

Frequently Asked Questions

**What is IR Microsystems' microLGD ?**

The microLGD is a Laser Gas Detector ("LGD") for safety, air conditioning, medical and selected process control applications in many industry sectors. Based on near-infrared *Tuneable Diode Laser Spectrometry* (TDLS), it offers gas detectivity in the low- to very high ppm-range. The systems are based on telecommunication-type laser diodes and offer advantages like extremely high target gas selectivity, functional safety and low cost-of-ownership. OEM sub-mounts or stand-alone systems continuously monitor gases like NH₃, O₂, CO₂, H₂O, or CH₄ and feature an innovative, patented measurement principle without the need for a reference channel. A complete list of measurable gases with detection limits can be found on the last page of this document.

What are typical microLGD applications ?

Applications are everywhere where gases need to be monitored for safety and security of personnel and industrial sites, as well as for residential safety. Depending on the boundary conditions, applications for industrial process control also can benefit from the many advantages of this measurement technique.

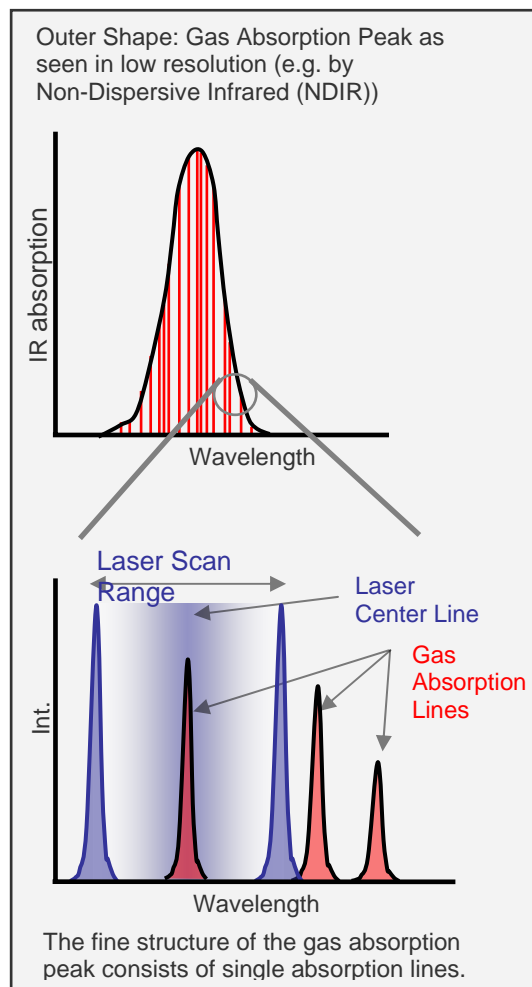
How does Tuneable Laser Diode Absorption Spectrometry work ?

Many gases have characteristic absorption bands in the infrared wavelength region. Interaction of infrared light with the gas molecules (absorption) leads to a decrease of intensity on a detector, depending on the gas concentration. When looked upon with high resolution, these bands show their fine structure, which - for gases with relatively small molecules - are made up of many individual absorption lines.

With TDLS, a single-mode, tuneable diode laser is wavelength-centered onto one of the fine absorption lines of the target gas. The laser is then driven to scan this absorption line within a very narrow range (typically 0.1 nm) to obtain the gas concentration.

Typically one laser is used to measure one gas. Due to the sharpness of the lines there is practically no cross-sensitivity with other gases. In the case where the absorption bands of two different gases overlap, it sometimes is possible to monitor the concentration of two different gases with one laser.

Due to the fact that telecom-type laser diodes are only available at wavelengths up to 2.7 μm , TDLS is rarely done in the wavelength range of the fundamental gas absorptions (3 to 9 μm). Instead, the first and second overtones of the absorptions bands are used, which lie conveniently in the range of 0.76 to 2.3 μm and enable the use of affordable telecom lasers.



Why can the microLGD measure without a reference channel and why is this advantageous?

