In Situ Synthesis of Metal Oxide Nanofiber on Microheater for Low Power Gas Sensing

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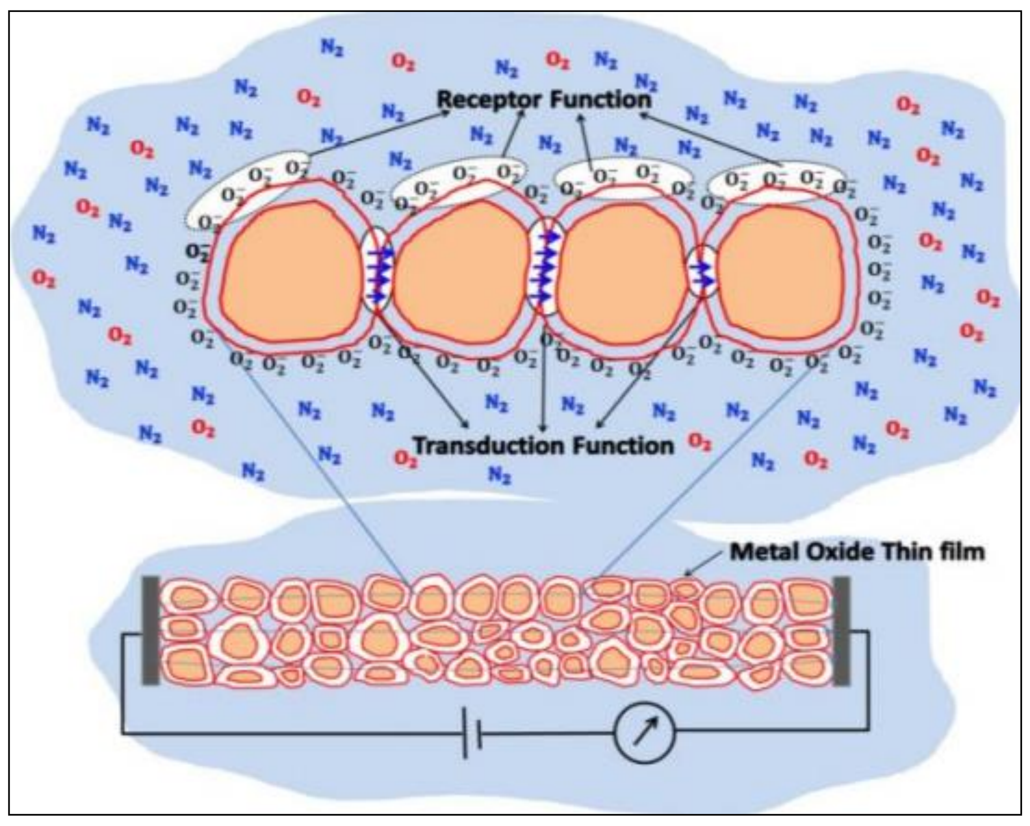
Abstract

There are many common volatile compounds that are highly hazardous to humans. Increasing the accessibility of gas sensing devices will raise awareness of these hazards in order to eliminate or minimize them. Low power consumption is necessary for the incorporation of gas sensors into modern portable electronics such as smartphones, nanostructured metal oxide sensors show the most promise for supplying this necessity. In this experiment, nanostructured metal oxides were synthesized and their morphologies were characterized with Scanning Electron Microscopy (SEM) for the purpose of producing highly responsive low power gas sensing devices. The performance of the synthesized metal oxides was observed by monitoring their electrical resistance over time as a response to an applied gas at multiple different concentrations.

