Tuesday, November 23th

Session Nanophotonics & Nano-optics

10:50 - 11:20 Keynote

Peter WEICHA, CNRS-LAAS, France

Abstracts

Keynote Speakers

Peter Wiecha

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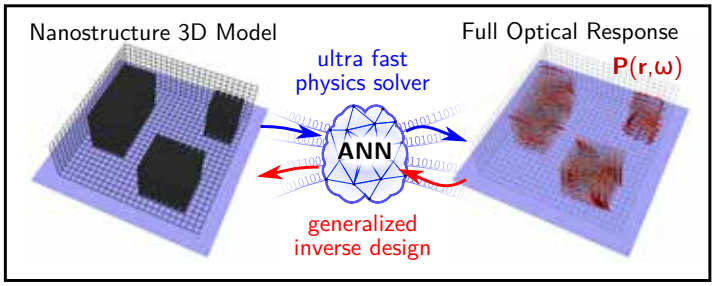
Biography

Peter Wiecha's main research interests are the interaction of light with subwavelength small structures, and applications of artificial intelligence in nano-optics and photonics. He studied physics at the Technical University of Munich in Germany where he wrote his Diploma thesis at the Walter Schottky Institute. In 2016 he obtained his PhD from the Université Paul Sabatier of Toulouse for a work on non-linear optical processes in nanostructures. After a postdoc at CEMES-CNRS Toulouse on the interaction of magnetic quantum emitters with non-magnetic nanostructures, he held a German DFG research fellowship between 2018 and the beginning of 2020, working with Prof. Otto Muskens at the University of Southampton on deep learning for nano-photonics. Since 2020 he is a permanent CNRS researcher (CRCN) at LAAS in Toulouse.

DEEP LEARNING MEETS NANO-OPTICS

Deep artificial neural networks (ANNs) have shown tremendous potential in solving problems that are very difficult to approach with conventional algorithms. Therefore, researchers from manifold areas including medicine, biology and physics increasingly use methods of AI to approach problems that were formerly hard or even impossible to solve [1]. ANNs can be very efficient in the analysis of large (scientific) datasets from simulations, microscopy, tomography or spectroscopy among others [2-5]. ANNs can learn to phenomenologically solve physical models with unprecendented speed and have proven to be able to predict approximate solutions to notoriously hard inverse problems [3-4]. In several proof-of-principle studies ANNs have been recently used for the on-demand conception of photonic devices and meta-materials [2].

I will introduce the core concepts of ANNs and how they can be employed to tackle problems in (nano-)optics, allowing to drastically accelerate numerical simulations or to solve inverse problems. I will describe how an ANN can be taught a generalized intuition of nano-scale light-matter interaction [4]. I will also show how ANNs can help in the evaluation of experimental data in nano-optics. An example is the combination of photonic nanostructures with ANNs for optical information storage, allowing to overcome a major constraint for the achievable data-density due to the optical diffraction limit [5].



© Illustration of an artificial neural network predicting the full, complex fields inside nanostructures of arbitrary shape, using as input a 3D discretization of the geometry. The model can be used e.g. as fast surrogate model for accelerated inverse design.
P. Wiecha, 2020

References

[1] Y. LeCun, Y. Bengio, and G. Hinton, Nature, vol. 521, no. 7553, pp. 436–444, 2015
[2] R. S. Hegde, Nanoscale Adv., vol. 2, no. 3, pp. 1007–1023, 2020
[3] U. Kürüm, P. R. Wiecha, R. French, and O. L. Muskens, Opt. Express, vol. 27, no. 15, pp. 20965–20979, 2019
[4] P. R. Wiecha and O. L. Muskens, Nano Lett., vol. 20, no. 1, pp. 329–338, 2020
[5] P. R. Wiecha, A. Lecestre, N. Mallet, and G. Larrieu, Nature Nanotechnology, vol. 14, pp. 237–244, 2019

Keywords: nano-optics; deep learning; numerical methods for photonics; plasmonics.

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The Nanoscience Meeting
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December, 8, 9 and 10

Thematic Session: Nanophotonics & nano-optics
Keywords: Nanomechanics, MEMS & NEMS, coherent perfect absorption

Coherent Perfect Absorption in coupled Nano-Opto-ElectroMechanical Systems

Franck Correia[1], Guilhem Madiot[1], Sylvain Barbay[1] and Rémy Braive[2]

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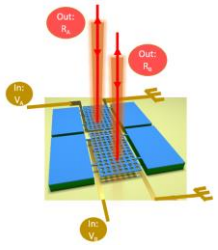
2. *Université de Paris, F-75006 Paris, France*

Coupled Nano-opto-electromechanical systems (NOEMS) are ideal platform to test physical concepts applied to mechanics. Large amount of various photonic structures able to couple to external fields were used to exhibit coherent perfect absorption (CPA) [1-3].
We hereby introduce our recent results on mechanical-like coherent perfect absorption (and transmission) phenomenon in a coupled nano-opto-electromechanical system. It consists in two mechanically coupled optomechanical cavities (Fig. 1), each cavity consisting of a membrane suspended over a pair of integrated interdigitated electrodes. On one hand, electromechanical transduction allows us to convert electrical energy injected into the system into mechanical displacements. On the other hand, optomechanical transduction enables to detect the system's displacements in the form of mechanical eigenmodes of the coupled NOEMS.
When coherently exciting both cavities with two identical excitations which phase difference and amplitudes are controllably varied (Fig. 2), it is possible to observe nonlinear variation of the mechanical response as absorption (or transmission) behaves in a photonic structure [4]. This variation is well understood and modelled by analytic forms or via the mechanical dynamics equations of our system.
Applications in optics pave the way for the NOEMS scheme that can for now deal with astonishing physics e.g. realization of optical switches, logical gates or polariton states to name a few.



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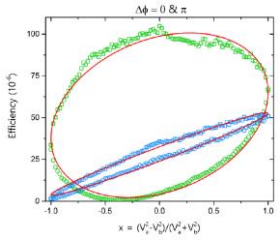

(2)

Figs. 1 and 2:
Artistic view of the experimental set-up.
Coherent absorption control in a linear two-port system (experiment and fit).

References: **[1]** Gutman *et al.*, Optics Letters **38**, Issue 23 (2013), **[2]** Papaioannou *et al.*, Light: Science and Applications, **5** (2016), **[3]** Baranov *et al.*, Nature Reviews Materials, **2** (2017), **[4]** Baldacci *et al.*, Life, New Materials and Plasmonics, **26** (2015).

Acknowledgment: FetProactiv HOT, ANR JCJC ADOR, Flagship NanoSaclay MaCaQu.

