



MASTER IN PHOTONICS – “PHOTONICS BCN” ERASMUS+ “EUROPHOTONICS”

MASTER THESIS PROPOSAL

Dates: April - September 2019

Laboratory : Plasmon Nano-Optics group
Institution: ICFO - The Institute of Photonic Sciences
City, Country : Barcelona, Spain

Title of the master thesis: Design optimization of photonic crystal nanocavities for near-field levitated optomechanics

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Keywords : photonic crystals, nanocavity, thermal stability, finite element analysis

Summary of the subject (maximum 1 page) :

Precise control over small, micro-sized, dielectric particles can be easily achieved today by means of optical traps. Using the momentum carried by light, forces can be exerted to confine and manipulate objects in a wide range of environmental conditions, providing a simple and versatile platform for the study of many intriguing problems in physical and life sciences. Yet, the use of conventional optical tweezers for trapping smaller and smaller particles, down to the nano-meter scale, becomes challenging: the optical response of a particle decreases with decreasing size, requiring a great increase in optical field intensity onto a diffraction limited spot size, to maintain trap stability. This generates associated problems such as thermal or material damage of the specimens trapped.

An alternative to conventional lens-based optical tweezers is the use of nano-optical resonators, to focus light below the diffraction limit and create larger field gradients over subwavelength distances, necessary for accurate manipulation of single nano-objects. In addition, the interaction of a nanoparticle with the rapidly decaying evanescent field from a nanophotonic cavity also allows the exploration of new trapping regimes of optomechanical nature (such as SIBA trapping) which require much less optical intensity and ease the problem of photo-thermal effects. Furthermore, the small mode volumes and high quality factors of nanophotonic cavities result in strong optomechanical coupling strengths between the cavity field and the particle, three orders of magnitude higher than conventional levitated optomechanical systems. This represents a step forward in the transduction and manipulation of particles motion at the quantum level.

When choosing a particular photonic nanostructure it is essential to investigate its mechanical and thermal properties, to better understand, first, its overall optical performance, and second, its level of interaction with a nearby trapped nanoparticle. This is indeed the aim of the master project: the successful candidate will mainly perform FEM simulations of the photonic crystal nanocavities fabricated at ICFO and used in our setup, tackling in particular the problem of thermo-optical instabilities. The goal is to find possible solutions in optimizing the structure for better heat dissipation, as well as better mechanical stability. The candidate will also use such results to perform some FDTD calculations of the nanocavity field and the main parameters which describe the optomechanical interaction with a levitating silica nanoparticle.

Additional information :

- * Required skills : knowledge of COMSOL Multiphysics and/or Lumerical FDTD, Matlab
- * Miscellaneous : basic level of English