



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 12, December 2024

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 8.524**

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)

# Development of Low Cost Static Gas Sensing Measurement System

S.S.Dange<sup>1</sup>, S.N.Dange<sup>2</sup>

Associate Professor, The Institute of Science, Dr Homi Bhabha State University, Mumbai, India<sup>1</sup>

Associate Professor, Jai Hind College, Churchgate, Mumbai, India<sup>2</sup>

**ABSTRACT:** Here, we report an indigenously designed and developed low-cost static gas sensing setup. The setup is developed using a glass flask and a compact, portable heating probe connected with a PID temperature controller to study the gas sensing properties of metal oxide semiconductor sensors across a temperature range of room temperature to 500°C. Thin films or pellets could be easily mounted on the heater probe and used for measuring sensor characteristics. The temperature controller provides accuracy of  $\pm 1^\circ\text{C}$  in operating temperature. A Keysight make Digital Multimeter, interfaced to PC is used to measure the sensor characteristics. Resistance or conductance of the sensor could be measured, logged and plotted in real time using Keysight make data logging software. The measurement setup can measure sensor resistance upto 100G $\Omega$ .

**KEYWORDS:** Gas Sensor, Static Gas sensing set up

## I. INTRODUCTION

A typical gas sensing system consists of a sensor material that interacts with target gases, a transducer that converts this interaction into measurable signals, and a data acquisition system for recording and analyzing the response. Gas sensors can be broadly categorized based on their operating principles, such as resistive, electrochemical, optical or acoustic sensors. Among these various sensors, resistive sensors measure changes in electrical resistance when exposed to target gases. So resistive sensors are widely used due to their simplicity, high sensitivity and cost-effectiveness. Characterizing gas sensors is an important process for understanding and optimizing the sensor performance. During the development stage, comprehensive testing is necessary to identify the key parameters for performance evaluation, which are essential for the production of sensors on a commercial scale. To assess the response of a resistive gas sensor, measurements of the sensor material's resistance or conductance are conducted both in ambient air and in the presence of a known concentration of the target gas.

In static gas sensing method, the sensor is placed within a confined chamber with a known volume. To measure the sensor's resistance at a specific concentration of the target gas, a predetermined quantity of gas is introduced into the chamber. The sensor's resistance is then measured over time until it reaches a stable or steady-state condition. This process allows for the assessment of the sensor's response to the desired gas concentration [1, 2]. The sensor's recovery is determined by removing it from the chamber and exposing it to ambient air. This step involves observing how the sensor's resistance changes upon transitioning from the gas-injected environment back to normal air conditions. By studying the recovery process, the sensor's ability to return to its baseline state and detect response for subsequent gas concentrations can be understood.

The Sensor Response or Sensitivity of the sensor (S) is defined as

$$S = R_{\text{air}} / R_{\text{gas}}, \text{ for reducing gases}$$

$$S = R_{\text{gas}} / R_{\text{air}}, \text{ for oxidizing gases}$$

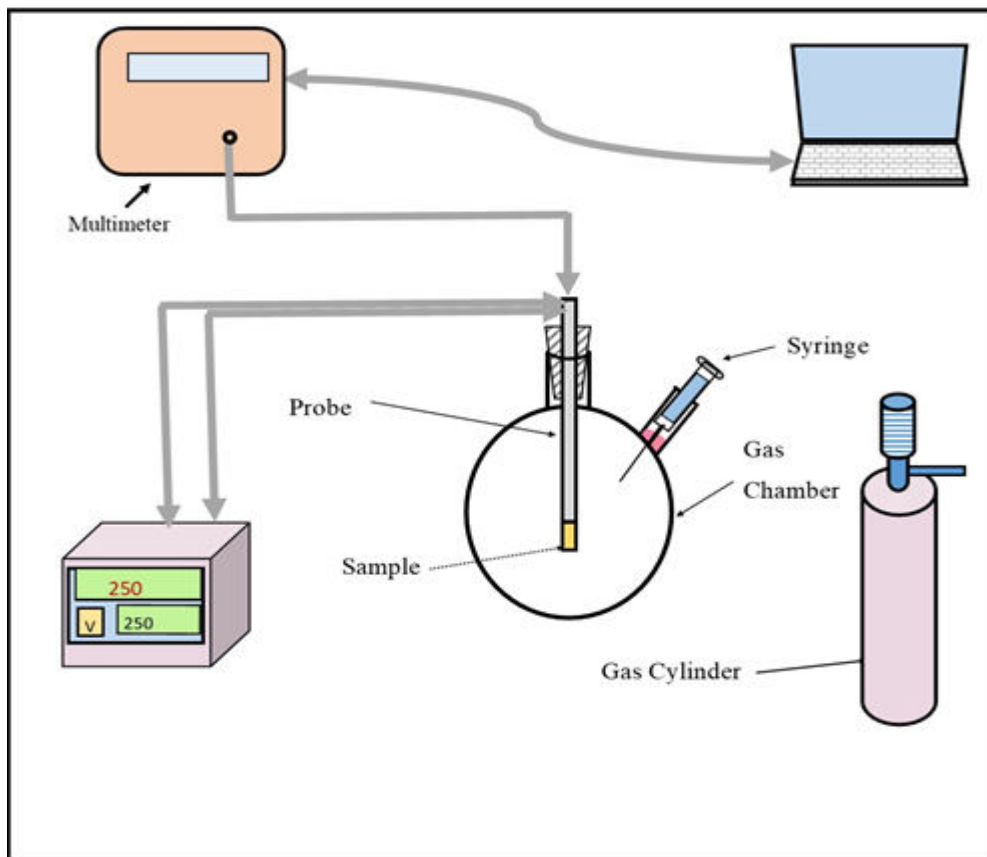
where,  $R_{\text{air}}$  is resistance of sensor in air

