Formaldehyde Vapor Sensor

Ola Akinsola, Ricardo Cardoza, Makayla Headley
Gymama Slaughter
Department of Computer Science and Electrical Engineering
Bioelectronics Laboratory

Howard Hughes Medical Institute
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MOTIVATION

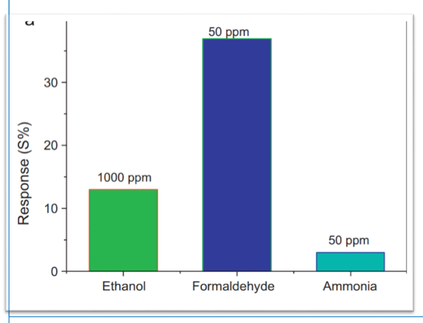
- Various environmental factors that threaten the longevity of art pieces in a museum setting
- Volatile organic compounds, such as formaldehyde is important to detect because of its deleterious effect on art pieces and museum patrons
- Here we designed and fabricated a formaldehyde vapor sensors that is:
  - Cost effective
  - Small and nonintrusive
  - Wireless
  - Low maintenance

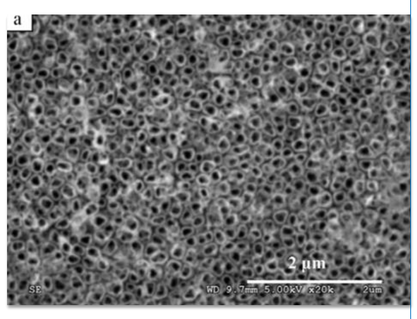
Crystals forming on ceramic piece due to exposure to formic Acid *The Walters Art Museum Part 11051*

PREVIOUS WORK

A Selective Room Temperature Formaldehyde Gas Sensor using TiO_2 Nanotube Arrays

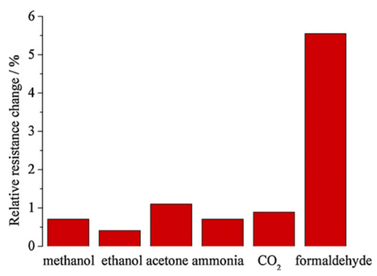
- Gas sensor made up of TiO_2 nanotubes on substrate
- Nanotubes made by electrochemical anodization Demonstrated response to 10 to 50 ppm formaldehyde
- Good selectivity compared to other gases
- Detection limit: 0.04 ppm

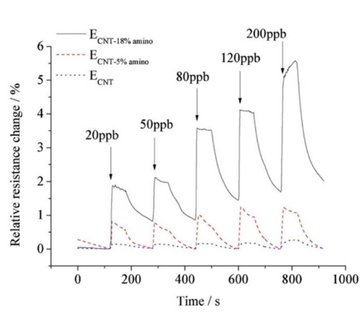




Multi-Wall carbon Nanotube Gas Sensors Modified with Amino-Group to detect low Concentration of Formaldehyde

- Sensors with MWCNTs modified with amino-groups
- Amino groups initiate chemical absorption
- Displayed high selectivity and fast response

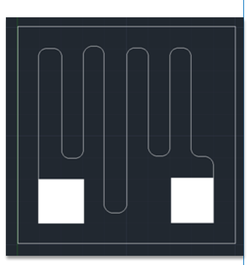




SENSOR FABRICATION

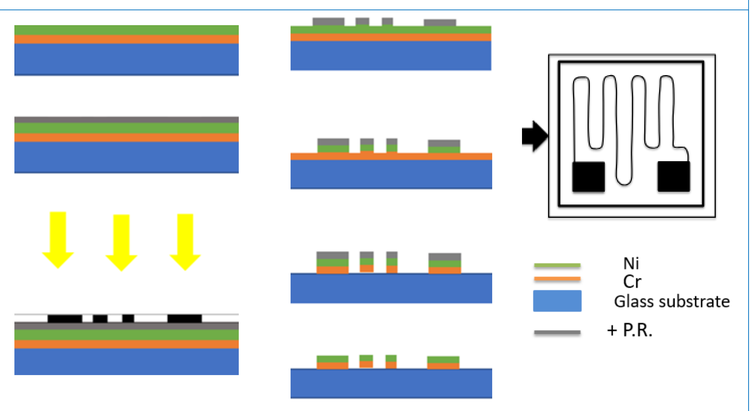
AutoCAD Serpentine Pattern

- AutoCAD → Serpentine pattern → resistive sensor
- Determine the resistance of the sensor where **R** is resistance in Ohms, **L** length of pattern, and **A** is the cross sectional area



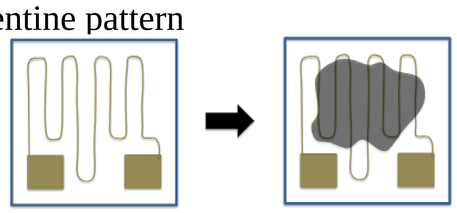
Photolithography

- Photolithography was used to transfer the serpentine pattern on to a Ni/Cr substrate



