Novel NDIR Sensors for Multi-Gas Sensing

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Twelve powerful brands within the Nynomic Group ensure successful solution development

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NYNOMIC
THE PHOTONICS GROUP

tec5
m·u·t
AVANTES
APOS
LAYTEC
SPECTRAL ENGINES
LemnaTec
SENSOR THERM
Image Engineering
MOG
nlir
PHOTECTURE

Twelve powerful brands within the Nynomic Group ensure successful solution development

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Eleven Brands – One Product Portfolio
The whole spectrum of non-destructive optical measurement!

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APOS

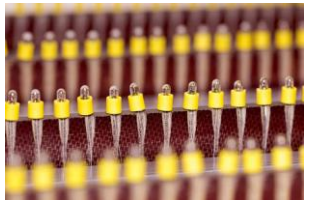
AVANTES

Image Engineering

LAYTEC

LemnaTec

MOG



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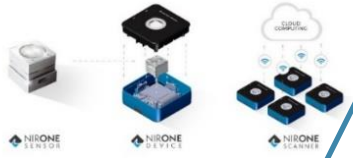
SENSOR THERM

SPECTRAL ENGINES



tec5

Brief overview of m-u-t GmbH

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Management:	Axel Witte, Christian Felsch
Net Sales:	> 23 Mio. EUR
Employees:	ca. 110
Foundation:	1995
Location:	Wedel (close to Hamburg)
Further Information:	www.mut-group.com

Growing markets within the m-u-t GmbH:
Spectrometric measurement and automation technology

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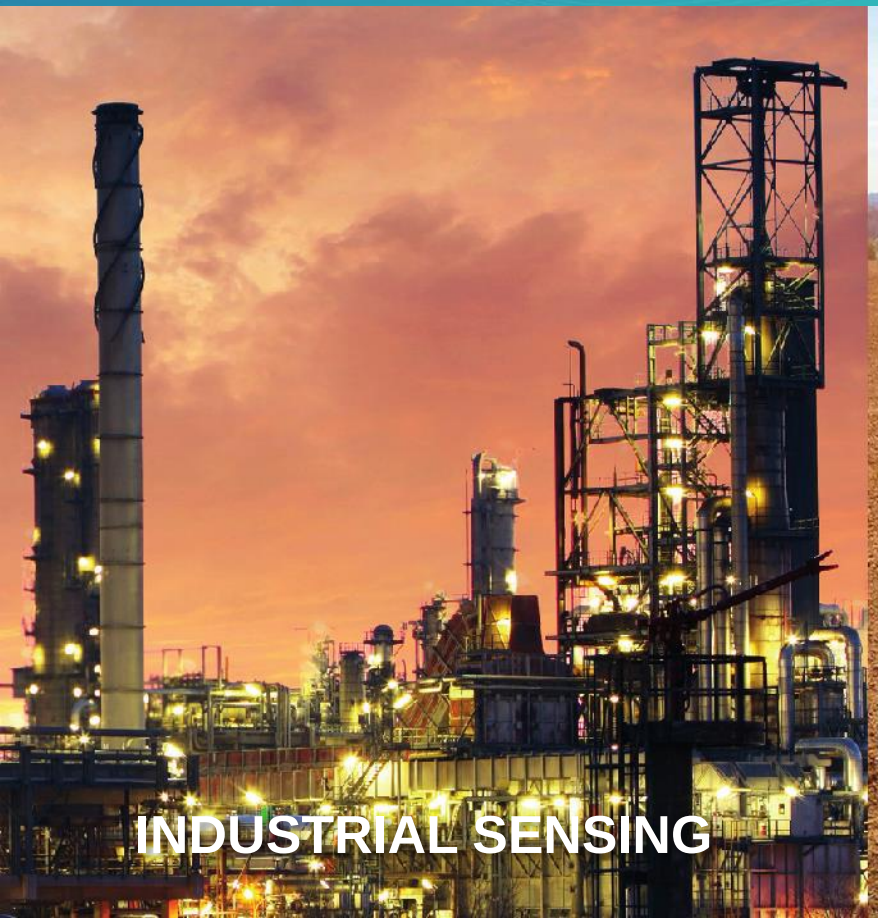

INDUSTRIAL SENSING

- Gas Sensing
- Fire Detection
- Transportation

GREEN TECH

- Agricultural Technology
- Environmental Technology

LIFE SCIENCE

- Medical Technology
- Lab Automation

Technology development in close partnership: From mathematics to the OEM measuring system – m-u-t as a one-stop-shop!

