

NANOPHOTONICS AND PLASMONICS BASED BIOSENSORS

Nanophotonics is a widely researched area that investigates light-matter interactions at a nanometer scale and plasmonics is one major subset in the field of nanophotonics that essentially deals with optical manipulation of light on engineered nanostructures and metamaterials. The incorporation of plasmonically engineered subwavelength nanostructures or metamaterials which can lead to optical manipulation and thus enhanced light-matter interactions resulting in various applications requires easy fabrication implementation. With the latest advances in nanofabrication technology, fabrication of subwavelength dimensions of nanostructures has become feasible using sophisticated top-down and bottom-up fabrication approaches. Further, the cost effectiveness is an important factor which should be taken into consideration in the implementation of plasmonic nanostructures and wafer-scalable metamaterials. The optical manipulation in designed subwavelength structures becomes realizable by controlling several dimensional parameters. The primary goal of this thesis is to study plasmonic sensors based on nanostructures and metamaterials majorly for three plasmonic applications, namely, surface-enhanced infrared absorption spectroscopy, narrowband absorber metamaterial and chiro-plasmonic sensing.

The first part of the thesis numerically investigates plasmonic nanostructures for efficient surface enhanced infrared absorption (SEIRA) substrates based on several configurations of complex plasmonic nanostructures. The numerical modelling is carried out using Finite-difference Time Domain (FDTD) simulations for studying the spectral properties of the nanostructures, including the spectral response in the desired spectral regime and electric field distribution at the

plasmon resonances noted in the proposed nanostructures. The SEIRA enhancement factor is found to be $\sim 1.7 \times 10^5$ which is substantially large compared to the previously reported enhancement factor values for plasmonic nanostructures.

The second part of this thesis presents a numerical modelling of simple structure for narrowband absorption in mid-infrared regime. The structure is based on simple design of a diabolo antenna which can be easily fabricated using a two-step fabrication process, essentially, a lithography and metallization process, as opposed to typical absorber designs employed tri-layered metal-insulator-metal based configurations. The two metasurfaces employed are ‘Babinet’ counterparts. The lithography step can be easily carried out using a photon polymerization laser direct write technique followed by a metallization process. The numerically modelling is carried out using Finite Element Method (FEM).

Finally, the third application studied is based on investigations of chiro-plasmonic metamaterials exhibiting giant chiro-optical responses. The chiral films, upon experimental investigations have shown a giant chiral response, the largest ever reported for a wafer-scalable chiro-plasmonic films. The samples in the study have shown large morphological variations which are inherent due to the top-down fabrication process employed for fabrication of the films. The experimental findings are correlated with computational models which are numerically investigated using Finite Element Method (FEM). The information from the computational predictions and its concurrence with the experimental data is highly relevant for enantiomer selective identification and sensing applications since the wafer scalable nanostructured films considered in this study are inherently porous easily allowing the diffusion of chiral molecules in regions of enhanced chiral electromagnetic hotspots.

This thesis work thus investigates key research areas of great interest to the scientific community in the field of nanophotonics and plasmonics and light-matter interactions at nanoscale focusing on applications pertaining to surface enhanced infrared absorption spectroscopy, narrowband absorption metamaterials and chirality detection using wafer-scalable metamaterials.