Fabrication and Testing of a Resistive Chemical Sensor

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Abstract

FABRICATION AND TESTING OF A RESISTIVE CHEMICAL SENSOR
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A chemical sensor was designed, fabricated, and tested as part of a Science Research Program between Naples High School and Microelectronic Engineering at Rochester Institute of Technology. The chemical sensor consisted of a polymer carbon film in contact with interdigitated gold electrodes. The electrical resistance is measured using an ohmmeter. Sensed chemical vapors cause the polymer to swell and results in an increase in electrical resistance. The sensor response as a function of time was measured while presenting various amounts and types of chemical vapors. The sensors response and recovery time where found to be a function of the type of chemical and its concentration.
Outline

- Introduction
- Design
- Fabrication Sequence
- Testing
- Results
- Conclusions
- Acknowledgements
- References
Introduction

Chemical sensors can be very specific like the carbon monoxide sensors for home use or less specific like the human nose. Sensors that are very specific require simple evaluation techniques such as the measurement of sensor electrical resistance. The less specific sensors require more complex evaluation techniques such as neural networks and artificial intelligence and usually an array of different sensors. The type of sensor described in this presentation could be of either type described above depending on the type of polymer used on the electrode array.
The objective is to design an electrode that could be combined with a conductive polymer that is sensitive to a single chemical or a variety of chemicals.
Maskmaking

The design file is sent to the MEBES electron beam mask writing machine creating the pattern in chrome on glass at 5X the actual size.
Fabrication Sequence

1. RCA Clean Wafers
2. Grow 5,000 Å oxide
3. Evaporated Chrome and Gold
4. Photolithography for Electrode Pattern
5. Wet Etch Gold
6. Wet Etch Chrome
7. Strip Photoresist
8. Coat with Photoresist to Protect During Sawing
9. Saw Wafers
10. Clean Wafers
11. Attach Clips
12. Apply Polymer
13. Test Sensor

The sensor consists of three layers on silicon substrate

- Insulator
- Gold
- Chrome
- Gold
- Chrome
- Silicon

1000Å
300Å
5000Å
Fabrication Details

Grow Oxide using Bruce Furnace Tube 1
1000 °C for 100 min

gives 0.5 micrometers (5000 Å) oxide
Evaporation of Chrome and Gold metals using the CHA Evaporator (right)

Tungsten Wire Coated With Chrome

Moly Boat for Heating Gold
Fabrication Cont…

Photolithography for metal pattern using Canon Stepper (bottom)

5X Mask
Fabrication Cont...

Etch gold
Etch chrome
Strip photo resist
Fabrication Cont…

Saw Wafers using Wafer Saw

Add Chip Pins (below)

K&S 780 Wafer Saw
Completed Electrodes

Upper Left: Finished Sensor with chip pins
Upper Right: Close up of interdigitated gold fingers
Completed Sensor

Mix a polymer with Carbon Black and apply a thin coat over interdigitated gold fingers.
Manual Testing

The resistance is measured using an ohmmeter. Measurements are taken every 15 seconds. Chemical fumes are presented to the sensor.

![Graph showing Micro Sensor Resistance (ohms) over time.]

**It WORKS!!**
Automated Testing

Computer controlled ohmmeter measures resistance every second for 3 min.

30s off, 30s on, 60s off, 30s on, 30s off
Results

30s off, 30s on, 60s off, 30s on, 30s off
0.5 ml Acetone/ 125 ml bottle = 4000 ppm
Resistance goes from ~100 ohms (no vapor) to ~ 100,000 ohms (with vapor)

30s off, 30s on, 60s off, 30s on, 30s off
Isopropanol ~ 10,000 ppm
No Response
Results

30s off, 120s on, 60s off, 120s on, 30s off
0.1 ml Acetone/ 125 ml bottle = 800 ppm
Resistance goes from ~100 ohms (no vapor) to ~ 4,000 ohms (with vapor)

Sensor shows no response to 1 ppm acetone (just measurement noise)
Conclusions

- The sensor responded to acetone vapor
- The sensor does not respond to Isopropanol
- The response is proportional to vapor concentration
- The recovery time was longer than the response time.
- Sensor does not respond to 1 part per million (ppm)
Future Work

- Testing with different polymers.
- I have designed another sensor that includes a heater that will help decrease the recovery time.
- See how a given sensor responds to an variety of different chemical vapors and concentrations.
Acknowledgements

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References

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Thank You!