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Optical Sensors And Their Use In Medical Field

Vijay Laxmi Kalyani, Varsha Sharma

***Vijay Laxmi Kalyani**, Government Women Engineering College, Ajmer, India*
vijaylaxmikalyani@yahoo.com
***Varsha Sharma,** Government Women Engineering College Ajmer, India*
12varshasharma@gmail.com

Abstract— Sensors are device which is identified and respond an electrical or optical signal. A sensor is much type like Temperature, pressure, level sensors, Bio sensors, Gas & chemical sensors, Acceleration, moisture, humidity, speed, etc. Optical sensor convert light ray into electrical signals. Optical sensor measure physical quantity of light. Optical sensor categories by wavelength, forward (drive) current, range, power dissipation, packaging type and maximum CE voltage. Generally wavelength used - 640 nm, 700 nm, 800 nm, 940 nm and 950 nm. And the maximum CE voltage can range from 5 V to 70 V. Most CE voltage for sensor is 30V.An optical sensor is a sensor which uses an optical fiber as a sensing component. A fiber are used because of narrow size, No electric power is used. In this paper we discuss optical sensors and their application in medical field.

Keywords—Optical Sensor, Optical sensor use in Medical Field

I. INTRODUCTION

A sensor is translator which is translating a nonelectric value into electric value. The output of sensor in the form of amplitude, frequency, phases.

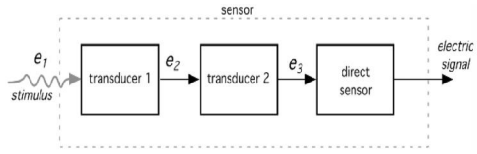

Figure 1: Sensor with various transducers

Many features are studied when we elect a sensor such as Accuracy, Environmental condition, Range Calibration, Resolution, Cost, Repeatability.
Sensor is classified in following category:

1 Primary Input quantity
2 Transduction principles,
3 Materials and Technology
4 Property
5 Application.

Property based sensor: Temperature sensor, level sensor, and pressure sensor, Bio sensor, Image sensor, Gas and chemical sensor [1].

Application based sensor: Industrial process control, Non-industrial area use in –Aircraft, Medical products, Automobiles, Consumer electronics, other type of sensors [1].

Power or energy based sensors: The power and energy sensor are active and passive sensor. The passive sensor is does not need an external energy source. The passive sensor is also known as a direct sensor. The active sensors need an external energy or power to perform their operation. Active sensor is also called a parametric since the property of active sensor is change by external energy or power.
Generally we use material in sensor is:

Inorganic	**Organic**
Conductor	Insulator
Semiconductor	Liquid, gas, or plasma
Biological substance	other [2]

II. FIBER OPTIC SENSORS

The fiber optics sensor is used to sense some quantity like temperature, pressure, vibration, displacement, rotations [3].

Figure 2: Fiber optic sensor
Source: https://www.elprocus.com/wp-content/uploads

A block diagram of fiber optics sensors is shown in fig. a photo detector used to determine the light source. The light is produce by source is connecting into fiber. Change in output power detect by photo detector. The sensor is sense the inner part as well as outer part.

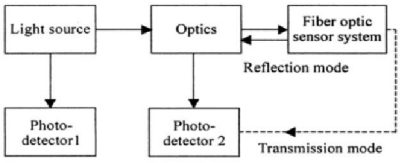

Figure 3: Block diagram of fiber optic sensor

A Classification of optic fiber sensor

1. Based on sensor location:

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1.1 Intrinsic fiber sensor: In intrinsic fiber sensor is sense transmission property of optical fiber like intensity, light, phase, temperature etc.

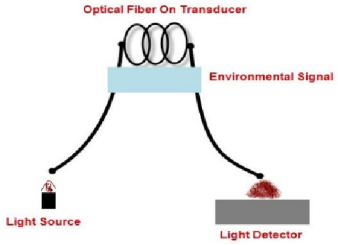

Figure 4: Intrinsic Optic fiber sensor
Source: https://www.elprocus.com/diffrent-types-of-fiber-optic-sensors/

1.2 Extrinsic fiber sensor: In Extrinsic fiber sensor modulated done outside the fiber. In Extrinsic fiber sensor is transmit light from source to a probe which is connected to fiber, return the resultant light signal from detector.

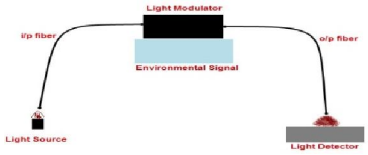

Figure 5: extrinsic fiber sensors

Source:https://www.elprocus.com/diffrent-types-of-fiber-optic-sensors/

2. Based on Operating principles:

In this classification fiber optic have a three sensor which is:

2.1 Intensity based Fiber optics sensor: This type of optic sensors, measure and modulates the intensity of the transmitted light through the fiber and devotion in intensity is measured using a detector placed at the output end of the fiber. It is used in multimode fiber technique.

