year, we have developed an experimental setup featuring a high power-controlled IR excitation path, specifically designed for compatibility with nearfield experiments. In this configuration, a gold nanomirror has been engineered at the tip of a tapered optical fiber. This nanomirror can be positioned in the near field of the doped nanoparticles, enabling precise studies of PA behavior as a function of the distance to the gold antenna. This setup also allows for the fine control of the nonlinear photon avalanche mechanism.

Preliminary experimental results demonstrate a clear influence of the gold nanomirror on the PA process when positioned in the near field. Current experiments are focused on investigating the contributions of various electric and magnetic dipole transitions, as well as the cross-relaxation process—an internal non-radiative mechanism that plays a critical role in the PA phenomenon.

References:
[1] Lee, C et al. Giant Nonlinear Optical Responses from Photon-Avalanching Nanoparticles. Nature 2021, 589 (7841), 230–235. https://doi.org/10.1038/s41586-020-03092-9.

Abstract

[2] Reynier, B. et al. Full Control of Electric and Magnetic Light–Matter Interactions through a Nanomirror on a near-Field Tip. Optica 2023, 10 (7), 841. https://doi.org/10.1364/OPTICA.486207.
[3] Reynier, B. et al. Nanoscale Control over Magnetic Light-Matter Interactions. arXiv preprint arXiv:2402.00666, 2024

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics & Chemistry
Keywords: MXene, infrared, near-field, PiFM

Surface Functional Group and Contaminant Mapping in MXene Materials via Photo-Induced Force Microscopy

Kevin Kim[1,2], Aurélien Bruyant[1], Jérémy Mallet[2]

1. *Light Nanomaterials, Nanotechnologies (L2n), CNRS UMR 7076, Université de Technologie de Troyes, Troyes, France*
2. *Université Reims Champagne-Ardenne, Reims, France*

MXenes, a versatile family of 2D materials [1], are attracting significant attention for applications in catalysis, energy storage, and sensing due to their large surface area and tunable surface chemistry. However, the same reactive nature that enables functionalization also makes MXenes susceptible to contamination, particularly by siloxane compounds during synthesis and handling. Detecting and mapping surface functional groups [2] and contaminants at the nanoscale is challenging with traditional techniques such as FTIR and XPS, which lack the spatial resolution needed for detailed surface characterization.

In this study, we propose to use Photo-Induced Force Microscopy (PiFM) [3], a near-field microscope that combines atomic force microscopy (AFM) with infrared (IR) spectroscopy, to achieve high-resolution chemical imaging of MXene surfaces in the mid-infrared range. PiFM enables the detection of specific functional groups and contaminants with nanoscale spatial resolution, allowing for precise mapping across the MXene surface. Notably, PiFM detected siloxane contamination that was undetectable by FTIR, enhancing the sensitivity of this method in identifying trace contaminants.

By providing nanoscale insights into surface chemistry, PiFM emerges as a powerful tool for MXene analysis, capable of detecting and mapping key chemical bonds such as C-O, C-F, and C-H, which are responsible for surface terminations. These terminations are critical in determining the material's chemical and physical properties. This capability addresses a significant need in MXene research, supporting the development of cleaner and more controlled synthesis methods and ultimately enhancing the reliability of MXenes in advanced applications.

References:
[1] *2D Metal Carbides and Nitrides (MXenes): Structure, Properties and Applications*; Anasori, B., Gogotsi, Y., Eds.; Springer International Publishing: Cham, **2019**. https://doi.org/10.1007/978-3-030-19026-2.
[2] Li, G.; Lian, S.; Wang, J.; Xie, G.; Zhang, N.; Xie, X. Surface Chemistry Engineering and the Applications of MXenes. *Journal of Materiomics* **2023**, *9* (6), 1160–1184. https://doi.org/10.1016/j.jmat.2023.08.003.
[3] Murdick, R. A.; Morrison, W.; Nowak, D.; Albrecht, T. R.; Jahng, J.; Park, S. Photoinduced Force Microscopy: A Technique for Hyperspectral Nanochemical Mapping. *Jpn. J. Appl. Phys.* **2017**, *56* (8S1), 08LA04. https://doi.org/10.7567/JJAP.56.08LA04.

Abstract

Acknowledgement:

This work is supported by the Graduate School NANO-PHOT (École Universitaire de Recherche, PIA3, contract ANR-18-EURE-0013) and region Grand-Est. The authors gratefully acknowledge the funding of the French ANR through the project Temposcopy (ANR-19-CE42-0008) as well as the ERDF support (CA0024879). Experiments were carried out using Nanomat platform (www.nanomat.eu). The authors acknowledge A.J. Drexel Nanomaterials Group for providing the MAX phase materials and Prof. Yury Gogotsi for fruitful discussions.

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics
Keywords: Super-resolution microscopy; Fluorescence lifetime; Molecularly imprinted polymers; Plasmonic materials

Single-molecule fluorescence lifetime imaging nanoscopy to study plasmonic and biomimetic materials

Chang ZHOU[1], Alessia DI FIORE[2], Xiu LIANG[3], Dangyuan LEI[3], Yannick DE WILDE[1], Karsten HAUPT[2], Ignacio IZEDDIN[1], Valentina KRACHMALNICOFF[1]

1. *Institut Langevin, ESPCI Paris, CNRS, PSL University, Paris, France*
2. *Laboratoire Génie Enzymatique et Cellulaire, UTC, CNRS, Compiègne, France*
3. *Department of Materials Science and Engineering, City University of Hong Kong, Kowloon, Hong Kong*

The revolution in bio-imaging deiven by the advent of Single Molecule Localization Microscopy (SMLM) has recently opened new avenues for the study of nanostructured materials [1]. Thanks to SMLM, it is possible to image light-matter interactions at the single molecule level with a resolution of a few nanometers on plasmonic, dielectric, or hybrid nanostructures.

At Institut Langevin, we have developed a cutting-edge microscopy setup that can simultaneously detect single fluorescent molecules and measure their fluorescence lifetime, enabling the acquisition of super-resolved fluorescence lifetime images. smFLIM enables the study of single molecule-environment interactions with high spatio-temporal resolution, spanning scales from 10 µm to 10 nm and from seconds to picoseconds. We have demonstrated that this setup can be used to study light-matter interactions on dielectric and plasmonic nanostructures, such as dielectric and gold nanoantennas and 3D gold cavity arrays, to measure their local density of electromagnetic states [2,3]. In addition, we utilized smFLIM and SMLM to investigate biomimetic materials. Here, we focus on the recent results that we obtained by applying smFLIM on biomimetic materials, such as plastic antibodies made of molecularly imprinted polymer (MIPs) [4], which can recognize a specific target. In collaboration with the Laboratory of Enzyme and Cellular Engineering in Compiègne, we studied the binding of a fluorescent antigen to a fluorescent synthetic antibody. The study of the fluorescence signal emitted by a single molecule bound to the antigen and the fluorescence signal emitted by fluorophores in the MIP allows the investigation of individual binding events, shifting from commonly performed ensemble measurements to single measurements.

References:
1. A. F. Koenderink R. Tsukanov, J. Enderlein, I. Izeddin, V. Krachmalnicoff., Nanophotonics, 11, 169-202 (2022).
2. R. M. Córdova-Castro, B. Van Dam, A. Lauri, S. A. Maier, R. Sapienza, Y. De Wilde, I. Izeddin, and V. Krachmalnicoff, Light: Science \& Applications 13.1 (2024): 7.
3. R. M. Córdova-Castro, et al., to be published (2024).
4. K. Haupt, Nat. Mater. 9, 612 – 614 (2010).

Title: Exciton in Halide Perovskite Nanoplatelets: Finite Confinement and Dielectric Effect in Effective Mass Approximation

Kaouther Tlili,†,‡ **(Presenting author)** Maria Chamarro,‡ Kais Boujdaria,† and Christophe Testelin ‡

†Université de Carthage, Faculté des Sciences de Bizerte, LR01ES15 Laboratoire de Physique des Matériaux : Structure et Propriétés, 7021 Zarzouna, Bizerte, Tunisia.

‡Sorbonne Université, CNRS, Institut des NanoSciences de Paris, F-75005, Paris, France.

Two-dimensional (2D) lead halide perovskite (LHP) nanoplatelets (NPLs) have garnered significant interest due to their exceptional optoelectronic properties, such as high exciton binding energy, narrow emission lines, and robust room-temperature excitonic stability. These features make them promising candidates for advanced photonic and optoelectronic applications [1], including light-emitting diodes [2], solar cells [3], and photodetectors [4]. Predicting and controlling excitonic properties in these systems is critical for their integration into practical devices.

In this study, we investigate the excitonic properties of $CsPbBr_3$ and $CsPbI_3$ NPLs using an advanced effective mass approximation (EMA) framework. The model incorporates quantum and dielectric confinements, finite potential barriers, and thickness-dependent carrier masses. Additionally, we explore the dependence of Bloch functions on the NPL width, enabling a detailed understanding of how lattice distortions and confinement modulate the electronic states near the band edges. This refined approach addresses the limitations of infinite-confinement models [5,6,7,8] and provides a realistic description of the excitonic behaviour in nanoscale systems.

Our results reveal a strong influence of dielectric contrast and quantum confinement on excitonic energy and binding energy. For thin NPLs, we achieve good agreement with experimental data [9,10], particularly when finite potential barriers and variable effective masses are included. The model demonstrates a significant enhancement in exciton binding energies due to dielectric effects and quantum confinement. Incorporating Bloch function dependence on NPL width further refines the description of excitonic fine structures, revealing critical interactions between carrier delocalization, dielectric mismatches, and finite potential offsets at interfaces.

This work establishes a robust theoretical framework for understanding and predicting the excitonic properties of LHP NPLs. The findings underscore the influence of the ligand environment and its importance on dielectric and finite confinement effects in achieving precise control over excitonic behaviour in quasi-two-dimensional materials.

References:

[1] Li, H. et al. (2021). Energy & environmental materials, 4(1), 46-64.

[2] Gan, X et al. (2017). 2D. *Solar Energy Materials and Solar Cells*, *162*, 93-102.

[3] Cui, J et al. (2021). *Science Advances*, *7*(41), eabg8458.

[4] Liu, X et al. (2017). *Small*, *13*(25), 1700364.

[5] Ghribi, A. et al. (2021).. *Nanomaterials*, *11*(11), 3054.

[6] Rajadell et al. (2017). *Physical Review B*, *96*(3), 035307.

[7] Movilla et al. (2023). *Nanoscale Advances*, *5*(22), 6093-6101.

[8] Gramlich, M et al. (2022). *Advanced Science*, *9*(5), 2103013.

[9] Bohn, B. J et al. (2018). *Nano letters*, *18*(8), 5231-5238.

[10] Wang, S et al. (2022). *Nano Letters*, *22*(17), 7011-7019.

Abstract

Thematic Session : Nanophotonics & nano-optics
Disciplinary fields involved : Physics
Keywords (max. 4-5)**: Single molecule, fluorescence, photophysics, single photon emission, orientation**

Optical characterization of a single molecule complete spatial orientation using intra-molecular triplet–triplet absorption

R. Trojanowicz[1], L. Douillard[1], L. Sosa Vargas[2], F. Charra[1] and S. Vassant[1]

1. *Université Paris-Saclay, CEA, CNRS, SPEC, 91191, Gif-sur-Yvette, France.*
2. *Sorbonne Université, CNRS, Institut Parisien de Chimie Moléculaire (IPCM), F-75005, Paris, France*

Progress in single molecule fluorescence experiments have enabled an in-depth characterization of fluorophores, ranging from their photophysical rates to the orientation of their emission dipole moments in three dimensions. However, one crucial spatial information remains elusive: the molecule orientation relative to its emission dipole moment. One can retrieve the latter only by the use of another noncolinear transition dipole moment. We experimentally demonstrate the optical retrieval of this information for single terrylene (Tr) molecules in a 30 nm thin para-terphenyl matrix [1]. We show, through second-order correlation measurements at varying excitation power and polarization, that Tr molecules experience an optically induced deshelving of their triplet states, mediated by two orthogonal intramolecular triplet–triplet absorption dipole moments. We take advantage of these two transition dipole moments to retrieve the full orientation of the Tr molecule, employing a 3-level scheme for the molecule photophysics and analytical calculations for the exciting electric field distribution. This modelling approach enables us to accurately describe both varying power and polarization measurements, giving access to the molecule's photophysical rates and to its complete orientation in three dimensions. This includes the orientation of the singlet emission dipole moment in the laboratory frame, and the orientation of the molecule plane with respect to the singlet emission dipole moment.

References:
[1] R. Trojanowicz, L. Douillard, L. Sosa Vargas, F. Charra and S. Vassant, Physical Chemistry Chemical Physics 26, 16350 (2024)

Acknowledgement:
The authors thank the ANR for funding through the project PlasmonISC (ANR-19-CE09-0009)

Abstract

Thematic Session: Nanophotonics, Nanomaterials
Disciplinary fields involved: Physics, Optics.
Keywords: Fluorescence enhancement, Dielectric mesoparticles, Multipolar resonances, Quantum yield optimization, Light-matter interactions

Surprisingly large fluorescence enhancement via all-dielectric spherical mesoparticles

Vadim Zakomirnyi[1], Alexander Moroz[2], Ilia Rasskazov[3]

1. *Lumière, Nanomatériaux, Nanotechnologies (L2n), UMR CNRS 7076, Université de Technologie de Troyes, Troyes 10004, France*
2. *Wave-scattering.com*
3. *SunDensity Inc., Rochester, NY 14604, USA*

Abstract
This study numerically demonstrates that homogeneous mesoscale dielectric spheres, with radii ranging from 50 to 500 nm, can enhance fluorescence by up to 10^4. This substantial improvement arises from multipolar resonances, which create intense electric field enhancements at the excitation wavelength of fluorescent emitters. Unlike traditional plasmonic systems, which suffer from significant Ohmic losses leading to nonradiative decay, dielectric particles mitigate these limitations due to their lossless nature in the visible range [1]. Using Nile Blue dye as a model emitter and TiO_2 spheres with a refractive index of 2.7, the research explores both internal and external emitter configurations to optimize fluorescence enhancement. The theoretical framework, implemented via Stratify MATLAB software [2], highlights that fluorescence enhancement depends on intrinsic quantum yield, radiative decay rate, and the emitter's spatial arrangement relative to the particle. Simulations show that tuning resonances to excitation wavelengths, rather than emission wavelengths, significantly boosts fluorescence enhancement rate [3]. The results are showing the potential of mesoscale dielectric particles in applications requiring high fluorescence sensitivity, including bioimaging, chemical sensing, and quantum information processing. Beyond averaged effects, the study anticipates even greater enhancements when individual fluorophores are optimally positioned in hotspots created by the mesospheres. This research establishes a novel and efficient pathway for advancing fluorescence-based technologies, leveraging simple dielectric geometries to achieve unprecedented control over light-matter interactions.

References:
1. Rasskazov, I., Zakomirnyi, V., Utyushev, A., Carney, P.S., Moroz, A., "Remarkable predictive power of the modified long wavelength approximation," JPCC 125(3), 1963–1971 (2021).
2. Rasskazov, I. L., Carney, P. S., Moroz, A., "STRATIFY: a comprehensive and versatile MATLAB code for a multilayered sphere," OSA Continuum 3(8), 2290–2309 (2020).
3. Zakomirnyi V., Moroz A., Bhargava R., Rasskazov I., "Large Fluorescence Enhancement via Lossless All-Dielectric Spherical Mesocavities," ACS Nano 18(2) 1621–1628 (2024).

Wednesday March 19th

4:30 P.M. - 6:30 P.M.

AMPHITHEATRE LOUIS ARMAND EST

Program of the session :

Chairs: Jean-Luc DUVAIL

HOUR	NAME	TITLE
16:30	**Juliette MANGENEY** **LPENS - CNRS**	**Two-level system in graphene double quantum dots and Tamm resonators for THz quantum technology**
17:00	Diana SINGH ICB - UBFC	Understanding the early-stage formation of electron traps responsible for light emission in memristive artificial neurons
17:15	Adrià MEDEIROS GARAY C2n - Université Paris Saclay	Heralding of a single spin via giant polarization rotations in a QD-based spin-photon interface
17:30	Roméo ZAPATA INSP - Sorbonne Université	All-optical generation of drift currents through inverse Faraday effect
17:45	Francesco TALENTI C2n - Paris Cité	AlGaAs microrings with mixed optical nonlinearities
18:00	PEPR - OFCOC	-
18:15	PEPR NANOFILN	-

Juliette MANGENEY (CNRS – LPENS, Paris)

juliette.mangeney@phys.ens.fr

Short biography

Dr Juliette Mangeney is a CNRS researcher in the NanoTHz group of the Laboratoire Physique de l'Ecole Normale Supérieure, Paris since 2012. Her main research focuses on exploring nanomaterials and novel physical concepts to develop advanced THz devices and instrumentation to support the development of THz technology. She currently coordinates an ERC consolidator project (2019-2025) on graphene quantum dots for coherent THz emission. Previously to her current position, she was a CNRS researcher at the Institute of Fundamental Electronics (IEF), Univ. Paris Sud, and studied devices and metrology tools driven by telecom optical waves for THz optoelectronics. She is the author of 101 publications in peer-reviewed journals, 29 invited talks and she holds 4 patents. She headed the French national network on "Nanodevices for THz and MIR radiation" from 2015 to 2023 and the French side of the Russian-French international research network FIRLAB from 2018 to 2022.

Two-level system in graphene double quantum dots and Tamm resonators for THz quantum technology

Quantum technologies are experiencing considerable growth in the microwave and optical domains, while their development in the THz spectral range is still in its infancy, but promises significant technological impact1. In this context, developing a novel technology to realize two-level quantum systems at THz frequencies compatible with direct on-chip integration would represent a major breakthrough

To this aim, graphene quantum dots are very attractive due to their high flexibility in engineering electronic states through their size, shape, and edges2. Here, we present a two-level system based on a hBN-encapsulated graphene double quantum dot (DQD) exhibiting a tunable transition frequency within the THz spectral range. Using low temperature transport measurements, we demonstrate a two-level system with resonance frequency of up to 0.14 THz. We further show that a single graphene QD exhibits a large THz electric dipole with a length of ≈230 nm, revealed by transport measurements under coherent THz illumination and the photon-assisted tunnelling phenomenon3. We also present original hybrid THz resonators4,5 that combine relatively high quality factors (Q~37) with a deep subwavelength mode volume (V~3.2x10−4λ3). Coupling graphene DQDs to these Tamm resonators opens new avenues for generating and detecting non-classical THz light states, essential building blocks of quantum technologies.

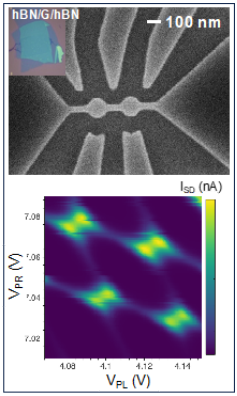


Figure 1 : Top) SEM image of the graphene DQD. Bottom) Measured charge stability diagram of a graphene DQD based device.

Abstract

Thematic Session: Nanophotonics & nano-optics, nanomaterials

Disciplinary fields involved: Physics

Keywords: Memristors, Resistive switching, Electroluminescence, Memristive emitter

Understanding the early-stage formation of electron traps responsible for light emission in memristive artificial neurons

Diana Singh[1], Maciej Cwierzona[1,2], Alexandre Bouhelier[1]

1. *Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 6303 CNRS, Université de Bourgogne, 21000 Dijon, France*
2. *Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University in Toruń, Poland*

Memristors are low-power nanoscale components characterized by their ability to replicate synaptic plasticity through the modulation of their electrical resistance [1]. This characteristic makes them particularly suitable for brain-inspired computing architecture such as neuromorphic networks [2]. Recent research has revealed that resistive switching of memristors can produce light emission, reminiscent of a biological phenomenon known as biophoton emission [3]. This electroluminescence is attributed to three main mechanisms: charge injection into luminescent defect sites [3, 4], inelastic tunneling and overbias emission [5]. This work focuses at understanding the early stage of defect formation responsible for light emission. We explore the build-up phase leading to volatile resistive switching with photoluminescence (PL) probes and explore the correlation with electron transport (Fig. 1).

The ultimate goal is to design integrated light sources for neuromorphic systems and advanced optoelectronic applications, particularly in facilitating light-matter interfacing in photonic circuits.

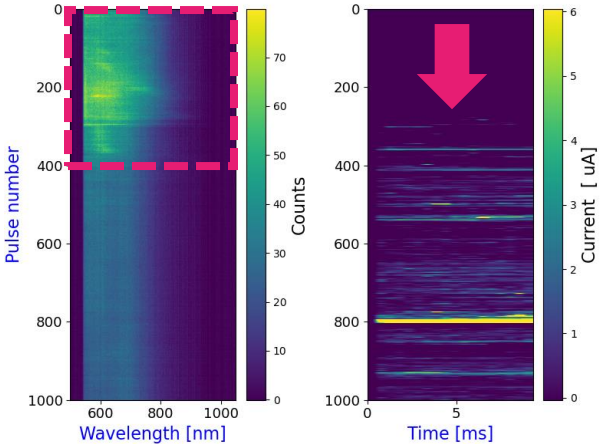


Figure 1: Evolution of PL spectrum and current in the Ag/PMMA/Ag memristor under repetitive voltage pulses (10 ms). Fluctuations of the PL spectra (magenta area) are preceding the current onset (magenta arrow).

References:

[1] Electrochemical dynamics of nanoscale metallic inclusions in dielectrics, Y. Yang et al., Nat Commun 5, 4232, 2014

[2] Low-Voltage Oscillatory Neurons for Memristor-Based Neuromorphic Systems, Q. Hua et al, Global Challenges, 3, 1900015, 2019

[3] Self-Induced Light Emission in Solid-State Memristors Replicates Neuronal Biophotons, K. Malchow et al., ACS Nano, 18, 35, 24004–24011, 2024

[4] Atomic scale memristive photon source, B. Cheng et al, Light Sci Appl **11**, 78, 2022

[5] Overbias and Quantum Tunneling in Light-Emitting Memristors, S. Hamida et al, Phys. Rev. Appl., 20, 2, 024057, 2023

Acknowledgement:

This work has been supported by the EIPHI Graduate School (contract ANR-17-EURE-0002) and Nicolaus Copernicus University in Toruń Center of Excellence project “From Fundamental Optics to Applied Biophotonics”.

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics
Keywords (max. 4-5)**:** Quantum Optics, Semiconductor QDs, Spin Physics, Polarization

Heralding of a single spin via giant polarization rotations in a QD-based spin-photon interface

Adrià Medeiros Garay[1], V. Vinel[1], E. Mehdi[1], M. Gundín[1], C. Millet[1], N. Somaschi[2], A. Lemaître[1], I. Sagnes[1], O. Krebs[1], D. A. Fioretto[1], P. Senellart[1] and L. Lanco[1,3]

1. *Université Paris Saclay, Centre de Nanosciences et de Nanotechnologies, CNRS, 91120 Palaiseau, France*
2. *Quandela SAS, 10 Boulevard Thomas Gobert, 91120 Palaiseau, France*
3. *Université Paris Cité, 75013 Paris, France*

Charged InAs/GaAs quantum dots (QD) are promising candidate platforms for quantum information processing. Entangling the spin degree of freedom of a charge confined in the QD and the polarization of single incoming photons would allow implementing deterministic spin-photon and photon-photon quantum gates. A promising strategy for this is to take advantage of the giant rotation induced by a single electronic spin on the polarization state of single photons, as in micropillar cavity-based spin-photon interfaces[1,2].

In our work, we use high-quality QD-based cavity devices (Fig. 1a) to produce spin-dependent reflected polarization states $|\Psi_{\uparrow(\downarrow)}\rangle$. We demonstrate the orthogonality between these two states $(\langle\Psi_\uparrow|\Psi_\downarrow\rangle = 0)$, by showing that the detection of a single reflected photon with polarization $|\Psi_\uparrow\rangle$ projects the spin into the $|\uparrow\rangle$ state with 96% fidelity. We perform the polarization tomography of a second photon arriving at a later time before spin relaxation occurs. This allows visualizing the states $|\Psi_\uparrow\rangle$ and $|\Psi_\downarrow\rangle$ in the Poincaré sphere, where they are shown to be opposite (Fig. 1b).

This orthogonality between $|\Psi_\downarrow\rangle$ and $|\Psi_\downarrow\rangle$ is crucial to allow producing novel maximally entangled states of the form $\frac{1}{\sqrt{2}}(|\Psi_\uparrow,\uparrow\rangle + |\Psi_\downarrow,\downarrow\rangle)$, between the electronic spin and an incoming photon. More advanced protocols, where a spin gets entangled with several incoming photons, are also within reach.

