Comparative Study Of Different Type Of PhysicalSensorsBased On Application

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ABSTRACT

In this paper we studied and compare the different type of fiber optic physical sensors based on its applications.Three types of Optical Fiber Sensor can be classified under this categories: first one is in the terms of sensing location, second one is in the terms of the operating principle, and third one is in the terms of application. Here we studied about the application based different type of optical sensors, under this we studied the physical sensors based on grating technique. Physicalsensorsisused to measure physical properties like temperature, stress, pressure etc. Chemical sensors used for pH measurement, gas analysis, spectroscopic studies, etc. Bio-medical sensors used in bio-medical applications like measurement of blood flow, glucose content etc. The physical sensors based on grating technique is such asFiber Grating, Fabry-P´erot interferometer (FPI), fiber Bragg grating (FBG), ,Interrogation Interrogators or demodulators,Fiber,Interferometer,Sensors,Fabry-Perot Interferometer Sensors, Fiber Mach-Zehnder Interferometer Sensors, Multimode Fiber Interferometer Sensors, High-Birefringence Fiber Loop Mirror Interferometer Sensors.

Keywords: fiber optic sensors(**FOSs**), Photonic Crystal(PH) ,fiber Bragg grating (FBG), Raman Optical Time Domain Reflectometer (OTDR),Fiber loop mirror (FLM),charged coupled device (CCD),Fabry-P´erot interferometer (FPI),high-birefringence fiber loop mirror (HBFLM)

I. INTRODUCTION

The field of fiber optics is as exciting as ever and continues to expand even faster than microelectronics. . Fiber optic sensing technology is perfectly established now a days and provides a range of solutions for an increasing gamut of applications in the areas ranging from structural health monitoring to bio photonic sensing, to name a few. The true age of optics, in which fiber optics is a very important part, is here and is expected to contribute in making the 21st century the century of photonics [1].Among the concepts, extended infrared sensors are making its appearance, and we have included a couple of chapters such as THz and Photonic Crystal Structures based sensing in this regard. New ideas and concepts are proposed and tested, not only for various traditional parameters such as strain, temperature, or pressure, but also for new concepts,

ISBN : 978-93-87793-79-8

applications, and phenomenon. Another important aspect is the resonance generated when using thin films together with optical fibers. Today they are used in applications varying from the Internet to microscopes. For the past decade, fiber optic biosensors have been touted as the means to revolutionize medical technology, dramatically improving patient care and cutting overall operating costs. They are immune to electromagnetic signals and are currently used in a variety of medical applications such as early cancer and AIDS detection [2]. In the medical field, the opportunities offered by optical fibers have always been advantageously exploited. In fact, the use of optical fibers in medicine goes back to the sixties, when fiber bundles were successfully pioneered in endoscopy, both for illumination and for imaging. Subsequently, cavitation laser surgery and therapy also benefited from fibers, which proved to be the most.

Fiber optic research has been expanding since fiber-imaging bundles were first put together in the late 1950s. While their initial use was solely as a means to transmit light over only a few tens of centimeters, fiber optics have evolved to become one of the most advanced mediums of transmission and translation available today. It have experienced atremendous growth since the 1970s and a number of importanttransitions into commercial sector have been achieved. Due to thespecific advantages, FOSs have been considered as not only the substitutes of conventional sensors but also the unique solution infields of industry, engineering and scientific research itself. As significant cases of developments in FOSs, the interferometry sensors, fiber grating sensors, photonic crystalfiber sensors and scattering based sensors are outlined, respectively. Furthermore, several potential areas, where FOS isbelieved to be the one and only effective solution, are alsodiscussed. Finally, trends in the development of FOSs are brieflyoutlined by combine with development of photonics.In optical engineering of sensing technology, recently the most important enabling technologies are based on structuring of fibres, either longitudinally or transversely. Bragg gratings are typical examples of longitudinally structuring of fibers, while micro-structured fibre (e.g. photonic crystal fibres) are the promising enabling technologies in terms of transversely structuring of fibers. Microstructure fibres, provide materials with dispersion characteristics unattainable with conventional materials, as well as otherwise unfeasible physical characteristics that can be controlled and realized for specific sensing applications [6]. Integration of novel functional material with fiber optic components is one of the new trends in the field of novel sensing technologies. 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) [1], Brillouin or Raman Optical Time Domain Reflectometer (OTDR) [2, 3]. However such sensing components can only detect limited physical parameters such as temperature or strain based on its principle of characteristic wavelength drifts. While the idea of optical fiber sensing technology with Nano-films is quite different. Optical Fiber is being used in diverse applications such as cold lighting in museums, construction of smart civil structures, and networking for communication. Among many issues associated with day-to-day handling of optical fibers, a fiber optic technician may have to solve problems regarding joining of optical fibers, location of fiber breaks, and fiber end preparation [4].