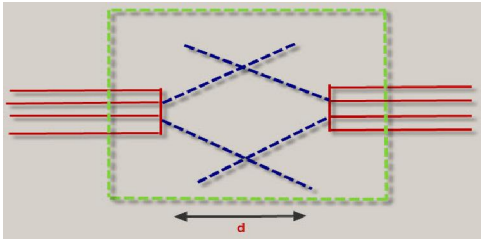

Figure 6: Intensity based fiber optic sensor
Source: https://www.elprocus.com/diffrent-types-of-fiber-optic-sensors/

2.2 Polarization Based fiber optic sensors: Polarization is important for Polarization properties of optical fibers are important for a some class of sensors. Polarization property easily modified by external variable. Modulated fiber optic sensors used for the measurement of a range of parameters. Special fibers and other components have been devised with specific polarization features and these are widely used in a variety of measurement applications as well as in communication and in signal processing.

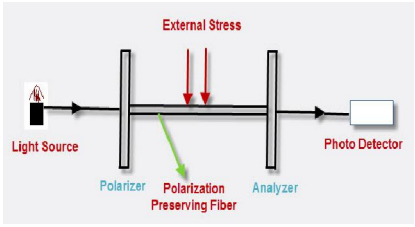

Figure 7: Polarization Based fiber optic sensors
Source: https://www.elprocus.com/diffrent-types-of-fiber-optic-sensors/

2.3 Phase Based fiber optic sensors: The most responsive fiber optic sensing method is based on the optical phase modulation. The total phase of the light along an optical fiber depends on the properties like the physical length of the fiber, transverse geometrical dimension of the guide, refractive index and the index profile of the waveguide. If we assume that index profile remains constant with environmental variations, then the depth of phase modulation depends on the other remaining parameters.

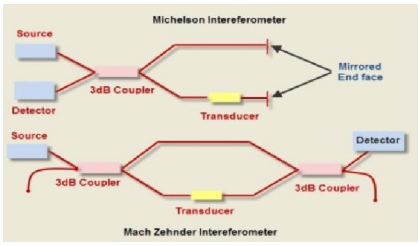

Figure 8: Phase based optic sensor
Source: https://www.elprocus.com/diffrent-types-of-fiber-optic Sensors/

3. Application Based on fiber optic sensor

3.1 Bio medical sensors: In biomedical and biotechnology area bio medical sensors are used to diagnosis a disease.bio medical sensor are different from general sensors .It's a analytic device which is convert biologically signal into electrically signal.

Figure 10: Biomedical sensor
Source: https://www.elprocus.com/diffrent-types-of-fiber-optic-sensors/

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III. FIBER OPTIC SENSOR USED IN MEDICAL FIELD

The huge research and evolution in this field. Fiber optic sensor is used in invasive or noninvasive. The small size of sensor is allows to inject into body tissue and their non-galvanic nature makes them genetically electrically protect. FO sensors are unresponsive to electromagnetic disturbances generate from electrical equipment.

Applications of FO sensors can be grouped in the various areas of application, like: In-vitro (e.g. for analysis of gases, bodily fluids or tissue samples), In-vivo, non-invasively (e.g. optrodes placed on the skin), In-vivo, invasively (e.g. in catheters or endoscopic tools), in harsh environments where electronics are not practical, like MRI [4].

Fiber optic bio sensor is divided in two category sensors based on a biocatalyzed reaction and those based on a selective binding reaction" [5].

Fiber optic sensor has many applications in medical area:

1. Dengue fever is disease, transfer by female "aedes aegypti mosquito" many laboratorial tests are available to detect this disease but all are taking a long time and need highly knowledgeable personnel. A fast good and simple method to diagnosis this diseases is optical fiber sensors. Localized Surface Plasmon Resonance (LSPR) phenomenon used in optical fiber sensors to detect dengue. When light influence on material enclosed by dielectric material spectral changes will occur change in refractive index [6].

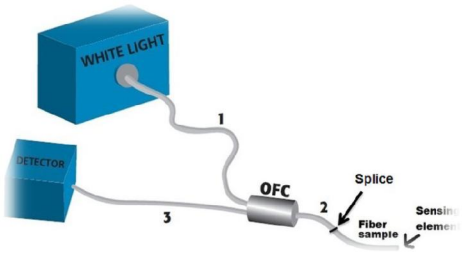

Figure 11: LSPR-based all-optical fiber sensor

2. DNA oligonucleotides to immobilized DNA targets fluorescence optical sensor oligonucleotides join with optical fiber complementary sequence are diagnosis by using fluorescent double stranded specific DNA ligand.[7]

3. To measure Blood sample and sent into a laboratory to determine content like sugar, protein cholesterol etc. its take a time because large no of measurement, laboratory far from test centre etc. to overcome this problem use a fiber optic sensors. It's fitted into catheter and place blood vessels and continually measurement are handled by sensors. [5].

4. Physical sensors are used to measure a variety of physiological specification, like body temperature, blood pressure, and muscle displacement. Imaging sensors encompass both endoscopic devices for internal observation and imaging, as well as more advanced techniques such as optical coherence tomography (OCT). [8]

5. Optical fiber sensor is measure carbon-dioxide pressure in the stomach. This sensor is based on color change of a CO_2-sensitive indicator layer. The layer is connecting to the optical fiber placed in the stomach. The optoelectronics unit is attached to laptop which is used to data acquisition and processing, and for calibration [9].

