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BLOOD GLUCOSE DETECTOR USING SURFACE PLASMON RESONANCE BASED PHOTONIC CRYSTAL FIBER

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***Abstract*— Optical Surface plasmon resonance (SPR) biosensors represent the most advanced and developed optical label-free biosensor technology. SPR optical biosensors are a powerful detection and analytical tool with broad applications in environmental protection, biotechnology, medical diagnostics, drug testing, and food safety and security. This project reviews the recent development of SPR biosensor technology whereby we can monitor blood glucose levels. Optical fiber sensors have advantages such as non-disposable, maintains good accuracy and higher sensitivity. The finite element method was used to investigate the guiding properties of light using the COMSOL Multiphysics-5.2a software. The proposed SPR-based sensor chip is analyzed using the confinement loss characteristics for various glucose levels. The maximum wavelength offset observed shows sugar levels in the human body.**

I. INTRODUCTION

Surface plasmon resonance (SPR) based Photonic Crystal Fiber (PCF) is a fiber-optic sensor that combines the properties of photonic crystal fibers and the sensitivity of surface plasmon resonance. Photonic crystal fibers have periodic air holes in their cladding that confine light to the core with high intensity. The addition of a metal layer to the surface of the PCF creates surface plasmons, which are collective oscillations of free electrons that can detect changes in the refractive index at the surface. This makes SPR-based PCF sensors highly sensitive and suitable for use as biosensors.

II. PROBLEM STATEMENT

Improper measurements of glucose levels can direct the patient to medicate unnecessarily, this leads to an inefficient manner of taking medicines which could make the problem even worse than before unknowingly.

To overcome this problem high accuracy tools are needed. This is where SPR based PCFs come into play by getting better results than conventional glucometer.

III. LITERATURE SURVEY

Photonic crystal fiber (PCF) is an optical fiber that possesses a distinctive microstructure consisting of an array of air holes or microstructures along its length. This unique feature has gained significant attention in various applications, including sensing, due to its compatibility with different sensing schemes, high sensitivity, and large surface-to-volume ratio.

Surface plasmon resonance (SPR) is a common sensing scheme used in PCF-based biosensors. SPR is a phenomenon that occurs when light couples with surface plasmons, which are oscillations of electrons on a metal surface. By depositing a thin layer of metal on the PCF's surface, light propagation can couple with SPR, causing a shift in the resonance wavelength that is highly sensitive to the surrounding medium's refractive index. As a result, SPR-based PCF sensors are ideal for label-free detection of biological molecules. In this review, we will discuss recent advances in the development of PCF-based biosensors.

Li et al. (2020) conducted a recent study on PCF-based biosensors, where they developed a surface plasmon resonance (SPR) sensor for the detection of bovine serum albumin (BSA). The PCF was coated with a thin layer of gold, and BSA was immobilized on the surface of the gold film. The sensor demonstrated high sensitivity and a low limit of detection (LOD), making it comparable to traditional SPR sensors.

In addition, fluorescence-based sensing schemes have also been investigated in PCF-based biosensors, where changes in the fluorescence intensity of a fluorescent material or molecule immobilized on the surface of the PCF are used to detect the presence of biological molecules.

Zhang et al. (2018) conducted a study to develop a PCF-based fluorescence biosensor for the detection of Escherichia coli (E. coli). The researchers coated the PCF with zinc oxide (ZnO) nanorods that were modified with a specific E. coli antibody. When E. coli was introduced to the sensor, the fluorescence intensity of the ZnO nanorods increased, enabling the detection of E. coli at concentrations as low as 10 CFU/mL (colony-forming units per milliliter).

Aside from SPR and fluorescence, other sensing schemes such as interferometry, Raman scattering, and absorption have also been explored in PCF-based biosensors. As an example, Yang et al. (2019) conducted a study to design a PCF-based absorption biosensor to detect glucose. To achieve this, a layer of graphene oxide (GO) was coated on the PCF and then modified with glucose oxidase (GOx). When glucose was introduced to the sensor, it was oxidized by GOx, resulting in a change in the absorption spectrum of GO. The sensor exhibited a sensitivity of 0.0512 dB/mM and a LOD of 3.63 μM.