ISBN : 978-93-87793-79-8

1. Optical Fiber Sensor Principles

Optical fibers deliver light from a light source to a sensing mechanism located at the fiber end, which is coupled to the interrogated medium (e.g. tissue). It consists of an optical source (Laser, LED, Laser diode etc.), optical fiber, sensing or modulator element (which transduces the measured to an optical signal), an optical detector and processing electronics (oscilloscope, optical spectrum analyzer etc.)[5, 7].

The general structure of an optical fiber sensor system is shown in figure1. Here, the light experiences a modulation by the interrogated tissue, and is returned via the same or different fiber(s) to a light measurement device where it can be detected and analyzed. Fibers can be bundled to increase the interrogation volume and improve signal to-noise by capturing a larger signal. This typically requires stripping the outer buffer (jacket) off the fiber to reduce overall diameter [7].

Optical components such as connectors, lenses, mirrors, fiber couplers, circulators, polarizers, phase modulators, and beam splitters can be configured to optimize the signal in the detector fiber. Single source-detector geometry results in a small sensor diameter with a small interrogation volume and high light collection efficiency [7].

For single wavelength detection and/or spectrally-unresolved total intensity, a photomultiplier tube or photodiode is used, whereas for spectral detection, a charged coupled device (CCD) or spectrograph/monochrometers is used. Conversion of detected light to electrical signal generally requires standard analog-to-digital circuitry [7].

Types of Optical Fiber Sensor Optical fiber sensors can be classified under three categories: The sensing location the operating principle, and the application.

Optical Fiber Sensor Based on the Sensing Location An optical fiber sensor can be classified as extrinsic or intrinsic.

Optical Fiber Sensor based on the Operating Principle or Modulation and Demodulation Process a fiber optic sensor can be classified:

An Intensity, a phase, a frequency, or a polarization sensor.

Optical Fiber Sensor Based on the application can be classified as follows[5]:

• Physical sensors: Used to measure physical properties like temperature, stress, etc.

• Chemical sensors: Used for pH measurement, gas analysis, spectroscopic studies, etc.

• Bio-medical sensors: Used in bio-medical applications like measurement of blood flow, glucose content etc.

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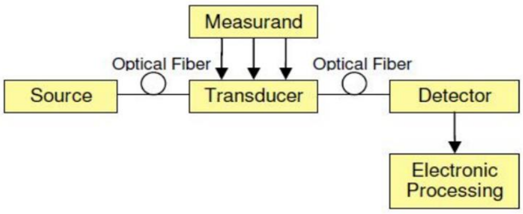

Figure 1: Basic components of an optical fiber sensor [5, 3]

II.Optical Fiber (Physical Sensors) - Temperature and Strain Measurement

2.Fiber Grating Sensors

In Fiber Bragg grating normally a germanium-doped silica fiber is used in the manufacture due to its photo sensitivebehavior, in this refractive index of the core changes with exposure to UV light[4]. The Grating sensor systems are the measurand-reading units that extract measurand information from the light signals coming from the sensing heads. The basic operation principle of an FBG sensor system is to monitor the shift in wavelength of the reflected Bragg signal with the changes in the measured. 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. Its application in many aeras such as biomdecial field as an environmental, gas sensors, pressure sensors, etc. [4].In more detail, a periodic structure is written into the core of an optical fiber and this periodic structure will reflect Specific optical wavelength, which is dependent on the periodicity. Since this period depends upon environmental temperature and externally applied strains and pressures.