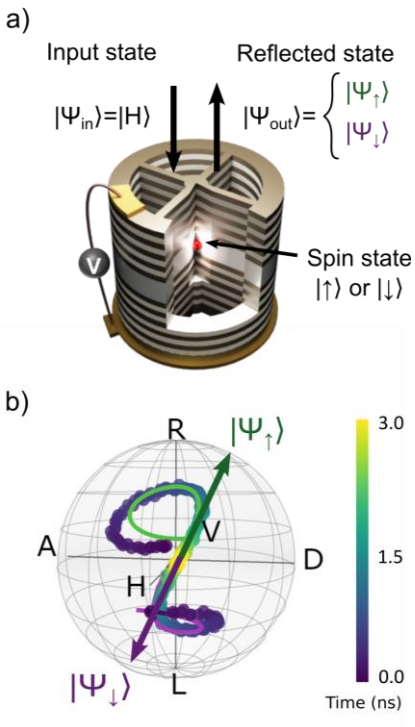


Fig. 1: a) Device under study and principle of the spin-dependent polarization rotation. **b)** Experimentally measured $|\Psi_{\uparrow(\downarrow)}\rangle$ states shown in the Poincaré sphere, measured through the tomography of the second reflected photon, as a function of the time delay after the spin projection by a first photon.

References:

[1] E. Mehdi et al, Nature Communications **15**, 598 (2024)
[2] M. Gundín et al, arXiv:2401.14976 (2024) *(to be published in PRL)*

Abstract

Thematic Session: Nanophotonics & nano-optics

Disciplinary fields involved: Physics

Keywords: Inverse Faraday Effect, Magneto Optics, Plasmonics, Photonics, Electronics

All-optical generation of drift currents through inverse Faraday effect

R. ZAPATA[1], X. YANG[1], Y. MOU[1], O. MARKOVIC[1], C. HAREAU[1], D. SINGH[2], A. BOUHELIER[2], M. MIVELLE[1],

1. *Institut des Nano Sciences de Paris, Nanophotonique et optique quantique, UMR 7588, Sorbonne Université*
2. *Laboratoire Interdisciplinaire Carnot de Bourgogne (LICB) UMR 6303, Université de Bourgogne*

The inverse Faraday effect allows the generation of stationary magnetic field through optical excitation only. This light-matter interaction in metals results from creating drift photocurrents via non-linear forces that light applies to the conduction electrons. In our group, we recently described the theory underlying the generation of drift currents in metals, particularly its application to plasmonic nanostructures using numerical simulations. We have also recently demonstrated that drift currents in a gold nanorod can be controlled by manipulating the polarization of light incident on photonic nanostructures [1]. In this work, we used this property to generate and control drift photocurrents in a gold strip with nanorods placed next to it (see Figure 1). We demonstrate theoretically and experimentally that by controlling the linear polarization incident on these structures we can manipulate the direction of the created photocurrents in the gold strip. The ability to generate photocurrents at nanoscale and potentially at ultra-fast timescales opens the way to the generation of nanoscale THz sources, with possible applications in the detection and recognition of molecules in extremely small volumes, or in the design of nanodevices with electric circuitry but optically driven.

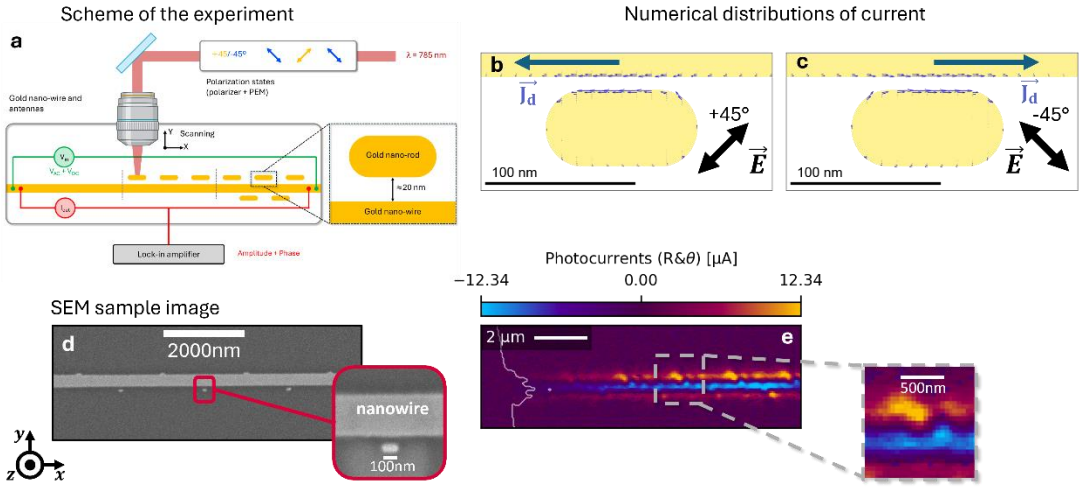


Fig 1: (a) Scheme of the nanowire close to the nanorods and the experimental roadmap of the detected currents flowing through the nanowire according to the position of the laser beam modulated for the polarizations ±45°. **(b)** Numerical distribution of the drift currents close to a nanorod for the polarizations ±45°. **(d)** SEM image of the fabricated nanoantenna. **(e)** Direction and amplitude of the detected photocurrents flowing through the nanowire.

References:

[1] X. Yang, Y. Mou, R. Zapata, B. Reynier, B. Gallas, and M. Mivelle, Nanophotonics, Volume 12, pages 687–694 (2023).

Abstract

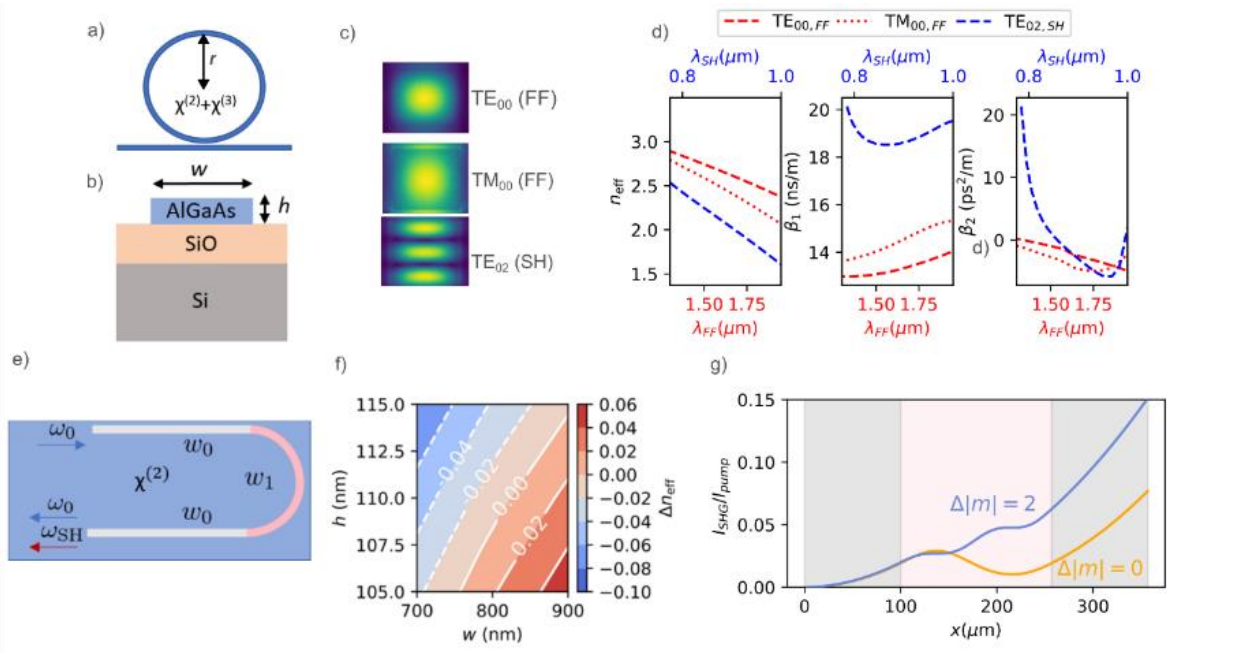
Thematic Session: Nanophotonics
Disciplinary fields involved: Physics
Keywords: nonlinear optics, AlGaAs, Frequency comb

AlGaAs microrings with mixed optical nonlinearities

F. R. Talenti[1,2], L. Lovisolo[1,2], A. Gerini[2], H. Peng[3], C. Koos[3], S. Wabnitz[4],

C. Alonso-Ramos[1], L. Vivien[1], G. Leo[2]

1. *Centre de Nanosciences et de Nanotechnologies (C2N), CNRS, Palaiseau, France*
2. *Laboratoire Matériaux et Phénomènes Quantiques (MPQ), Université Paris Cité, Paris, France*
3. *Institute of Photonics and Quantum Electronics (IPQ), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany*
4. *Dip. Ingegneria elettronica e telecomunicazioni (DIET), Sapienza University of Rome, DIET, Rome, Italy*



We present the modelling and design of $\chi^{(2)}$+$\chi^{(3)}$ nonlinear waveguides for harmonic and optical frequency comb (OFC) generation. We consider a ring configuration (Fig. a) based on an $Al_{0.18}Ga_{0.82}As$ epitaxial layer on a SiO_2 substrate (Fig. b). In today's state-of-the-art of optical parametric oscillators based on AlGaAs microrings [1], the typical height of the waveguide cross-section is h≈400 nm. The doubly resonant condition between TE_{00} and TM_{00} modes at the fundamental frequency FF (λ_{FF}=1.55 μm) and the TE_{02} mode at the second harmonic (SH, λ_{SH}=0.775 μm) is fulfilled for a width w≈610nm (Fig. c). The resulting group velocity dispersion is anomalous around λ_{FF}, but normal at λ_{SH} (Fig. d), which is detrimental for soliton OFC.

Abstract

For this reason we conceive the design of a purely $\chi^{(2)}$ optical feedback. This consists of a U-shaped AlGaAs waveguide (Fig. e) doubly resonant for the TE_{00} mode at λ_{FF} and the TM_{00} mode at λ_{SH}. In the two straight sections, modal phase matching requires a null difference between their effective indices Δn_{eff}, and this condition can be readily met by spanning the parameter space formed by h and w (Fig. f). In the curved section, due to the specific tensorial properties of the zinc-blende $\chi^{(2)}$, we must fulfill a directional quasi-phase matching (QPM) condition, which implies $|\Delta m|=2$, where m is the azimuthal number of the interacting modes [2]. Thus, to achieve an efficient SHG, the width of the straight sections (w_0) must differ from that of the curved section (w_1) (Fig. g).

References :

[1] L. Chang et al., Nature Communications 11, 1331 (2020).
[2] E. J. Stanton et al., Optics Express 28, 9521 (2020).

Acknowledgement:

This work was funded by ANR, within the French-German bilateral "Quadcomb" project (ANR-22-CE92-0065, DFG-505515860).

FRANCE 2030
PROGRAMME DE RECHERCHE
ÉLECTRONIQUE

ABSTRACT
Journées scientifiques PEPR électronique 18-21mars 2025

OFCOC: Optical frequency comb on a chip

Laurent Cerutti[1], Christian Grillet[2], Yoan Léger[3], Konstantinos Pantzas[4], Vincent Reboud[5], Quentin Wilmart[5]

1. *IES, University of Montpellier, CNRS, F-34000, Montpellier, France*
2. *Institut des Nanotechnologies de Lyon, CNRS-UMR-5270, Ecole Centrale de Lyon, Ecully, France*
3. *Univ Rennes, INSA, CNRS, Institut FOTON – UMR 6082, F-35000 Rennes, France*
4. *Centre de Nanosciences et de Nanotechnologies, CNRS, Univ Paris-Saclay, Palaiseau, France*
5. *Univ. Grenoble Alpes, CEA, LETI, F38000 Grenoble, France*

Awarded the Nobel Prize in Physics in 2005, the work on optical frequency combs has revolutionized the field of optics, enabling high-resolution spectroscopy with applications in health, environment, security, and information technology. However, frequency combs remain largely confined to niche applications due to their complex implementation. Recently, the first demonstrations of on-chip frequency combs (microcombs) have opened up possibilities for their use in everyday life, such as portable virus or gas sensors, as well as in industrial, space, and military applications.

In the OFCOC project, we aim to develop the first integrated, broadband, robust, reliable, and miniaturized microcomb source on a fully semiconductor platform. To achieve this goal, we are focusing on three technological levers. For integration, we have recently achieved initial results in microtransfer printing of antimonide-based interband cascade lasers on silicon, which will be used to pump Kerr comb resonators on chip. For microcomb generation, we have developed SiGe microring resonators with state-of-the-art quality factors for generating MIR combs, with promising nonlinear behaviors. Additionally, we have fabricated GaP-based photonic circuits on the GaP/GaAs platform with state-of-the-art propagation losses and have proposed novel evanescent coupler designs currently being tested on the Leti SiN platform for optimal generation of combs at telecom wavelengths. Finally, we have demonstrated highly efficient second-order nonlinear frequency conversion using an original phase matching scheme on the GaP nonlinear platform, which will be used for comb referencing and spectral extension.

ANR-22-PEEL-0005

cea cnrs C'NANO anr

FRANCE 2030 PROGRAMME DE RECHERCHE ÉLECTRONIQUE

ABSTRACT

Journées scientifiques PEPR électronique 18-21mars 2025

NanoFiLN : Nanophotonic based on $LiNbO_3$ Films

Soazig Leforestier [1], Olivier Gauthier-Lafaye[2], Mathieu Chauvet[3]

1. *CEA, Leti, Univ. Grenoble Alpes, F-38000 Grenoble, France*
2. *CNRS, LAAS, F-31400 Toulouse, France*
3. *Université Marie et Louis Pasteur, CNRS, institut FEMTO-ST, F-25000 Besançon, France*

In the past decade, a renewed interest has emerged for integrated photonics based on $LiNbO_3$ (LN) triggered by the availability of high-quality LN films on insulator (LNOI). These LNOI structures constitute an inspiring platform to develop integrated components with extreme light confinement providing enhanced performances for emblematic active functions such as modulators or frequency converters.

In this frame, the NanoFiLN project aims to set up a national academic technological sector for new-generation integrated optics based on LNOI. The consortium relies on three complementary methods for developing LN films offering a wide variety of thickness (from 100 nm to few µm): grinding-polishing, ion slicing and epitaxy. First developments on passive waveguides have been realized. For instance, waveguides etched in 600nm thick LNOI exhibiting propagation loss lower than 0.25 $dB.cm^{-1}$ at 1.55 µm have been fabricated using a RIE equipment. Bragg-mirrors carved in these waveguides have also been demonstrated with sharp responses of typical 3nm bandwidth and with an extinction ratio exceeding 20dB. Performances of more elaborated devices such as MIR generation by difference frequency generation, fabricated from thicker LN films, will also be exposed.

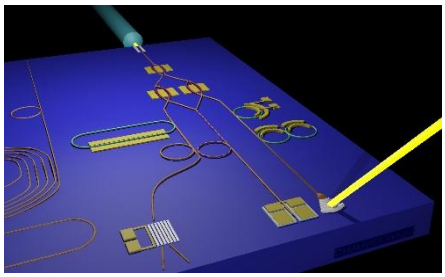


Figure 1 : artistic view of a LNOI photonic chip

The long-term ambition of the NanoFiLN project is to produce highly integrated multifunctional photonics chips as depicts in figure 1. Hybridization with complementary platforms such as SiN is also targeted.

ANR-23-PEEL-0004

Thursday March 20th

2:00 P.M. - 4:30 P.M.

AMPHITHEATRE LOUIS ARMAND EST

Program of the session :

Chairs: Valentina KRACHMALNICOFF & Jean-Baptiste TREBBIA

HOUR	NAME	TITLE
14:00	**Aloyse DEGIRON** **MPQ - CNRS**	**Hybridizing colloidal quantum dots with structured photonic environments reveals unintuitive optoelectronic properties**
14:30	Benjamin ROUSSEAUX FEMTO-ST - Université Marie et Louis Pasteur	Semiclassical theory of strong coupling between emitters and optical resonators
14:45	Marius GAUCHET ILM - UCBL	Exploring Chiroplasmonic Effects on Single Metallic Nano-Objects
15:00	Matthias PAULY MdC, Institut Charles Sadron, ENS de Lyon	Chiral assembled thin films of plasmonic nanowires
15:15	Guillaume LAGUE INSP - Sorbonne université	Pump-probe investigation of charge carrier spin dynamics and dynamic nuclear polarization in FAPbI3 polycrystalline films
15:30	Thomas PONS LPEM - INSERM	Sub-monoexcitonic lasing of semiconductor nanocrystals in polymeric parabolic microcavities
15:45	Alban GASSENQ ILM - UCBL	CdSe Quantum dots integrated into micro-lenses made by photolithography
16:00	Kaouther TLILI INSP - Sorbonne Univ.	Exciton in Halide Perovskite Nanoplatelets: Finite Confinement and Dielectric Effect in Effective Mass Approximation
16:15	Arjun BABU ICCF - Université Clermont Auvergne	Comparative Study of Luminescent Coatings Containing YVO4:Eu3+ Nanoparticles of Different Sizes

Aloyse DEGIRON (CNRS – MPQ, Paris)

https://mpq.u-paris.fr/don/

Short biography

Aloyse Degiron received the PhD in physics from the University of Strasbourg in 2004. In 2005, he joined the metamaterial research team of David R. Smith at Duke University (USA) as a postdoctoral researcher. In 2008, he was appointed as an assistant research professor in the same group. From 2009 to 2018, he worked at the Institut d'Electronique Fondamentale in Orsay as a researcher for the French National Center for Scientific Research (CNRS). In 2018, he moved to the Matériaux et Phénomènes Quantiques laboratory in Paris where he explores new phenomena in optoelectronics using colloidal nanocrystals and photonic nanostructures

Hybridizing colloidal quantum dots with structured photonic environments reveals unintuitive optoelectronic properties

Colloidal quantum dots (QDs) offer attractive opportunities for light sources, detectors and solar cells. They can self-assemble into solid compact layers and their properties can be adjusted with great flexibility during their synthesis to address frequency windows that are otherwise difficult and/or expensive to cover with standard semiconductors [1]. One of the current frontiers in the field is to increase the performances and to obtain new functionalities by hybridizing QD films with tailored photonic environments, such as gratings, metasurfaces or optical antennas. In this talk, I will show that such hybridization produces quite unexpected features, such as carrier lifetimes that are essentially independent of their photonic environment, even if the latter contains sharp resonances that strongly enhance the emission or, to the contrary, no resonance at all [2]. I will rationalize these observations with carrier thermalization arguments [2-4], discuss their fundamental implications and show how these effects can be leveraged in optoelectronic devices [5,6].

Keywords

Financial support for this work comes from the European Research Council grant FORWARD (reference: 771688).

Acknowledgement

Financial support for this work comes from the European Research Council grant FORWARD (reference: 771688).

References

[1] J. Zhang, S. Zhang, Y. Zhang, O. A. Al-Hartomy, S. Wageh, A. G. Al-Sehemi, Y. Hao, L. Gao, H. Wang, and H. Zhang, Laser Photon. Rev. 17, 2200551 (2023).
[2] P. He, A. Caillas, G. Boulliard, I. Hamdi, P. Filloux, M. Ravaro, E. Lhuillier and A. Degiron, ACS Photon. 11, 437 (2024).
[3] J.-J. Greffet, P. Bouchon, G. Brucoli, and F. Marquier, Phys. Rev. X 8, 021008 (2018).
[4] A. Caillas, S. Suffit, P. Filloux, E. Lhuillier and A. Degiron, J. Phys. Chem. Lett. 12, 5123–5131 (2021)
[5] A. Caillas, S. Suffit, P. Filloux, E. Lhuillier and A. Degiron, Nano Lett. 22, 2155 (2022).

Abstract

Thematic Session: Nanophotonics & nano-optics

Disciplinary fields involved: Physics

Keywords: nanophotonics, quantum emitters, quasinormal modes, electromagnetism

Semiclassical theory of strong coupling between emitters and optical resonators

Benjamin Rousseaux[1], Tong Wu[2] and Philippe Lalanne[2]

1. *FEMTO-ST Institute, Université de Franche-Comté, CNRS, 15B avenue des Montboucons, 25030, Besançon Cedex, France.*
2. *Laboratoire Photonique, Numérique et Nanosciences (LP2N), IOGS- Université de Bordeaux-CNRS, 33400 Talence Cedex, France.*

One of the long-standing aims of nanophotonics is to achieve the highest possible coupling between quantum emitters, such as molecules, and the highly confined electromagnetic modes of nanoscale resonators. This is all the more complex as such modes can be numerous and highly lossy, in contrast to high-*Q* optical cavities, but with exciting prospects for e.g., quantum sensing or photochemistry at the single-emitter level. Here, we propose a comprehensive semi-analytical framework describing the complex coupling mechanisms occurring between quantum emitters and nanoresonators with intricate architectures involving coupled quasinormal modes [1]. Such modes are expressed in an uncoupled-mode basis and a coupled-mode basis, allowing a wide variety of parameters to be explored with agility and uncovering non-trivial single-emitter strong coupling dynamics. With our formalism, we revisit nanophotonic designs intended to explore single-emitter strong coupling [2], and investigate the potential role played by atomic-size defects, recently named "picocavities" [3], in such experiments.

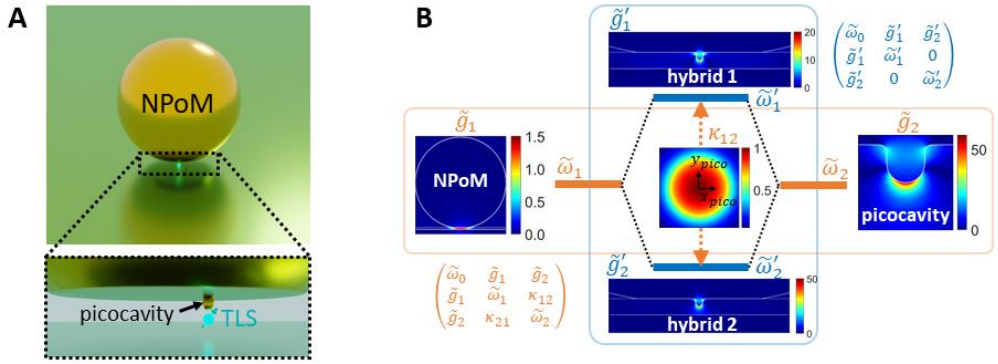


Figure 1: The formalism, illustrated with an emitter (TLS) coupling to a nanoparticle-on-mirror (NPoM) featuring a picocavity (**A**). **B**: Coupling analysis in the uncoupled (orange box) and coupled (blue box) bases.

References:

1. Sauvan, C. et al. *Phys. Rev. Lett.* **110**, 237401 (2013).
2. Chikkaraddy, R. et al. *Nature* **535**, 127–130 (2016).
3. Baumberg, J. J. *Nano Lett.* **22**, 5859–5865 (2022).

Acknowledgement:

The authors acknowledge financial supports from the WHEEL (ANR-22CE24-0012-03) Project.

Thematic Session : Nanophotonics & nano-optics

Disciplinary field : Physics

Keywords : Metamaterial, Chirality, Circular dichroism, Single-particle spectroscopy

Exploring Chiroplasmonic Effects on Single Metallic Nano-Objects

M. Gauchet[1], M. Pellarin[1], M-A. Lebeault[1], C. Bonnet[1], E. Cottancin[1], R. Bachelot[2], F. Perrier[3]

1. *Institut Lumière Matière, UMR5306 - UCBL – CNRS, 10 rue Ada Byron, 69622 Villeurbanne CEDEX, France*
2. *Laboratoire Lumière, nanomatériaux et nanotechnologies – L2n, Université de Technologie de Troyes & CNRS EMR 7004, 12 rue Marie Curie, CS 42060, 10004 Troyes Cedex, France*
3. *Amplitude Laser Group, 11 avenue de Canteranne, Cité de la Photonique, 33600 Pessac, France*

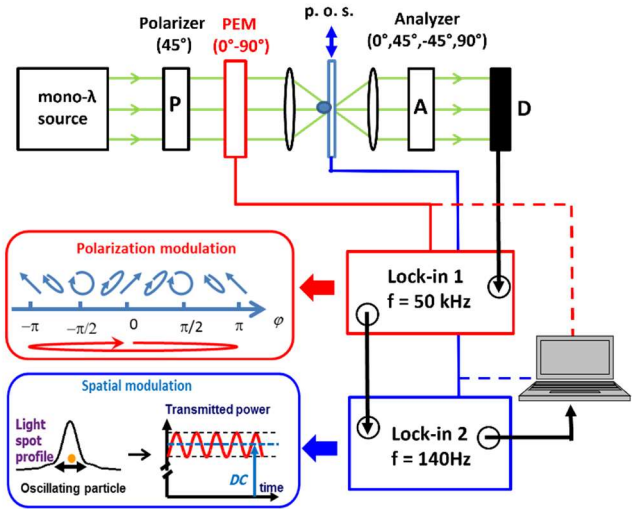
Metamaterials are artificial nano-structured materials engineered to exhibit properties not found in nature, attracting significant attention to fundamental research and practical applications due to their exotic and tunable optical properties. Chiral metamaterials, in particular, enable precise control over the states of polarization of light and enhance optical activity [1].

To understand the fundamental mechanisms underlying the generation of circular dichroism and to avoid the averaging effects resulting from the response of a collection of metallic nano-objects (MNOs), investigations at the single-particle level are imperative.

In this approach, we illuminate the MNO with a focalized beam in a confocal geometry and detect its transmission extinction. A photo-elastic modulator (PEM) is used to control the polarization states of the incident light allowing the extraction of anisotropic properties of MNO (linear and/or circular dichroism and birefringence) [2]. To significantly improve the signal-to-noise ratio, we developed an extremely sensitive experimental setup (see fig.) combining Polarization Modulation Spectroscopy (PMS) and Spatial Modulation Spectroscopy (SMS) [3], along with a data analysis protocol to determine an effective Jones matrix bearing the anisotropic parameters of individual nanostructures.

