National Conference on Information, Communication, VLSI and Embedded systems (ICVE 2K16)
(16 - 17 March 2016)
International Journal of Engineering Research & Science (IJOER)
ISSN: [2395-6992] [Vol-2, Issue-3 March- 2016]

SPR Based Sensor for Detection of Hepatitis A Virus in Water

Savitha[1], R.Bhargava Rama Gowd[2]

[1,2]Department of ECE, The Oxford College Of Engineering, Bangalore, India

Abstract— *In recent years Surface Plasmon Resonance (SPR) is gaining large interest in research areas because of its fast response and its high sensitivity. SPR is a detection method which is used to analyse the bimolecular interaction taking place near metal-dielectric interface. This is a technique with which we can measure the small variation finding in the refractive index near the surface of metal with higher sensitivity. This change in refractive index is measured due to the interaction in the molecules. In this paper we are designing a sensor which can detect Hepatitis virus present in water by using this SPR technique. Simulation results show a distinct shift in the wavelength spectrum for chemicals in water and normal water .This SPR based sensor is highly sensitive. Here channel waveguide dependent SPR sensor structure is used and simulation is done by Rsoft Full Wave tool.*

Keywords— Water, SPR, Refractive Index

I. INTRODUCTION

According to the World Savvy Monitor report, the diseases due to water contamination are the primary cause of death worldwide. Over three million people die each year due to water related diseases [1]. Fatal diseases are malaria, diarrhea, arsenicosis, fluorosis, cholera, typhoid, some less fatal diseases are schistosomiasis, guinea worm diseases. Moreover, Bio-war is the latest and most destructive weapon of terrorism. Even little concentration of deadliest bacteria or virus or slightest concentration of chemical like mercury, arsenic can endanger the life of millions. This calls for an acute need of sensor system to secure drinking water supply integrity. People living in villages or in low developed region may have higher risk of getting infected due to water contamination there is also an escalating need to monitor the water contamination in urban areas as well. The incidence of contamination and the ways contaminated water can penetrate the human life cycle are shocking. The sources of water pollution are sewage, toxic industrial chemicals coming out of factories, fertilizers and pesticides flown out from farms, e-waste from IT industry, oil spills in sea and others. These pollutants has contaminated sea, rivers, lakes and ponds and also ground water. Viruses present in water might be harmful for human health and life. Nowadays over 100 pathogenic human virus species occur in water polluted with sewage. Chlorination, which is the most pop ular disinfection method, is not able to remove easily viruses from treated water. Due to this, it's necessary to detect viruses in water before treatment in order to determine disinfectant dose and to ensure the sanitary safety level of treated water. The aim of this paper is to detect the virus in water sample.

II. SURFACE PLASMON RESONANCE

Surface plasmon resonance is a non-destructive analysis method used for investigating thin layers of molecules upon a metal surface. SPR is capable of finding changes in refractive index taking place near the surface of a metal. This sensor is mostly used in the study of bio-molecular interactions and the detection of chemical and biological analytic in areas such as protection of environment, food safety and medical diagnostics It also provide the benefit of real time and label-free technology. Interaction of metal surface with light leads to a phenomenon called SPR. At the metal surface bundle of electrons named Plasmons are induced due to the incident light energy in specific condition. For the occurrence of excitation of plasmon, the energy and momentum of these particles must be conserved during photon transformation into plasmon This occurs when the wave vector for the photon and plasmon are equal in magnitude and direction for the same frequency of the waves. Wave vector magnitude depends on the media refractive indices where interaction of EM wave with propagation path occurs and its direction is same as that of propagation of wave[2]. At specific wavelength transfer of energy will be carried out. Plasmon's oscillate in the direction of metal surface and their motion results in an electric field above and below the metal surface. Any changes in the local environment results in change in resonant wavelength, the magnitude of this called SPR shift is directly proportional to variation the material property.

National Conference on Information, Communication, VLSI and Embedded systems (ICVE 2K16)
(16 - 17 March 2016)
International Journal of Engineering Research & Science (IJOER)
ISSN: [2395-6992] [Vol-2, Issue-3 March- 2016]

In SPR at the boundary of two media there will be oscillation of charges. At the boundary charge density field vector reaches its maximum and deteriorates into the media. This wave produced is a TM-polarized wave. At the interface by applying suitable Electromagnetic boundary specifications, we can derive the surface plasmon propagation constant and is as follows:

$$\beta sp = \omega/c \ \{(\varepsilon metal * \varepsilon dielectric)/(\varepsilon metal + \varepsilon dielectric)\} \ ½ \quad (1)$$

Where
ω: Angular frequency
c: Speed of light =3*108 m/s
εmetal= εmr + iεmi: Permittivity of metal
εdielectricl= εdr + iεdi: Permittivity of dielectric

Permittivity of gold is complex valued and dependent on wavelength. Hence we have used Gold as sensing layer in our experiment. The wave vector of the propagating Plasmon wave is

$$ksp= \omega/c \ Re\{(\varepsilon metal * \varepsilon dielectric)/ (\varepsilon metal +\varepsilon dielectric) \} \ ½ \quad (2)$$

From this equation we discover that wave vector of the propagating wave at the Boundary of metal and dielectric material is real part of the propagation constant. When the matching of surface plasmon and waveguide mode phase velocity occurs, there is a stimulation of surface plasmon in the multilayer structure after the propagation of light through the waveguide, when surface plasmon is evaluated with traditional guided mode; dependency on wavelength is more in surface plasmon.

