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Local and deterministic integration of plasmonic and luminescent nanoparticles

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The prospect advances in quantum applications have made the fabrication and manipulation of single photon sources a recurrent subject of study during the last years. In this context, the integration of single photons through low loss photonic integrated circuits (PICs) is a challenge that faces several difficulties concerning the stability, simplicity, robustness, and efficiency of the used integration technique. In this work, we demonstrate a new approach of patterning individual nanoparticles using two-photon polymerization (TPP) coupled to surface functionalization and colloidal deposition [1]. First, the surface is chemically patterned by fabricating ultrathin single polymer dots through one shot direct laser writing in a pre-functionalized photopolymer [2]. After developpement, the sample is immersed in a colloidal solution of negatively charged nanoparticles. These later will be selectively trapped on the positively charged surface of polymer dots. This approach makes it possible to achieve local and deterministic integration of single nanoparticles. Thanks to a deep photochemical study concerning the threshold polymerization energy of the pre-functionalized photopolymer, we identified a diffusional regime allowing to adjust the competition between polymerization and inhibition and thus to tune the polymer thickness of polymer dots. This in turn allowed us to control the number of trapped NPs. We have succeeded in immobilizing single gold NPs, fluorescent Nitrogen Vacancy center nanodiamonds (N-V NDs) and CdSe/CdS/ZnS single quantum dots (QDs). This approach was used to successfully integrate single QDs at the vicinity of a plasmonic nano-antenna that, based on our FDTD simulations, will efficiently couple the single photon emission through a TiO_2 ridge which by turn will couple this emission through a low loss Ion Exchange Waveguide (IEW). The single photon emission was confirmed by g2 measurements and the local integration precision was confirmed using photoluminescence (PL) mapping.

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Photochemical imaging of near-field in chiral nanostructures

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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 [2]. 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 (DR1) 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 [3]. We recently demonstrated that chiral effects and field dissymmetry in plasmonic nanostructures can be imaged with this technique [4]. Here, we apply photochemical imaging to chiral metallic nanostructures composed of two coupled gold nanorods. Each rod has a length of 140 nm, a width of 70 nm and a height of 50 nm. They are separated by a 40 nm wide gap and are shifted with respect to each other by a distance '*S*' along their long axis. We show that the near-field chiral response can be imprinted in the photopolymer. It is shown that it is possible to experimentally map the near-field dissymmetry factor [5], which is the contrast in the local near-field response of the object under RCP and LCP excitation.

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Study of thermoplasmonic properties of AuNPs in visible and near infrared region

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Photothermal therapy (PTT) is a technique used for cancer treatment that exploits the thermoplasmonic properties of gold nanoparticles (AuNPs). In fact, AuNPs convert electromagnetic radiation into heat due to the excitation of the plasmon. Such property can be used for the thermal ablation of tumor cells. AuNPs of specific sizes and shapes are able to convert visible or near-IR radiation into heat [1]. The aim of this project is to study the thermoplasmonic properties of AuNPs in the visible to near-IR area, by observing and analyzing temperature variations. The first part of this study consists of synthesizing different shapes and sizes of AuNPs to exploit their physico-chemical properties. The AuNPs are characterised by UV-Visible to determine the position of the localized surface plasmon resonance (LSPR). In a second part, we focus on the the thermoplasmonic study of AuNPs alone and after functionalization with a PEG molecule. Using a thermal camera, we measure the temperature rise induced by laser excitation on colloidal solutions at different wavelengths. We determine the direct influence of several experimental conditions: size, shape and environment of the AuNPs, on the temperature variation. One can observe a correlation between the plasmon resonance of the AuNP and the heat of the solution as well as an influence of the PEG layer on the temperature increase.

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Sensitizing Silicon Carbide for Enhanced Photocatalytic Applications Using Platinum Nanoparticles

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Silicon carbide (SiC) has emerged as a promising material for various applications due to its exceptional physical and chemical properties. In recent years, the integration of SiC with noble metal nanoparticles has gained significant attention for enhancing its photocatalytic performance. This study focuses on sensitizing SiC with platinum nanoparticles (Pt NPs) to harness their catalytic properties and improve the photocatalytic efficiency of SiC-based systems.

The sensitization of SiC was achieved through a facile and scalable method involving the synthesis and deposition of Pt NPs onto the SiC surface. Initially, Pt NPs were synthesized using a controlled reduction method, followed by their immobilization onto the SiC substrate using various techniques, such as drop-casting, spin-coating, or electrochemical deposition. The choice of deposition method and optimization of experimental parameters influenced the coverage, distribution, and stability of the Pt NPs on the SiC surface.

The sensitized SiC samples were characterized using various techniques, including scanning electron microscopy (SEM) and X-ray diffraction (XRD), to investigate the morphology, size and distribution of the Pt NPs. Additionally, spectroscopic techniques, such as UV-Vis absorption spectroscopy and photoluminescence spectroscopy, were employed to evaluate the optical properties and charge carrier dynamics of the sensitized SiC samples.