Preliminary studies have been conducted on dimers of golden nano-spheres, well-known for their linear optical anisotropy. Additionally, MNOs with chiral geometries are expected to exhibit circular dichroism. To characterize both linear and circular anisotropies, we probed isolated gold MNOs exhibiting a simple shape anisotropy, considered as enantiomers of 2D-chiroplasmonic objects when deposited on a substrate [4].

Experimental results on both linear and circular dichroism and birefringence measurements for single MNO will be discussed and compared to numerical simulations to illustrate the versatility of this technique.



[1] Oh, S.S., Hess, O, **2**, 24 (2015)

[2] Schellman J., Jensen H.P, Chem. Rev., **87**, 1359-1399 (1987)

[3] Billaud P. et al, Rev. Sci. Instrum. **81**, 043101 (2010)

[4] Ventsislav K. et al, Adv. Mater, **25,** 2517-2534 (2013)

Abstract

Thematic Session: Nanophotonics & nano-optics

Disciplinary fields involved: Chemistry

Keywords: Plasmonics, chiral assemblies, circular dichroism, silver nanowire

Chiral assembled thin films of plasmonic nanowires

Wenbing Wu[1], Benjamin Boglio[1], Yann Battie,[2] Olivier Félix[1], Matthias Pauly[1, 3]

1. *Université de Strasbourg, CNRS, Institut Charles Sadron, UPR 22, F-67200 Strasbourg, France*
2. *Université de Lorraine, LCP-A2MC, UR 4632, F-57078 Metz, France*
3. *ENS de Lyon, CNRS, LCH, UMR 5182, F-69342 Lyon, France*

Abstract

Chiral assemblies of plasmonic nanoparticles have attracted increasing attention over the last years due to promising applications in fields such as molecular sensing or as optical circular polarizing elements.[1] Metamaterials that can control the flow of electromagnetic waves in unprecedented ways need to have subwavelength dimensions, i.e. in the range of tens of nm for optical applications, and their properties are not only governed by the constitutive materials but also often depend on the nanoscale structure and hierarchical organization of the individual building blocks. A big challenge resides in the hierarchical organization of the nanoscale building blocks into two- or three-dimensional structures with well-controlled location and orientation across multiple length scales.

In this talk, I will present how Grazing Incidence Spraying can be used to assemble anisotropic nanoparticles as mono- and multilayer thin films on large areas with tunable particle density and orientation.[2] Furthermore, the combination with the Layer-by-Layer assembly technique allows building helical (and thus chiral) multilayer large-area thin films in which the composition and orientation can be controlled independently in each layer.[3]

These films display very high chiroptical activity over a broad wavelength range with g-factor values up to 1.8 in the near IR range.[4] The optical properties (polarized transmittance, CD spectroscopy and Mueller Matrix Polarimetry) as function of the thin film geometry will be detailed, with a special emphasis on how the chiroptical properties depend on the architecture of the assembly. The properties of chiral mirrors built from these assemblies will also be discussed.[5]

References:

[1] W. Wu, M. Pauly, *Mater. Adv.* **2022**, *3*, 186–215.
[2] H. Hu, M. Pauly, O. Felix, G. Decher, *Nanoscale* **2017**, *9*, 1307–1314.
[3] H. Hu, S. Sekar, W. Wu, Y. Battie, V. Lemaire, O. Arteaga, V. L. Poulikakos, D. J. Norris, H. Giessen, G. Decher, M. Pauly, *ACS Nano* **2021**, *15*, 13653–13661.
[4] W. Wu, Y. Battie, V. Lemaire, G. Decher, M. Pauly, *Nano Lett.* **2021**, *21*, 8298–8303.
[5] W. Wu, Y. Battie, C. Genet, T. W. Ebbesen, G. Decher, M. Pauly, *Adv. Opt. Mater.* **2023**, 2202831.

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: **Physics**
Keywords: Pump-probe, Faraday rotation, lead halide perovskites, hyperfine interaction

Pump-probe investigation of charge carrier spin dynamics and dynamic nuclear polarization in FAPbI3 polycrystalline films

G. Lague [1], F. Bernardot [1], V. Guilloux [1], L. Legrand [1], J. Sánchez-Diaz [2], S. Galve-Lahoz [2], C. Testelin [1], I. Mora-Seró [2] and M. Chamarro [1]

[1]Sorbonne Université, CNRS, Institut des NanoSciences de Paris, Paris, France.
[2] Institute of Advanced Materials (INAM), Universitat Jaume I, Castelló de la Plana, Spain.

Abstract

For more than a decade now, the interest in metal-halide perovskites has kept growing continuously. Their remarkable optoelectronic and photovoltaic properties make them very promising candidates for solar cells and light emitting devices applications. In addition to those outstanding properties, hybrid lead-halide perovskites, like $FAPbI_3$, show a strong spin orbit coupling and spin selective optical transitions. These spin properties, so far poorly studied compared to the optoelectronic ones, could lead to very promising spintronics applications.

In this work, we used time-resolved pump-probe Faraday rotation measurements with an applied magnetic field to study the coherent spin dynamics of electrons and holes in $FAPbI_3$ polycrystalline films. The photo-induced Faraday rotation (PFR) measurements under a transverse magnetic field allowed us to determine both electron and hole g-factors and dephasing times. The values obtained for the Landé factors of the electron and the hole are similar to the values obtained for $FA_{0.9}Cs_{0.1}PbI_{2.8}Br_{0.2}$ in previous works [1]. The dephasing times, determined from the PFR signal, are also comparable to the ones for other halide-perovskites $MAPbI_3$ [2], $CsPbBr_3$ [3] and $FA_{0.9}Cs_{0.1}PbI_{2.8}Br_{0.2}$ [1] previously studied. These results represent a first step towards potential spintronics applications for $FAPbI_3$.

The important role of the hyperfine interaction in the longitudinal relaxation was evidenced by experiments under a longitudinal magnetic field. A significant dynamic nuclear polarization was obtained, explained by the strong hyperfine interaction between the holes and the Pb atoms. A similar behaviour as the one in $FA_{0.9}Cs_{0.1}PbI_{2.8}Br_{0.2}$ was observed [4].

Abstract

References:

[1] Kirstein et al Adv Mat 34, 2105263 (2022).
[2] G. Garcia-Arellano et al, JPCL 12, 8272, (2021).
[3] Belyk et al. Nature Comm, 10, 673, (2019).
[4] Kudlacik et al. ACS Photonics 11, 2757-2769, (2024).

Acknowledgement:

This work was supported by the French National Research Agency (ANR IPER-Nano2, ANR-18-CE30-0023) and the French Ministry of Foreign Affairs for funding through the project PHC-Utique (CMCU 22G1305).

Abstract

Thematic Session : Quantum Dots: from synthesis to properties
Disciplinary fields involved: Physics, Chemistry
Keywords: nanocrystals, optical gain, microcavities, laser

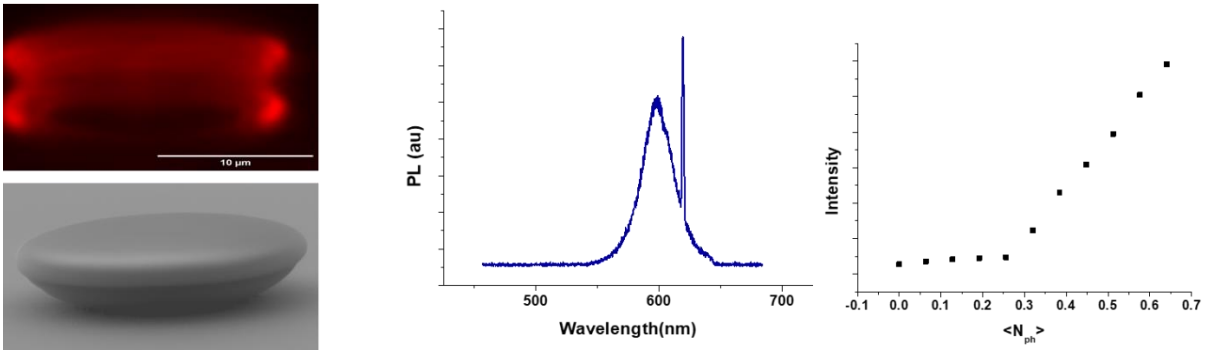
Sub-monoexcitonic lasing of semiconductor nanocrystals in polymeric parabolic microcavities

Charlie Kersuzan,[1,2] Sergei Celaj,[2] Antony Nghangha,[1] Céline Roux-Byl,[1] Xiangzhen Xu,[1] Willy Daney de Marcillac,[2] Agneš Maître[2] and Thomas Pons[1]

1. *Laboratoire de Physique et d'Etude des Matériaux, ESPCI Paris – PSL, CNRS, Sorbonne Université UMR8213, 10, rue Vauquelin, 75005 Paris, France*
2. *Institut des NanoSciences de Paris, CNRS, Sorbonne Université UMR7588, 4 place Jussieu, 75005 Paris, France*

Abstract

Semiconductor nanocrystals are an interesting category of materials for optical gain, thanks to their attractive optical properties, their inexpensive colloidal synthesis and easy solution processability. In particular, they could facilitate miniaturization and integration into microphotonic devices thanks to the realization of microlasers, for sensing or other photonic applications. Optical gain and lasing have been previously demonstrated from the biexcitonic state, due to the degeneracy of the band edge states. Efficient pumping into the biexcitonic state is however hampered by Auger recombination into a non-lasing mono-excitonic state. Here, we study amplified stimulated emission of CdSe-CdS core/shell, quantum shell and nanoplatelet nanocrystals and their lasing characteristics. We load these nanocrystals into polymeric parabolic microcavities realized by laser photolithography. We show that the high quality factor of these microcavities enable lasing of quantum shells and nanoplatelets in the sub-monoexcitonic regime. We explain this new behavior by a comprehensive model of nanocrystals photophysical properties.



Left: Fluorescence microscopy and scanning electron microscopy image of a parabolic microcavity. Middle: Emission spectrum of a quantum-shell microcavity near threshold. Right: Emission intensity as a function of excitation power, in units of average number of absorbed photons per nanocrystal.

Acknowledgement:

We acknowledge funding from iMat (Sorbonne Université) and ANR grant Nanowhispers (ANR-21-CE42-0029).

Abstract

Thematic Session Nanophotonics
Disciplinary fields involved Chemistry and Engineering
Keywords: Microlenses, Quantumdots, Processing, lithography

CdSe Quantum dots integrated into micro-lenses made by photolithography

L. Issoufou Alfari[1], J. Houel[1], A. Belarouci[2], H. Sahib[1], S. Guy[1], F. Lerouge[3], M. Leocmach[1], B. Mahler[1], A. Gassenq, [1],*

1. *Université Claude Bernard Lyon 1, Institut Lumière-Matière UMR5306 CNRS, F-69622 Villeurbanne, France*
2. *Institut des Nanotechnologies de Lyon, UMR 5270, CNRS, ECL, INSA, UCBL, F-69134, LYON, France.*
3. *Laboratoire de Chimie, Ecole Normale Supérieure de Lyon, CNRS, UCBL, UMR5182, F-69364 LYON France*

Microlens arrays are very useful in photonics for various applications such as imaging, sensing, and solar cells [1]. Many fabrication methods have been developed, but they are mostly limited to passive materials. Therefore, integrating nano-emitters into microlenses offers great potential for photonics applications, such as wavelength conversion for micro-display technologies.

In this work, we present a fast and cost-effective method to fabricate microlenses with integrated core/shell CdSe/$Cd_xZn_{1-x}S$ quantum dot red emitters [2] using photolithography and thermal reflow [3]. To achieve this, we chemically modified a commercial photosensitive resist. First, the quantum dots were synthesized and mixed into the AZ9260 commercial photoresist solvent (propylene glycol monomethyl ether acetate) using ligand exchange [4]. This quantum dot-loaded solvent was then combined with the photoresist which was patterned into micro-disks (with diameters ranging from 20 to 5 µm) via ultraviolet lithography. These micro-disks were subsequently heated, causing them to form microlenses through the softening of the photoresist. Tests on light emission and lifetime confirmed that the quantum dots inside the microlenses remain efficient and unaffected by the fabrication process. This method demonstrates thus a simple and effective way to create micro-lenses with CdSe-based quantum dots for photonics applications [5].

References:

[1] Cai et al., *Microsc. Res. Tech.*, **2021**, https://doi.org/10.1002/jemt.23818.
[2] Baronnier et al., *Phys. Chem. Chem. Phys.*, **2021**, https://doi.org/10.1039/d1cp02927d.
[3] Lee et al., *J. Micromechanics Microengineering*, **2008**, https://doi.org/10.1088/0960-1317/18/3/035012.
[4] Issa et al., *ACS Appl. Mater. Interfaces*, **2023**, https://doi.org/10.1021/acsami.2c22533.
[5] Issoufou Alfari et al., *Submitt. to Opt. Mater.*, **2024**.

Acknowledgement:

The authors would like to thank the NanoLyon platform for the cleanroom facilities, and the Institute Light Matter for funding. L.Issoufou Alfari, B. Mahler and M. Leocmach acknowledge support from ANR Grant VitriPSA ANR-21-CE06-0025-02.

Abstract

Thematic Session Nanophotonics
Disciplinary fields involved Physics and Engineering
Keywords: Rare-earth, Processing, micro-structures

Rare Earth doped microstructures made by pulse laser deposition

Antoine BERNARD[1], Antonio PEREIRA[1], Régis OROBTCHOUK[2], Hai-Son NGUYEN[2], Sébastien CUEFF[2], Etienne CLEYET-MERLE[1], Stephan GUY[1], Tam NGUYEN[2], Ali BELAROUCI[2], Yannick GUYOT[1], Alban GASSENQ, [1],*

1. *Université Claude Bernard Lyon 1, Institut Lumière-Matière UMR5306 CNRS, F-69622 Villeurbanne, France*
2. *Institut des Nanotechnologies de Lyon, UMR 5270, CNRS, ECL, INSA, UCBL, F-69134, LYON, France.*

Rare Earth (RE) nano-emitters are promising for numerous applications in photonics such as quantum optics and on-chip amplification [1]. One of the remarkable properties of RE trivalent lanthanides is that their emissions are slightly influenced by their environment, as the spatial extension of the 4f orbitals is smaller than the fully occupied higher orbitals. The emission properties of RE-doped materials are therefore very similar to those of the isolated ion. For practical applications, they can be integrated into oxide hosts. However, they are complex to process, especially by etching, which limits their performance and increases fabrication costs [1].

In 2021, we first demonstrated that lift-off processing in Pulsed Laser Deposited (PLD) layers can avoid etching for the fabrication of microstrips based on Europium (Eu)-doped Y_2O_3 hosts because this technique allows low temperature and directive deposition [2]. Later, we extended our method to different materials, such as amorphous or crystalline Y_2O_3 and Al_2O_3 with different doping, including Erbium ($^4I_{13/2} \rightarrow {}^4I_{15/2}$ infrared transition) and Europium ($^5D_0 \rightarrow {}^7F_2$ red transitions). Broader emission is measured in amorphous materials, while sub-transitions are observed in crystalline hosts after annealing [3]. We also improved this method for higher-resolution microstructures, showing a strong increase in photoluminescence using diffraction gratings [4]. Finally, we recently demonstrated low-loss waveguides [5] and promising photonic crystals with this technique. Our work thus demonstrates that lift-off processing in PLD layers offers new possibilities for RE doped micro- and nano-device fabrication.

References:

[1] Hendriks et al., *Adv. Phys. X*, **2021**, https://doi.org/10.1080/23746149.2020.1833753.
[2] Gassenq et al., *Opt. Express*, **2021**, https://doi.org/10.1364/oe.416450.
[3] Gassenq et al., *Appl. Phys. A*, **2023**, https://doi.org/10.1007/s00339-023-06549-6.
[4] Gassenq et al., *Opt. Lett.*, **2023**, https://doi.org/10.1364/OL.486893.
[5] Bernard et al., *Submitt. to Appl. Phys. Lett.*, **2024**.

Acknowledgement:

The authors would like to thank the NanoLyon platform for the cleanroom facilities, and the ANR Grant IDEAL for funding.

Abstract

Thematic Session: Nano-photonics & Nano-optics

Disciplinary fields involved: Chemistry

Keywords : YVO_4 :Eu^{3+} nanoparticles, Sol-gel synthesis, Luminescent coating, Particle size

Comparative Study of Luminescent Coatings Containing YVO_4:Eu^{3+} Nanoparticles of Different Sizes

Arjun Babu[1], François Réveret[1], Anthony Barros[1], Federico Cisnetti[1], Kevin Lemoine[1], Damien Boyer[1]

1. *Université Clermont Auvergne, Clermont Auvergne INP, CNRS, Institut de Chimie de Clermont-Ferrand (ICCF), F-63000, Clermont-Ferrand, France.*

Recently, the development of luminescent nanoparticles (NPs) exhibiting high quantum yield has emerged as a tremendous goal in the race for miniaturization of optical systems like LED lighting or display devices [1]. Herein, we have studied the influence of NPs size on the optical properties of luminescent coatings. To this end, two types of YVO_4:Eu^{3+} NPs, with average diameters of 10 nm and 340 nm, were synthesized by two different hydrothermal processes [2,3]. This lanthanide ions doped vanadate is well-known to produce a strong red emission upon UV excitation. Then, structural, morphological and optical characterizations were performed to analyse these nanophosphors in detail. Eu^{3+} concentration was evidenced by elementary analysis and Rietveld refinement. Afterwards, these YVO_4:Eu^{3+} NPs were incorporated in a sol-gel based hybrid material with different loading rates and then luminescent coatings were achieved by spin-coating these suspensions onto glass substrates [4]. Their thickness was determined by profilometry and micro-reflectivity measurements. Furthermore, the effect of mass loading and nanoparticle size on the optical properties of luminescent films was also investigated by conducting photoluminescence and UV-visible spectroscopies. Finally, the angular emission distribution was analysed to estimate the photons trapped inside the structure depending on the surface roughness and the NPs size.

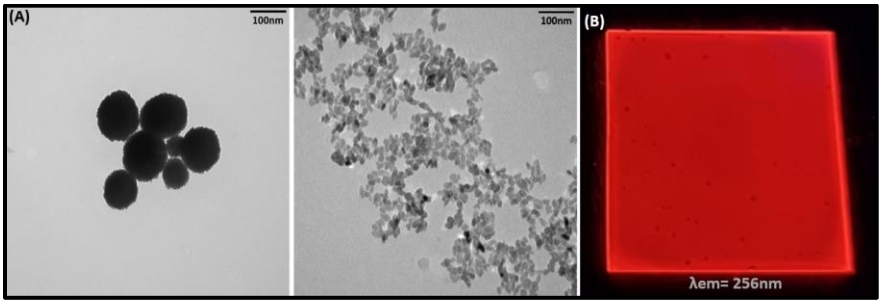


Figure 1. (A) TEM Images of synthesized YVO_4:Eu^{3+} NPs and (B) Image of prepared coating.

References:

1. Terraschke et.al. Chem. Rev. 2015, 115, 11352. 2. Chen.et.al Phys. Chem. Chem. Phys., 2010, 12, 7775

3. K. Riwotzki et.al. J. Phys. Chem. B 1998, 102, 10129 4. Toide et.al. J Sol-Gel Sci Technol 104, 478 (2022)

Acknowledgement:

This work (AutoLum Project) was supported by the International Research Center "Innovation Transportation and Production Systems" of the I-SITE CAP 20-25.

Friday March 21th

10:30 A.M. - 12:30 A.M.

AMPHITHEATRE LOUIS ARMAND EST

Program of the session :

Chairs: Maria TCHERNYCHEVA & Erik DUJARDIN

HOUR	NAME	TITLE
10:30	**Davy GERARD** **L2n - UTT**	**Self-hybridization and hot electron generation in aluminum nanoantennas**
11:00	Jean-François BRYCHE L2n - CNRS	Control of heat anisotropy by pump-probe spectroscopy and imaging method of photodegradation at the nanoscale
11:15	Céline MOLINARO IS2M - CNRS	Macro to nanoscale polymerization induced through controlled heat generation by thermoplasmonics
11:30	Sugi KORATH SHIVAN CINAM - Aix Marseille University	Engineering metasurfaces by plasmon-assisted nanoreactors
11:45	Emmanuel O. IDOWU ICMCB - CNRS	Synthesis of Si@Au core-shell particles for directional light scattering
12:00	Karmel de Oliveira LIMA LCIM - CEA	Nanocomposite scintillators: enhancing nanoparticle incorporation and optical stabilization
12:15	Valentin ALLARD	Optical Nearfield characterization of Nb2O5 and SiO2 dielectric thin films for quantitative measurement in the visible spectral range

Davy GERARD (UTT - L2N, Troyes)

https://recherche.utt.fr/light-nanomaterials-nanotechnologies-l2n/members/davy-gerard

davy.gerard@utt.fr

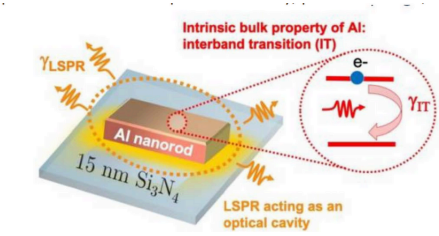
Short biography

Davy Gérard obtained his PhD in physics in 2004 from the University of Burgundy (Dijon) for his work on near-field optical microscopy applied to photonic crystals. In 2008, he joined the Light, nanomaterials, nanotechnologies (L2n) laboratory. Davy Gerard's research focuses on light-matter interactions at the nanoscale, particularly in the vicinity of metallic nanostructures. This encompasses the use of optical antennas and metasurfaces to manipulate light emission, the development of novel plasmonics materials, and the study of chiroptical interactions. His current research endeavors center on aluminum as a novel plasmonic material, particularly in the context of UV-plasmonics, collective resonances in arrays of nanoparticles, and chiral plasmonics.

Self-hybridization and hot electron generation in aluminum nanoantennas

Strong coupling is typically observed between two distinct entities or between an entity and its environment (e.g., an atom and a cavity). However, it can also occur between two distinct excitations within the same object, a phenomenon that has been less extensively investigated. In this work, we present evidence of strong coupling between localized surface plasmon resonances and the interband transition in aluminum nanorods. This coupling is evidenced by optical spectroscopy and electron energy loss spectroscopy (EELS), supported by numerical simulations. The strong coupling involves multiple orders of plasmon modes, including dark modes. The corresponding Rabi energy, which defines the energy splitting between the two polaritonic branches, is determined in each case. Importantly, the use of EELS allowed us to experimentally map the hybrid modes with nanoscale resolution, giving further evidence of the strong coupling. Moreover, a dedicated numerical model [1] is employed to demonstrate that strong coupling in the near-infrared region facilitates efficient hot electron generation, exploiting the hybrid nature of the modes.

The plasmonic component provides a high absorption cross-section, while the interband transition ensures efficient hot electron generation. As a result, aluminum nanorods emerge as a highly efficient source of hot electrons in the visible and near-infrared regions, with possible applications in localized photochemistry, photodetection, and solar energy harvesting.



References

1] Muravitskaya, A.; Movsesyan, A.; Avalos-Ovando, O.; Bahamondes Lorca, V. A.; Correa-Duarte, M. A.; Besteiro, L. V.; Liedl, T.; Yu, P.; Wang, Z.; Markovich, G.; Govorov, A.O. Hot Electrons and Electromagnetic Effects in the Broadband Au, Ag, and Ag–Au Nanocrystals: The UV, visible, and NIR Plasmons. ACS Photonics 2023, 11, 68–84.

Abstract

Thematic Session (Nanophotonic & Nano-optics)
Disciplinary fields involved (Physics)
Keywords (Heat transfer, Near-field, Phonon-polaritons)**:**

Non-monotonic radiative heat transfer in the transition from far field to near field

Victor Guillemot[1], Riccardo Messina[2], Valentina Krachmalnicoff[1], Rémi Carminati[1,3], Philippe Ben-Abdallah[2], Wilfrid Poirier[4], Yannick De Wilde[1]

1. Institut Langevin, ESPCI Paris, Université PSL, CNRS, 75005 Paris.
2. Laboratoire Charles Fabry, Institut d'Optique, CNRS, Paris-Saclay University, 91127 Palaiseau Cedex.
3. Institut d'Optique Graduate School, Paris-Saclay University, 91127 Palaiseau.
4. Laboratoire national de métrologie et d'essais (LNE), 78197 Trappes.

Radiative heat transfer between two bodies separated by a nanometer-sized gap can be orders of magnitude larger than that predicted by classical radiative heat transfer based on Planck's law. Indeed, when the gap distance between the surfaces gets substantially smaller than the thermal wavelength ($\lambda_{Wien} \approx 10$ µm at 25°C), the contribution of surface modes such as surface phonon polaritons allows energy to tunnel through the gap [1]. While several experimental demonstrations of this near-field contribution have already been achieved [2], [3], here we focus our studies to what happens in the transition regime from far field to near field.

