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INTEGRATED SENSOR SYSTEMS

Miniaturized photoacoustic gas measurement systems

Fraunhofer IPM has developed an innovative, compact and inexpensive measurement system based on the principle of photoacoustics for detecting carbon dioxide. It combines a compact measurement and detection chamber with a thermal emitter and a specially enclosed microphone.

From factories and conference halls to cars or trains, the ability to monitor indoor climates is important wherever large numbers of people gather together in an enclosed environment. This is because the effects of so many people exhaling simultaneously may lead to the air quality of a room deteriorating dramatically in just a few minutes. Even a moderate increase in the content of CO_2 in the atmosphere may cause fatigue and impair concentration, while a significant rise leads to dizziness and headaches. For an optimal air conditioning an accurate reading of the concentration of carbon dioxide in the enclosed space is needed. What's more, in addition to maintaining a healthy environment, an efficiently managed ventilation unit saves on heating costs.

Fraunhofer IPM has developed a miniaturized photoacoustic gas measurement system capable of detecting CO_2 indoors. The solution combines a compact measurement and detection chamber with a modulated thermal emitter and a specially enclosed microphone. The user-friendly optical setup and compatible components, such as the MEMS (microelectromechanical systems) microphone from the field of mobile radio technology, enable the sensor system to be used in a range of applications. These mass-produced parts also make the device very cost-efficient. The miniaturization and integration of the system components mean that the sensor consumes very little energy. A further advantage of the solution is its ability to measure gases selectively thanks to its special two-chamber design.

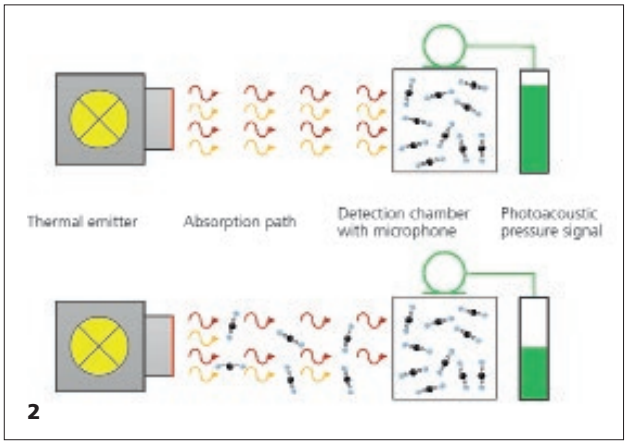
Converting light into sound

The measurement system is based on the photoacoustic effect, which was first explained by Alexander Graham Bell, the inventor of the telephone. The effect describes the conversion of light energy into sound as a result of it being absorbed by gas molecules. During the photoacoustic measurement method, the absorption of electromagnetic radiation by molecules is measured directly using a pressure transducer that detects the increase in pressure arising from the absorption. This means that, in contrast to other infrared measurement systems, the radiation itself does not require detection. The formation of the photoacoustic signal can be divided into a number of stages. Firstly, the electromagnetic radiation is absorbed by the molecules at very specific wavelengths. The resulting increase in energy causes the molecules to move more quickly, which leads to a rise in pressure in the system. The elevated pressure can

MINIATURIZED GAS MEASUREMENT SYSTEMS

Fraunhofer IPM boasts many years of experience in the development, design, characterization and production of miniaturized sensors and systems for measuring gases. Gas sensors monitor industrial processes, detect leaks or regulate the indoor climate. Thanks to their use of sophisticated technology, the sensors can also collect reliable, precise measurements in challenging conditions.

1 *The air quality inside vehicles can be monitored using photoacoustic gas sensor systems.*

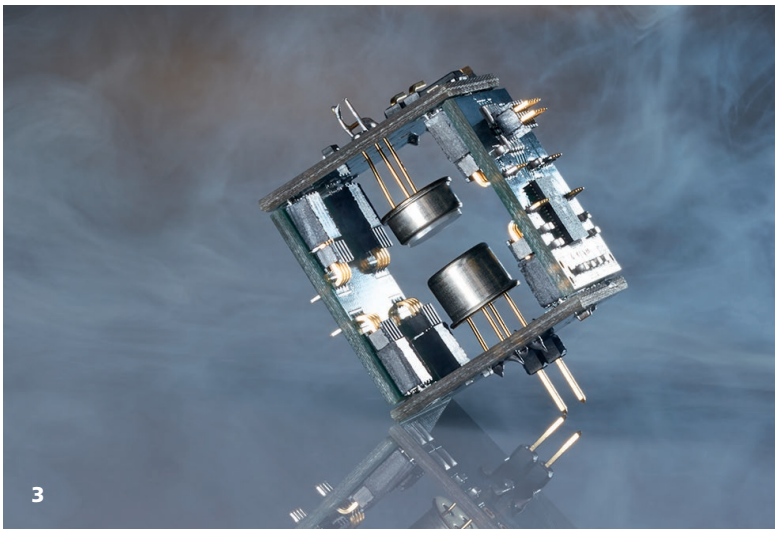


2 *Principle of operation of the photoacoustic measurement system with a two-chamber design. The ambient air is measured on the absorption path. In the detection chamber, the gas to be measured is used as the gas-selective detector.*

then be detected as a sound wave using a microphone in a closed chamber. This is made possible as a result of the light energy having been converted into sound.

Ideal measurement principle for compact systems

Conventional indoor air monitoring units are expensive and sensitive to temperature. Replacing the radiation detector with a standard, commercially available microphone, the solution developed by Fraunhofer IPM is significantly less expensive than other systems. The distances between the components and, as a result, the optical path are considerably shorter in photoacoustic sensors than in comparable absorption measurement methods. Inexpensive miniaturized photoacoustic measurement systems, manufactured in large quantities, can be used for a diverse range of applications. In addition to ensuring a healthy environment in conference halls, their small size makes them ideal for maintaining a safe atmosphere in any enclosed space where CO_2 may form. Examples include bar taps, refrigeration and freezer units, wine cellars, medical equipment and industrial production lines, where overly high concentrations of CO_2 present serious health risks.



3 *High CO_2 concentrations impair the climate, indoors as much as outdoors. A compact, low-cost CO_2 sensor by Fraunhofer IPM is based on the principle of photoacoustics.*

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