5th International Conference on Science, Technology and Management
India International Centre, New Delhi (ICSTM-16)
30th July 2016, www.conferenceworld.in ISBN: 978-93-86171-00-9

REAL TIME MONITORING OF SEMICONDUCTOR GAS SENSORS

Naini Garg[1], Ajay Beniwal[2], Sudeshna Bagchi[3]

[1]M.Tech Student, UCIM, Panjab University, Chandigarh, (India)

[2]M.Tech Student, ECE Department UIET, Kurukshetra University Kurukshetra, Haryana, (India)

[3]Scientist, Agrionics, CSIR-CSIO, Chandigarh, (India)

ABSTRACT

The present paper examines Taguchi based commercial gas sensors such as TGS 822 and TGS 825 for their use in detecting various volatile organic compounds (VOCs) such as ethanol, methanol etc. Their use is investigated on the bases of performance characteristics of the sensors such as sensitivity, selectivity, reproducibility, response time and recovery time. Ideally the sensor should have high sensitivity and selectivity and short response and recovery times. This paper describes the real time analysis of the sensing performance of Taguchi gas sensors using NI USB 6210 DAQ hardware.

Keywords—Conducting polymers, Electronic nose, Metal oxide, sensor array, Volatile organic compounds.

I. INTRODUCTION

In most of the industries, gases have been used as raw materials. Therefore, it has become very important to develop highly sensitive gas detector. Traditionally analytical techniques such as Gas chromatography, ion mobility spectroscopy, NMR and mass spectroscopy were used for sensing purposes [1]. Apart from their high cost and complexity, most of these techniques require sample preparation making the real time analysis difficult. So these analytical instruments were replaced by chemically sensitive solid state devices such as electronic nose [2]. An electronic nose is just like human nose, developed to mimic human sense of smell. Various gases being colourless and odourless makes a person unaware of its presence as it cannot be sensed by human nose, for such purpose e-nose consisting of sensor array is developed. Many types of gas sensors are available such as conductometric gas sensors that include metal oxide or conducting polymers as its sensing element, optical sensors, catalytic, electrochemical and surface acoustic gas sensors [3]. Out of these conductometric gas sensors are widely used now days because of its structural simplicity, low cost and easy fabrication [4]. Taguchi sensors such as TGS 822, TGS 825 etc. are commercially available conductometric gas sensors consisting of tin dioxide (SnO_2) as its sensing element whose conductivity changes on exposure to various target gases which accounts for its sensing performance. Online monitoring of the sensors is important for the long term detection of volatile organic compounds (VOCs) [5]. Literature survey suggests that online or the real time monitoring of sensors have not been carried out much till date. So, the main aim of this paper is to represent the real time monitoring of the sensor showing its response on exposure to different types of volatile organic compounds such as ethanol, methanol etc.

II. EXPERIMENTAL SETUP USING TGS 822 AND TGS 825 SENSOR

The sensing layer of TGS 822 and TGS 825 is a tin oxide (SnO_2) semiconductor based deposited on alumina substrate with an integrated heater. The sensor has low conductivity in clean air, however, when the sensing element of sensor is exposed to various gases, conductivity of the sensor increases depending on the concentration of gaseous vapours in contact with the sensing layer. The change in sensitivity is calculated in terms of change in resistance given as [6];

Sensitivity (S) = $R_{gas} – R_{air}/ R_{air}$

(1)

Where, R_{gas} and R_{air} is the resistance of sensor in presence of gas and clean air respectively. The experimental set up is shown in Fig.1.

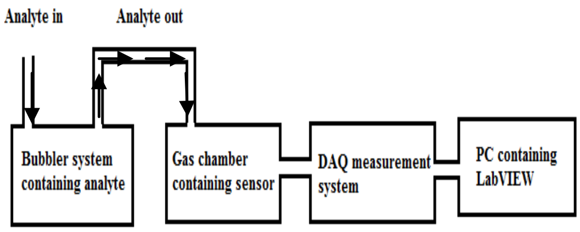


Fig. 1 Experimental Set-up

The set up consists of sample delivery system (bubbler system) consisting of two values for sample inlet and outlet, gas chamber containing sensor, fan to spread gaseous vapours uniformly inside the chamber and a humidity sensor, DAQ measurement system and pc containing LabVIEW software.

