Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Starting full time from April 2024
Presentation at the end of July or beginning of September 2024

Laboratory: Nonlinear Optics and Lasers Lab
Institution: Universitat Politècnica de Catalunya
City, Country: Terrassa (Barcelona), Spain

Title of the master thesis: Wavelength and position dependent light localization and enhancement in photonic structures
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Keywords: photonic structures, nano-photonics, linear and nonlinear light-matter interaction

Summary of the subject (maximum 1 page):
Optical properties of photonic crystals have emerged as being pivotal for the study of light - matter interaction enhancement, leading to pioneer applications in nanophotonics, all-optical devices and photonic chips. Artificial periodic photonic structures in one, two and three-dimensions can alter and sometimes create new effective dispersion relations compared to bulk materials, allowing strong control over light propagation and consequently over light–matter interactions. Moreover, when combined with different types of absorptive (or emissive such as quantum dots) materials placed at the surface or at particular positions inside the structure, new scenarios may be exploited. In particular, the enhancement of the electromagnetic field obtained due to its localization either at the surface or inside the nanostructure is very important for applications in optical sensing or light emission including the UV range. To advance in these directions is very important to develop new experimental techniques to measure this enhancement in such micro and nano structures.

This project aims to conduct pioneering experimental and numerical studies of the wavelength dependent light localization and enhancement in 3D photonic crystals by implementing an experimental platform to obtain a spatial and spectral map of the light enhancement in such structures. Since the fabrication process of such samples is still under investigation, the results on the characterization are essential to continue improving the fabrication techniques and geometries. Our mid- long term purpose is to be able to develop functional structures for sensors and sources.

We will investigate:
1) 3D stopped-light chirped woodpile ceramic photonics structures. Wavelength dependent light localization. These structures can efficiently enhance the electromagnetic field at a particular position

inside the crystal and consequently, the linear and nonlinear absorption, with application to optical sensing devices. We will make a prospective of the enhancement of light absorption when the structures are doped with absorbers or active materials.
2) 1D topological photonic structures with surface-enhanced electromagnetic states. The intensity of the electromagnetic fields at these states in dramatically enhanced, which produces an enhanced linear and nonlinear light-matter interaction. Harmonic generation and enhanced absorption on graphene will be studied.

Objective 1: Study of the theoretical behaviour and numerical simulation of different geometries of sub-wavelength modulated structures for the dispersion relation and modes characterization.
Objective 2: Spectral imaging set-up implementation and measurements of the wavelength dependent slowed light localization in specially designed 3D ceramic photonic structures.
Objective 3: Experimental measurement of the surface localized modes in 1D topological photonic structures trough the analysis if the second harmonic generation.