MEMS GAS SENSOR FOR KIDNEY DIESESE DETECTION

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Disease detection using non-invasive ways is being extensively explored worldwide. Here we present the sensing of low concentrations of ammonia, which is a marker of kidney issue in human body. Hence by monitoring the breath ammonia levels one can decide whether the person is suffering from kidney problem or not. There are other health issues viz-a-viz. diabetes, liver diseases, pulmonary tuberculosis, breast cancer, lung cancer, renal disease, acute asthma, rheumatoid arthritis, etc., which can be monitored using exhaled breath. For instance, acetone for diabetes, carbonyl sulphide, carbon disulphide, isoprene for liver diseases, pentane for rheumatoid arthritis [1-3], ammonia for kidney are used as specific biomarkers. Being a non-invasive way, breathe analysis for disease detection has various advantages such as easy sample collection, less complexity of breath compared to urine or blood, etc. [4].

Human breath consists of several gases and these gases are indicators for different diseases. Increasing ammonia levels in breath indicates kidney disease. Here we present a low power MEMS based gas sensor which can sense as low as 500 ppb concentration of ammonia with a response time of less than 30 seconds. Sputtered SnO_2 film with proper annealing is used as sensing layer. Repeated sensing cycles are used to verify the sensor repeatability. Microheater integrated in the device was characterized for reliability for 120 hours. The power consumption of the device for ammonia sensing is observed 25mW for the operating temperature 220 °C.

Device fabrication has been done using standard unit processes. Fig. 1 shows the intermediate steps of the device fabrication. Operating temperature was decided from the curve shown in Fig. 2, and the sensor response with varying ammonia concentration is shown in Fig. 3.

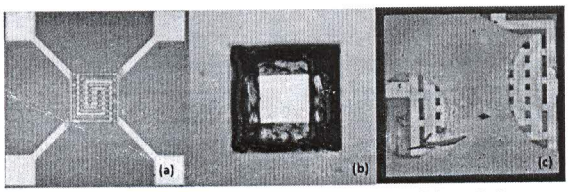

Fig. 1. Fabricated device a) front side of the device b-c) backside during silicon removal. (complete silicon is removed)

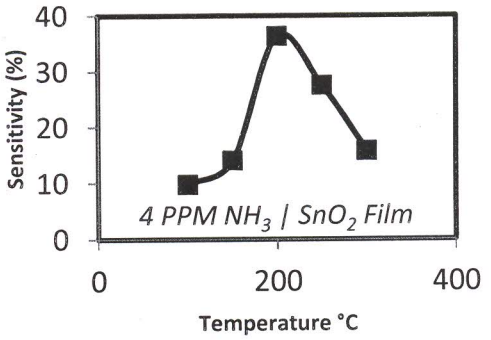

Fig. 2. Temperature optimization curve of SnO2 for ammonia sensing.

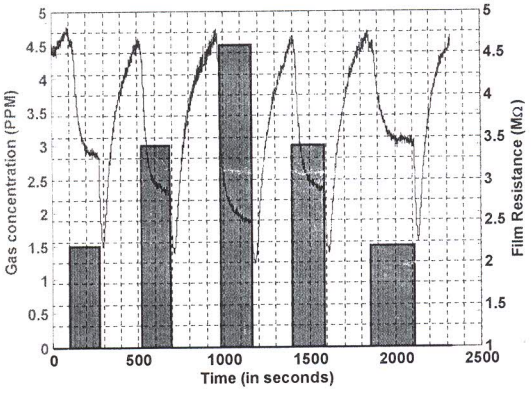

Fig. 3. Sensing characterization of sensor device for 1.5ppm, 3.0ppm and 4.5 ppm.

References

[1]. Kao KW, Hsu MC, Chang YH, Gwo S, Yeh JA. A sub-ppm acetone gas sensor for diabetes detection using 10 nm thick ultrathin InN FETs. Sensors 2012; 12(6): 7157-68.

[2]. Sehnert SS, Jiang L, Burdick JF, Risby TH. Breath biomarkers for detection of human liver diseases: preliminary study. Biomarkers 2002; 7(2): 174-87.

[3]. Humad S, Zarling E, Clapper M, Skosey JL. Breath pentane excretion as a marker of disease activity in rheumatoid arthritis. Free radical research communications 1988; 5(2): 101-6.