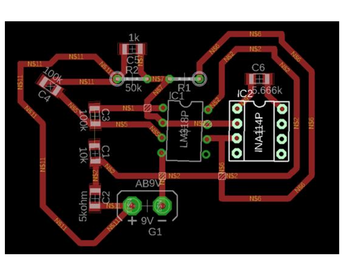
Carbon Nanotubes Application

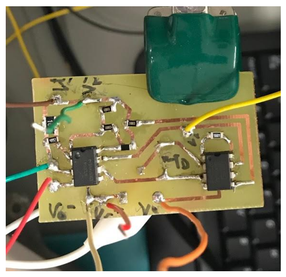
- Carbon Nanotubes shown to increase sensitivity to vapor detection
- Carbon nanotubes applied to a cellulose wafer to make a film that is then applied over serpentine pattern



ANDERSON LOOP

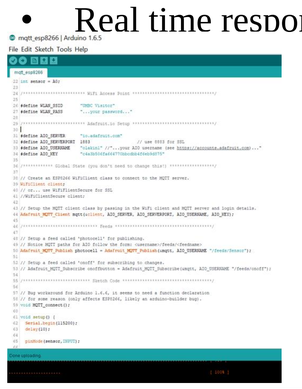
- Anderson loop circuit was implemented on PCB to provide a constant current to the vapor sensor.
- Once fabricated, resistors and Op-amps soldered onto the board
- Constant current produces less noise which leads to more accurate results

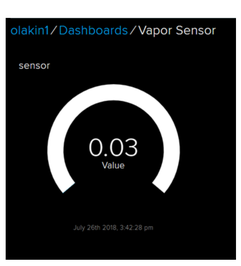


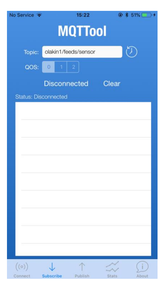


WIRELESSS INTEGRATION

- Cost effective wireless microcontroller used to connect sensor to mobile App
- Multiple sensors can be connected at once
- Real time responses







References

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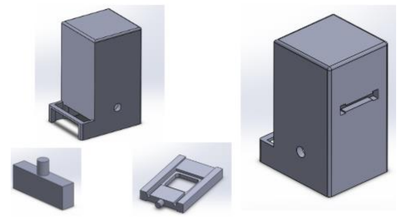
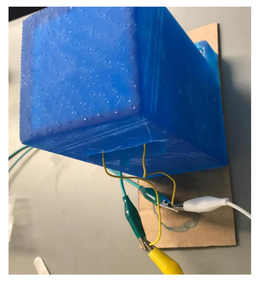
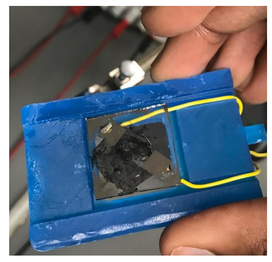
2. Xie, Haifen & Sheng, Changhao & Chen, Xin & Wang, Xingyan & Li, Zhi & Zhou, Jia. (2012). Sensors and Actuators B: Chemical. 168. 34–38.

EXPERIMENTAL SETUP

- Ethanol, Methanol, Acetone, Isopropyl Alcohol, and Formaldehyde
- Vapor chamber used for vapor exposures

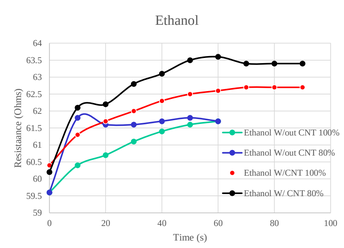


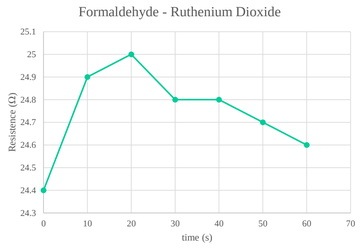


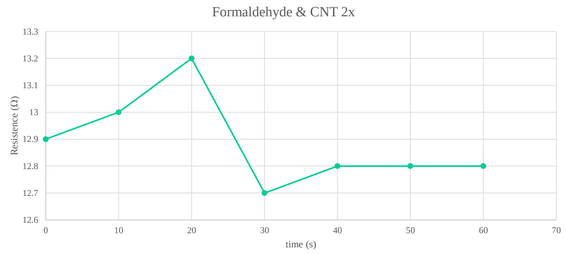


RESULTS

- Gold modified with either CNT or Ruthenium Oxide were used as the vapor sensing element.







CONCLUSION

- Gold Substrate showed promising results and resistance to temperature affects
- Reversibility shown
- Wireless component allows for ease of use
- Small concentrations are able to be detected

FUTURE WORK

- Continue testing with gold modified substrate
- Improve experimental set-up for vapor exposures
- Testing with room temperature vapors
- Implementation at the Walters Museum

ACKNOWLEDGEMENT

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