The photocatalytic activity of the sensitized SiC samples was evaluated through the the generation of hydrogen through water splitting under visible light irradiation. The performance of the sensitized SiC photocatalysts was compared to the SiC without Pt NPs to assess the catalytic enhancements achieved through sensitization. The results demonstrate that the integration of Pt NPs onto SiC surfaces effectively enhances the photocatalytic activity of SiC. The sensitized SiC samples exhibited improved absorption of light in the visible range, increased charge separation, and enhanced catalytic efficiency compared to pristine SiC. This study highlights the potential of sensitizing SiC with Pt NPs for advanced photocatalytic applications.

# Magnesium nanoparticles for metal enhanced fluorescence

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Magnesium nanoparticles (Mg NPs) have recently attracted attention for plasmonic applications owing to Mg's broad plasmonic response (UV to IR), its biocompatibility and abundance in Earth's crust, as well as its HCP crystal structure that gives rise to a variety of NP shapes.[1] While much work has been done on characterising Mg's optical response,[2] Mg NPs' performance in enhanced spectroscopies, such as in surface enhanced Raman spectroscopy (SERS) and metal enhanced fluorescence (MEF), is yet to be revealed. Mg is appealing for MEF as its wide working wavelength range leads to a large operating range for matching with fluorophore absorption/ emission energies, including in the UV.

In this work, we present the fluorescent properties of Mg NPs, naturally surrounded by a thin MgO layer, coated with a silica spacer of varying thickness and a fluorescent dye. Our preliminary results show fluorescence emission from fluorescein supported on Mg, both in bulk and single particle level, and a clear indication of fluorescence intensity decrease upon oxidation of the metallic Mg core. To support experimental results, we have also performed numerical studies investigating the effects of MgO, silica coating and tip rounding on the electric field enhancement of various Mg NP shapes present in the sample.

Figure 1. Plasmonic and fluorescent properties of fluorescein coated Mg NPs.
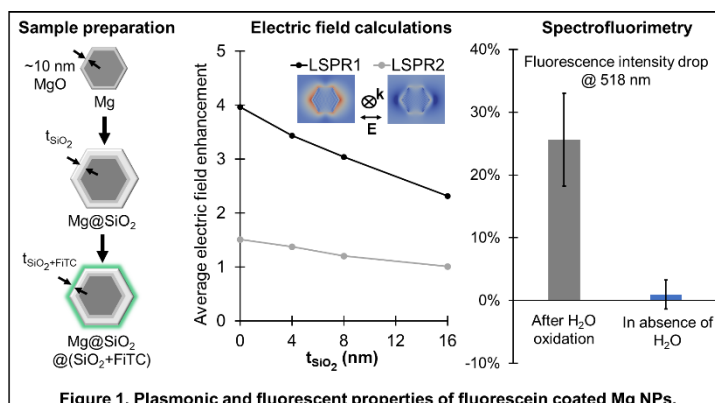
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MoS$_2$-based Nanoantennas for Nanophotonic Applications

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Light manipulation at the nanoscale is a priority research avenue in photonics. It has been shown in many laboratories around the world that the electric and magnetic components of optical waves can be controlled on the nanoscale by using resonant nanostructures, which form the basis of modern nanophotonics and are known as optical nanoantennas. Generally, nanoantennas can be separated into several types depending on the material they are made from and on the corresponding operation principles: metallic (often referred to as plasmonic) and dielectric. The plasmonic nanoantennas are characterized by a strong localization of the exciting electromagnetic field at the nanometer scale but suffer from dissipative losses, that can be overcome by using dielectric nanoantennas. These latter are fabricated from materials with a high refractive index and the lowest possible absorption coefficient in the optical range. Recently, transition metal dichalcogenides (TMDCs) nanoantennas, in the form of nanodisks, demonstrated distinct Mie resonances [1]. In the present study we present an in-depth study of the sulfurization of monocrystalline α-MoO$_3$ thin films [2], pre-deposited on a substrate by atomic layer deposition (ALD), by means of annealing at a temperature around 700 °C in the presence of gaseous hydrogen sulfide (H$_2$S) as sulfur source. Advanced characterization techniques, including Raman spectroscopy, X-ray diffraction (XRD) and photoluminescence spectroscopy were used to understand the fundamental properties of the achieved MoS$_2$ thin films. Additionally, we delved deeper into the spatial distribution (nanometer scale) of luminescent properties across the surface of MoS$_2$ thin films (by using the cathodoluminescence technique, CL), revealing information about the excellent homogeneity and quality of the films. Finally, we show the fabrication process and CL characterization of MoS$_2$ nanoantennas by combining electron beam lithography and reactive ion etching techniques.

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Biocompatible fluorescent carbon dots nanoparticles for security markings

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For many years, cultural property in general and archaeological artefacts have been liable to be stolen during and after the excavation process in order to be introduced to the black market. Globally, it is commonly estimated that the illicit trafficking of cultural heritage ranks among the biggest illicit trade in the world, grossing several billion dollars[1].