We present high precision measurements of the radiative heat transfer of a glass microsphere immersed in a thermal bath in vacuum facing three different planar substrates (SiO2, SiC and Au), which exhibit very different optical properties in the infrared region. Using a thermoresistive probe on a cantilever combined with a very low noise metrological Wheatstone bridge, we measure the temperature variation of the microsphere as a function of the gap size with milliKelvin accuracy, as shown in Fig. 1. For planar substrates supporting surface polaritons giving rise to an enhanced electromagnetic local density of states in the infrared [4], we observed a non-monotonic behavior of the radiative flux between the microsphere and its environment when the microsphere is brought closer to the substrate from the far-field to near field, as shown in Figure 2 [5]. Using the Landauer formalism, we demonstrate that this unexpected behavior is related to the singularities of dressed emission mechanisms in

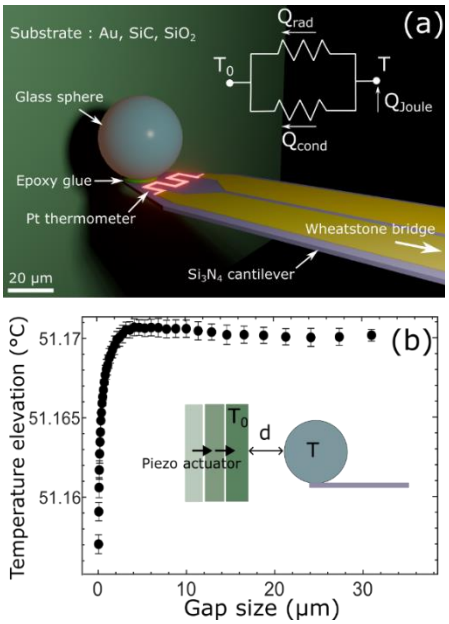


Figure 1: Schematic representation of the setup. (a) A 40µm diameter glass microsphere faces a flat substrate made of gold (Au), silicon carbide (SiC) or fused silica (SiO2). (b) Temperature measurement of the sphere $\Delta T = T - T0$ as a function of the gap size d.

Abstract

the three-body system sphere-substrate-bath with respect to the separation distance. Finally, we show that our experimental setup is a tool of choice for the study of multi-body radiative heat transfer [6].

This work was supported by the "Investissements d'Avenir" program launched by the French Government (Labex WiFi) and by the Agence Nationale de la Recherche (NBODHEAT project, ANR-21-CE30-0030).

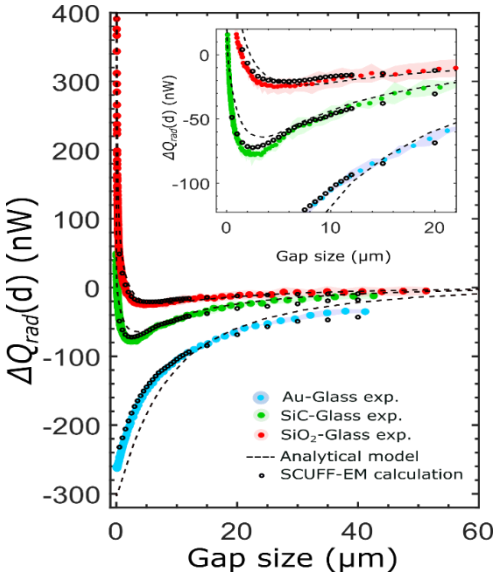


Figure 2: Gap-size dependence of the flux variation between the microsphere and its environment for three different substrates. Analytical model and SCUFF-EM simulations.

References:

[1] J.-P. Mulet, K. Joulain, R. Carminati, and J.-J. Greffet, Enhanced radiative heat transfer at nanometric distances, Microscale Thermophysical Engineering 6, 209 (2002).

[2] E. Rousseau, A. Siria, G. Jourdan, S. Volz, F. Comin, J. Chevrier, and J.-J. Greffet, Radiative heat transfer at the nanoscale, Nature Photonics 3, 514 (2009).

[3] A. Fiorino, D. Thompson, L. Zhu, B. Song, P. Reddy, and E. Meyhofer, Giant Enhancement in Radiative Heat Transfer in Sub-30 nm Gaps of Plane Parallel Surfaces, Nano Letters 18, 3711 (2018).

[4] A. Babuty, K. Joulain, P.-O. Chapuis, J.J. Greffet, Y. De Wilde, Blackbody Spectrum Revisited in the Near Field, Phys. Rev. Lett. 110, 146103 (2013).

[5] V. Guillemot, R. Messina, V. Krachmalnicoff, R. Carminati, P. Ben-Abdallah, W. Poirier, Y. De Wilde, Non-monotonic radiative heat transfer in the transition from far field to near field, arXiv:2410.20394 (2024).

[6] S.-A. Biehs, R. Messina, P. S. Venkataram, A. W. Rodriguez, J. C. Cuevas, P. Ben-Abdallah, Near-field radiative heat transfer in many-body systems, Reviews of Modern Physics 2, 93 (2021).

Abstract

Thematic Session : Nanophotonics & Nanooptics
Disciplinary fields involved (eg. Chemistry, Physics, Biology …)**: Physics & Chemistry**
Keywords (max. 4-5)**: Thermoplasmonics, plasmonic sensing, pump-probe spectroscopy, hot carriers dynamics.**

Control of heat anisotropy by pump-probe spectroscopy and imaging method of photodegradation at the nanoscale

Marlo Vega[1,2,3], Paul-Ludovic Karsenti [1,4], Paul G. Charette[1,2,4], Julien Moreau[3], Michael Canva[1,2], Jean-François Bryche[1,2,4]

1. *Laboratoire Nanotechnologies Nanosystèmes (LN2) - IRL3463, CNRS, Université de Sherbrooke, UGA, ECL, INSA Lyon, Canada.*
2. *Institut Interdisciplinaire d'Innovation Technologique, 3IT, Université de Sherbrooke, Canada.*
3. *Laboratoire Charles Fabry - UMR 8501, Université Paris-Saclay, IOGS, CNRS, France.*
4. *Faculté des Sciences, Université de Sherbrooke, Sherbrooke, Canada.*

By absorbing and converting light into heat, metal nanoparticles behave as sources of heat that could be utilized in fields such as biosensors, energy or photocatalysts.

In this work, we first investigate the photothermal heating of asymmetric nano-crosses by ultrashort light pulses. We focus on gold crosses on gold film atop a glass substrate. Samples are fabricated by e-beam lithography [1,2]. The crosses are 300/410 nm lengths, 60 nm height, 60 nm width with periods 530-640 nm. We show experimentally and numerically that the spatial distribution of non-thermal energy density and temperature inside the two arms of the crosses can be controlled with the polarization and fluence of the pump pulse. We also demonstrate the importance of considering non-thermal electron ballistic displacement to reproduce the measured experimental data in pump-probe spectroscopy [2].

Secondly, we investigate induced photodegradation phenomena. We report a new methodology for patterning and imaging surface chemistry with nanoscale resolution. It relies on SEM imaging of silica nanobeads as nano markers of local photodegradation on and around gold nanostructures, as generated under pulsed illumination (Fig1). This localized photothermal degradation could be used for sensing applications where molecules need to be localized only in areas of high electric field [3].

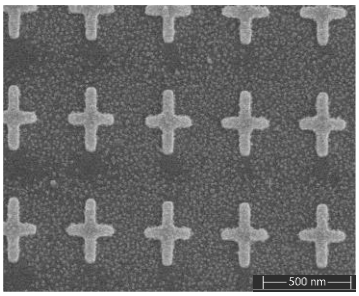


Figure 1. SEM pictures of local photodegradation between gold nanocrosses.

References :

[1]. P. Bresson, J-F Bryche, *et al.*, "Improved two-temperature modeling of ultrafast thermal […]", Physical Review B, 102, 15 (2020). 10.1103/physrevb.102.155127

[2]. J-F Bryche*; M. Vega*, *et al.*, "Ultrafast Heat Transfer at the Nanoscale: Controlling Heat Anisotropy," ACS Photonics, 2023, 10, 4. 10.1021/acsphotonics.2c01968.

[3]. J-F. Bryche *et al.,* "Spatially-Localized Functionalization […] Enhanced Plasmonic Sensing Efficacy," Nanomaterials, 2022, 12, 20. 10.3390/nano12203586

Abstract

Thematic Session: Nanophotonics & Nanooptics

Disciplinary fields involved: Physics & Chemistry

Keywords: thermoplasmonics, polymerization, gold nanoparticles, fs laser, cw laser

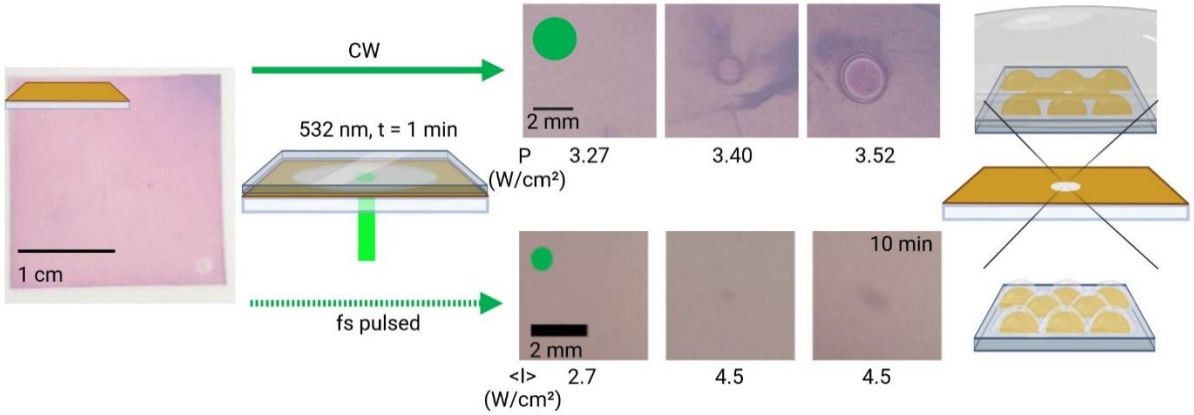
Macro to nanoscale polymerization induced through controlled heat generation by thermoplasmonics

C. Molinaro[1,2], A. Khitous[1,2], S. Haacke[3], O. Soppera[1,2]

1. *Université de Haute Alsace, CNRS, IS2M UMR 7361, Mulhouse, France*
2. *Université de Strasbourg, Strasbourg, France*
3. *IPCMS, Université de Strasbourg, Strasbourg, France*

Localized surface plasmon induced polymerization of free-radical acrylate monomers is an efficient, smart, and versatile method for preparing metal/polymer hybrid nanoparticles (NPs) with accurate control of the thickness and spatial distribution of the polymer on the NP surface. Through decay processes, the plasmon emitted light, hot charge carriers and heat. While the photochemical pathway is well known for generating hybrid NPs,[1] thermoplasmonic effects have not been used in this context.

Here, we investigated thermoplasmonic route to graft polymer onto gold NPs. First, we developed a thermopolymer with a threshold temperature around 130°C. A 532 nm laser illumination was used to match the gold NPs plasmonic resonance. Here, we addressed specifically thermopolymerization through two different laser regime with a continuous and fs-pulsed laser illumination (see figure below).



In continuous laser illumination, a 100-µm thick polymer dot is observed. Its size might be surprising in comparison with the nanometric size of the NPs. This observation can be explained by a collective heating effect.[2] By comparison, in the fs-pulsed laser illumination, a nanometric polymer (dark spot) is generated only around each NPs. In conclusion, by addressing the laser regime in a specific way, it is possible to generate nanometric to almost millimetric polymer through thermoplasmonics, opening new pathway for grafting thermoresponsive materials at different scale.

References:

[1] A. Khitous *et al.* JPCC 2024 [2] C. Molinaro *et al.* ACS Appl. Polym. Mater. 2024

Acknowledgement: *This work was supported by a French government grant managed by the Agence Nationale de la Recherche under the France 2030 investment plan, reference ANR-22-EXLU-0002.*

Abstract

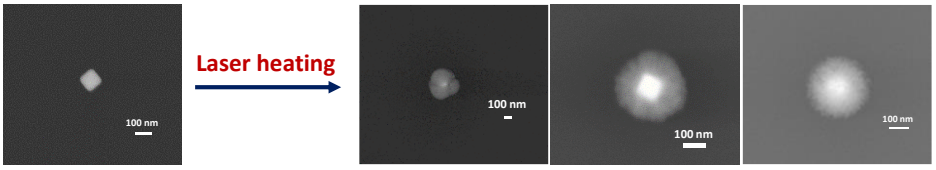
Thematic Session (Nanophotonics & Nanooptics)
Disciplinary fields involved: Physics and chemistry
Keywords: Plasmonics, photothermal, nanomaterials, assembly

Engineering metasurfaces by plasmon-assisted nanoreactors

Korath Shivan Sugi[1], Nathan Ullberg[2], Peeranuch Poungsripong[1], Guillaume Baffou[2], and Beniamino Sciacca[1]

1. *Aix-Marseille Univ, CNRS, CINaM, Marseille 13288, France*
2. *Institut Fresnel, CNRS, Aix-Marseille Université, Domaine Universitaire Saint-Jérôme, 13397 Marseille, France*

Plasmonic metal nanoparticles (NPs) have garnered significant attention as heat sources due to their ability to generate and confine temperature gradients into ultra small volumes, which is attributed to their unique optical properties.[1, 2] Moreover, they are also employed in fabricating plasmonic metasurfaces, as they offer large spectral tunability and enhanced resistance to fading compared to conventional pigment-based color generation methods.[3] In this study, we present a novel approach for designing metasurfaces through plasmon-assisted hydrothermal reactions.[4] The methodology involves generating a localized temperature field by irradiating individual plasmonic NPs or arrays with a focused laser, followed by optical wavefront microscopy for temperature characterization.[5] Precise control over shell formation is achieved by modulating laser irradiance, which enables rapid manipulation and fabrication of diverse shell thicknesses within a single experimental setup, in contrast to traditional autoclave synthesis techniques. We have extended this strategy to engineer plasmonic metasurfaces with tailored properties. We believe that insights gained from this investigation will significantly contribute to the development of hierarchical plasmonic nanoparticle based metasurfaces.



References:

1. Oksenberg, E.; Shlesinger, I.; Xomalis, A.; Baldi, A.; Baumberg, J. J.; Koenderink, A. F.; Garnett, E. C., Energy-resolved plasmonic chemistry in individual nanoreactors. *Nature Nanotechnology* **2021,** *16* (12), 1378-1385.
2. Baffou, G.; Quidant, R., Thermo-plasmonics: using metallic nanostructures as nano-sources of heat. *Laser & Photonics Reviews* **2013,** *7* (2), 171-187.
3. Hail, C. U.; Schnoering, G.; Damak, M.; Poulikakos, D.; Eghlidi, H., A Plasmonic Painter's Method of Color Mixing for a Continuous Red–Green–Blue Palette. *ACS Nano* **2020,** *14* (2), 1783-1791.
4. Kamarudheen, R.; Kumari, G.; Baldi, A., Plasmon-driven synthesis of individual metal@semiconductor core@shell nanoparticles. *Nature Communications* **2020,** *11* (1), 3957.
5. Baffou, G.; Bon, P.; Savatier, J.; Polleux, J.; Zhu, M.; Merlin, M.; Rigneault, H.; Monneret, S., Thermal Imaging of Nanostructures by Quantitative Optical Phase Analysis. *ACS Nano* **2012,** *6* (3), 2452-2458.

Acknowledgement:
We thank Amidex (project NACHT) for funding.

Abstract

Thematic Session: Nanophotonics & Nano-optics

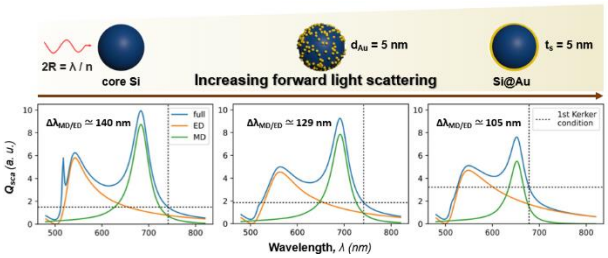
Disciplinary fields involved: Chemistry, Physics

Keywords: Mie resonances, core-shell particles, directional scattering, electron energy loss spectroscopy (EELS), darkfield spectroscopy

Synthesis of Si@Au core-shell particles for directional light scattering

Emmanuel O. Idowu[1], Lucien Roach[1], Kevin O'Connor[2], Jonathan G. C. Veinot[2], Sabrina Lacomme[3], Julien Proust[4], Jérôme Plain[4], Xiaoyan Li[5], Mathieu Kociak[5], Alexandre Baron[6,8], Virginie Ponsinet[6], Peter Wiecha[7], and Glenna L. Drisko[1]

Metamaterial researchers have sought to create nanostructures with strong directional optical scattering to control light propagation at the nanoscale. Core-shell architectures comprised of both optically resonant cores and shells have been suggested as candidate particles in which the spectral overlap of the electric and magnetic dipoles can be controlled to create strong directional scattering. [1] Crystalline silicon is one of the best-known dielectric materials for manipulating visible light. [2] The arrangement of these particles into a 2D array could allow us to realize metasurfaces lacking absorption losses and suppressing unwanted reflections. This could be interesting for flat optical devices, light harvesting, holograms, etc. [3] In this study, we present the synthesis of Si@Au core-shell particles. We characterized the resonant behavior of the core-shell particles using electron energy-loss mapping and optical single-particle scattering spectroscopy. These observations were supported by T-matrix simulations and Mie-theory calculations of the scattering spectra (*see Figure*). The result showed that Si@Au particles demonstrated a slightly better directional forward scattering, which could be improved further by obtaining a thin continuous shell. However, the problem with the optical response is the particular, non-conducting character of the thin shell.



Mie theory and T-matrix simulated scattering spectra for core Si, decorated and core-shell Si@Au particles with (a) 170 nm diameter Si core (b) Au shell composed of particles 5 nm in diameter, with a surface coverage of 50 % or (c) a continuous Au shell with a 5 nm thickness.

References:

1. Chaâbani, W., *et al. The Journal of Physical Chemistry C*. **2021**. 125 (37), 20606–20616.
2. O'Connor, K. M., *et al. Chemistry of Materials*. **2023**. 35 (19), 7967–7973.
3. Negoro, H., *et al. Advanced Optical Materials*. **2022**. 10 (8), 2102750

Acknowledgement:

This project is supported by funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (Scatter, Grant agreement No. 948319) and the Agence Nationale de la Recherche (ANR) under the project AIM (ANR-23-CE09-0011).

1. Univ. Bordeaux, CNRS, Bordeaux INP, ICMCB, UMR5026, 33600 Pessac, France.
2. Department of Chemistry, University of Alberta, Edmonton, Alberta T6G 2G2, Canada.
3. Univ. Bordeaux, CNRS, INSERM, Bordeaux Imaging Center, UAR3420, 33600 Pessac, France.
4. Light, Nanomaterials, Nanotechnologies (L2n), CNRS UMR 7076, Univ. Technology of Troyes, 10000 Troyes, France.
5. Université Paris-Saclay, CNRS, Laboratoire de Physique des Solides, 91405 Orsay, France.
6. Univ. Bordeaux, CNRS, CRPP – UMR5031, Pessac, 33600 France.
7. LAAS, Université de Toulouse, CNRS, 31000 Toulouse, France.
8. Institut Universitaire de France, 1 Rue Descartes, 75231 Paris Cedex 05, France.

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Chemistry, Physics
Keywords: nanoparticles, nanocomposites, quantum plates, scintillation

Nanocomposite scintillators: enhancing nanoparticle incorporation and optical stabilization

Karmel de Oliveira Lima[1], Cora Moreira da Silva[1], Victor Buridon[1], Michele D'Amico[2], Patrick Gredin[3,4], Alban Ferrier[3,4], Hana Buresova[5], Dominique Rothan[5], Vincent Schoepff[1], Dominique Tromson[1], Guillaume H. V. Bertrand[1]

1. *Université Paris-Saclay, CEA, List, F-91120, Palaiseau, France*
2. *Nexdot,Romainville, France*
3. *Chimie ParisTech, PSL University, CNRS, Institut de Recherche de Chimie Paris, Paris, France*
4. *Faculté des Sciences et Ingénierie, Sorbonne Université, Paris, France*
5. *NuviaTech Instruments & Healthcare, Rueil Malmaison, France*

The detection, recognition and quantification of nuclear material remains critical priorities in the current geopolitical context for national security and nuclear safety. Plastic scintillators are widely used in portable detection devices due to their low cost and production adaptability. However, they have limitations, especially in identifying high-energy gamma (γ) emitters, due to their low effective atomic number (Z_{eff})[1]. Recent advancements in nanomaterials enable the development of nanocomposite scintillators with higher Z_{eff} and great light yields, significantly improving γ-ray detection efficiency in polymer matrices.

In this study, CdSe/CdS dot-in-plates are incorporated into a polystyrene (PS) matrix. The higher density, robustness, and tunable absorption and emission wavelengths of these quantum plates (QP) have the potential to significantly enhance γ detection performance. To achieve optimal performance and optical long-term stability, various reaction parameters were investigated. The nanocomposite scintillators were characterized using transmission electron microscopy (TEM) to evaluate particle distribution after the polymerization process and the influence of surfactant presence. Photophysical characterizations were performed to determine their optical properties and scintillation yield over time.

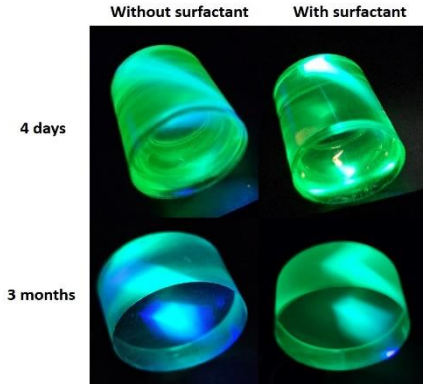


Figure 1. Nanocomposite scintillators were prepared both without and with surfactant. Images were captured under 400 nm excitation at various time intervals following the polymerization process.

1. G. H. V. Bertrand, M. Hamel and F. Sguerra, "Current Status on Plastic Scintillators Modifications", Chemistry – A European Journal, 20, 15660–15685 (2014).

Acknowledgement:

This work is supported by the French National Research Agency (Agence Nationale de la Recherche) under grant agreement ANR-22-CE39-0011-01. The authors acknowledge the Imagerie-Gif core facility supported by l'Agence Nationale de la Recherche (ANR-10-INBS-04/FranceBioImaging; ANR-11-IDEX-0003-02/ Saclay Plant Sciences).

Poster Session

NANOPHOTONICS & NANOOPTICS

N° POSTER	TITLE	NOM	Prénom
1	Plasmon-induced thermo-polymerization of PETA in presence of various thermal initiators	BASTIDE	Mathieu
2	Twin-photon generation and manipulation in thin film lithium niobate on insulator waveguides	BENCHEIKH	Kamel
3	24 mode universal photonic processor in a femto second laser writing platform	BENEFICE	Maelle
4	Tomographic Shearmetry of Flows at Cell Surfaces using Nanoprobes	BONETTI	Marcello
5	Thousand-fold Purcell factors for single molecules in DNA origami-assembled gold nanocube dimers	CAPUZZO	Marco
6	Bright, large and flexible structural colors	CHOUITER	Manele
7	SMARTLIGHT PLATFORM: a french key facility for smart photonics	CLUZEL	Benoit
8	GaAs Schottky diodes with sub-micron anode for THz applications	CUVELLIER	Jean-Baptiste
9	Ultrasensitive Label-Free Optical Detection Based on Functionalized Plasmonic Nanofilms and Enhanced Phase Singularity	DU	Fusheng
10	Optimized Electron Beam Lithography for the Fabrication of Resonant Waveguide Gratings	DUSSARD	Antoine
11	Controlling fluorescence of perovskite quantum dots with nanostructured aluminum	GARCELON	Eloïse
12	Mapping of Surface Acoustic Waves for Mid-Infrared Integrated Acousto-Optics	GÉRODOU	Thomas
13	High sensitivity Grating-SPR based sensor using Low-Loss Surface Plasmon modes coupling for the detection of H2	MEYER	Arnaud
14	Enhancement of quadratic nonlinear responses from resonant Gallium Phosphide nanospheres	GUENGARD-MORINEAU	Lola
15	Optically magnetizing gold nanoantennas through the Inverse Faraday effect	HAREAU	Chantal
16	Molecular photoactuators at the nanoscale	ISHOW	Eléna
17	All-optical, interconnect-free Arithmetic and Logic Units (ALU): design by hybrid AI, nanofabrication and experimental demonstration	KHITOUS	Amine
18	Nonlinear generation of orbital angular momentum in metasurfaces	LECASBLE	Célestin
19	Microscope stabilization for single particle tracking in thick biological tissues using phase imaging	MANKO	Hanna
20	Skyrmion Generation in a Plasmonic Nanoantenna through the Inverse Faraday Effect	MIVELLE	Mathieu
21	Compact Light Projector Metalens	OUSSAID	Ziad
22	ZnO nanowire-based gratings for light extraction enhancement	RÉVERET	François
23	Photonic crystal nanostructures for strong atom-photon interaction in a quantum network	SAUTEL	Valère
24	Thermalization of photons in disordered scattering media	SONCIN	Lorenzo
25	From optically-pumped towards electrically-pumped ridge polariton laser	SOUISSI	Hassen
26	Photoluminescence enhancement based on multi-material metasurfaces	SRAJ	Ali
27	In-rich InGaN/GaN nanowires for red light emitting diodes	TCHOULAYEU POSSIE	Nidel Dilan
28	Optimization of thermochromic perovskites (RENiO3) radiative properties for thermal screening application	TOSTIVINT	Pierre-Antoine
29	Enhanced Near-Infrared Plasmonic Sensing Chips with Ultra-Thin Optical Absorption Nanolayer Fabricated by Cross-beam Pulsed Laser Deposition	ZAKIROV	Nurzad
30	Composites nanoparticles/liquid crystals, structure and electro-optical properties	ZHOU	Muyan

Abstract

Thematic Session Nanophotonics & nano-optics, Nanochemistry & Nanoparticles,
Disciplinary fields involved Physics, Chemistry
Keywords (max. 4-5)**: Thermoplasmonics, Gold Nanoparticles (AuNPs), Thermopolymerization, Thermal Initiators**

Plasmon-induced thermo-polymerization of PETA in presence of various thermal initiators

Mathieu Bastide[1,2], Olivier Soppera[1,2], Céline Molinaro[1,2]

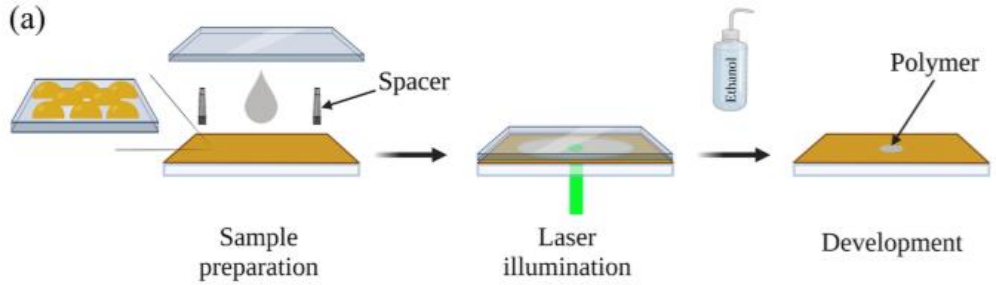
1. *Université de Haute Alsace, CNRS, IS2M UMR 7361, Mulhouse, France*
2. *Université de Strasbourg, Strasbourg, France*

Abstract

We have previously introduced a novel thermopolymerization method using gold nanoparticles (AuNPs) to determine the heat generated during plasmonic effects.[1,2] The system employs Pentaerythritol Triacrylate (PETA) as a monomer combined with different thermal initiator. Upon laser irradiation at 532 nm, the AuNPs generate heat that initiates the polymerization of the thermal formulation, enabling temperature mapping of the substrate.