III. STRUCTURE DESIGN

The structure consists of 4 layers that are Gallium Arsenide, silicon dioxide, silicon and gold which is a sensing layer shown in Fig 1. Due to the low refractive index of the metal layer and high refractive index of dielectric the surface plasmon modes associated with these will not combine due to difference in the wave vector since the gold layer is having high degree asymmetry. The sensor layer results in the generation of two different surface plasmon modes which will propagate without influencing each other through the waveguide. There will be excitation of the silicon waveguide ground mode at the gold layer end. This results in either constructive or destructive interface of ground mode depending on the relative phase of the surface Plasmon mode.

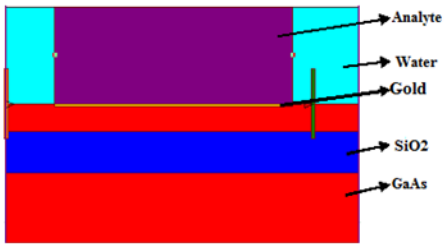

FIG 1. 4-LAYER SPR STRUCTURE

IV. RESULT

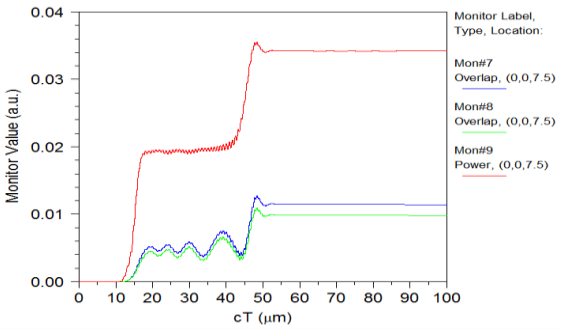

FIG 2. POWER LEVEL FOR HEPATITIS VIRUS

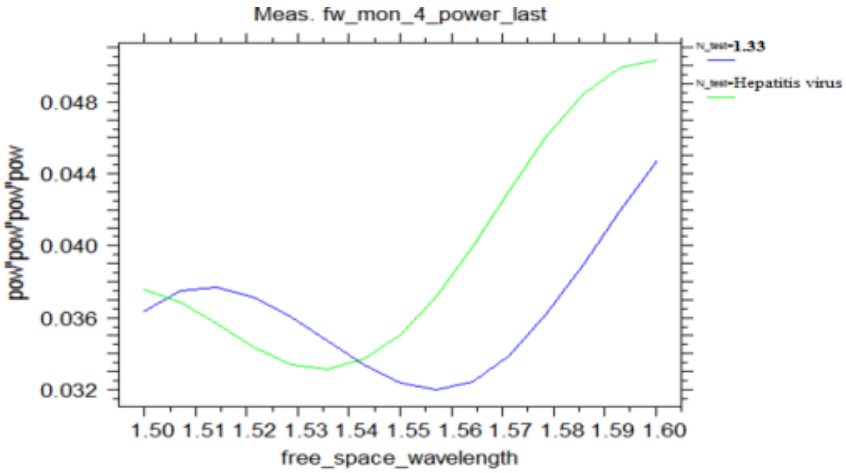

FIG 3. SHOWING WAVELENGTH SHIFT FOR HEPATITIS VIRUS

V. CONCLUSION

SPR is a powerful direct sensing technique. It is one of the most advanced real time technology. The optical biosensor designed by using this technology highly sensitive to minute variation in the refractive index value. Using this optical biosensor we are detecting the Hepatitis Virus in water. We are obtaining different power levels for normal water and water with virus and we can also observe the shift in wavelength for these by using Rsoft CAD tool.

REFERENCES

[1] www.worldsavvy.org/monitor/water.

[2] PatilHarshada, VaniSene, Sriram G, Indumati T S and PreetaSharan "Gallium arsenide based surface plasmon resonance for glucose monitoring" International Conference on optical and Photonic engineering (OPEN2015), 2015.

[3] HomolaJ S. Yee, and Gauglitz G, "Surface plasmon resonance sensors: review, "Sens Actuators B Chem,54,3-15(1999)

[4] Harris Rd, JSWilkinson, "Waveguide Surface Plasmon Resonance Sensors," Sens. Actuator.B ,29, 261 267(1995).

[5] Cao, J.; Sun, T.; Grattan, K. T. V. Gold nanorod-based localized surface plasmon resonance biosensors: A review. Sens. Actuators. B Chem. 2014, 195, 332-351