III. DETECTION PROCEDURE

The sensor is made to interact with different concentrations of various types of volatile organic compounds such as ethanol, methanol etc. The experimental procedure starts with calculation of the baseline resistance (i.e. resistance of sensor in the clean air) followed by opening of the valve for the injection of gas. As soon as sensing element of sensor comes in contact with the vapours of target gas analyte its conductance increases. The response of the sensor is observed until it saturates to determine its sensitivity and response time. The gas in the chamber is then flushed with the help of vacuum to determine its recovery time. After cleaning the chamber, again, that particular gas is injected in order to account for the reproducibility of the sensor and the same procedure is repeated for various other target gases to know about the selectivity of the sensor. The response of sensor to the target gas is shown in Fig. 2.

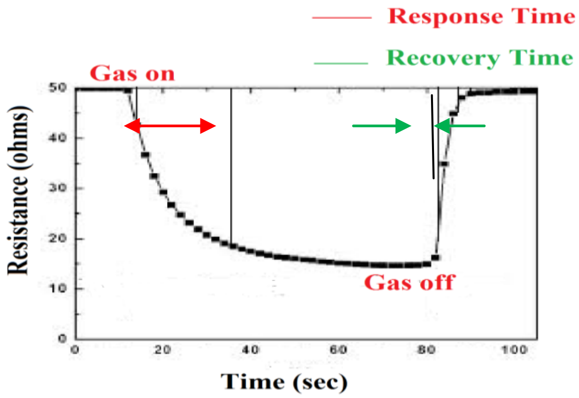


Fig. 2 Response curve of sensor

Response time is the time taken by sensor to reach from 10 to 90% of its maximum peak value whereas recovery time is the time taken by sensor to reach 90 to 10% of the baseline response.

IV. DATA ACQUISITION

Data acquisition refers to the method of collecting or acquiring data from the sensor head in the form of electrical quantity. Data acquisition measurement system acts as an interface between sensor and the pc containing LabVIEW software. NI USB 6210 DAQ was used to acquire signal from the sensors present inside the gas chamber. The acquired signals were processed inside the DAQ hardware and the output was displayed on the pc containing LabVIEW software. NI USB 6210 DAQ is as shown in Fig. 3.

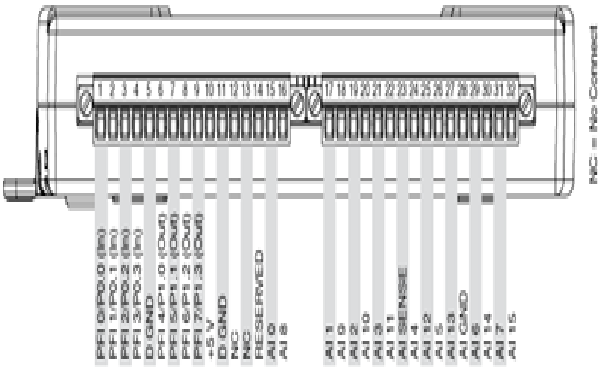
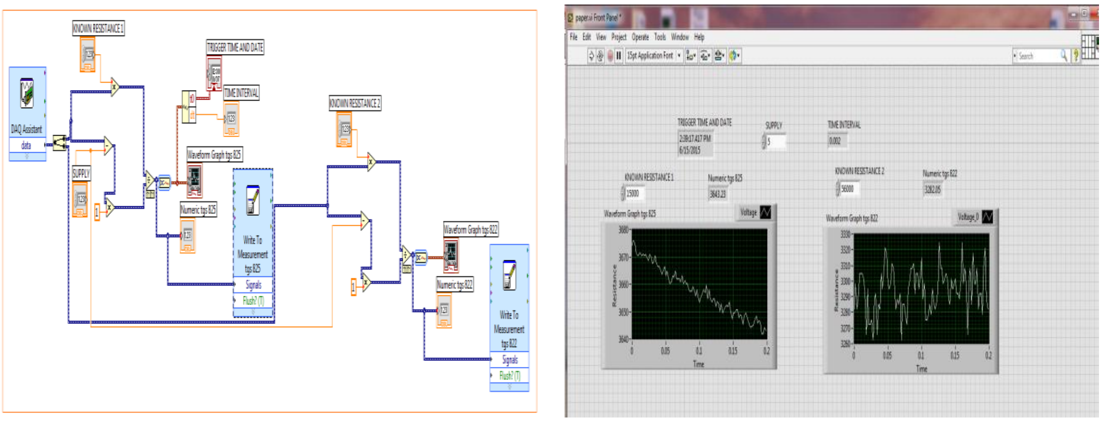


