Spr Based Biosensors Design for Detection of Different Skin Types Cancer

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Abstract

The progress in the field of bio-medical is increasing rapidly. SPR based melanoma provides the accuracy to detect the affected cancerous cell on any skin types. The growth in the small black spot in malignant and invasive melanoma of normal cell over affected cell is unpredictable to detect cancer in any skin types biosensing application sensors have by focusing on the graphene layer. The FDTD simulation guides the SPR to provide the configuration concentration on the Metal-Insulator-Metal (MIM) layer. Simulations are performed on different types of Asian, Caucasian and Dark skin on SPR based biosensor. The ultra-high sensitivity of biosensors can be calculated at a higher rate using R-soft tool and the readings are observed in optical meter. From the obtained simulation results, the sensitivity of the Asian skin is 8812nn/RIU, Caucasian skin is found to be 6064nm/RIU and Dark skin is 9290nm/RIU. The design is emphasized in a way that will show various application on melanoma detection with a sensitivity of 8055nm/RIU for the wavelength of 1550nm. It has been observed that for 1550 nm wavelength.The light speed at which the waveguide travels is up to $3*10^{-8}$ m/s. Finally, the sensitivity, accuracy and quality factor has been computed and found to be very high.

Keywords: SPR, Biosensors, MIM, Sensitivity, Quality factor, Accuracy, FDTD, Melanoma.

1. Introduction

Cancer has been characterized for effecting more than 200-300 various disease. Cancer is caused uncontrollably where the nucleus cells keep multiplying rapidly day by day and the cancer spreads in the human body. The effected cells destroy the blood stream and also the bone marrow. The abnormal growth of the tissue can be different for skin types where the cells multiply in a very large number. The normal mole looking like structure, increases in size and shape and also the mole colour keeps changing stage by stage. The melanoma to be confirmed in epidermis of the outer layer of the skin which do not spread to lumps in melanoma. The melanoma can be present in any of the skin types on the growth of the cancer tissue. The two most pront test that is done under melanoma detection is Decision DX where the tumours have a low risk of spreading. There are different types of vaccinates that are given at early stage like polio, measles, mumps can prevent the cancer from spreading. The various stages are considered in order to analyse the cancer content in the top layer of the skin. The melanoma to be summarized in various categories like TYPE I , II, III, IIA, IIB, IIC, IID,IV. This cancer cells gets effected from the breast tissue. The chances of survival is 5 years. The signs may include dumpling of skin, change in the shape. Females are most prone to melanoma cancer the excess of exposure to uv rays can also cause and lead to melanoma cancer. The early stage cancer are detected by considering the variation in refractive indices of cell in stages and in order achieve better performance the variation of defect in the photonic crystal is adopted by surface Plasmon technique. The graphene layer is the allotrope of carbon giving more transparency in electric and magnetic field. This strong metal layer of graphene are arranged hexagonally on the plane.

SPR based optical sensors have emerged as a unique solution. Although, sensors based on conventional techniques are well established, Plasmon based sensors has gained attention of the researchers across the world. PC is characterized by periodic arrangement of rods (for rods in air) or holes (for holes in slab). The benefit of using PC is that by modifying the size and location of the holes/rods in the lattice structure, the output spectrum, can be modulated to reach values which are impossible with traditional optical sensors based devices. PC provide solution for practical applications where monitoring of Refractive Index(RI) changes is important, such as, monitoring of changes in complex structures bio analytes.

Surface Plasmon resonance (SPR) is the collective oscillation of electrons in a solid or liquid stimulated by incident light. The resonance condition is established when the frequency of light photons matches the natural frequency of surface electrons oscillating against the restoring force of positive nuclei. SPR in nanometer-sized structures is called localized surface Plasmon resonance. SPR is the basis of many standard tools for measuring adsorption of material onto planar metal (typically silica) surfaces or onto the surface of metal Nano particles. It is the fundamental principle behind many colour-based biosensor applications and different lab-on-a-chip sensor

Electronic and magnetic surface Plasmon obey the following dispersion relation

$$k(\omega) = \frac{\omega}{c} \sqrt{\frac{\epsilon 1 \epsilon 2 \mu 1 \mu 2}{\epsilon 1 \mu 1 + \epsilon 2 \mu 2}}$$

Implementation of an FDTD (Finite-Difference Time-Domain) solution for Maxwell's equations, must establish a computational domain. The computational domain is simply the physical region over which the simulation will be performed. The E and H fields are determined at every point. E and H fields are returned by the simulation. Data processing may also occur while the simulation is ongoing. FDTD technique computes electromagnetic fields within a compact spatial region, scattered or radiate.

