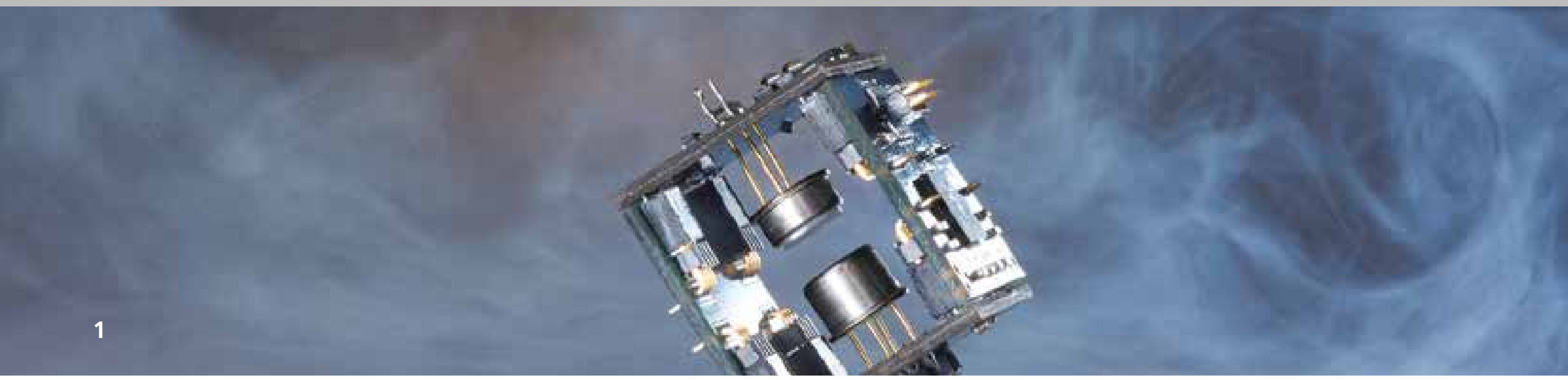
Fraunhofer IPM

FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES IPM



1 *Compact photoacoustic two-chamber-sensor system for CO_2 measurement (dimensions: 25 mm × 25 mm × 25 mm).*

MINIATURE PHOTOACOUSTIC GAS MEASUREMENT SYSTEMS

Fraunhofer IPM has developed an innovative, compact photoacoustic system for the detection of carbon dioxide (CO_2). The system combines a miniaturized measurement and reference cell with a tunable thermal emitter and a capsuled microphone. A miniature optical setup and corresponding components such as standard MEMS microphones as used in mobile communications technology make the system flexible in operation. Using these elements as active components keeps system costs low. Thanks to miniaturization and integration of the system components the photoacoustic system measures gases selectively, achieving an optimized measurement signal while at the same time consuming less power.

Photoacoustic measurement

The photoacoustic measurement method was first explained by Alexander Graham Bell in 1880. During photoacoustic measurement, rather than using a beam detector, the absorption of electromagnetic radiation by molecules is measured directly by means of a pressure transducer which detects the increase in pressure arising from the absorption.

The formation of the photoacoustic signal can be divided into a number of different stages: Firstly, the electromagnetic radiation is absorbed by the molecules at specific wavelengths. The resulting energy increase becomes manifest in faster molecule movement, which leads to a rise in pressure in the system. A microphone detects this pressure increase in a closed cuvette in a non-resonant operation mode. The absorbed light energy has been converted into an acoustic sound wave.

A high-output light source produces a maximum photoacoustic signal in a very small

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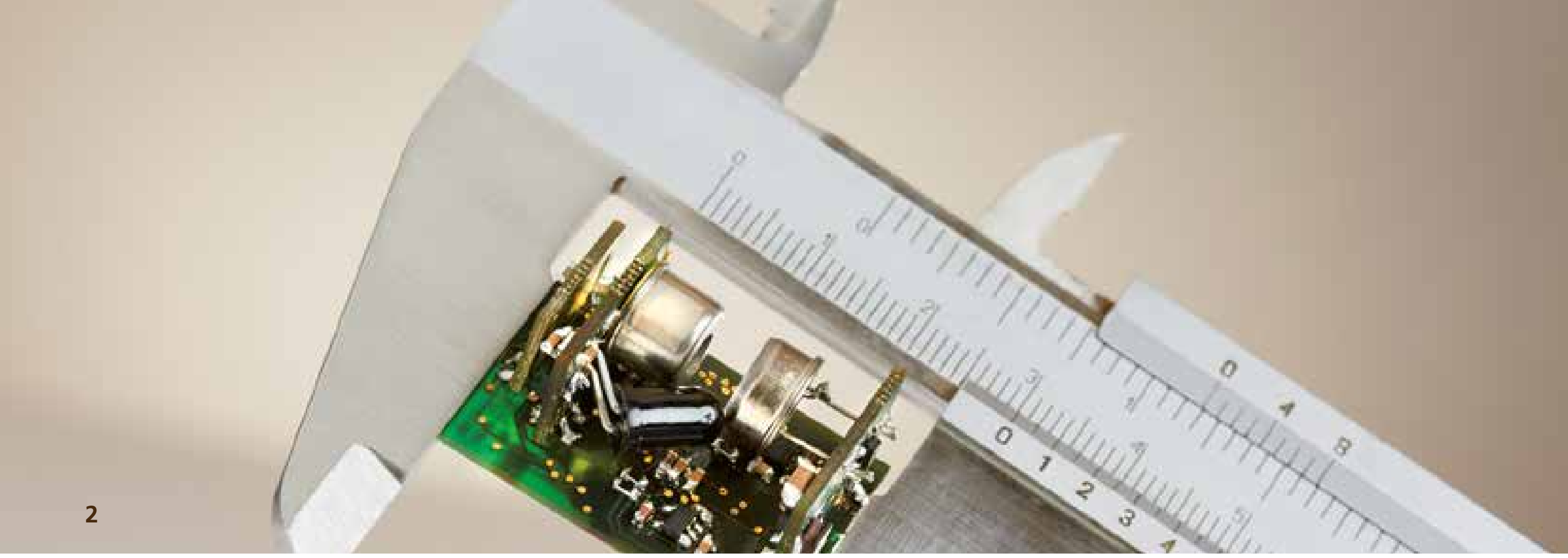