The methodology involves depositing the thermal formulation on AuNPs-coated substrate and exposing it to varying laser powers. The thermopolymerization is visibly detectable as polymerized regions correlate with localized heating induced by AuNP irradiation. Importantly, the study validates the thermal pathway by excluding photopolymerization, owing to the transparency of the formulation in the irradiation spectrum. Differential Scanning Calorimetry (DSC) and hot-plate tests confirm the temperature needed to reach the polymerization threshold for each thermal initiator.

This approach leverages collective heating effects from densely packed AuNPs, which amplify temperature distribution beyond individual nanoparticle scales. Experimental results demonstrate the precise control of polymer dot size and shape based on laser power and exposure duration.
This thermoplasmonic polymerization framework provides a rapid, marker-free method to probe heat generation. Its potential extends to fabricating metal-polymer nanocomposites and verifying temperature models in plasmonic systems.



Reference :
1 Molinaro, C., Khitous, A., & Soppera, O. (2024). ACS Applied Polymer Materials.
Acknowledgement: *This work is supported by Fondation de la Maison de la Chimie.*

Abstract

Thematic Session : Nanophotonics & nan-optics
Disciplinary fields involved : Physics
Keywords: Nonlinear optics, Quantum optics, Thin Film Lithium Niobate

Twin-photon generation and manipulation in thin film lithium niobate on insulator waveguides

E. M. Valentini[1], A. Henry[1,2], D. Barral[3], I. Zaquine[3], N. Belabas[1] , A. Boes[4,5,6], A. Mitchell[4], K. Bencheikh[1]

1. *Centre for Nanoscience and Nanotechnology, CNRS, Université Paris-Saclay, UMR 9001,10 Boulevard Thomas Gobert, 91120, Palaiseau, France*
2. *LTCI, Télécom Paris, Institut Polytechnique de Paris, 19 place Marguerite Perey, 91120, Palaiseau, France*
3. *Laboratoire Kastler Brossel, Sorbonne Université, CNRS, ENS-PSL Research University, Collége de France, 4 place Jussieu, F-75252 Paris, France*
4. *Integrated Photonics and Applications Centre (InPAC), School of Engineering, RMIT University,Melbourne, VIC 3001, Australia*
5. *Institute for Photonics and Advanced Sensing (IPAS), University of Adelaide, SA 5005, Australia*
6. *School of Electrical and Electronic Engineering, University of Adelaide, SA 5005, Australia*

Twin photon sources constitute one of the elementary building blocks necessary for the manipulation and processing of quantum information. The entanglement and superposition properties of twin photons are two quantum characteristics widely exploited in different protocols quantum information. A new emerging platform based on thin film lithium niobate on insulator (LNOI) [1], allows stronger confinements of optical modes, opening the way to the manufacture of increasingly compact and integrated devices. This new lithium niobate platform in thin film has enabled numerous pioneering demonstrations in classical and quantum optics in recent years. Indeed, with sub-micrometric optical modes propagating in waveguides produced on this platform, the optical intensities become very high and nonlinear and electro-optical interactions increasingly effective.
We will present our work on the generation and manipulation of twin photons in periodically poled lithium niobate waveguide fabricated on the LNOI platform [2], going from the source characterization to Hong-Ou-Mandel like experiment in the frequency domain. We will also present the perspectives towards the generation and manipulation of non-gaussian quantum states on this plateform.

References:
[1] Di. Zhu, L. Shao, M. Yu, et.al., ‘’Integrated photonics on thin-film lithium niobate’’**,** Adv. Opt. Photon. **13**, 242 (2021).
[2] A. Henry, D. Barral Rana, I. Zaquine, A. Boes, A. Mitchell, N. Belabas, and K. Bencheikh, “Correlated twin-photon generation in a silicon nitrite loaded thin film PPLN waveguide,” Opt. Express, **31**, 7277 (2023).

Abstract

Acknowledgement:
We acknowledge the support of the international Associated Laboratory in Photonics between France and Australia (ALPhFA+)

Abstract

Thematic Session: Nanophotonics & nano-optics

Disciplinary fields involved: physics, quantum, photonics, photolithography

Keywords: Universal Photonic processor, Femto second laser writing, reconfigurable MZI

24 mode universal photonic processor in a femto second laser writing platform

Andrea Barzaghi[1], Maëlle Bénéfice[1,] Francesco Ceccarelli[1], Giacomo Corrielli[1], Valerio Galli[1], Marco Gardina[1], Vittorio Grimaldi[1], Jakub Kaczorowski[1], Francesco Malaspina[1], Roberto Osellame[1], Ciro Pentangelo[1], Andrea Rocchetto[1], Alessandro Rudi[2,1]

***Authorship are sorted alphabetically**

[1]Ephos, Inc., 333 Bush Street, San Francisco, CA 94104, USA.
[2]SDA Bocconi School of Management, Via Sarfatti 10, Milano, 20136, Italy.

Abstract (**no longer than 250 words** or 18 lines max. incl. figure), Calibri 11, single line spacing, black)

Photonic integrated circuits are gaining traction in quantum communications, computing, and sensing [1]. Universal photonic processors (UPPs) [2] are particularly promising due to their ability to perform any unitary transformation on a quantum photonic state. These processors rely on programmable Mach-Zehnder interferometers (MZIs) and are fabricated using materials like silicon nitride, silicon, and glass. Among fabrication techniques, femtosecond laser writing (FLW) [3] stands out as a cost-effective method for creating high-quality, low-loss waveguides in glass substrates across a broad wavelength range. FLW also enables polarization transparent operation [4], the formation of hollow microstructures, enhancing thermal insulation and reducing power dissipation and crosstalk in thermo-optic MZIs.

This work introduces the first 24-mode FLW-UPP, the most complex UPP to date, optimized for quantum dot single-photon sources at 925 nm. It achieves low insertion losses of 3.5 dB, making it suitable for advanced multi-photon quantum experiments. By incorporating suspended waveguides, the device efficiently operates 600 thermo-optic phase shifters with under 30 W power consumption, requiring only a simple thermo-electric cooler. A three-step photolithography process ensures high phase stability and long-term reliability. Standard calibration methods, combined with machine learning, compensate for fabrication tolerances and enable precise phase control. The fully equipped device, featuring optical fibers and electrical connectors, integrates seamlessly into experimental setups. Preliminary calibration results demonstrate a high reproducibility in directional coupler performance, with amplitude fidelity exceeding 97% on unitary matrix switching. These findings highlight FLW-UPPs' potential for advancing scalable quantum photonic technologies.

References (max. 5):

[1] Wang, Jianwei, et al. "Integrated photonic quantum technologies." *Nature Photonics* 14.5 (2020): 273-284.
[2] Bogaerts, Wim, et al. "Programmable photonic circuits." *Nature* 586.7828 (2020): 207-216.
[3] Corrielli, Giacomo, et al. "Femtosecond laser micromachining for integrated quantum photonics." *Nanophotonics* 10.15 (2021): 3789-3812.
[4] Pentangelo, Ciro, et al. "High-fidelity and polarization-insensitive universal photonic processors fabricated by femtosecond laser writing." *Nanophotonics* 13.12 (2024): 2259-2270.

Abstract

Thematic Session Nanophotonics & nano-optics, nanomaterials, nanobioscience & nanomedicine, nanochimie &nanoparticules **:**
Disciplinary fields involved: Nanoparticles, Microfluidics, Biology
Keywords (max. 4-5): LaPO4:Eu, Polarized Photoluminescence, Shear Stress

Tomographic Shearmetry of Flows at Cell Surfaces using Nanoprobes

Author 1[1], author 2[2], etc. (Calibri 11, bold, RVB 52 73 94 color)

Marcello Bonetti[1], Arianna Giannetti[2], Zijun Wang[1], Qilin Zou[1], Lilian Magermans[1], Claire Desalles[2], Bruno Louis[3], Marcel Filoche[3], Abdul Barakat[2], Thierry Gacoin*[1], Jongwook Kim*[1]

1. PMC, *École polytechnique*, *Palaisseau, France*
2. *LADHYX, École polytechnique, Palaisseau, France*
3. *IMRB, Paris Est, Creteil, France*

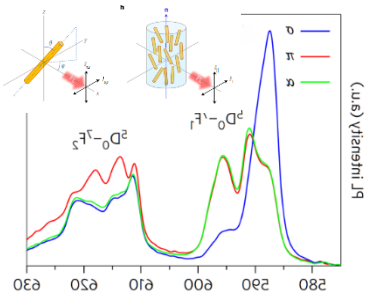


Figure 1 Photoluminescence spectrum of LaPO4 :Eu [1]

We have developed a novel shearmetry method that allows us to locally probe shear stress inside a microfluidic channel[1]. The technique consists in measuring the photoluminescence (PL) spectra of LaPO4:Eu nanorods using a confocal microscope with a focal volume of less than 1 µm^3. Since the rods exhibit strongly polarized PL, we are able to correlate the PL spectra to the orientation of a single particle or the collective orientation of an ensemble of particles[1]. The latter is defined by the director and the orientational order parameter of the ensemble. By means of a calibration function we are then able to convert the order parameter into flow shear[1].
We apply this technique in diverse fields in which direct measurements of shear are of interest. Our specific aim now is to study how shear forces are transduced intracellularly to activate biological responses responsible for the pathological events[2,3] by measuring shear stress at the cell surface. Major steps for this goal have been achived by functionalizing the particles with a zwitterionic polymer to make them colloidally stable in physiological solution[4] and a first proof of concept has already been done with human cells[5].

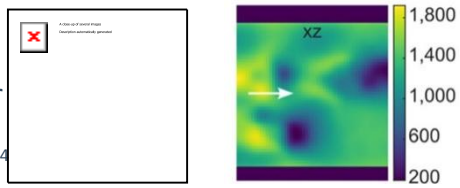


Figure 2 tomography at cell surface[4]

References (max. 5):
1 J. Kim et al., Monitoring the orientation of rare-earth-doped nanorods for flow shear tomography. Nature Nanotech. 12, 914(2017)

Abstract

2 Y. S. Chatzizisis et al., Role of Endothelial Shear Stress in the Natural History of Coronary Atherosclerosis and Vascular Remodeling: Molecular, Cellular, and Vascular Behavior. J. Amer. Coll. Card. 49, 2379-2393 (2007).
3 Y.-S. J. Li, J. H. Haga, S. Chien, Molecular basis of the effects of shear stress on vascular endothelial cells. Journal of Biomechanics 38, 1949-1971 (2005).
4 Zijun Wang, Fanny Delille, Sophie Bartier, Thomas Pons, Nicolas Lequex, Bruno Louis, Jongwook Kim, and Thierry Gacoin *Langmuir* 2022 *38* (34), 10512-10519
5 Zijun Wang, Qilin Zou, Lilian Magermans, Gabriel Amselem, Claire A. Dessalles, Bruno Louis, Marcel Filoche, Thierry Gacoin, and Jongwook Kim*ACS Nano* 2024 *18* (44), 30650-30657

Acknowledgement:
(*calibri 10)*

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics, Chemistry
Keywords: Plasmonic resonators, DNA origami technology, Fluorescence microscopy

Thousand-fold Purcell factors for single molecules in DNA origami-assembled gold nanocube dimers

Marco Capuzzo[1], Claudia Corti[1], Nicolas Triomphe[2], Gabriel Vazquez[2], Sylvie Marguet[3], Gaëtan Bellot[2], Sébastien Bidault[1]

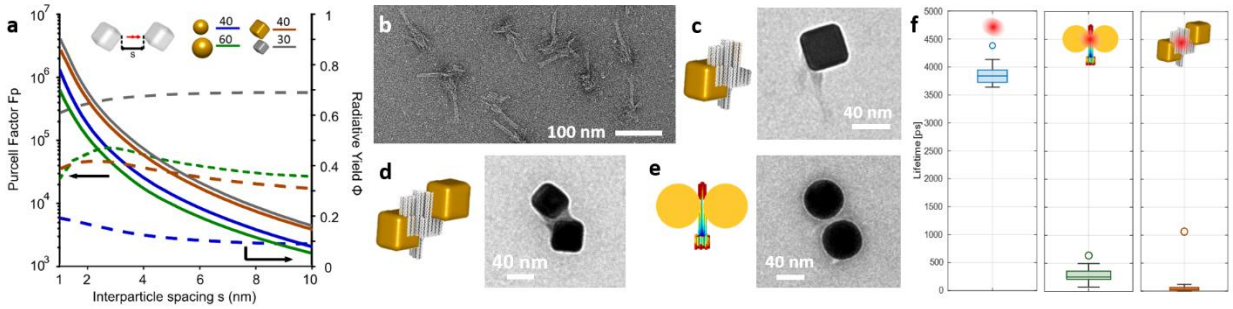
1 Institut Langevin - ESPCI Paris – PSL
2 CBS - Centre de Biochimie Structurale, Univ. Montpellier
3 CEA Saclay - Univ. Paris-Saclay

The extreme field confinements provided by dimers of gold nanoparticles not only allow the enhancement of single molecule fluorescence by several orders of magnitude [1] but can also accelerate spontaneous emission thanks to the Purcell effect to reach coherent light-matter interactions at room temperature such as a strong coupling regime [2]. We recently proposed the use of dimers of gold nanocubes to maximize both the Purcell factor and the emission yield for single emitters, compared to dimers of spheres (Fig. 1-a) [3].

To produce gold nanocube dimers featuring a single molecule between their tips, we exploit the exquisite nanoscale control afforded by DNA origamis (Fig. 1-b). The DNA origami is designed to be grafted specifically on the tips of the gold nanocubes (Fig. 1-c), allowing the successful assembly of nanocube dimers along their tips (Fig. 1-d). To compare the optical properties of these nanostructures to nanosphere dimers, another DNA origami was designed to assemble two 60 nm gold spheres (Fig. 1-e).

Single-molecule measurements reveal a significant reduction in fluorescence lifetimes when the emitter is positioned in gold nanosphere and nanocube dimers, with a significant gain in Purcell factor for nanocubes (Fig. 1-f). In the latter case, some single molecules feature lifetimes that cannot be differentiated from the instrument response function, indicating lifetimes below 5 ps and Purcell factors of 1000 or more. These results open exciting perspectives for the study of coherent light-matter interactions with bright single quantum emitters at room temperature.

Abstract



References:
[1] S. Bidault et al., ACS Nano 10, 4806 (2016)
[2] J. Heintz et al., ACS Nano 15, 14732 (2021)
[3] J. Heintz et al., J. Phys. Chem. Lett. 13, 11996 (2022)

Abstract

Thematic Session : Nanophotonics & nano-optics

Disciplinary fields involved : Materials Chemistry

Keywords : Metasurface, Structural color, Visible modulator, Conductive polymers

Bright, large and flexible structural colors

Manele CHOUITER[1,2], Fengdi LI[1], Hafid EL-IDRISSI[1],Eduardo ALVEAR[1]
Frederic VIDAL[2], Cedric PLESSE[2], Pierre-Henri AUBERT[2], Xavier SALLENAVE[2]

1. *VALEO Lighting Systems, Bobigny, FRANCE (* manele.chouiter@valeo.com / eduardo.alvear@valeo.com)*
2. *LPPI, Cergy, FRANCE*

Structural colors, achieved through nanoscale engineering of light interactions, offer a sustainable alternative to traditional dyes and pigments. The purpose of our study is to convert sunlight into desired colors for illuminating large surfaces, reducing power consumption during the day, and enhancing compactness of traditional displays. This approach aims to provide a high-visibility, energy-efficient solution for large panels. Key challenges include color generation [1], ensuring high visibility, and achieving a scalable pixelated surface. The reflective structure consists of a broadband absorber [2], based on a metallic substrate (aluminum <100nm), a dielectric layer (PMMA <300nm), and a semi-transparent slab (gold and chromium <5nm). This structure is modeled using Lumerical's FDTD solver which irradiates it with a broadband light source to simulate sunlight.

Large-scale reflective surfaces (5cm x 5cm) are fabricated using spin coating and metallization processes. Optical characterizations are performed using a spectrophotometer (KONICA Minolta CM-5), showing broadband structural color reflections, presented in Fig. 1 (a). The main difference is the transparent dielectric layer thickness made with PMMA that plays an important role in the obtained color reflection, presented in Fig. 1(b). Both theoretical and experimental results demonstrate bright, large, and flexible structural colors. Future work will focus on the activation and dynamic modulation of these nanocavities using conjugated polymers, enabling color tuning by adjusting the nanocavity thickness.

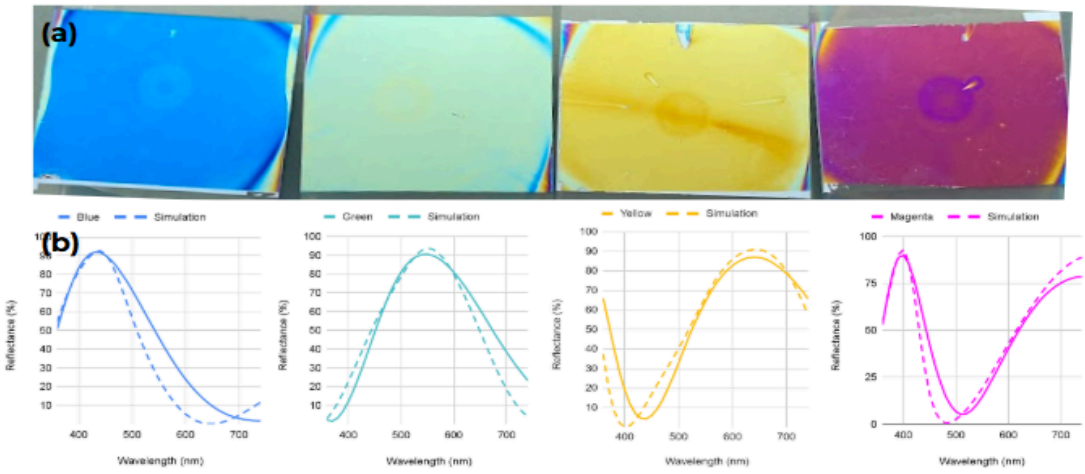


Figure 1: (a) Large-scale reflective surfaces of 5cm x 5cm size are fabricated through spin coating and

metallization processes. (b) Broad-band structural-color reflection optically characterized using Konica Minolta CM-5 spectrophotometer.

References:
[1] Ropars, G., & Le Floch, A. (2007). Interféromètre de Jamin-Fabry-Pérot et dynamique des films de savon. Sciences de l'ingénieur. https://doi.org/10.51257/a-v1-re91
[2] Rossi, S., & Jonsson, M. P. (2021). Highly reflective optical nanocavities for structural coloration by combining broadband absorber and Fabry-Pérot effects. Journal of Optics (United Kingdom), 23(1). https://doi.org/10.1088/2040-8986/abccfe

Acknowledgement:
We would like to thank Pr. Xavier Sallenave, Frederic Vidal, Cedric Plesse and Pierre-Henri Aubert and their team at LPPI and Alan from C2N for their help and insights.

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved : Physics
Keywords (max. 4-5)**: Smart Photonics, AI**

SMARTLIGHT: a key French Facility for Smart Photonics

Benoit Cluzel[1]

1. *Université de Bourgogne Europe, Laboratoire ICB, UMR CNRS 6303*
   9, avenue Alain Savary, 21078 DIJON Cedex

Abstract
Labeled EquipEx+ in 2021 and member of PEPR LUMA platform hub since 2025, the SMARTLIGHT platform is hosted by the Laboratoire Interdisciplinaire Carnot de Bourgogne (Dijon) and the FEMTO-ST Institute (Besançon). It is equipped with unique facilities dedicated to the development of photonic technologies combining artificial intelligence and light sciences. This infrastructure aims to catalyze innovation in photonics through state-of-the-art equipment and an interdisciplinary approach.
It is divided into four technology clusters, each equipped with innovative equipment funded by France 2030, and region Bourgogne-Franche-Comté: 1) The optoelectronics cluster groups together equipment for the preparation and characterization of optoelectronic signals up to 100GHz. 2) The Multimodal Microscopy Cluster houses ten optical microscopy stations, with various configurations, including far-field and near-field microscopy. 3) The 3D Optics Cluster offers solutions for the production of fiber-reinforced components, integrated photonic circuits and optofluidic devices, including a 3D glass printer with nanometric resolution. 4) The Ultrafast Laser Cluster includes fifteen femtosecond laser systems for ultra-short process analysis and micro-nanostructuring, covering a wide range of wavelengths and energies, and coupled to a variety of spatial and temporal shaping and characterization devices.

Acknowledgement:
This work benefited from the facilities of the SMARTLIGHT platform funded by the Agence Nationale de la Recherche (EQUIPEX+ contract « ANR-21-ESRE-0040 ») and Région Bourgogne Franche-Comté.

Abstract

Thematic Session: Nanoelectronics, nanomagnetism & Spintronics
Disciplinary fields involved (eg. Chemistry, Physics, Biology …)**: Nanotechnology, Astrophysics**
Keywords (max. 4-5)**: Schottky diode, THz detection, GaAs**

GaAs Schottky diodes with sub-micron anode for THz applications

Jean-Baptiste CUVELLIER[1,2], Lina GATILOVA[1,2], Jeanne TREUTTEL[1], Antonella CAVANNA[1]

1. *LIRA, Observatoire de Paris, Université PSL, CNRS, 75014 Paris, France*
2. *C2N-CNRS, 10 Bd Thomas Gobert, 91400, Palaiseau, France*

A better understanding of galaxy and star formation, of the chemical composition of the atmospheres of moons and planets, could be provided by studying their radiation in the TeraHertz region (0.3 – 5 THz) [1,2]. Planar GaAs Schottky diode-based mixers remain one of the best solutions for the fabrication of heterodyne receivers with high sensitivity and spectral resolution at ambient and cryogenic temperatures. Small diodes with sub-micron anode diameters allow the realisation of frequency mixers, operating at 0.3-2 THz. Recently, we have developed and delivered a 1.2 THz monolithically integrated frequency mixer (MMIC) with state-of-the-art performance for the Submillimetre Wave Instrument (SWI) on board ESA's JUpiter ICy moon Explorer (JUICE) [3,4]. Our current work aims to further increase the operating frequency and develop the fabrication process for robust and high performance GaAs Schottky diode based MMIC mixers capable of reaching the 2-5THz region. At these frequencies, the performance of the diodes starts to be strongly affected by various parasitic elements (junction capacitance, air-bridge inductance, series resistance, substrate contributions, etc.). In this work we study the influence of anode size reduction on the electrical characteristics of diodes. The key steps of our fabrication process (based on the e-beam lithography) for the fabrication of planar GaAs Schottky diodes with submicron anode diameter (0,1 to 4 µm²) are presented. The fabricated diodes have been electrically characterised and their parameters were extracted from DC measurements. The influence of the fabrication conditions (metal deposition, annealing temperature, etc…) on diode characteristics is also discussed.