The MIM (Metal Insulator Metal) layer is playing the major role in the sensors the electric and magnetic field is very strong. The insulator layer is the graphene layer which is the hexagonal plane when we include the three different types of the skin types the blood sample is taken and place on the sensor effective manner. The blood based on different layer gets accumulated on the on the graphene layer. The MIM layer supports the analyte. The metal layer to be produced is said to be gold that is a good conduct of electricity and also supports the layer from exfoliation.The figure below describes each layer fig 1.1 and fig 1.2.
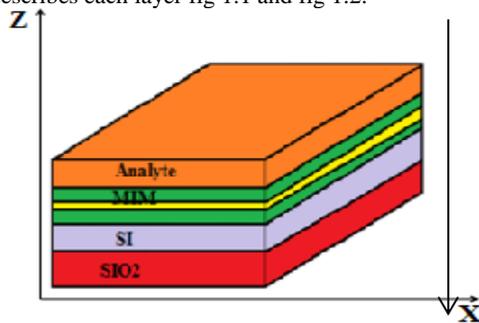
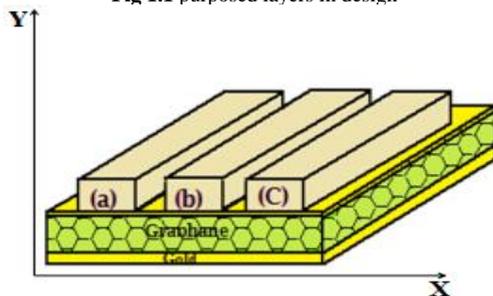

Fig 1.1 purposed layers in design

Fig 1.2 Cross-sectional view of the MIM layer (a) Asian skin,(b) Dark skin, (c) Caucasian skin.

The MIM (Metal Insulator Metal) have a fixed length which is limited in the metallic region of the surface Plasmon resonance. The cut-off at this region is not observed and remain in-phase for the dimension of the waveguide.

The Transverse mode in the MIM layer is eq (1)

$E_x{}^{input} = e^{-ikx1} \pm e^{-ikx1}$

$E_z{}^{input} = \left(\frac{K_x}{K_{X1}}\right) * [e^{-ikx1} \mp e^{-ikx1}]$

$H_y{}^{input} = \left(\frac{-\omega e_1}{Ck_x}\right) * [e^{-ikx1} \mp e^{-ikx1}]$

$K_z \geq \frac{\omega}{c} \sqrt{e_{dielectric}}$

The light confinement of MIM structure

$K_{x\ metal} = \frac{\omega}{c} \left(\frac{E^2_{of\ metal}}{E_{of\ metal} + E_{dielectric}}\right)^2 > \frac{\omega}{c} (E_{dielectric})^{0.5}$

2. Design and Operation Principle

The main purpose of this sensors is to make the work faster and easier in a particular sensor. The SPR sensor is designed for all the skin types in a particular sensors and they are mounted in the Lab-on-chip. The electromagnetic wave in transverse wave has its dielectric waveguide to be passing in the the direction parallel to the metal/dielectric layer. The light is getting confined in the gold layer. The simulation is done in the R-soft CAD tool with the FDTD simulation.

$$k_i = \left(\frac{2\pi}{\lambda}\right) n sin\theta_i$$

Where

K_i is a component of the incident light wave vector parallel to glass interface.
Θ_i is the incident light angle.
λ ijgs the wavelength of the incident light.
n is the refractive index of the prism.