3. Fiber Bragg Grating Sensor Interrogation Interrogators or demodulators

In this sensors wavelength-change interrogator is based on intensity measurement. Information associated to wavelength variation is obtained by monitoring the intensity of the light beam after passing the filter at the detector [8]. For the intensity-based demodulators, the use of intensity referencing is necessary because the light intensity might be changed not only due to the reflection wavelength variation but also due to the power fluctuation of the light source, the disturbance in the light-guiding path, or the intensity dependence of light source on the wavelength. Fig.2. shows the schematic diagram of the FBG [13].As mentioned, the measurand is encoded spectrally for FBG sensors, and hence the interrogators are usually meant to measure the Bragg wavelength shifts and convert the results to measured data. In the laboratory, when one is designing and developing fiber grating sensors, optical spectrum analyzers are usually used in monitoring grating reflection or transmission spectra. To date, many interrogators have already been developed with both passive and active detection schemes. Passive detection scheme interrogators refer to those that do not use any electrical, mechanical, or optical active devices [8]. The simplest way to think about measuring the wavelength shift of light reflected from an FBG without monitoring the spectrum is to use a linearly wavelength-dependent optical

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filter. By monitoring the reflected light power change instead of monitoring the spectrum shift, optical spectrum analyzers would be replaced in the sensor system.

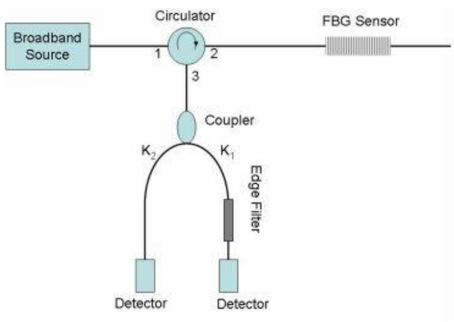

Figure 2: FBG sensor configuration with an edge filter as an interrogator

4. Fiber Interferometer Sensors

There are many kinds of fiber interferometers nowadays, such as Fabry-P´erot interferometers, Mach-Zehndner interferometers, etc., and many of them have already found applications in optical fiber sensors [10]. Since the interfering spectra are usually directly related to the length of the optical path, these sensors have high sensitivity to many external perturbations, such as temperature, strain, pressure, etc. which could vary the optical path [9].

5. Fabry-Perot Interferometer Sensors

The bulk optics version of the FPI has been widely used for high-resolution spectroscopy with very compactsensing region can be extremely sensitive to perturbations that affect the optical path length between the two mirrors [12].Sometimes also called the Fabry-P´erot etalon, consists of two mirrors of reflectance R1 and R2 separated by a cavity of length L containing a medium of refractive index n. Mathematical analysis developed decades ago for the bulk FPI also applies to the fiberoptic versions of interest here. The individual mirrors in the FPI can be characterized by transmissions Ti and reflectivities Ri, such that Ti + Ri = 1 (i = 1, 2). The excess loss, which corresponds to the portion of the incident power absorbed or scattered out of the Beam by the mirror is neglected. Fig 3.Shows the Fabry-Perot Interferometer Sensors [11].

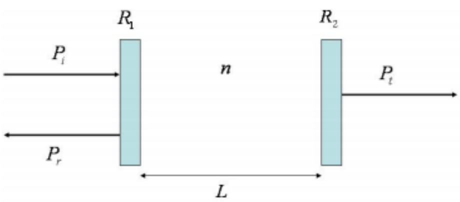

Figure 3: Fabry-P´erot interferometer, with Pi, Pr, and Pt the incident, reflected, and transmitted optical power, respectively.

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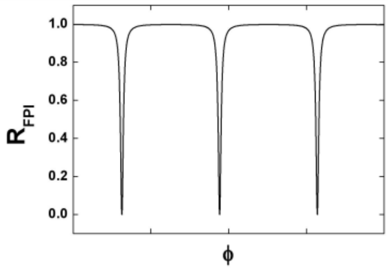

Figure 4: Typical Fabry-P´erot interferometer reflection spectrum.

6. Fiber Mach-Zehnder Interferometer Sensors

The MZI consists of three stages, an initial 3-dB directional coupler which splits the input signals, a central section where one of the fiber lengths is longer by ΔL than the other to give a wavelength dependent phase shift between the two arms, and another 3-dB coupler which recombines the signals at the output. In the central region, when the signals in the two arms come from the same light source, the outputs from these two guides have a phase difference Δthe Mach-Zehnder interferometer (MZI) is a device used to determine the relative phase shift between two collimated beams from a coherent light source [12]. The interferometer has been used, among other things, to measure small phase shifts in one of the two beams caused by a small sample or the change in length of one of the paths. They could be used as wavelength-dependent multiplexers [13] as well as optical fiber sensors. For the fiber MZI, the principle is the same as bulk-optics based MZI. Fig. 5.Illustrates an individual fiber MZI.