In an infrared gas detector, the light is emitted by a light source, passes through the gas volume to be measured and is then captured by an infrared detector. As the light incident on this detector depends on both gas concentration and emitted light intensity, NDIR gas detectors need a second infrared detector (and a second electronics channel) to yield information about the performance of the light source, which degrades over time. In contrast to this, the innovative, patented measurement principle incorporated into the microLGD device allows extraction of both concentration and light intensity information from one single photodiode. This measurement principle eliminates the need for an additional detector/electronics channel and offers the associated cost savings. It also enables very stable and robust gas detectors because the possibility of differently degrading measurement and reference channel (leading to false readings) is excluded.

What kind of gases can be measured by the microLGD ?

TDLS can measure gases that have relatively simple molecular structures where the absorption bands have distinct and resolved fine structure (see gas list on the next page). More complex or ring-shaped molecules (i.e. Benzene) do not show these narrow absorption lines for physical reasons.

How many different gases can be measured with one microLGD ?

In principle, a microLGD can measure one gas because the tuning range of a laser diode is limited to a few nanometers. However, it is sometimes possible to measure two gases with the same laser if the absorption lines are closely interlaced. In any case, it is possible to integrate multiple lasers into one microLGD and to operate them by multiplexing.

What kind of laser diodes are employed by the microLGD ?

The measurement technique is based on telecom-type, single-mode lasers. Appropriate laser diodes are Distributed Feedback (DFB) lasers and Vertical Cavity Surface Emitting Lasers (VCSEL's). Fiber coupling could be an option for some applications.

Advantages of the microLGD:

- Highly selective to target gas, virtually no cross-sensitivity
- No direct contact with gas, no degradation or poisoning
- No need for reference channel due to innovative, patented measurement principle
- Intrinsically functionally safe (sensor status monitored permanently)
- High dynamic range (about 10^4)
- Stable & accurate, practically no 0-drift
- Long life-time (min. 5 years)
- No consumables
- Fast response - from milliseconds to seconds depending on the required detection limit
- Potential for low power consumption
- Low cost potential for high-volume applications
- Fast recovery
- Long calibration cycles
- Easy to operate
- Low maintenance
- Low cost-of-ownership

What are the minimum detection limits of the microLGD ?

The detection limit is different for each gas. However, the detection limit can be lowered by increasing the physical size of the absorption path (twice the absorption length gives a detection limit lowered by a factor of two), or by increasing the measurement time (signal-to-noise increases with the square-root of the measured time, i.e. measuring 100 times longer gives a detection limit lowered by a factor of 10). A list of minimum detection limits, based on a measurement time of 1 s is given at the end of this document.

What is the measurement range of the microLGD ?

The detection system has a high dynamic range of typically 1,000 to 2'000 times the minimum detection limit. This is an advantage over many other technologies where only low or high concentrations can be measured.

What is the precision of the microLGD ?

The precision is typically better than 1 % of the reading.

What is the zero-drift of the microLGD ?

Up to date no zero-drift has been observed in our or customer measurements.

What is the linearity range of the microLGD ?

The microLGD measurement technique yields a perfectly linear relation between signal and concentration over a very wide range of gas concentrations. An additional linearization algorithm (mandatory for NDIR devices) is therefore superfluous, and the implementation of different measurement ranges is straightforward.

What is the temperature range of operation for the microLGD ?

The systems have been successfully tested from -20°C to $+60^{\circ}\text{C}$, and up to 100% relative humidity (non-condensing). Further testing is on-going.

List of microLGD Target Gases :

The following is table of target gases with known NIR absorption lines for measurement by TDLS. The values are based on measurements at room temperature, 1 atm, in 1 second. Measurements on NH_3 were used to calculated values for other gases using an absorbance of $8 \cdot 10^{-6}$, under the assumption of absence of optical noise and a microLGD performance as of 20.02.2007. The concentration corresponding to the *Root Mean Square* (RMS) noise level (σ) is given in ppm m and in ppm's for a 20 cm absorption path. Detection limits and precision may degrade where a difficult measurement matrix is present.

Gas		RMS Noise σ , 1 m	RMS Noise σ , 20 cm
NH_3	Ammonia	0.16 ppm	0.80 ppm
CH_4	Methane	0.20 ppm	1.00 ppm
CO_2	Carbon Dioxide	0.60 ppm	3.00 ppm
H_2O	Water	0.05 ppm	0.25 ppm
O_2	Oxygen	62.00 ppm	310.00 ppm

Other gases like CO, HF, HCl, HBr, HI, HCN, H_2S , H_2CO , PH_3 , NO, NO_2 , N_2O , C_2H_2 , C_2H_4 , etc. on request.

