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Modeling of CO₂ Gas Detector Using Comsol Multiphysics

Mishra Ankit^{1*} and Choudhary kumar Ashutosh²

¹Dept of Electrical Engineering, Amity University Chhattisgarh

²Dept of Computer Science, Amity University Chhattisgarh

ABSTRACT

In these papers we have simulated carbon dioxide sensor using COMSOL Multiphysics (MEMS module). These sensors are cheap, highly sensitive and selective. We got the results of CO₂ detector electric potential variation at 300C temperatures with high dependability using less power.

KEYWORDS: COMSOL Multiphysics, CO₂ gas detector.

***Corresponding author**

Mr. Ankit Mishra

Department of Electrical Engineering

Amity University Chhattisgarh

Kharora, Chhattisgarh 493225

Email: Ankitmishra004@gmail.com

INTRODUCTION

The CO₂ gas in the atmosphere is one of the main reason for global warming, consequently monitoring CO₂ gas in the atmosphere is essential for good atmospheric conditions. To detect atmospheric carbon dioxide (CO₂), the CO₂ sensor is required. Currently, in present world there are many CO₂ sensors are available, usually, they are fabricated by using the infrared sensing devices (IRD), but the magnitude of these sensors are relatively large and they required a very high power and temperature for the operation¹.

In this paper, we suggested a designed CO₂ sensor in micrometer size (110 μm), which is designed by using a MEMS module of COMSOL Multiphysics software. The different type of CO₂ sensors presently used is Mixed Oxide Sensors², NASICON-based sensors³, CNT sensors⁴, Gas Chromatographs and Spectroscopic Sensors (Non-Dispersive Infrared-NIRD). Similarly, in⁴, the aspect on wireless, passive Carbon Gas Sensor is given.

This type of detector has the disadvantage like high power consumption, would like high operational temperature, not easy for mobility circuits and sophisticated procedure. NIRD sensors needed additional power input in the order of mill watts and may price between fifty to five hundred USD. Potentiometric mixed chemical compound detectors and NASICON based sensor are quite tough to induce stabilized activity⁵, this variety of sensors measure to rely on concentration of gas and operational temperature ought to be quite 350 C. The greenhouse gas detector is often wont to calibrate warmth performance of the sensor; numerous sensors forever have thermal inertia and finite heat electrical phenomenon, which alter the waveform of the Temperature versus Time⁶. At present, it is essential to provide high-quality CO₂ gas sensors for many fields like food industries, agriculture industries, air-conditioning, and atmospheric monitoring due to the massive rise of CO₂ levels in the atmospheric because of greenhouse effects⁷. Solid state potentiometric CO₂ sensors are precisely favorable to detect low levels of CO₂ concentrations; also they provide the firm reaction, ease, and long term stability. The sensor's electromotive force (emf) displays a linear relationship with the logarithm of CO₂ concentration based on solid electrolyte for an air quality control system⁸. In Electric noses for observing environmental pollution and building relapse model arranged the detail case study about the present system for examining the use of different sensors grid system concerning urban air fumes monitoring for carbon monoxide, carbon dioxide (CO, CO₂) gases for three different regions in Alexandria- Egypt and 2 different traffic roads⁹. In solid-state potentiometric CO₂ sensor in dense film technology for breath examination described with the detail observing of the CO₂ gas, the concentration which is valuable in numerous applications, for example, to define the air quality, to monitor food quality or for breath analysis. In it is projected a low-power-consumption CO₂ gas sensor using ionic liquids for green energy management. They study of the

impedance of the ionic liquid material having low concentration of the CO₂ gas which increases in the air. In this paper, we suggested a sensor which protects the Gold electric terminals of the sensor by dropping the foam drop over the sensor electrodes, which reduce the atmospheric oxygen effect on the sensor performance. In this sensor model,¹⁰ we examine the electric potential variation with respect to the arc length plotted on the top surface gold electrodes of the CO₂ sensor. The sensor resides of an interdigitated transducer (IDT) etched onto a piezoelectric SiO₂ substrate and enclosed with the foam material. The mass of the foam material increases as it increases the absorption of CO₂ from the air. The bottom layer of copper material is exertion as a heater for CO₂ sensor¹¹.

MODEL DEFINITION

The Geometry of the CO₂ Detector

Fig. 1 shows a cross-sectional view of the CO₂ gas detector in the COMSOL Multiphysics simulation software. The gold electrodes are fixed on both cross surfaces of SiO₂ and Si-surface film. The higher exterior is painted by a BF₄ foam material to guard the electro-active portion of the device¹², the globule then covers the whole surface of the sensor. BF₄ is the best.

