Abstract

Nanophotonics is the study of the interaction of light with nanometer scale structures. At such a scale, structures may exhibit a resonant behavior as their size is close to the wavelength of visible light. This resonant behavior enhances light-matter interactions and could therefore be beneficial for countless applications ranging from biosensing, light harvesting to even cancer therapy. Plasmonic resonators have consequently been of interest to the scientific community because of their resonant interaction with light. High refractive index subwavelength resonators made of dielectrics or semi-conductors (silicon for instance) have also recently emerged as a promising way of enhancing light-matter interactions through the excitation of Mie resonances while suffering from less dissipative losses than plasmonic resonators. The work presented in the scope of this thesis is mostly concerned with the theoretical and experimental study of the resonant interaction between light and high refractive-index scatterers. We first studied the optimal interactions of light with subwavelength resonant scatterers. The objective was in fact to determine the conditions that optimize the scattering or absorption of light by subwavelength sized scatterers. Asymptotic resonance conditions for Mie resonators were subsequently determined and were used to derive approximate models capable of predicting the resonant behavior of high-index dielectric resonators. High-refractive index resonators can be seen as open photonic cavities. The modes of this type of cavities, that only have a finite lifetime as they suffer from radiative losses, are usually referred to as Quasi Normal Modes (QNM). Using pole expansions of the S matrix associated with high refractive index scatterers, we derived QNM expansions of the scattered field of Mie resonators that also evidenced the presence of a non-resonant response. We then showed how QNM expansions could be used to describe the scattering problem in the time domain. Finally, we experimentally studied nonlinear effects in silicon nanodisks. In particular, we measured the degenerate four-wave mixing signal obtained while pumping at two different wavelengths. We observed a large enhancement of the four-wave mixing signal from the nanodisks as compared to an unpatterned silicon thin film when the two pump wavelengths were close to the wavelengths of two resonances of the nanodisk.