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Green Tech

Manure turnout

- Ingredient analysis of slurry during application – directly integrated in the slurry stream
- Direct integration of the measured values into the central machine control
- Nutrient balance and proof of application quantities
- Flexible use for the analysis of ingredients by individual system calibrations for many different substrates
- DLG-ACCEPTED "Ingredients in cattle manure, in pig manure, in mixed cattle and pig manure and in liquid fermentation residue"

ANERKANNT 2021 DLG WWW.DLG.ORG

MUT GMBH NIR SPEEDSPY ONBOARD MANURE MIT KALIBRATIONSMODELL WIRTSCHAFTSDÜNGER V14.3.1

- ✔ **Inhaltsstoffe in Rindergülle: TM, N_{Gesamt}, NH_4-N, P_2O_5, K_2O**
- ✔ **Inhaltsstoffe in Schweinegülle: TM, N_{Gesamt}, NH_4-N, P_2O_5**
- ✔ **Inhaltsstoffe in Mischgülle aus Rinder- und Schweinegülle: TM, N_{Gesamt}, P_2O_5, K_2O**
- ✔ **Inhaltsstoffe in flüssigem Gärrest: TM, N_{Gesamt}, NH_4-N, P_2O_5**

DLG-Prüfbericht 7122

Technology development in close partnership: From mathematics to the OEM measuring system – m-u-t as a one-stop-shop!

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Green Tech

Moisture and content measurement in-line in the crop flow

- Measurement of quality parameters during the harvesting process
- Determination of dry matter in the crop flow of the forage harvester for corn, grass, GPS and alfalfa
- Measured values are available to the machine control for process optimization in-process
- Harvest sensors allow farmers to analyze crops to make better farming decisions
- Ability to visualize the data and make it available to farmers as harvest maps
- A high-precision measurement is crucial for the exact dosing of silage additives

Technology development in close partnership: From mathematics to the OEM measuring system – m-u-t as a one-stop-shop!

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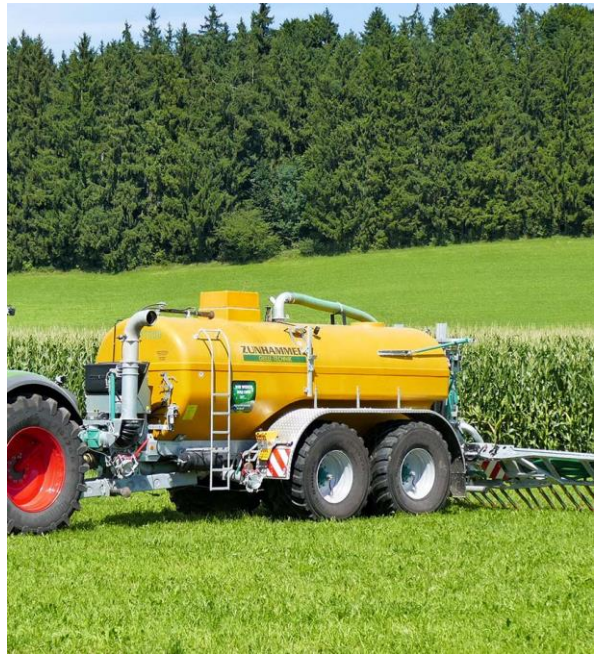
Green Tech

Multi-USE

Use of an NIR sensor for several substrates on different machines in a company:

- Liquid manure or crops
- Biogas
- Feeding
- …



Technology development in close partnership: From mathematics to the OEM measuring system – m-u-t as a one-stop-shop!