The challenge of the project is to be able to implement a safe technical solution which makes it possible to mark archaeological artefacts in a unique way. Carbon dots are a 0D nanomaterial made of a hybrid structure with a graphene like core of sp^2 carbon and an outer shell of amorphous sp^3 carbon. Since they are composed mainly of carbon, they constitute a safer alternative to heavy metals quantum dots and allow us to avoid trace contamination before analysis. Moreover, carbon black which is the basis of the black inks used, are chemically identical to C-dots. We integrated carbon dots synthetized using a protocol from Yan et al[2] into a protective coating used for marking cultural artefacts. The coating produces orange photoluminescence under UV but also green light excitation, constituting a new kind of security marking.

Figure 1. Carbon dots in solution under green laser excitation;
Figure 2. Clear nail polish for classic marking (left) and carbon dots incorporated to clear nail polish for marking (right) under visible and UV light.

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Correlation between DNA bases and the intensity of the Raman bands with SERS

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Raman spectroscopy has become a popular tool for analyzing biological samples such as DNA. It allows us to access to the vibrational levels of molecules and thus to identify the chemical composition and to observe the structure of molecular systems. [1]

In this work, we recorded the SERS spectra of DNA strands with different sequences and grafted at the surface of gold nanoparticles. Our objective is to study the correlation between the DNA sequences and its base composition and the intensity of Raman bands observed in SERS.

To reach a high density of DNA on the surface of the gold nanoparticles, the DNA strands include a thiol group (SH) at their 5' end and are conjugated to gold nanoparticles using the freeze-thaw cycle method.

SERS measurements are performed on dried drops deposited on a glass slide. We recorded 5 spectra for each sample using a 785nm excitation wavelength. We observed several bands that can be assigned to the different bases and to the phosphate backbone. For instance, the bands of ring breathing mode of adenine and the carbonic skeleton of the DNA are observable at 733cm^{-1} and 1029cm^{-1} respectively. [2]

We then compare the relative intensity of the different bands such as the 733cm^{-1} or 1029cm^{-1} ones. We found that the relative intensity of the 733cm^{-1} band is correlated with the amount of adenine in the DNA sequence. This study provides a new approach for reliable quantification and analysis of genetic information associated with DNA molecule sequencing.

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Immobilization of gold nanoparticles by DNA hybridization to code information

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DNA is a large and complex molecule which contains genetic information that determines the physical and biological characteristics of a living organism[1,2]. However, the use of DNA is no longer limited to genetic. Nowadays, DNA is also used to encode information[3,4], as it can store large quantities of data in a nanoscale space. This use of DNA as a data storage offers many advantages, such as durability and storage density, and can be used in many different fields.

The challenge of the project is to develop a technique to encode information in a nanoparticle-based ink and to be able to collect and read the coded information once deposited on a surface. We use DNA hybridization to ensure the selectivity of the recognition technique. In fact, by hybridizing nanoparticles on a surface using DNA coding (Figure 1) and by collecting the spectral response of the nanoparticles, it is possible to detect and recognize the code.
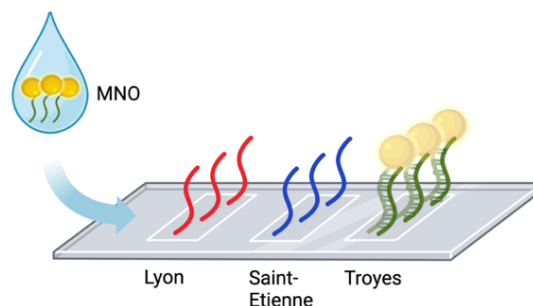

Figure 1: Principle of information coding using DNA

First, we verified our hybridization protocol by hybridizing DNA strands with fluorophores at their ends. Then, we immobilized gold nanoparticles and Qdots on a glass substrate by DNA hybridization. Finally, we explored the potential use of the analysis principles of Antigen Covid tests or ELISA tests.

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Dual interferometric color control of light scattering and specular reflection

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More and more structural colors succesfully replace pigment-based ones. Most of the proposed solutions relies on plasmonic architectures, that is subdiffractive structures, demanding rather complicated and expensive techniques. Reproducible,cost-effective,large scale fabrication methods remain challenging. We report on the design of sub-micronic metasurface (cylinders of given depth or height) allowing for control of spatial distribution of the scattered light as well as management of the ratio between specular and diffusely reflected light. Interferometric control is here provided thanks to quasi Fabry-Perot cavities of given depth, diameter, spatial distribution and density.

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White light interferometry applied to local spectroscopy of oriented assemblies of silver nanowires

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Oriented assemblies of silver nanowires (AgNW) have the remarkable ability to manipulate light, and in particular the polarization of light. These anisotropic materials created by bottom-up technology are prepared using a simple and versatile method called "Grazing Incidence Spraying" (GIS) allowing to control the in-plane orientation of anisometric nano-objects like AgNWs.[1] The latter can be combined with the layer-by-layer (LbL) approach to prepare anisotropic multilayer films with unprecedent complexity. Their optical properties are determined not only by the properties of the individual elements, but also by how they interact with each other, probably through coupling effects. The main challenge of this work is to study how light interacts with these nanostructures on a microscopic scale and to control their optical behavior on a macroscopic scale. White light interferometric microscopy can be used to obtain a two-dimensional spectral map with micrometric or submicrometric resolution. We have developed new local spectroscopy methods using white light interferometry [2]. One of the main advantages of our optical configuration is the ability to perform local spectroscopy measurements (pixel by pixel or by area), in addition to topography measurements [3]. With just one measurement, we have access to topographic and spectral information at exactly the same location. In parallel we have also developed a super-resolution local spectroscopy technique using the microsphere technique [4] allowing a lateral resolution of up to 100 nm, with the advantages of being marker-free and providing multimodal acquisitions. The measurement set-up has been improved to include TE and TM polarization measurements of the samples. Here we will show some preliminary results from samples deposited on glass slides or silicon wafers using combined GIS/LbL technology and studied by local spectroscopy.

