SPECTRO.sens
A new approach to industrial gas analysis

Optical measurement methods have been established in industrial gas analysis for many years and are also an integral part of Wi.Tec-Sensorik GmbH's product portfolio. The NDIR method enables a wide range of different gases to be detected with a high degree of accuracy. The requirements for measurement accuracy, detection limits and stability are constantly increasing in some areas of application, making technological improvements essential. The laser-based SPECTRO.sens gas measurement module (TDLAS) represents a significant step in this direction and is designed to effectively complement existing measurement capabilities in the NDIR field.

Measuring principle of the SPECTRO.sens

Optical gas measurement methods make use of the property of molecules to absorb infrared radiation. To do this, a beam of light is passed through a cuvette of length L containing the gas mixture to be analysed. The aim is to determine the concentration c of the gas being measured. This is calculated using Lambert–Beer's law:

$$U(c) = U_0 \cdot e^{-\alpha \cdot c \cdot L} \qquad [1]$$

Here, U_0 is the measurement voltage at the radiation receiver (5) with nitrogen in the analysis cuvette, U(c) is the measurement voltage with the gas mixture to be analysed in the analysis cuvette, α is the absorption coefficient of the measurement gas, and L is the geometric length of the analysis cuvette. As the laser beam passes through the analysis cuvette twice, the optical path length is thus doubled to 2·L.

Rearranging this equation in terms of c yields the equation for determining the required gas concentration c:

$$c = -\frac{ln\left[\frac{U(c)}{U_0}\right]}{\alpha \cdot L} \qquad [2]$$

Using the parameters U(c), U_0, the length L and the absorption coefficient α specified in the literature, the exact gas concentration c can be calculated. As the pressure and temperature in the analysis cuvette affect the gas density, this error must be eliminated by applying an appropriate correction. The result is a highly accurate and long-term stable gas analysis.

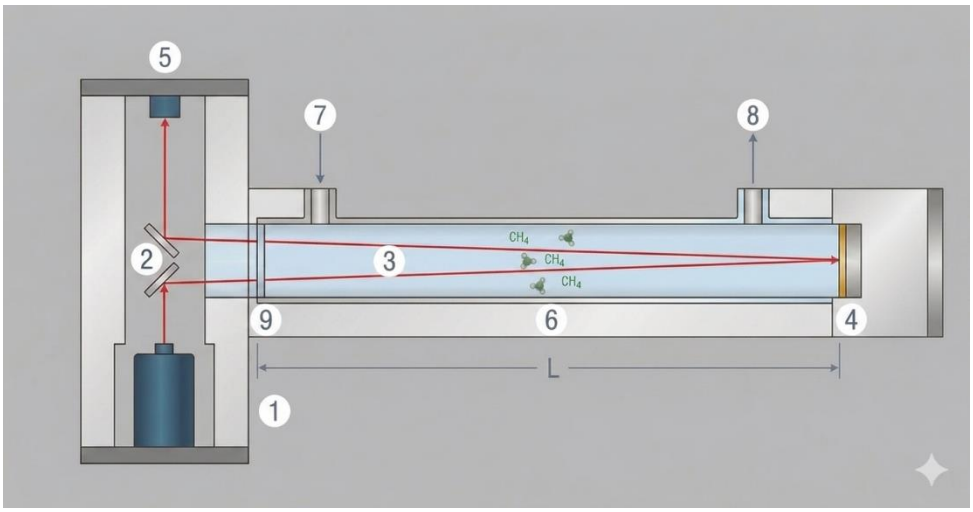

Abb. 1 : Optischer Strahlengang des SPECTRO.sens mit 1. durchstimmbare Laserdiode, 2.Umlenlspiegel, 3.Laserstrahl in der Analysenküvette, 4. Umlenkspiegel, 5. Strahlungsempfänger, 6. Analysenküvette (AK), 7. Gaseingang, 8. Gasausgang, 9. Fenster zur Analysenküvette.