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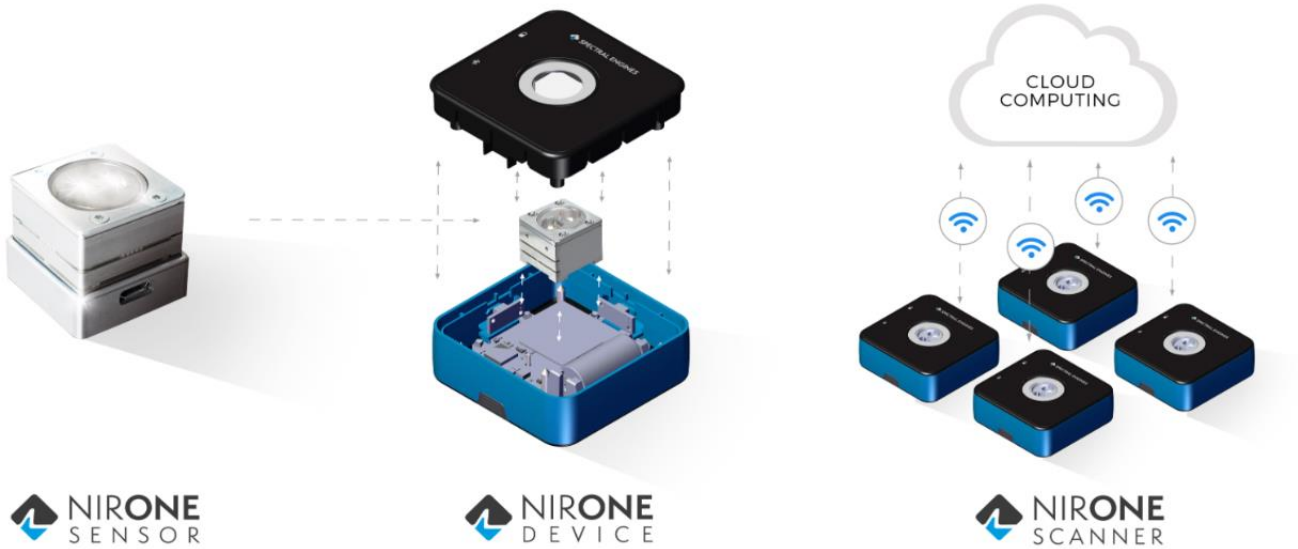
Green Tech

Handheld

- Fast and accurate measurements: With a Handheld NIR sensor, farmers can quickly and accurately take measurements of soil samples, plant material or feed
- Determination of nutrient and moisture content in real time
- Make informed decisions!
- Simple operation, intuitive user interfaces and only a few steps to take a measurement
- Cost-efficiency: No more time-consuming transport of samples to the laboratory, no more laboratory analysis



NIR Spectrometer
Development and Production in Wedel

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- **Cloud-based analytics**
- **On-site laboratory**
- **Measurement of contents**
  - Explosives
  - Drugs
  - Alcohols
  - …

Spectrometer systems for production control…
…safeguarding your investment

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Example 1: Early fire detection

- Patented integrated distance measurement to initiate extinguishing / cooling optimally and to enable maximum extinguishing agent output per m²
- Unique object recognition, detection of the smallest possible hot spots despite large, moving and permitted heat sources (e.g. wheel loader, truck exhaust, ...)
- Investment safe and expandable
- Proven continuous operation (24/7) under the most adverse environmental conditions
- Active cooling for continuous operation at up to 70 ° C
- VdS G 220008 approval

Industrial Sensing

Example 2: Multi-gas sensor for hydrocarbons

- Infrared Multi-Gas Sensor using NDIR-Technology
- No chemical reaction in the Multi-Gas Sensor, no on-site test gases required, no moving parts, therefore durable and long-term stable
- 8 gases in one sensor – no cross-sensitivities
- CO, CO2, CH4, C2H2, C2H4, C2H6, C3H8, C4H10, gas humidity (water, H2O) and many more are detected
- Up to 6 additional sensor modules possible, such as: H2, O2, temperature (T), relative humidity (RH), acceleration (a) and pressure (p)

Application example: Enhancing Transformer Safety…
… with Dissolved Gas Analysis (DGA)

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- Insulation oil is used in high-power transformers
- Insulation oil breaks down over time, liberating gases
- Concentration of dissolved gases and their ratios indicate types of deterioration, such as pyrolysis or partial discharge
- Rate of gas generation indicates severity
- DGA is used for preventive maintenance
- DGA usually consists of sampling the oil and sending the sample to a laboratory for analysis
- Mobile DGA units can be transported and used on site as well; some units can be directly connected to a transformer