Comparison with other Detection Technologies



What are the advantages of the microLGD compared to NDIR detectors ?

Both NDIR and the microLGD monitor the absorption of infrared light by the target gas. NDIR detectors select the appropriate wavelength by filtering the light of a thermal light bulb through an interference filter. This filter has a spectral width of typically 100 nm around the chosen wavelength and thus, is orders of magnitude wider than the absorption bands fine structure that is used by the microLGD for cross-sensitivity-free measurements.

Zero Cross-Sensitivity: While overlapping gas absorption peaks pose a serious problem to NDIR detectors, the high resolution approach of the microLGD makes this a non-issue. Even when two absorption bands of different gases overlap, the individual lines of the fine structure of the bands are simply interlaced so that a clear separation of the two gases is always possible by choosing the appropriate line.

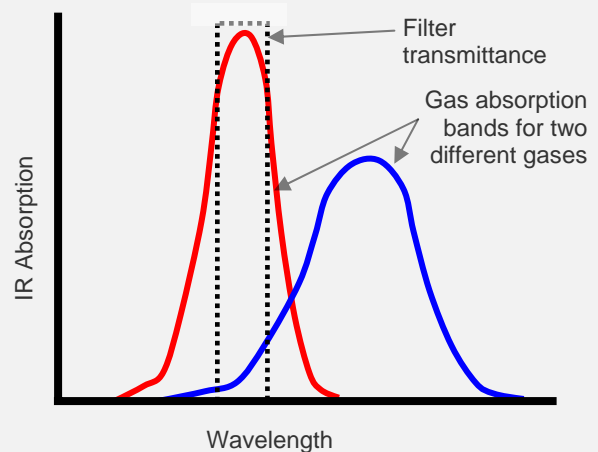
Better Long-Term Stability with Single-Channel Systems: As mentioned above, NDIR detectors need a second measurement channel as reference in order to monitor the light intensity of the bulb that changes intensity over time due to ageing. As the reference channel has a separate detector and a separate narrow band interference filter, difference in these devices compared with the measurement channel and different ageing can lead to drift. Therefore calibration needs to be relatively frequent.

The microLGD uses a special measurement technique connected to proprietary electronics (patented), which extracts the required intensity information from the detector signal. Therefore, there is no need for a reference channel or frequent calibration routines.

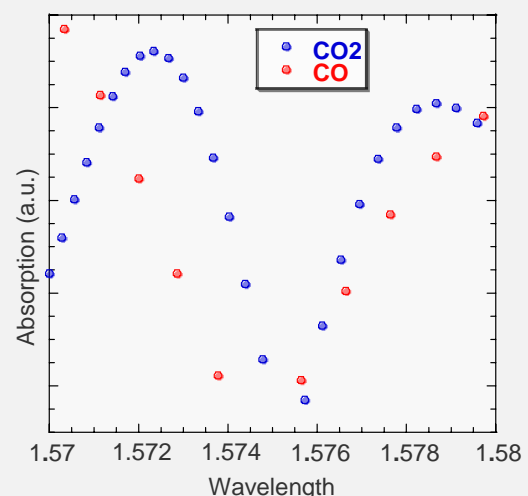
Lower Power Consumption: The thermal light bulb of a NDIR detector uses electrical power to generate a broad spectrum of intensities – very much like a light bulb in a ceiling lamp. The optical filter is tuned to the gas absorption wavelength and therefore uses only a tiny fraction of the emitted light, leaving the main portion of the used electrical power wasted.

In contrast to this, the laser diode of the microLGD emits 100% of its light at exactly the wavelength of interest, wasting only a minimal amount due to the conversion efficiency of the laser. Therefore, the microLGD will have a lower power consumption in most applications.

A NDIR detector will be subject to cross-sensitivities when absorption bands of different gases overlap. Furthermore, the detected concentration will change with the intensity of the light bulb, which makes a separate reference channel mandatory for stable operation.