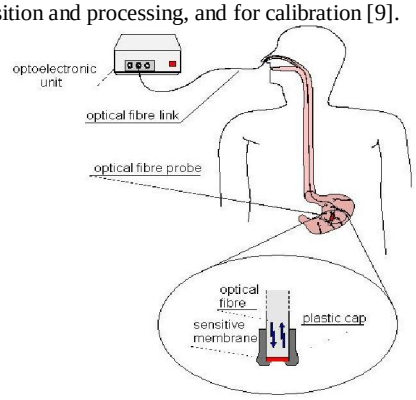

Figure 12: optical sensor for CO_2 detection in the stomach
Source: http://spie.org/Images/Graphics/Newsroom/Imported

6. Glucose sensor:

Optical sensor couple with Mach-Zehnder interferometric waveguide and optical fibers to measure slight changes of aqueous sugar concentrations. [10]. this sensor is high sensitivity, simplicity, reliability and continuous monitoring. In this method refractive index change with concentration of sugar. In this method one arm of interferometer is covered with glue and isolated from sugar solution, the other one is define sugar solution. If the concentration of sugar is change, the phase of propagating light is change. Phase of other arm is not change it's remain constant. Hence the output intensity from the interferometer is directly related to the concentration of the sugar solution.

7. **MRI Fiber Optic Sensor for Brain Injury**

A MRI fiber optic sensor is used to sense the angular position and captured the velocity and acceleration during the operation.

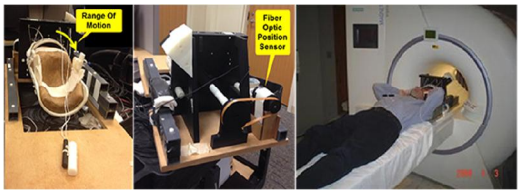

Figure 13: MRI-safe device brain injury
Source: https://www.ecnmag.com/article/2014/05/fiber-optic-sensors-enable-new-mri-applications

As shown in Figure 14, the data is corresponding to real time with MRI image. The sensor is control a hardware function. The fiber sensor is high resolution of 8192 and fast update rate of 850µs allows a recording of some 500 data points for one event [11].

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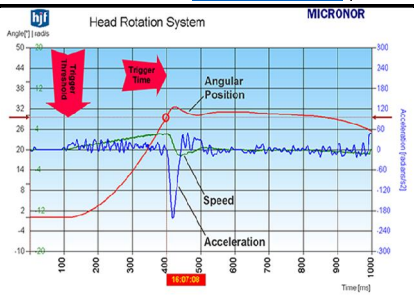

Figure 14: Data Output
Source: https://www.ecnmag.com/article/2014/05/fiber-optic-sensors-enable-new-mri-applications

8. MRI Fiber Optic Sensor for cardiac stress testing:

MRI Fiber Optic Sensor is use in cardiac imaging provide good image and calculation and patient safety over ultrasound techniques. EXCMR .Inc. developed a MRI safe Treadmill in MRI suite. EXCMR is able to find cardiac imaging after exercise. When a treadmill and image system is located remotely we cannot gets result instantly.

The MRI Safe Treadmill is shown in Figure metallic material is used in MRI Scanner [11].

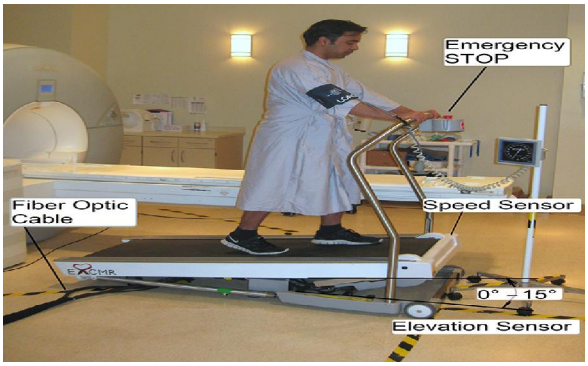

Figure 15: MRI-safe treadmill systems for improved heart imaging under cardiac stress
Source: https://www.ecnmag.com/article/2014/05/fiber-optic-sensors-enable-new-mri-applications

CONCLUSION

The objective of this paper provides an overview of optical sensor and use in area in medical. This paper is summarized basics optical sensor characteristics.

III. FUTURE SCOPE

Now a day's optical fiber demand in Novel Techniques like such fiber optic probes in Raman and Attenuated Total Reflectance are used for communications, military and defense, biomedical image. This is also helpful in prevent drugs spurious.

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AUTHOR'S DETAILS

Vijay Laxmi Kalyani is currently working as Assistant Professor in the department of ECE in GWECA, Ajmer. She has attended various workshops, conferences, FDP, STC etc. and also published many research papers in various International Journals, National Journals and Conferences, she is also a member of IAENG.

Varsha Sharma is pursuing M.Tech (III -Sem) in Digital Communication in GWECA, Ajmer.