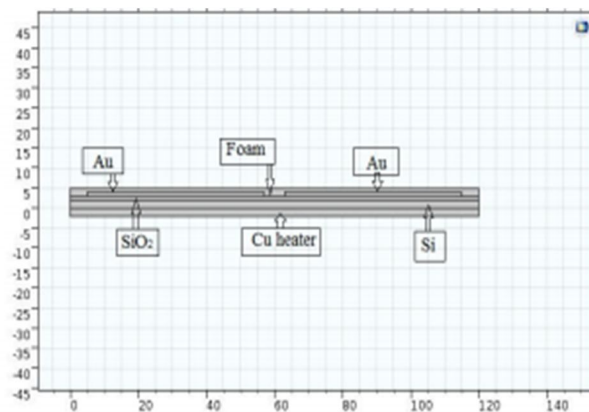


Figure I: Geometry and Dimensions of the CO₂ detector

Fig.1. also, demonstrations the dimensional view of the detector, the height of the sensor is 7 μ m and the length of the sensor is 120 μ m. The gap between the two electrodes is 10 μ m and from both the border side it is 5 μ m distances maintained.

Boundary Conditions

The model is simulated underneath with flexible material over the piezoelectric material and the foam is at the higher layer of the model¹³. Foam is used to captivate the CO₂ gas. The model has an intervallic boundary condition at the vertical edge and simulated for Eigen frequency as a solver¹⁴. Solid mechanics, electric current, electrostatics, and heat transfer physics are sequentially solved in the geometrical conduction.

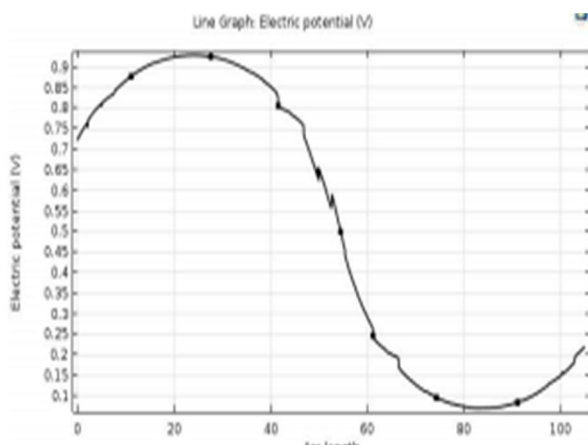


Figure II: Electric Potential VS Field

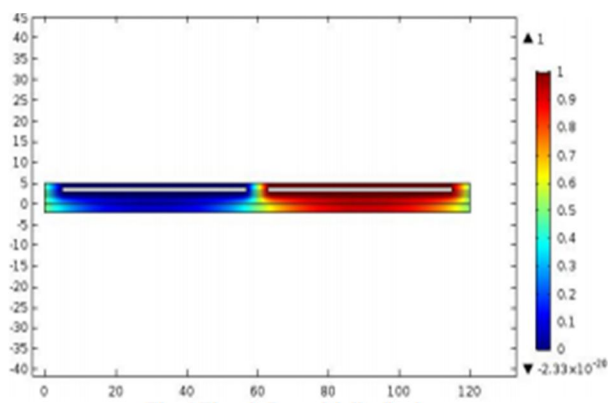


Figure III: Thermal image

RESULT AND DISCUSSION

The irreversible reaction of SiO_2 and CO_2 is given in (4). Where, produced CO_2 is negatively charged. When CO_2 get adsorb on SiO_2 layer electrons are transferred from SiO_2 to CO_2 i.e. CO_2 extract electrons from SiO_2 . As electrons are transferred from SiO_2 , the potential of SiO_2 is increases (*). Potential distribution in SiO_2 is increases with increase in concentration of CO_2 . The basic cause of impedance varies with CO_2 concentration is shown by following graph decreases the overall cost of the sensor. The optimum design is simulated and its deformation effect.

CONCLUSION

Nowadays, considerable amount of work is being carried out in order to develop sensors that are more cost efficient, simple to use, sensitive and selective. Research efforts have developed gas sensors for inflammable and toxic gases. Sensors are all around us and their prevalence is growing rapidly. Sensors play a very important role in the modern society with all the modern technology around us. CO_2 sensor is cheap and can be easily fabricated.

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