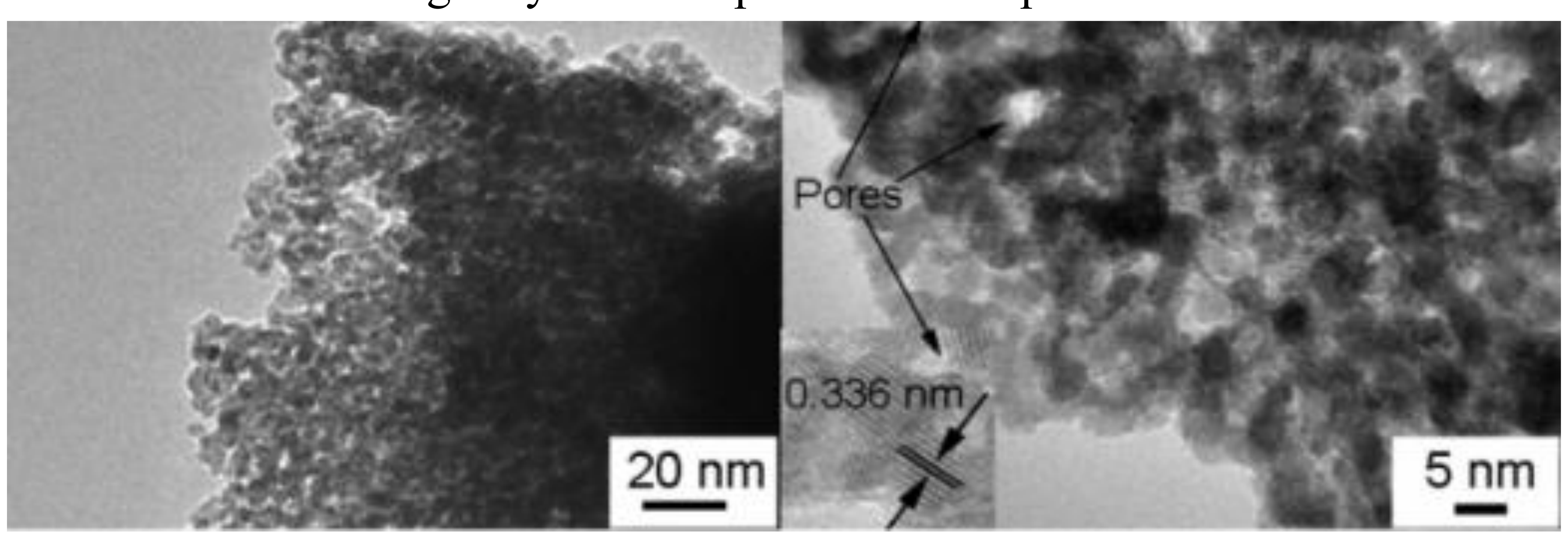
Background

The adsorption or desorption of oxidizing or reducing gas particles on the metal oxide surface change its concentration of charge carriers, which alters the electrical resistivity of the metal oxide.[1] This results in a change in conductivity that is proportional to the surrounding concentration of the oxidizing or reducing gas particles, which is the underlying phenomenon that allows the application of metal oxides as gas sensors.



Metal Oxide Gas Sensing Illustration[1]

Increasing the surface area of metal oxides provides greater contact with surrounding gas particles. Decreasing the volume of the metal oxide lowers the amount of energy required to raise it to a particular temperature. Producing nanostructured metal oxides provide a solution to optimize both parameters. Nanostructured porous tin oxide has demonstrated detection of carbon monoxide using only 7mW of power consumption.[2]



Transmission electron microscopy images of highly porous tin oxide [2]

Methods

- Synthesize a metal oxide precursor solution.
- Deposit the solution onto the microheater by spin coating.
- Plasma etch the deposited solution.
- Anneal *in situ*.
- Characterize the surface using SEM
- Monitor resistance response with respect to variable gas concentration

References

[1] Prabakaran Shankar et al.: Gas sensing mechanism of metal oxides: The role of ambient atmosphere, type of semiconductor and gases - A review. Sci. Lett. J. 2015, 4: 126