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Optical Tamm states in 2D nanostructured magnetophotonic structures

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Optical Tamm modes are highly confined electromagnetic modes appearing at the interface between a metal layer and a Bragg mirror. Here, the metal is patterned to form a grating, and a magnetic layer is added between the metal and the Bragg mirror. The use of a grating allows for the creation of additional modes [1] and a direct access to the last layer of the Bragg mirror where the energy of the Tamm mode is concentrated.

We numerically explore in this work the Transverse Magneto-Optic Kerr effect (TMOKE) signal in this 2D nanostructured magnetophotonic structure. The simulated TMOKE signals reach values that are comparable to conventional magnetoplasmonic structures. Using different angles and planes of incidence as well as different polarizations, several Tamm modes supported this structure are also investigated. These modes provide high energy confinement in between the metal stripes, paving the way for higher sensitivities in bio- and chemical sensing applications.
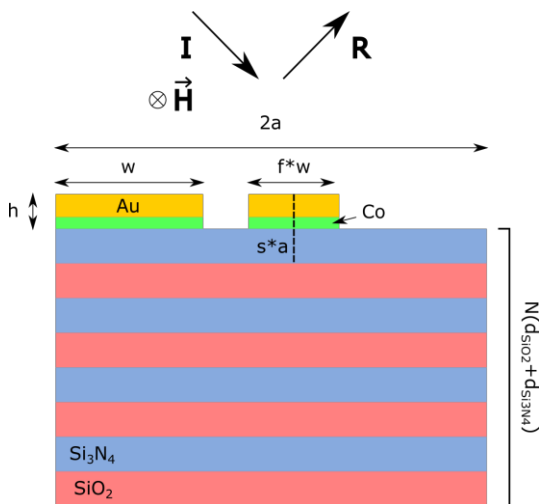
Magnetophotonic structure
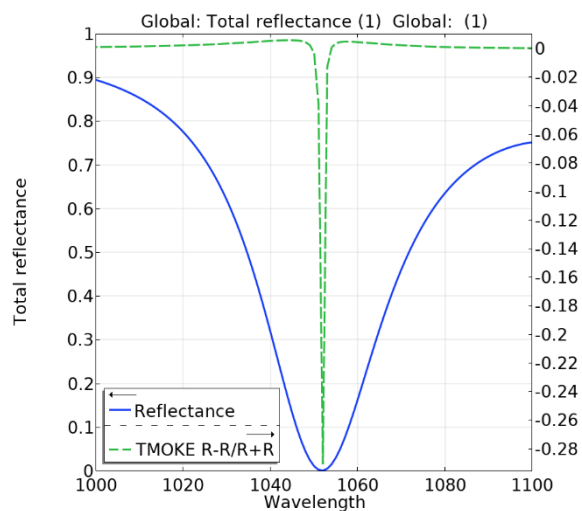
Reflectivity and TMOKE signal

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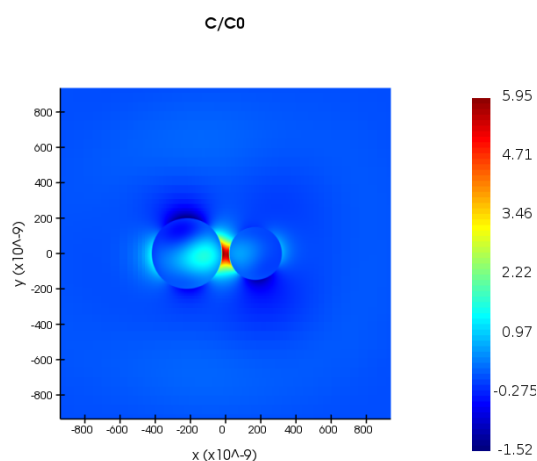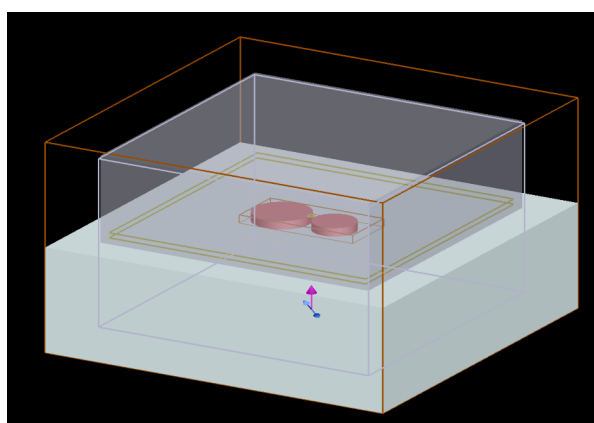
Plasmonic Nanotweezers for Enantiomer Separation

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Enantiomer separation is a critical step in the synthesis of many compounds, as a chirality change can lead to many undesirable effects – up to turning medicine into poison [1]. While many chemical methods rely on bulk separation, isolation of specific compounds in small quantities with high precision remains insufficient, Optical tweezers have been demonstrated to be a tool of growing interest for contactless manipulation on single objects down to the molecular scale especially for enantiomer separation. By combining with plasmonic structures, they are optimized to allow manipulation at the sub-wavelength scale [2].

