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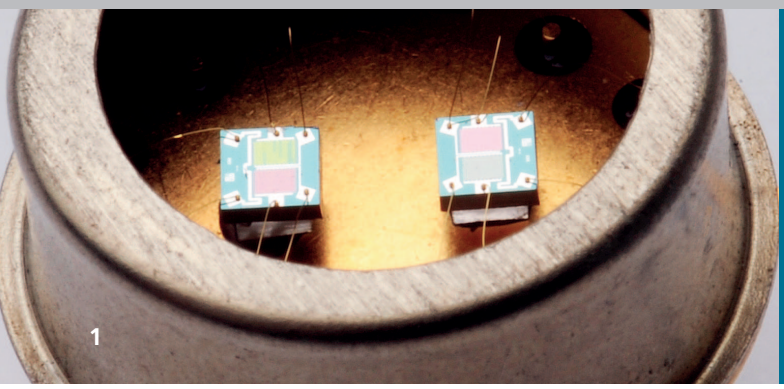


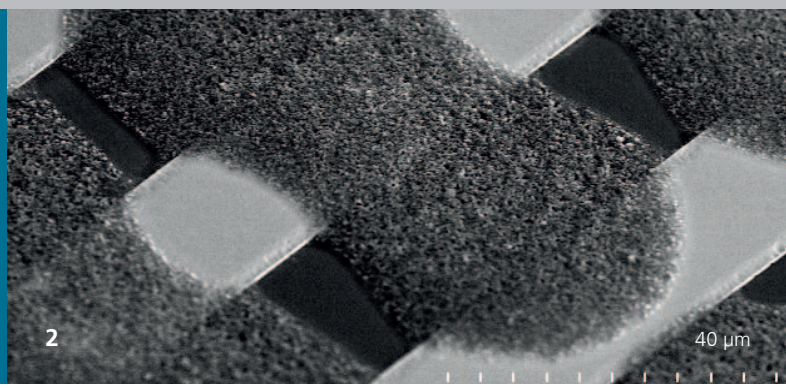


1 *Metal oxide gas sensor array with four different sensitive elements.*
2 *Inkjet printed chromium-titanium oxide layer.*

# SEMICONDUCTOR GAS SENSORS

## USING THIN AND THICK FILM TECHNOLOGY

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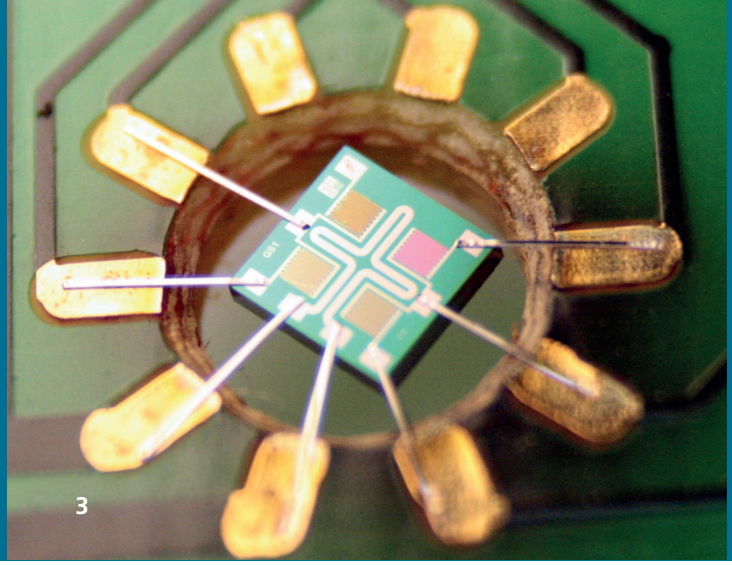
### Method

Semiconductor gas sensors (metal oxide sensors) are electrical conductivity sensors. The resistance of their active sensing layer changes due to contact with the gas to be detected. In the ideal case, the gas reacts with the sensor surface in a completely reversible reaction. Due to their chemical composition and properties, metal oxide gas sensors are well-suited for a wide range of applications and for the detection of all reactive gases. Depending on the material used and the gases that need to be detected, typical operating temperatures range between 300°C and 900°C. Fraunhofer IPM develops application-specific semiconductor gas sensors with metal oxides such as $SnO_2$, $V_2O_5$, $WO_3$ and $Cr_{2-x}Ti_xO_{3+z}$. If required, catalysts such as Pt or Pd are used. The sensitive metal oxide layers are applied on customer-specific substrates using thin or thick film technology by sputter and evaporation systems or inkjet printers.