- Online monitoring of electrical equipment is an integral part of the smart grid
- Online monitoring is possible with m-u-t's multi-gas sensor
- Oxygen O2, Hydrogen H2, Methane CH4, Ethane C2H6, Propane, C2H8, Ethylene C2H4, Acetylene C2H2, Carbon Monoxide CO, Carbon Dioxide CO2 are detected simultaneously

m-u-t OEM multi-gas Platform

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OEM multi-gas sensor with NDIR technology

- Multi reflection White cell (named after J. U. White)
- Compact design with high absorption length
- Measuring range: a few ppm to several thousand ppm for many typical gases
- m-u-t proprietary 9-channel detector
- 1 reference channel
- 8 free channels: optimally adaptable to the measurement requirements of our OEM customers / OEM products by OEM filter equipment
- No chemical reaction in the multi-gas sensor
- No onsite test gases necessary
- No moving parts, therefore durable and long-term stable
- 8 channels/gases in one sensor – no/minimal cross sensitivities
- Filters for e.g. CO, CO2, CH4, C2H2, C2H4, C2H6, C3H8, C4H10, gas humidity (water, H2O)

m-u-t OEM multi-gas Platform

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Up to 6 positions for conventional physical or chemical sensors

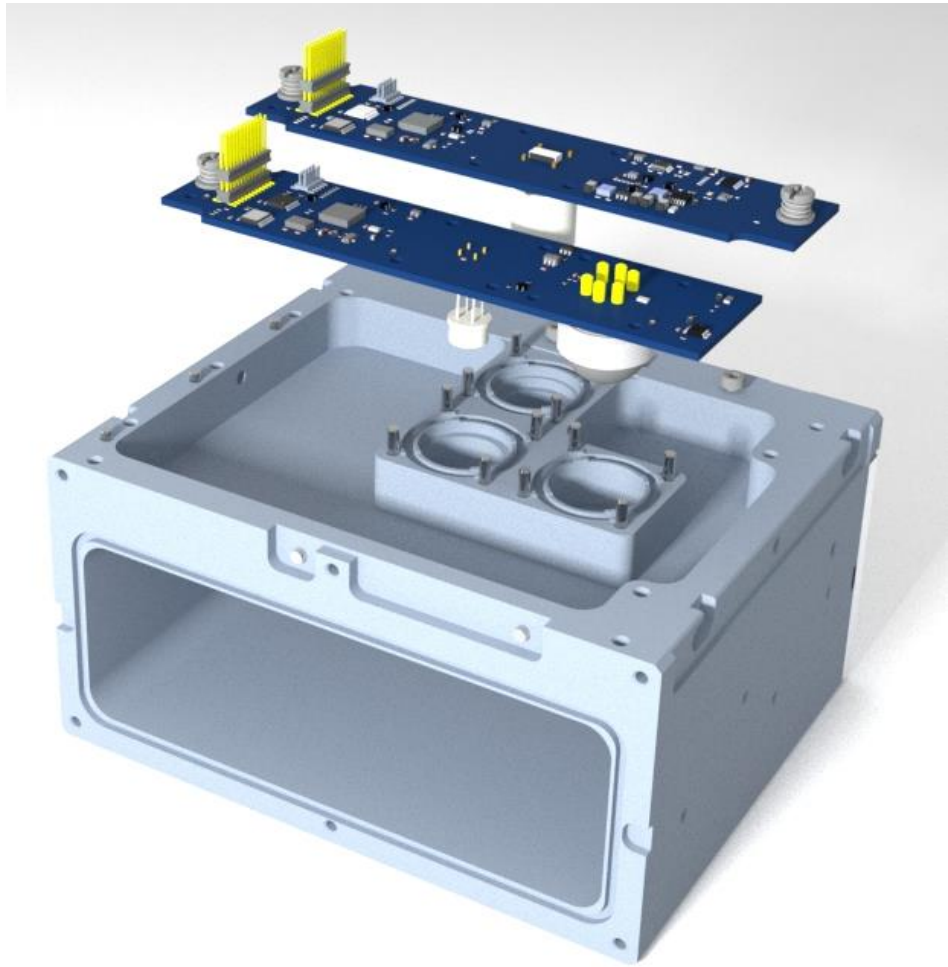
- H2, O2 or similar
- Temperature (T)
- Relative humidity (RH)
- Pressure (p)