Design of the SPECTRO.sens

The gas analysis described is carried out by the SPECTRO.sens in the NIR band around 1.667 µm. This band (Fig. 2) is completely free of interfering absorption lines, such as those from water vapour (H_2O) and other hydrocarbons (HC). Gas measurement can be carried out using any absorption line within this band. For this purpose, the strongest lines are usually used, such as the line at 1.651 µm. During operation, the laser is tuned to one of these absorption lines using the diode current, so that the spectrum of the absorption line lies within a range of 0.5 nm (Fig. 3).

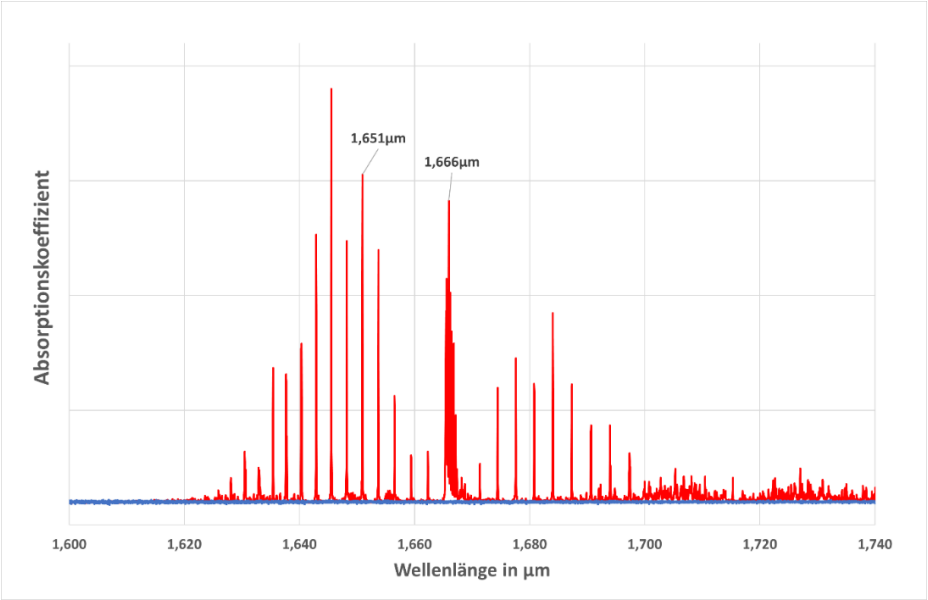

Abb. 2: NIR-Absorptionsspektrum von Methan (rot) um 1,667µm. Das Wasserdampfspektrum (blau) weist in diesem Spektralbereich keine störenden Absorptionslinien auf.

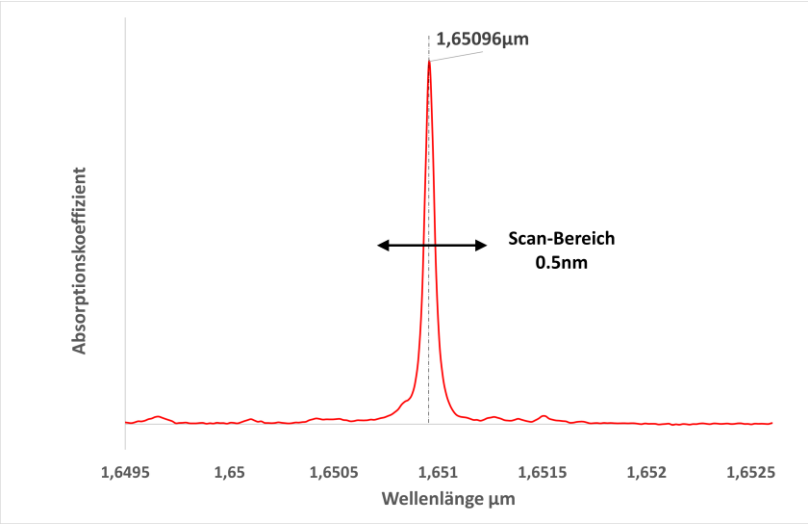

Abb. 3: CH_4-Absorptionlinie zwischen 1,6485µm bis 1,6525µm mit dem dazugehörigen Scan-Bereich von 0,5nm um das Zentrum der Absorptionslinie herum.