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Thematic Session: Nanophotonics & nano-optics
Keywords: Chirality, Gold-Nanoparticles, Silica Nano-helices, Grazing Incidence Spraying

Design of photonic nanostructures via chirality induction

Jie Gao,[1] Wenbing Wu,[2] Vincent Lemaire,[2] Alain Carvalho,[2] Sylvain Nlate,[1] Thierry Buffeteau,[3] Reiko Oda,[1] Yann Battie*,[4] Matthias Pauly*,[2] Emilie Pouget*[1]

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In the field of functional nano-materials, the chiral structures like helices or twisted ribbons are of great interest because of their optical and mechanical properties. In the present work, functional hybrid nano-helices are synthesized by use of organic chiral self-assemblies forming very well defined helix structures as templates. The mineralization of these self-assemblies allows creating silica nano-helices with very well controlled morphologies in term of diameter and pitches [1]. We also focused particularly on the formation of short helices (length control), individualized and well-dispersed in solution [2], and their hierarchical organization at a macrometric level.

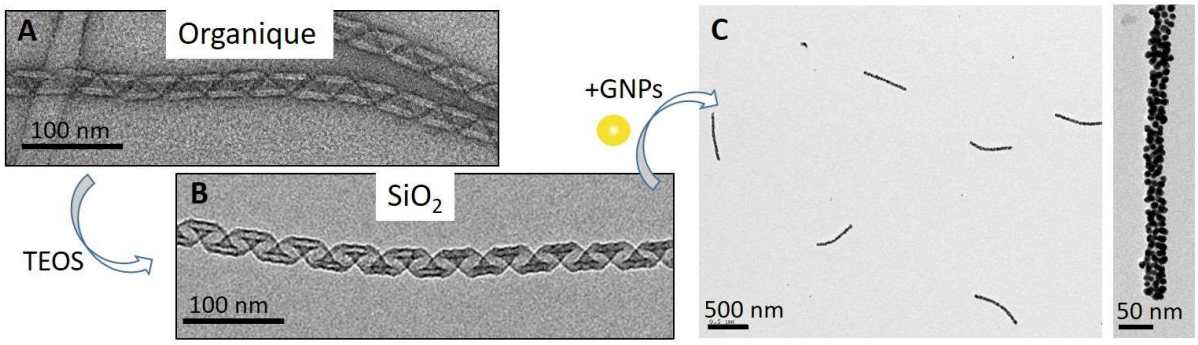

Figure. A- Amphiphile molecules self-assembly into nanometric chiral structures and B- their silica transcription. C- Grafting of gold nanoparticles.

These nanohelices are then used as template for the grafting of gold nanoparticles to create photonic devices [3]. Because the Gold@silica nanohelices synthesized are well dispersed, it has been possible to align and organize them on different levels via Grazing Incidence Spraying processes, inducing a modulation of the photonic properties by the 2D and 3D organizations [4].

References: [1] Delclos et al., NanoLetters 2008, 8(7), 1929-1935. [2] Okazaki et al., ACS Nano 2014, 8(7), 6863-6872. [3] Cheng et al. ACS Nano 2017, 11 (4), pp 3806–3818. [4] Gao et al. ACS Nano 2020, 14, 4, 4111–4121

Acknowledgment: LabEx AMADEus (ANR-10LABX-42), JST (Japan) and Chinese Scholarchip Council are gratefully acknowledged.

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Thematic Session: Nanophotonics & nano-optic
Keywords: Chiral plasmonics, photopolymers, chirality, circular polarization.

Near-Field Photochimical Imaging Of Chiral Nanostructures

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1. *Lumière, nanomatériaux, nanotechnologies (L2n), Université de Technologie de Troyes & CNRS ERL 7004, Troyes 10004, France.*

Chiral nanostructures interact differently with right and left circularly polarized light. Moreover, they exhibit enhanced electric and magnetic near-fields leading to the so-called superchirality. This effect can be used for the detection of chiral biological objects with high enantio-sensitivity. Indeed, the optical chirality *C* is correlated with the rate of excitation of the chiral molecule [1], so that increasing the optical chirality at the location of the molecule can significantly improve its detection. We present here a subwavelength imaging approach that is based on the interaction between the highly exalted near-field of chiral nanoparticles and an azobenzene molecule (DR1, disperse red 1) grafted to a polymeric chain (i.e. PMMA). Under illumination, the azobenzene molecules undergo photo-isomerization cycles, which induce a displacement of matter inducing measurable topographical modifications that can be tracked using atomic force microscopy. Therefore, we obtain in the polymer a map of the near-field of the chiral nanostructures [2]. We recently demonstrated that chiral effects and field dissymmetry in plasmonic nanostructures can be imaged with this technique [3]. Here, we apply photochemical imaging to chiral metallic nanostructures, such as chiral coupled nanorods.

References:

[1] Tang, Y. And Cohen, A. E. 2010. *Phys. Rev. Lett*. 104, 163901.
[2] Plain, J. Wiederrecht, G. P. Gray, S. K. Royer, P. and Bachelot, R. 2013. *J. Phys. Chem. Lett*. 2013, 4, 2124-2132.
[3] Horrer, A. Zhang, Y. Gérard, D. Béal, J. Kociak, M. Plain, J. and Bachelot, R. 2020. *Nano Lett*. 20, 509–516.

Acknowledgment:
This work is funded by the Région Grand Est and the Conseil Général de l'Aube.

References:

[1] J. M. Rye, C. Bonnet, F. Lerouge, M. Pellarin, J. Lermé, S. Parola, and E. Cottancin*, Single gold bipyramids on a silanized substrate as robust plasmonic sensor for liquid environments*, Nanoscale. **10**, 16094-16101 (2018).
[2] T. H. Chow, N. Li, X. Bai, X. Zhuo, L. Shao, and J. Wang, Gold Nanobipyramids: An Emerging and Versatile Type of Plasmonic Nanoparticles, Acc. Chem. Res. **52**, 8, 2136–2146 (2019).
[3] J. R. G. Navarro, D. Manchon, F. Lerouge, E. Cottancin, J. Lermé, C. Bonnet, F. Chaput, A. Mosset, M. Pellarin, and S. Parola, *Synthesis, electron tomography and single – particle optical response of twisted gold nano – bipyramids*, Nanotechnology. **23**, 14 (2012).

Acknowledgment:

We acknowledge the USTH French consortium that support this work and the French Region Auvergne Rhône-Alpes, project SCUSI n°1700936601.