Measurement outside of the gas chamber

- Acceleration (a)
- Pressure (p)
- Temperature (T)

Interfaces

- Power supply 24 VDC
- Data RS422 (RS485 optional)
- Process interface:
  - Flexible or rigid pipe connection
  - Flange
  - Specific adaptations
- Interface for temperature control (option)

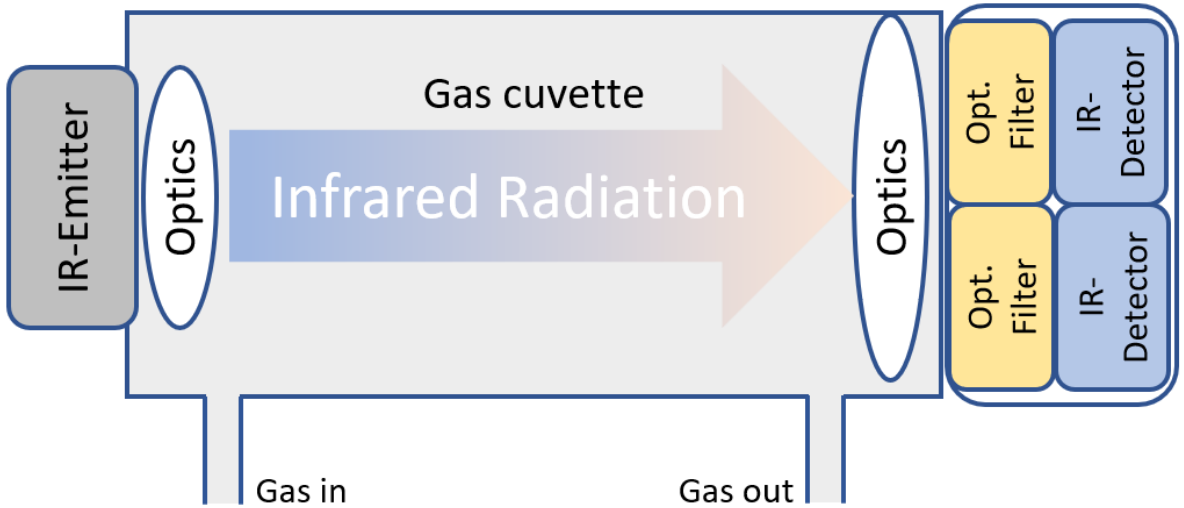


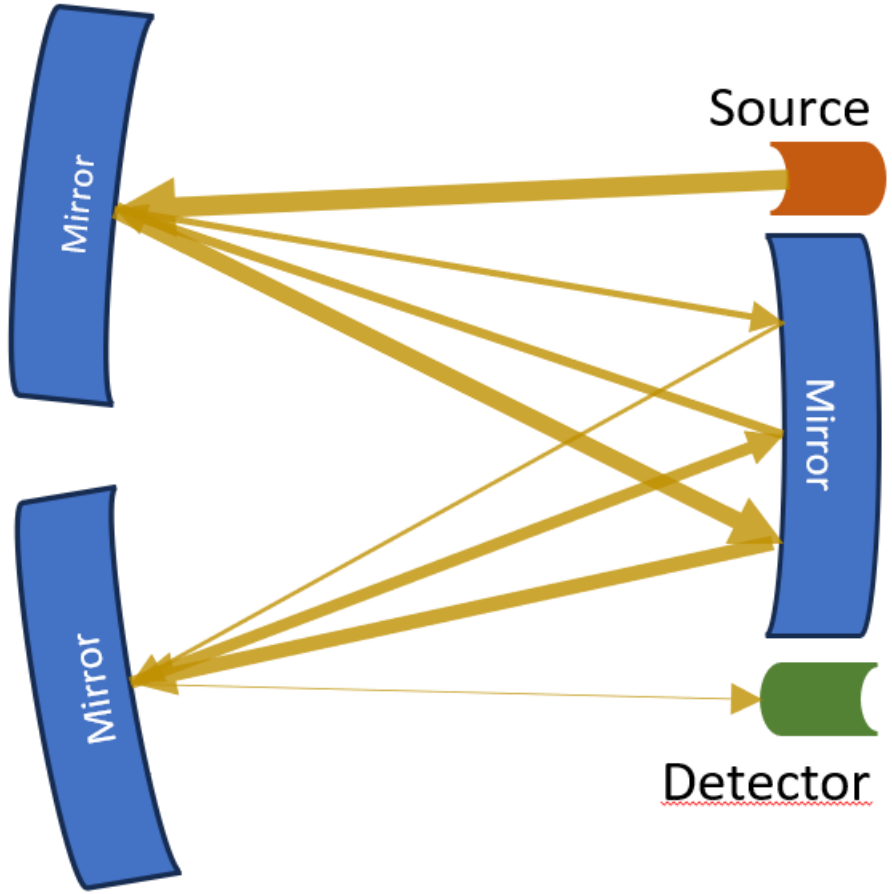
What is NDIR?
And how does it work?