[1] T. de Graauw et al., "The Herschel heterodyne instrument for the far-infrared (HIFI)," Astron. Astrophys., vol. 34, pp. 3–20, Jul. 2009.

[2] J. W. Waters et al., "The Earth observing system microwave limb sounder (EOS MLS) on the Aura satellite," IEEE Trans. Geosci. Remote Sens., vol. 44, no. 5, pp. 1075–1092, May 2006.

[3] A. Maestrini, *et al.,* "1080-1280 GHz Schottky Receiver for JUICE-SWI With 1600-2600K DSB Receiver Noise Temperature", 29th IEEE International Symposium on Space THz Technology (ISSTT2018), Pasadena, CA, USA, March 26-28, 2018

[4] J. Treuttel, *et al*., "1200 GHz High Spectral Resolution Receiver Front-End of Submillimeter Wave Instrument for JUpiter ICy Moon Explorer: Part I - RF Performance Optimization for Cryogenic Operation," in *IEEE Transactions on Terahertz Science and Technology*, vol. 13, no. 4, pp. 324-336, July (2023), doi: 10.1109/TTHZ.2023.3263623

Abstract

Thematic Session: Nano-photonics & Nano-optics
Disciplinary fields involved: Physics
Keywords: Optical sensor; Surface plasmon resonance; Phase singularity; 2D nanomaterial

Ultrasensitive Label-Free Optical Detection Based on Functionalized Plasmonic Nanofilms and Enhanced Phase Singularity

Fusheng Du[1], Kevin Kim[1,2], Kathrine Nygaard Borg[1,3], Rodolphe Jaffiol[1], Aurélien Bruyant[1], Jeremy Mallet[1,2], Shuwen Zeng[1*]

1. *Light, Nanomaterials, Nanotechnologies (L2n), Université de Technologie de Troyes & CNRS UMR 7076, Troyes, France*
2. *Laboratoire de Recherche en Nanosciences (LRN), Université de Reims Champagne-Ardenne, Reims, France*
3. *Department of Biomedical Engineering, The Chinese University of Hong Kong, China*

Abstract:
Rapid plasmonic detection is crucial for early disease diagnosis and molecular biology research, yet conventional sensors often rely on amplification labels to enhance sensitivity. To overcome this limitation, we developed a surface plasmon resonance (SPR) sensor based on enhanced phase singularity, causing a giant position shift in the reflected beam – known as Goos-Hänchen (GH) shift, achieving a GH shift of 9.2 µm for 0.5% glycerol (6×10^{-4} RIU) and a figure-of-merit (FOM) of 1.5×10^{4} µm/RIU using a 50 nm gold nanofilm.

With aptamers as recognition units, the sensor demonstrated exceptional biomolecular detection, achieving a detection limit of 1 fM for tumor necrosis factor-alpha (TNF-α), highlighting its potential for high-sensitivity diagnostics.

To enhance performance, we propose to integrate MXene 2D materials (specifically $Ti_3C_2T_x$) which are recognized as promising plasmonic nanomaterials due to their low cost and high control in the visible range spectrum. Our SPR technique enabled precise optical absorption control of pure MXene with a resolution of 1 nm thickness. Theoretical analysis revealed that integrating two layers of MXene onto a gold film substrate can dramatically reduce reflection intensity by five orders of magnitude and enhance the Goos-Hänchen shift by over 130 times compared to a pristine gold film. Therefore, our subsequent research will be dedicated to achieving higher sensitivity detection by integrating MXene into plasmonic structures.

Abstract

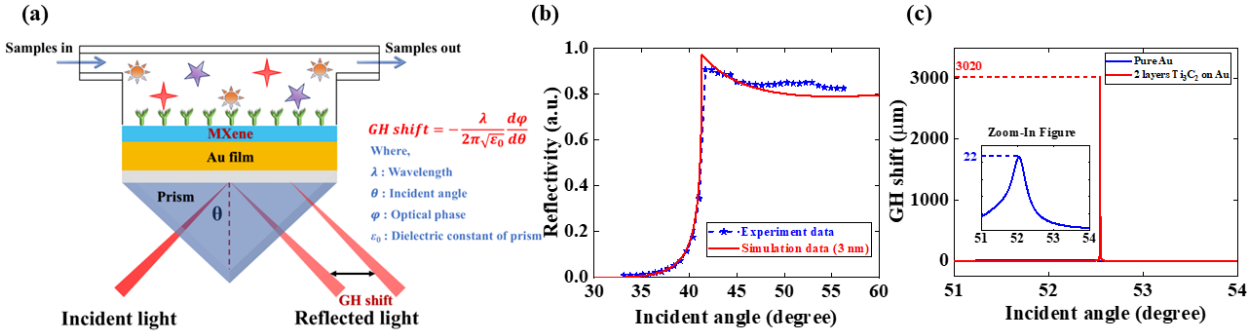


Figure 1: a) Schematic of the SPR biosensor based on GH shift and MXene enhancement; b) Comparison between experiment and simulation of 3 nm pure MXene on glass; c) Simulation results of 2-layer MXene on Au film and comparison with pure Au.

References:

[1] Kathrine, N. B. et al., Enhanced biosensing of tumor necrosis factor-alpha based on aptamer-functionalized surface plasmon resonance substrate and Goos-Hänchen shift. *Analyst*, 149, 3017-3025 (2024).

[2] Saeid, K. A. et al., Investigation of the optical and electronic properties of functionalized Ti3C2 MXene with halide atoms using DFT calculation. *Materials Today Communications*, 35:106136 (2023).

[3] Wu et al., Few-layer $Ti_3C_2T_x$ MXene: A promising surface plasmon resonance biosensing material to enhance the sensitivity. *Sensor Actuat B-chem* 277: 210-215 (2018).

Acknowledgements:

This work is supported under the UTT project Stratégique NanoSPR (OPE-2022-0293), and the Graduate School (Ecole Universitaire de Recherche) "NANO-PHOT" (ANR-18-EURE-0013). Financial support of Nano'Mat (https://www.nanomat.eu) by the Ministère de l'enseignement supérieur et de la recherche, the Conseil régional Grand Est, the FEDER fund, the Conseil general de l'Aube, and the postgraduate studentship of UTT are also acknowledged.

Abstract

Thematic Session : Nanophotonics & Nanooptics, Functional thin films, Nanostructures & 2D materials
Disciplinary fields involved : Physics
Keywords (max. 4-5)**:** Electron beam lithography, Nanostructuration, Structural colour

Optimized Electron Beam Lithography for the Fabrication of Circular Resonant Waveguide Gratings

A. Dussard[1,2], N. Gananathan[2], H. Kadiri[1,2], A. Rumyantseva[1], C. Tuambilangana[2], S. Kostcheev[1] and G. Lérondel [1]

1. *Light, nanomaterials, nanotechnologies (L2n), Université de Technologie de Troyes (UTT) & CNRS UMR 7076, 12 rue Marie Curie, BP 2060, 10010 Troyes, Cedex, France*
2. *SURYS - IN Groupe, Parc d'activités Gustave Eiffel, 22 Av. de l'Europe, 77607 Bussy-Saint-Georges, France*

Electron beam lithography (EBL) systems are widely used for their high resolution, enabling writing features down to 10nm. Beyond this high resolution, a significant advantage over alternative lithographic techniques lies in EBL's ability to fabricate complex shapes that are unachievable by other means.

The time-intensive process of this lithographic technic however limits the size of the patterned area. Here is presented an optimization of EBL writing time, and its use to fabricate a circular Resonant Waveguide Grating[1,2] (RWG) to produce innovative optical effects. It includes: dose reducing via the associated material issues, Monte-Carlo simulations for electron-matter interaction at different acceleration voltages and the interaction volumes overlapping, and eventually the realization of a RWG. The designed structure aims to elevate the security degree of optical authentication features thanks to an innovative optical effect in terms of colors, and security control.

References :

[1]. Recent Advances in Resonant Waveguide Gratings, July 2018, Laser & Photonics Review 12(3rd ed.), DOI:10.1002/lpor.201800017.
[2]. D. Rosenblatt, A. Sharon and A. A. Friesem, "Resonant grating waveguide structures," in *IEEE Journal of Quantum Electronics*, vol. 33, no. 11, pp. 2038-2059, Nov. 1997, doi: 10.1109/3.641320.

Abstract

Thematic Session Nanophotonics & nano-optics
Disciplinary fields involved Physics
Keywords (max. 4-5)**:** plasmonics, aluminum, fluorescence, quantum dots

Controlling fluorescence of perovskite quantum dots with nanostructured aluminum

Eloïse Garcelon[1], Liudmila Tratsiuk[1], Davy Gérard[1], Jérôme Martin[1]

1. *Light, nanomaterials, nanotechnologies, CNRS UMR 7076, Université de Technologie de Troyes, Troyes, France*

Aluminum nanostructures, known for their unique plasmonic properties in the UV-visible spectrum, have emerged as a promising avenue for enhancing light-matter interactions, particularly photoluminescence. In this study, we investigate the interaction between aluminum nanostructures and halogenated inorganic perovskites. This coupling is corroborated by extinction, fluorescence, and lifetime measurements, which are further supported by numerical simulations. Specifically, this study examines a resonant coupling between localized surface plasmon resonances in aluminum nanorod arrays and colloidal metal halide perovskite nanocrystals. The emitters are colloidal cesium lead tribromide ($CsPbBr_3$) perovskite nanocrystals (NCs). The nanocrystals in question typically measure between 2 and 20 nm in diameter and exhibit an emission wavelength of approximately 510 nm [1]. A layer of $CsPbBr_3$ in PMMA is deposited onto the aluminum nanostructures via spin coating (Figure 1).

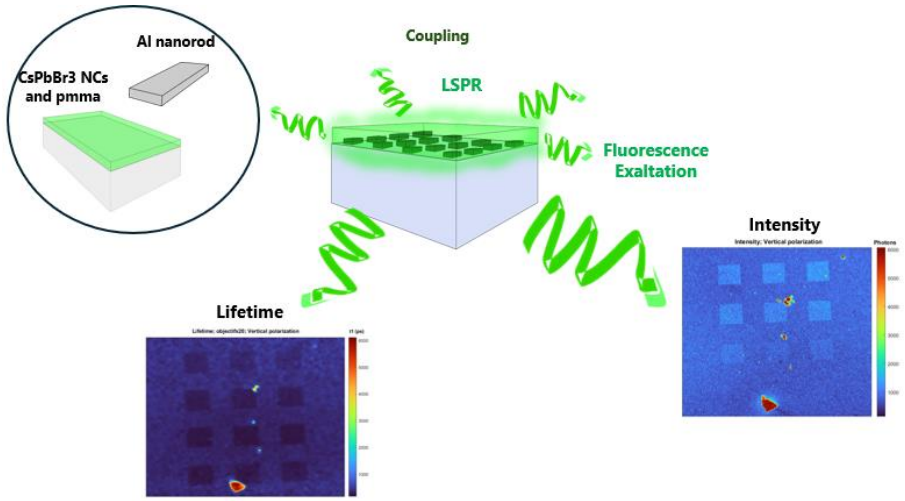


Figure 1: Sketch of the hybrid system, also showing representative photoluminescence measurements.

The fluorescence emission from the perovskites NCs is investigated as a function of the size of the aluminum nanoparticles. We observe an alteration of the photoluminescence emission in presence of the Al nanostructures, with an enhancement of the $CsPbBr_3$ emission as well as a reduction of their lifetime.

[1] Protesescu, L. et al., Nanocrystals of Cesium Lead Halide Perovskites (CsPbX 3 , X = Cl, Br, and I): Novel Optoelectronic Materials Showing Bright Emission with Wide Color Gamut. Nano Lett. 2015, 15, 3692-3696.

Abstract

Thematic Session: Nanophotonics & Nanooptics

Disciplinary fields involved: Physics

Keywords (max. 4-5)**: Mid-Infrared, III-V Integrated Photonics, Acousto-Optics**

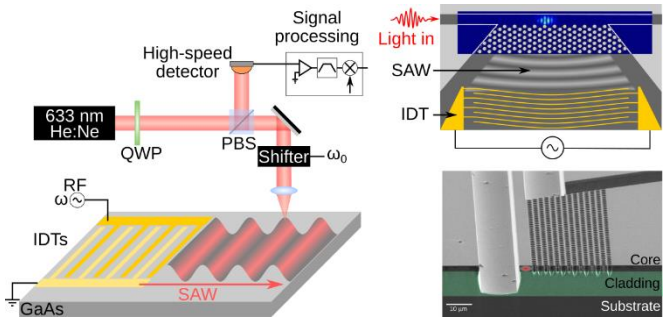
Mapping of Surface Acoustic Waves for Mid-Infrared Integrated Acousto-Optics

Thomas Gérodou[1, 2], Martina Morassi[1], Aristide Lemaître[1], Adel Bousseksou[1], Damien Teyssieux[3], Mathieu Jeannin[1]

1. *Centre de Nanosciences et de Nanotechnologies, UMR9001 CNRS, Univ. Paris Saclay, 91120 Palaiseau, France.*
2. *Physics Department, École Normale Supérieure, PSL University, 75005 Paris, France.*
3. *FEMTO-ST Institute, CNRS, Université de Franche-Comté, SUPMICROTECH, 25030 Besançon, France.*

Photonic integrated circuits have seen extensive progress in the past decades, predominantly at near-infrared frequencies. Bringing these technologies to the mid-infrared range (mid-IR, 3-30µm) is of significant interest, typically in sensing applications thanks to the atmospheric windows and molecule absorption bands it hosts. Unfortunately, some essential optoelectronic functionalities are not easily available in the mid-IR [1], in particular fast pure phase modulation. A promising approach to such devices is acousto-optics (AO) [2]: mechanical excitations of an optical waveguide can phase-shift the guided light.

The long mid-IR wavelengths bring challenges in terms of materials, but also device geometry as optical waveguides and acoustic wavelengths become of comparable sizes. We propose to tackle this difficulty using photonic-phononic crystals on GaAs, providing control over confinement of both light and sound. Designing and optimizing these devices relies critically on visualizing surface acoustic waves (SAWs). This can be achieved with a scanning heterodyne interferometer [3] (left), allowing mapping SAWs amplitude and phase. We report measurements on SAW-generating devices (IDTs) validating the mapping capabilities and the sensitivity of the interferometer, and preliminary simulations and fabrications results of optomechanical crystals for integrated mid-IR AO modulation (right).



References:

[1] Lin et.al., *Mid-infrared integrated photonics on silicon: a perspective*, Nanophotonics **7**, 393 (2017)

[2] De Lima et al., *Compact Mach-Zender acousto-optic modulator*, Appl. Phys. Lett. **89**, 121104 (2006)

[3] Teyssieux et al., *Absolute Phase and Amplitude Mapping of Surface Acoustic Wave Fields*, IEEE 2013 Joint UFFC, EFTF and PFM Symposium (2013)

Acknowledgement:

We thank Raffaele Colombelli and Jean-Michel Manceau for scientific discussions. This work was done within the C2N micro nanotechnologies platforms and partly supported by the RENATECH network and the General Council of Essonne. This work was supported by: ANR PIA funding ANR-20-IDEES-0002, France 2030 funding ANR-11-IDEX-0003 Graduate School of Physics - PhOM axis, and ANR JCJC Project Acousto-MIR (2025).

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics
Keywords: hydrogen, ppb, switch, optic

High sensitivity Grating-SPR based sensor using Low-Loss Surface Plasmon modes coupling for the detection of H_2

P. Giraud[1], A. Meyer[1], I. Girault[1], I. Verrier[1], C. Varenne[2], J. Brunet[2], A. Ndiaye[2], and Y. Jourlin[1]

1. *Affiliation 1*
   Laboratoire Hubert Curient, Réseaux, CNRS, Université Jean Monnet Saint-Etienne, Saint-Étienne, France
2. *Affiliation 2*
   Institut Pascal, Photon, CNRS, Université Clermont Auvergne, Clermont-Ferrand, France

The underlying principle is the plasmon-triggered switching effect, a phenomenon involving two propagating diffraction orders (the 0th and the -1st) reflected from a relatively deep grating [1,2]. The resulting oscillations in diffraction efficiency produce two crossing points, which locally shift in angle whenever the surrounding medium changes. Using a normalized differential measurement, we can convert intensity variations into a direct estimate of angular shifts, thus enabling a simple and robust sensing method.

A 120 nm gold grating of 284 nm depth and 935 nm period was coated with 15 nm of palladium layer and placed in a controlled chamber where a mixture of filtered air and hydrogen at known concentrations was introduced. An 850 nm laser diode in TM polarization, modulated at 1 kHz, illuminated the transducer at WP2, and the 0^{th} and -1^{st} diffracted orders were recorded over time with two photodiodes in synchronous detection.

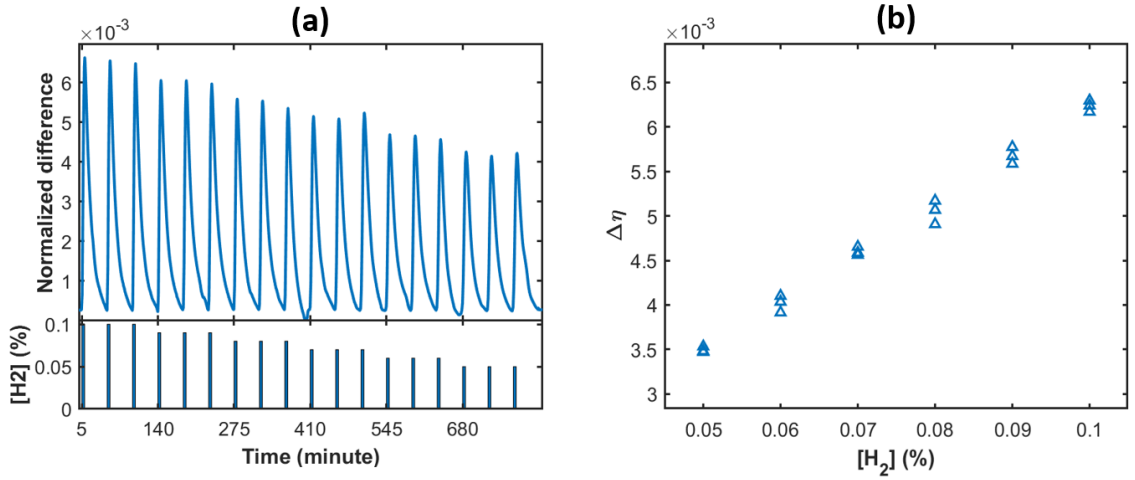


Figure 1: (a) Response to stepwise decreasing H_2 concentration (0.1-0.05%) composed of 3 cycle for each H2 concentration in filtered air at room temperature. (b) Measured Δη as a function of H_2 concentration derived from (a)

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics & Chemistry
Keywords: Mie resonators, Gallium phosphide, Colloidal nanostructures

Large-scale fabrication of colloidal GaP nanoresonators

Lola Guengard-Morineau[1], Gauthier Roubaud[1], Jeanne Heintz[1], Samuel Grésillon[1], Sébastien Bidault[1]

1. *Institut Langevin, ESPCI Paris, Université PSL, CNRS, 75005 Paris, France*

Thanks to their enhanced and confined optical near-fields, broadband subwavelength resonators have the ability to enhance light-matter interactions at room temperature. Over the last few years, high-index dielectrics have emerged as an alternative platform to plasmonic materials due to their low ohmic losses [1]. In particular, the excitation of electric and magnetic modes in resonant dielectric nanostructures provides enhanced optical fields within the resonator, allowing the enhancement of nonlinear optical responses.

By associating mechanical grinding and laser-based thermal treatments, we produce colloidal gallium phosphide (GaP) nanospheres, which combine high-quality resonances, negligible absorption in the visible & near-infrared ranges (above 450 nm) [2] and high quadratic nonlinear susceptibilities. We are currently trying to correlate linear scattering spectroscopy, nonlinear spectroscopy and electron microscopy in order to study the influence of the nanosphere size on second harmonic generation to demonstrate how Mie resonances at the fundamental and/or second harmonic wavelength allow an enhancement of the nonlinear response by several orders of magnitude. These results open exciting perspectives for the large-scale and low-cost fabrication of efficient nonlinear optical nanoresonators.

References

[1] S. Bidault, M.Mivell, N.Bonod « Dielectric nanoantennas to manipulate solid-state light emission », J.Appl. Phys. 126. 094104 (2019)

[2] D. Shima, H. Sugimoto, A. Assadillayev, S. Raza, M. Fuji, Gallium Phosphide Nanoparticles for Low-Loss Nanoantennas in Visible Range. Adv. Optical Mater., 11, 2203107. (2023)

Acknowledgement:
This work was by LABEX WIFI (Laboratory of Excellence within the French Program “Investments for the Future”)under references ANR-10-LABX-24 and ANR-10-IDEX-0001-02 PSL*.

Abstract

Thematic Session : Nanophotonics & Nanooptics
Disciplinary fields involved: Physics
Keywords : Inverse Faraday Effect, Magnetic Force Microscopy, Plasmonics, Nanophotonics

Optically magnetizing gold nanoantennas through the Inverse Faraday effect

Chantal Hareau[1], Romeo Zapata[1], Eric Charron[1], Mathieu Mivelle[1].

1. *Institut des Nanosciences de Paris (INSP), Sorbonne Université, CNRS, Paris, France*

The inverse Faraday effect is a magneto-optical phenomenon by which a circularly polarized light can magnetize matter. In particular, in gold, the conduction electrons are put into circular motion via the non-linear forces that light applies on them [1]. These induced currents in metals open the possibility of generating stationary magnetic fields via optical excitation only. Plasmonic nanoantennas appear as an interesting playground for enhancing and manipulating magnetic fields below the diffraction limit, which is important for potential applications in data storage technologies. In our group, we recently described the theory underlying the generation of these drift currents in plasmonic nanostructures using numerical simulations. We demonstrated that a gold photonic nano-antenna, optimized by FDTD calculations, allows, under high excitation power, to maximize the drift currents and generate stationary magnetic fields in the tesla range and at the nanoscale [2]. However, a thorough experimental characterization of the optically induced magnetic fields has yet to be conducted.
We study the spatial features of these magnetic fields using Magnetic Force Microscopy (MFM). This technique measures the forces between a nanometric magnetic probe and the stray magnetic field of the measured sample, allowing for real-space imaging of the magnetic fields coming from the nanoscale structures. Here, we characterized these near-field interactions using coaxial nanostructures under optical excitation. These experiments show a feature linked to the presence of the antenna when the latter is optically excited (Figure 1). Our experiments illustrate how MFM can be tailored to study non-conventional magnetic systems with a nanometric resolution.

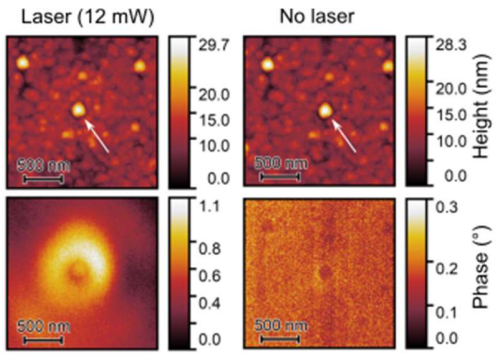


Figure 1: MFM measurements on a coaxial nano-antenna with and without laser excitation. The white arrow indicates the position of the antenna.

References :
[1] Hertel, Journal of Magnetism and Magnetic Materials, 2006
[2] Yang et al., ACS nano, 2022

Abstract

Thematic Session : Nanophotonique & Nano-optique
Disciplinary fields involved : Chemistry, photophysics, nanomechanics
Keywords : Photoactuators, nanomechanics, single nanoparticle, soft nanomaterials

Molecular photoactuators at the nanoscale

Federico Zizzi,[1,2] Etienne Bequet-Ermoy,[1] Stéphane Cuénot[2], Eléna Ishow[1]

1. *Nantes Université, CNRS*
   CEISAM UMR 6230, Nantes, F-44000 France
2. *Nantes Université, CNRS*
   Institut des Matériaux de Nantes Jean Rouxel, Nantes, F-44000 France

Severe concerns about eco-sustainability have recently prompted reflection on small molecule-based functional materials (SMFMs), capable to respond to an external trigger in a cooperative manner, as naturally encountered in numerous biological regulation mechanisms.[1] Whereas cooperative effects have long been studied in polymeric materials, very little attention has been paid on SMFMs whose molecular constitution could be harnessed to lead to extensive structural rearrangements under tiny perturbations.[2] Extending these studies on single nanoparticles made out of self-assembled molecules requires tools adapted to the measurements of soft materials at the nanoscale[3] and accurate control of the light-induced changes. Thanks to the use of self-assembled photochromic nanoparticles manufactured by flash precipitation,[4] we want to show that geometrical photoswitching can reversibly be triggered in solution and followed at the single nanoparticle level by combining atomic force microcopy (AFM) and *in situ* dual illumination. Progressive disintegration of the nanoparticles after several cycles of expansion-contraction caused by alternating vis and UV illuminations could be noticed and ascribed to strong adhesion effects (Figure 1).[5] These results open perspectives into the design of drug-delivery nanocarriers where on-command drug release should better exploit the strong non-covalent intermolecular interactions established at the interface between nanoparticles and biological tissues.