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Thematic Session: Nanophotonics & nano-optics
Keywords: plasmon, bimetallic, ultrafast, transient

Sharp spectral variations of the ultrafast transient near-ultraviolet light extinction by bimetallic gold-silver nanoparticles

Tadele Orbula Otomalo,[1] Lorenzo Di Mario,[2] Cyrille Hamon,[3] Doru Constantin,[3] Khanh-Van Do,[1] Patrick O'Keeffe,[2] Daniele Catone,[2] Alessandra Paladini,[2] and Bruno Palpant[1]

1. *Université Paris-Saclay, CNRS, ENS Paris-Saclay, CentraleSupélec, LuMIn, Gif-sur-Yvette, France*
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Shining plasmonic nanoparticles (NPs) with ultrashort laser pulses generates transient phenomena which can be exploited in a wide range of fields. These phenomena can be ascribed to the ultrafast dynamics of the metal hot electron gas induced by multiphoton absorption [1]. Besides, the NP size, shape and composition influence the characteristics of the localized surface plasmon resonance. In this communication, we present both the stationary and transient optical responses of gold nanorods coated with a silver shell with variable thickness (AuNR@Ag) [2]. Broadband transient absorption spectroscopy was carried out to determine the ultrafast dynamics of the optical response of these nanoparticles (NPs) [3]. The results are analyzed with a two-step model [3,4]. We demonstrate the influence of both the different plasmon modes which evolve with NP shape and the balance between absorption and scattering contributions on the NP optical response. It is found that high-energy transverse modes generate strong and spectrally-narrow variations of the NP extinction (Fig. 1). In addition, it is shown that the transient optical response is more sensitive to resonance modes than its stationary counterpart.

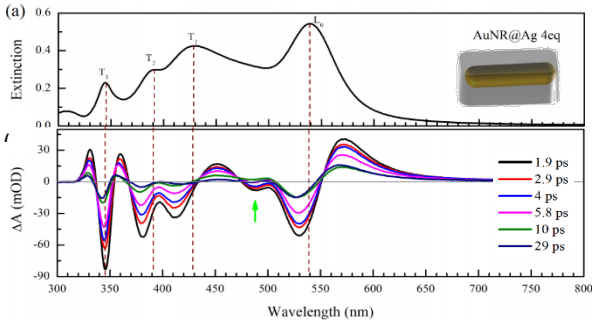

Fig. 1: (a) Experimental stationary extinction spectrum of AuNR@Ag NPs with equivalent Ag:Au molar ratio of 4. One longitudinal dipolar mode and 3 multipolar transverse modes can be identified. (b) Ultrafast transient variation of the absorbance spectrum induced by interaction with a pump laser pulse, probed at different time delays. Strong and narrow features can be associated with the plasmon modes. The green arrow points a bleaching zone which reveals the existence of an additional resonance mode, hidden in the stationary case (a).

1. X. Hou, N. Djellali and B. Palpant, ***ACS Photonics* 5**, 3856–3863 (2018).
2. C. Hamon, C. Goldmann, and D. Constantin, ***Nanoscale* 10** (38), 18362-18369 (2018).
3. L. Di Mario, T. O. Otomalo, D. Catone et al., ***Phys. Rev. B* 97**, 115448 (2018).
4. T. Labouret and B. Palpant, ***Phys. Rev. B* 94**, 245426 (2016).

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Thematic Session: Nanophotonics & nano-optics
Keywords: nanoparticles, plasmon-phonon coupling, acoustic vibrations, Raman spectroscopy

Polarization dependent inelastic light scattering by acoustic vibrational modes of Au nanoparticles

M. M. Timm[1,2], A. Crut[2], L. Saviot[3], A. Mermet[2], L. Joly-Pottuz[1], K. Masseneli-Varlot[1], and J. Margueritat[2].

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The measurement of acoustic vibrational modes is fundamental to the full comprehension of the mechanical properties of nano-objects, since they are connected to the intrinsic characteristics of the material, such as crystallinity, size, shape and elasticity.[1] At the nanoscale, when localized plasmons couple to localized vibrations, the enhancement of inelastic light scattering signals from acoustic vibrational modes is expected.[2] In this contribution, we investigate the coupling between plasmon and acoustic vibrations of assemblies of 100 nm Au nanocubes using low-frequency Raman spectroscopy. We show that changes in incident polarization affect the plasmon and thus modify the distribution of the electrical field inside the particles, therefore modifying the efficiency of the scattering by the acoustic vibrational modes. We also analyze the polarization of the scattered light for a given incident polarization as a way to correlate the behavior of the vibrational modes to the plasmon modes. We are able to observe a symmetric response of the vibrational modes related to the excited plasmon modes. The acoustic modes detected experimentally are identified with the help of numerical simulations representing vibrational and plasmon modes.

References:
[1] Hodak, J. H.; Martini, I.; Hartland, G. V. Spectroscopy and Dynamics of Nanometer-Sized Noble Metal Particles. J. Phys. Chem. B 1998, 102 (36), 6958−6967
[2] Girard, A., Lermé, J., Gehan, H., Mermet, A., Bonnet, C., Cottancin, E., Crut, A., Margueritat, J. Inelastic Light Scattering by Multiple Vibrational Modes in Individual Gold Nanodimers. *The Journal of Physical Chemistry C* 2019 *123* (23), 14834-14841

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Thematic Session: Nanophotonics & nano-optics
Keywords: single nanoparticle, gold bipyramids, plasmonics, scattering, polarization.

Single gold bipyramid orientation measured by scattering polarization spectroscopy

Cam Nhung Vu[1], Zakarya Ouzit[2], Agnès Maître[2], Laurent Coolen[2], Frédérique Lerouge[3], Julien Laverdant[1].

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2. *Sorbonne Université, CNRS, Institut de NanoSciences de Paris, INSP, F-75005 Paris, France*
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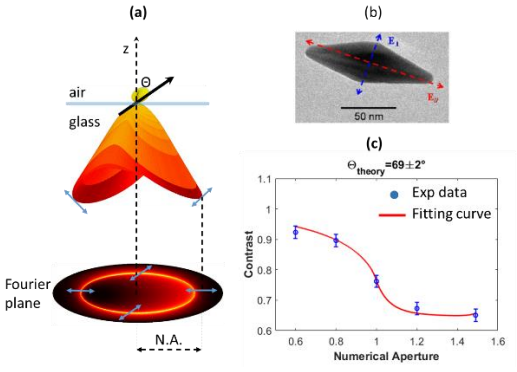
Among elongated plasmonic nanoparticles, gold bipyramids (AuBPs) are particularly interesting due to their sharp-end tips. It shows strong local electric field enhancement and narrow longitudinal resonance in the near infrared region that are favorable for photonics, sensing, and biomedical applications [1,2]. For many applications, monitoring the spatial orientation of nanoparticles is a key point for optimizing plasmonic coupling as well as extracting environment information. A AuBP with high aspect ratio can be modeled as two independent orthogonal dipoles with strong polarized scattering along the longitudinal component [3].

