Engineering the spectral response produced by metasurfaces based on multi-material arrays.

Metallic nanoparticles can support resonances when the metal's electrons oscillate in phase with an exciting electromagnetic wave. These Localized Surface Plasmon Resonances (LSPR) are currently studied in many different research fields to improve a number of physical phenomena, like the photon-to-electron conversion efficiency in solar panels as well as the electron-to-photon conversion efficiency in light-emitting diodes (LEDs). By correctly choosing the metallic material of the nanoparticles, one can tune the spectral range in which they can have an exalting effect. Indeed, gold nanoparticles present resonances in the red part of the visible spectral range where aluminum nanoparticles present resonances in the blue one. Unfortunately, LSPR present very poor-quality factors compared to other resonant phenomena, mainly because they are largely damped within the metallic material. However, when the metallic nanoparticles are organized as arrays, one can observe a diffraction phenomenon which makes it possible to couple all the nanoparticles together and to reduce the damping of their LSPR. This collective resonance, called Surface Lattice Resonance (SLR), takes place when the LSPR is coupled to an in-plane (grazing) diffraction order [1]. This sharp resonance is very interesting for many applications like emission enhancement in LEDs or in biomedical imaging. However, if the metasurface is based on one metallic material, the spectral range of its optical response is limited.

The **objective** of this project is to design an array composed of nanoparticles of two different materials (gold and aluminum in a first place) in order to excite many SLR modes and to spectrally tune them in the absorption and emission bands of emitting molecules or quantum dots.

The following **methodology** will be used:

- Numerical simulation of the bimetallic network allowing the optimization of the geometry (diameters of the different particles, pitch of the network, shape of the mesh, etc.) in order to obtain good quality SLR modes at the required spectral positions (in progress via the use of Lumerical software (FDTD))
- Manufacturing by double electronic lithography of the bi-metallic network (technique mastered by Dr. Anne-Laure BAUDRION, supervisor of the thesis)
- Optical characterization of SLR modes via extinction micro-spectroscopy (microscope already operational at L2n and possibility of doing all these characterizations at ITODYS with the thesis co-director, Pr. Nordin FELIDJ).
- Characterization by fluorescence microscopy of the emitters deposited on the surface of the bi-metallic network (FLIM microscope already at L2n and operational)

Applications: The applicant must hold a master's degree in physics, or in a field related to Electromagnetism and/or Photonics. An aptitude for experimental work is necessary for the success of this project. An experience of work in a clean room environment and skills in numerical simulation will be highly appreciated.

Please send a CV, your Master grades, and a motivation letter to Anne-Laure BAUDRION (anne_laure.baudrion@utt.fr). A recommendation letter will be highly appreciated.

L2n laboratory: https://recherche.utt.fr/light-nanomaterials-nanotechnologies-l2n

Nano'Mat platform: https://www.nanomat.eu

[1] Vasil G. Kravets, Andrei V. Kabashin, William L. Barnes, and Alexander N. Grigorenko, Plasmonic Surface Lattice Resonances: A Review of Properties and Applications, Chem. Rev., 118, 5912−5951 (2018).