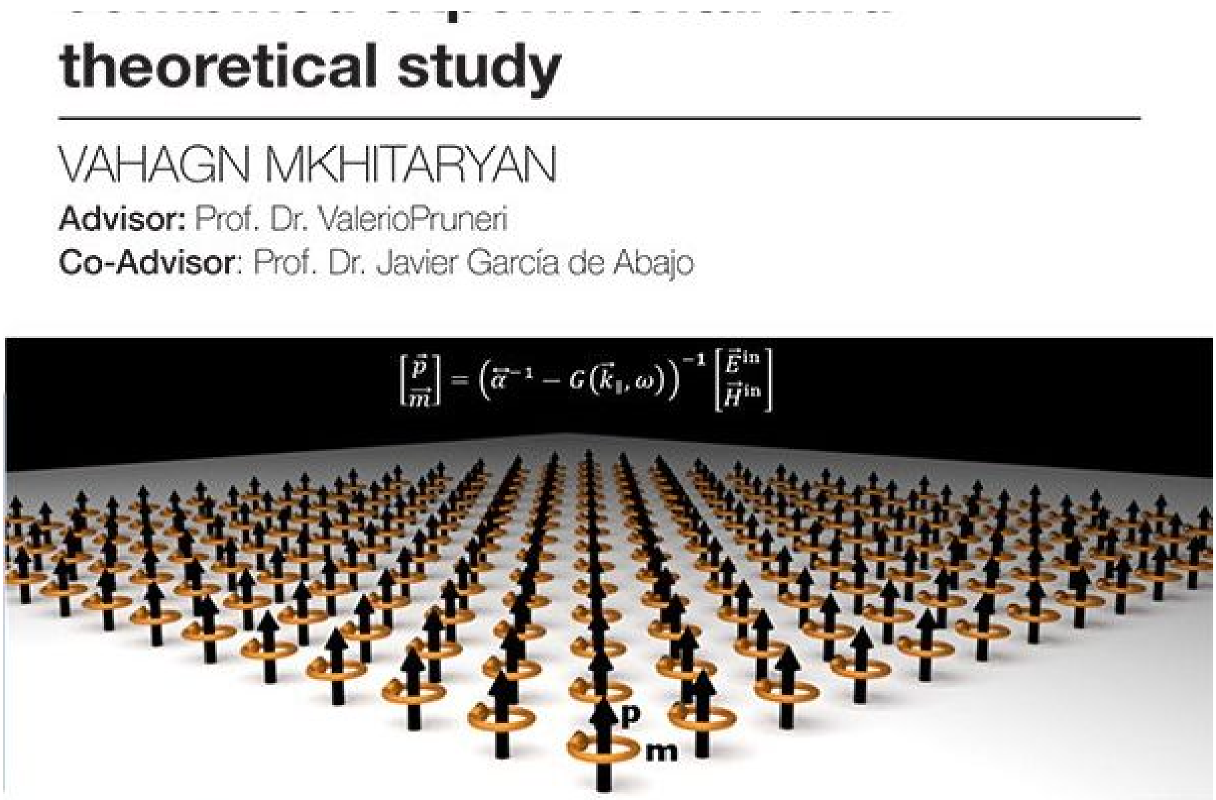

PhD Thesis Defense VAHAGN MKHITARYAN 'Nanophotonics of Ultrathin Films and 2D Periodic Structures: A Combined Experimental and Theoretical Study'

VAHAGN MKHITARYAN

September 26, 2017

Tuesday September 26, 11:00. ICFO Auditorium

VAHAGN MKHITARYAN

Optoelectronics

ICFO-The Institute of Photonic Sciences

Photonics is a key enabling technology for many applications ranging from communications to energy and medicine. Its success is largely relying on our capability to appropriately control light in optical devices. To this end, the understanding of light-matter interaction occurring in the devices is a crucial element for finding effective solutions to the challenges posed by the targeted applications.

This thesis is devoted to understand light-matter interaction in periodic nanostructures and ultrathin films and create modelling and design tools for functional optical devices, some of them demonstrated experimentally.

We start by investigating the needed theoretical methods for describing the interaction of light with surface periodic nanostructures. We carry out a comprehensive study of the transmission, reflection and dispersion properties of 2D periodic arrays and their stacks, including, the study of more complex structures as well, such as, defects in periodic lattices, random arrays of scatterers and multicomponent lattices, and the calculation of the local density of electromagnetic states in the array.

We then show how to use the developed theory to design and understand the behaviours of application-specific devices/structures, made of 2D periodic structures and multilayer stack of thin films.

A first device demonstrator consists in periodic arrays of nanoholes performated in a gold film covered with Ge2Sb2Te5 (GST), a phase change material layer.We investigate the effect of GST?s phase transitions on the transmission resonances of these structures. Wavelength shifts as large as 385 nm are demonstrated in configurations with broad resonances. Additionally, excitation of GST with short pulses allows ultrafast tuning of these resonances in the ps regime without producing any phase transition. Finally, tuning of narrower resonances with shifts of 13 nm is also demonstrated.

In a second device demonstrator, a perfect absorber, we show how interference effects, occurring in multilayer thin film structures, can be exploited to achieve nearly 100% absorption. Two perfect absorption regimes are identified: the first one broadband and in the visible; the second one resonant and in the near infrared (NIR) region of the wavelengths. We show that the proposed method enables conceptually simple devices that are easy to fabricate. Moreover, we show that GST constitutes an essential layer for a new class of optical absorbers that can be dynamically tuned. In contrast, previous structures required cumbersome fabrication steps and were not dynamically tunable.

In a third device demonstrator, a structure with multilayer thin films is used to design and fabricate an anti-reflective, highly transparent electrode, with world-record low sheet electrical resistance and high optical transmission.

In summary, the thesis capitalizes on modelling tools for light-matter interaction at the nano-scale, which are adapted to a general class of device structures and allow us to design optical surfaces based on thin films and nano-structuring with unprecedented performance. This is demonstrated through the design and experimental realization of resonant optical filters with very large tunability, perfect absorbers with very high dynamic range and transparent electrodes with record electro-optical performance.

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Thesis Director: Prof Dr. Valerio Pruneri

Thesis Co-director: Prof Dr. Javier Garcia de Abajo