Category: - 'MEMS and Sensors '

Study of Temperature Optimization of MEMS based ZnO_x Thin Film Gas Sensor for Detection of Acetone Vapour

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***Abstract*- ZnO thin films are being developed in a wide variety of devices because of their unique piezoelectric, optical and electrical properties. Its chemical, electrical and mechanical properties strongly depend on its microstructure. MEMS structures based on thin zinc oxide films are used as the sensitive elements for the application of gas sensors. The key issue in MEMS based ZnO sensor development is the control of the sensing layer properties in order to meet the specific requirements of gas sensing. The development of thin film gas sensor based on MEMS structure is a rapidly growing area, enabling fabrication of arrays of sensor elements coupled with reduced power consumption and enhanced sensitivity using microhotplates based on thin membranes (3-5 µm) due to low thermal mass. This paper presents the study of temperature optimization for MEMS based ZnO_x thin film sensor considering the best operating temperature for such sensors. The ZnO_x thin film gas sensor are being developed on Si_3N_4 platform by using the MEMS structure for the detection of volatile organic compounds (VOC) such as acetone. The required temperature which is easy to generate in any battery powered MEMS structures where the total power dissipation is of the order of millwatt. The effect of the operating temperature on the sensing properties of the undoped ZnO_x thin films is studied for this purpose. The performance of the sensor is found admirable for acetone (CH_3-CO-CH_3) at the operating temperature ranging from 150°C to 375°C with a maximum response is at 300°C. The high acetone gas sensitivity and low operating temperature of ZnO thin film gas sensors are attributed to the surface morphology and the surface reaction kinetics.**

***Index Term*- MEMS, Thin film gas sensor, Zinc oxide (ZnO), Acetone vapour detection**

I. INTRODUCTION

The development of gas sensor by microelectronic technology has many advantages, i,e. small size, low cost low power consumption, and the possibility of integration with microelectronic circuits. Most metal oxide gas sensors, work at high temperature of the order of 350°C. This implies rigid restrictions on the available technologies. Integrated thin film gas sensor requires thermally isolated platform for elevated temperature operation of the sensing thin film [1]. Therefore in situ heating is one of basic requirement for micro gas sensor which use metal oxide semiconductor as a sensing film. Until now, several works have been carried out to get a microsensor and it is generally known to use a membrane structure for an integrated micro gas sensor [2-6]. These specific advantages have made silicon as a convenient substrate for different gas-sensing materials. In recent years the efforts of gas sensor designers were aimed at: (a) increasing of gas sensitivity and improvement of their selectivity, (b) reduction of electronic power, consumption by resistive heater of gas sensors, and (c) decreasing of response and recovery times.

The main purpose of the present proposal is to develop a small and micro gas sensor, using MEMS technology, so that these sensors will replace the bulky sensing system. Small and compact devices will consume very little power and MEMS devices further reduce the power consumption. Using a suspended MEMS platform is expected to consume little power, of the order of few milliwatt, which is highly suitable for hand held battery operated gas sensing systems. Present trend shows different metal oxides are being explored as sensing elements, the widely used metal oxides are zinc oxide (ZnO), iron oxide, tungsten oxide (WO_3), titanium oxide (TiO_2) and tin oxide (SnO_2) [7,8]. This paper presents the study of temperature optimization for MEMS based ZnO_x thin film sensor considering the best operating temperature for such sensors. The ZnO_x thin film gas sensors are being developed on Si_3N_4 platform by using the MEMS structure for the detection of volatile organic compounds (VOC) such as acetone.

II. ZINC OXIDE – AS A SENSING MATERIAL

In recent years, many researchers have devoted themselves to improving the performance of ZnO sensors, in order to lower its working temperature and enhance the gas sensitivity. Very recently, nanocrystalline ZnO gas sensors have attracted more attention due to their better properties of detecting pollutants, toxic gases, alcohols and food industries, especially for fish freshness estimation [9], or as gas sensing devices integrated on one single chip to make an 'electric nose' (e-nose) configuration [10-16]. ZnO is known as a good sensing material to detect reducing gases such as CH_3COCH_3, H_2, CH_4 and CO. This material also suffers from long term stability, sensitivity to ambient humidity, and poor selectivity [7]. By adding certain impurities it is possible to bring down the lower temperature detection limit of detection to the range of 150 to 350°C. The popular application of ZnO is its hetro-structures with other material components. Their use as a gas sensor, in which the surface conductivity changes, in response to adsorbed gases, made them an ideal candidate in the early days of surface science. The grain size and the porosity of the sensing material are the most important factors for high sensitivity and short response time for these sensors.

III. OPTIMIZATION OF SENSOR TEMPERATURE

Zinc Oxide synthesized in thin film and the typical response curve for nanosized thin film, showing their response to acetone (CH_3COCH_3) vapor when operated in the range of 100°C–450°C, is shown in Fig-1. Various literature surveys have been carried out to get the optimized sensing temperature and approximate curve has been plotted. This graph shows the response of this vapor at various temperatures and is based on the published literature.

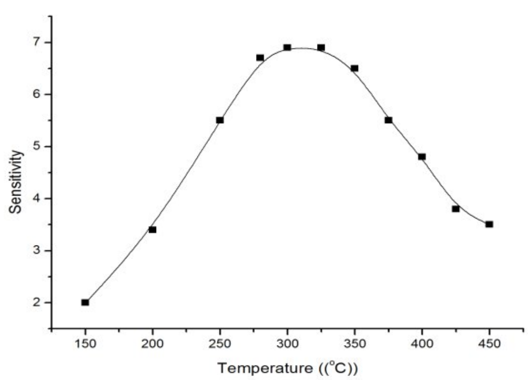

FIG 1: Zinc Oxide thin film response to 100 to 800 ppm CH_3COCH_3 when operated from 150°C-450°C. It is analyzed from the response that sensitivity reduces above the optimized temperature. Data points are from Ref [17-22].

With the reference from this data the optimized temperature range for the sensing of CH_3COCH_3 vapor is found to be sensitive but the maximum sensitivity is around 310°C. Beyond this temperature value the sensitivity decreases and the performance decreases.

IV. CONCLUSION

MEMS based gas sensor using zinc oxide (ZnO) thin film has been studied optimization temperature of the sensor was evaluated to be 100°C–450°C. The maximum sensitivity for zinc oxide thin film is found as 150°C–300°C. The nanothin film also plays an important role in finding the sensitivity and selectivity, hence it is concluded that MEMS based zinc oxide film is has a good sensitivity for the CH_3COCH_3 vapor at comparatively lower temperature.

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VI. REFERENCES

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