measurement volume. The electromagnetic radiation emitted is modulated and coupled, via a measuring section, into the photoacoustic cell containing the target gas. The microphone of the photoacoustic cell detects the pressure fluctuations arising from the injection of the modulated radiation. If molecules of the target gas are present in the measuring section, they absorb part of electromagnetic radiation, which in turn decreases the signal in the photoacoustic cell. If the measurement chamber does not contain any target gas, there is a maximum pressure signal.

The distinct advantage as compared to classical filter photometers is the elimination of optical filters that drift when the ambient temperature changes. As the filter does not entail any wavelength restrictions, a significantly reduced measuring section is feasible. In addition, inexpensive microphones can be used as detectors.

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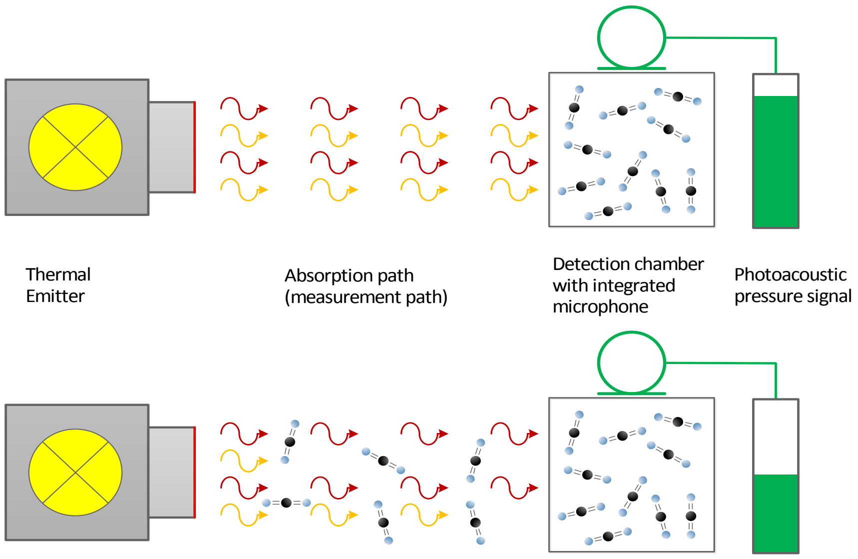

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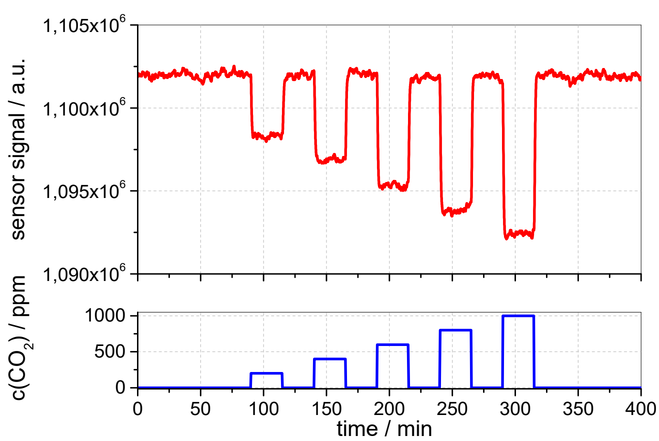

2 Compact photoacoustic two-chamber-sensor system for CO_2 measurement with integrated disturbance compensation (dimensions 20mm × 30mm × 15mm).

3 Functional principle of the photoacoustic measurement system. The system is not cross-sensitive due to the detection chamber filled with the target gas.

4 Test measurements with carbon dioxide in nitrogen show the suitability of the sensor system for measurements at room temperature. A resolution of 50 ppm CO_2 is acheived over the entire measurement range up to 5000 ppm CO_2.

Gas-specific characterization

The measurement system is designed for detecting CO_2 in ambient air. By adding heavy, non-IR active inert gases to the detector cell, the sensitivity of the system can be significantly enhanced. Fraunhofer IPM is currently working on a further miniaturization of the system.