3. Purposed Structure

Fig 1.1 depicts the SPR structure for various skin types on a particular sensor the focus on the MIM layer is concentrated on the water layer. The structure is designed in such a way that any skin texture have the ability to check the melanoma content with the help of the sensors. The light ray passing to the metal insulator layer penetrates the light which hits the MIM in contact with the analyte of the sensors.FullWAVE calculates the electromagnetic field as a function of time and space for an arbitrary refractive index structure in response to an excitation, and can display this field at time intervals. The geometric parameters of a FullWAVE monitor are defined by a center point (X0, Y0, Z0), values for the width *w*, height *h*, and length *l*, and two tilt angles ϕ and θ.
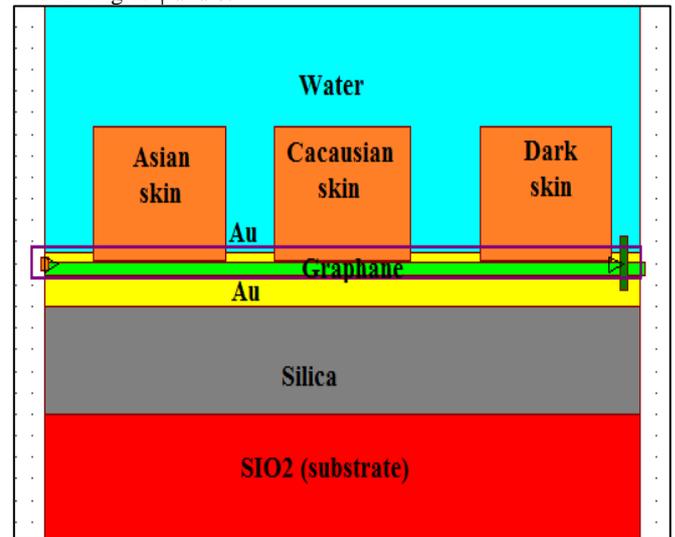

Fig 1 Top-view of the SPR sensor.

The above structure is the sensor that is designed by placing the different layers on one another each layer have the different refractive index and maintained the thickness of each analytes that has been placed the substrate is acting as the grip to the sensors. The light travels with the wavelength of 1550 nM/RIU across the layers. These sensor design is prominent and very accurate in the result point of view it has been designed in the R-Soft. The transverse wave medium is responsible for the waveguides. The Gaussian pulse of laser is used to excite and the particular structure .

4. Simulation Results

By analyzing the wavelength propagating of the TM polarized design sensor light and by observing the variation in the light

property it is subjected to different refractive index of the analyte. This design sensor can be used for different sensing application like medical environment monitoring etc. Here in the figure 1.4 the correlation between the output power wavelength shows the changes record for different refractive index by the designed sensors.
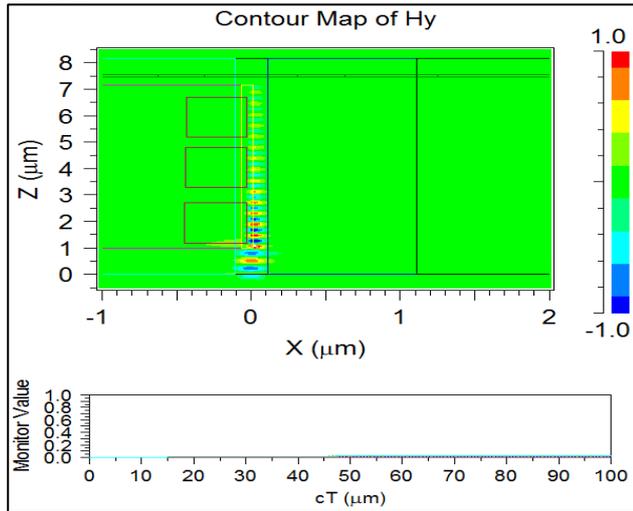

Fig 2 Light ray passing from the source in the sensor.

In the Fig 2 the light is passed through the concentrated area where the light to be travelled in the speed of $3*10^{-8}$ m/s^2. The confinement of the light in the contour map of magnetic plane has found to have there particular polarisation.transmission spectrum of normal cell where the graph has been plotted for frequency with respect to amplitude. A monitor records both field values and electromagnetic quantities such as power or energy density as a function of time or frequency. This output be used for further post-processing if needed.The stop time is being calculated in the cT wrt the monitor value it is observed that there is no change in the stop time it is being constant throughout the entire simulation .
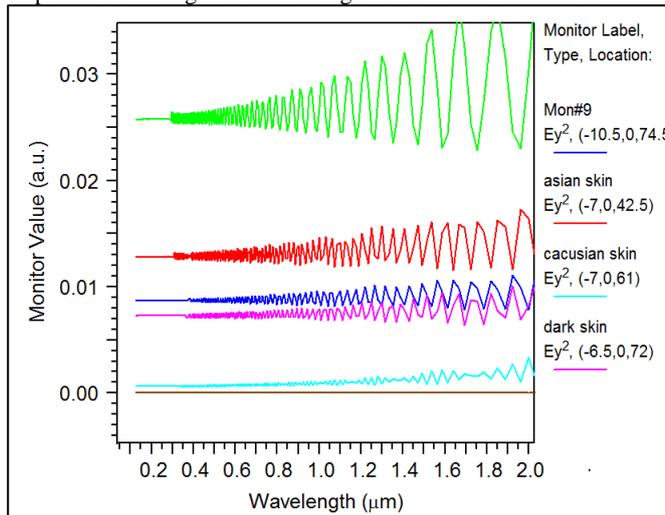

Fig 3 The different skin types with respect to the w   .

