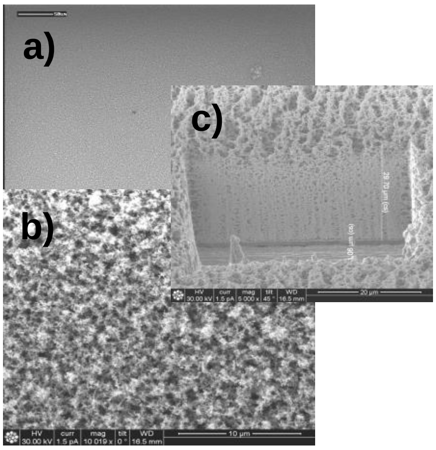
EBERHARD KARLS UNIVERSITÄT TÜBINGEN

Low Cost Sensor for Online-Monitoring of Formaldehyde

Technology Description



a) Scanning electron microscope picture of the surface topology of the sensitive $In_4Sn_3O_{12}$-layer (scale bar = 50 µm)
b) Scanning electron microscope picture of the surface topology (scale bar = 10 µm)
c) Cross section of the sensitive layer (scale bar = 20 µm)

Formaldehyde is well known for its negative effects on humans. The World Health Organisation (WHO) classifies it as a “known human carcinogen”. In Germany maximum workplace concentration (AGW-Value) is 0.3 ppm, the legal benchmark for indoor concentration amounts to 0.1 ppm. The State of California allows annual average levels (REL) for indoor air of only 0.002 ppm. Nevertheless the substance is widely used in building materials, furniture or clothing. The worldwide annual production amounts to 20 million tons.
So far the analysis of indoor concentrations is only possible via expensive methods, normally requiring GC or HPLC analysis in the lab. So called MOX (metal oxide) sensors theoretically permit an online-monitoring, but there is so far no instrument available for the detection of relevant concentrations in the ppb-range at reasonable costs.
Our invention presents a novel MOX-sensor based on $In_4Sn_3O_{12}$ as sensitive layer with sensitivities for formaldehyde being two orders of magnitude above those of established reference sensors. Our sensor allows an online/realtime-monitoring of formaldehyde in day to day settings, at low cost. The invention also describes the methods for the production of the sensitive layer, which consists of nanocrystalline $In_4Sn_3O_{12}$.

Innovation

Now:

- MOX-sensor with $In_4Sn_3O_{12}$ as sensitive layer
- Excellent cross selectivity to CO/CO_2
- Online-detection of formaldehyde in the range of 5 - 300 ppb

Up to now:

- MOX-sensors consisting of less sensitive NiO, SnO_2:Sb, Pd, Pt, ZnO
- Low sensitivity for formaldehyde compared to cross interferences from carbon monoxide, hydrogen and benzene
- Online-detection difficult because sensors detect in the range of 1 -500 ppm

Applications

The new sensor is suitable for permanent online-measurement and will allow realtime monitoring of formaldehyde:

- In companies, for the control of air quality, thus ensuring employees health
- At home, for the control of air quality, ensuring a secure surrounding
- For an efficiency monitoring for formaldehyde filter applications

Proof of Concept

Please turn over for further details

Requested Cooperation/IP Status

Industrial partner for licensing
EP patent granted, Priority date**:** 2010-07-13

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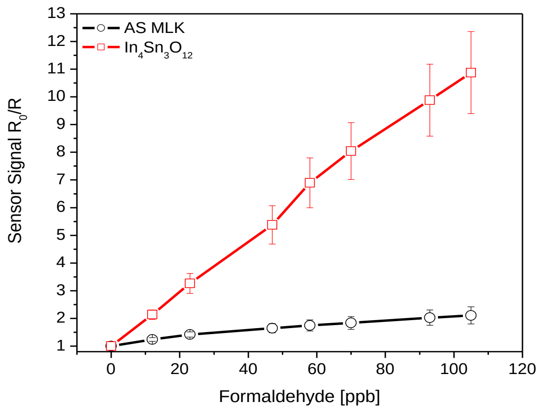
EXPERIMENTAL DATA

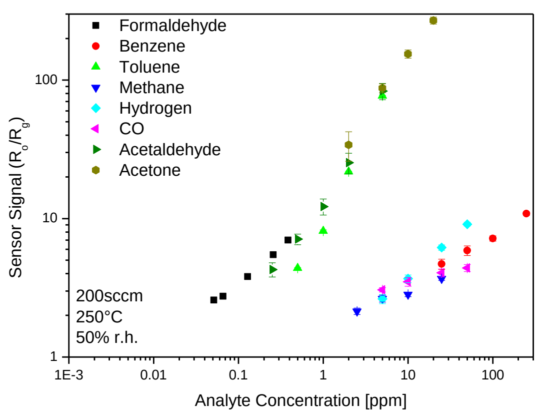
High Sensitivity for Formaldehyde compared to a Reference Sensor



Our new sensor outperforms the given reference sensor.

Calibration curve of our new formaldehyde sensor, employing $In_4Sn_3O_{12}$ as a sensitive layer, is shown in red.
Calibration curve of a sensor purchased from company Applied Sensor, Germany, is shown in black. In this specific case, this sensor is chosen as a reference sensor because of its performance; it is the best performing, commercially available sensor for formaldehyde detection, as proven by an inhouse semiconducting metal oxide based sensor screening.

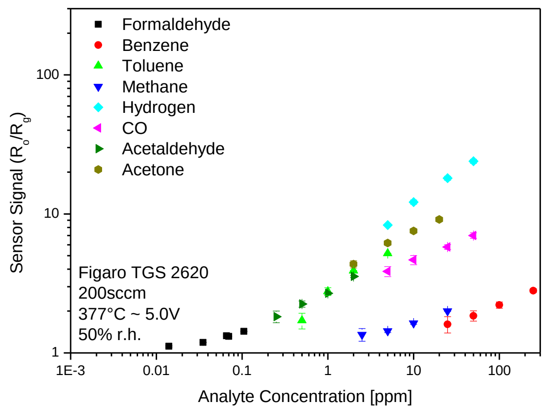
Higher Selectivity for Formaldehyde compared to other Indoor Air Pollutants



Given here, the cross selectivity investigation of our new sensor employing $In_4Sn_3O_{12}$ in regard to most common indoor air pollutants.

There are two types of responses as indicated by the different slopes of the calibration curves. Whereas the sensor shows a great sensitivity for the group of aldehydes (including the ketone), he doesn't respond likewise to small molecules (H_2, CO, CH_4) and benzene. This feature raises the opportunity to selectively sense for example formaldehyde in the presence of CO and alike. For a de novo identification of formaldehyde within an unknown mixture of gases in, for example, indoor air, a combination with further sensors might be necessary.

Better Discrimination than Commercially Available Products



Cross selectivity investigation of the Figaro TGS 2620 sensor (the standard reference sensor in our lab) in regard to the most common indoor air pollutants.

As can be seen, the TGS sensor is not able to distinguish between gases like formaldehyde, CO and hydrogen since the calibration curves do have approximately the same slope.

REFERENCES

Jens A. Kemmler, Suman Pokhrel, Johannes Birkenstock, Marco Schowalter, Andreas Rosenauer, Nicolae Bârsan, Udo Weimar, Lutz Mädler: Quenched, nanocrystalline $In_4Sn_3O_{12}$ high temperature phase for gas sensing applications, , Sensors and Actuators B, 161, 2012, 740-747.

J. Kemmler, S. Pokhrel, L. Mädler, U. Weimar, N. Barsan: Flame spray pyrolysis for sensing at the nanoscale, Nanotechnology, 24, 2013, 1-14.