International Journal of Advancements in Technology

Altawell, Int J Adv Technol 2016, 7:4
DOI: 10.4172/0976-4860.1000164

Research Article OMICS International

Machine Olfaction Device (MOD) Chambers with Two Sensors

Najib Altawell*

Energy and Procurement, Royal Hill, Greenwich, London, UK

***Corresponding author:** Najib Altawell, Energy and Procurement, Royal Hill, Greenwich, London, UK, Tel: 07443539188; E-mail: najib.altawell@gsm.org.uk

Rec date: June 09, 2016; **Acc date:** June 15, 2016; **Pub date:** July 10, 2016

Abstract

The Electronic Nose (or eNose) presently possesses a number of challenges, such as short life-time of the sensors; sensitivity towards moisture; narrow selectivity; relatively expensive; mostly used as a laboratory tool and in some cases results can be difficult to reproduce due to the presence of multiple sensors.

The present available devices either lack mobility or are not designed for a long term use. Most of these devices use arrays of sensors, i.e. eNoses, rather than two sensors. Also, the design of the chamber in most present devices can add problems, such as replacement of the sensor, long term functionality and other related issues.

This paper is aimed at developing a novel and improved machine olfaction device (MOD) with on-board data processing capability for monitoring applications. Such a system will be able to use two sensors rather than an array of sensors, as is the case with the present eNose devices. The aim is for a real time MOD which can be used inside and outside the laboratory and for domestic and commercial purposes as well. This new approach can be achieved within the design provided in this paper.

Keywords: MOD; Sensor; Chambers; Commercial; Challenges

Introduction

The idea of designing an MOD (Machine Olfaction Device) to be used for various purposes, i.e. for commercial and non-commercial applications, has been around since the first eNose was invented by Persaud and Dodd, 1982 [1]. A large number of books and articles concerning MODs have been written and published, mostly connected to the food and beverage industry [1].

There are many areas of interest as well, where applications of the MOD/E-Nose can benefit society in general, the following are just few examples:

Industrial

On-line process control and production; quality assurance and quality control (QA/QC) activities within a large range of the industrial sectors.

Environment

Monitoring environmental pollution in general.

Fraud

Identifying unauthorized copies and imitation for various goods/ products (e.g. wines, spirits, perfumes and cosmetics).

Law

Detection of vapours from explosives and drugs.

Health and Safety

Detection of bacteriological and chemical contamination.

MOD

The MOD chamber and the continuous functioning of the device during replacement of a malfunctioning sensor can be an issue. This paper examines these challenges via a new MOD design which shaped itself after examining important factors, such as:

Many of the present MODs are large, bulky and too expensive.

There are still several problems affecting currently available systems, (e.g. inaccuracy, difficulty in obtaining the same or similar results under similar conditions) which affect their wider use in other areas (e.g. medicine, environment).

How reliable is the system and what kind of standardisation will be required?

There are only one or two Mixed Metal Oxide Semiconductor (MMOS) sensors in the proposed device. As a small portable mobile unit, the system application can be used for validation within the lab environment and outside it, mostly for the purpose of long term monitoring.

In general, the MMOS sensor main aspects are similar to those of p-type CAP25 sensor (or similar later versions). As with the majority of sensors presently available on the market, the sensor can be affected by humidity, temperature and sample flow rate. For this reason all the parts which make up the system should be working constantly in an efficient way in order to get a correct reading via the sensor(s). Also, the sensor chamber should be fully and permanently sealed, with the exception of the opening/closing cap - as illustrated in the chamber design in Figures 1-5.

Citation: Altawell N (2016) Machine Olfaction Device (MOD) Chambers with Two Sensors. Int J Adv Technol 7: 164. doi: 10.4172/0976-4860.1000164

Sensor drift can be a problem. The drift itself can be related to the type of sensor films being used, sensor architectures and the sensor age. Why is drift a problem? If it is not possible to obtain the same result on the same sample, under similar conditions, then drift can be one of the causes. The problem can usually be corrected either statistically, through calibration, or by simply replacing the old sensor with a new one.

The MOD and Sensor

An illustration of the principles of a working system for an MOD with a single sensor is shown in Figure 1. The change in the design of the MOD is concentrated mainly on the chamber and the replacement of the sensor in order to provide an MOD with continuous function, to reduce cost and save time whenever there is the need to replace the sensor with a new one. The design in this paper uses two chambers instead of one (Figures 2 and 3). This approach will provide the solutions for many problems from which the present MOD devices suffer. However, it is not possible for the two chambers to be taken out as they are permanently fixed during the manufacturing process inside the device. In this way the MOD device can be easily maintained and the results, consequently, are far more accurate than the present systems available on the market.

