# Design and Simulation of a Metal-Assisted Guided Mode Resonance Based Biosensor for Visible Range Operation

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**Abstract:** The design and simulation of a metal-assisted guided mode resonance (MaGMR) based biosensor is presented for sensing in the visible region. The MaGMR structure shows 76.3% sensitivity enhancement for 25nm analyte thickness in comparison with the standard guided mode resonance (GMR) structure with the same design parameters.

## 1. Introduction

Recent demand for high throughput cost effective point of care biosensors has led to an increased scientific interest towards GMR gratings working in the visible region [1]. This allows the use of regular smartphone cameras for readout, which can further reduce the overall system cost [2]. The sensitivity of GMR gratings is a function of grating period, which in turn, also determines the resonant wavelength of the structure. Working on the lower wavelength visible regime usually leads to lower device sensitivity [3].

MaGMR has been shown to improve the sensitivity of GMR structures by placing a metal layer underneath the GMR waveguide structure [4]. In this work, we have designed a MaGMR based sensor for operation in visible range of the spectrum. The sensitivity of the MaGMR and GMR sensors is then compared for a range of analyte thicknesses starting from 15nm to 100nm, with 25nm being the typical assay size for biosensors [1,3].

## 2. Design and Simulation

The GMR grating used in the present work is shown in Fig. 1(a). It consists of a silicon nitride based waveguide embedded with grating structure on top of a thick silicon dioxide layer. Initially, the waveguide thickness and grating height have been optimized, and their values have been considered as 120nm and 50nm respectively for all the simulations. A grating period of 400nm with 50% duty cycle is chosen for all the simulations in order to achieve the resonant reflectance peak within the visible region for the given design parameters (Fig. 1(c)).

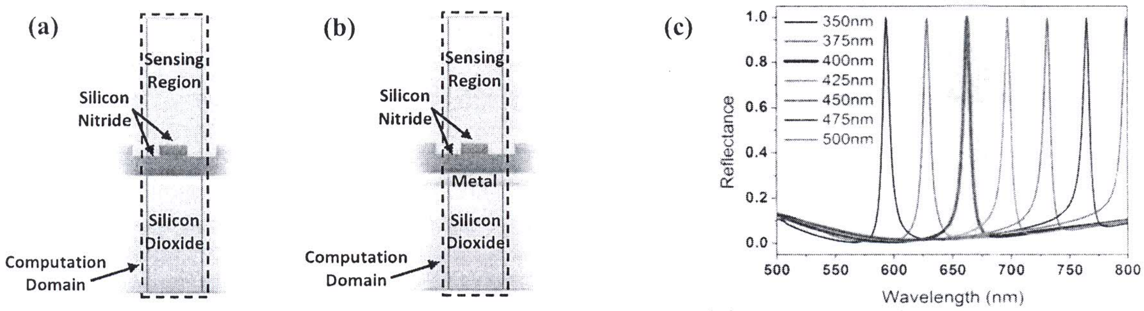


Fig. 1. Design geometry for the (a) GMR and (b) MaGMR structures used for simulation. (c) Resonant reflectance peaks for different gratings periods of the GMR structure.

A suitable metal underlayer is then selected to be used in the MaGMR structure shown in Fig. 1(b). The effects of metal properties and thickness on the behavior of MaGMR device are then studied to select the metal and the optimum value of the metal underlayer thickness. The performances of both of these devices are then compared for a variety of analyte thicknesses. All the simulations have been carried out in COMSOL Multiphysics® [5] software tool using TE-mode of excitation.

## 3. Results and Discussions

The field profiles for both GMR and MaGMR structures at the resonance are shown in Figs. 2(a) and 2(b). The metal layer acts as a reflector thereby leading to an asymmetrical field distribution, which is visible from the corresponding image (Fig. 2(b)). This causes the presence of a larger percentage of evanescent field in the sensing region which improves the device sensitivity.