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A HISTORICAL PERSPECTIVE OF SENSORS

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Abstract

Now a days electronic sensors are mostly fabricated through micro/nano technologies. The size of key components of the devices, such as thin films or three dimensional small structures are usually within micrometer or even down to nanometer. The MOS sensors (MOSFET and MOS capacitor) due their potentiality in high-level integrated circuits draw much attention to researchers to use in gas sensing field. The gas sensor find applications in various fields, such as in fire detectors, leakage detector, controllers of ventilation in cars and planes food and beverage industries, in the analysis of perfume, in diagnostic medicine and alarm devices, etc. If a gas sensor is placed in a particular region where in a possibility of inimical leakage of gases occurs, huge loss of property and human life may be saved and number of accidents may be reduced. The control and monitoring of pollutant gas and chemical species in environment are being done successfully using sensor technology. The specific demand for gas detection and monitoring has emerged particularly as the awareness of the requirements to protect the environment has grown. Environmental protection, as well as energy-saving, is possible only by detection and monitoring of toxic, hazardous, flammable and exhaust gas. These events spur scientist and technologist to design and fabricate a gas sensor which can detect gases with utmost accuracy.

Keywords: *Sensor, Electrical Value, Stimulus, Sensing Surface*

Discussion and Analysis

"*The sensor is a device that receives a stimulus and responds with an electrical signal*".

Sensors as the name itself used are devices that make us aware of some specific parameter variation or presence of some specific conditions in environments. The word stimulus means the quantity, property or condition that is sensed and converted into an electrical signal. Sensors may be understood as a translator of a generally non electrical value into an electrical value. Among the sensors, the gas sensor is the most important area of research and presently emphases is being given to the design and develop the highly sensitive, selective and reproducible gas sensors in small size. A simple definition of gas sensor can be granted- *"A gas sensor is devices that detect the presence of different toxic and*

combustible gases/vapors present in the environment". The presence of the particular gas can be detected on the basis of interaction between the measure and (test gas) and sensing surface of the fabricated sensors by measurements of change in resistance, capacitance, work function, mass, Optical characteristics, etc with exposure to the test gases.

Thin film type gas sensors have drawn much interest because of their potential applications for micro-sensors. The first thin film sensor using Zinc Oxide (ZnO) on a borosilicate glass plate was reported by ***T. Seiyama*** *et al* [12] in **1962.** The vacuum evaporation method is used for the deposition of ZnO thin film. This sensor is based on the fact that the adsorption and desorption of gases causes a change in electrical conductivity of the film. He observed that the addition of a small amount of other gas to the carrier gas causes a change in conductivity of the film due to adsorption of CO2, C6H6, C2H5OH, etc.

Titanium dioxide has gained great importance in the field of gas sensing. The sensing properties of TiO2 thin films are based on its surface interactions with reducing or oxidizing gases which as a result, affects the conductivity of the film. In the field of chemical sensors, the structural stability, porosity and high surface to volume ratio are key properties for a sensing film. Several workers have been used TiO2 as a sensing film for detecting a large number of oxidizing, reducing gases and various hydrocarbon vapors

L. Harshal reported titanium dioxide (TiO2) thin film hydrogen detector using a sandwiched structure consisting of titanium-titanium dioxide-platinum. It was suggested that the structure is a highly selective detector for hydrogen. The detection of the H2 was based on a change in conductance of TiO2 with exposure to hydrogen gas. On the basis of response of H2 gas they conclude that the fabricated sandwiched structure is a suitable detector of H2.

A. Khurshid studied a TiO2 based Schottky diode as a hydrogen sensor and found that the chemical structure of the interface depends strongly on the crystal orientation of TiO2, which results in the different electrical characteristics of the Pd/TiO2 diodes. When the device is exposed to hydrogen, the hydrogen atoms at the Pd surface diffuse to the interface and reacts with interfacial adsorbed oxygen, leading to the formation of adsorbed water. Simultaneously, a hydrogen atom penetrates the TiO2 bulk through channels perpendicular to the interface forming oxygen vacancies and thus increasing the donor density.

M Abbas reported, the XPS study on Nb-doping TiO2 thin film based sensor for the detection of Oxygen using the Sol-Gel method. They found that XPS properties led to knowledge about chemical composition. The measurement reveals that Nb-doping in TiO2

improve the sensing properties towards oxygen and sensitivity increases by 40% at operating temperature 190 0C.

G. Subramaniam investigated nano-sized titanium dioxide thin films for alcohol sensing with different doping (Niobium ethoxide and hydrogen hexachloro platinate) concentration on alumina substrates. The TiO2 thin films were prepared using the sol-gel process. They found that fabricated sensor showed highest response for methanol at 400 0C and other test gases ethanol and propanol at 500 0C.

In the gas sensor field, semiconductor technology has been a major subject of intensive research and continuous development occurred during the last few decades. The instruments like mass spectrometry, flame emission spectrometry, infrared spectrometry, colorimetric, etc. are used to bled, monitor and on-line analysis of the ambient constituents [5]. But due to the complexity and high cost of functioning these instruments, interest has been developed to produce a simple low-cost gas sensing element using microelectronic technologies [6]. However, these sensors are not selective enough to identify a particular gas, as a sensor gives the unitary response to any environment [7]. Highly complex integrated circuits can now be manufactured on a large scale and at a low price for computing and information processing; these have been readily used for automation processes. To identify/specify a single gas or mixture of gases, a novel idea of Electronic Nose (sensor array) has been developed as a major achievement in gas sensing field [8-9]. Today, the world is still facing various problems such as environmental pollutions, analysis of food and drug for health safety, detecting and tracing of explosive materials in military applications, etc. Thus, for controlling and monitoring these, demand is still growing for small and IC compatible sensors using microelectronic technology with fast response (data accessing) and low price.