Plasmonic structures are of great interest due to their large tunability and panel of parameters – material used, shapes, size, etc. While achiral structures can be overlooked due to their non-chiral nature, they can in fact exhibit local chirality change under correct conditions. [3] In this communication, we exemplifly the principles of chiral optical forces nearby plasmonic structures. Using numerical simulations, we show a local chirality enhancement even for achiral shapes, leading to chiral optical force generation.

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On the orientation mechanism of non-polar dyes in light-emitting guest-host systems

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After many years of development, OLEDs have continuously been optimized to reach higher efficiency, for which the horizontal orientation of the emitter molecules is one of the dominant factors [1]. For the purpose of studying intrinsic orientation without electrostatic interaction, our work considers non-polar dyes, namely TTPA, BSBCz, DIP and DBP. While the emitter orientation has been studied in neat film as a basic approach, their behavior in guest-host systems has not been studied widely. In this work we focus on the correlation between emitter concentration and its orientation. With the results from experimental and simulation study, we also discuss the possible orientation mechanism of emitter molecules on the substrate surface in terms of molecular structure, possibility to form crystallites and the effective glass transition temperature (T_g) of the guest-host system. We observe that isotropic structure of the emitter as well as the crystallized and aggregated molecules are not favorable for horizontal orientation. However, molecules having a rod-like structure have the tendency to arrange horizontally to the substrate. These results contribute to a further understanding of orientation of non-polar emitter molecules.

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Surface plasmon resonance sensorgram treatment in complex space

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Surface plasmon resonance (SPR) biosensors detect changes in the refractive index (RI) of a biochip surface which is coated with a plasmonic film. These changes indicate the presence of a specific target substance and can be measured by observing the shift in the angular or spectral plasmonic resonance. In a real detection system, plasmonic resonance undergoes both an angular shift and slight deformation in the response curves. Neglecting this deformation can affect measurement precision. Recent studies [1-2] have utilized a phase and intensity-based SPR sensor to improve accuracy and obtain more information about the sample. This research demonstrates how considering both phase and intensity measurements, even at a single measurement angle, significantly enhances the precision of RI measurement. The measured data is projected onto a complex space using the reflectivity expression $R=|Re(r)+ i\ Im(r)|^2$, where r represents the experimental complex reflectivity. Fast angular scans are performed at different time points during the experiment to enable offline correction, through an evaluation in the complex space (cf. figure 1 below). By considering the distinct behaviors of the intensity and phase components in response to SPR deformations, this technique provides a more accurate measurement of the effective RI. This study contributes to a broader understanding of the behavior of SPR responses in the complex space.
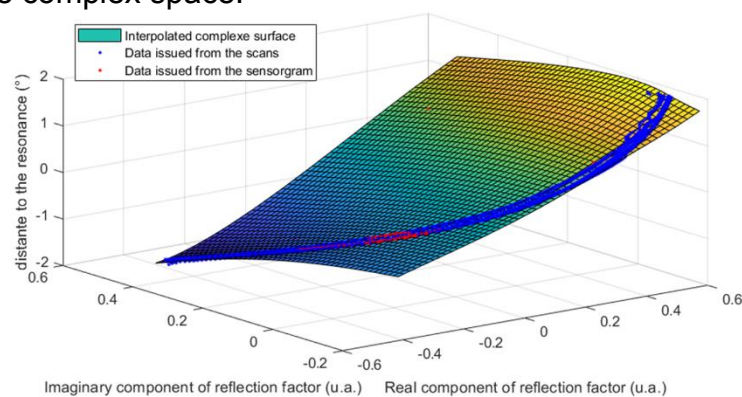

Figure 1: SPR angular scans and sensorgram projection in the complex space.

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Symbolic Regression for the retrieval of the effective refractive index of a dilute system with spherical metallic nanoparticles