Herein, we perform the determination of single AuBP (**Figure b**) orientation on a glass substrate from polarimetric measurements based on dark-field scattering spectroscopy with controlled collection angles (**Figure a**). In particular, we demonstrate for the first time, at the single AuBP level, the strong influence of the collection angle on the polarization contrast (**Figure c**).



Our work shows how in a dark-field field microscope, the polarization measurement strongly depends on the experimental configuration. In particular, a very high numerical aperture objective may give access to more scattering but will reduce the polarization and may lead to errors in the interpretation.

Wednesday, November 24th

Session Nanophotonics & Nano-optics

10:50 - 11:20 Keynote

Patrice GENEVET, CNRS-CRHEA, France

Abstracts

Keynote Speakers

Patrice GENEVET

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Biography

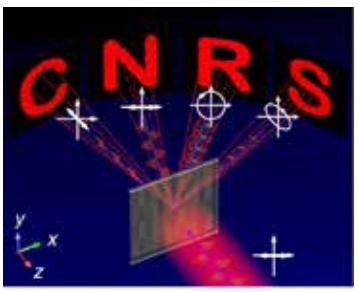
Patrice Genevet received his Ph. D. degree at the université Côte d'Azur, France in 2009 on localized spatial solitons in semiconductor lasers and amplifiers.He did five years as a research fellow (2009– 2014) in the Capasso group (SEAS, Harvard University) in collaboration with Prof. Scully (Texas A& M University). In 2014, he obtained the position of senior research scientist at A⋆STAR, Singapore. In 2015, He joined CNRS as permanent 'Chargé de Recherche'.He is the recipient of the 2017 Aimé-Cotton Price from the French Physical Society, the ERC starting Grant 2015 on Functional flat optical components and applications and the 2019 ERC proof of Concept. P. Genevet research activities concern the development of optical metamaterials, metasurfaces and their applications.

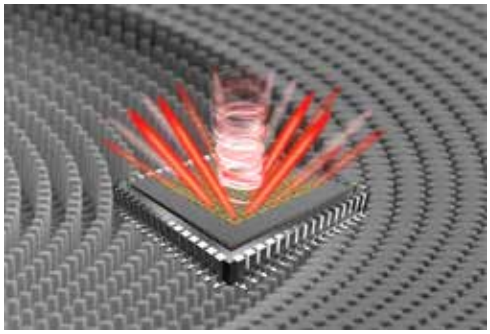
APPLICATIONS OF METASURFACES

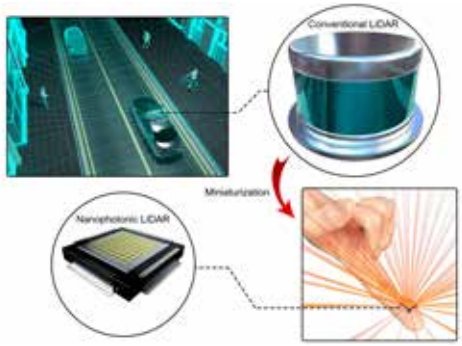
A class of planar and wavelength-thick optical components exhibiting exceptional optical properties have emerged in recent years. These artificial interfaces, known as metasurfaces, can manipulate the wavefront of light in almost any desired manner, leveraging on the scattering properties of the subwavelength nanostructures. Currently, this technology is creating new application opportunities and efforts to realize dynamic tuning, broadband applications and industrial production are proposed.

In this presentation, I will discuss basic designs and fabrication methods of metasurfaces and summarize various applications for beam steering, polarization control and monolithic integration of metasurfaces in opto-electronic systems. As an alternative of conventional bulky, the development of this technology is expected to create a positive disruption in modern optical technologies, in particular in the fields of imaging, holography, 3D dynamic image rendering, AR/VR and LiDAR systems.

Keywords: nanophotonics; metamaterials; metasurfaces; LiDAR; Vectorial Beam shaping; holography.







Thematic Session: Nanophotonics, nano-optics & nanomaterials

Keywords: Dielectric metasurfaces, electron-beam lithography, etching, Finite-Difference-Time-Domain, wavefront control

Challenges in Nanofabrication for Efficient Optical Metasurfaces

Adelin Patoux[1,2,3], Gonzague Agez[1], Christian Girard[1], Vincent Paillard[1], Peter R. Wiecha[2], Aurélie Lecestre[2], Franck Carcenac[2], Nicolas Mallet[2], Guilhem Larrieu[2, 4] and Arnaud Arbouet[1]

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2. *LAAS-CNRS, Université de Toulouse, CNRS, Toulouse, France*
3. *AIRBUS DEFENCE AND SPACE SAS, Toulouse, France*
4. *LIMMS CNRS-IIS, University of Tokyo, Tokyo, Japan.*

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

Optical metasurfaces are planar metamaterials composed of subwavelength artificial structures allowing controlling optical properties of an incident light such as its phase, amplitude and polarization. Metasurfaces have become an exciting topic of interest in recent years due to their high efficiencies, very thin shape, and potential to combine different optical functionalities. [1] They have raised immense expectations as cheaper and lighter alternatives to bulk optical components. However, while being more efficient and versatile, metasurfaces are pushing further the level of requirement on the manufacturing precision in nanofabrication.

In this work, we address the challenges in metasurface nanofabrication on the example of a highly efficient meta-deflector fabricated by Electron Beam Lithography. We study in detail by numerical simulations the influence of the most common fabrication errors on the optical response of the metasurface. These results allow to quantitatively assess the tolerance to fabrication errors depending on which geometrical aspect of the nanostructures is being impacted. We identify the parameters that have the strongest impact and demand the highest precision to optimize the metasurface performance.

We illustrate these results with the design, fabrication and characterization of a silicon metasurface-based beam deflector operating in transmission at 750nm. This deflector shows theoretical and experimental deflection efficiencies of 92% and 89%, among the highest reported in the litterature. [2]

References (max. 5):
[1] : **A review of dielectric optical metasurfaces for wavefront control**

Kamali, S., Arbabi, E., Arbabi, A., & Faraon, A. (2018)., *Nanophotonics*, *7*(6), 1041-1068.

[2] : **High-Efficiency Visible Light Manipulation Using Dielectric Metasurfaces**

Rifat Ahmmed Aoni *et al*, *Sci Rep* **9,** 6510 (2019).

Acknowledgment: A.P. acknowledges support by Airbus Defence and Space (ADS), through a Ph.D. CIFRE fellowship (No. 2008/0925). This work was supported by the computing center CALMIP in Toulouse and by by LAAS-CNRS micro and nanotechnologies platform member of the French RENATECH network.

