Comparative Study of Different Type of Fiber Optics Sensors

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Abstract

In this paper we try to compare the different type of fiber optic sensors based on different technique. Here we study and analised the three type of sensors. First one is a nano flim based sensors ,second is Lossy Mode Resonance based fiber optic sensor and third one is Plasmonics-based fiber optic sensor.In nano based ,thin films work as sensitive elements and transducer to get response and feedback from various environments. LMR based sensors are able to work independently of the specific polarization of light for sensing operations. In addition to sensing, LMR phenomena can also be utilized as wavelength filters for communication purposes. In SPR sensing system which is based on a very logical reason of guidance of light in optical fibers is also based on TIR. Since, a prism is used in SPR sensing system, sensitivity of a SPR sensor depends on how much the resonance angle shifts with a given change in refractive index of the sensing layer.

Keywords

LMR(Lossy Mode Resonance), SPR(surface plasmon resonance), FiberBraggrating (FBG).

I.INTRODUCTION

Fiber optic sensor technology promises bright future prospects with significant advancements in the coming years.In modern era researchers motivated to study the potential of fiber optics for data communications, sensing, and other applications. This technology has been very popular in the past few decades with its promising benefits. Due to its ability to carry gigabits of information at the speed of light, it increased the research potential in optical fibers. It has resulted in great economical benifits useing of low cost optical sources and detectors in place of conventional devices for measuring various physical, chemical, and biological parameters. It is pure dielectric in nature by which it can be effortlessly used in many perilous areas where conventional sensors may not work effectively is one of the important reasons for theincreased demand for fiber optic sensors.Another adavantage, especially for remote sensing and telemetry applications is the fast response of fiber optic sensors which makes it possible to send large amount of sensing information over long distances via optical fibers [1–4]. In optical engineering of sensing technology, recently the most important enabling technologies are based on structuring of fibres, either longitudinally or transversely.Integration of novel functional material with fiber optic components is one of the new trends in the field of novel sensing technologies. In order to modulate the properties of light, optical waveguides coated with metal and semiconductors have been very popular [5–8]. The combination of fiber optics with functional materials offers great potential for the realization of novel sensors.Typically the in optical fibre sensing technology, fibre itself acts as sensing elements and also transmitting elements, such as fiber Bragg grating (FBG) [9],Brillouin or Raman Optical Time Domain Reflectometer (OTDR) [10, 11].The combination of fiber optics with sensitive nano-films offers great potential for the realization of novel sensing concepts. A typical fiber optic sensing system consists of a light source, fiber as a sensing element and a detector. Light is transmitted from a light source and passes through an optical fiber sensing probe, which senses change in the desired environmental parameter. The sensor modulates one or more characteristics of light viz, intensity, wavelength, amplitude or phase and then the modulated light is transmitted from the sensor to a signal processor, which in turn converts it into a signal for processing. Last revolution emerged as designers to combine the product out growths of fiber optic telecommunications with optoelectronic devices to create fiber optic sensors.

II. 1.Nano–Flim based sensors

It is one of novel sensor over traditional technology, it apply in order to way that fiber optic is work as signal carrier while thin flim is work as sensitive element. Nano-films can be realized by many techniques including e-beam evaporation [12], magnetron sputtering [13], spin-coating [14], electro-chemical plating [15], etc. nano-films can be realized by many techniques including e-beam evaporation . It is the diversity of measurement parameters compared to the common fiber sensing technologies such as FBG and OTDR.There are many principal under which novel fiber optic sensors can be developed,such as:Evanescent wave interaction, Micro-mirror, Fiber Bragg grating,Micro-structured fiber, Micro-machined, Fabry-Perot. In Evanescent wave interaction nano flim is deposited by eatching and polishing at certain level and applied Evanescent wave ,the change in dielectric occure due to effect of evanescent wave and in other hand when Nano-film is deposited on the polished fiber-tip,it cause the generation of micro-mirror ,[16] is basically dependent on the refractive index of micro-mirror; Therefore change can be recorded by the variation of the reflected intensity . In Fiber Bragg grating normally a germanium-doped silica fiber is used in the manufacture due to its photo sinsitive behaviour,in this refractive index of the core changes with exposure to UV light. It reflects particular wavelengths of light and transmits all others. fiber grating itself acts as light signal carrier while sensitive thin films or coatings act as transducers for environmental parameters.Micro-structured fiber-It is also called photonic crystal fiber or holy fiber in which confined the light by photonic band gap which is not not possible in conventional optical fiber. By changing the refracting index,we find the systamatic change in amplitude and wavelength of light and hence sensors can be occur. Its application in many aeras such as biomdecial field as an enviornmental ,gas sensors, pressure sensors,etc.