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Symbolic Regression (SR) is an extensively used tool that has proven to be very effective in theoretical studies within different research fields [1]. It provides a closed-form expression that describes the problem studied, without requiring information about its algebraic form [2]. Recently, we have successfully used SR to model the optical properties of transparent and absorbing dielectrics [3]. This motivated us to extend the applicability of SR to problems with turbid media. Dilute systems of Mie metallic particles have been previously studied [4]. In this approach, the system is replaced by an homogeneous medium described by an effective refractive index. We make use of Symbolic Regression to retrieve, from spectral information, a closed-form expression that represents the effective refractive index of a dilute system formed by spherical *Cu* nanoparticles, with a double dependency on the radius of the particle and the incident wavelength. Although we considered a simple case, there are no evident restrictions to extend this approach to more complex configurations.
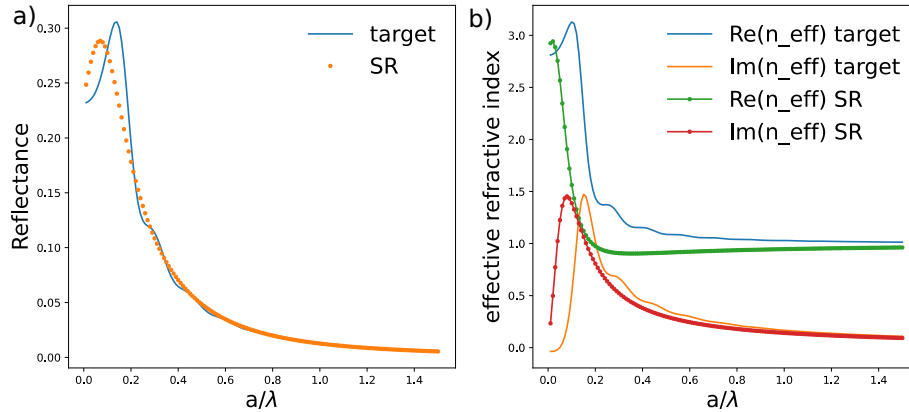

Figure 1: a) Reflectance calculated for the effective refractive index, b) effective refractive index. In all figures straight lines denote the reported values [4], and dotted lines denote the values retrieved by SR.

$$n_{eff} = 1 + \frac{0.377\frac{\lambda}{a} - 0.203 + i0.264}{-2.045\frac{\lambda}{a} + 2.194 + 0.151\frac{a}{\lambda}}$$

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Magnesium Plasmonic Array Fabrication with Nanosphere Lithography

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Nanosphere lithography (NSL) is a common and successful approach to fabricating high quality, large-area plasmonic arrays. Using conventional plasmonic materials (Ag, Au, Cu), such arrays of nanotriangles or nanoholes have been employed in refractive index sensing and surface-enhanced Raman spectroscopy. Here, we use this well-established technique to fabricate magnesium (Mg) arrays, show the potential of Mg as a plasmonic device material, and address challenges in the fabrication processes. Specifically, we used monodispersed polystyrene nanospheres to form a self-assembled hexagonally packed monolayer on a water-air interface. The monolayers were then used as a mask for Mg deposition, performed in ultra-high vacuum with a thermal evaporator placed in an argon-filled glovebox. We first found that the quality of the arrays varied greatly with deposition rate. Once optimized, this deposition was performed with 3 different nanosphere diameters as masks (350, 500, and 750 nm). The absorbance profiles of the arrays vary with nanosphere diameter as expected and as predicted from numerical simulations with FDTD.

Furthermore, to show the potential use of Mg arrays in sensing applications, we coated a thin layer of alumina as a protective layer with atomic layer deposition. This layer was demonstrated to prevent oxide and hydroxide formation in aqueous environments, with thicker layers providing better resistance. The optical response of the array redshifted with increasing alumina thickness, as expected. These results show that Mg, an unconventional but cheap, abundant, and biocompatible metal, can be used as a sensor array.

Gold nanoparticle networks in topological defects of smectic liquid crystal

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A liquid crystal (LC) is a mesophase where the molecules are free to move as in a fluid, but show a certain degree of order as in a crystal lattice. Under specific conditions, a thin film of LC can form a pattern of flattened hemicylinders called "oily streaks" that present different kinds of topological defects (1D and 2D defects) able to trap and orient nanoparticles [1]. When using gold nanoparticles, this composite can activate interesting plasmonic properties coming from the interaction of the nanoparticle networks. Previous results from our group show the coexistence of chains and hexagonal networks of gold nanospheres oriented along the hemicylinder direction, confirmed also by Xray diffraction experiments [1]. We are currently interested in using gold nanorods functionalized with thiol-ended polystyrene. Absorption measurements reveal that these rods can form chains in the 1D defect and ribbons in the 2D defect. The defects being strictly oriented in the LC pattern, we obtain these two assemblies with a unique orientation, allowing activation of the plasmonic properties by light polarization. The chains present an end-to-end configuration of the rods, leading to the formation of aligned plasmonic cavities of giant exaltation between the rods. In contrast the ribbons correspond to a side-to-side assembly. The side-by-side assembly is perpendicular to what was previously observed for nanorods functionalized with alkyl chains, making us believe that the ligands monitor the orientation of nanorods with respect to the 2D defects. Controlling nanorod concentration we control the coexistence of the two kinds of assembly, allowing activation of light absorption from the composite.