Example for interlaced absorption lines: Blue dots represent the absorption lines for CO₂, and red dots represent those of CO. Although the peaks in NDIR would grossly overlap, laser spectrometry can distinguish between lines as little as 0.25 nm apart (second CO dot from the left).



Optical Fiber Capability: The wavelengths used are in the range of 760 – 2,300 nm, which makes it possible to couple the laser to standard optical fibers for remote measurements, or to use one laser for multiple measurement locations.

What are the Advantages of the microLGD compared to Electro-chemical or Catalytic Detectors ?

Zero Poisoning, No Ageing: Electrochemical detectors are always in direct contact with the gas. They are prone to ageing as the measurement principle is based on a chemical reaction depleting the sensor substance. This leads to short life times, typically of about one year. This life time decreases when the gas to be measured is present frequently. The response is rarely specific to a single gas, which may lead to costly false alarms. Issues with 0-drift for multiple reasons are frequent. Therefore, calibration are necessary in short intervals, which in turn increases the cost-of-ownership for initially low-cost instruments. The sensors are also sensitive to pressure and humidity changes. Pellistors are also subject to poisoning, especially by silicon and halogen compounds. Span loss from ageing cannot be monitored and can only be detected during calibration.

As the microLGD is an optical detector without direct contact to the gas, it is not at all subject to poisoning or degradation. Humidity and pressure changes around normal atmospheric conditions have no influence. Calibrations are enduring and recovery from high concentrations is instantaneous. Any ageing of the optical components is taken care of by the internal reference routine. This enables life times well in excess of 5 years.

No Cross-Sensitivity: Most electrochemical detectors and pellistors are not specific to the gas they have been built for and issues with cross-sensitivities are numerous. On the contrary, for the microLGD, cross-sensitivity to other gases is virtually zero if the bands from the absorption fine structure are carefully chosen.

Functional Safety: The European norm **IEC 61508** is regarded as "good practice" for security sensors. It requires functional safety from any device and needs redundancy (i.e. 2 redundant detectors within one sensor) and constant monitoring of the sensor status. With an optical sensor, this is achieved by monitoring the light source intensity (which is a basic feature of the microLGD measurement principle). However, **electrochemical gas sensors or pellistors cannot comply with this norm** as any testing degrades the sensor performance and due to this operators of security sensitive installations (chemical plants, refineries etc) will have to replace electrochemical sensors in the future.

Higher Speed: The microLGD relies on an optical measurement where the gas concentration is measured with an internal repetition rate of 20 kHz (or higher). Depending on the required detection limit, the output can be given on intervals between a few milliseconds and a few minutes. In contrast to this, detectors based on chemical reactions are severely limited by the speed of these reactions.

High Dynamic Range: Most detection technologies can either measure only low concentrations (e.g. electrochemical detectors below 100 ppm) or high concentrations (catalytic sensors in the % range). The high dynamic range of the microLGD (1'000 – 2'000 times the detection limit) makes it very versatile for many applications, without the need to use 2 or 3 different detection technologies in the same instrument to cover the range of interest.

What are the advantages of the microLGD compared to Solid State Sensors (MOS) ?

No cross-sensitivity, no influence from environmental parameters: Solid state sensors are sensitive to humidity and generally have poor selectivity for toxic gases. Also, variations in the oxygen content lead to unreliable readings. Exposure to high gas concentrations can lead to irreversible changes to the 0-gas reading, as well as to the sensitivity. On the contrary, cross-sensitivity to other gases, humidity or oxygen is virtually zero for the microLGD if the bands from the absorption fine structure are carefully chosen. There is no direct contact to the gas to be measured.

Low power consumption: A solid state sensor needs to be continuously at high temperature to be operational, which leads to significant power consumption. In applications where this is an issue, e.g. portable instruments, the microLGD could have the advantage of lower power consumption.

Functional Safety: Please refer to the section on electrochemical sensors. Solid state sensors cannot comply with the European norm **IEC 61508**.

If you have additional questions or if you would like to discuss an application, please contact us at:

IR Microsystems
Rue Daniel Colladon, PSE-C
1015 Lausanne
Switzerland

Tel.: +41 21 693 8528
Fax: +41 21 693 8529
Email: microLGD@ir-microsystems.com
Web: www.ir-microsystems.com