Metal Oxide Semiconductor (MOS) Sensors

Reliable detection in a MOS environment

AppliedSensor metal oxide semiconductor (MOS) sensors use metal oxide-based sensing thick films deposited onto a Si-micro-machined substrate (micro sensors). The substrate contains electrodes that measure the resistance of the sensing layer, and a heater that heats the sensing layer to 200°C to 400°C.

The sensor responds to changes in the composition of the ambient atmosphere with a change in the resistance of the sensing layer. A large number of toxic and explosive gases can be detected, even at very low concentrations.

Micro sensors operate in wide ambient temperature

MOS sensors detect a wide range of gases, including CO, NO_2, NH_3, H_2S, CH_4, and a wide variety of volatile organic compounds (VOCs). These maintenance-free sensors show high sensitivity, good stability, long lifetime, and short response/recovery times. They can be operated in a wide ambient temperature range (-40°C to +70°C) and a humidity range of 0 to 100% RH without condensation.

Miniaturization possibilities

The gas sensor and heating element in AppliedSensor MOS sensors is integrated on a thermally isolated membrane, resulting in low power consumption and a low thermal time constant. Compact and power efficient, these micro sensors are well suited for installation in battery-operated devices.

Key Benefits

- High sensitivity and short response/recovery times
- Highly stable with long product life
- Detects ranges of gases, including CO, NO_2, NH_3, H_2S, CH_4 and a wide variety of VOCs
- Energy efficient low power consumption
- Small size for convenient installation
- Well suited for installation in battery operated devices

Applications (Target Gas)

- Automotive (CO and NO_2)
- Indoor air quality (CO and VOCs)
- Safety (CO, CH_4, propane)
- Consumer (VOCs)

Chemical Principle

The sensing layer is a porous thick film of polycrystalline SnO_2. In normal ambient air, oxygen and water vapor-related species are adsorbed at the surface of the SnO_2 grains. The sensing of target gases takes place as follows:

For reducing gases such as CO or H_2, a reaction takes place with the pre-adsorbed oxygen and water vapor-related species which decreases the resistance of the sensor. For oxidizing gases such as NO_2 and O_3, the resistance increases. The magnitude of the changes depends on the microstructure and composition/doping of the base material, on the morphology and geometrical characteristics of the sensing layer and substrate, as well as on the temperature at which the sensing takes place. Alterations of these parameters allow for the tuning of the sensitivity towards different gases or classes of gases. (See Figure 1.)

Transducer Principle

The changes in composition of the ambient atmosphere will determine changes in resistance of the sensing layers. In practice, the relationship between sensor resistance and concentration of the target gas usually follows a power law. Over a large range of concentrations, it can be described by:

$$R \cong K \cdot c^{\pm n}$$

"c" is the concentration of the target gas, "K" is a measurement constant, and "n" has values between 0.3 and 0.8. The positive sign is used for oxidizing gases and the negative sign for reducing gases.

Figure 2 shows a basic electrical circuit, which can be used for measurement of the sensor resistance R_S:

- The heating voltage V_H is applied between 1 and 3; typical values for both types of sensor are between 2 and 5 V.
- The measuring voltage VS is applied between 2 and 4; it is recommended that the value should not exceed 5 V. For determination of the R_S, V_{out} is measured and R_L is known.

The relationship between R_S and V_{out} is:

$$R_S = R_L \left(\frac{V_S}{V_{out}} - 1 \right)$$

Typical Response Curves

Figures 3 and 4 show typical behavior for a thick-film MOS sensor when exposed to a series of CO pulses. The sensor resistance drops very quickly immediately after CO exposure, and after removal of CO from the ambient atmosphere, the sensor resistance will recover to its original value after a short time. The speed of response and recovery will vary according to the operation temperature, the type of sensing layer, and the gases involved.

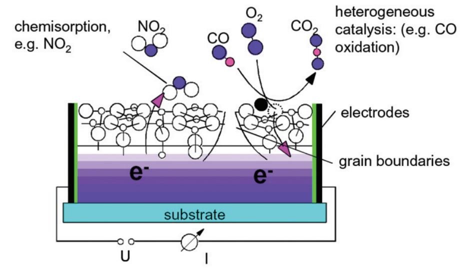

Figure 1: Sketch of an MOS sensor illustrating the detection principle. The resistance of the sensing layer changes when molecules react on the surface.

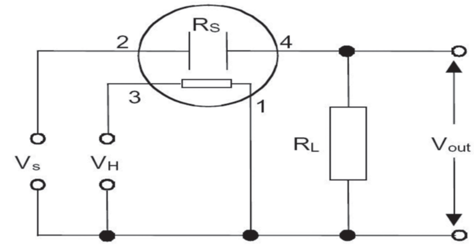

Figure 2: Electronic circuitry for operation of an MOS sensor with heater.

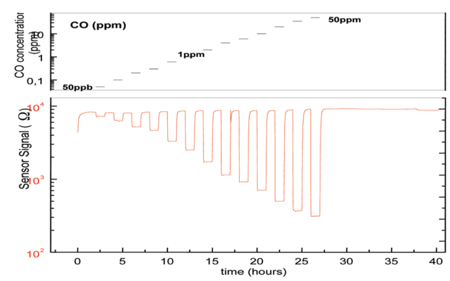

Figure 3: Response of a thick-film MOS sensor to CO.

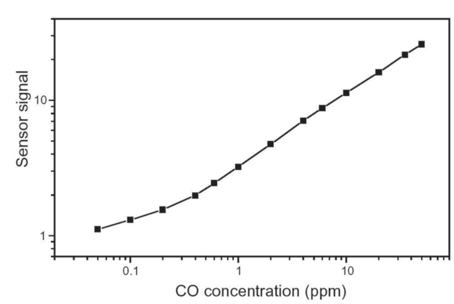

Figure 4: CO concentration vs. sensor signal for a thick-film MOS sensor.

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