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Controlling the polymerization pattern of diazonium salts through heat and hot electron generation in gold nanoparticles

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Aryl diazonium salts (DS) have been known for over a century and became important building blocks in organic synthesis due to their ability to covalently couple with a wide variety of compounds. Recently, DS have been undergoing a Renaissance driven by the possibility of their grafting on a surface. This grafting can be induced by electron transfer and followed by aryl radical formation together with the elimination of a nitrogen molecule.[1] Simultaneously, the spontaneous grafting is also possible caused by the thermodynamic instability of DS, which accelerates upon heating. Since gold nanoparticles are able to generate both hot carriers and heat under illumination [2], we can distinguish grafting mechanisms of DS and control their polymerization pattern on gold nanoparticle surface. We demonstrate that choosing the excitation wavelength that match interband transition, where the most of energy transforms into heat, we obtain a uniform growth of the polymer on the gold nanoparticle surface (Fig. 1). While the excitation of the plasmon resonance leads to the polarization-dependent pattern, corresponding to plasmonic hot spots (Fig. 1).
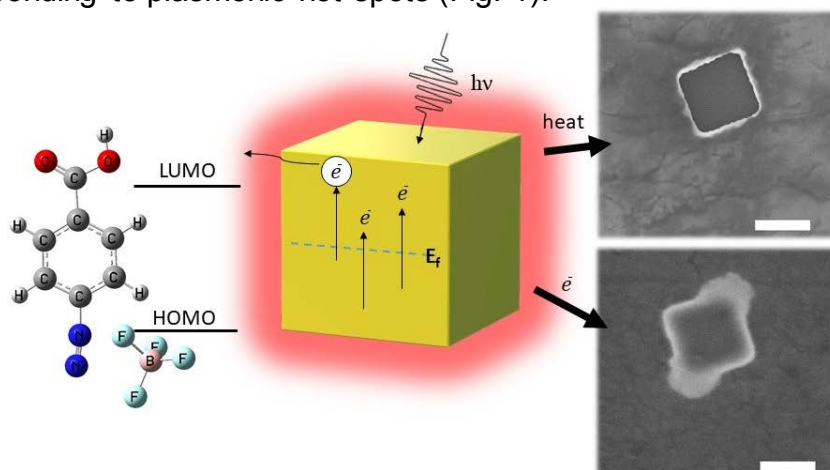
Fig. 1 Scheme of DS polymerization on a gold nanocube with experimental SEM images

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Broadband optical properties of MXene nanoparticles

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MXenes, two-dimensional titanium carbides and nitrides have metallic properties, high conductivity and are considered one of the most promising materials for energy storage in batteries and supercapacitors [1-2]. At the same time, the possibility of using MXenes in photonics is much less well studied, although a number of papers suggest their use in surface-enhanced Raman spectroscopy [3], phototherapy of cancer [4], broadband absorbers [5] and plasmonic devices [6].

To investigate the optical response of Ti_3C_2, precise ellipsometric measurements of the dielectric function of a titanium carbide crystal over a wide range from 300 to 3300 nm on a thin film fabricated by vacuum filtration were performed in this work. A good agreement between the measured and simulated transmittance spectra of Ti_3C_2 films of different thicknesses was demonstrated and the band structure of titanium carbide was calculated to confirm the validity of the results. These studies have shown that Ti_3C_2 exhibits a dual dielectric-plasmonic response over a wide spectral range.

Inspired by recent success in fabricating transition metal dichalcogenide nanospheres that retain the crystalline structure and optical response of its bulk counterpart [7], in this work we proposed the use of Ti_3C_2 nanoparticles as theranostic agents for cancer therapy. It was found that Ti_3C_2 nanospheres can simultaneously absorb radiation resonantly in two important biomedical therapeutic spectral windows. In the first window (700 - 980 nm), Ti_3C_2 outperforms gold, silicon and competes with titanium nitride. Meanwhile, in the second window (1100 - 1700 nm), which has greater potential for cancer therapy, Ti_3C_2 outperforms all other materials by a wide margin due to localized plasmon resonance.

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Analysis of bias-stress effect on S-DNTT-10-based OTFTs via SERS

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Organic thin-film transistors (OTFTs) features low cost, large-area fabrication, and high flexibility compared with inorganic transistors. The electric performance was affected by organic semiconductor (OSC).[1] S-DNTT-10 (as one OSC material) was utilized into the OTFTs[2] and performed well electric performance.[2] Our study aimed to further explore the electric characteristics of top-contact-OTFTs fabricated by the PVD method through Raman technique. High mobilities exceeding 5,5 cm2.V-1. s-1 are consistently obtained in the lab using PVD.

