Master in Photonics – "PHOTONICS BCN"
ERASMUS+ "EUROPHOTONICS"

MASTER THESIS PROPOSAL

Dates: April - September 2020

Laboratory : NANOPTO group
Institution : ICMAB-CSIC
City, Country : Barcelona, Spain

Title of the master thesis: Chemical nanoparticle lithography for the fabrication of plasmonic arrays using colloidally synthetized building blocks.

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Keywords : Plasmonics, soft lithography, array patterning, lattice plasmon resonances, surface enchanced Raman scattering.

Summary of the subject (maximum 1 page) :

Plasmon are the collective oscillations of the conduction band electrons of a metal at the metal-dieletric interface, in response to an external electromagnetic field. When the dimension of the metallic object is smaller than the wavelength associated with the external field (i.e. a metallic nanoparticle), the oscillation will be localized inside the nanoparticle volume, giving rise to a variety of nanoscale phenomena that are the grouped into the field of plasmonics. Plasmonic nanoplatforms are widely used in tailoring nanoscale light-matter interactions to confine light into deep subwavelength volumes.[1–3] These systems enable unprecedented enhancement of weak optical signal (fluorescence, infrared (IR) absorption, Raman scattering), with important applications in sensing,[4] bioimaging,[5,6] and solar cells.[7,8]
Recently, ordered plasmonic nanoparticle arrays emerged as exceptional plasmonic platforms, thanks to their ability of sustaining surface lattice plasmonic resonances that are delocalized over large areas (hundreds of microns), and are characterized by long lifetimes.[9] Prof. T Odom demonstrated the use of these collective oscillations for sensing, lasing, and second harmonic generation.[10]
However, these plasmonic arrays are conventionally fabricated using lithographic processes (*e.g.* e-beam lithography or photolithography) which offer access to large areas fabrication, but yields polycrystalline structures with high optical losses and limited quality factors, all major limitations for the realization of photonic devices.[11] On the other hand, plasmonic nanoparticles

prepared *via* colloidal synthesis are characterized by higher optical performances,[12] but their organization with nanoscale precision in large-scale devices remains a challenge. As such, the unmatched library of nanoparticles achievable with synthetic nanochemistry, and the possibility of tailoring frequency, polarity, chirality, and spatial localization of the plasmon resonances manipulating nanoparticle size, shape, composition, and surface chemistry, is vastly unexplored in the fabrication of photonic platforms.[13] The supervisor of this master thesis proposal developed a methodology that enable the fabrication of patterned plasmonic structures over large-scale substrates using colloidally fabricated high-quality building-blocks (**Figure 1C**). This technique, called chemical nanoparticle lithography, is a subtractive soft-lithographic protocol for the patterning of plasmonic building blocks using a nanoparticle monolayer as starting material, and exploiting simple condensation reactions as driving force (**Figure 1A-B**).

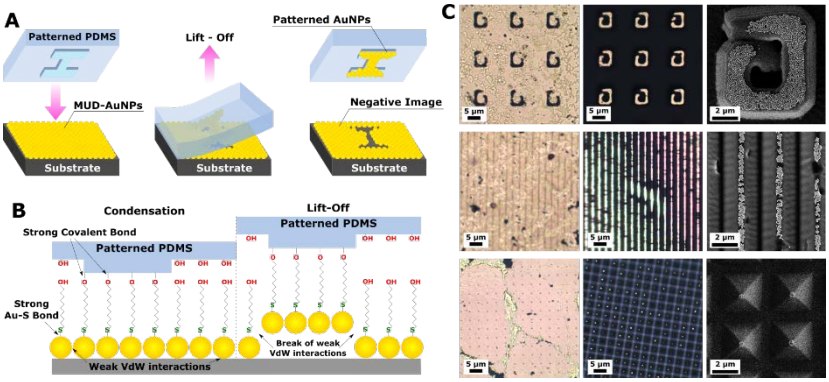

Figure 2: Schematic illustration of chemical nanoparticle lithography (**A**), and the interactions involved (**B**). **C:** Bright-field micrograph of the negative image with the imprinted pattern (**left**), bright-field micrograph (**center**) and scanning electron microscopy image (**right**) of the patterned PDMS after lift-off for: spirals (1st row), gratings (2nd), and islands (3rd).

<u>This master thesis proposal will focus on the application of chemical nanoparticle lithography for the fabrication of plasmonic arrays, in the characterization of their optical properties, and in the tuning of the same properties synthetizing appropriate building blocks, focusing on their size, shape, composition and surface chemistry.</u>

This master provides a unique opportunity for a student to be trained in the state-on-art of colloidal chemistry and the fabrication of real photonic devices. The candidate will learn all the fundamental concept of synthetic colloidal chemistry and self-assembly at the nanoscale. Moreover, he/she will familiarize with optical and structural characterization methods, including UV-vis, optical microscopy, dark-field spectroscopy, and electron microscopy (both transmission and scanning).

Additional information :

* Required skills: we search for a highly motivated and enthusiastic researcher. Experience in plasmonics will be highly valued. All the main communication will be held in English (a level B2 in written and spoken English is desired)

* Miscellaneous : The NANOPTO group is composed of a multidisciplinary team of physicists, chemists and engineers. The candidate will join a family of international researcher, a rewarding and motivating work environment, with the main goal of enjoying the discovery process that thrust scientific innovation.