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Research paper



The Study of Baccilus Cereus on Surface Plasmon Resonance Based Biosensor

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Abstract

SPR biosensors have obtained elaborate application in the area of biological interactions and detection for chemo-bio analytes, where the benefits of real-time, label attraction potential and label-free technique are prominent. SPR techniques are implementing. Non-Invasive biomolecule monitoring by using blood samples from the body. Sensor development involves high sensitivity. Of them all, the SPR configurations with waveguide coupling has a waveguide mode and surface plasma mode, coupled via an evanescent field in scattered manner thus providing superior control on the reaction and can ultimately lead to superior sensitivity and additionally promote loosely diversified, multichannel and swift stimuli devices construction, capable of distinguishing particular sensor responses from random response and capable of concurrent detection of many analytesin analogy to waveguide coupled configuration which being heavy. With the above requirements our present work puts limelight on sucha multi waveguide integrated optical based SPR biosensor. This paper presents a unique work of analyzing the bacterial content in human blood sample with respect to water and protein as immersion layers. Results include analyzing the simulation results with patterns of waveform and frequency for individual B. cereus var. mycoides and B. megaterium bacteria respectively.

Keywords: *Surface Plasmon, Fullwave, Bacillus Cereus and TM mode.*

1. Introduction

In the last two decades, optical sensors based on surface plasmon resonance (SPR) have been widely researched and numerous SPR sensor configurations have been developed. SPR biosensors have become an essential tool for the study of biomolecular interactions and have been applied in the detection of chemical and biological analytein areas including proteomics, medical diagnostics, environmental monitoring, food safety and security. In order to obtain localized measurements and remote sensing, miniature fibre optic SPR sensors were developed in early 1990 [1].

They are protected to electro-magnetic interference, capable of executing remote sensing, and allow one to give a multiplexed detection within a sole device. Normally, there are dual detection etiquettes that can be executed in optical bio-sensing layers. They are: fluorescence-based detection and label-free detection [2].During fluorescence-based detection, either target molecules or bio-recognition molecules are categorized with fluorescent tickets such as dyes; the strength of the fluorescence indicates the presence of the target molecules and the interaction strength between target and bio-recognition molecules. Meanwhile fluorescence-based detection being tremendously sensitive with the detection limit down to a single molecule [3]grieves from tedious labelling procedures letting it interfere with the operations of abiological entity.

SPR a label-free recognition gadgets estimates refractive index (RI) modification done by molecular reactivity, which is connected to the sample concentration or local surface density, as a auxiliary of total sample mass. As a result, the detection signal does not gauge down with the analyte volume. This nature is particularly attractive when ultra-small (femtoliter to nanoliter) recognition volume is tangled and is beneficial over fluorescence-based recognition whose signal frequently depends on the total amount of analytes in the detection volume or on the detection planar region.

2. Bacillus Cereus in Blood

Septicemia/sepsis is a critical blood stream infection caused by bacteria in parts of the body such as lungs or skin through which it enters the blood stream which causes poisoning of blood [4]. Bacteria's are tiny micro organisms and they feed for survival on other species however it requires iron for its existence. Bacteriarequire an essential iron rich that circulates in the body and penetrates inside the tissues. "Haemoglobin" is used to transport oxygen through the body. It consists of four sub-chains which carries an iron containing "haem co-factor". The hemoglobin gets packed tightly into the RBC in such a way that the red blood cells don't even have a nucleus and are only considered to be hemoglobin carrying machines [5].

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The lack of nucleus leads to a condition where the nucleus neither divides nor grows therefore being put in bone marrow for around 3 months red blood cells are discretely removed and replaced. All of this circulating iron is a great opportunity for pathogenic bacteria which develops various systems to get hold of it. Firstly they have to break down the red blood cells usually by secreting various chemicals that break up the cell membrane, releasing the hemoglobin. Once the hemoglobin inside bacterium is broken down it releases the iron which it carries. The iron in hemoglobin is carrying oxygen, which means that there is potential for reactive oxygen species to be released and cause havoc inside the cell [6].

3. Proposed System

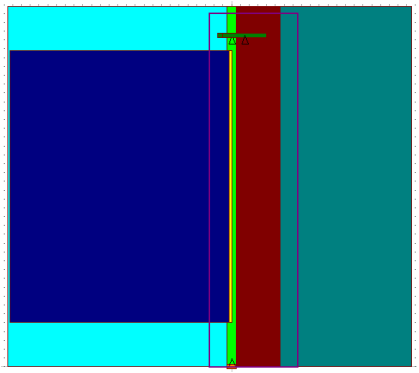


Fig. 1: Proposed SPR biosensor design

An analytical work has been done on the propagation of TE-Polarized waves in four layer slab waveguide (asymmetric waveguide) and the variation of TE mode properties with refractive index and thickness of cladding layer. We developed a mathematical model for the four layer structure with different refractive indices in each layer. This four layer model can be used for the biosensor for medical application. Additionally, the dispersion relation of asymmetric waveguide has also been derived and computed.



