Development of an Array of Chemiresistive Sensors for Early Detection of Diseases through Breath Analysis

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Breath Analysis for Disease Detection

Traditional methods for the detection and diagnosis of diseases are often invasive, expensive, painful and time-consuming.

Breath analysis is a promising candidate to detect and monitor non-invasively various diseases at their earliest stages [1].

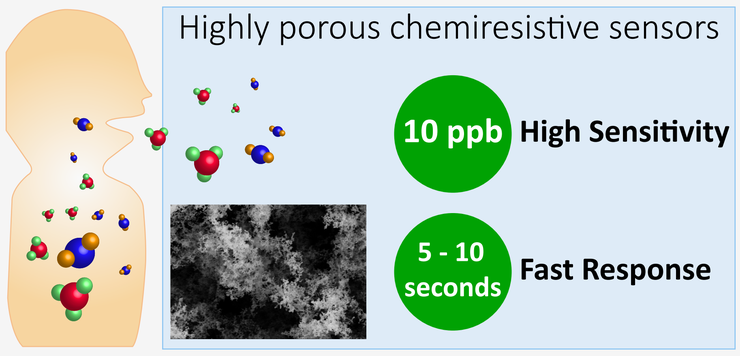
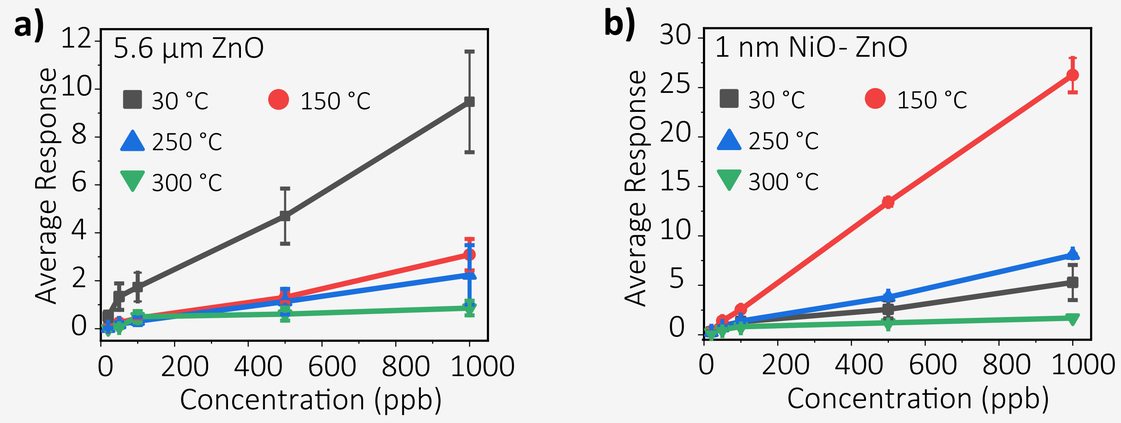
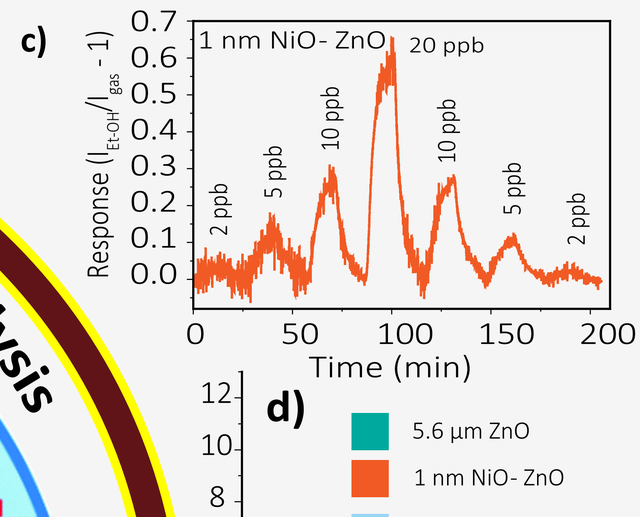


Figure 1. Highly porous chemiresistive sensors in medical diagnostics.

A sensor array offers many advantages over traditional tools such as low cost, fast response, low power comsumption and portability [2].