From the above Fig 3 it is clearly shown the graph of the Asian,cacasian and dark skin types when the ight is travelling through all this layer then the refractive index varies with respect to the wavelength. Hence forth the graph actually decides the types of the layer with the skin types in the wavelength. The Gaussian envelope function is defined such that τ is the pulse time in units of cT set in the Pulse Time field, and *td* is the Delay Time in unit of τ, and therefore unitless. The wavelength ranging from 1330 nm and 1550 nm of the output obtained of three different skin types of light envelop indicates the various skin considered in the pulsed wave under investigation.
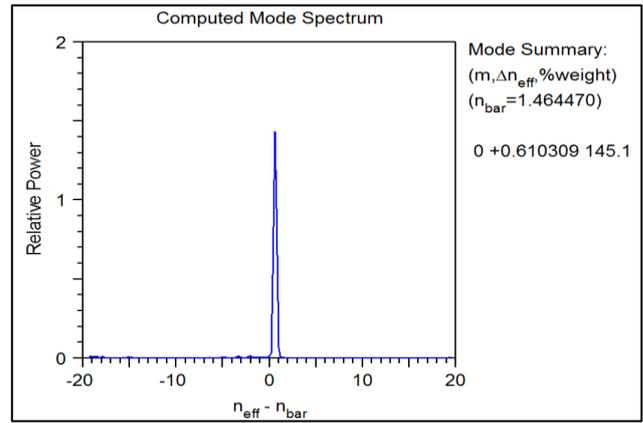

Fig 4 Power with efficiency and bar coefficient obtained from Q-factor

Fig 4 The graph above is the power calculated by keeping the efficiency and coefficient it is said that there is a 0.6 shift on the X-axis the shift that has been happened is found to be on the imaginary plane the real plane is found to be zero power dissipation. Hence in Lab-on -chip the power dissipation calculation is very necessary. The behavior of cervical cancer cell for frequency with respect to amplitude where the positive maximum amplitude
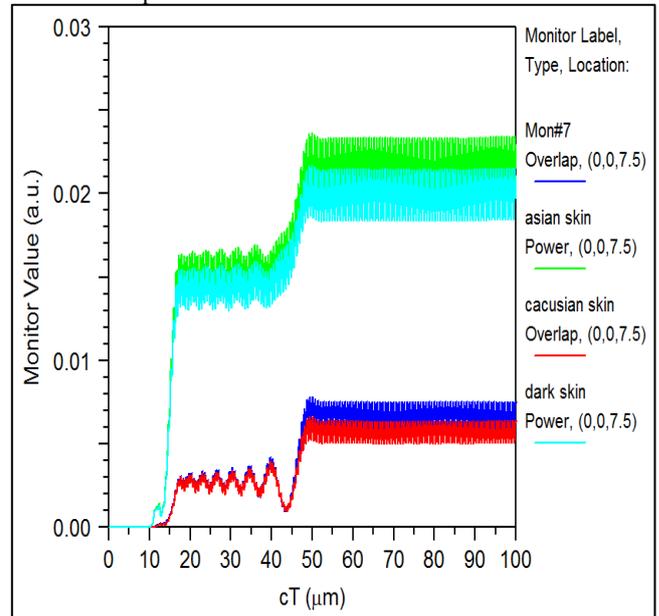

