Sensing using Multiple Plasmonic Resonances in Metallic Gratings

Introduction

Grating coupled surface plasmon resonance (GCSPR) and Waveguide coupled surface plasmon resonance (WCSPR) are alternatives to Kretschmann's configuration to excite forward and backward propagating surface plasmons (SPs), localized surface plasmon resonances (LSP) and Waveguide coupled modes. GCSPR offer the possibility of excitation of SPs at near normal incidence angles, thus providing a better method to integrate plasmonic sensors on a chip along with other optical devices. However, a single resonance does not provide adequate information about the refractive index, thickness of analyte and substrate refractive index simultaneously.

In this paper, we present the transmission characteristics of negative diffraction orders coupled to different SP modes in plasmonic grating structures coated with a homogeneous dielectric. The principal advantage of negative diffraction orders is that for narrowband excitations, as the refractive index of the analyte increases, the angular position of the resonance decreases hence enabling detection of higher refractive indices without a very high numerical aperture objectives for collection. Secondly, under a broadband excitation, these structures exhibit multiple types of resonances and each of them blue shift with increases in refractive index of the analyte, thickness of the analyte and refractive index of the substrate.

Simulation Results

A Binary Metal Grating (BMG) of finite thickness and period, on a BK-7 glass substrate was analyzed for its sensitivity to a homogeneous dielectric film (acting as a superstrate) with different refractive indices and subwavelength thicknesses. Simulations of these structures were performed using a homemade Rigorous Coupled Wave Analysis (RCWA) and the field distributions were obtained using a commercial finite elements full wave solver. Under normal incidence, using a broadband source in BMG three distinct modes could be excited corresponding to WCSPR (Waveguide Coupled Surface Plasmon Resonances), SP mode, leaky mode (at metal/ glass substrate interface) as shown in Figure 1., along with the field distributions for these resonance. Both the WCSPR and SP modes of BMG offer a sensitivity of 500nm/RIU; however the Full Width at Half Maximum (FWHM) of the waveguide modes is 35nm which is much lower compared to 95nm of the SP mode. Secondly, the thickness of the superstrate can be ascertained using the spectral position of the SP mode and the WCSPR mode. A third mode excited in these structures corresponds to the leaky mode coupled to the metal substrate interface and offers sensitivity only to substrate's refractive index.

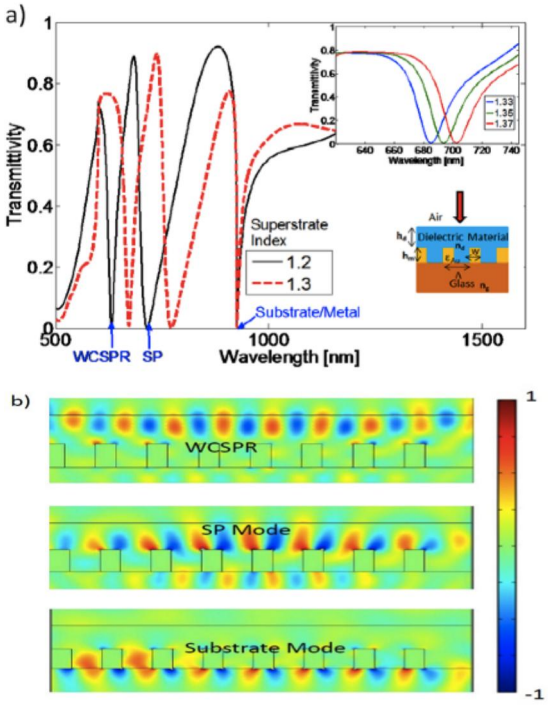

Figure 1. Transmittivity for BMG configuration and the field distributions for different resonances.

Summary

In summary, we conclude that a single grating layer based GC/WCSPR offer easiness of fabrication and provide sensitivities of the order of 500nm/RIU with broadband excitation at normal incidences.

Publication

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