Measurement of attenuation of MID IR radiation due to gas absorption using:

- Broadband IR-emitter
- Gas cuvette with suited absorption length
- Broadband IR-detector with dielectric bandpass filters

- Multireflection White cell[1)] to keep the module compact





1) named after J. U. White

What is NDIR?
And how does it work?

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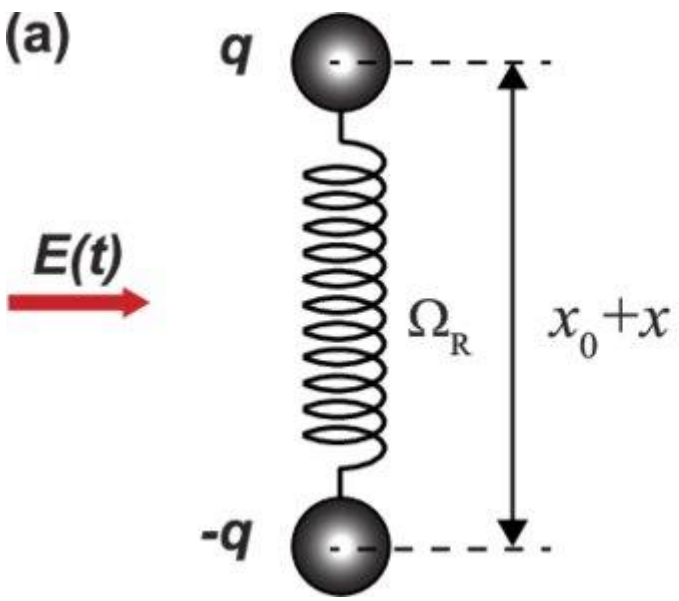
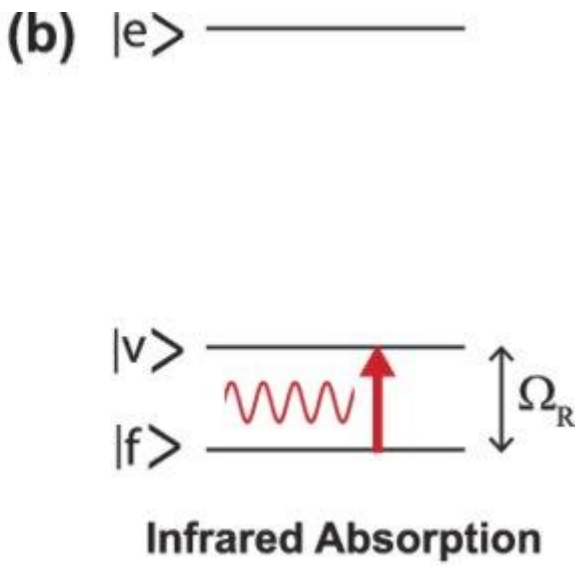
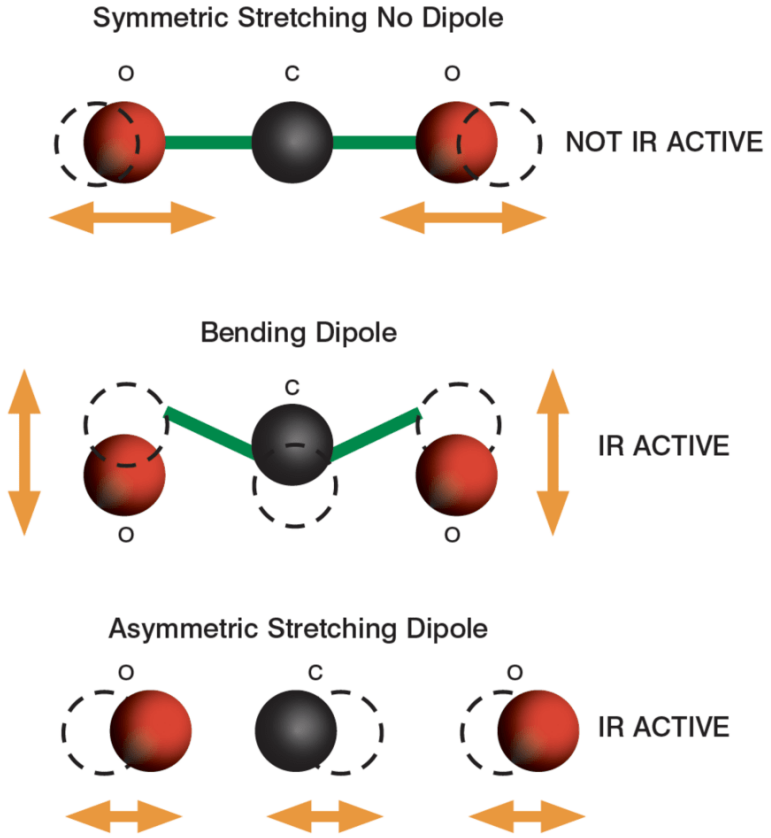
- Molecules absorb IR energy specific to their strutcure