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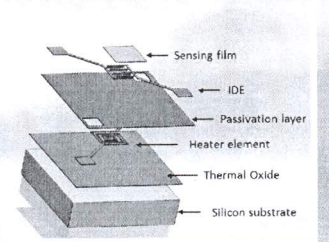
INTRODUCTION

1. Kidney dieses leads to increased ammonia levels in breath.
2. Ammonia concentration > 1 ppm is an indication of kidney related disease(s).
3. MEMS gas sensors consume low power and are highly sensitive.
4. Fabricated Sensors are highly reliable and are suitable for low level ammonia sensing.

MEMS Gas Sensor

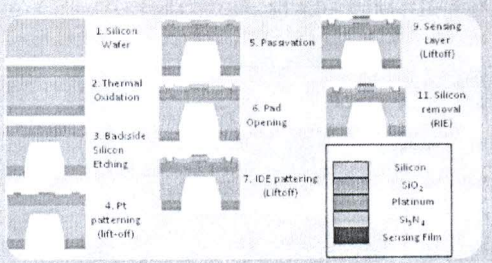


MEMS gas sensor device schematic

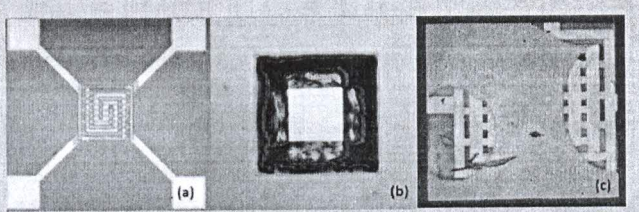
It has three important parts:

1. **Microheater**
2. **Interdigitated electrodes**
3. **Sensing film**

MEMS Gas Sensor Fabrication

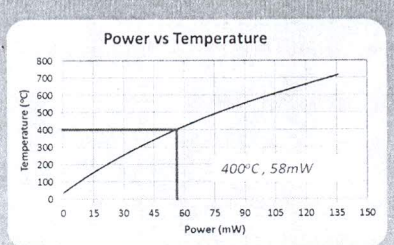


MEMS Gas sensor fabrication flow

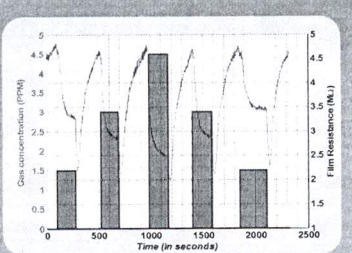


Fabricated device a) front side of the device b-c) backside during silicon removal. (complete silicon is removed)

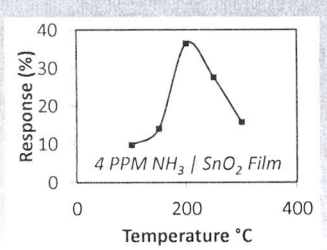
Characterization



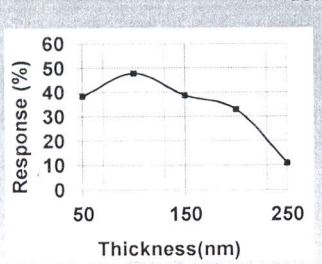
Power consumption vs Temperature



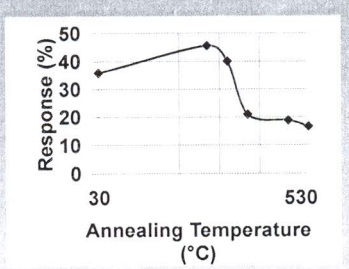
Sensing characterization of sensor device for 1.5ppm, 3.0ppm and 4.5 ppm.



Temperature vs Response : Operating Temperature = 210-220°C



Sensing Film Thickness Optimization



Annealing Temperature Optimization

Conclusions

1. Low concentrations of Ammonia has been successfully measured.
2. Technology has the potential of giving a breath analyzer for kidney dieses detection.
3. Process technology can be extended for other sensing film as well.

Acknowledgements

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References

1. Kao KW, Hsu MC, Chang YH, Gwo S, Yeh JA. A sub-ppm acetone gas sensor for diabetes detection using 10 nm thick ultrathin InN FETs. Sensors 2012; 12(6): 7157-68.
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4. Manolis A. The diagnostic potential of breath analysis. Clinical chemistry 1983; 29(1): 5-1
5. Prajesh, Rahul, Nishit Jain, and Ajay Agarwal. "Low power highly sensitive platform for gas sensing application." Microsystem Technologies (2015): 1-8.