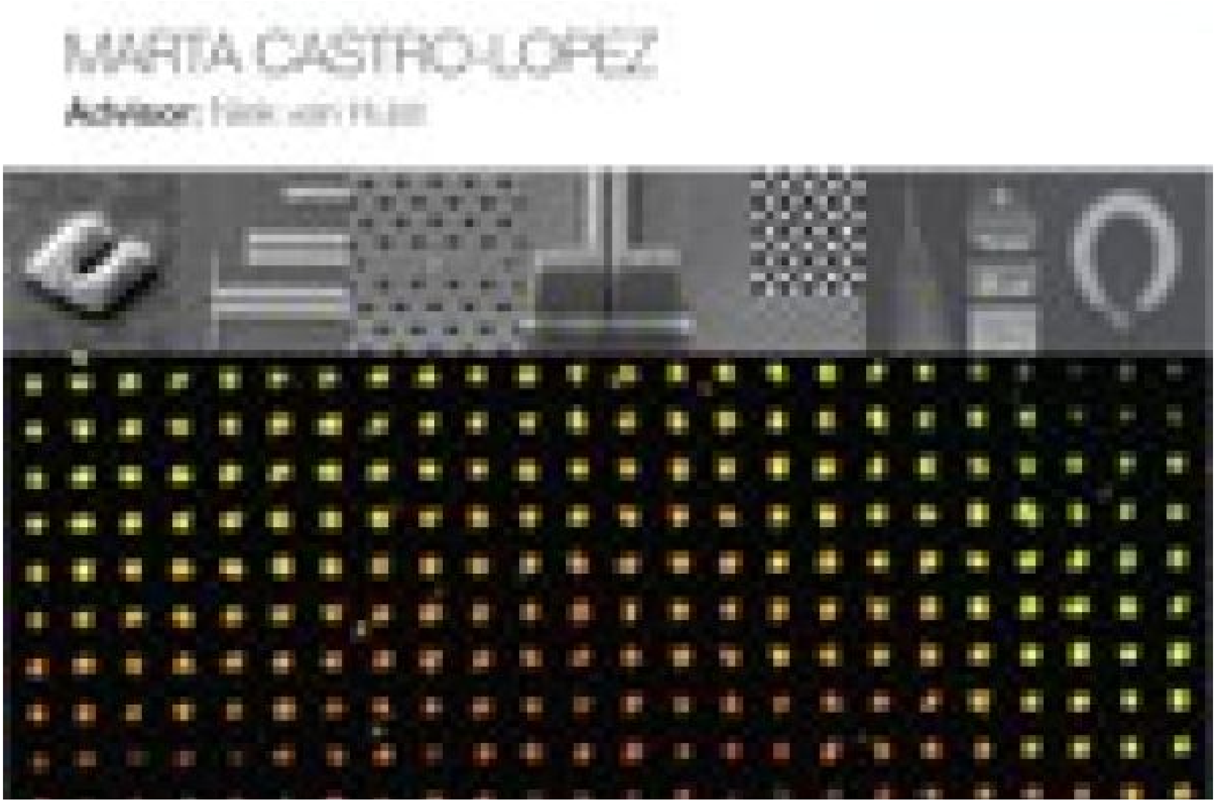

PhD Thesis Defense MARTA CASTRO 'Nanophotonic Structures for Light Control at the Nanoscale'

MARTA CASTRO

December 17, 2013

Tuesday December 17, 11:00. ICFO Auditorium

MARTA CASTRO

Molecular Nanophotonics

ICFO-The Institute of Photonic Sciences, SPAIN

During the past decades light has become indispensable in daily life technology and fundamental research. The ability to manipulate it at will has been the goal of a considerable number of studies. This manipulation has been historically restricted to the macro- and microscopic regime due to the limitations set by diffraction. Nevertheless, in recent years, new advances in nanofabrication and nanomanipulation have opened the door for achieving light control at the nanoscale. In this progress, light-matter interaction became at the heart of most studies in the most diverse fields. Achieving a predefined control over this interaction continue to be a critical aspect for the exploitation of nanophotonic systems as building blocks for more advanced applications.

With this goal in mind, this thesis is based on the fabrication, characterization and control of nanophotonic systems consisting of plasmonic structures coupled to photon emitters. The first challenge that needed to be overcome for the realization of this work was the creation of coupled systems in a controlled and reproducible manner. High resolution fabrication tools for the creation of metallic nanostructures as well as high accuracy methods for the positioning of the emitters are required. This was achieved mainly by means of electron beam lithography (EBL) and chemical functionalization of surfaces (Chapter 2). The ability to fabricate metallic nanostructures and couple them to photon emitters gives no insight on the optical behavior of those or the coupled system. At the same time, the optical response of a photon emitter coupled to a metallic nanostructure is mainly determined by the optical response of the structure itself. For that reason, the fabricated nanostructures need to be optically characterized first in isolated mode. This characterization will allow us to optimize the structure design, i.e. material, size and shape to achieve a particular optical response. At the same time it will be shown how to disentangle the emission resonance from the excitation resonance in order to control them independently. This analysis will help on the selection of a specific structure design for a particular application (Chapters 3 and 4). Once the optical response of the structures in isolated mode is well understood, the inclusion of emitters will open the way for the study and control of the coupled system. As an example, the propagation of quantum dots emission is controlled by coupling them to plasmonic transmission lines (Chapter 5). With this, the fabrication-characterization-control loop will be closed and all the steps will have been addressed.

The results presented in this thesis show the importance of a good selection of the design, i.e. material, size and shape of the metallic nanostructure in order to maximize the performance of the system. In effect, the systematic variation of these three parameters shows the possibilities in controlling the optical response, i.e. enhancement, angular pattern, polarization and spectrum of metallic nanostructures even at the level of a single nanopad. At the same time, aluminum is presented as a promising plasmonic metal for nonlinear purposes and gold as a versatile material for tuning its optical response. Controlling the emission/absorption properties of nanoemitters via coupling them to metallic structures opens new possibilities in the most diverse fields. In this thesis, the propagation of their emission is shown to be guided several microns through plasmonic transmission lines. The promises envisioned for this kind of nanophotonic systems make the route towards controlling them a necessary step in order to take full advantage of their potential.

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Thesis Advisor: Prof. Niek F. Van Hulst