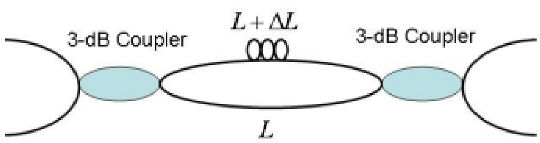

Figure 5: Configuration of a basic Mach-Zehnder interferometer, which consists of two 3-dB couplers, two arms with different length.

7. Multimode Fiber Interferometer Sensors

Multimode fiber (MMF) interferometer is one kind of fiber MZI. The sensor configuration is shown in Fig 6. A section of MMF is sandwiched between two single-mode fibers (SMFs). The fundamental mode that propagates along the SMF will couple into the MMF. When the light couples into the MMF, many modes are excited, each of which has a different propagation constant. When they recouple back into the SMF after passing through a section of MMF, the modes interfere, since each mode has experienced a different phaseShift (This could be considered as the case of MZI because different modes have passed different lengths of optical path due to the different propagation constants). If only two dominant modes (LP01 and LP02) are excited, the resultant interference fringe pattern is approximately sinusoidal with a uniform extinction ratio determined by the ratio of the intensities in the two modes (e.g., the best mode operation is to launch equal power in the two modes).

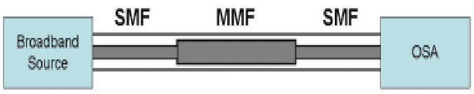

Figure 6: Schematic of all-fiber multimode fiber interferometer. SMF: single-mode fiber; MMF: multimode fiber; OSA: optical spectrum analyzer.

8. High-Birefringence Fiber Loop Mirror Interferometer Sensors

Fiber loop mirror (FLM) is a very attractive device for use in optical fiber communications or for use as an optical fiber sensor [10]. A high-birefringence fiber loop mirror (HBFLM) is a specific fiber loop mirror which is usually formed by a 3-dB optical coupler, a polarization controller, and a section of high-birefringence fiber (HBF), as shown in Fig. 7. The HBFLM acts like a band pass filter for the input signal. The input light is split into two beams propagating clock wisely and counterclockwise by means of the 3-dB coupler. Each of the resultant beams is decomposed into two beams after it travels through the HBF [13]. The polarization controller changes the polarization states of both the clockwise and counterclockwise beams. The counter propagating beams recombine at the coupler and exhibit interference due to the phase difference experienced in the HBF for different polarization components. The transmission spectrum of the HBFLM is approximately a periodic function of the inverse wavelength.

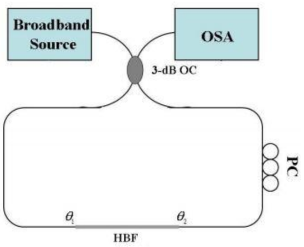

Fig: 7.High-birefringence fiber (HBF)

III.Conclusion:

By this comparative study we find that Physical Sensorsis used for different type parameter measurements. Such as TemperatureStrain, pressure etc. In the Brag Grating technique, which reflects particular wavelengths of light and transmits all others. By periodically reflect Specific optical wavelength, this period depends upon environmental temperature and externally applied strains and pressures [14]. Its application in many areas such as biomedical field as an environmental, gas sensors, pressure sensors, etc. While Fiber Bragg Grating

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Sensor Interrogation Interrogators or demodulators is wavelength-change interrogator is based on intensity measurement. Another one is the Fiber Interferometer Sensors which have high sensitivity to many external perturbations, such as temperature, strain, pressure, etc. which could vary the optical path.Fiber Mach-Zehnder Interferometer Sensors (MZI) is a device used to determine the relative phase shift between two collimated beams from a coherent light source [12]. Multimode fiber (MMF) interferometer is one kind of fiber MZI in which sensor configuration is sandwiched between two single-mode fibers (SMFs). The fundamental mode that propagates along the SMF will couple into the MMF [14]. When the light couples into the MMF, many modes are excited, each of which has a different propagation constant. And at last we study about the high-birefringence fiber loop mirror (HBFLM) which is a specific fiber loop mirror is usually formed by a 3-dB optical coupler, a polarization controller, and a section of high-birefringence fiber (HBF) .

IV. ACKNOWLEDGEMENT

The author is highly gratitude for Ph.D. supervisor, Dr.Taran Kumari Roy Associate professor PG Dept. Of Physics B.R.A .Bihar University, muzaffarpur for doing this Project work.

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