1.1Optical Fiber Hydrogen Sensors Based On WO3-Pd Thin Film on Fiber Tip

A novel optical fiber hydrogen sensing system which can show better sensitivity towards hydrogenconcentrations. It is one of the excellent example of Nano-Film based sensor. This sensor has a quick response during the hydrogen characterization and detect hydrogen as low and high. Here Fiber Bragg grating (FBG) and AGE light are used. A pair of Fiber Bragg grating (FBG) is employed for hydrogen sensing and measurement of high-low reflectivity that is as shown in Fig. 1. FBG with different reflectivity can be prepared by controlling the exposure time to excimer laser [17]. The peak intensity of high reflective FBG (FBG1), which is hardly influenced by the hydrogen sensitive film, is used as reference. When hydrogen is injected into gas room, the reflectivity of the hydrogen sensitive film decreases quickly, with lower peak intensity of FBG2.However, the peak intensity of FBG1 hardly changes due to its high reflectivity. Therefore, the value of I1/I2 increases quickly with the increase of hydrogen concentration in the gas room. The quick response rate of the hydrogen sensor can be attributed to the high optical power focused on the core of single mode fiber. Ou et al. [18] reported that WO3/Pd film had a quick response rate and better sensitivity when heating at a higher temperature. By utilizing ASE as light source, the hydrogen sensitive film deposited on the fiber core can be maintained at higher temperature. The reason for this phenomenon is due to the excellent hydrogen responsibility of WO3-Pd/Pt. composite film under higher temperature. Further improvements, such as optimization of hydrogen sensitive film, utilization of more stable ASE light source and high-low FBGs with smaller wavelength difference, can be conducted to improve the performance of the hydrogen sensor. WO3 film has good gasochromic effect when Pd or Pt film is employed as catalyst layer. Pd film has good selectivity towards hydrogen and Pt has good stability in air. In this work WO3 thin film and Pd/Pt composite films are selected as sensitive and catalyst layer, respectively. WO3-Pd/Pt composite films were deposited on the end-face of singe mode fiber as sensing element. . The optical fiber hydrogen sensing system can detect hydrogen as low as 50 ppm at room temperature of 25 °C. The hydrogen sensor has a quick response during the hydrogen characterization and the sensor show better sensitivity towards lower hydrogen.

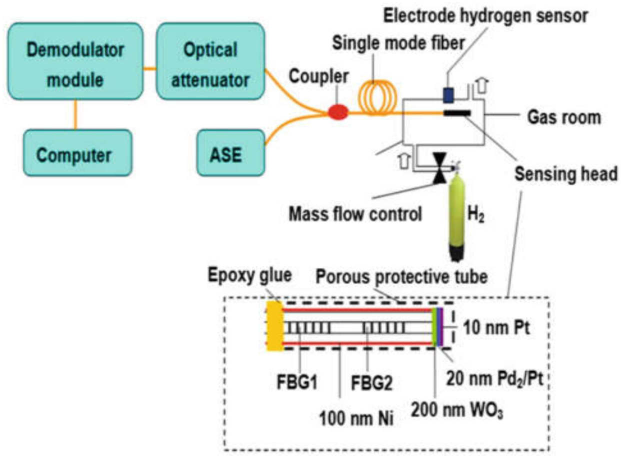

Fig.1. Concept and configuration of optical fiber hydrogen sensing system.