This spectral data is analysed in accordance with Eq. 2, thereby yielding the desired gas concentration c. As measurements are always taken outside the line during each scan, the zero value U0 is also obtained, which serves as a reference value. Undesirable drift phenomena, such as those commonly encountered in NDIR technology, are therefore effectively compensated for. The SPECTRO.sens is thus characterised by high long-term stability and is therefore also very low-maintenance. By design, zero-point or end-point adjustment is not required. This is a significant advantage over conventional NDIR technology. Furthermore, cross-sensitivities to other gases are very low or non-existent. Even high concentrations (e.g. 100 vol.%) of ethane, propane or butane are effectively compensated for, so that no significant cross-sensitivities can be measured. Cross-interferences from water vapour are undetectable.

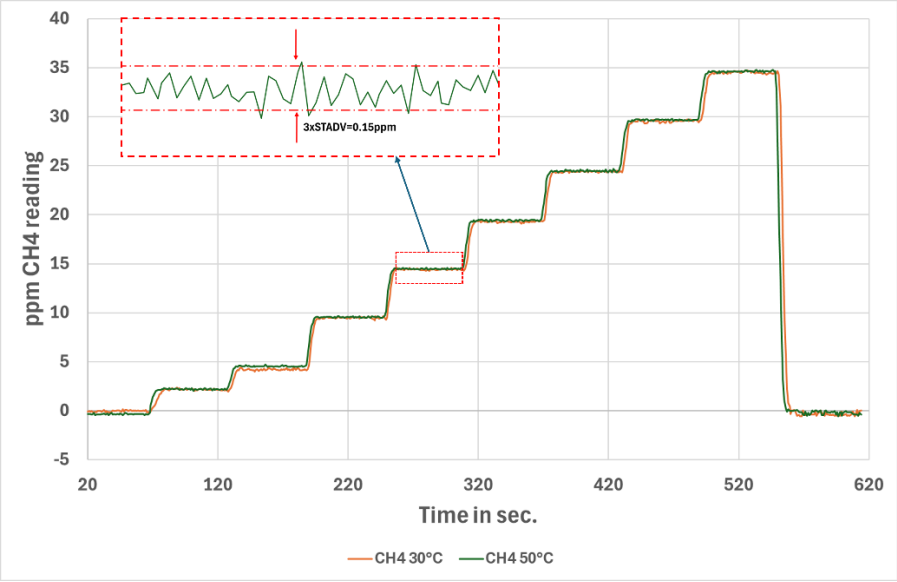

Abb. 4: Aufnahme der Kennlinie von 0ppm, 2,5ppm, 5ppm,10ppm...35ppm CH_4 in N_2.

The optical bench of the SPECTRO.sens is shown in Fig. 5. It is stabilised at an operating temperature of 50°C using several heating elements, thereby preventing any influence from external temperature changes. In Fig. 4, the calibration curve was recorded in 5 ppm increments at 30°C and 50°C. Both recordings are identical, meaning that the influence of temperature is also negligible. Furthermore, this stabilisation prevents condensation (falling below the dew point) from forming in the analysis cuvette. A pressure and temperature sensor also measures the pressure and temperature values in the analysis cuvette, which are used for compensation.

To protect against external influences, the SPECTRO.sens is supplied in a thermobox (Fig. 6), which consists of a robust sheet steel housing and is fitted with thermal insulation on the inside. Both the gas supply and the electrical connectors can be connected very easily from the outside.

