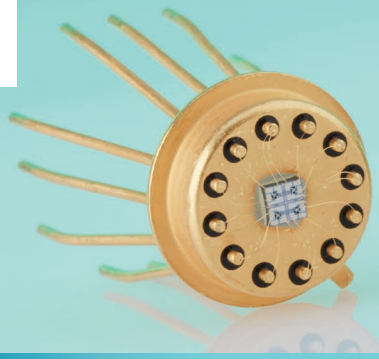
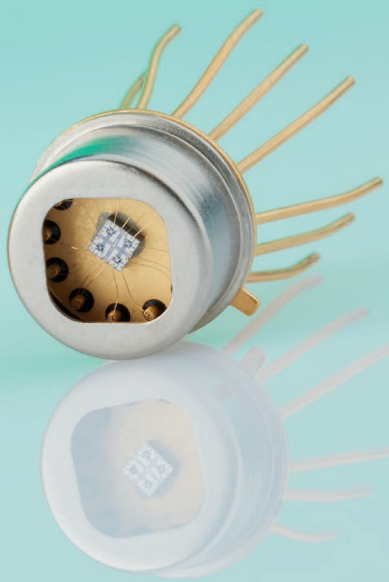
Fraunhofer IPM





Semiconductor gas sensors

Small, low-power and cost-efficient

Small and conductive metal oxide gas sensors: The array with four gas-sensitive elements is placed on a chip surface of 1.6 × 1.6 mm².

In recent years, semiconductor gas sensors (or metal oxide sensors, MOX) have become smaller and more powerful. At the same time, they also continue to consume less energy. Thanks to innovative manufacturing methods, miniaturized gas sensors can currently be produced in large volumes and with a low cost factor.

Wide range of applications

Semiconductor gas sensors (or metal oxide sensors, MOX) are increasingly used in environmental monitoring, in industry, and also in everyday life. They monitor the concentration of toxic gases, outdoors as well as indoors such as in buildings or vehicle cabins. Semiconductor gas sensors perform important measuring tasks in safety technology, the food industry, air conditioning technology, or medicine. In the future, new-generation gas sensors will also play a role in the networked production of Industry 4.0.

Fraunhofer IPM can draw on more than 20 years of experience in the development of semiconductor gas sensors. Research focuses on the development and modification of gas-sensitive materials, sensor substrates as well as methods for the cost-effective production of the materials and sensors.

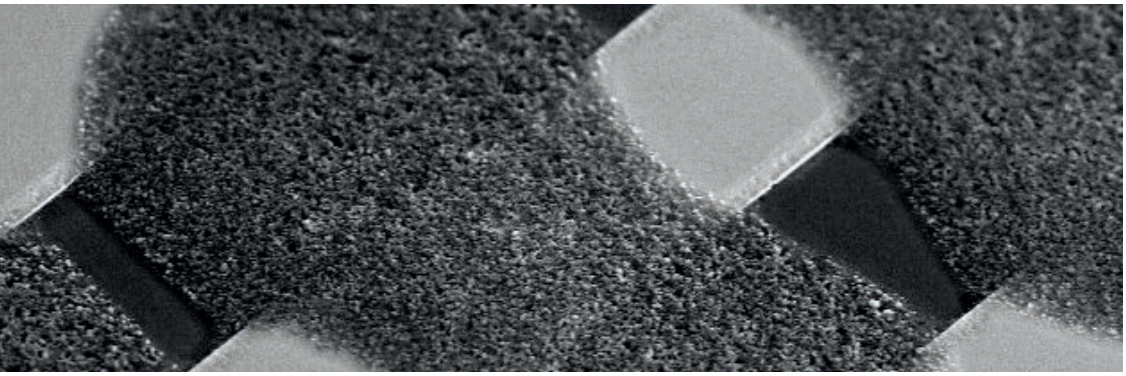
The power consumption of MOX gas sensors depends on the construction of the sensor. Sensors on Si-bulk substrates require a power output of approx. 1 watt (at 400 °C). Micromechanical superstructures, so-called micro-hotplates, ensure a thermal decoupling of the sensor from the housing and thus significantly reduce power consumption.

Optimized sensor design

Sensors designed by Fraunhofer IPM typically have gas-sensitive surfaces of 45 × 45 µm², with the total surface of the sensor array measuring 1.6 × 1.6 mm². The structures are generated by wet chemical etching. At an operating temperature of 400 °C, sensors of this type operate using less than 15 milliwatt, so that battery operation is basically possible. Micro-hotplate arrangements also allow operation with rapid temperature changing cycles. The heating times of this sensor construction lie in a range of a few milliseconds.

Our offer

- Development of materials tailored to customer needs and specific applications
- Development of custom-tailored substrates and sensor geometries
- Gas specific characterization of sensors, benchmarking
- Concepts for sensor manufacturing
- Technology consulting



Printed chromium-titanium-oxide layer on platinum structures

Gas-sensitive materials

The gas-sensitive metal oxide layers are deposited on a non-conducting substrate such as ceramic, silicon or on customer specific materials using thick- or thin-layer technology. Current coating procedures are sputtering and evaporating, but also the printing of gas-sensitive inks.

For the manufacture of low-power sensors, printable metal oxide inks specially developed by Fraunhofer IPM are deposited onto a substrate. A photolithographic process is not required in this case. The particularly porous printed layers ensure a favorable surface-to-volume ratio, resulting in higher sensitivity. Sensitive materials used are metal oxides such as tin oxide with a platinum or palladium addition, lanthanium-indium-oxide, tungsten oxide or chromium-titanium-oxide. The sensor layout, for example, features four semiconductor gas sensors based on these metal oxides, so that a large bandwidth of relevant gases can be detected. To increase the selectivity, each sensor can be heated separately and placed on a separate sensor platform.

Gas-dependent characterization

Fraunhofer IPM has its own gas measurement stand for the qualification of gas sensors. This measurement stand allows for a simultaneous application of up to eight test gases, the regulation of temperature, gas flow and humidity as well as the recording of the resulting signal paths. By default, N_2, O_2 or up to eight different test gases can be applied simultaneously.

Semiconductor gas sensors

Semiconductor gas sensors (also: metal oxide sensors, MOX) are electrical conductivity sensors. The resistance of its active sensor layer changes upon contact with the gas to be detected. MOX gas sensors react to almost all reducing and oxidizing gases and thus not only enable the detection of trace gases such as carbon monoxide (CO), nitric oxides (NO_x), ammonia (NH_3), sulfurous gases (H_2S, SO_2), hydrocarbons (C_xH_y), but also the analysis of complex aromas such as volatile organic compounds (VOCs). A high level of selectivity is achieved through a suitable chemical coating. Depending on the material and target gas, operating temperatures between 300 °C and 900 °C are necessary to ensure the intrinsic conductivity of the sensor. The sensitivity level depends on the gas and ranges from a few ppb to the percentage range. The detection limit depends on the gas-sensitive material.

Power consumption

Sensor on Si-bulk substrate	Quartz-glass spacer as heat sink Contacting via Au-bonds	up to 1300 mW
Sensor freely suspended in the housing	Contacting via Pt-gap welding	approx. 700 mW
Sensor on Si-hotplate or Si-membrane	Contacting via Au-bonds	< 100 mW

All specifications and features are subject to modification without notice.

Contact

Dr. Benedikt Bierer
Group Manager Integrated Sensor Systems
Phone +49 761 8857-263
benedikt.bierer@ipm.fraunhofer.de

Fraunhofer Institute for Physical Measurement Techniques IPM
Georges-Köhler-Allee 301
79110 Freiburg, Germany
www.ipm.fraunhofer.de/en