WHITE *PAPER*

THE ART OF FASTEST PRECISION

This white paper describes typical NDIR applications and how infrared sources from INFRASOLID improve the analysis precision with best resolutions, highest stability and fastest measurement times.

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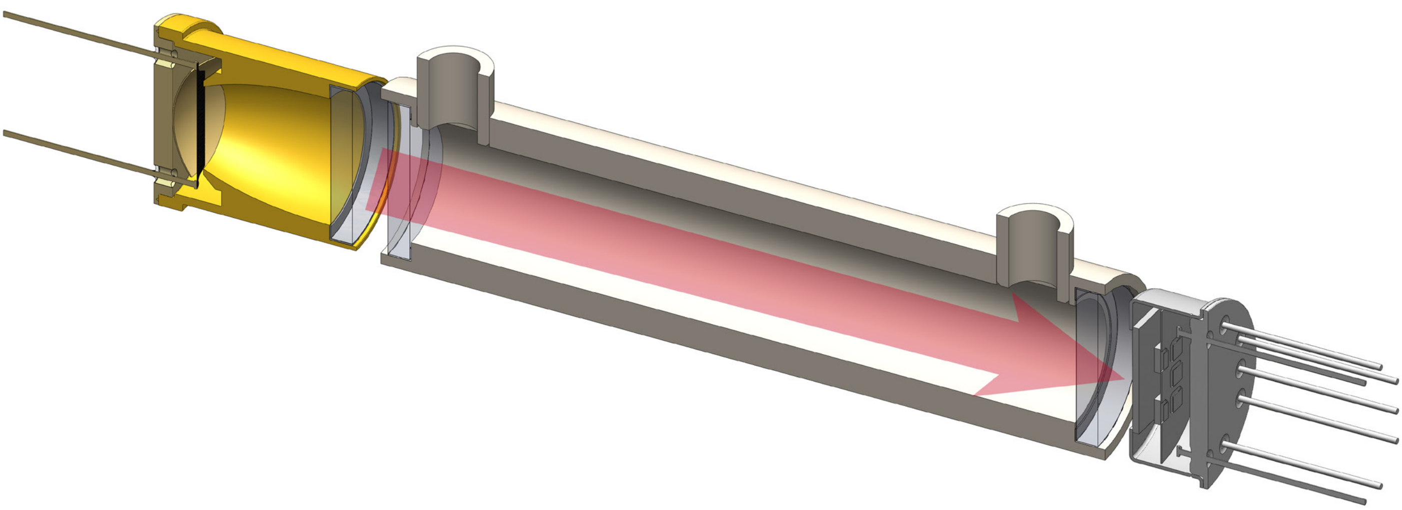
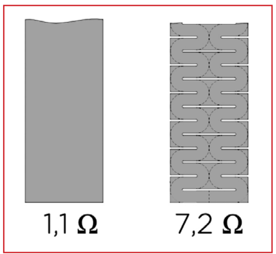


INFRASOLID®

How to get the highest optical power to any detector at 2-20 μm - Three Innovations from INFRASOLID

Patented design of IR Emitters from INFRASOLID



The robust emitting filament is designed as a double meander which adds mechanical stability even during operation and increases the electrical resistance. Typically, the resistance is increased from around 1Ω to ranges up to 10Ω. This way, the source delivers up to 1 watt optical power with only 2.5 watt electrical power. A recommended driving circuit is shown in Fig. 15.

Fig. 1: Increased electrical resistance with double meander, patented by Infrasolid GmbH

The high output power of Infrasolid thermal IR emitters in TO packages is achieved with three innovations:

1. The patented coating technology increases the emissivity on both sides of the filament (Fig. 2)
2. Since the filament is coated on both sides, the radiating element

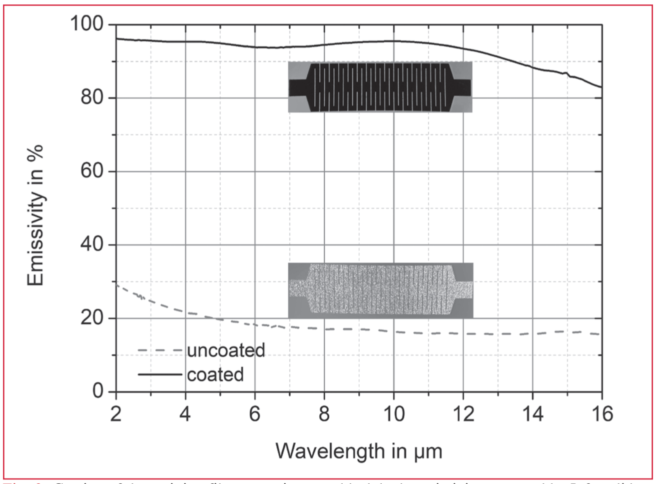


Fig. 2: Coating of the emitting filament to increase black body emissivity, patented by Infrasolid GmbH - used on both sides of the filament

area is doubled and the backside emission is transmitted to the front through the special designed reflector at the bottom of the housing.

3. The total IR emitted radiation is further collimated with a second reflector designed as a Winston Cone, thus increasing the total optical power reached at the detector side.