In conclusion, PCF has emerged as a versatile platform for biosensing, offering high sensitivity, large surface-to-volume ratio, and compatibility with different sensing schemes. Despite significant advancements in PCF-based biosensor technology, there are still several obstacles that require attention. These include enhancing the stability and reproducibility of sensors and reducing the signal-to-noise ratio.

A. *Scope:*

We present a dual band capable monopole antenna design for Wireless Fidelity (Wi-Fi). At the top of the antenna, the two rectangular pieces are positioned together and joined by a monopole strip.shortened ground field at the substrate's rear. When creating double bands at 2 GHz-2.45 GHz and 5 GHz-
5.8 GHz, which span the 2.45 GHz and 5.8 GHz Wi-Fi operation bands, the two rectangular portions have different sizes. The antenna's primary radiation field is functional.The rectangular monopole antenna is formed in the front view by a combination of different forms. Three rectangular monopole antennas are combined, with a larger rectangle controlling the upper operating mode and a middle rectangle controlling the lower operating mode. The back of the land plane shows the framework.

B. *Objective:*

The objective of this project is to design a D – Shaped PCF and study its properties and optimize its design parameters for better sensitivity and efficiency through a physics simulation software named Comsol Multiphysics

C. *Advantages of Existing system:*

An advanced form of optical fibre called Photonic Crystal Fibre (PCF) has a number of benefits over conventional fibre optic lines. The following are some major benefits of photonic crystal fibre:

- Broadband Transmission: When compared to traditional optical fibres, PCF allows for the transmission of a wider spectrum of wavelengths. A wide spectrum of light, including visible, infrared, and ultraviolet wavelengths, are efficiently transmitted thanks to the well designed periodic air-hole structure of PCF. PCF is suitable for a variety of applications that require broadband transmission as a result.
- High Nonlinearity: PCF has a high nonlinearity, which enables it to produce and control nonlinear optical phenomena with efficiency. Applications like nonlinear optics, supercontinuum production, and frequency conversion benefit greatly from this property. Due to PCF's high nonlinearity, small and effective devices can be created for a variety of uses, such as telecommunications and laser technology.
- Dispersion features that can be precisely tailored, such as chromatic dispersion and dispersion slope, are made possible by PCF. By changing the structural features of the PCF, such as the air-hole size and lattice constant, the dispersion characteristics may be tailored to match specific requirements. This capacity can be advantageous for applications needing important dispersion management, such as high-speed optical communication systems or dispersion correction.
- Enhanced Light guiding: PCF's distinct construction, which includes a microstructured cladding region, allows for effective light guiding through the fibre core. By containing the light inside the core, the air-hole construction improves control over light propagation and lowers losses. Compared to conventional fibres, this better light guidance capabilities enables improved transmission efficiency and decreased attenuation.
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- Applications for Specialty Fibres: PCF is a good fit for a variety of specialty fibre applications due to its adaptable design and distinctive characteristics. It has been applied to high-power laser delivery, optical trapping, biological imaging, and fibre optic sensing. Different forms of light-matter interactions can be accommodated by PCF, which creates new opportunities for creative research and applications.
- Despite having distinct advantages, PCF is made to work with existing fibre infrastructure since it is compatible with them. It may be seamlessly incorporated into current fibre networks, enabling progressive adoption and compatibility with established optical fibre infrastructure.

It's vital to remember that the specific benefits of PCF can change based on the application and design specifications of the PCF.