[2] In Situ Localized Growth of Porous Tin Oxide Films on Low Power Microheater Platform for Low Temperature CO Detection
Hu Long, Anna Harley-Trochimczyk, Tianyi He, Thang Pham, Zirong Tang, Tielin Shi, Alex Zettl, William Mickelson, Carlo Carraro, and Roya Maboudian
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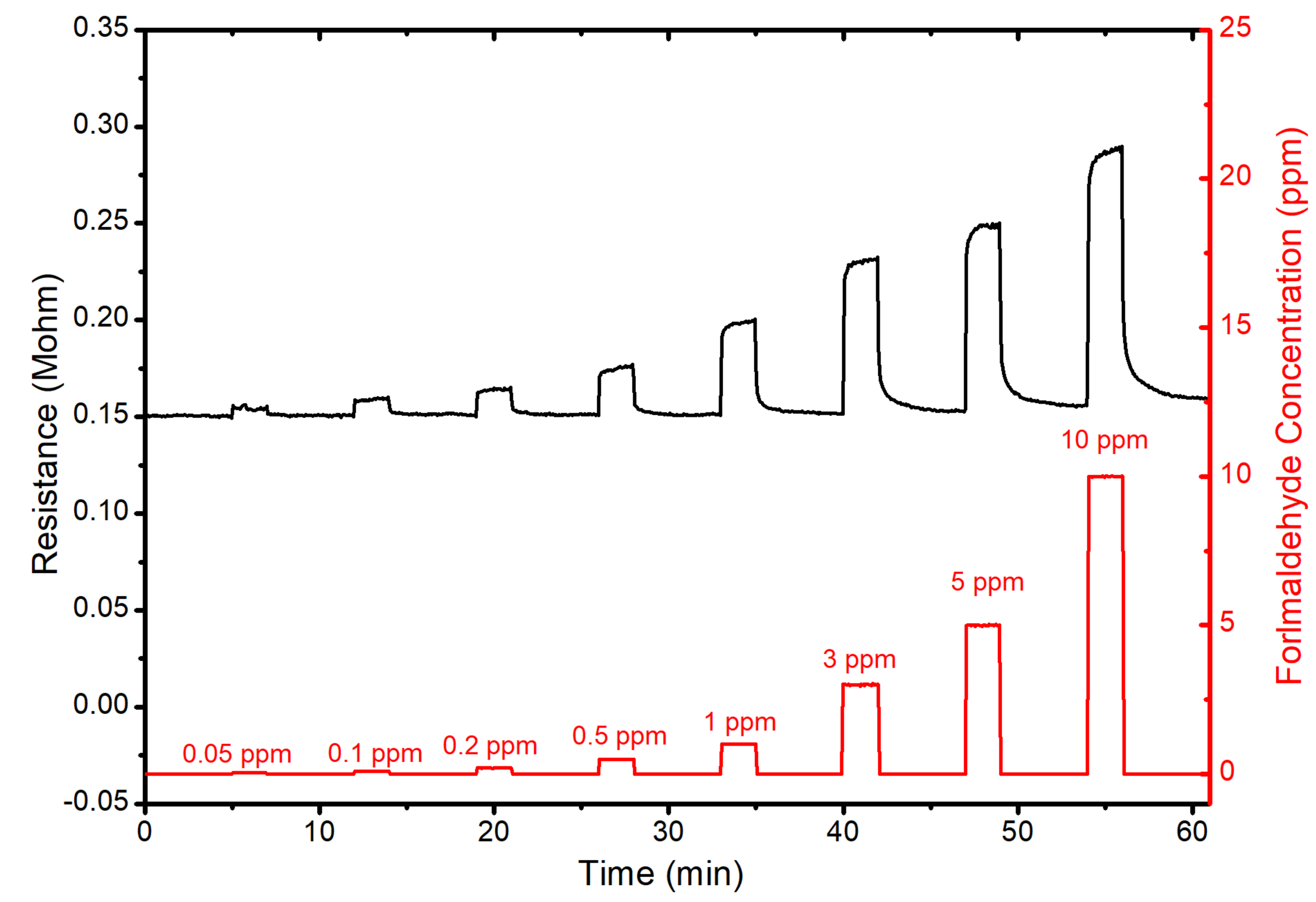
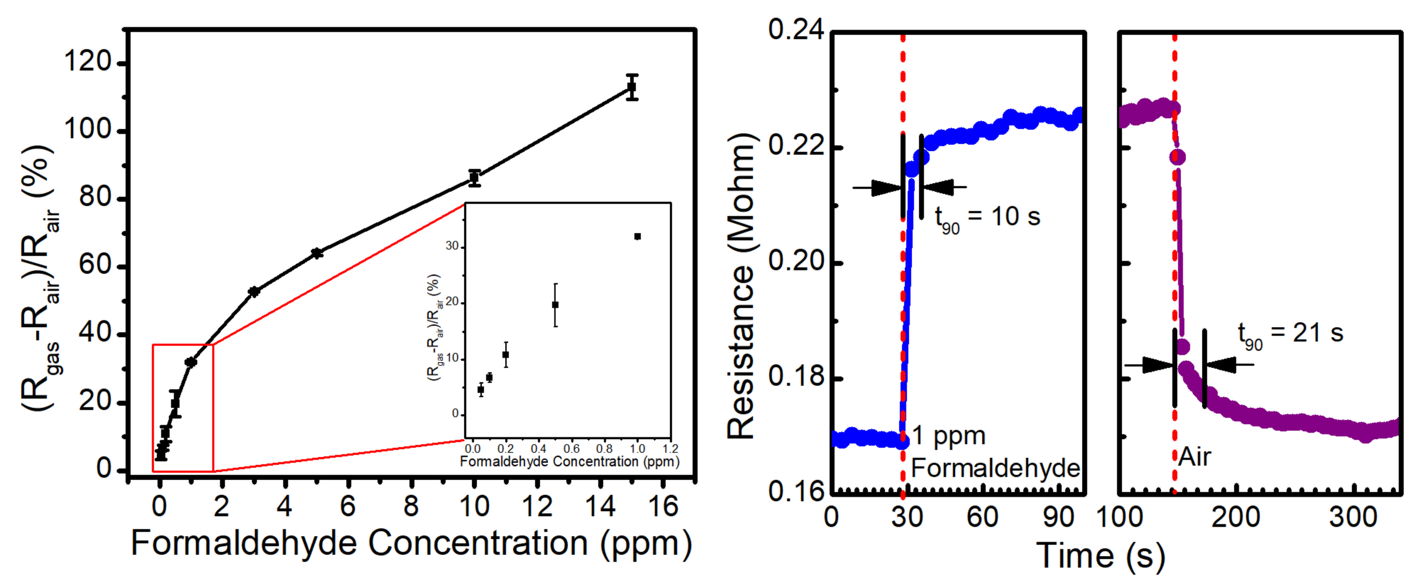
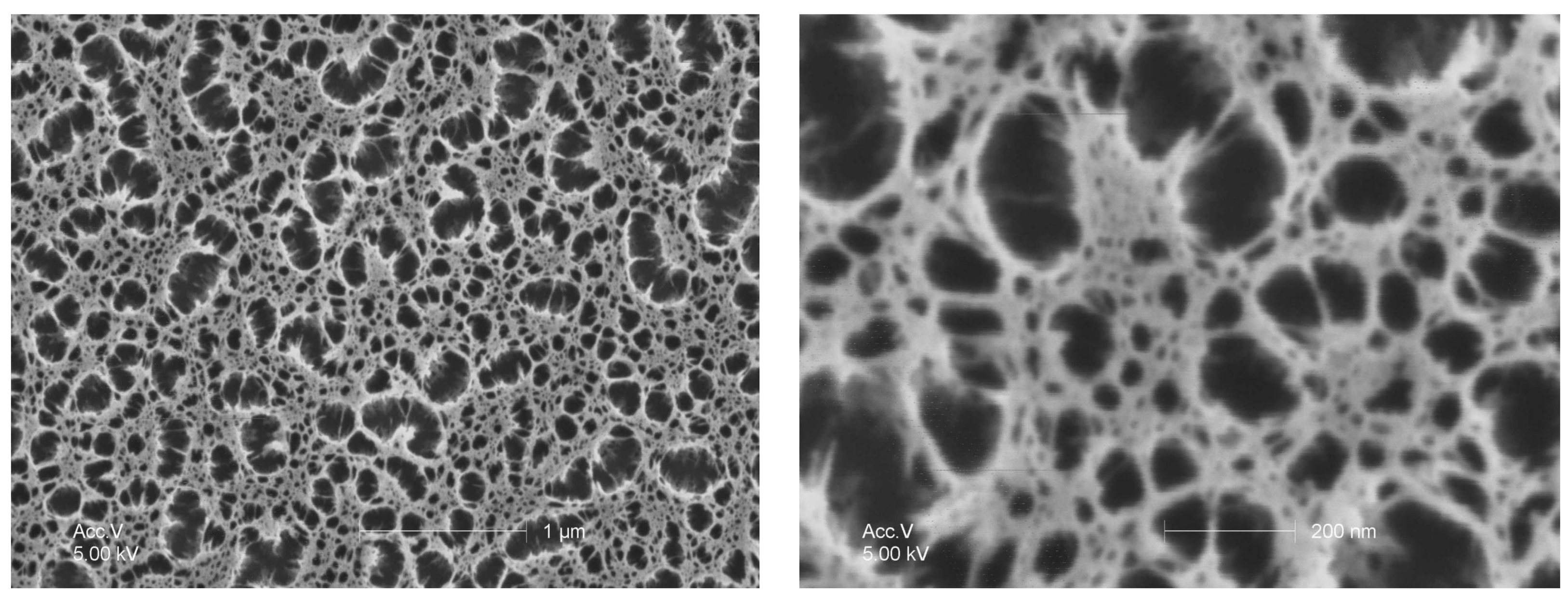
Results





Response of cobalt oxide with respect to formaldehyde gas



SEM images of indium oxide. 65k times magnified on the left, 250k on the right

Conclusion

This method has demonstrated to produce metal oxide fibers that are highly responsive to variations in gas concentration with a fast response time and low power consumption.

Future Work

More metal oxides should be produced from this method and tested in order to form an array of different metal oxides to produce separate response signals for differentiating between distinct gas species .

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