Simulated Breath Analysis using Chemiresistive Sensors





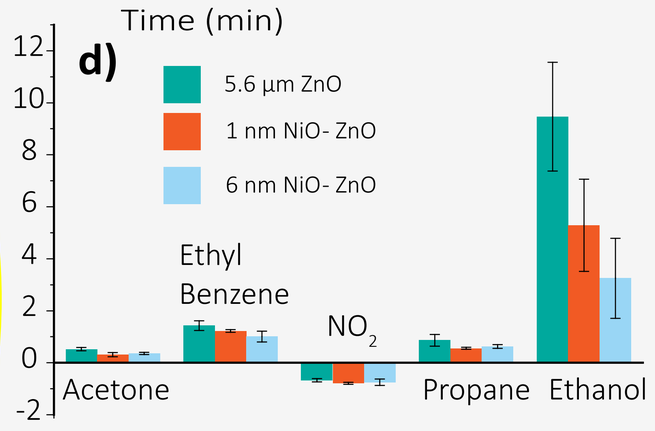
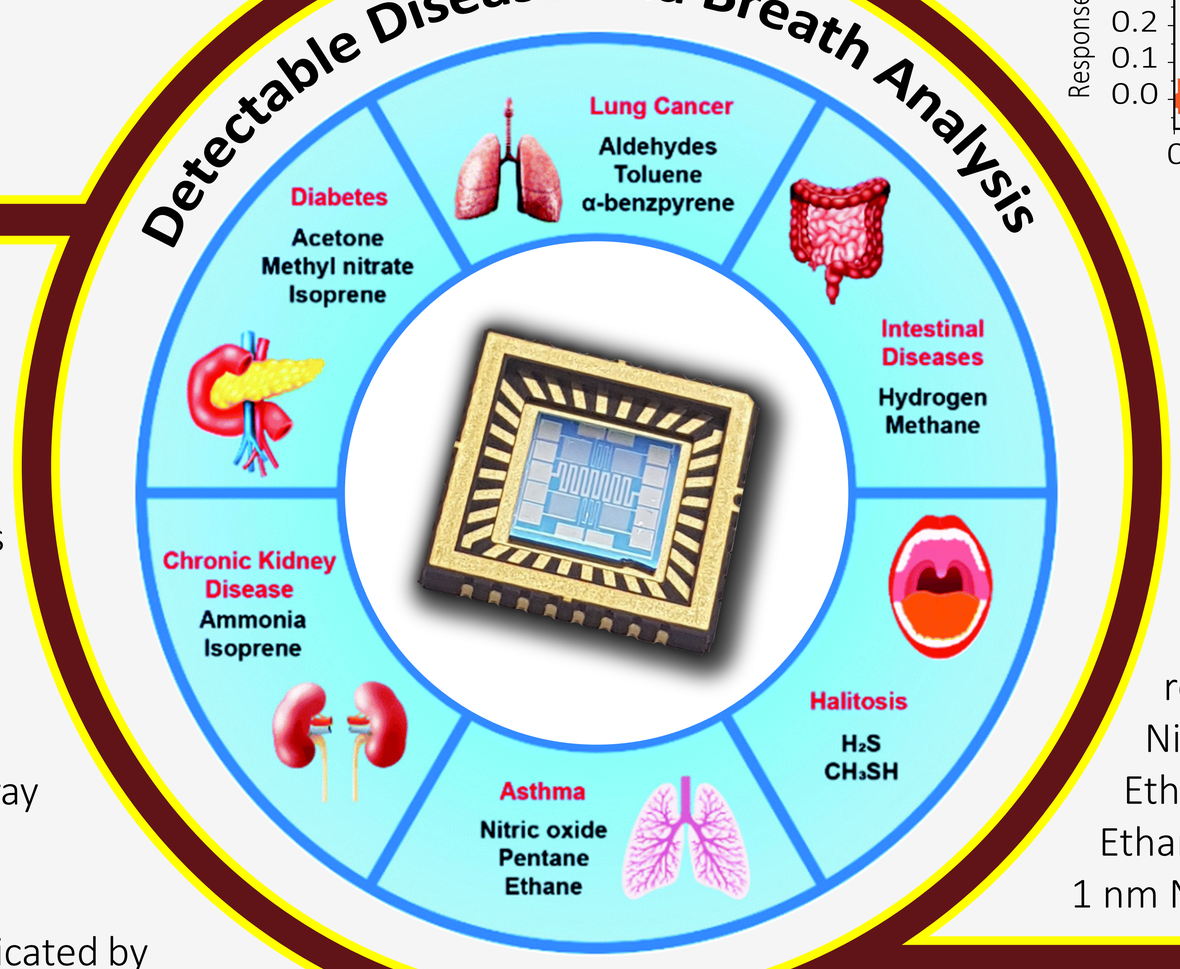


Figure 5. a) 20 ppb- 1 ppm Ethanol responses for ZnO b) for 1 nm NiO-ZnO at various temperatures c) Ethanol response to 2 ppb- 20 ppb Ethanol at 150 °C d) various gases to ZnO, 1 nm NiO-ZnO and 6 nm NiO-ZnO at 30 °C.



