TEMPERATURE OPTIMIZATION OF MEMS BASED ZnO_x THIN FILM GAS SENSOR FOR ETHANOL VAPOUR DETECTION

M. Dwivedi[1, 2], T. Dadhich[1], T. Mudgal[1], A. Rani[1], A. K. Sharma[1], J. Bhargava[1], V. Vyas[2] and G. Eranna[1]

[1]Sensors and Nanotechnology Group
Central Electronics Engineering Research Institute (CEERI)
Council of Scientific and Industrial Research (CSIR)
Pilani-333031, Rajasthan, India
[2]Banasthali University, Banasthali-304022, Rajasthan, India
[1]E-Mail: mohinidwivedi@gmail.com, eranna@ceeri.ernet.in,+91-1596-252260

Abstract

Thin film based gas sensors have great influence in many important areas, namely environment monitoring, domestic safety and automotive applications. 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 improved sensitivity using microhotplates based on thin membranes (2-3 µm) via low thermal mass. ZnO is popular because of its high surface activity in chemical environment. This paper presents the study of temperature optimization for MEMS based ZnO_x thin film sensor considering the best operating temperature. The ZnO_x thin film gas sensor is developed on Si_3N_4 platform by using MEMS structure for the detection of Volatile Organic Compounds (VOC). The effect of operating temperature on sensing properties of undoped ZnO_x thin film is studied in the presence of ethanol (C_2H_5OH) vapour. The enhancement of ethanol sensing properties is promising for application as an alcohol breath analyzer. Sensitivity of the sensor optimized considering the minimum operating temperature as the properties of deposited thin film reduces drastically at higher operating temperature, which again affects the overall performance of sensor. The sensitivity measurement is performed in the temperature range of 100 ^oC to 500 ^oC for ethanol. Performance of sensor is found excellent for C_2H_5OH at the operating temperature ranging from 250 ^oC to 370 ^oC. This is a temperature which is easy to create in any battery powered MEMS structures because of millwatt power dissipation to maintain such temperatures.

Keyword: MEMS, Thin film gas sensor, Zinc oxide (ZnO_x), Ethanol Vapor Detection.

INTRODUCTION

Thin film based gas sensors have great influence in many important areas, namely environment monitoring, domestic safety and automotive applications. The thin film of the metal oxides can be grown by various processes such as CVD, sputtering, evaporation, pyrolysis and sol-gel techniques [1, 4, and 5]. Sensor materials for detection of alcohols, especially ethanol, are being actively developed. The interest in ethanol is connected with its wide application in chemistry, medicine, and the food industry. Metal oxides are widely used for detection of ethanol. Ethanol sensors are being enhanced, and as is the case for other analytes, the problems of sensitivity, selectivity, and stability are being addressed. An ideal chemical sensor would possess high sensitivity, dynamic range, selectivity and stability; low detection limit; good linearity; small hysteresis and response time; and long life cycle. MEMS technology with thin film based sensors offer an expensive and simple method for monitoring gases. The change of the electrical conductivity of semiconducting materials upon exposure to reducing gas ethanol (C_2H_5OH) has been used for gas detection.

ZINC OXIDE – AS A SENSING ELEMENT

ZnO is attracting considerable attention for its possible application to UV light emitters, spin functional devices, gas sensors, transparent electronics and surface acoustic wave devices. It has a wide bandgap of 3.37eV and a large exciton binding energy of 60eV at room temperature. ZnO has the wurtzite structure type, which is the thermodynamically stable phase under normal ambient conditions. ZnO thin film is a best approach to use it as a sensing material and there many ways one can deposit on different substrates [8]. ZnO is sensitive to many gases, and has satisfactory thermal stability during use. At present, ZnO is one of promising semiconductor gas-sensing materials. Generally, nanometer-sized materials have been widely studied in recent years, due to their good gas sensitivity caused by high surface activity. Among useful semiconducting metal oxides as sensing materials, zinc oxide (ZnO) has been extensively investigated for detection of ethanol vapor (C_2H_5OH), toxic and inflammable gases such as NH_3, NO_2, H_2 and CO.

OPTIMIZATION OF SENSOR TEMPERATURE

The Gas detection technique is primarily based on a change in the electrical resistance of the semiconducting metal oxide films [5]. Zinc Oxide synthesized in thin film and the typical response curve for nanosized thin film, showing their response to ethanol (C_2H_5OH) vapor when operated in the range of 100 °C – 500 °C, is shown in figure. Performance of sensor is found excellent for C_2H_5OH at the operating temperature ranging from 250 ^{o}C to 370 ^{o}C. Various Literature survey has been carried out to get the optimized sensing temperature and approximate curve has been plotted.

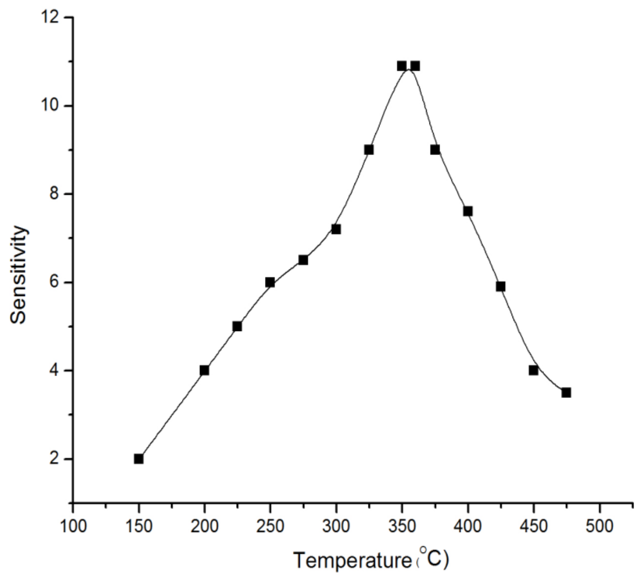

Fig : Zinc Oxide thin film response to 100 to 800 ppm C_2H_5OH when operated from 250 °C–370 °C. It is analyzed from the response that sensitivity reduces above the optimized temperature. Data points are froms ref. [4, 5, 6 ,7,11 and 12]

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 – 500 °C. The maximum sensitivity for Zinc Oxide thin film is found as 250 °C – 370 °C. The Nanostructure of the thin 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 C_2H_5OH vapor at comparatively lower temperature.

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