2. Lossy Mode Resonance Based Sensors

In the past couple of years, lossy mode resonance (LMR) phenomena has attracted the attention of researchers with its promising benefits in the field of fiber optic sensing. LMR based sensors have become a useful tool in sensing applications ranging from physical sensing to bio sensing in a short span of time [19]. LMR phenomena can also be explored with other Nano particle based sensing techniques like LSPR .In addition to sensing, LMR phenomena can also be utilized as wavelength filters for communication purposes. LMR based sensors are able to work independently of the specific polarization of light for sensing operations. In optical fiber sensors, the medium for the propagation of light rays is an optical fiber. If fiber cladding is removed and some other thin film material is deposited over the unclad portion, it introduces losses in the light propagation and the extent of these losses depend upon the properties of thin film material. These sensors does not get affected by the geometrical parameters of fiber and primarily depends on the thickness of thin film material like evanescent wave and surface Plasmon resonance (SPR) based sensors[20].Various geometries of fiber probes such as straight, D-shaped, tapered etc., have been explored till date. The basic principle of LMR based fiber-optic sensors was explained and various benefits such as sensitivity and detection accuracy enhancement by using double thin film layers, tapered and D-shape geometry for LMR based fiber-optic sensors were addressed [21]. Bending and tapering of multimode fiber based LMR sensors improve the detection accuracy without affecting their sensitivity. However, in single mode fiber based LMR sensors the side polishing and tapering of fibers improve both the detection accuracy and sensitivity. Another method to improve the sensitivity is by using two LMR supporting thin film layers of higher refractive index instead of one. . The popularity of LMR sensors is primarily based on two reasons: first, these are free from the requirement of specific polarization of light, and secondly due to the capability of tuning its sensitivity by just adjusting thickness of the thin film. Also, another exclusive property of LMR devices is multiple LMR generation with increasing thickness which can be utilized in wavelength filtering applications. The requirement of specific polarization of light, and secondly due to the capability of tuning its sensitivity by just adjusting thickness of the thin film. Also, another exclusive property of LMR devices is multiple LMR generation with increasing thickness which can be utilized in wavelength filtering applications. Finally, future scope of the LMR sensing technology and possible research in this emerging area are suggested [22].LMR cannot be considered just a cost effective solution in the field of sensing as all the LMR generating materials show high sensitivity in the NIR spectral range [23]. LMR based fiber-optic sensors are expected to be a major contributor to the sensing research community with comparably high sensitivity along with its various advantages over the other fiber since the unveiling of optical fiber technology.

LMR based fiber-optic sensors are expected to be a major contributor to the sensing research community with comparably high sensitivity along with its various advantages over the other fiber since the unveiling of optical fiber technology. Reproducibility for an early detection of different diseases and biological processes sensitivity and detection accuracy for various sensing applications.

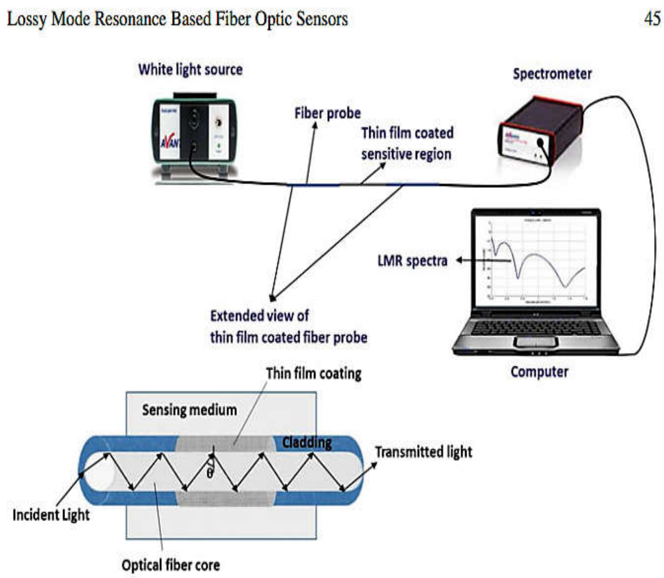

Fig. 2 Experimental setup used for LMR based fiber optic sensing.