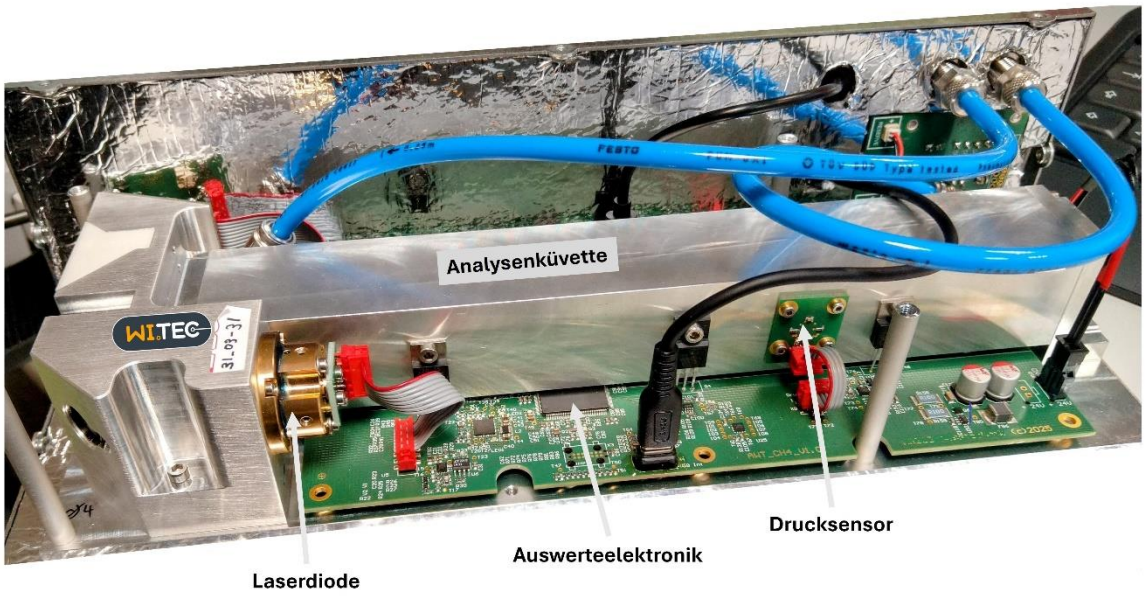

Abb. 5: Optische Bank des SPECTRO.sens mit der dazugehörigen Auswerteelektronik, integriert in einer Thermobox.

Abb. 6: Thermobox mit integriertem SPECTRO.sens-Aufbau. Von außen erkennbar sind die Gasanschlüsse (4/6-Schlauch), Eingang der Spannungsversorgung (24VDC) und Datenkommunikation (RS232- und CAN-Interface).

Measurement characteristics

The measuring range for the SPECTRO.sens is specified as a maximum range and, for the configuration described, is 0–100,000 ppm CH_4 or 0–10 vol.% CH_4. Accuracy remains constant across the entire measuring range, enabling precise measurements in both the ppm and vol.% ranges. A subdivision into graduated measurement ranges (0–100 ppm, 0–1,000 ppm, etc.) is therefore not required. With a shorter analysis cuvette, a maximum range of up to 100 vol.% CH4 would also be possible. The other measurement characteristics are listed in Table 1.

Tabelle 1: Geräteeigenschaften der Methanmessung

Parameter	Values / Range
Measured gas	Methane CH4
Measuring range	0–100,000 ppm
Detection limit	<0.15 ppm
Accuracy	2 ppm or 2% of the displayed value
Zero stability	±2 ppm per month
End-point check	Once a year
Cross-sensitivity (QE)	No cross-sensitivity to H_2O, CO_2, N_2O and other gases
T90% time	<5 s
Temperature range	5–50 °C
Pressure range	500–1,100 hPa
Update Rate	1Hz
Power	24VDC±2,5V

Conclusion

With the innovative SPECTRO.sens, Wi.Tec-Sensorik GmbH of Wesel offers a further innovation in gas analysis that provides significant advantages for certain gases. Its integration into the Thermobox described here makes it easier for OEM users to incorporate it robustly into their measurement systems or plants. In particular, the virtually maintenance-free operation of the SPECTRO.sens results in low operating costs and high reliability in gas analysis. Further gas measurements with the SPECTRO.sens, such as water vapour (H2O), ammonia (NH3), carbon monoxide (CO) and oxygen (O2), are in the pipeline.

For further information, please visit:
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