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Thematic Session: Nanophotonics & nano-optics
Keywords: Silicon, Hyperdoped nanostructures, plasmonics, Green's dyadic method

Hyper doped silicon based tunable mid-IR plasmonic metasurfaces

Clément Majorel[1], Jean-Marie Poumirol[1], Nicolas Chery[1], Vincent Paillard[1], Christian Girard[1], Nicolas Mallet[2], Guilhem Larrieu[2], Fuccio Cristiano[2], Peter R. Wiecha[2], A-S. Royet[3], S. Kerdilès[3], P. Acosta-Alba[3], Caroline Bonafos[1]

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3. *CEA-LETI, Universite Grenoble-Alpes, Minatec Campus, Grenoble, France*

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

Originally, the field of plasmonics was focused on metals due to their high concentration of free electrons. In nanostructures these electrons lead to localized surface plasmon resonances (LSPR) varying in the visible range with the nature of the metal, nanostructure shape and dielectric environment. Recently, an interest arose for a new category of plasmonic materials, heavily doped semiconductors. The doping of semiconductors makes it possible to artificially insert free carriers inside the material. Due to their lower free carrier densities comparing to metallic nanostructures, heavily doped semiconductor present plasmonic responses in the mid to near infrared range. In addition to shape and environment, the LSPR is now tunable with the quantity of activated dopants [1, 2].
We present here an extension of the Green Dyadic Method (GDM) to these new materials to predict the extinction, absorption and scattering properties of arbitrarily shaped structures in a complex environment [3].
We demonstrate that our model is well-suited for this new kind of materials by comparing our theoretical curves with experimental measurements performed using micro Fourier Transform Infrared spectroscopy (FTIR) on Si nanodisks heavily doped with P and elaborated by top down techniques. To confirm the correlation between the doping concentration and the spectral position of the LSPR, the measurements were carried out on identical arrays of Si nanodisks doped with increasing P concentration, in the range 10^{20}-10^{21} cm^{-3}. Finally, GDM allows the exploration of the influence of parameters as nanostructure shape, size, lattice periodicity and dielectric environment on the measured LSPR properties.

References (max. 5):
[1] Joseph M. Luther, Prashant K. Jain, Trevor Ewers and A. Paul Alivisatos, "Localized surface plasmon resonances arising from free carriers in doped quantum dots," Nature Mater. 10, 361–366 (2011)

[2] Nicolas J. Kramer, Katelyn S. Schramke, and Uwe R. Kortshagen , “Plasmonic Properties of Silicon Nanocrystals Doped with Boron and Phosphorus ,” NanoLett. 15, 5597−5603 (2015)
[3] Clément Majorel, Vincent Paillard, Adelin Patoux, Peter R. Wiecha, Aurélien Cuche, Arnaud Arbouet, Caroline Bonafos and Christian Girard, “Theory of plasmonic properties of hyper-doped silicon nanostructures,” Optics Communications 453, 124336 (2019).

Thematic Session: Nanophotonics & Nano-optics

Keywords: supercontinuum generation, photonic integration, nonlinear optics, mid-infrared, silicon photonics

2-octaves on-chip mid-infrared supercontinuum generation

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The mid-infrared (mid-IR) wavelength range has attracted substantial attention in the past two decades, especially for spectroscopy and sensing applications, as a wide variety of molecules features strong resonances in this spectral region[1]. Even though mid-infrared light sources have reached an impressive level of technological maturity, the wavelength range covered by a single device is still limited to a narrow spectral band. To overcome this limitation, the use of nonlinear optical phenomena is an alternative solution that enables light conversion emission over an ultra-wide spectral range. In this context, integrated supercontinuum generation (SCG) is extensively studied in silicon-based platforms as a mean to provide broadband and coherent light in the mid-IR regime[2].

This work reports the first on-chip supercontinuum demonstration reaching deep-mid-IR wavelength, up to 13 µm. This work relies on Ge-rich graded-index SiGe platform[3], which benefits from a wide transparency window, a large nonlinear coefficient, and unique possibilities in terms of GVD engineering for fine dispersion tailoring. Two-octave SCG is achieved in a compact 5.5 mm long device, covering an unprecedented wavelength range from 3 to 13 µm. An in-depth study is reported, showing the influence of the pump wavelength and pump power on the supercontinuum spectra. Therefore, these results pave the way for the realization of a wideband, coherent and compact long-wave mid-IR source using a single chip-scale compact device.

1. Popa, D. & Udrea, F.. *Sensors* **19**, 2076 (2019).
2. Sinobad, M. *et al. Optica* **5**, 360-366 (2018).
3. Montesinos-Ballester, M. *et al. Opt. Express* **28**, 12771-12779 (2020).

Acknowledgment:
European Research Council (ERC) Nº 639107-InsPIRE, EU Horizon-2020 FET microSPIRE project N° 766955. Fabrication partially performed at the Plateforme de Micro-NanoTechnologie/C2N, which is partially funded by the "Conseil Général de l'Essonne". This work was partly supported by the French RENATECH network. PoliFAB is also acknowledged for waveguides fabrication.

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December, 8, 9 and 10

Thematic Session: Nanophotonics & nano-optics, Nanomaterials,
Keywords: UpConversion, Biological imaging, Photochemisty

UpConverting NanoParticles: from small to Ultrasmall "Nanolamps"

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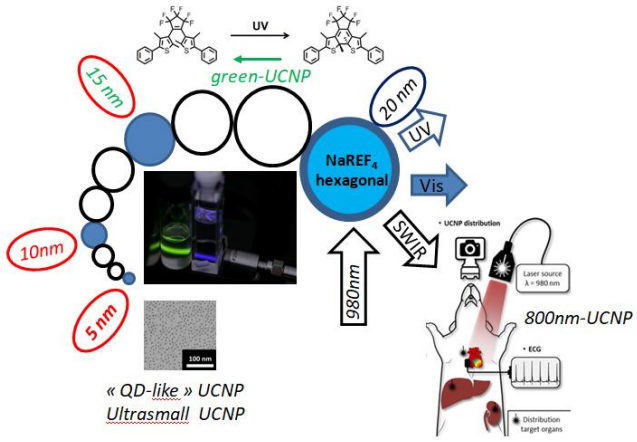
Upconverting Nanoparticles (UCNPs) present the fascinating property to transform low energy infra red light into more energetic ones, from the NIR up to the UV range, therefore becoming attractive tools for biological applications. In the past years we have questioned several issues bound to the use of such particles. Thus, we demonstrated that simple Yb, Tm-doped $NaYF_4$ nanocrystals could be used as "Trojan horse bioimaging probe" to image the pericardic cavity of a living mouse in the NIR region (800nm).[1]



However, such crystals can also be used to trigger photochemical processes. We have thus proposed a simple approach to quantify chemically the photon flux produced by such "nanolamps ».[2] Eventually, a crucial question remains the crystals' size, usually larger than the classical Quantum Dots. To tackle this issue we have modified the composition and the synthetic protocol. Functional particles a small as 3.5nm were successfully obtained. These points will be developed among others in the lecture

References :
1-M. Kermorgant *et al*. *PLoS ONE*, **2019**, *14*, e0225729. 2- B. Amouroux *et al*. *Beilstein J. Org. Chem*., **2019**, *15*, 2671-2677. 3- B. Amouroux *et al*. *Inorg Chem*. **2019**, *58*, 5082-5088.