How MOD work?

There are various types of devices to detect gases and vapour/odours (e.g. gas detectors, single and multiple sensors for MOD) and all of them work under the same principles, i.e. change of current resistance [2]. Regarding the detection system within the MOD, any device is usually made-up of two important parts:

- A single or an array of chemical sensors.
- A pattern-recognition system.

A single or an array of chemical sensors provides a set of measurements. With the help of a pattern-recognition system, comparison is made with the pattern of measurements obtained to stored patterns of similar materials already known to the device.

All films on a set of electrodes (i.e. sensors) start out at a measured resistance, called the sensor's baseline resistance. If there is no change in the composition of air, the films stay at the baseline resistance and the percentage change is zero. If there is a change, then an identification of the sample can be made. When the above two systems are working correctly, we have what many call an MOD (which can be a single or multiple sensor system).

Challenges

As a result of successful worldwide research in this field, a number of common problems associated with MOD have been already solved, or at least have been provided with partial solutions. For example, problems related to signal drift, humidity, temperature and air quality. Some of these problems have been addressed by designing higher quality sensors (e.g. electro-spray for QMB sensor production) as well as by designing better performing chambers [3].

The most important part in any MOD device is the chamber. For this reason, the chamber has been looked at in more detail in this paper.

The approach in the new design, therefore, is that the content of the chamber will be a disposable part in the device. When the life cycle of the sensor is over, then the content of the chamber will be replaced with a new one. The chamber is a permanently sealed component (apart from the opening and closing cap for the purpose of providing access to change the faulty sensor or the filter) which contains the sensor (MMOS), temperature sensor, relative humidity sensor and the gas (sample) input and output path.

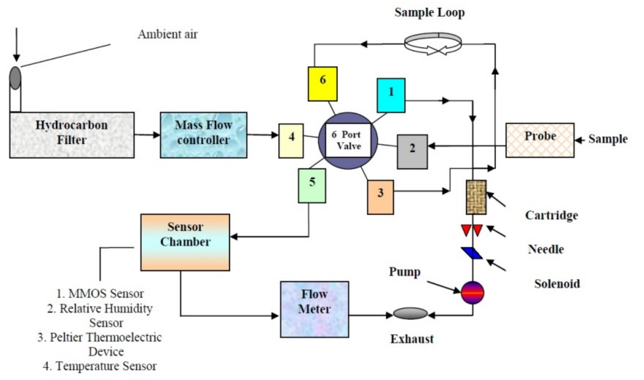

Figure 1: Schematic diagram of a single MMOS sensor.

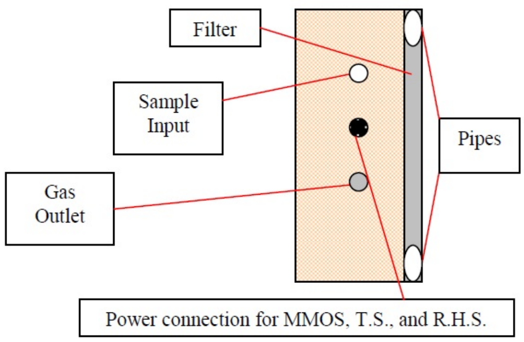

Figure 2: Top view of the mobile MOD.

The new design provides additional space for another chamber which can be used for at least two purposes. The first is to work as a spare chamber which can take over immediately, if the first chamber malfunctions.

The chamber connections to various parts of the MOD device are shown in Figure 4 below.

Metal-Oxide Semiconductors (MOS)

These sensors were originally produced in Japan in the 1960s and were used in 'gas alarm' devices.

Metal Oxide Semiconductors have been used more extensively in eNose instruments and are widely available commercially [4]. These sensors are made of a ceramic - heated by a heating wire and coated by a semi-conducting film. They can sense gases by monitoring changes in conductance during the interaction of chemically sensitive materials with molecules that need to be detected in the gas phase.

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Out of many MOS, the material which has been experimented with most is tin dioxide - SnO2. This is because of its stability and sensitivity at lower temperatures [5]. Different types of MOS may include oxides of tin, zinc, titanium, tungsten, and iridium, doped with a noble metal catalyst, such as platinum or palladium. MOS is subdivided into two types [5]: MOS with thick film and MOS with thin film.

Thick films: Less sensitive (poor selectivity), it needs a longer time to stabilize, higher power consumption. This type of MOS is easier to produce and therefore costs less to purchase [5].

Thin films: Unstable and difficult to produce and therefore more expensive to purchase. On the other hand, they have much higher sensitivity and much lower power consumption than the thick films [6].

