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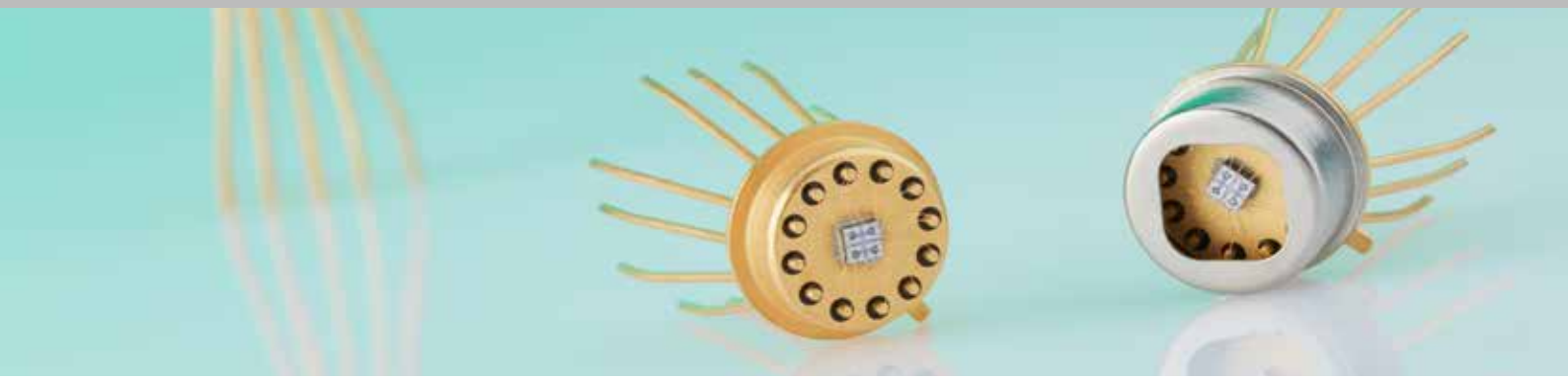
FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES IPM



^ *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.*

SEMI-CONDUCTOR GAS SENSORS

In recent years, semi-conductor 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. That is why in future such sensors will not only be used in industry, but increasingly also in everyday life. Digitization in the "smart home" and in vehicles, but also mobile applications – for example for the monitoring of certain vital functions – are driving the use of miniaturized semi-conductor gas sensors. Aside from established applications in safety technology, the food industry, air conditioning as well as in medicine, the new generation of gas sensors will in future also handle measuring tasks in the networked production of Industry 4.0.

Fraunhofer IPM can draw on more than 15 years of experience in the development of semi-conductor 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.

"Low power": optimized sensor design for low power consumption

The power consumption of metal oxide gas sensors (MOX) depends on the construction of the sensor. Sensors on Si-Bulk substrates require a power output of approx. 1 watt (at 400 °C). Micro-mechanical superstructures, so-called "micro-hotplates", ensure a thermal decoupling of the sensor from the housing and thus significantly reduce power consumption. Sensors designed by Fraunhofer IPM have gas-sensitive surfaces of 45 × 45 µm², with the total surface of sensor array measuring 1.6 × 1.6 mm². The structures are generated by wetchemical 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

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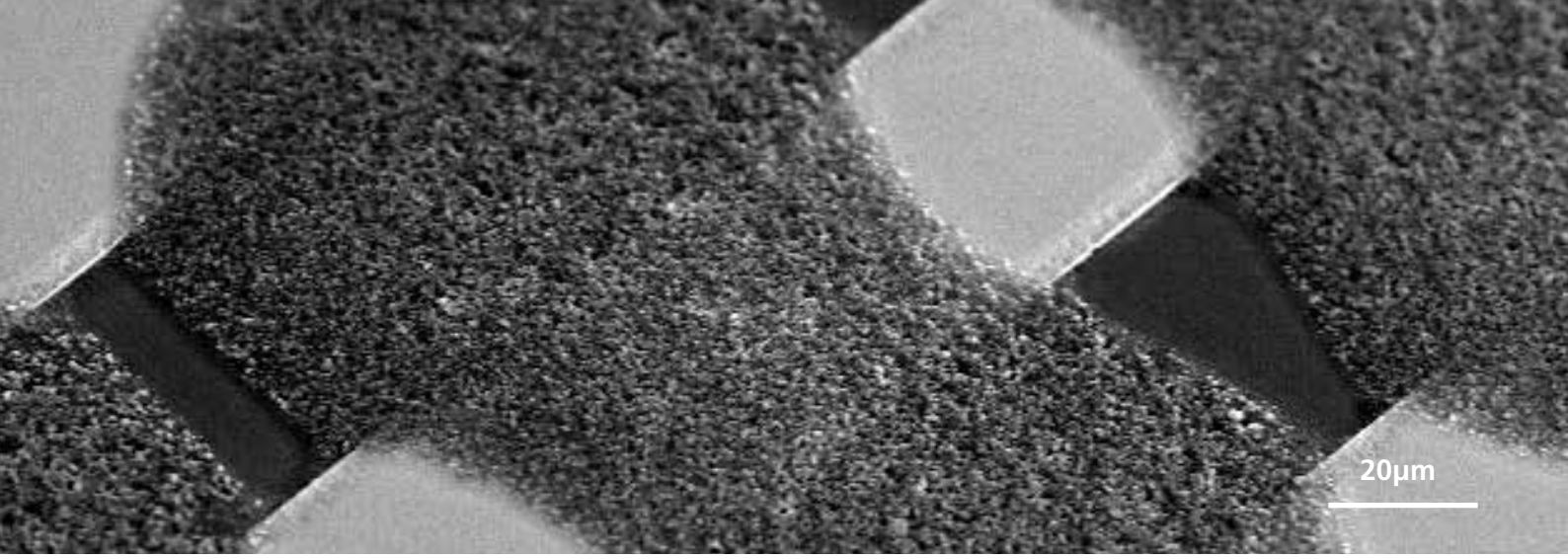

^ *Printed chromium-titanium-oxide layer on platinum structures.*

arrangements also allow operation with rapid temperature changing cycles. The heating times of this sensor construction lie in a range of a few milliseconds.

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 at 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 semi-conductor 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 sensor 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.

Semi-conductor gas sensors

Semi-conductor 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	Approx. 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	Approx. 100 mW

All specifications and features are subject to modification without notice.