Fig. 2: Color code of materials

The structure comprises of 4 layers - silicon dioxide, Titanium Dioxide, and (gold) sensing layers as shown in Figure 1. The high degree of anisotropy linked with the gold layer guarantee that the surface plasmon modes linked with the upper and lower of the metal-dielectric interfaces will under no circumstances be able to couple, their wave vectors fluctuate too much.

4. Material Description

Table 1: Waveguide material

SI. No	Waveguide	Refractive index	Thickness
1	Gold	0.57443312	0.074
2	Water	1.33	5
3	Zns-Sio2	2.198	0.22
4	Sio2	1.45	0.101
5	Titanium Dioxide	2.62	1

5. Optical Simulation

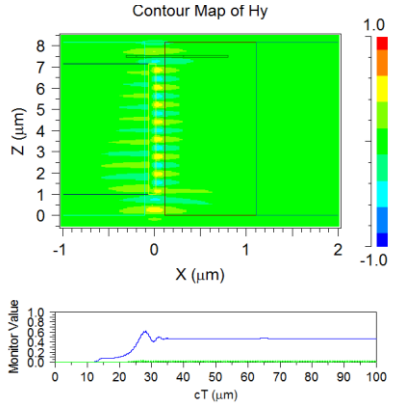


Fig.3: Excitation at SiO_2- TiO_2 junction

Simulation has been done using various refractive indexies. Such as individual cells of B. cereus var. mycoides and B. megaterium bacteria in water and proteins as immersion layer whichcomparatively varies in the output.

5.1. Wavelength, frequency and monitor values graphs for B. megaterium of Bacillus cereus with water as immersion layer

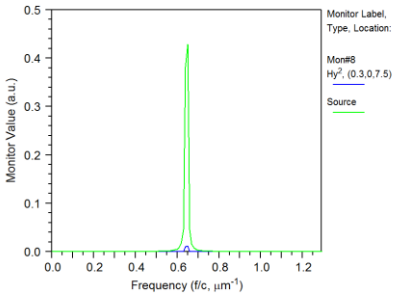


Fig.4: Frequency graph for B. megaterium of Bacillus cereus with water as immersion layer

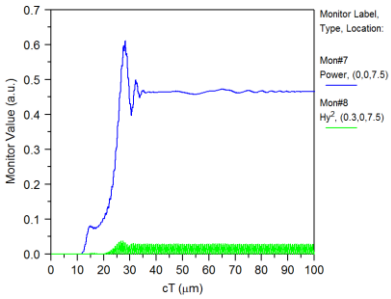


Fig.5: Monitor values graph for B. megaterium of Bacillus cereus with water as immersion layer

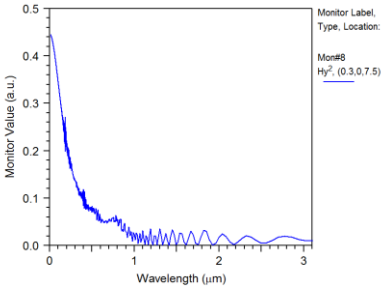


Fig.6: Wavelength graph for B. megaterium of Bacillus cereus with water as immersion layer

5.2. Wavelength, frequency and monitor values graphs for B. cereus var. mycoides with water as immersion layer

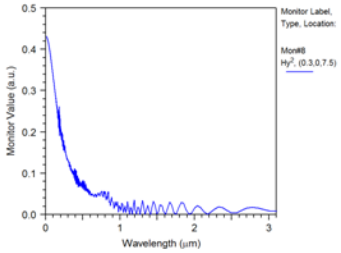


Fig.7: Wavelength for B. cereus var. mycoides with water as immersion layer

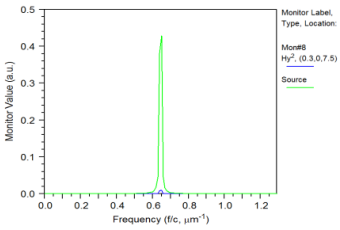


Fig.8: Frequencygraphs for B. cereus var. mycoides with water as immersion layer

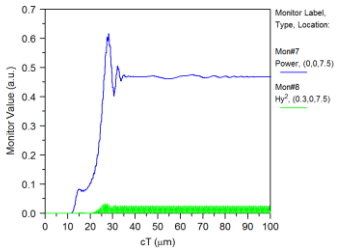


Fig.9: Monitor values for B. cereus var. mycoides with water as immersion layer

5.3. Wavelength, frequency and monitor values graphs for B. cereus var. mycoides with protien as immersion layer

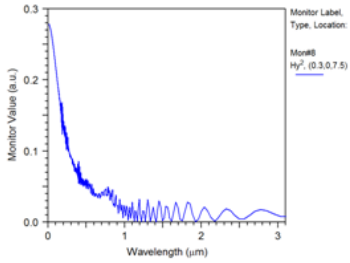


Fig.10: Wavelength for B. cereus var. mycoides with protein as immersion layer

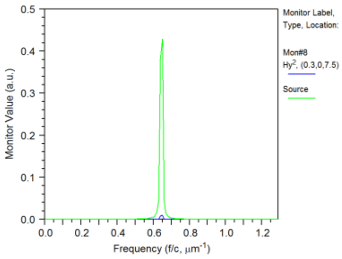


Fig.11: Frequency graphs for B. cereus var. mycoides with protein as immersion layer