https://www.researchgate.net/publication/326645669_Tutorial_Coherent_Raman_light_matter_interaction_processes/figures?lo=1, https://www.aweimagazine.com/press-release/further-spectroscopic-methods/

Gas absorption spectra
Compensation of cross-sensitivities

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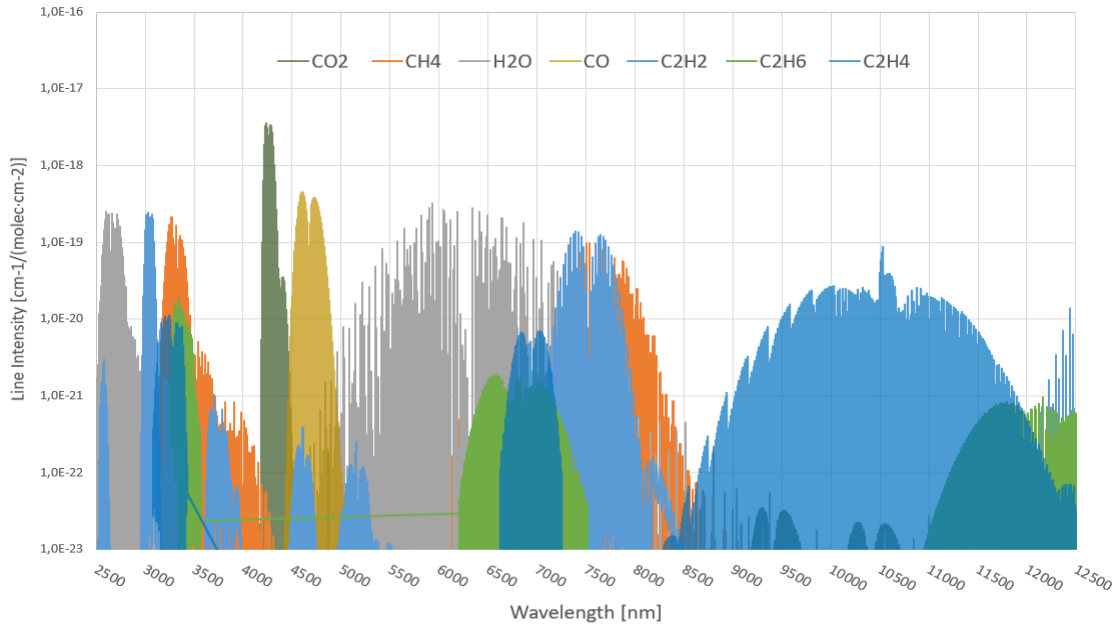
Internal compensation of cross-sensitivities

- Many NDIR channels have cross sensitivities with other gases
- Some are quite strong
- By measuring all interfering gas components simultaneously, cross-sensitivity compensation can be done within the multi-gas sensor
- NDIR channels can be compensated by other NDIR channels
- NDIR channels can be compensated by conventional sensors (e.g. humidity, temperature, pressure)
- Conventional sensors can be compensated by NDIR channels or other sensors.

