Fraunhofer IPM

Photoacoustic sensor for CO_2 measurement according to the indirect method as an SMD component. The sensor is not even half the size of a sugar cube and with a resolution of 20 ppm is suitable for monitoring CO_2 in ambient air.

Photoacoustic gas measurement systems

Selective measurements at low power consumption

Gases can be detected very accurately and selectively using photoacoustic spectroscopy (PAS). Possible applications range from harsh industrial environments to indoor air monitoring and medical applications. Fraunhofer IPM develops photoacoustic measurement systems that are particularly compact and energy-saving, depending on the application.

Photoacoustic spectroscopy

The photoacoustic measurement method was already described by Alexander Graham Bell in 1880: If a gas sample in a measuring cell is irradiated with a pulsed light source, the gas molecules will absorb the light and the gas sample will heat up. Given a constant volume size of the measuring cell, this will produce acoustic waves whose frequency matches the modulation frequency of the light source. These acoustic waves, i.e. the photoacoustic signal, can be detected with sound transducers (e.g. commercial MEMS microphones). The signal amplitude correlates with the strength of the absorption and thus provides information about the gas concentration in the measuring cell.

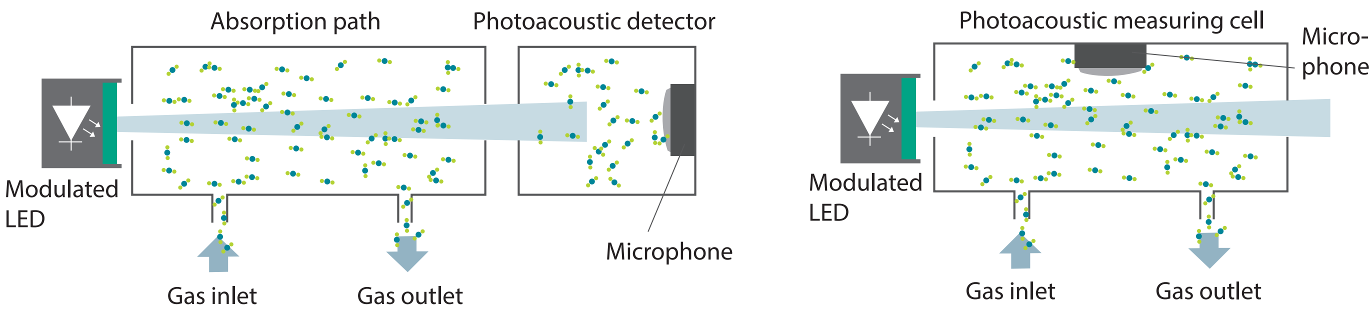
Indirect and direct photoacoustics

Photoacoustic sensors can be set up in two ways: directly (single-chamber method) and indirectly (dual-chamber method). In the direct method, the sound wave is generated and detected in the sample gas itself; whereas in the indirect method, the target gas is hermetically sealed in a detector, which is then used in an absorption spectrometer setup. Both methods have advantages and disadvantages depending on the application and should be used depending on the measurement task.

Sensors using the direct method are often operated in acoustic resonance to further increase sensitivity.

Our offer

- Customer- or application-specific system concepts
- Gas-dependent characterization of systems and benchmark tests
- Creation of production concepts
- Technology consulting



Functional principle of a sensor according to the indirect (l.) and the direct method (r.). Since the detection chamber is filled with target gas, the system is free from cross-sensitivities caused by the gas matrix.

LED, laser or IR-emitter as light source

Depending on the target gas and application, different geometries of measuring cells and different light sources are selected. Both factors essentially determine the price and size of the gas measurement system. Cost-effective measurement systems that use LEDs as light sources, for example, can determine the target gas concentrations very sensitively (in the 1 ppm range). If lasers are used as light sources, the sensitivity of the measurement systems reaches values in the low ppb range.

From emission measurement to blood gas analysis

Fraunhofer IPM has experience in developing photoacoustic gas sensor systems for very different applications: For a compact SO_2 measurement system used for emission measurement in the exhaust gas scrubber on ships, Fraunhofer IPM employs a resonant single-chamber measuring cell with a UV LED as a light source. Thus, the required high resolution of 1 ppm in the measuring range up to 50 ppm SO_2 is achieved.

An indirect photoacoustic sensor developed at Fraunhofer IPM detects methane with a resolution in the sub-ppm range. For this purpose, a photoacoustic methane detector was combined with a long-path cell also developed at Fraunhofer IPM. Thanks to an LED as the light source, the sensor is also drift-stable and economical in terms of power consumption.

For a miniaturized photoacoustic CO_2 sensor used for the detection of indoor air quality, a non-resonant measuring cell was combined with an infrared LED and a MEMS microphone. This allows for a particularly small sensor – with a resolution of 20 ppm in the measuring range for ambient air concentrations up to 5000 ppm CO_2. The overall dimensions of the sensor are just 8 x 7.5 x 17 mm³.

Our miniaturized sensor systems for continuous, transcutaneous monitoring of the CO_2 concentration (tcpCO_2) in the blood function according to the same concept: A microsensor with an optically active gas volume of only a few hundred nanoliters was developed for the required concentration range of 5 to 25% CO_2 with a resolution of 0.1%. The sensor can be applied to the skin, e.g. via a patch. Due to the blood circulation in the tissue, CO_2 can diffuse through the skin and through a gas-permeable membrane into the detection cell. In this way, the tcpCO_2 value is very close to the arterial value.

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