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Thematic Session: Nano for Imaging, diagnosis and therapy
Keywords: Orientation analysis, Rare-earth, Nanorod, $NaYF_4$, Polarization

Three-Dimensional Orientation Analysis of Nanocrystals via Polarized Luminescence of Rare-Earth Dopants

Jeongmo Kim[1], Reinaldo Chacón[2], Zijun Wang[1], Eric Larquet[1], Khalid Lahlil[1], Aymeric Leray[2], Gerard Colas des Francs[2], Jongwook Kim[1], and Thierry Gacoin[1]

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Abstract
Orientation of anisotropic nanocrystals can be analyzed by examining the polarized emission of dipoles inherent in nanocrystals. Up to date, retrieving a three-dimensional (3D) orientation was made by observing a *single* emission dipole along multiple viewing angles or by scanning with a rotating polarizer. However, this method is practically limited as it requires a sophisticated optical setup and is sensitive to various external sources of error. In this work, we propose a new orientation analysis technique using a rare-earth doped nanocrystal that possess coupled *multiple* emission dipoles. Simultaneous comparison of relative intensities of these multiple emission dipoles enables an 3D orientation analysis from a single viewing angle. The unique nature of lanthanide luminescence originating from the electric and magnetic dipoles further enables an analysis with a single-shot emission spectrum[1,2]. Eu^{3+}-doped $NaYF_4$ nanorods we considered as a proof of concept to demonstrate this straightforward orientation analysis. The analysis is performed using a conventional fluorescence microscope and the direct orientation imaging of $NaYF_4$:Eu^{3+} nanorods proved a high accuracy of proposed analysis technique. This novel technique would find a new applicability into the mechanical behaviors of various nano- and biomolecular systems.

References
[1] J-W. Kim *et al.*, *Nat. Nanotechnol*, 12, 914 (2017)
[2] J. Kim *et al.*, *Submitted* (2020)

Acknowledgment
The authors thank Lucio Martinelli for the polarizing optical microscope setup. This research was supported by the French national research agency (ANR) in the framework of the SpecTra project (ANR-16-CE24-0014-01), and by Fondation Recherche Médicale (DCM20181039556, programme Chimie pour la Médecine).

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December, 8, 9 and 10

Thematic Session: Nanophotonics & nano-optics
Keywords: phononic waveguide, slow acoustical waves, optomechanical oscillators

Slow acoustical waves in the GHz for integration of nano-optomechanical oscillators

Giuseppe Modica[1], Rui Zhu[1], Robert Horvath[1], Gregoire Beaudoin[1], Isabelle Sagnes[1] and R. Braive[1,2]

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Oscillators in the ultra high frequency regime (UHF) are present in almost every domains, from industry to daily applications. However, the price to pay for their great phase noise performances is the limited integrability due to the bulky architecture needed for the oscillations stabilization. Optomechanical crystals with working frequency in the GHz have shown great compactness and integrability in the last few years [1]. Combining them with acoustic waves could lead to a new generation of ultra-stable optomechanical oscillators working directly at the frequency of interest with potentially low phase noise.

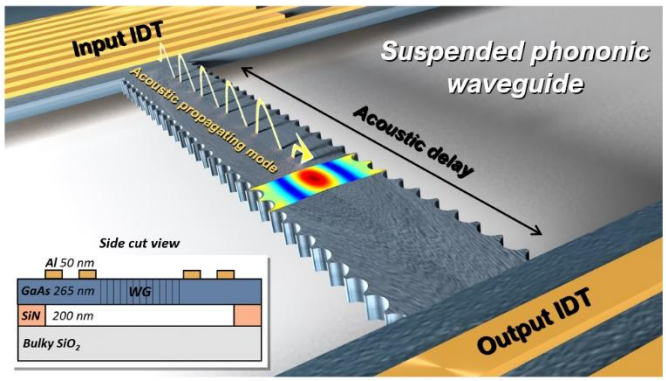

Figure 1 Schematic view of a suspended phononic waveguide, designed to have low group velocity, between two IDTs used for transmission measurements.

In the envisioned device, the resonator part is made by a 1D photonic crystal suspended over a silicon waveguide, sustaining optical modes around 1.55um and mechanical modes around a few GHz [2]. A key-element in such a scenario is the possible introduction of the needed delay for oscillations stabilization thanks to phononic waveguides. In particular, exploiting the properties of a slow propagating acoustical mode, it will be possible to introduce the needed hundreds of ns delay in a fully-integrable manner. Design, fabrication and experimental results of a slow acoustic mode in the GHz propagating through a III-V semiconductor phononic waveguide will be shown. Detailed group delay extrapolation and integration possibility with a 1D photonic crystal resonator will be additionally discussed.

Wednesday, November 24th

Session Nanophotonics & Nano-optics

16:00 - 18:05 Keynote

Gérard COLAS DES FRANCS, Univ. Bourgogne-ICB, France

Abstracts

Keynote Speakers

Gérard COLAS-DES-FRANCS

Professor at Bourgogne University
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Biography

Gérard Colas-des-Francs is full professor at the Université de Bourgogne. Alumni of ENS Cachan (1994). He holds a doctorate in Physics (2002) from the University of Toulouse, where he worked on fluorescence in a surface-tip junction. He then moved to University of Münster (Germany) as a Marie Curie fellow where he investigated highly resolved optical near-field microscopy. He has joined the Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB) in 2004. His current interests are focused on the fundamental aspect of nanophotonics, surface enhanced spectroscopies, and quantum plasmonics. He is currently the head of the submicron optics group at ICB.

PLASMONICS PURCELL FACTOR: RECONCILING CLASSICAL AND CQED APPROACH AND DOWNSCALING QUANTUM OPTICS TO THE NANOSCALE

Optical microcavities can store light for a long time allowing efficient light-matter interaction with important applications such as low threshold laser, or single photon generation. Light-matter interaction is generally quantified thanks to the Purcell factor Q/V where Q and V refer to the quality factor and mode volume of the cavity, respectively. Cavity quantum electrodynamics (cQED) relies on the extremely high quality factor but at the price of diffraction limited sizes. That is why strong efforts have been done since a decade to transpose cQED concepts to nanophotonics and plasmonics, taking benefit from the deeply subwavelength confinement of localized surface plasmon polaritons (LSP).