Fig 5 illustrates the Three bus waveguites w.r.t the monitor value in a.u unit the samples shows the different shift in the time irrespective of the other samples the maximum shift per monitor value is 0.024 a.u at the wavelength of 1550 nm.The separate simulation program, after simulating the waveguide structure. The graphical display shows a color-coded contour plot of the optical field.
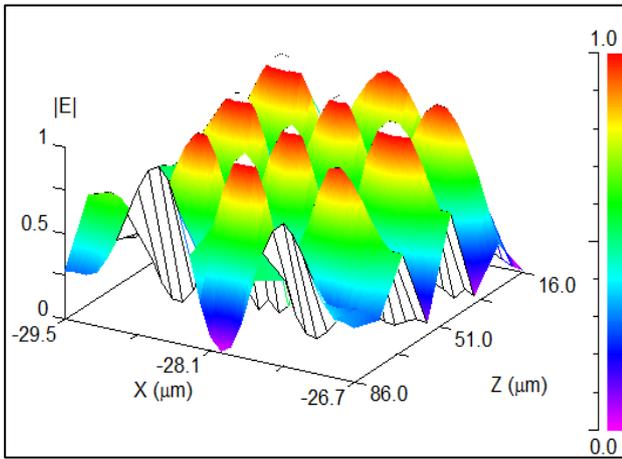
Fig 6 Countor mapshows the 3D shift in waveguides

The above fig 6demonstrates the 3D format in the waveguide shift of all three malignant sample with their respective RI in the sensor design along the electric and magnetic field in the transverse wave medium.
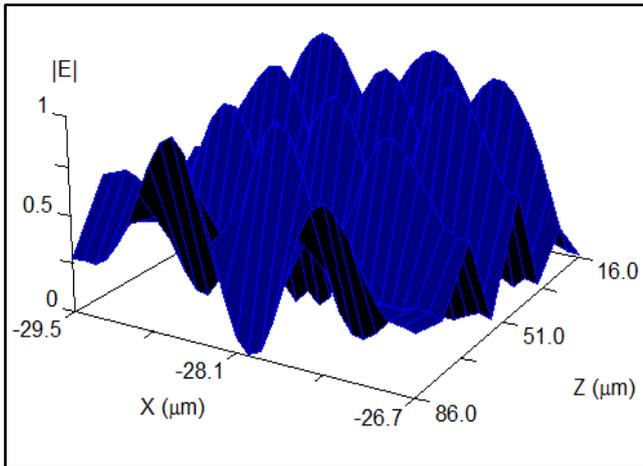

Fig 7 Countor map shows the 3D shift in waveguidesin the wireframe .

The countor map show the 3D shift of the waveguides in the form of a wire the X position at three different shift in the axis -29.5,-28.1,-26.7 and towards the Z axis it is 86.0,51.0,16.0 this shift in the wave is due to the RI value in the existing sensors.
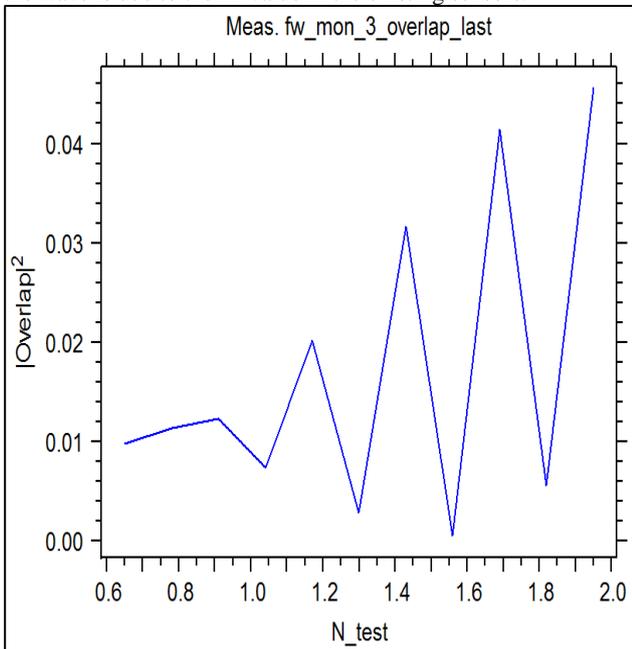