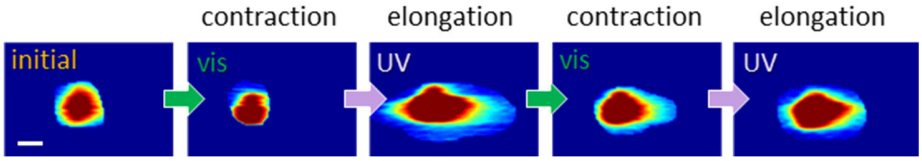


Figure 1. AFM imaging of a single photochromic organic nanoparticle subjected to alternating vis and UV light (1 mW.cm^{-2}). Scale bar (extreme left image): 250 nm.

References :
1) S. Krause, B. L. Feringa, *Nat. Rev. Chem.* **2020**, *4*, 550-562. 2) F. Xu, B. L. Feringa, *Adv. Mater.* **2023**, *35*, 2204413. 3) S. Cuenot, P. Gélébart, C. Sinquin, S. Colliec-Jouault, A. Zykwinska, *J. Mech. Behav. Biomed. Mater.* **2022**, *133*, 105343. 4) S. Hoang, S. Olivier, S. Cuenot, A. Montillet, J. Bellettre, E. Ishow, *ChemPhysChem* **2020**, *21*, 2502. 5) E. Bequet, V. Silvestre, S. Cuenot, E. Ishow, *Small* **2024**, *20*, 2403912.

Acknowledgement:
CNRS MITI (Mechanobiology Challenge), Nantes University (NExT i-site) and ANR (ANR-21-CE06-0034-01 project) are gratefully acknowledged for their essential financial support.

Abstract

Nanophotonics & nano-optics:
Disciplinary fields involved: Physics, Artificial Intelligence
Keywords (max. 4-5)**: Arithmetic and Logic Units, Modal plasmonics, non-linear photoluminescence, hybrid artificial intelligence**

All-optical, interconnect-free Arithmetic and Logic Units (ALU):

design by hybrid AI, nanofabrication and experimental demonstration

Florian Dell'Ova,[1] Yoann Brûlé,[1] Nicolas Gros,[2] Amine Khitous,[1] Aurélie Bertaux,[2] Aymeric Leray,[1] Ouassila Labbani Narsis,[2] Christophe Nicolle,[2] Gérard Colas des Francs,[1] Alexandre Bouhelier,[1] Erik Dujardin[1] *

1. *Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB), CNRS UMR 6303, Université Bourgogne Europe, 21000 Dijon, France*
2. *Connaissances et Intelligence Artificielle Distribuée (CIAD), EA 7533, Université Bourgogne Europe,*

We demonstrate a new concept of all-optical computing units based on the shaping of plasmonic modal landscape in micrometric on-chip 2D cavities to realize reconfigurable Arithmetic and Logic Units (ALU).[1] Our interconnect-free optical devices perform multi-bit logic gate functions in a single cavity without ALU cascading, therefore obviating loss in vias and so the need for gain to restore the binary signal. Moreover, we show that a single cavity can be programmed to perform simultaneously multiple logic functions, including a first 1-bit full adder. [2]
The main challenge on the way to increasing the functional Boolean complexity is the design of the cavity shape and of the excitation/detection parameters for which no established design rules exist. To break this conceptual lock, which also happens to be a computational bottleneck, we have developed a de novo hybrid artificial intelligence tools comprising both deep learning AIs [3] and ontologies [4] in order to (1) speed up simulation of the near-field optical response of the 2D gold cavities, (2) explore and optimize both the cavity shape in the subset of polygons and the excitation/detection parameters in order to perform a given complex Boolean function. We demonstrate our approach by targeting the 1-bit and 2-bit full adders.

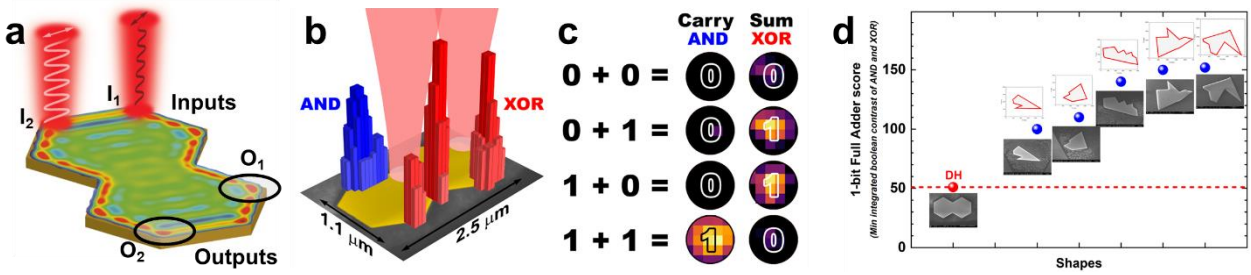


Figure 1*. (a) Scheme of DH-shaped ALU operation.[1,2] (b,c) Experimental 1-bit adder response and truth table of a DH cavity.[2] (d) Performance roadmap of HAI-designed 1-bit adder cavities that outperform the DH (unpublished).*

Abstract

References:

[1] U. Kumar, A. Cuche, C. Girard, S. Viarbitskaya, F. Dell'Ova, R. Al Rafrafin, G. Colas des Francs, S. Bolisetty, R. Mezzenga, A. Bouhelier, E. Dujardin, **ACS Nano**, 15, 13351 (2021). (DOI)

[2] F. Dell'Ova, Y. Brulé, D. Shakirova, N. Gros, J. Bizouard, A. Leray, A. Bertaux, O. Labbani Narsis, C. Nicolle, G. Colas des Francs, A. Bouhelier, E. Dujardin. **ACS Photon.**, 11, 752 (2024) (DOI)

[3] M. Janmaijay, C. Brahim El Vaigh, N. Gros, A. Bertaux, O. Labbani Narsis, S. Kumar, G. Colas des Francs, A. Bouhelier, C. Nicolle, E. Dujardin, **Engineering Applications of Artificial Intelligence**, 2024, submitted.

[4] O. Labbani Narsis, E. Dujardin, C. Nicolle, N. Gros, *14th International Conference on Formal Ontology in Information Systems ,*FOIS 2024 (DOI)

Acknowledgement:

This work has been partially funded by the French Agence Nationale de la Recherche (ANR-20-CE24–0001 DALHAI and ISITE-BFC ANR-15-IDEX-0003), the EIPHI Graduate School (ANR-17-EURE-0002). Device characterization was performed at the technological platforms SMARTLIGHT and ARCEN Carnot with the support of the French Agence Nationale de la Recherche under program Investment for the Future (ANR-21-ESRE-0040)

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics
Keywords: OAM, SHG, metasurface, wavefront shaping

Nonlinear generation of orbital angular momentum in metasurfaces

C. Lecasble[1], R. Que[1], L. Coudrat[1], A. Gerini[1], M. Morassi[2], A. Lemaître[2], N. Efremidis[3], A. Degiron[1], and G. Leo[1,4]

[1] MPQ, Université Paris Cité & CNRS, Paris, France
[2] C2N, Université Paris Saclay & CNRS, Palaiseau, France
[3] University of Crete and Foundation for Research and Technology - Greece
[4] Institut Universitaire de France

Abstract — Structured light, denoting optical fields with non-trivial phase and/or polarization textures, plays an ever-increasing role in physical and life sciences.[1] One of the most emblematic classes of structured light is formed by optical vortices, that is beams with helical wavefronts and a topological charge that quantifies the number and winding direction around a singularity. This phase texture is associated with an orbital angular momentum (OAM), which offers useful degrees of freedom for metrology, telecoms, and quantum optics.[2] Metasurfaces have recently proven successful in creating OAM, especially in the linear regime. In the nonlinear domain, of importance for future classical and quantum information, to date OAM has mostly been created in qualitative ways. Here, we underscore the potential of nonlinear dielectric metasurfaces for versatile structured-light generation, with a focus on the generation of second harmonic vortices with high OAM order and purity, via meta-holograms fabricated in a III-V semiconductor monolithic platform (see Figure 1).[3]

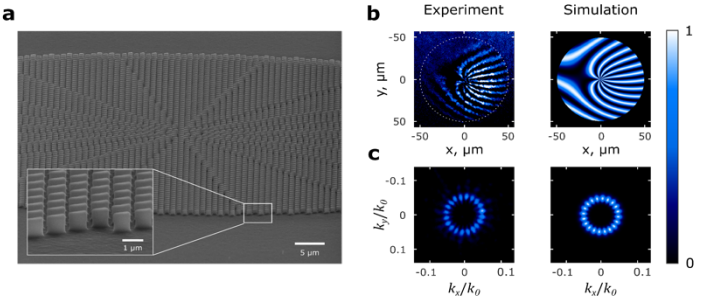


Figure 1. SH vortex beam with m = 10. a) SEM image of the metasurface. b,c) Experimental (left) and simulated (right) SH interference pattern (b) and intensity (c).

References:

1. A. Forbes et al., "Structured light", Nature Photonics" **15**, 253 (2021).
2. A. M. Yao et al., "Orbital angular momentum: origins, behavior and applications", Adv. Opt. Photon. **3**, 161 (2011).
3. V. F. Gili et al., "Monolithic AlGaAs second-harmonic nanoantennas", Opt. Expr. **24**, 15965 (2016).

Acknowledgement:
We acknowledge funding from the METAFAST H2020-FETOPEN-2018-2020 project (grant agreement no. 899673) and the MEGAPHONE project (ANR-22-CE92-0090) from Agence Nationale de la Recherche. We acknowledge support from the European Research Council grant FORWARD (reference: 771688).

Abstract

Thematic Session (Nanophotonics & nano-optics)**:**
Disciplinary fields involved (Optics, Physics, Biology)**:**
Keywords (*super-resolution microscopy, phase imaging, bioimaging, stabilization*)**:**

Microscope stabilization for single particle tracking in thick biological tissues using phase imaging

Hanna MANKO, Marc TONDUSSON, Laurent COGNET.

LP2N, Institut d'Optique Graduate School, CNRS, University of Bordeaux, Talence, France

Abstract

Super-resolution microscopy enabled investigation of the molecular structures and dynamics at nanoscale levels. Such high resolution in most cases comes by the price of long acquisition times. Thus the stabilisation of the sample drift becomes essential in order to obtain high quality structural or single molecule tracking data. Despite various methods available to perform correction of lateral sample drifts, it remains challenging to maintain the microscope focus with high precision. This becomes more complex in thick samples especially when the use of trans-illumination mode is imposible.

In this work we demonstrate that the application of cross-correlation-based method to label-free phase imaging enables precise microscope stabilization in 3D in real time. This approach can be utilized in both trans- and back-illumination modalities, making it suitable for a wide range of sample types. We demonstrate its effectivity for single particle tracking experiments performed in both fixed and live brain tissues.

Skyrmion Generation in a Plasmonic Nanoantenna through the Inverse Faraday Effect

Xingyu Yang[1], Ye Mou[1], Bruno Gallas[1], Sébastien Bidault[2], and Mathieu Mivelle[1]
[1]Sorbonne Université, CNRS, Institut des NanoSciences de Paris, INSP, Paris, France
[2]Institut Langevin, ESPCI Paris, Université PSL, CNRS, Paris, France

Skyrmions are topological structures characterized by a winding vectorial configuration that provides a quantized topological charge. In magnetic materials, skyrmions are localized spin textures that exhibit unique stability and mobility properties, making them highly relevant to the burgeoning field of spintronics. In optics, these structures open new frontiers in manipulating and controlling light at the nanoscale. The convergence of optics and magnetics holds therefore immense potential for manipulating magnetic processes at ultrafast timescales. Here, we explore the possibility of generating skyrmionic topological structures within the magnetic field induced by the inverse Faraday effect in a plasmonic nanostructure [1]. Our investigation reveals that a gold nanoring, featuring a dark mode, can generate counter-propagating photocurrents between its inner and outer segments, thereby enabling the magnetization of gold and supporting a skyrmionic vectorial distribution. We elucidate that these photocurrents arise from the localized control of light polarization, facilitating their counter-propagative motion. The generation of skyrmions through the inverse Faraday effect at the nanoscale presents a pathway towards directly integrating this topology into magnetic layers. This advancement holds promise for ultrafast timescales, offering direct applications in ultrafast data writing and processing.

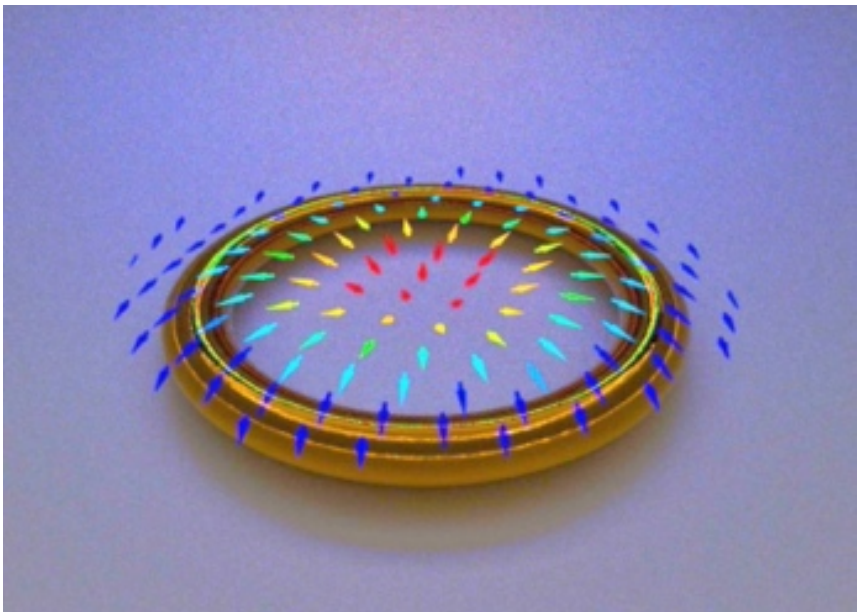


Figure 1. Illustration of a ring-shaped gold plasmonic nanoantenna for magnetic field generation by inverse Faraday effect supporting a skyrmionic topology.

Reference

[1] Xingyu Yang *et al*. “Skyrmion Generation in a Plasmonic Nanoantenna through the Inverse Faraday Effect.” arXiv:2402.17426 (2024).

Abstract

Thematic Session: Nanomaterials and nanophotonics

Disciplinary fields involved : Physics

Keywords: Dielectric metasurfaces, Monochromatic light projection, Phase control

Compact Light Projector Metalens

Ziad OUSSAID[1,2], Pierre ALBOU[1], Hafid EL-IDRISSI[1], Eduardo ALVEAR[1]
Daniele MELATI[2], Béatrice DAGENS[2]

1. *VALEO Lighting Systems, Bobigny, FRANCE (ziad.oussaid@valeo.com / eduardo.alvear@valeo.com)*
2. *C2N, Université Paris-Saclay, FRANCE*

Light projection systems are essential in modern society, they are present in our daily life. The increasing global demand for interior and exterior lighting solutions highlights the urgent need for more energy-efficient and sustainable technologies. The purpose of our study is to achieve weight reduction and compact materials for light projector systems. This approach aims to provide a miniaturization of optical devices (flat, thinner and lighter optical lenses). Key challenges include visible light management and large-diameter surfaces. A potential solution to miniaturize and functionalize our lighting modules are Metasurfaces. Metasurface is a flat surface with nanostructures periodically distributed at subwavelength distances enabling the control over light phase, intensity, and polarization **[1]**.

Large-scale metalens (1mm x 1mm) design process involves three steps. First, the unit-cell or meta-atom is determined to assess transmission and phase based on height and periods using the RCWA solver (n=2.34, k=0.001 at 635nm). The active material is deposited on a D263Teco substrate. Second, the Gerchberg–Saxton algorithm **[2]** integrates the pattern to match the target phase profile. Third, unit-cells from step 1 are distributed to meet the phase target, and near-field projection is tested using the FDTD solver. The metalens have been fabricated using Deep-UV lithography **[3]** with a diameter of 1 mm, as illustrated in Fig 1(a) and integrated using an optical setup to project a pattern defection, as illustrated in Fig 1(b-c). Both theoretical and experimental results demonstrate compact light projector metalens. Future work will focus on the incorporation of light source energy distribution, optical characterization analysis (FoV) and large scale evaluation (beyond 1mm).

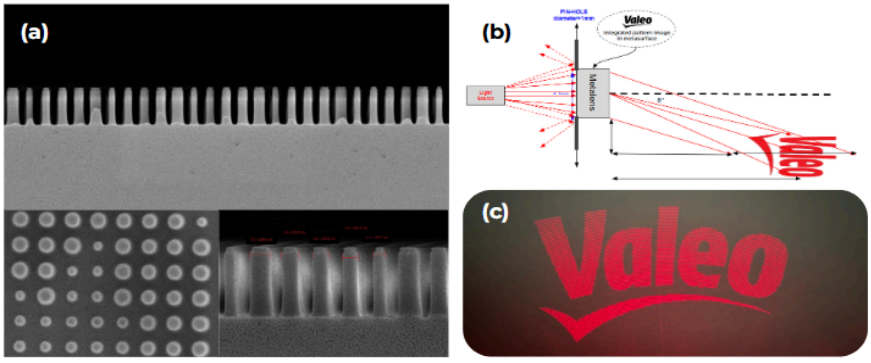


Fig. 1. (a) Metalens Cross section image obtained by using Scanning Electron Microscope. (b) Schematic of the light projection setup using a 635 nm source through a 1mm diameter pinhole corresponding to the metalens size. (c) Picture of the pattern projection result.

Abstract

References :
[1] Overvig, A.C., Shrestha, S., Malek, S.C. *et al.* Dielectric metasurfaces for complete and independent control of the optical amplitude and phase. *Light Sci Appl* 8, 92 (2019)
[2] Guoqiang Huang, Daixuan Wu, Jiawei Luo, Liang Lu, Fan Li, Yuecheng Shen, and Zhaohui Li, "Generalizing the Gerchberg–Saxton algorithm for retrieving complex optical transmission matrices," Photon. Res. 9, 34-42 (2021)
[3] Leuschel, B., Gwiazda, A., Heni, W. *et al.* Deep-UV photoinduced chemical patterning at the micro- and nanoscale for directed self-assembly. *Sci Rep* 8, 10444 (2018)

Acknowledgement:
We would like to thank Pr. Beatrice Dagens and Daniele Melati and their team at C2N for their help and insights.

Abstract

Thematic Session: Nanophotonics & nano-optics

Disciplinary fields involved: Physics

Keywords: Nanowires, Angle resolved PL, Light extraction, Purcell effect

ZnO nanowire-based gratings for light extraction enhancement

Emmanuel Centeno[1], Aubry Martin[2,3], Audrey Potdevin[3], François Réveret[3], Rafik Smaali[1], Jesukpego Anorld Capo Chichi[1], Victor Kalt[4], David Riassetto[2], Geneviève Chadeyron[3]

1. *Université Clermont Auvergne, CNRS, Clermont Auvergne INP, Institut Pascal, F-63000 Clermont-Ferrand, France*
2. *Université Grenoble Alpes, CNRS, Grenoble INP, LMGP, 38000 Grenoble, France*
3. *Université Clermont Auvergne, CNRS, Clermont Auvergne INP, ICCF, F-63000 Clermont–Ferrand, France.*
4. *Laboratoire Hubert Curien, Université Jean-Monnet, IOGS, UMR CNRS 5516, 42000 Saint-Etienne, France*

In solid state emitting devices, photonic trap inside layers and substrate is a well-known problem. Due to the refractive index mismatch, a significant part of emitted photons is lost by total internal reflection. Photons are guided within the structure and escape through the edge. To prevent this leak, surface texturing is mainly used such as micro or nano structuration[1], optical grating[2] or photonic crystal[3]. In this work, we investigated the light extraction of ZnO nanowire-based gratings (Figure 1a) through optical measurements and electromagnetic simulations[4]. In our structure, ZnO nanowires (NWs) act as emitter and also as antenna to increase the light extraction. The directionality of the emitted photons is evidenced by angular resolved photoluminescence (ARPL) measurements (Figure 1b). We studied the influence of the NWs length on the emission profile. Electromagnetic simulations allowed to identify the disorder effect on light extraction and to estimate with accuracy the different processes involved in the spontaneous light emission enhancement such as the light injection and extraction efficiencies. Moreover, we showed that the resonant behavior of the grating enhances the internal quantum efficiency of ZnO NWs thanks to the Purcell effect.

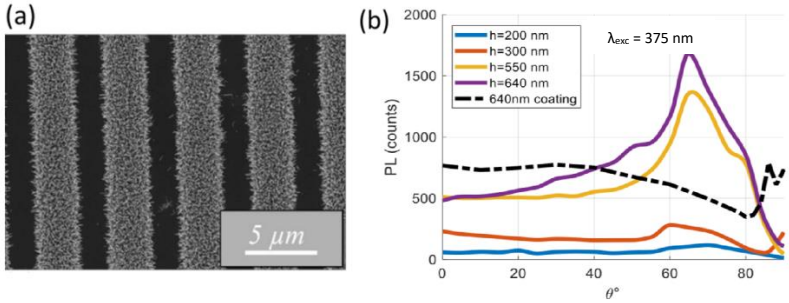


Figure 1: (a) Top view SEM image of ZnO NWs based gratings. (b) ARPL measurements for an emission wavelength of 600 nm for gratings of 4 µm periods, 2 µm strips width, recorded for different grating heights at room temperature. The dashed curve corresponds to the ARPL measurements for a 640 nm NWs coating.

References:

1. Leung, S.-F. et al. J. Phys. Chem. Lett. 2014, 5 (8), 1479. 2. Jamadi, O. et al. Light Sci. Appl. 2018, 7 (1), 82.
3. McGroddy, K. et al. Appl. Phys. Lett. 2008, 93 (10), 103502
4. Centeno, E. et al. ACS Applied Optical Materials 2024, 2, 725

Acknowledgement:

The authors thank the French “Agence Nationale de la Recherche” for its financial support in the frame of the ANR SMARtLEDs project (ANR-19-CE08-0001).

Abstract

Thematic Session : Nanophotonics & nano-optics
Disciplinary fields involved : Physics
Keywords : Nanophotonics, Photonic crystals, Waveguides

Photonic crystal nanostructures for strong atom-photon interaction in a quantum network

Valère Sautel[1], Adrien Bouscal[2], Malik Kemiche[1,3], Sukanya Mahapatra[2], Nikos Fayard[4], Jérémy Berroir[2], Tridib Ray[1], Jean-Jacques Greffet[4], Fabrice Raineri[1], Ariel Levenson[1], Kamel Bencheikh[1], Christophe Sauvan[4], Alban Urvoy[2], and Julien Laurat[2]

1. *Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Saclay, 91120 Palaiseau, France*
2. *Laboratoire Kastler Brossel, Sorbonne Université, CNRS, ENS-Université PSL, Collège de France, 4 place Jussieu, 75005 Paris, France*
3. *IMEP-LAHC, Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, 38000 Grenoble, France*
4. *Université Paris-Saclay, Institut d'Optique Graduate School, CNRS, Laboratoire Charles Fabry, 91127 Palaiseau, France*

Atom-photon interaction plays a key role in quantum information science and technology. In order to allow an efficient exchange of information between the atom and the photon, efforts have been made by the scientific community to strengthen this interaction. A way to achieve this goal is to use integrated photonic nanostructures such as slow modes optical waveguides, leading to the field of waveguide quantum electrodynamics.

Our team at C2N is working on the design and fabrication of photonic crystal waveguides exhibiting slow optical modes. Our team works in collaboration with the Quantum Optics team at LKB which is focusing on the trapping of ultracold Rubidium atoms. Trapping these atoms in the vicinity of carefully designed photonic crystal waveguides [1] allows strong atom-photon coupling without a cavity.

In this poster, I will present our work on photonic crystal band structure engineering in order to optimize photonic-crystal-based nanostructure waveguides compatible with rubidium atoms having an optical transition at 780 nm. The structures must be able to propagate the probe laser at 780 nm and the lasers used for trapping the atoms in their vicinity with minimum losses.

I will also present the different nanophotonic components surrounding the slow mode photonic crystal waveguides which will allow efficient coupling of light from free space into the slow waveguide.

Abstract

References:
[1] Adrien Bouscal *et al, "Systematic design of a robust half-W1 photonic crystal waveguide for interfacing slow light and trapped cold atoms",* 2024 *New J. Phys.* **26** 023026.

Acknowledgement:

This work was supported by the Agence Nationale de la Recherche through Project Nanostrong (ANR-18-CE47-0008)

Abstract

Thematic Session: nanophotonique
Disciplinary fields involved: Physics
Keywords (max. 4-5)**: Bose gas, chemical potential, disorder, scattering, nano-beads**

Thermalization of photons in disordered scattering media towards Bose Einstein condensation

Lorenzo Soncin, Valentina Krachmalnicoff, Romain Pierrat, Remí Carminati

1. *Institut Langevin, ESPCI, PSL*

Photons represent the most common Bose gas. The sun or thermal light sources are examples of black body radiators that we encounter every day. Unlike other Bose gases, photons exhibit a vanishing chemical potential, meaning that their number is not conserved when the temperature of the black body is varied. This results in the impossibility of obtaining a Bose-Einstein Condensate (BEC) of light, because as the temperature decreases, the photons simply fade. However, in 2010, a BEC of photons was first realized in the group of M. Weitz at the University of Bonn (1). This was achieved inside an optical microcavity after a process that ensures the photons follow the Bose-Einstein distribution with a non-zero chemical potential, i.e., thermalization.
In this session, I will discuss our efforts to replicate this thermalization process, where instead of using a microcavity to trap light, we draw inspiration from random lasers (2) by utilizing a disordered scattering medium composed of polystyrene nanobeads.
The results of the work carried out so far, both numerically and experimentally, reveal a change in the emission spectrum behavior, which deviates from that of a fluorescent molecule and instead resembles that of a Bose gas of photons with a non-zero chemical potential. Building on this, we will proceed to investigate Bose-Einstein condensation by employing new types of scattering media.