Therefore, an exact definition of the plasmonic Purcell factor is of strong interest to engineer quantum plasmonics devices but also for a better understanding of the light matter interaction at the nanoscale. I will introduce this concept with particular attention devoted to the role the radiation leakages that prevents to extrapolate standard cQED definition for the mode volume. The Purcell factor also constitutes a simple parameter and permits a scale law approach profiting from the strong maturity of cQED concepts and adapt them to nanophotonics. I will discuss cooperative emission by quantum plasmonic superradiance, paving the way towards ultrafast and extremelly bright optical nanosources.

Keywords: quantum plasmonics; Purcell factor; superradiance.

Thematic Session: (Nanophotonics & nano-optics)
Keywords: (hybrid nanoplamonics, quantum nanosource, photoluminescence, nano-photochemistry)

Polarization can drive photoluminescence in hybrid plasmonic nanosources

Dandan Ge[1], Sylvie Marguet[2], Ali Issa[1], Safi Jradi[1], Jérôme Plain[1], Céline Fiorini[3], Ludovic Douillard[3], Olivier Soppera[4], Xuan Quyen Dinh[5], Tao Xu[6], Christophe Couteau[1], and Renaud Bachelot[1,6]

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[4] Université de Haute Alsace, CNRS, IS2M UMR 7361, F-68100 Mulhouse, France
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[6] Sino-European School of Technology, Shanghai University, Shanghai, PR China

In microscale optoelectronics, the possibility to precisely control the spatial distribution of the active medium allows for the optimization of systems and devices. At the nanoscale, this issue still constitutes a challenge, especially in the domain of hybrid plasmonic nanosources.[1,2] We report on a study of the spatial overlap between the exciting optical near-field and the nanoscale active medium whose position in space is controlled *via* surface plasmon-triggered two-photon polymerization of a photosensitive formulation containing nano-emitters. By using different geometries of gold nanoparticles and different modes of plasmon excitation, nano-emitter-containing active medium can be structured selectively with different degrees of symmetry in the close vicinity of the metal nanoparticles. The resulting hybrid plasmonic nano-emitters (e. g. Fig. 1) are shown to be highly sensitive to the direction of polarization used for exciting the system. By decreasing the concentration of the nano-emitters within the formulation, single quantum emitters can be trapped in the vicinity of gold nanocubes. As a result, we report preliminary observation of a polarization-driven nano-switch in the single photon regime.[3]

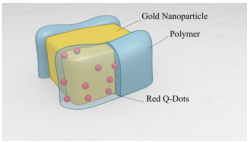

Fig.1 illustration of a hybrid plasmonic nanosources

References: 1. X. Zhou et al. Nano Lett. 15, 7458 (2015), 2. G. Colas des Francs et al. J. Opt. 18 094005 (2016), 3. D. Ge et al. Nat. Com. 11, 3414 (2020)
Acknowledgement: ANR, NFR, FEDER, EU, CSC, Région Grand-Est, Département Aube

Thematic Session: Nanophotonics & nano-optics

Keywords: quantum nano-optics, nitrogen-vacancy center, nanoxerography, silicon nanoantennas

Controlled positioning of single-photon emitters and coupling to dielectric nanoantennas by AFM-nanoxerography

M. Humbert[1,2], N. Mallet[3], A. Lecestre[3], P. Wiecha[3], G. Larrieu[3], V. Larrey[4], F. Fournel[4], V. Paillard[2], E. Palleau[1], A. Cuche[2] and L. Ressier[1]

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Abstract (**no longer than 250 words**)

One rising field in nano-photonics aims to better understand and control the interaction between single quantum emitters (quantum dots, molecules, colour centers) and photonic or plasmonic nanostructures. Numerous studies actually focus on the ability to precisely position single-photon sources, which is of primary interest for fundamental studies as well as for novel applications at the nanometre-scale [1]. While an abundant literature reports light-matter interactions involving plasmonic nano-antennas, limitations due to Ohmic losses have led to alternative research on high index dielectric nanostructures [2]. In particular, silicon nano-antennas present Mie resonances in the visible spectrum, leading to several phenomena such as angular directivity of scattered light [3], magnetic resonances, or near-field enhancement of emission from localized sources [4].

We present results of nanodiamond (ND) directed assemblies on a SiO_2/Si substrate (compatible with CMOS technology) using AFM-nanoxerography [5]. Negatively charged nitrogen-vacancy centers (NV^- centers) hosted in NDs are point source single-photon emitters with a broadband emission spectrum between 600 and 800nm. They are photo-stable, making them suitable emitters for quantum nano-photonics experiments. We control the number of NDs (i.e. of NV^- centers) from several tens down to a single one, and attain a high precision on the emitters positioning. Then, we transfer this method on SOI-type substrates covered by silicon nanoantennas fabricated by e-beam lithography. We compare experimental results with numerical simulations based on the Green Dyadic Method (GDM) and study the photodynamics of quantum emitters positioned in the gap of silicon dimers of varying dimensions by time-resolved confocal luminescence measurements.

References (max. 5):
[1] J. Wang, F. Sciarrino, A. Laing, et M. G. Thompson, « Integrated photonic quantum technologies », *Nat. Photonics*, oct. 2019, doi: 10.1038/s41566-019-0532-1.
[2] A. I. Kuznetsov, A. E. Miroshnichenko, M. L. Brongersma, Y. S. Kivshar, et B. Luk'yanchuk, « Optically resonant dielectric nanostructures », *Science*, vol. 354, n° 6314, p. aag2472, nov. 2016, doi: 10.1126/science.aag2472.
[3] P. R. Wiecha *et al.*, « Strongly Directional Scattering from Dielectric Nanowires », *ACS Photonics*, vol. 4, n° 8, p. 2036‑2046, août 2017, doi: 10.1021/acsphotonics.7b00423.
[4] A. F. Koenderink, « Single-Photon Nanoantennas », *ACS Photonics*, vol. 4, n° 4, p. 710‑722, avr. 2017, doi: 10.1021/acsphotonics.7b00061.
[5] E. Palleau, N. M. Sangeetha, G. Viau, J.-D. Marty, et L. Ressier, « Coulomb Force Directed Single and Binary Assembly of Nanoparticles from Aqueous Dispersions by AFM Nanoxerography », *ACS Nano*, vol. 5, n° 5, p. 4228‑4235, mai 2011, doi: 10.1021/nn2011893.

