DETECTION OF MELANOMA CANCER CELL BY DESIGNING A SPR BASED BIOSENSOR

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Abstract—This paper presents the Nano cavity Implementation of the biosensors in the detection of melanoma cancer tissue. The key challenge in the work is to provide the accuracy for the biosensors and the results are obtained. The developed design shows a path advancing field of medical aspects with the development of Nano plasmon technologies. The Surface Plasmon Resonance (SPR) technology is used, the concept depends on the refractive index of the selected slab layer. The refractive index material of the normal cancer by comparing it with the refractive index of the melanoma cancer tissue in order to know the tissue is cancerous or non-cancerous. Sensitivity for different sensor design is investigated. The overall highest sensitivity obtained is 300 nm/RIU for 1550 nm of wavelength.

Keywords—SPR, sensitivity, biosensors, Refractive index, Photonic crystal.

1. Introduction

The cancer is most extensively increasing and has led to huge number of deaths. According to the survey nearly 200 out of 400 men and women suffer from cancer. The normal tissue present in human body may consist of a cancerous or a non-cancerous tissue. Basically, the lung cancer consists both the normal and abnormal tissue. The abnormal tissue is of two types they are primary stage and the secondary stage. The primary consists of Hepato-cellular carcinoma, which again has a cancer or non-cancer tissue. These primary cancer starts effecting the lungs. The secondary stage consists of Liver Metastasis; these is the malignant type of the affected cancer caused from other organs of the body. The secondary cancer also has affected and non-affected tissue. These tissue spreads on the lung and this might cause secondary lung cancer. There is a need to differentiate between primary and secondary cancer. The rate of surviving is very less, and the death rate are relatively high in this case. This can be cured under the detection during earlier stage. Malignant tumour can be classified into two separate types i.e. primary and secondary. Primary liver tumour originates in the liver. Secondary liver tumour originates somewhere else in the body and spreads to the liver.

The sensor design offers plasmonic nanostructures that intensify fluorescence signal in biosensors that rely on epifluorescence geometry, in which the fluorophore absorbs and discharges light from the identical track vertical to the substrate surface. The first is an intersected relief gold grating that provisions propagating surface plasmon polaritons (SPPs) and second, gold nanoparticles embedded in refractive index symmetric atmosphere displaying collective localized surface plasmons. The designed provides a platform for the development of the bio medical devices in photonics field which provides a wide range of medical applications. Optical biosensors based on surface plasmons revealed superiority to other methods due to its speedy and extremely sensitive response. Also, the thin gold metal layer is being embedded to the silver layer to attain higher sensitivity which improves the biosensor.
Nano cavity photonic crystal biosensor for different cancerous tissue is analyzed in different metal layers. Figure 1 shows 3-layered SPR structure biosensor designed for finding out melanoma tissue. The software’s used are RSOFT and Optifdtd. The same design is being simulated using two different
software’s to analyses various factors such as sensitivity, frequency analysis, transmission spectrum analysis and power spectrum analysis.

![Contour Map of Hy](image)

**Fig. 2:** Snapshot of Simulation Window

| Waveguide layer | Refractive Index (1550µm) | Thickness (µm) |
|-----------------|---------------------------|----------------|
| SiO2            | 1.45                      | 2              |
| Lower Si        | 3.45                      | 0.22           |
| Upper Si        | 3.45                      | 0.101          |
| Gold (Au)       | 0.574                     | 0.04           |
| ZnTe (Ag)       | 0.896                     | 0.04           |

**Table 1: Parameters considered during the analysis**

The above figure represents the light confinement and the metal layers with their exact value and thickness is also mentioned in Table 1. The metals RI values are considered at 1550µm wavelength. The thickness of the materials is also displayed in the table. By this SPR structure the cancerous tissues is investigated. Each layer is being selected after various research and the several calculated parameters. In this sensor waveguide is created by adding layered metal layers one above the other and providing the respective refractive indices value. The infected melanoma tissues are compared with normal tissue and the variations in the graphs are observed and thoroughly analyzed.

**2. DESIGN AND WORKING PRINCIPLE**

The main reason of this biosensing application is to develop a particular sensor that can detect the affected area with a particular set of the tissue and thus to produce the accuracy that is present in the biosensors which is made to be implemented in Lab-On-Chip under the concept of the SPR, Plasmon based sensors has gained attention of the researchers in advancement of technology. Photonic Crystals is categorized by periodic arrangement of holes (for holes in slab) or rods (for rods in air). But the SPR technology advances in finding further more accurate results when compared to Photonic Crystals. By
this parameter the researchers have adapted in finding out various applications related to biomedicals also the study of devices regarding its packaging, mechanical properties, need of the light source are also analyzed in the recent inventions.