3. Fiber Optic SPR Sensor

In this phenomenon the guiding of light is occur on the principle of total internal reflection and angular interrogation method [24].Here the prism is used for SPR sensing application. The sensor is applied in such a way that by removing the cladding from a certain small portion (middle portion for most of the cases) of the fiber core and is coated with a metal layer, which is further surrounded by a dielectric sensing layer (Fig. 3).There is still a lot of scope for work in Plasmonics-based fiber optic biosensors with high sensitivity, detection accuracy, and reproducibility for an early detection of different diseases and biological processes. Itcan be designed as a tip-probe, which may be highly useful in biomedical diagnostic applications such as endoscopy.

In this, spectrum of the light transmitted after passing through the SPR sensing region is detected at the other end. The sensing is accomplished by observing the wavelength corresponding to the dip in the spectrum [25].The sensing principle of SPR sensors is based for a given frequency of the light source and the dielectric constant of metal film. The resonance angle is determined by using angular interrogation method. The resonance angle is very sensitive to variation in the refractive index (or, dielectric constant) of the sensing layer. As increase in refractive index of the dielectric sensing layer increases the resonance angle. The performance of a SPR sensor is analyzed with the help of twoparameters: sensitivity and detection accuracy or signal-to-noise ratio (SNR). Forthe best performance of the sensor both the parameters should be as high as possibleto attain a perfect sensing procedure. Sensitivity of a SPR sensor depends on how much the resonance angle shifts with a given change in refractive index of the sensing layer. Its properties vary significantly when the wavelength shifts from visible to near or mid-infrared region therefore, If the shift is large, the sensitivity is large. Due to this it is very critical factor for the selection of metals and dielectrics in infrared.

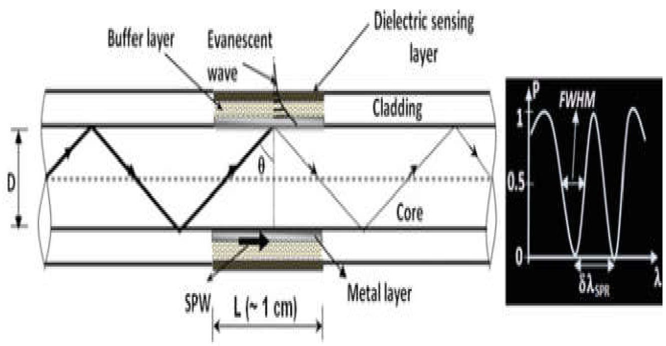

Fig. 3 Illustration of a typical fiber optic SPR sensor. D is fiber core diameter and L is SPR sensing region length.

Therefore, highly comprehensive theoretical and experimental analyses of Plasmonics-based fiber optic sensors in infrared are required.

III. CONCLUSION

On comparing these three sensors we found that in Nano Sensor the films were deposited on the end-face or the tip of optical fiber as sensing element. When it detected change in ambient environment, the optical path difference of thin films increased or decreased accordingly. Hence properties of the ambient environment can be measured by optical fiber sensors. The hydrogen sensor has a quick response during the hydrogen characterization, and the sensor showed better sensitivity towards lower hydrogen concentrations. While LMR based fiber-optic sensors technology has motivated research on the geometry of fiber optic probe for further enhancing the sensitivity and detection accuracy for various sensing applications, it played a major contribution to the sensing research community with comparably high sensitivity along with its various advantages over the other fiber optic sensors.This.Phenomena can also be explored with other Nano particle based sensing techniques like LSPR. On other hand, Plasmonics fiber optic sensors have a lot of potential to work in infrared for various defense and biomedical applications. The Plasmonics-based fiber optic bio sensors have high sensitivity, accurate detection, and reproducibility for an early detection of different diseases and biological processes. ThePlasmonic properties vary significantly when the wavelength shifts from visible to near or mid-infrared region. Therefore, highly comprehensive, theoretical and experimental analysis of Plasmonics-based fiber optic sensors in infrared are required.

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