### Application Areas and Measuring Range

Semiconductor gas sensors can be used for a wide array of applications, ranging from safety equipment (explosion, leakage, fire, contamination and poisoning protection) up to emissions and air quality monitoring, quality assurance, process instrumentation and measurement technology. For example, gases such as carbon monoxide (CO), nitrogen oxide ($NO_x$), ammoniac ($NH_3$), sulfurous gases ($H_2S$, $SO_2$) and hydrocarbons ($C_xH_y$) as well as volatile organic compounds (VOCs) can be detected. The measuring range depends on the gas being detected and covers from a few ppb into the percent range. The detection limit depends on the respective gas sensitive material.



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## Power Consumption

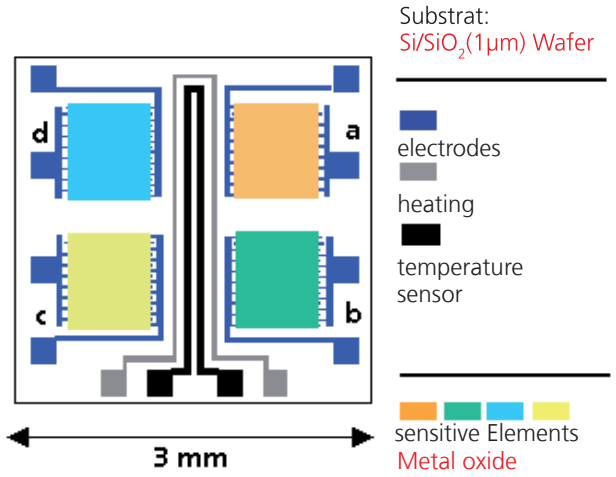
The power consumption of the metal oxide gas sensors varies based on the design of the sensor. Fraunhofer IPM standard sensors, i.e. sensors on Si bulk substrates, require approximately 1.3 W of power (at 350°C). The power consumption can be reduced by the thermal decoupling of the sensor from the housing, for example through the use of micromechanical structures, called »micro-hotplates«. The power consumption of sensors of this type is less than 150 mW. In addition, such designs can be operated with quick temperature changing cycles. This type of sensor configuration can be heated up in a few ms.

## Gas specific Sensor Characterization

To qualify the gas sensors, Fraunhofer IPM has its own in-house gas test bench. The test bench can be used to subject the sensors simultaneously to eight different test gases and record the signals of the sensor.

**Power Consumption**

| | | |
|---|---|---|
| *Sensor on Si Bulk substrate* | *Quartz glass spacer as heat sink*<br>*Contact via Au bonding* | *approx. 1300 mW* |
| *Sensor suspended in housing* | *Contact via Pt welding* | *approx. 700 mW* |
| *Sensor on Si hotplate or Si membrane* | *Contact via Au bonding* | *approx. 100 mW* |

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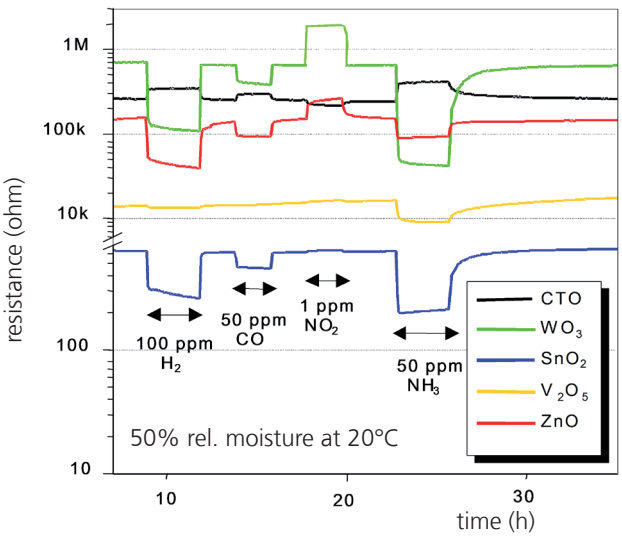


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3 *Gas sensor array suspended in the housing.*

4 *Schematic diagram of a metal oxide gas sensor array.*

5 *Sensor response of metal oxide gas sensor array to various test gases.*