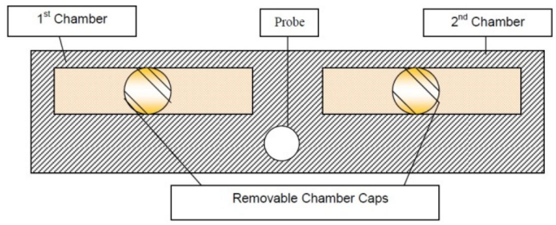

Figure 3: The outer bottom side end of the chamber showing power connection, sample input and outlet.

The second is to enable the MOD to function with two sensors - at the same time - if the need arises, i.e. it can be programmed to function with more than one sensor.

Sensor and Chamber

Changing the sensor in the new design is very simple and easy to perform. In fact the simplicity in changing the sensor is as easy as changing a light bulb (Figure 4).

For the purpose of heavy duty application, the MOD needs to work within an environment where monitoring continuously is required i.e. 24 hours a day, over a period of many months, in real-time. In order to overcome the three months life cycle period of the sensor in these situations, a second chamber is provided.

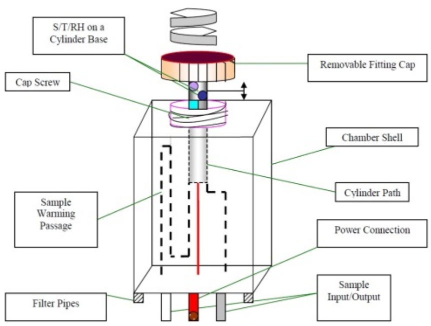

Figure 4: The outer shell of the chamber showing the cylinder base (attached to it "from inside" the sensor/RH and Temperature Controller) being inserted inside the shell.

A few days before the expiry date of the first sensor, the software program of the device will trigger the power supply for the second sensor. In this way, the three days required to stabilize the second sensor would have been achieved before the expiry date of the first sensor. Therefore, device function will not be interrupted, as usually happens if we have a single chamber.

The content of the chamber (with the malfunctioning sensor) can be taken out safely without interrupting the work/function of the device and can be easily replaced with a new one (Figures 5 and 6 in the following page).

Changing the filter will work in a similar way as changing the sensor, i.e. without interpreting the function of the device (Figure 5 below).

Manufacturing process

Polycrystalline is the most common porous material used for thick film sensors, usually prepared in a process called 'sol-gel', as briefly explained below:

$SnCl_4$ is provided in the form of an aqueous solution then the added ammonia will precipitate tin tetra hydroxide.

The precipitate tin tetra hydroxide will be dried and later calcinated at 500-1000°C.

The resulting tin dioxide powder will be ground and mixed with dopands (metal chlorides) [7,8]. In order to remove the chlorine, as well as getting the pure metal, the powder will be heated.

For the purpose of screen printing, paste will be made-up from the powder.

Finally, with a layer of few hundred microns, the paste will be left to cool (e.g. on a tube alumina or plain substrate).

Sensing mechanism

The change of 'conductance' in the MOS is the basic principle of the operation in the sensor itself. That means the change in conductance takes place when an interaction with a gas happens. The conductance will vary depending on the amount of concentration of the gas itself.

Metal oxide sensors types [7]: The n type usually responds to 'reducing' gases, while p-type respond to 'oxidizing' gases.

- n-type (zinc oxide, tin dioxide, titanium dioxide iron (III) oxide).
- p-type (nickel oxide, cobalt oxide).

The n type usually responds to 'reducing' gases, while p-type respond to 'oxidizing' gases.

Operation (n-type): As the current is applied between the two electrodes, via the metal oxide, oxygen in the air will start to react with the surface and accumulate on the surface of the sensor, consequently 'trapping free electrons on the surface from the conduction band' [7]. In this way, the electrical conductance decreases as resistance in these areas increases - due to lack of carriers (i.e. increase resistance to current), as there will be potential barriers between the grains (particles) themselves.

When the sensor is exposed to reducing gases (e.g. CO) the resistance drops as the gas usually reacts with the oxygen and therefore an electron will be released. Consequently, the release of the electron

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increases the conductivity as it will reduce the potential barriers and let the electrons start to flow [7].

