Latin American Journal of Education
www.lajoe.org

OPTICAL SENSORS: OPERATING PRINCIPLE AND APPLICATIONS.

https://doi.org/10.5281/zenodo.17907637

Dilfuza Muxammadjonovna Xatamova
Senior Lecturer, Department of Chemistry, FSU.
dxatamova75@gmail.com
https://orcid.org/0009-0001-5912-1320
Qambarova Rayhona Otabek qizi
Raxmonova Fotimaxon Orifjon qizi
Zokirova Mubinabonu Muzaffar qizi
Students of the Chemistry Department, FSU.

ABSTRACT: *This article analyzes optical sensors, their working principles, and applications in key fields such as medicine, industry, and environmental monitoring. Optical sensors operate by detecting changes in light intensity, wavelength, or phase. The study focuses on sensor classification, spectroscopy-based detection, and modern technological trends such as fiber Bragg grating sensors and plasmonic biosensors.*

KEYWORDS: *Optic sensor, passive optic, active (laser), fiber optic, spectroscopic, plasmonic.*

INTRODUCTION

Optical sensors are an integral part of modern technological processes, which provide accurate information about the physicochemical properties of the environment through light. Sensors based on optical fibers, lasers, photodiodes and spectrometers are widely used in many areas, such as industry, robotics, medicine, nuclear power, security systems.

Since the solution of a number of important environmental problems is associated with the study of the quantitative and qualitative composition of the gaseous environment, great importance is attached to the development of fast, reliable, inexpensive and easy-to-use analytical instruments that determine the chemical composition of gases.

This class of sensors combines chemical and biological sensing with the achievements of optoelectronic technologies. Optical sensors have several advantages:

-the use of optical sensors allows you to register the entire optical spectrum and obtain more information;

-optical sensors are not affected by electrical noise;

-usually, devices such as a comparison electrode are not required for the operation of optical sensors, the reagent-holding phase can be easily replaced.

Latin American Journal of Education
www.lajoe.org

That is why disposable sensors are widely used. Chemical sensors have various qualities and directly monitor the chemical composition of industrial and natural objects in a fully automated manner. The rapid development of sensor technology can be seen from the fact that about a dozen international journals, a number of monographs and reviews have been published in this field in recent times.

The term sensor is a general technical term, and although it has been used for several decades, the devices based on them have been used since humanity tried to study the physical, chemical and biological state of its environment. However, in recent years, the capabilities of microprocessors have increased dramatically, and interest in creating sensing devices similar to the human mind has increased.

A sensor is a device that can detect incoming movements and signals or alerts from the external environment and respond accordingly. The incoming movements (input) can be light, heat, motion, concentration, pressure or other environmental phenomena. The output (output) is usually a signal that is converted into a human-readable display at the sensor location or transmitted electronically over a network for reading or further processing. In most cases, sensors are called sensors or detectors[1-3].

Sensors play a key role in the Internet of Things (IoT). The Internet of Things is a system of interconnected electronic devices that collect and transmit data. They allow for the creation of an ecosystem for collecting and processing information about a given environment, which can be monitored, controlled, and monitored more easily and efficiently. Sensors bridge the gap between the physical world and the logical world, acting as the eyes and ears of the computing infrastructure that analyzes and operates on the data they collect.

Its meaning is explained by the rule given to the term sensor, adopted in accordance with the Electrical Transducer Nomenclature and Terminology (ANSI Standard). This standard was prepared by the American Society of Instrumentation and defines a sensor as “a device that provides a specific measurable quantity result.” At the same time, the result is defined as an "electrical quantity", and the measurand is defined as a "physical quantity, property or condition being measured"[4-5].

LITERATURE REVIEW

In the scientific literature, optical sensors are recognized as the most reliable technology with high accuracy, independence from electromagnetic interference, and the possibility of remote measurement. FBG sensors, plasmonic SPR sensors, spectroscopic analysis methods are considered the most effective optical detection technologies.

On the creation of optical chemical sensors, one can mention O.Wofbeis (Germany), Mallins (England), Lakovich (USA), and others. In Uzbekistan, the

Latin American Journal of Education
www.lajoe.org

work of a number of scientists such as A.M.Gevorkyan, A.M.Nasimov, Ye.Abdurakhmonov, Z.N.Normuradov, B.J.Kabulov on various issues of chemical sensors can be cited [6].

Methodology. The article was prepared by theoretical analysis and systematization of scientific sources. The mechanisms of operation of sensors were analyzed based on physical parameters such as optical light intensity, wavelength, refractive index, absorption coefficient. The comparative advantages of fiber-optic, laser and plasmonic sensors were studied.

RESULTS

Although all information processing is currently carried out using electrical signals, the signals produced should not be limited only to their quantity. In the future, the information obtained from optical signals will become very diverse.

A sensor is a sensor that receives changes in the environment (temperature, pressure, light, gas composition, humidity, chemical reaction, etc.) and converts them into a signal (usually an electrical signal) that can be processed.

Complex analytical systems such as gas chromatographs and spectrometers are not considered sensors based on the above definitions. Obviously, complexity should not imply a sharp limitation. Interestingly, according to the ANSI standard (American National Standards Institute), it is considered acceptable to use the term "sensor" instead of "sensor". If we look at the literature, we see a more contradictory situation. Middelhoek and Noorlag describe a sensor as a device that converts an electrical signal into an optical signal.