References:

1. Jan Klaers, Julian Schmitt, Frank Vewinger, and Martin Weitz. Bose–einstein condensation of photons in an optical microcavity. Nature, 468(7323):545–548, Nov 2010.

2. Hui Cao. Random lasers: Development, features and applications. Opt. Photon. News, 16(1):24–29, Jan 2005.

Abstract

Thematic Session Nanophotonics & nano-optics
Disciplinary fields involved Physics
Keywords: Exciton-polariton laser, waveguide

From optically-pumped towards electrically-pumped ridge polariton laser

H. Souissi [1], E. Cambril [1], M. Gromovyi [2], B. Alloing [2], E. Frayssinet[2], J. Zuniga-Perez[2], V. Develay [3], C. Brimont [3], L. Doyennette [3], T. Guillet[3], S. Bouchoule[1]

1. *Centre de Nanosciences et de Nanotechnologies, CNRS, Université Paris-Saclay, France*
2. *Université Côte d'Azur, CNRS, CRHEA, Rue Bernard Gregory, Valbonne 06560, France*
3. *Laboratoire Charles Coulomb (L2C), Université de Montpellier, CNRS, Montpellier, France*

Abstract

The polariton laser is characterized by its operation mode, which relies on the stimulated relaxation of polaritons from an exciton reservoir into a final polaritonic state. Unlike conventional diode lasers, localized pumping on only part of the cavity is possible. Moreover, the laser regime transitions from continuous-wave operation at low temperatures [1] to a mode-locking regime as the temperature rises [2]. These demonstrations were conducted in an optically pumped GaN waveguide.

In this work, we aim to generate polaritons under localized electrical injection in a waveguide. The waveguide is epitaxially grown on c-plane sapphire using MOVPE. It features a 163 nm-thick GaN active layer sandwiched between P- and N-doped AlGaN claddings, forming a PIN junction. The fabrication of the laser structures involves integrating vertical high-reflectivity (R > 80%) Bragg mirrors (DBRs) at the ends of the ridge waveguide (forming cavities 60 µm to 600 µm in length) and requires six steps of electron beam lithography. We will detail the fabrication challenges.

These cavities were studied under continuous-wave (CW) and pulsed electrical injection, but no laser effect was observed. This outcome led to the concept of partially exciting electrical cavities by optical means, contributing partially to current injection. The laser effect was successfully demonstrated from 70K to 300K using this approach. The next step involves conducting experiments that combine optical and electrical pumping to investigate the factors hindering effective electrical injection. We will detail the achieved electrical performance.

References:
[1] H. Souissi et al., Ridge Polariton Laser: Different from a Semiconductor Edge-Emitting Laser, Phys. Rev. Appl., **18**, 044029 (2022)

[2] H. Souissi et al., Mode-locked waveguide polariton laser, Optica, **11**, 962 (2024)

Acknowledgement:
This work was partially supported by ANR project NEWAVE (ANR-21-CE24-0019), by Comb-on-GaN project (Labex GaNeXT ANR-11-LABX-0014) and by the French RENATECH network.

Abstract

Thematic Session Nanophotonics & nano-optics.
Disciplinary fields involved Chemistry, Physics.
Keywords Nanoparticles, Localized surface Plasmon Resonance, Surface Lattice Resonance, Quantum Dots.

Photoluminescence enhancement based on multi-material metasurfaces

Sraj Ali[1], Dewynter Manon[1], Baudrion Anne-Laure[1], Cheng Pascal[2], Chevillot Alexandre [2], Felidj Nordin[2]

1. *L2n, CNRS UMR 7076, Université de Technologie de Troyes, France.*
2. *ITODYS, UMR 7086, Université Paris Cité, France.*

Abstract

Single nanoparticles have emerged as powerful structures for manipulating light at the nanoscale by supporting localized surface plasmon resonance (LSPR) modes. When arranged periodically in arrays, these nanoparticles support collective optical modes known as Surface Lattice Resonances (SLRs), which enhance light-matter interactions and provide highly tunable spectral responses [1]. Several parameters influence Surface Lattice Resonances (SLR). Nanoparticle size, material composition (Au, Al, Ag), and shape strongly impact SLR behavior. Array-level factors such as pitch size, surrounding medium, array size, and light incidence also play important roles in tailoring SLR modes [2][3]. The goal of this project is to engineer arrays that exhibit SLR spectra aligned with the emission and absorption spectra of quantum dots and other emitters, thereby enhancing their photoluminescence. To achieve this, bi-material arrays are considered, composed of combinations of gold, aluminum, silver, magnesium, and other metals, as they have demonstrated strong potential for supporting high-quality SLR modes due to the coupling of the localized surface plasmon resonance (LSPR) of each individual nanoparticle [4]. Parameters are optimized through a series of simulations using COMSOL, followed by sample fabrication via electron beam lithography. Absorption measurements and FLIM microscopy are conducted to evaluate their optical properties and measure the photoluminescence enhancement factor.

References:

[1] Rodriguez, S.; Schaafsma, M.; Berrier, A.; Gomez Rivas, J. Collective Resonances in Plasmonic Crystals: Size Matters. Phys. B 2012, 407, 4081–4085.
[2] Kelly, K. L.; Coronado, E.; Zhao, L. L.; Schatz, G. C. The Optical Properties of Metal Nanoparticles: the Influence of Size, Shape, and Dielectric Environment. J. Phys. Chem. B 2003, 107, 668–677.
[3] Kreibig, U.; Vollmer, M. Optical Properties of Metal Clusters; Springer Science & Business Media, 2013.
[4] M.Dewynter, et al. (Article in progress), The first article to demonstrate SLR in Bi-Material array

Abstract

Thematic Session : Nanophotonics & Nano-optics
Disciplinary fields involved : Physics
Keywords : InGaN/GaN NWs, MBE, light emitting diode, doping

In-rich InGaN/GaN nanowires for red light emitting diodes

Nidel Tchoulayeu, Martina Morassi, Krishnendu Sarkar, Quang-Chieu Bui, Laurent Travers, Julien Chaste, Jean-Christophe Harmand, Maria Tchernycheva, Noëlle Gogneau

1. *Centre de Nanosciences et Nanotechnologies, Département de photonique/Département des matériaux, Université Paris-Saclay, CNRS, UMR9001, 10 Boulevard Thomas Gobert, 91120 Palaiseau, France*

Indium-rich $In_XGa_{1-X}N$ alloys are very interesting for applications such as blue-to-red light emitting diodes. The particular choice of these direct-gap materials comes from their ability to cover the large spectral range from the infrared of InN (0.65eV) to the ultraviolet of GaN (3.4eV) as a function of the Indium content, and therefore cover the visible spectrum with the RGB colours of interest for displays.
Today, InGaN's commercial LEDs are fabricated from 2D epitaxial layers on Sapphire substrates, which work well for the blue spectral range. However, when we tend to increase the indium content above 20%, the formation of dislocations and indium clusters leads to a deterioration in the material quality. To overcome these problems, one approach is to grow LEDs in the form of nanowires, using GaN nanowires as pseudo-substrate for growing InGaN. Due to their small footprint, nanowires are free from dislocations and allow easier stress relaxation through their free lateral surface [1].

In this contribution, we describe the growth of InGaN/GaN nanowires on Si (111) by molecular beam epitaxy. Earlier, we achieved In-rich defect free heterostructures with photoluminescence wavelength up to 600 nm [1]. Here, we discuss the key parameters for their growth, especially the In/Ga flux ratio defining NWs morphologies, and substrate temperatures allowing to control the In content and in particular to further shift the wavelength towards the red color. We also studied here the influence of doping, using Mg as p-dopant, and Si as n-dopant in view of the optimization of the electrical injection in the p-GaN/InGaN/n-GaN LED. We performed SEM / EDX analysis of InGaN/GaN heterostructures in nanowires, which show that the InGaN insertion tends to form a core-shell structure, with an InGaN core surrounded by a GaN shell. The red InGaN/GaN nanowire LED fabrication is underway.

References :
[1] M. Morassi et al., Cryst. Growth Des. **18**, 2545 (2018)

Abstract

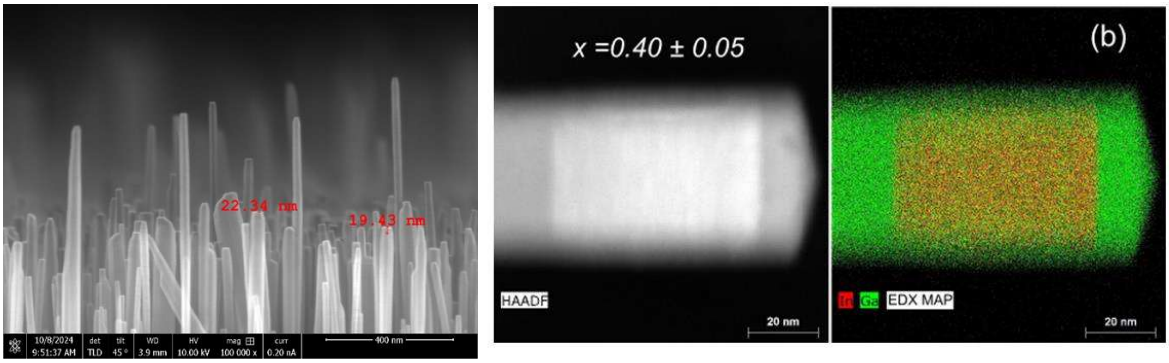
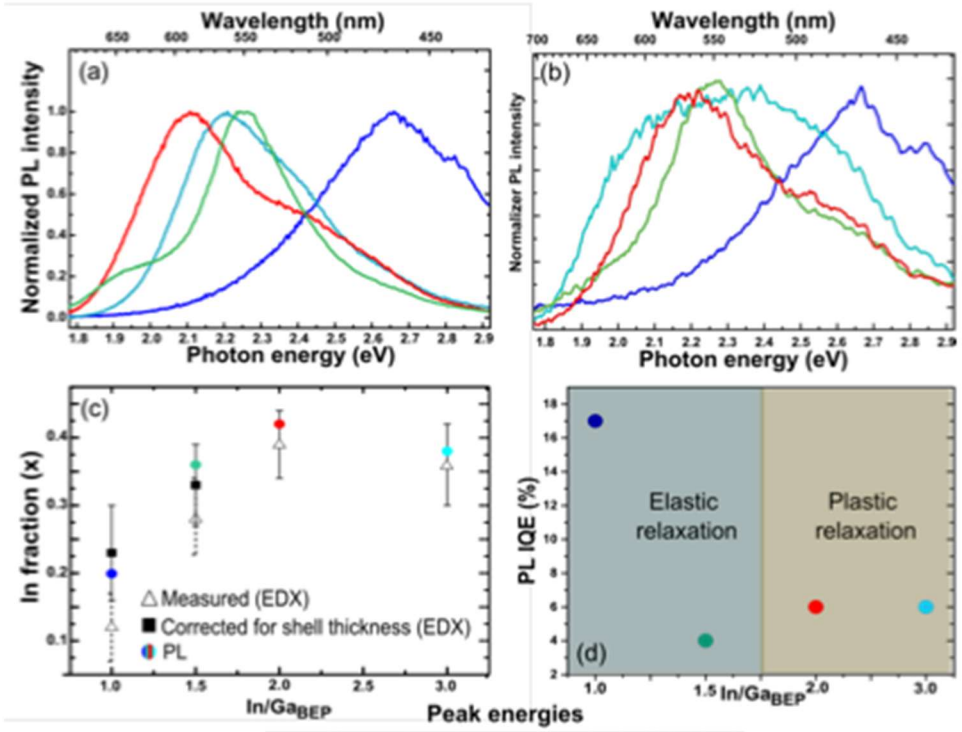


Fig. 1 Left – SEM imae of InGaN/GaN nanowires. Right – TEM image and the EDX map of the $In_xGa_{1-x}N$ insertion.



In/Ga	Sample name	4 K (eV)	300 K (eV)
1	#C016	2.65	2.7
1.5	#C028	2.25	2.3
2	#C017	2.2	2.2
3	#C041	2.1	2.3

Figure 2: Photoluminescence of InGaN nanowire ensembles at (a)10 K and (b) 300 K. (c) In fraction estimated from the PL peak and measured by EDX. (d) Optical internal quantum efficiency. Summary table.

Abstract

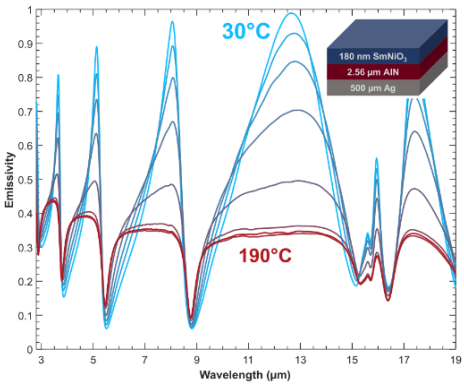
Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics and material sciences
Keywords: Rare-earth nickelates, emissivity, multi-layer, S-matrix, genetic algorithm

Optimization of thermochromic perovskites (*RE*NiO_3) radiative properties for thermal screening application

Pierre-Antoine Tostivint[1], Jérémie Drévillon[2], Fabien Capon[1]

1. *Institut Jean Lamour, CNRS, Université de Lorraine, F-54000, Nancy, France*
2. *Institut Pprime, CNRS, Université de Poitiers, F-86022, Poitiers, France*

Abstract (**no longer than 250 words** or 18 lines max. incl. figure), Calibri 11, single line spacing, black)



Since the end of the 90's, rare-earth nickelates thin film synthesis progress highlighted their remarkable properties allowing thermal regulation and infrared stealth applications [1,2,3].
Lately, the Institut Pprime's work on the spectral control and optimization of the radiative properties using simulation tools (scattering matrix) and metaheuristics algorithms, and the recent advances in thermochromic thin films elaboration and characterization by the Institut Jean Lamour encouraged an association between these groups. It allowed to design thin films and particular structures with interesting temperature dependent radiative properties and avoiding experimental trial and fail strategy.
In order to solve thermal screening issues, complexes structures such as thermally activated Fabry-Pérot cavities can be imagined to generate an important emissivity variation with temperature. Indeed, at low temperature, rare-earth nickelates acts as a semi-transparent material while as high temperature, it behaves as a mirror, therefore activating the Fabry-Pérot cavity.
This work will present, first of all, the $SmNiO_3$ thin film elaboration by sputtering and the obtention of the optical indexes depending on the temperature by infrared spectroscopic ellipsometry. And then, I will present you the different optimization who can be done to obtain high variation of emissivity or thermal screening.

References (max. 5):
[1] N. E. Massa, J. A. Alonso, M. J. Martinez-Lope, I. Rasines, « Reflectivity, transmission, and photoinduced infrared spectra of NdNiO3 », *Phys. Rev. B*, vol. 56, n°3, p.986-989,1997.
[2] C.Napierala, M.Edely, P.Laffez, L.Sauques, « Thermo-optical effect of Nd0.3Sm0.7NiO3 ceramic in the infrared range », *Opt.Mater*., vol. 31, n°10, p. 1498-1501,2009.
[3] J. F. De Natale, P. H. Kobrin, « Lattice distorsion effects on electrical switching in epitaxial thin film NdNiO3 », *J. Mater. Res*., vol.10, n°12, p. 2992-2995, 1995.

Abstract

As shown in Fig. 2a), the transducer's response is clearly sensitive to hydrogen concentrations between 0.1 and 0.05 %. Fig. 2b) presents the change in the normalized differential signal before and after each hydrogen cycle. The linearity of these responses enables the differentiation of distinct hydrogen concentrations, culminating in a detection limit of 50.07 ppb, given a measured white noise level of $\sigma = 9.12 \times 10^{-8}$.

References (max. 5):

1. Sauvage-Vincent J, Jourlin Y, Petiton V, Tishchenko AV, Verrier I, Parriaux O. Low-loss plasmon-triggered switching between reflected free-space diffraction orders. Opt Express. 2 juin 2014;22(11):13314.

2. Parriaux O, Jourlin Y. Lossless 0th and- 1st order switching by dual-excitation of grating waveguide mode. Journal of Optics. 2019;21(7):075603.

Acknowledgement:

The authors acknowledge the NanoSaint-Etienne platform (CNRS RENATECH+) for providing the fabrication facilities and the NAPA company for the replication. This work was funded by the Région Auvergne-Rhône-Alpes (France) under the CAPTHY project.

Abstract

Thematic Session: Nanophotonics & nano-optics
Disciplinary fields involved: Physics
Keywords: Optical biosensor; Phase-change material; Thermal tuning; Ultrasensitive biosensing

Enhanced Near-Infrared Plasmonic Sensing Chips with Ultra-Thin Optical Absorption Nanolayer Fabricated by Cross-beam Pulsed Laser Deposition

Nurzad Zakirov[1,2], Shaodi Zhu[1], Amine Zitouni[2], Etienne Charette[2], Wenqiang Xiang[2], Boris Le Drogoff[2], Mohamed Chaker[2*], Shuwen Zeng[1*]

1. *Laboratoire Lumière, nanomatériaux et nanotechnologies – L2n, Université de Technologie de Troyes & CNRS UMR 7076, 12 rue Marie Curie, CS 42060, 10004 Troyes Cedex, France*
2. *Institut National de la Recherche Scientifique, Centre Energie Matériaux &Télécommunications, Universitédu Québec, Varennes, Québec PQ J3X 1S2, Canada*

Plasmonic biosensing is an optical technique that is based on refractive index change when the target molecules interact with the sensing surface. The integration of nanotechnology offers novel approaches to address challenges in biosensing systems.

Our work is focused on designing a novel thermal tunable Surface Plasmon Resonance (SPR) sensing chip with tungsten (W)-doped vanadium dioxide (VO_2) nanolayer, known for its unique insulator-to-metal phase transition in the near-infrared region[1]. Herein, to obtain the precise control of thickness and surface roughness of the W-VO_2 layer, we adopted the cross-beam pulsed laser deposition (CB-PLD).

An abrupt phase change occurs at the resonant dip angle where the reflected light intensity is approaching zero. The sharp phase jump results to a large Goos-Hänchen (GH) shift which has a more sensitive biosensing response[2].

This study presents the fabrication of a light-absorbing 2 at.% W-doped VO_2 film positioned between the substrate and gold film for biosensing application[3]. Under 988 nm laser excitation wavelength reversible thermal tunability of W-VO_2/gold SPR sensing chip was demonstrated. High-temperature measurements showed intensity reduction of the reflected light at the SPR angle, enhancing GH shift sensitivity.

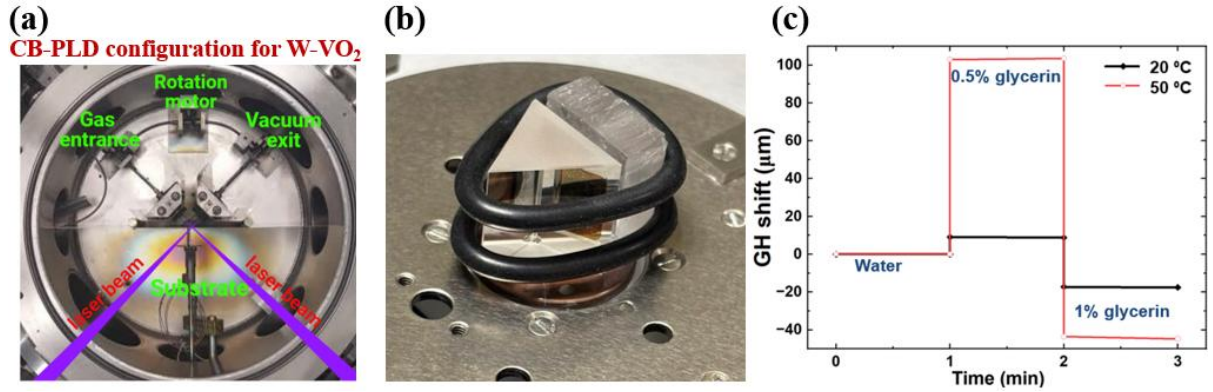


Figure 1: a) CB-PLD configuration; b) Prism with the sample and fluidic chamber on the heater; c) Experimental GH shift measurements with heating plate for W-doped VO_2 / gold sample

Abstract

References:
[1] Cueff, Sébastien, et al. "VO_2 nanophotonics." APL Photonics 5.11 (2020).
[2] Zhu, Shaodi, et al. "Label-free biosensing with singular-phase-enhanced lateral position shift based on atomically thin plasmonic nanomaterials." Light: Science & Applications 13.1 (2024): 2.
[3] Chaker, Mohamed. "Pulsed Laser Deposition: A Flexible Tool for the Synthesis of Advanced Functional Materials." 2020 IEEE International Conference on Plasma Science (ICOPS). IEEE, 2020.

Acknowledgement:

This work is supported under the UTT Project Stratégique NanoSPR (OPE-2022-0293) and the Graduate School (Ecole Universitaire de Recherche) “NANO-PHOT” (ANR-18-EURE-0013). Financial support of Nano’Mat (http://www.nanomat.eu) by the Ministère de l’enseignement supérieur et de la recherche, the Conseil Régional Grand Est, the FEDER fund, the Conseil général de l’Aube, and the co-funding for postgraduate studentship of INRS are also acknowledged.

Abstract

Thematic Session: Nanocomposite
Disciplinary fields involved: Chemistry, Physics
Keywords: smectic, assembly, fluorescent, gold

Composites nanoparticles/liquid crystals, structure and electro-optical properties

Muyan Zhou[1], Myriam Uros[2], Jean de Dieu Niyonzima[1,3], Haifa Jeridi[4,1], Lamya Essaoui[1], Caterina Tosarelli[1], Alina Vlad[5], Alessandro Coati[5], Sébastien Royer[1], Isabelle Trimaille[1], Michel Goldmann[1], Bruno Gallas[1], Doru Constantin[6], David Babonneau[7], Yves Garreau[4,8], Bernard Croset[1], Lydia Sosa-vargas[2] and Emmanuelle Lacaze[1]

1. Sorbonne Université, CNRS, Institut des Nano-Sciences de Paris (INSP), F-75005 Paris 2. Sorbonne Université, CNRS, Institut Parisien de Chimie Moléculaire Paris (IPCM), F-75005 Paris, France 3. Physics Department, School of Science, College of Science and Technology, University of Rwanda, P.O. Box 3900 Kigali, Rwanda 4. ECE Research Center (LyRIDS), ECE Engineering School, 75015 Paris, France 5. Synchrotron SOLEIL, BP 48, L'Orme des Merisiers, 91192 Gif sur Yvette Cedex 6. Institut Charles Sadron, CNRS and Université de Strasbourg, 67034 Strasbourg 7. Université de Poitiers, ISAE-ENSMA, CNRS, PPRIME, Poitiers 8. Université Paris Cité, CNRS, Laboratoire Matériaux et Phénomènes Quantiques (MPQ), F-75013, Paris.

Abstract

Smectic liquid crystal 8CB, assembled on a rubbed polyvinyl alcohol polymer substrate, forms structures known as oily streaks, where smectic layers curve into flattened hemicylinders, creating ribbon-like grain boundary topological defects parallel to the substrate and of width between 300 and 400nm [1]. These defects can confine nanoparticles (NPs), such as gold or semiconductor nanospheres, forming ordered, self-oriented ribbon-like monolayers of NPs all parallel to each other, of orientation controlled by the rubbed polymer substrate [2]. By controlling solvent evaporation, we demonstrate that the proportion of oily streaks with fewer dislocations increases, promoting the formation of straight, high-quality NP ribbons. The length of these ribbons increases with NP concentration, reaching lengths of over 6 µm with a large density reaching around one ribbon per µm. In previous experiments, nanospheres and nanorods have successfully formed ribbons confined in the topological defects with various ligands but only with isolating ribbons. Building on the success of these long NP ribbons, the next step involves replacing the isolating ligands with conjugated units to create semiconductive chemical ligands. These new ligands are expected to enhance interactions with 8CB liquid crystals, leading to a more ordered nanoparticle arrangement. Furthermore, the conducting ligands will be synthesised to improve electron transfer between nanoparticles, imparting unique electrical properties to the resulting composites.

References :

[1] Jeridi H, de Dieu Niyonzima J, Sakr C, et al. The unique orientation of 1D and 2D nanoparticle assemblies confined in smectic topological defects[J]. Soft Matter, 2022, 18(25): 4792-4802.

[2]Do S P, Missaoui A, Coati A, et al. From chains to monolayers: nanoparticle assembly driven by smectic topological defects[J]. Nano Letters, 2020, 20(3): 1598-1606.