Fig. 3 NI USB 6210 DAQ [8]

NI USB 6210 DAQ consists of 32 pins out of which 16 pins in the form of channels are available for analog input that means signal from the array containing sixteen sensors can be monitored at the same time. Real time monitoring set up and the LabVIEW program developed is as shown in Fig. 4 and Fig. 5.

Fig. 4 Real Time Monitoring Set-up

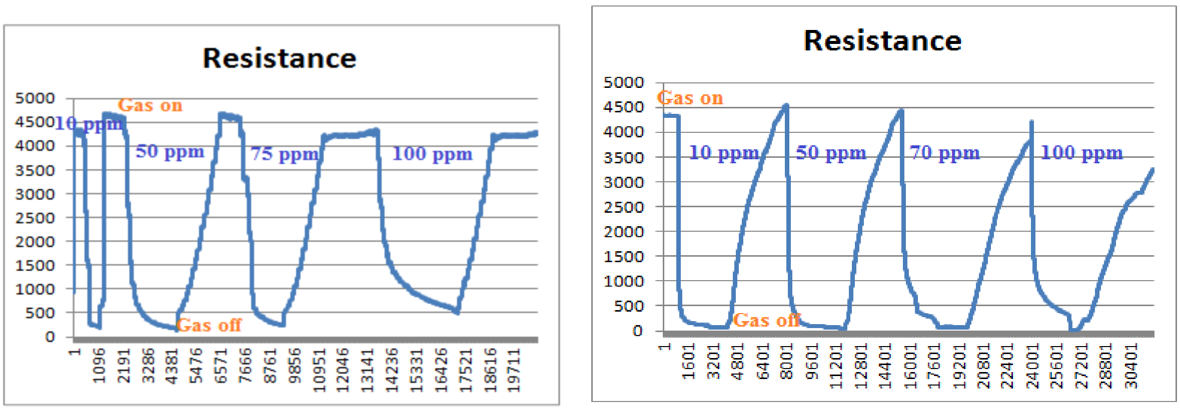


(a) **(b)**

Fig. 5 LabVIEW Program (a) Block Diagram (b) Front Panel

V. RESULTS

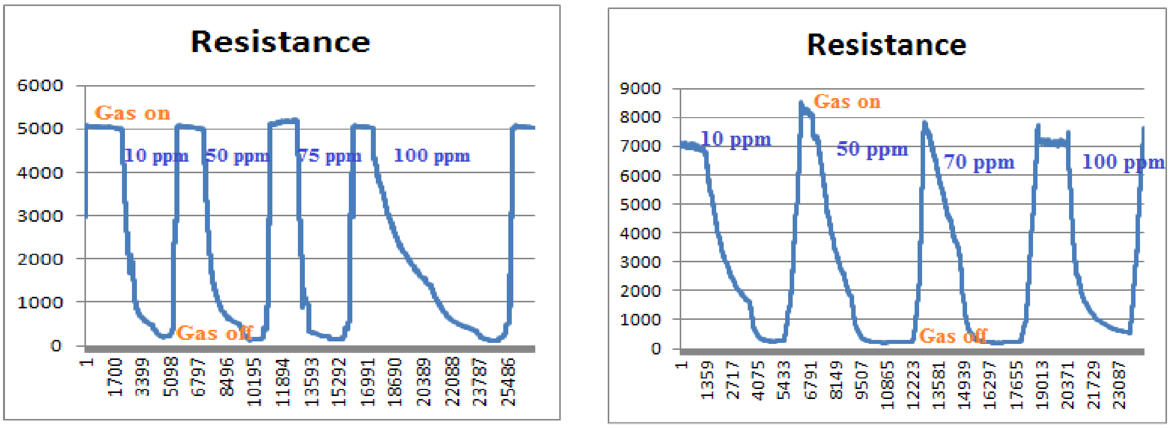
TGS 822 gas sensor is used for the detection of alcohol in breath. The characteristic graphs for different volatile organic compounds with different concentrations using TGS 822 [7] gas sensor are shown in Fig. 6. The compounds used are ethanol and methanol with different concentrations varying from 10-100 ppm.