We have done the related tasks: (i) Performed a DFT simulation[3] to identify the nature of molecular vibration in the measured Raman spectrum of S-DNTT-10 thin-films as shown Fig.1 (a), (ii) Achieved SERS (Surface-enhanced Raman spectroscopy) maps on the 10 nm thick Au nanostructures[4] forming the OTFT electrodes as illustrated Fig.1 (a). (iii) Studied the changes in the OTFT performances and molecular characteristics under the electrodes after bias stress for 40 minutes using an electric measurement setup colocalized with the Raman system (Fig.1 (b)).
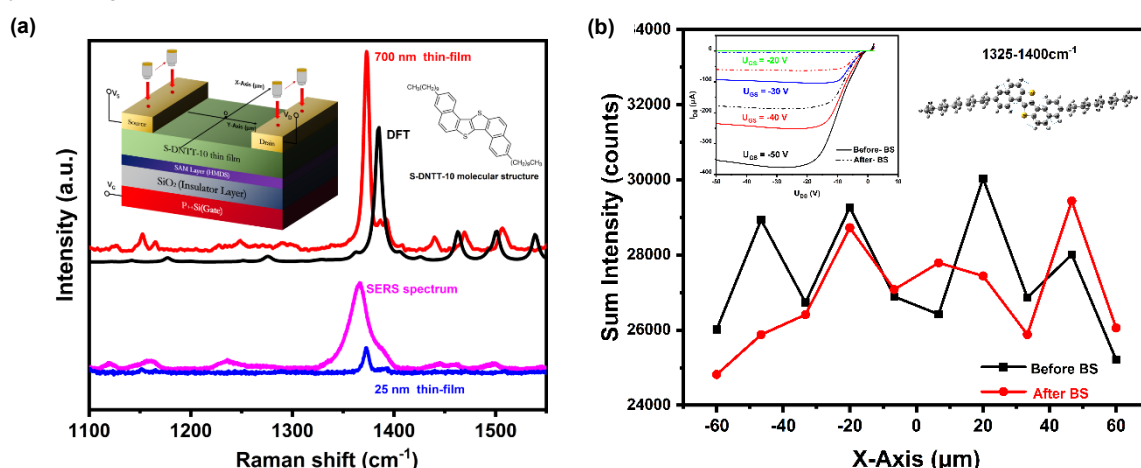

Fig 1. (a) Simulated and measured Raman spectrums of S-DNTT-10. (b)Sum-intensity of 1325-1400 cm^{-1} region of the SERS spectrum along the source electrode associated with the output plots before and after bias stress (BS) for 40 min at U$_{DS}$ = -50V and U$_{GS}$ = -50V. "X-Axis" is perpendicular to the channel, above the electrode

Firstly, we confirmed S-DNTT-10 molecular vibrational modes and we enhanced the weak Raman signal using SERS. Secondly, we measured the SERS signal on the electrodes before and after bias stress. The results show changes in the sum intensities (counts) for both the 1108-1140 cm^{-1} band (the C-H band) and the 1325-1400 cm^{-1} band (C=C and C-S bands). This suggests an influence of the electric field on inner and peripheral molecular bonds. Other measurements suggest that the effect could be related to the electric field strength. The stress also reduces the effective mobility, suggesting a pi-electron overlapping degradation. This could demonstrate that the degraded performance of OTFTs due to bias stress is correlated with a change of the molecular organization. Additional comparison of SERS measurements at the source and drain electrodes will be discussed to support field strength influence.

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Large scale self assembly of silicon Mie resonators for optical metasurfaces

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We presented a microfluidic platform to produce a pattern with particular size design within a microchannel, based on sequential capillarity-assisted Si nanoparticles assembly. The NPs assembly result is shown in **Fig.1**, the SEM micrograph of a randomly selected assembly area 1 and area 2 showing the deposition of single NPs is presented. The filling rate is almost 100%, and the Si NPs arrays stays well organized on the substrate after removing PMMA. This is also confirmed by AFM image shown in **Fig.1** (f inset). First transmission optical measurement has been obtained and presented in **Fig.1** (f) and shows an optical resonance in NIR. Other optical measurements on a larger range are in progress and will be presented.
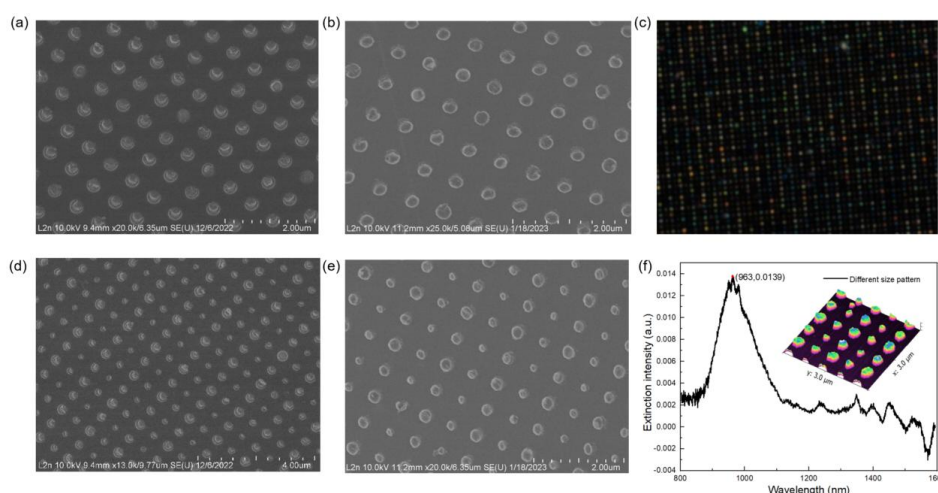
Fig. 1 NP assembly. SEM micrograph of a randomly selected assembly area 1 showing the deposition of single NPs (a) with PMMA matrix and (b) after removing the mask. (c) Dark field optical image of a randomly selected assembly area after removing PMMA mask. SEM micrograph of a randomly selected assembly area 2 showing the deposition of single NPs (d) with PMMA matrix and (e) after removing PMMA. (f) Extinction spectrum of area 2 assembled by SmartForce after removing PMMA. The inset picture is the corresponding AFM image for this area.

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