$R_{\text{gas}}$ , is resistance of sensor after exposure of gas

## II. EXPERIMENTAL DETAILS

In this work we have developed an indigenously designed static environment gas sensing set up to test the response of sensor to particular gases as shown in figure. This gas sensing setup can be described in four parts as shown in figure 1.

1. Gas test chamber
2. Heater probe
3. Control unit
4. Measuring and Data logging unit



**Figure 1: Schematic of Gas Sensing Measurement Set up**

### i) Gas Test Chamber

We have used a 500ml glass flask with two necks as gas test chamber as shown in figure 2. These necks are air sealed and used as inlets for injecting test gas and placing removable indigenously developed heater probe as shown in figure 2. The known volume of a test gas can be inserted into the test chamber using calibrated air tight syringe and needle.

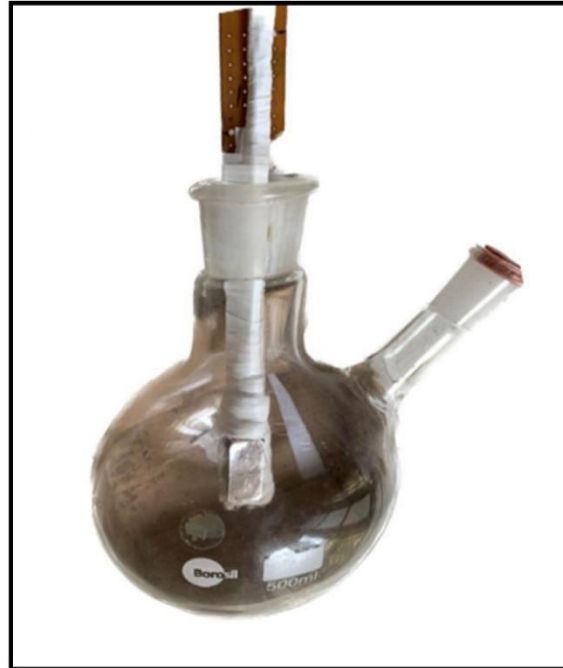


Figure 2: Gas test chamber

(ii) Heater Probe

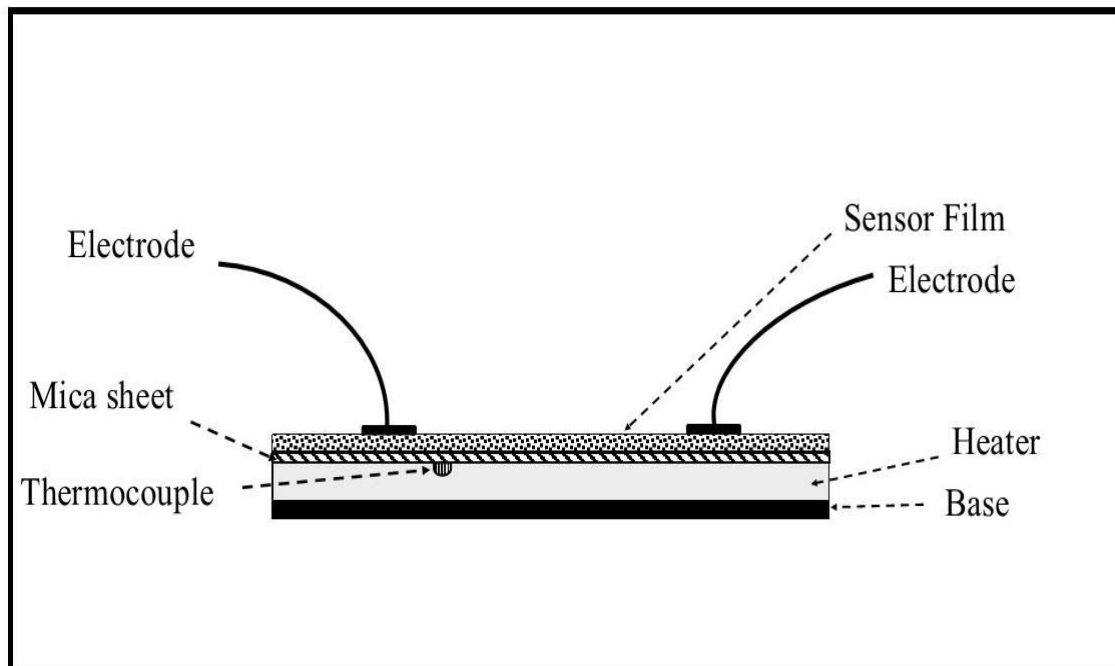


Figure 3: Schematic of heater probe

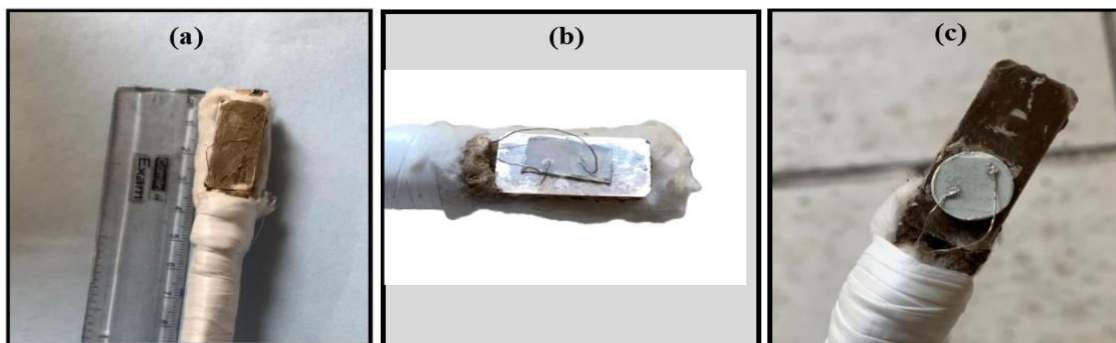
**Figure 4 : Heater Probe**

Figure 3 shows the schematic of heater probe. The heating probe is specially made in way that only the surface temperature can be varied from room temperature to 500 °C in a small area of about 1.5 X 2.5 cm as shown in figure 4. Electrodes used are thin platinum (or gold ) wires, which are attached to the sensor probe such that they can easily be connected to the sensor material using silver paste. The electrodes are connected in a way that the tension between electrodes and the contacts with the sensor surface is considerably reduced so that the probe can easily be inserted or removed from the chamber without disturbing the electrode contacts. The sensor element is mounted on the probe using a mica sheet which electrically insulates the sensor material from the heater. The samples were attached on the mica sheet for measurements using silver paste as adhesive. The heater is properly insulated from all other sides and placed on a PCB for support. A J-type thermocouple is integrated into the heater probe beneath the mica sheet for sensing and controlling the temperature. All the wires connecting heater, thermocouple and electrodes are properly insulated using ceramic beads and glass fibre sleeves.

### iii) Control Unit

The control unit consists of a proportional-integral-derivative (PID) temperature controller, power source for the ceramic heater and connectors connecting the heater probe. The temperature controller has an accuracy of about +/- 1°C. The PID controller is connected to the J-type thermocouple, which is incorporated into the ceramic heater, to regulate and monitor the operating temperature.

### iv) Measuring and Data Logging Unit

The sensor response is measured as the change in resistance or conductance of the sensor material with time using a Keysight Digital Multimeter. The multimeter is interfaced with a PC, which records the data and displays the real-time variation in resistance or conductance of the material using Keysight data logging software.