(a) (b)

Fig. 6 Response of TGS 822 towards (a) Methanol (b) Ethanol

TGS 825 is a special sensor, used for the detection of hydrogen sulphide at low concentrations [9][10], but instead the sensor was tested for its sensitivity towards alcohols. The sensor was tested for same analyte as in case of TGS 822. Graphical results of real time monitoring of above mentioned volatile organic compounds at different concentrations using TGS 825 are as shown in Fig. 7.



(a) (b)

Fig. 7 Response of TGS 825 towards (a) Methanol (b) Ethanol

From the graphical results, sensitivity of TGS 822 and TGS 825 can be calculated using (1). The calculated sensitivities corresponding to both sensors for alcohols under test at different concentrations are shown in TABLE 1.

TABLE 1. Sensitivity of TGS 822 and TGS 825

Conc. (In ppm)	TGS 822		TGS 825	
	Ethanol	Methanol	Ethanol	Methanol
10	0.975	0.942	0.962	0.956
50	0.978	0.952	0.972	0.968
70	0.981	0.992	0.973	0.969
100	0.994	0.995	0.980	0.974

VI. CONCLUSION

As can be seen from the characteristics graphs of TGS 822 and TGS 825, resistance of the sensor is high in the clean air while it decreases in the presence of analyte. The decrease in resistance is dependent on concentration of analyte vapours to which the sensor is exposed to. Thus the decrease in resistance is proportional to the concentration of analyte. Sensitivity of the sensor increases with the increase in concentration of analyte. From the graphical response and the sensitivity calculations it is concluded that metal oxide based gas sensors have excellent sensitivity, good response and recovery times but poor selectivity as it responds to all alcohols under test with almost equal sensitivity.

VII. ACKNOWLEDGEMENT

First and foremost, I would like to thank Dr. Rupinder Tewari, Director and Dr. Indu Pal Kaur, Ex-Director, UCIM, Panjab University, Chandigarh for empowering me this opportunity and inspiration. I express my sincere gratitude to Ms. Sudeshna Bagchi (Scientist), CSIO, Chandigarh and Assistant Professor Anil Kumar Sharma, UCIM, Panjab University, Chandigarh for their stimulating guidance, continuous encouragement, positive attitude and supervision throughout the course of present work. I extend my sincere thanks to NIPER, Mohali for SEM and UCIM Department, Panjab University, Chandigarh for XRD.

REFERENCES

[1] G. Neri, First Fifty Years of Chemoresistive Gas Sensors, Chemosensors, vol. 3, pp. 1–20, 2015.

[2] K. Arshak, E. Moore, G. M. Lyons, J. Harris, and S. Clifford, A review of gas sensors employed in electronic nose applications, Sens. Rev., vol. 24, no. 2, pp. 181–198, 2004.

[3] G. Korotcenkov, Metal oxides for solid-state gas sensors: What determines our choice?, Mater. Sci. Eng. B Solid-State Mater. Adv. Technol., vol. 139, pp. 1–23, 2007.

[4] R. John Bosco Balaguru and B.G. Jeyaprakash, Mimic of a Gas sensor, Metal Oxide Gas Sensing Mechanism, Factors Influencing the Sensor Performance and Role of nanomaterials based gas sensors, pp 1-30.

[5] W. Chen, Q. Zhou, F. Wan, and T. Gao, Gas sensing properties and mechanism of Nano-SnO2-based sensor for hydrogen and carbon monoxide, Journal of Nanomaterials, vol. 2012. 2012.

[6] S.A. Waghuley, Tin Dioxide/Polypyrrole Multilayer Chemiresistor As A Hydrogen Sulfide Gas Sensor, E. Devices, vol. 10, pp. 433–437, 2011.

[7] P. Information, TGS 822 - for the detection of Organic Solvent Vapors.

[8] DAQ M Series NI USB 621x User Manual.

[9] P. Information, TGS 825 - Special Sensor for Hydrogen Sulfide.

[10] Amalia Berna, Review: Metal Oxide sensors for Electronic Noses and Their Application to Food Analysis, J. Sensors, vol 10, pp 3882-3910, 2010.