The advantage of using SPR is that by altering the size and position of the metal layers, the output spectrum, can be controlled to reach values which are impossible with outdated optical sensors-based devices. The light when passed through the sensor plasmons are created. These plasmons are observed in the monitor for the analysis. The variations for the normal cell with respect to melanoma cancer cell was observed. These observed simulated results helps in detection of Melanoma cancer tissue. Coupling using waveguide:

Figure 3 shows waveguide based SPR sensor to excite surface plasmon at the boundary between the metal and waveguide. Here principle for the coupling of the light and surface plasmon is identical as that of prism coupler. Incident light propagates along the waveguide, when the light meets the metal layer it stimulates the plasmon and associates with the surface plasmon at the boundary. Waveguide sensor has advantages like it can be measured easily; reduction is laid-back and also it has upright stability.

![Waveguide based SPR sensor](image)

**Fig 3: Waveguide based SPR sensor**

SPR delivers answer for real-world applications where monitoring of Refractive Index (RI) changes is vital, such as, monitoring of changes in complex structures of bio analytes.

\[
K = \sqrt{k_x^2 + k_y^2 + k_z^2} \\
K = n = n \\
\lambda \text{ and } c \text{ are the wavelength in vacuum.}
\]

The R.I is n1 and n2

\[
K2 = 0 \text{ (Now only 2D)} \\
k' + ik''
\]

Where \(k'\) =

\[
k''\]

- Dielectric constant of the Real part in the metal
- Imaginary part of the dielectric material

\(k'\) - Propagation efficiency

\(k''\) - Imaginary part of propagation constant

Sensitivity:

\[
S_n = \frac{\delta \lambda_{res}}{\delta n_{analyte}}
\]

Where \(\delta \lambda_{res}\) is a shift in the resonance wavelength

\(\delta n_{analyte}\) change in the refractive index of analyte.
3. SIMULATION RESULT
The simulation flowchart is shown in figure 4. In figure 5 the frequency graph is being plotted with respect to the obtained monitor values. The monitor value for the melanoma tissues results in a larger peak value when compared with normal tissue. In the below figure 6 it is observed that the transmission spectrum for normal tissue and melanoma tissue having the different indication, the wider dip results obtained indicates the Melanoma cancerous tissue. These data’s variation results obtained clearly explains the differences obtained for normal tissue with the melanoma tissue. These data can be used as a primary requirement in building up of a physical photonic waveguide sensor to detect the melanoma tissue.

Fig. 4: Simulation Flowchart

![Simulation Flowchart](image)

Fig. 5a: Frequency Graph for Normal Tissue
Fig. 5b: Frequency Graph for Melanoma Tissue

Fig. 6a: Transmission spectrum for Normal Tissue

Fig. 6b: Transmission spectrum for Melanoma Tissue
Fig. 7: Most Analysis obtained for finding Sensitivity

From the analysis it is observed that distinct shift in wavelength is observed for different analyte values. Figure 7 shows shift in wavelength for different analyte. Using the Sensitivity formula, the obtained sensitivity is 300nm/RIU.

Fig. 8: Waveguide Sensor Design Silver as a sensing layer

Figure 8 illustrates the silver layer embedded into the design. The similar procedure for finding the melanoma tissue was carried out and their respective graphs where plotted. The results obtained with gold and the silver provided identical results.
Table 2. Sensitivity Calculation

| DESIGN         | SENSITIVITY (nm/RIU) |
|----------------|----------------------|
| Gold SensingArm| 300                  |
| Silver SensingArm| 300                |

From the Table 2 the gold layer and the silver layer results in the same sensitivity values. But the gold is preferred over the silver because the silver get oxidized. Due to this drawback silver is eliminated and the gold metal layer is being embedded onto the waveguide sensor.

4. CONCLUSION & FUTURE WORK

The photonic SPR detection of the bio sensing application in the paper depends on the sensitivity. The simulation in the paper is done in order to give the analogy on the work focused the observance of the entire simulation is done in a particular sensor using Lab-On-Chip the result obtained is the actual result keeping the concept of reducing human effort. The analogy is made in such a way that single sensor can detect the lung cancer probability. This Biosensor will be very much valuable in probing the cancer level in the human body as can be an interim part of the cancer security. The designed sensor is not only a boon for society but can also be immensely helpful in situation of biological warfare.

The sensor can be fabricated on implementation of IC (Integrated chip) as it is minimalizing cost effective and even reduced power consumption and also no more dissipation can occur. Furthermore, enhancement in the device can also be done under necessary condition. The Surface Plasmon resonance is the most widely adopted technique to analyze the biomolecular interactions and also detecting the components of interest present in the samples over the metal surface in real time. The sensitivity of the designed sensor has been calculated and found to be 300nm/RIU. The analysis is carried out by varying the refractive index which resulted in the proper functioning of the device by producing the shift in the wavelength thus making the proposed design compact and relatively easy.

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6. References

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