Fig 8 N_test of the sensor with the over lapping test

The above graph depictis the simulation done in the most parameter the overlapping sequence used in the SPR sensors forms the test Fourier transform of the time response of this system, which is the wavelength response of the circuit The oscillations of the resonant cavity can clearly be seen since the refractive index of the cavity changes as a function of wavelength, the resonance response changes as well
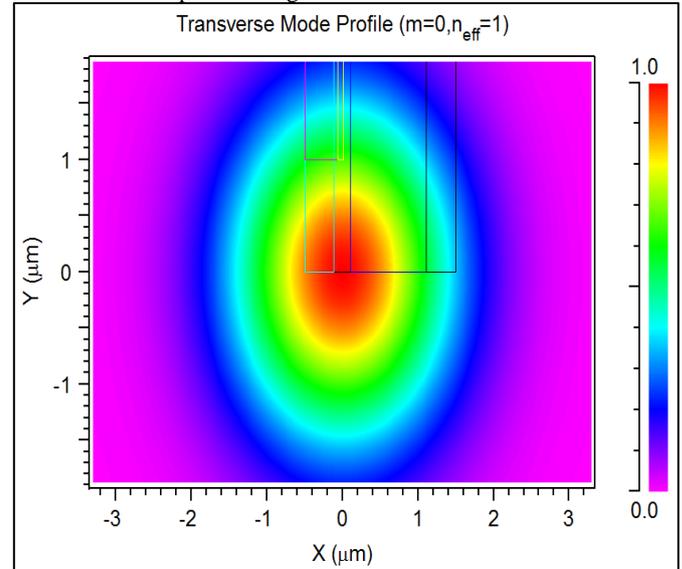

Fig 9 Light confinement through the source

The Fig 9 implies the 3D format of the light confinement in the transverse mode profile with considering the modes where m=0, n=1 index changing as a function described by a data file. The plot shows the reflected field from the waveguide. sensor design in all the axis in XZ axis YZ axis and the sensor chip mounted in nm strip in the transverse medium .

5. Purposed Tables

Table 1.1 shows the background description of the SPR structure in the simulation tool R-soft.

Table 1.2   It has the design description of metals for the wavelength of Asian skin ,cacausian skin and dark skin in which the refractive index of the metal is calculated in order to get results. The expected results for the abnormal tissue.

Table 1.1: Description for the design.

Waveguide segment	Refractive index	Thickness
Asian skin	1.36	1.23
Cacausian skin	0.94	1.23
Dark skin	1.44	1.23
Graphane	2.0660	0.083
Gold	0.52406	1.5
Silicon dioxide	0.728	5
Silica	3.445	0.22
Water	1.3180	1

Table1.2: Design description for layers.

Simulation Tool	Fullwave
Dimension	2d
Free Space Wavelength	1
Index Difference	0.01
Background Index	1.2
Component Width	5

6. Conclusion

The main goal to be eradicating is minimizing the sensor to the nano-scale integtation with optical based integrated circuits. The plasmonic based waveguide is designed is such a way that the sensor can detect any skin that contains melanoma in skin. The wavelength shift in the graphs gives the clear view. The changes in the graphs shows the different changes in the Refractive index in the Asian, Caucasians and dark skin. The sensor is designed in Lab-on chip fabrication is done in the single strip like sensors. These sensors designed for making convenient to make it use normally in daily life. We can observe changes in the power spectrum as we vary the refractive index values. It can be considered as highly sensitive and accurate The sensor can be fabricated on implementation of IC(Integrated chip) as it is minimizing cost effective and even low power consumption no more dissipation can occur. This Biosensor will be very much useful in examining the skin level in blood as can be an intermediate part of the sensor security.The result obtained shows sensitivity of 8055 nm /RIU and a Q factor of 10654.3. The result is much higher than previously published result of 4000nm/RIU for PC-IMRR type optical sensor implementation.

Acknowledgement

Reference

[1]. Photonic Crystal Based Micro Interferometer Biochip (PC-IMRR) for Early Stage Detection of Melanoma, Nandhini V L, Dr. K. Suresh Babu, Dr. Sandip Kumar Roy and Dr. Preeta Sharan

[2]. Sensitivity Improved SPR Biosensor Based on the MoS_2/Graphene-Aluminium Hybrid Structure, Leiming Wu, Yue Jia, Leyong Jiang, Jun Guo, Xiaoyu Dai, Yuanjiang Xiang and Dianyuan Fan, Journal of Lightwave Technology, Vol., 35, No. 1, January 1, 2017.

[3]. Briliant abhi parbow "Graphane based portable SPR sensor for the detection of mycrobacterian tuberculosis DNA strain" proceed engineering 168(2016)541-545.

[4].Layla Pires, Valentin Demidov, I. Alex Vitkin, Vanderlei Bagnato, Cristina Kurachi, Brian C. Wilson, "Optical clearing of melanoma in vivo: characterization by diffuse reflectance spectroscopy and optical coherence tomography," J. Biomed. Opt. 21(8), 081210 (2016), doi: 10.1117/1. JBO.21.8.081210.

[5] J .A .Dionne ,L.A.Sweatlock "Plasmon slot waveguides : Towards chip-scale propagation with sub wavelength -scale localization "