### III. RESULTS AND DISCUSSION



Figure 5 : Experimental Set up of gas sensing measurement system

#### Measurement Procedure:

Figure 5 shows the experimental setup used for gas sensing measurements. To carry out the gas sensing measurement, the sensor films or pellets are mounted on the heater probe using silver paste. The electrode contacts are made at appropriate positions using silver paste. The required operating temperature is set on the control unit and the sensor films are kept in ambient air conditions for sufficient time to ensure stability. The heater probe is then inserted into the gas chamber and the sensor film is allowed to stabilize for a suitable period before testing.

To measure the sensor response to a test gas, a specific volume and concentration of the test gas is drawn into a syringe and introduced into the chamber through a needle. This needle is inserted into another neck of the gas chamber, which is air-sealed with silicon rubber to prevent gas leakages. Sensing measurements are performed by exposing the sensor film to the test gas in the sealed chamber. The operating temperature can be varied from room temperature to 500°C, and the gas concentration is adjusted as needed by changing the syringe's gas volume and concentration.

For recovery measurements, the heater probe is removed from the gas chamber and exposed to the ambient air environment. The corresponding resistance or conductance of the sensor film is recorded in real time using the data logging software. A plot of the resistance or conductance of the sensor with time is displayed on the PC, as shown in Figure 6. These curves illustrate the ZnO film's response to a reducing test gas at different gas concentrations.



Figure 6: Real time gas sensing measurement of sensor

#### **IV. CONCLUSION**

We have indigenously designed and developed static gas sensing measuring system. The system can operate from room temperature up to 500°C. It is suitable to study the resistive gas sensors in the thin film and pallet form for sensor resistance upto 100GΩ. The response curves were successfully recorded using this measurement system for sensors based on doped and undoped ZnO thin films. This home-made setup provides ease of use, portability, and cost-effectiveness, making it highly practical for gas sensing studies.

#### **ACKNOWLEDEMENT**

We are thankful to our home institutions. We are also thankful to Prof. Pravin More, The Institute of Science, Dr Homi Bhabha State University, Mumbai and Dr Niranjana Ramgir, BARC, Mumbai for their guidance and support.

#### **REFERENCES**

1. D. K. Aswal, S. K. Gupta, 'Science and Technology of Chemiresistor Gas sensors,' Nova Science Publishers, India, 2007.
2. R.S. Niranjana, Y.K. Hwang, D.-K. Kim, S.H. Jung, J.-S. Chang, I.S. Mulla, 'Nanostructured tin oxide: Synthesis and gas-sensing properties,' Materials Chemistry and Physics, vol. 92, pp. 384-388, 2005
3. C. A. Papadopoulos, D. S. Vlachos, J. N. Avaritsiotis, 'Comparative study of various metal oxide based gas sensor architectures,' Sensors and Actuators B, vol. 32, pp. 61-69, 1996.
4. P. K. Sharmil, N. S. Ramgir, C. P. Goyal, N. Datta, S. Srivastava, M. Kaul, A. K. Debnath, D. K. Aswal, Y. K. Vijay, S. K. Gupta, International Conference on Advanced Nanomaterials and Emerging Engineering Technologies (ICANMEET), 2013.
5. A. Menzel, K. Subannajui, F. Göder, D. Moser, O. Paul, and M. Zacharias, 'Multifunctional ZnO nanowire-based sensor,' Adv. Funct. Mater., vol. 21, pp. 4342-4349, 2011.
6. V. Balouria, A. Kumar, A. Singh, S. Samanta, A. K. Debnath, A. Mahajan, R. K. Bedi, D.K. Aswal, S.K. Gupta, J.V. Yakhmi, Enhanced H<sub>2</sub>S response of Au modified Fe<sub>2</sub>O<sub>3</sub> thin films. Sens. Actuators B: Chem. 157,466, 2011.
7. J. Zhang, Z. Qin, D. Zeng, and C. Xie, 'Metal-oxide-semiconductor-based gas sensors: Screening, preparation, and integration,' Phys. Chem. Chem. Phys., vol. 19, no. 9, pp. 6313-6329, 2017.
8. K. G. Krishna, S. Parne, N. Pothukanuri, V. Kathirvelu, S. Gandhi, and D. Joshi, 'Nanostructured metal oxide semiconductor-based gas sensors: A comprehensive review,' Sens. Actuators A Phys., vol. 345, p. 113758, 2022.
9. R. S. Niranjana, Y. K. Hwang, D.-K. Kim, S. H. Jung, J.-S. Chang, and I. S. Mulla, 'Nanostructured tin oxide: Synthesis and gas-sensing properties,' Mater. Chem. Phys., vol. 92, pp. 384-388, 2005.



INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details