D. *Disadvantages of existing system:*

While Photonic Crystal Fiber (PCF) has several advantages as a biosensor, there are also some potential disadvantages to consider:

- Complexity: PCF biosensors can be more complex to manufacture and operate compared to traditional biosensors. The fabrication process of PCF is more involved and requires specialized equipment, and the setup and operation of PCF biosensors may require more expertise.
- Fragility: The presence of tiny air holes in the cladding of PCF can lead to its increased fragility compared to conventional optical fibers, posing potential concerns in certain use cases.
- Limited wavelength range: The properties of PCF are highly dependent on the wavelength of the light being used. This means that the detection range of PCF biosensors can be limited to specific wavelength ranges.
- Limited multiplexing: Multiplexing refers to the ability to detect multiple analytes simultaneously. While PCF biosensors can be designed to detect multiple analytes, the limited range of wavelengths that PCF can operate in can make multiplexing more difficult.
- Sensitivity to temperature and strain: PCF is more sensitive to temperature and strain compared to traditional optical fibers, which can affect the accuracy and reliability of PCF biosensors.

Overall, while PCF biosensors have several advantages, they may not be suitable for all applications, and the potential disadvantages should be carefully considered when choosing a biosensor technology.

E. *PROPOSED METHODOL0GY*

The proposed methodology presents a modelling of a D – Shaped PCF which is capable for blood glucose sensing. Initially all the parameters are arbitrarily taken and studied its properties. Then according to the outputs the design parameters are tuned properly. All the data is collected from the COMSOL software which processes the data and serially represents it. The data is collected in an excel file and graphs are produced for better understanding of the results. The final design is tuned for high sensitivity and efficiency. Thus this model can be used as a sensor and is capable for fabrication

IV. DESIGN

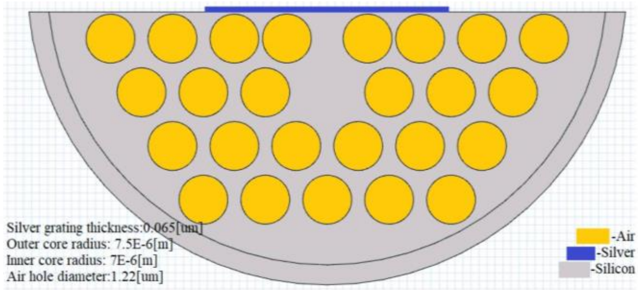

Fig. 4.1 : D - Shaped Photonic Crystal Fiber (PCF)

V. RESULTS AND INTERPRETATION

The Finite Element Method in COMSOL multiphysics 5.2a software was utilized to investigate and analyze the confinement loss of the suggested PCF. The attained values of the confinement loss is taken into an excel sheet and observed as follows.

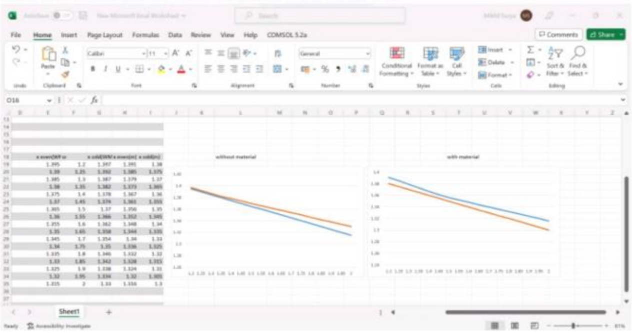

Fig 5.1. Difference in the effective refractive index before and after adding the silver slab.

Slight bend in the right graph represents the SPR phenomenon which took place after addition of the silver slab at 1.55 um.

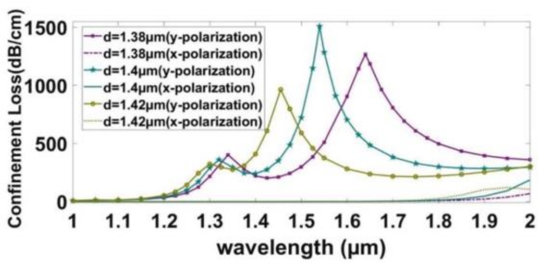

Fig 5.2. Variation of the confinement loss according to the change in Diameter of air hole.