Design and Fabrication

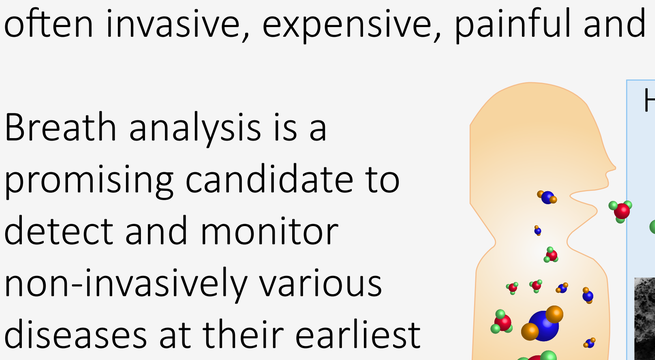


Figure 2. The design of a sensor array with 4 sensors.

A sensor array was designed and fabricated by photolithography process on a 5 mm x 5 mm silicon substrate.

The sensor chip contains 4 sensors, 2 temperature detectors and 1 heating element. All of the components were made of Platinum with a thickness of around 200 µm.

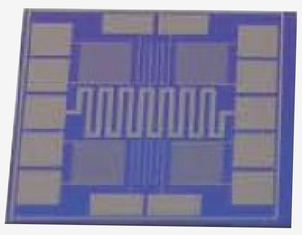


Figure 3. Fabricated sensor array.

Future Research

- Various highly porous materials will be tested for different biomarkers to improve the selectivity.
- An array of 50 sensors would be developed and translated into a portable and a wearable breath analyzer.
- Various sensing technologies would be combined in a single sensor array.

Characterization

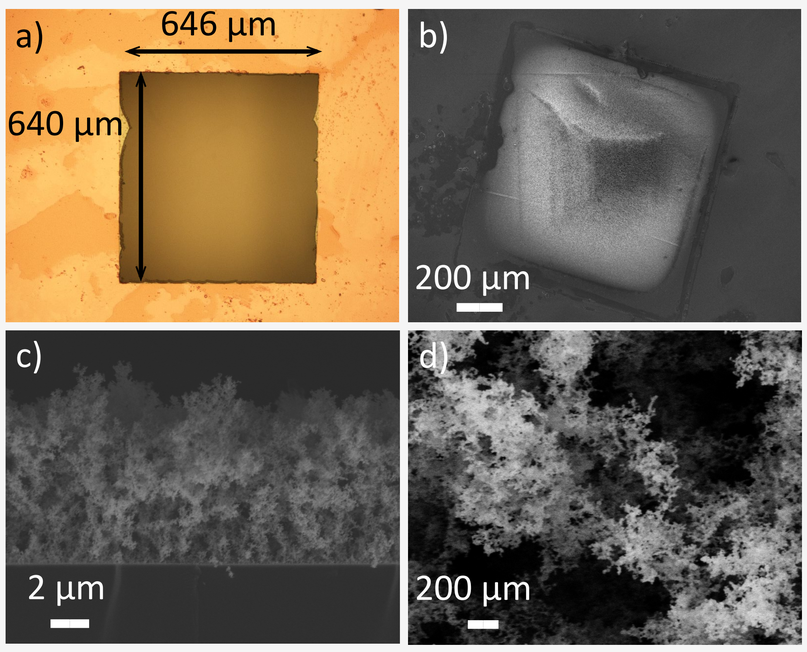


Figure 4. a) Optical microscope analysis of a shadow mask design to deposit sensing materials on a sensor array using flame spray pyrolysis b) SEM analysis of ZnO film (5.6 µm) using the shadow mask c) Cross-sectional SEM analysis of 5.6 µm thick porous ZnO film d) SEM analysis of highly porous ZnO film.

Acknowledgements

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References

1. Behera, B.; Joshi, R.; Anil Vishnu, G. K.; Bhalerao, S.; Pandya, H. J. Electronic nose: a non-invasive technology for breath analysis of diabetes and lung cancer patients. *J Breath Res* **2019**, *13*, 024001-024023.

2. Tricoli, A.; Nasiri, N.; De, S. Y. Wearable and Miniaturized Sensor Technologies for Personalized and Preventive Medicine. *Advanced Functional Materials* **2017**, 27 (15), 1605271-1605290.