Acknowledgment:
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December, 8, 9 and 10

Thematic Session: Nanophotonics & nano-optics
Keywords: thin layer, organic dye, photo-bleaching, grating, wavelength selection

Wavelength selective grating fabricated by thin dye layer local photo-bleaching using laser writer

Alban Gassenq,[1] Kevin Chevrier,[1] Antoine Bard,[1] Jean-Michel Benoit,[1] Clémentine Symonds,[1] and Joel Bellessa,[1]

1. *Institut Lumière Matière, UMR5306, Université de Lyon, CNRS, F-69622, LYON, France.*

We propose a method to fabricate wavelength selective gratings based on thin dye layer local photo-bleaching. Usually, grating working wavelength ranges are limited by refractive index contrasts which exist over a wide wavelength domain. In this work, we have used local photo-bleaching on a 10 nm thick dye layer in order to modulate its refractive index over a limited wavelength range. Even though photo-bleaching is often considered as a limitation for organic emitter; here, this property is exploited to locally suppress dye emission and absorption at the microscale with abrupt interfaces (Figure 1-a) and no change in layer thickness (+-2 nm) (Figure 1-b). Using such method, periodic patterns were fabricated and exhibit diffraction only for wavelengths at around 590nm wavelength with a spectral selectivity of 11 nm. Based on laser writer flexibility and efficiency, this study shows the high potential of local photo-bleaching for making compact wavelength selective gratings. Figure 1 shows examples of fabricated samples (Figure 1-a) and the associated topography measurement by atomic force microscopy (Figure 1-b). These results have been recently published in [1].

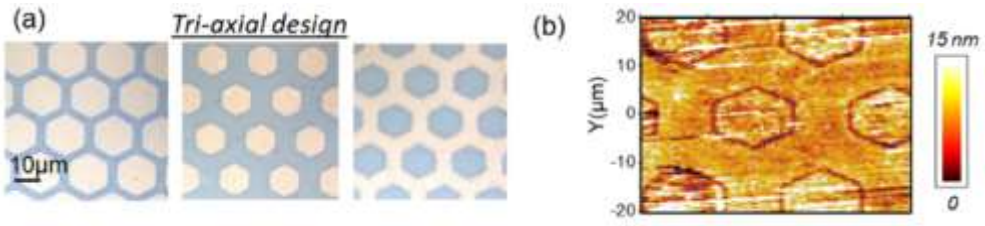

Figure 1 : *Image of fabricated samples for periodic micro-structures with tri-axial design obtained by a) optical microscopy and b)* atomic force microscopy

[1] Alban Gassenq et al, Applied Optics Vol. 59, Issue 19 (June 2020) https://doi.org/10.1364/AO.393103

Acknowledgment: The authors would like to thank the Nanolyon Platform for clean room facilities and the ANR Plashybrid project for funding (ANR-18-CE30-0014).

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December, 8, 9 and 10

Thematic Session: (Nano for Imaging, diagnosis & therapy)
Keywords: (Biochemical functionalization, biosensors, fluorescence spectroscopy, FRET, quantum dots)

Unexpected enhancement of Förster Resonant Energy Transfer thanks to quantum dots aggregation

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As fluorescent probes [1], colloidal semiconductor quantum dots (QDs) are often used as building blocks for the design of biosensors. Based on Förster Resonant Energy Transfer (FRET), it is possible to couple QDs with target species like fluorescent streptavidin molecules (FSA). In this case, QDs are functionalized by biotin molecules through N-hydroxysuccinimide (NHS), as they are able to bind with FSA. Given that QDs are known to agglomerate in the presence of NHS, we wondered if it could be possible to benefit from this aggregation in order to enhance the efficiency and to lower the detection threshold of such FRET-based sensors. By varying the quantities of NHS and biotin, we shew the existence of an optimum for which FRET is indeed enhanced: in terms of detection threshold, aggregated-QD-based sensors lead to a limit down to 5 nM, while it is up to 80 nM for non-aggregated ones [2]. However, this new biosensor design involving QDs aggregation requires a fine monitoring of the emission spectrum of QDs in order to distinguish hetero-FRET (between QDs and FSA) from homo-FRET (between QDs within a same aggregate) to avoid misleading interpretations. This is why we provide a complete characterization of the QD fluorescence throughout their chemical functionalization with NHS and biotin, supporting that such precautions are mandatory.

[1] T. Noblet, L. Dreesen, J. Hottechamps et al., *Phys. Chem. Chem. Phys.* **19**, 26559 – 26565 (2017).
[2] J. Hottechamps, T. Noblet, L. Dreesen, *ChemPhysChem* **21**, 853 – 862 (2020).

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Thematic Session: Nanophotonics & nano-optics
Keywords: Aluminum, UV Plasmonic, nanoparticles, microscopy

Colloidal Aluminum Nanoparticles Synthesis for UV Plasmonic

Marion Castilla[1], Silvère Schuermans[1], Gil Markovich[2], Uri Hananel[2], Davy Gérard[1], Jérôme Martin[1], Jérôme Plain[1], and Julien Proust[1]

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Aluminum nanostructures appear as a good alternative to gold or silver because of the broad range of their plasmonic resonances (UV to NIR) and their reduced cost.[1][2]. The main ways developed to obtain aluminum nanostructures are essentially based on top-down techniques (lithography's, laser ablation…).
Contrary to silver, these structures are very stable in air because of oxygen inclusion, a 3nm native passivation alumina layer is created and act as a protective layer. However, deterioration appears in a solvent for these structures [3].
Nevertheless, a lot of biological experiments occur in the UV range and aluminum nanostructures could help to enhance fluorescence detection. Consequently, it is of first importance to be able to work in organic solvents [4]. Consequently, the main objective is to synthesis colloidal aluminum nanoparticles with a tunable size and a sufficient stability in solvent in order to use them for biological sensing.

Based on sonochemistry and solvothermal reaction, we created a new way to synthesis aluminum nanoparticles in organic solvent with a short size distribution and a spherical appearance.
By varying controlled parameters, we are able to obtain different size with plasmonic responses in the UV range. Moreover, we built an UV homemade setup, equated to a confocal microscope, in order to measure the optical response of single nanoparticles. The final aim is to do Metal-Enhanced Fluorescence of organic fluorophores for biological applications.

References:

[1] Martin, J. Kociak, M. and al. 2014. Nano lett. 14,10, pp. 5517-5523
[2] Martin, J. Plain, J. 2015. J. Phys. D. Appl.Phys. 48: 184002
[3] Zhang, F. Proust, J. and al. 2017. J. Phys. Chem. C, 121, 13, pp. 7429-7434
[4] Akbay, N. Lakowicz, J.R. and Ray, K. 2012. J. Phys. Chem. C, 116, 19, pp. 10766-10773

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