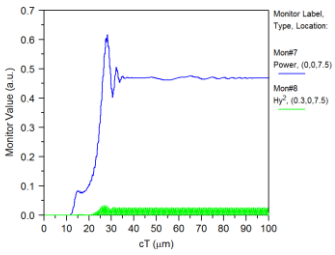


Fig. 12: Monitor values for B. cereus var. mycoides with protein as immersion layer

5.4. Wavelength, frequency and monitor values graphs for B. megaterium with Protein as immersion layer

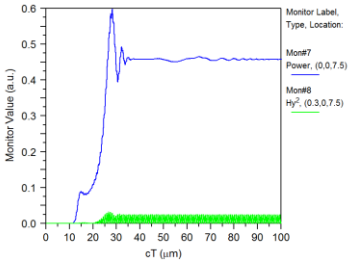


Fig. 13: Monitor values graph for B. megaterium of Bacillus cereus with water as immersion layer

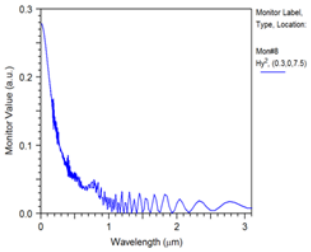


Fig.14: Wavelength graph for B. megaterium of Bacillus cereus with protein as immersion layer

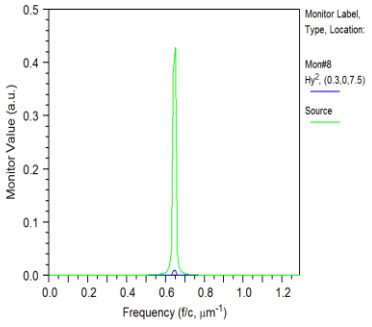


Fig.15: Frequency graph for B. megaterium of Bacillus cereus with protein as immersion layer

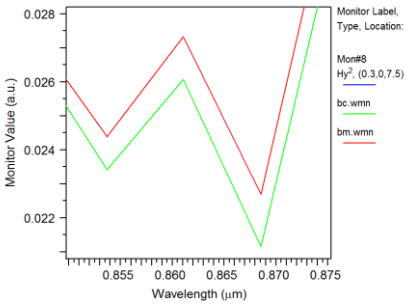


Fig.16: Wavelength comparision graph for B. megaterium and B. cereus var. mycoides with protein as immersion layer

From the above figure 15 we can observe that there is a wavelength peak difference between the two different bacterial cell where the peak differences varies between 0.025-0.026 a.u.

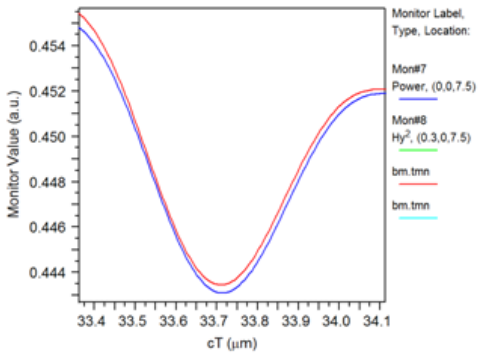


Fig.17: Monitor value comparision graph for B. megaterium and B. cereus var. mycoides with protein as immersion layer

The figure above gives the comparision between the monitor value graphs showing peak graph differences between the B. cereus var. mycoides and B. megaterium.

6. Conclusion

In order to investigate the behaviour of the given sensor, we did a computational analysis of on multilayer patterns where the utility of TMM is found useful. We shall take with SPR in multilayer boundary and see the effects of material properties under SPR spatial distribution. Then we extrapolated the analysis of SPR on to multilayer planar waveguide and fixed up the complex propagation constant of the gold sensing sectors of the device keeping it as a multilayer planar waveguide using TMM and Newton's method of numerical simulation. Also, we did few simulations of SPR in FULLWAVE to begin and later by the model and frequency domain analysis.SPR is a real-time technology with highly sensitive optical sensing technology is demonstrated with blood sample that includes bacteria. The corresponding peaks for different bacterial cells were observed. The transmission spectrum thus obtained for a range of valuesfor individual B. cereus var. mycoides and B. megaterium bacteria's respectively, using the output from FULLWAVE simulation tool, shows signature of respective bacterial level. Thus the graphs obtained are to be considered as a reference values to verify the existence of these bacteria in blood. There is a frequency shift as the dielectric constant is fluctuated while varying Refractive index values (R.I) respectively. The graph clearly indicates for wavelength (1.55nm) there is a distinct shift in the transmission graph plot, so it can be said as highly accurate and sensitive. The sensitivity was tabulated to be 1000nm/RIU.

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