They made an electroacoustic device that receives and transmits similar acoustic waves. From the series of such devices, we see that the two names (sensor and sensor) are equivalent. They have synonyms such as detector, meter (for example, current meter), etc. Although ANSI staff also provides other terms and definitions related to sensors, there is no general rule about the electrical and mechanical parts of sensors. In practice, there are no rules for standard sizes for sensor devices, such as analog/digital electrical devices (except for temperature sensors). One important reason for this is that the sensors used in this field are currently constantly expanding their capabilities and limits, and we cannot use such standards for an uncertain limit.

On the other hand, the lack of standards hinders the widespread use of sensors, and this problem should be solved as soon as possible:

- optical chemical sensors have a number of advantages over electrochemical sensors. These include simplicity of manufacture, use of inexpensive materials, resistance to external influences, etc.

- the use of sol-gel technologies in the preparation of optical chemical sensors shows good results. Since the sol-gel layer based on a silicate precursor has advantages over a polymer base, the

Latin American Journal of Education
www.lajoe.org

practical significance of the work is determined by the fact that [7-8].

Below, based on the sources studied, the types of optical sensors, their working principle, physical quantities, advantages and areas of application are presented.

Table 1. Classification of optical sensors.

Sensor type	Operating principle	Main physical quantity	Advantages	Application area
Passive optical	Light absorption/transformation	Intensity	Cheap, simple	Monitoring
Active (laser)	Laser reflection and interference	Phase	High accuracy	LIDAR, robotics
Fiber-optic	Light modulation in fiber	λ, n	Noise-resistant	Bridge monitoring
Spectroscopic	Absorption/emission spectrum	λ	High chemical accuracy	Gas analysis
Plasmonic	SPR phenomenon	Refractive index	High biosensitivity	Virus/bacteria diagnostics

Common characteristics of a sensor include:

1. Primary sensing element — the part that directly detects a physical or chemical change.
2. Transducer — converts the detected change into a signal.
3. Output signal — can be analog or digital.
4. Measurement range — the range of values over which the sensor can operate.
5. Accuracy and sensitivity — the main metrological characteristics of the sensor.

Table 2. Areas of application of sensors.

Industry	Application	Sensor type	Parameter	As a result, it is used in
Medicine	Blood composition, SpO2 measurement	Spectroscopic	SpO2, Hb	Diagnostics
Industry	Temperature/pressure control	FBG	T, P	Monitoring
Ecology	Gas concentration	IR sensor	CO2, NOx	Environmental control
Security	Fire, smoke detection	Optical sensor	Smoke Density	Alarming

Latin American Journal of Education
www.lajoe.org

Robotics	Distance detection	LIDAR	3D Model	Autopilot systems

DISCUSSION

Light modulation plays a key role in the operation of sensors. Modern nanophotonic elements allow increasing sensitivity by 10–100 times. Plasmonic sensors are capable of detecting biomolecules at a level of one part per million. It is clear that optical sensors are actively used in various fields according to their operating principles, and this requires their improvement.

CONCLUSION

Optical sensors play an important role in future technologies in almost all fields. Their high sensitivity, resistance to electromagnetic interference, safety, and the ability to measure from long distances make them the most effective technologies in industry, medical diagnostics, and environmental monitoring.

REFERENCES:

1. Rasulov K.R. «Analitik kimyo»; T.: G‘.G‘ulom, 2004 yil, 106-109 betlar
2. Fayzullayev O. Analitik kimyoning nazariy asoslari T.: Yangi asr avlodi 2006 yil, 203-206 betlar
3. G‘ulomova M.T., Norov Sh., Turopov N. «Analitik kimyo» T.: Voris nashriyoti, 2009 yil, 56-64 betlar
4. "Electrical Transducer Nomenclature and Terminology", ANSI Standard MC6.1-(1975) ISA S3 7.1.
5. P.Kumar Yadav, R.Srivastava* and N.Chaurasiya. Optical Fiber Sensor: Review and Applications. IJCRT: Volume 6, Issue 1 March 2018, pp. 1359-1362. 26. Th. Allsop, R. Neal. A Review: Evolution and Diversity of Optical Fibre Plasmonic Sensors. Sensors 2019, 19, 4874; doi:10.3390/s19224874
6. Yangibayev S., Mo‘minov O‘.M. Qattiq tanali ion-selektiv elektrodlarni modernizatsiya qilish. “Yangi O’zbekiston yoshlari va uchinchi renessans” mavzusidagi iqtidorli talaba va magistrantlarning ilmiy-amaliy konferensiya materiallari to’plami. Navoiy, 2022-yil, 10-iyun.
7. Tsipis Ekaterina, Vladislav Kharton. Solid State Electrochemistry II: Electrodes, Interfaces and Ceramic Membranes. 2011 Wiley-VCH Verlag & Co. KGaA, Boschstr. 12, 69469 Weinheim, Germany.

Nipanshi Tyagi, Pinki Rani. Enzyme Electrodes and its Application. International Journal of Research in Engineering, Science and Management Volume-1, Issue-9, September-2018