Light manipulation in multilayered photonic structures

Abstract

This thesis is devoted to novel nano-optical phenomena and devices based on multilayered photonic structures sustaining electromagnetic surface waves. First, a hybrid dielectric-metallic multilayer is considered, able to sustain electromagnetic surface modes called *Tamm plasmons*. The coupling of emitters to Tamm modes is exploited in order to obtain a highly directional fluorescence emission from a single nanoaperture in a metal film. The increased directionality and beaming of the emission coupled to Tamm modes is demonstrated experimentally through back focal plane images of the fluorescence intensity. Experimental observations are well supported by rigorous calculations, performed by means of a Finite-Difference Time-Domain model. Next, electromagnetic surface waves sustained by a total dielectric multilayer are considered, called *Bloch surface waves*. An original device for enhancing the radiative decay rate and directing the emission of organic dyes located on the surface of a patterned dielectric multilayer stack is presented. The device is based on a cavity for Bloch surface waves surrounded by a circular outcoupler to redirect the coupled emission at low numerical aperture. A streak-camera based spectroscopic setup is implemented in order to demonstrate the Purcell effect through spectral and temporal measurements of the coupled emission. Also, Bloch surface waves are further exploited for producing vectorial vortex beam through a mechanism involving a spiral diffraction grating on top of a dielectric multilayer. The vortex beam is generated in a two-step process, involving a spin to orbital angular momentum conversion from a focused circularly polarized beam into radially propagating Bloch surface waves and a Bloch surface wave diffraction in free-space, with the additional phase distribution imparted by the spiral diffraction grating. Experimentally, Back focal plane imaging plus Stoke's polarimetry techniques are implemented in order to retrieve the angular distribution and polarization state of the diffracted light. The mechanism effectively generates a vortex beam carrying orbital angular momentum at low numerical aperture.