Abstract

Plasmonics nanostructures and nanoantennas have been widely studied and employed for the development of various optical devices. Two physical phenomena, surface plasmon polaritons (SPPs) and localized surface plasmons (LSPs), have been harnessed to develop several types of optical sensors and integrated optical devices. This thesis primarily focuses on developing platforms for surface-enhanced Raman scattering (SERS) based sensors and the study of plasmonic switches for near-field switching. Firstly, the nanohole arrays in a thin gold film have been studied for the development of SERS substrates. Finite-difference time-domain (FDTD) simulations were carried out to study the effects of various geometrical parameters as well as the polarization of light on the performance of the devices. The FDTD simulations show that the bridge-bowtie nanohole array and crossed bridged-bowtie nanohole array exhibit large electromagnetic enhancement of SERS and have the SERS enhancement spread over a much larger area than what could be present in SERS substrates consisting of nanopillar arrays or nanopillar plasmonic nanoantennas. The second plasmonic device studied in this thesis comprises of a plasmonic nanoantenna in the vicinity of a nanogroove. FDTD simulations show that the electric field enhancement of the plasmonic nanoantenna is significantly improved via interaction between the bowtie nanoantenna and the nanogroove. The third plasmonic device proposed in this thesis is based on the combination of a directive nanoantenna and a bowtie nanoantenna. In this device, a localized source is employed to excite the directive nanoantenna, which in turn drives the bowtie nanoantenna. FDTD simulations were employed to obtain the radiation characteristics of the directive nanoantenna and the electric field enhancements in the vicinity of the bowtie nanoantenna excited by the directive nanoantenna. The electric field enhancements in the bowtie nanoantenna that is driven by a directive nanoantenna are compared with those for direct excitation of the bowtie nanoantenna by a dipole source or by plane wave source. The effect of various geometrical parameters of the nanoantennas on the device performance have been studied. Finally, a novel optical switch based on plasmonic nanoantennas lying on top of a thin film of a phase change material is studied, such that the near-field properties of these nanoantennas can be switched by varying the

phase of the film. The FDTD simulations are carried out first to demonstrate that the near-field intensity in the vicinity of the plasmonic nanoantennas can be substantially switched by changing the phase of the film from the semiconductor state to the metallic state.