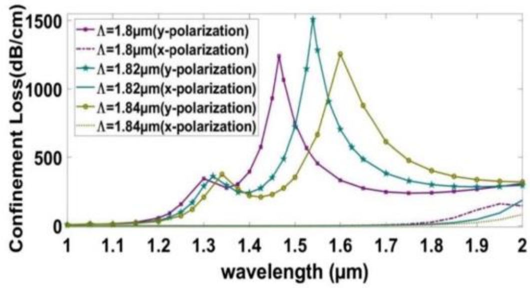

Fig 5.3. Variation of the confinement loss according to the change in radius of the core.

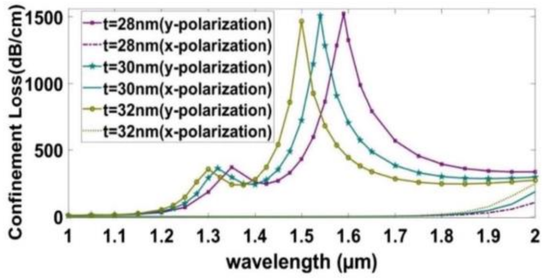

Fig 5.4. Variation of the confinement loss according to the change in thickness of the silver slab.

We can observe that the confinement loss is at its peak at 1.55 um

VI. CONCLUSION

By using the COMSOL software we have successfully constructed a D-Shaped PCF model.

Thus we have observed that using the silver grating on the surface has drastically improved the sensitivity of the fiber.

Optimised parameters are attained and thus can be used for fabrication.

C. *References*

1. E Wijaya, C Lenaerts, S Maricot, J Hastanin, "Surface plasmon resonance-based biosensors: From the development of different SPR structures to novel surface functionalization strategies'' in Proc. 2nd Int. Conf. Inventive Res. Comput. Appl. (ICIRCA), (2020).
2. DEP Souto, J Volpe, CC Goncalves, CHI Ramos,"A brief review on the strategy of developing SPR-based biosensors for application to the diagnosis of neglected tropical diseases" Int. J. Adv. Comput. Sci. Appl. (2021).
3. AM Shrivastav, U Cvelbar, I Abdulhalim "A comprehensive review on plasmonic-based biosensors used in viral diagnostics" Commun Biol 4, 70 (13 Oct 2021)
4. S Mostufa, AK Paul, K Chakrabarti "Detection of hemoglobin in blood and urine glucose level samples using a graphene-coated SPR based biosensor" (2022)
5. Doshi, R., Apthorpe, N., & Feamster, N., "Detection of blood plasma concentration theoretically using SPR-based biosensor employing black phosphor layers and different metals". IEEE Biomedical Workshops (BW).(2020).
6. Yang, X., Lu, Y., Liu, B., Yao, J.: Polarization characteristics of high-birefringence photonic crystal fber selectively coated with silver layers. Plasmonics 13, 1035–1042 (2018).
7. Liu, C., Wang, L., Wang, F., et al.: Tunable single-polarization bimetal-coated and liquid-flled photonic crystal fber flter based on surface plasmon resonance. Appl. Opt. 58, 6308–6314 (2019).
8. Li, T., Zhu, L., Yang, X., et al.: A refractive index sensor based on H-shaped photonic crystal fbers coated with Ag-graphene layers. Sensors 20, 741 (2020).
9. Alharbi, R., Irannejad, M., Yavuz, M.: A short review on the

role of the metal-graphene hybrid nanostruc ture in promoting the localized surface plasmon resonance sensor performance. Sensors 19, 862 (2019).
10. M. M. Rahman et al., "Gold-coated photonic crystal fiber based polarization filter for dual communication windows," Opt. Commun. 461, 125293 (2020).
11. E. A. A. Hagras et al., "Multi-functional photonic crystal fiber splitter for the two commu nication bands," Opt. Fiber Technol. 52, 101986 (2019).
12. J. Wang et al., "Ultrashort polarization beam splitter based on liquid-filled dual-core photonic crystal fiber," Appl. Opt.57(14),3847(2018)