The algorithms of the compensation are created with a multi-parameter calibration procedure (multivariate calibration).



Multivariate calibration and data processing

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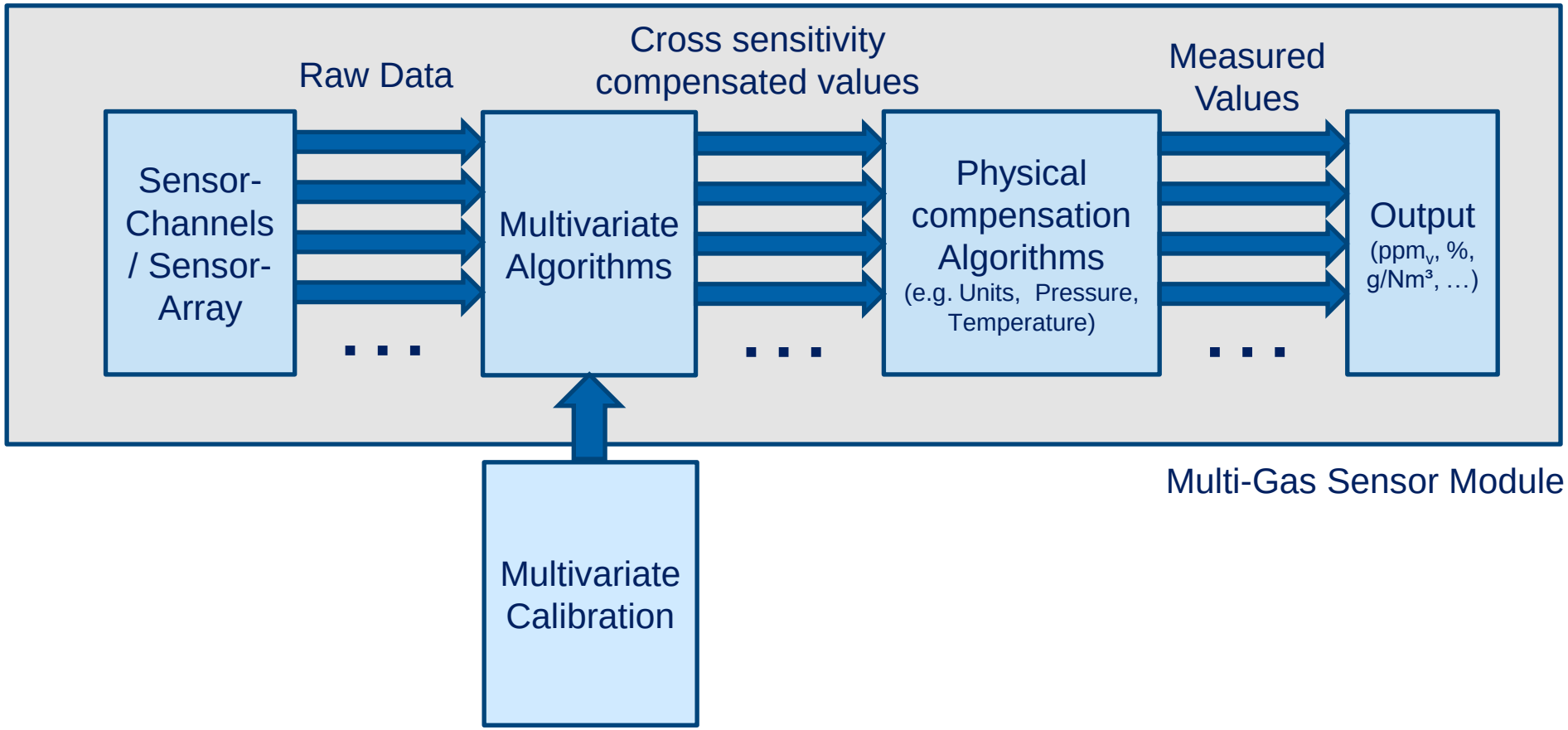
Functional Multi-Gas Platform Block Diagram



Contact
Your point of contact for Gas Sensing

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Thank you for your attention!