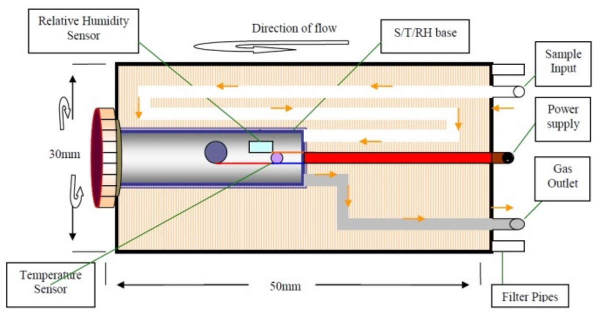

Figure 5: Cross section of the chamber.

Operation (p-type): Oxidising gases (e.g. O_2, NO_2) usually remove electrons from the surface of the sensor and, as a result of this, charge carriers will be produced.

Signals and pre-processing

The MOD is basically a device containing non-specific sensor(s) alongside a pattern recognition system [5]. Therefore, the data processing components can range from a powerful desktop to a limited computational portable system, depending on the final requirements needed and the actual size of the device desired. A small portable device may need embedded pattern analysis software; therefore the complexity of training algorithms in many cases is much higher than during the operation stage [5]. Some algorithms should be trained off-line using a host computer, as the embedded software may not be sufficient for the type of operations for which we are intending to use the device. The process, therefore, from the sensor response until the final classification for the MOD, can be summarised in the following points:

- Sensor response (raw measurement)
- Pre-processing
- Normalised measurements
- Feature extraction
- Classification
- Vapour/Odour Class

However, in order to get accurate results, the MOD sensor(s) should be sensitive for any minute changes which may take place around it. The sensor response will be amplified and the data processing will interpret the final result.

The main purposes of the pre-processing are to:

- Reduce noise
- Remove drift
- Translate the data

The aim of the pre-processing in the MOD is simply to choose a number of values (parameters) which represent the sensor response. This is an important procedure as it may affect the performance of the pattern analysis system. In addition to the above, it is part of the work for the signal pre-processing to compensate for sensor drift and preparing the feature vector for further processing [8].

The old method involved opening the chamber and replacing the malfunctioning sensor with a new one, then waiting three days for the sensor to stabilise.

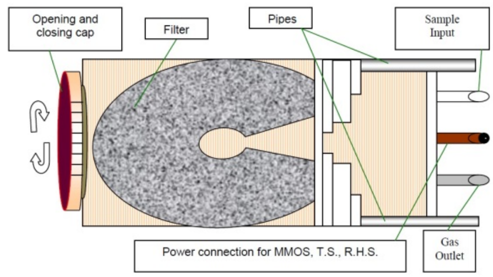

Figure 6: Filter attached at the back of the chamber – both filter and chamber contents are disposable items.

When functionality and time is important, then the above method is no longer practical. Not being able to use the device for a period of time is simply not acceptable way in today's demanding market.

Therefore, the principles used in the new design can easily overcome the above problems. As we are aware, for any device to be successful in the market then market conditions for the device have to be fulfilled. These conditions will be in the form of easy to use, continuous functionality (over a reasonable period of time), relatively low cost and finally (most important point) the device is able to do the job it is intended for accurately.

Conclusion

MOD device applications are important and numerous. These applications can range from the food and agriculture industries, petroleum qualitative and quantitative analysis, disease diagnosis, detection of explosives, environmental applications, quality control applications in the automotive industry and many more. In fact MOD devices are becoming essential within various vital industries for the simple reason in that they can help in provide a safer and better standard of living. However, further development and improvement within this field is still needed in order to facilitate accurate results. Also, cost and lifecycle are other important issues which need to be addressed. In order to achieve the above, a new chamber design has been provided in this paper. Replacing the sensor and, consequently, providing continuous function for the MOD over a long period of time, this design has provided new solutions for better performance.

References

1. Persaud K, Dodd G (1982) Analysis of discrimination mechanisms in the mammalian olfactory system using a model nose. Nature 299: 352-355.
2. Stetter JR, Penrose WR (2001) The Electrochemical Nose. Chicago, Electrochemistry Encyclopedia, USA.
3. Ampuero S, Bosset JO (2003) The electronic nose applied to dairy products: a review. Sensor Actuat B-Chem 94: 1-12.
4. Nagle HT, Schiffman SS, Osuna GR (1998) The How and Why of Electronic Noses. IEEE 35: 22-34.
5. Sberveglieri D (1999) Metal-Oxide Semiconductors.
6. Nose Office (2003) NOSE II - The Second Network on Artificial Olfactory Sensing. University of Tuebingen, Germany.

7. Arshak K, Moore E, Lyons GM, Harris J, Clifford S (2004) A review of gas sensors employed in electronicnose applications. Sensors Rev 24: 2.

8. Osuna GR (2002) Pattern Analysis for Machine Olfaction: A Review. IEEE Sensors J 2: 189.