Actually, we understand the sensor function by comprising it to human organisms called as natural sensors. All living organism system has various kinds of sensory groups, such as eyes, ears, skin, nose, and tongue, and a signal treatment system centralized in the brain. The brain processes the signals from natural sensors and actuates. Analogous to this organism system, there are different man-made devices (sensors) named as optical sensor (eye), pressure sensor (skin), chemical sensor (nose), etc., in which, information is also transmitted and processed in electrical form, however, through the transport of electrons. Sensors and actuators act as extensions of human senses and are quite crucial in everyday

life. On the first basis, the sensor may be classified into two categories as physical sensors and chemical sensors. The Physical Sensors are those, in which the input parameter is a physical property (like pressure, temperature, light, etc.),
while in Chemical Sensor, the chemical property (like gas, odor concentration/smell, biological or chemical species, etc.) that to be trace out and converted into an electrical signal.

There are different types of gas sensors available based on their basic structure, the technology employed in the fabrication process, way of gas interaction with sensor materials and also another factor. The interaction of gas/vapor with sensor surface (material) is due to chemical reactions, adsorption and absorption phenomena, etc. These interactions induce changes in material properties e.g. resistivity, capacitance, mass, work function, or in the reflection indices. At present, different types of gas sensors, which are compatible with standard bulk IC processes, are being developed as Thin film, Thick film, and MOSFET/MOS capacitor, etc. Depending on the use of sensing materials, the gas sensors may be also classified as organic and inorganic sensors. The classification of gas sensors are:

Physical Sensor

A physical sensor is a device that identified the physical quantities (like temperature, pressure, optical, humidity etc.) and converts it into a signal which can be read by an observer. There are various types of physical sensor such as:

Optical Sensors

An optical sensor or detector converts incident light rays into an electronic signal. It measures the physical quantity of light and converts it into a form that is readable by an instrument. It may be either internal or external. The optical sensors based on the sensing principles as: absorbance caused by the absorptivity of the analyte itself, reflectance measurement of intensity of light emitted by chemical reaction in the receptor system, fluorescence measured as positive emission-effect caused by irradiation, refractive index measured as the result of a change in solution compositions and light scattering based on effects caused by particle by definite size present in the sample. The sensing materials used are oxides such as WO3, NiO, Mn3O4, CuO, TiO2, SnO2, and polymers, etc.

Temperature Sensor

A temperature sensor is a device, generally a resistance temperature detector (RDT) or thermocouple which collects the data from a particular source for temperature and converts

the data into an understandable form of a device. The most common type of sensor is thermometer which is used to measure temperature of solid-liquid and gases. There are several types of temperature sensors which are as follows: thermometers, thermistors, thermocouple, infrared sensor, and RTD, etc.

Chemical Sensor

The detection of chemical species and their concentration is a big concern of the researchers as well as many industries. The chemical sensors are defined as devices that transfer chemical information, ranging from the concentration of a specific sample component to total composition analysis, into an analytically useful signal. Within the last fifty years, a large number of research work is dedicated to chemical sensors focusing on sensing materials, device design and electronic. The conceptual design of chemical sensing system and processes corresponding to each stage are:

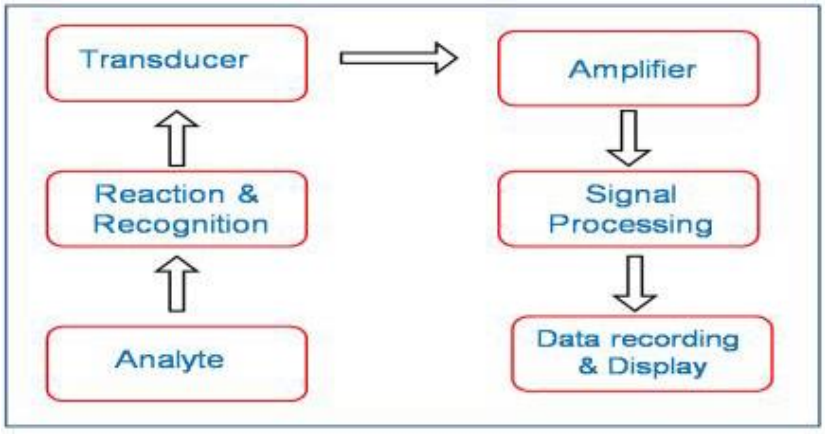

Diagram :1 Sensor architecture block diagram

The new families of the sensor were introduced and improved in many aspects such as efficacy, accuracy, and compatibility with IC technology. On the basis of structure, technology employed in the fabrication process, way of gas interaction with sensor materials and also other factors, etc the sensor is divided into different types. The interaction of gas/vapor with sensor surface (material) is due to chemical reactions, adsorption and absorption phenomena, etc. These interactions induce changes in materials properties e.g. resistivity, capacitance, mass, work function, or in the reflection indices. At present, different types of gas sensors, which are compatible with standard bulk IC processes, are being developed as thick film, thin film, carbon nanotubes (CNT), Schottky diode, MOSFET and MOS capacitor, etc. The researchers have classified gas sensors based on their sensing

principle, applications, and substrate type, etc. The most common classification relies on the sensing principle. The solid-state gas sensors are broadly classified into four groups as MOS sensor, thick-film sensor, thin film gas sensors and
conducting polymer gas sensors.

References

L. Harshal : Physics Review Bulletin, 1254 (45), 2015
A. Khurshid : Gas Sensors and their applications; Oxford University Press, 2016
M Abbas : Review of Sensing Technologies, 2016
Subramaniam : Thin Film Gas Sensors, 2017
Singh K. : Indian Journal of Physics, 1655 (95), 2017