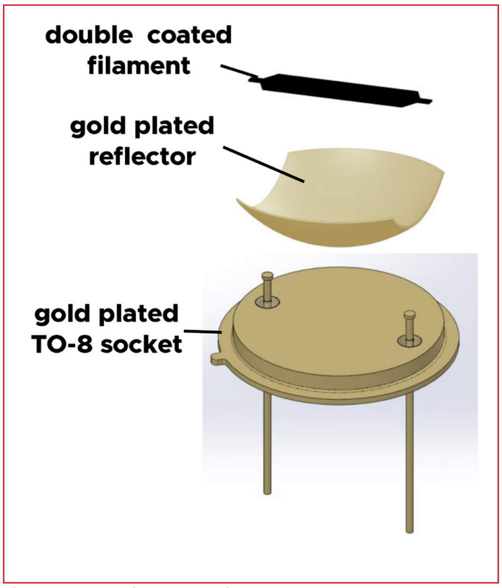


Fig. 3: Package design of Infrasolid's TO-8 package

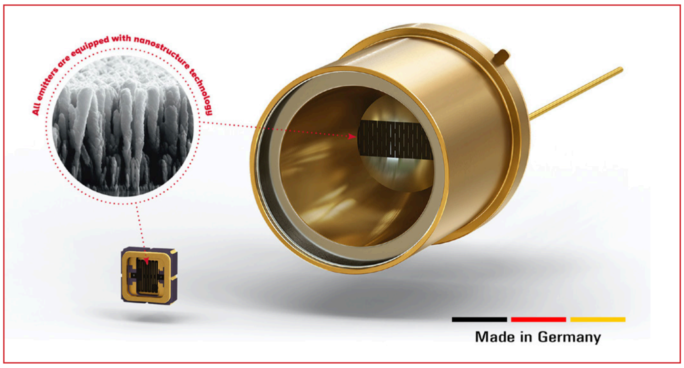


Fig. 4: Highest power thermal emitter in TO-8 housing using **double coated** filament and **two reflectors**, bottom reflector and Winston cone collimator.

Infrasolid's TO-8 infrared sources deliver the highest sensor signal compared to other available emitters in the market. Fig 5. compares the optical output power of encapsulated infrared emitters in TO-8 package with CaF_2 filter. Furthermore, the sensor noise signal can be reduced by a factor of 2 due to the stable optical output of Infrasolid's emitter and its patented IR emitter setup. This results in a tremendous performance enhancement in classical NDIR setups.

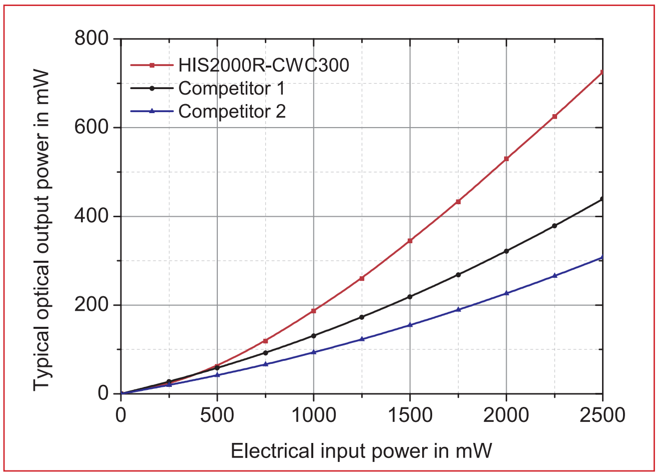


Fig. 5: Optical output power of encapsulated IR emitters in TO-8 package with CaF_2 filter

Fig. 6 compares the sensor signal at different wavelengths from encapsulated infrared emitters in TO-8 package (2.5 W input power, 5 Hz modulation frequency) in a typical NDIR gas sensor set-up (4-channel detector, 200 mm optical path length). Especially for Sulfur hexafluoride (SF_6) analysis, the MIR range around 10.5 μm is very important and shows the greatest advantage for Infrasolid's TO8 emitters with up to 10 times more signal.

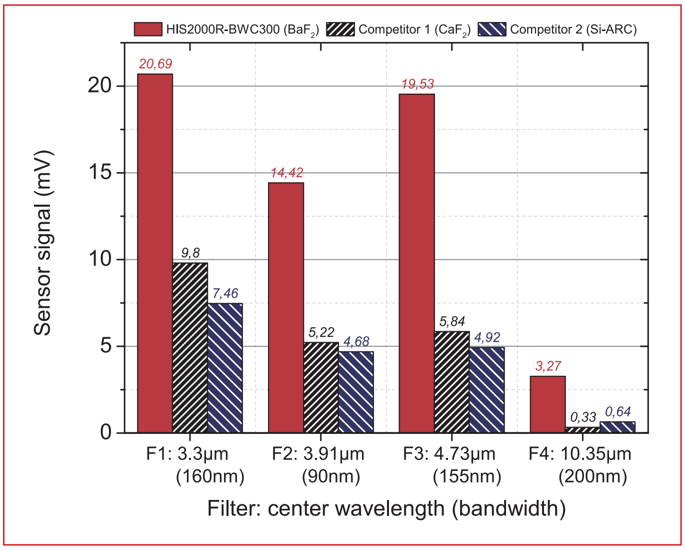


Fig. 6: Performance comparison of encapsulated IR emitters in NDIR setup.

NDIR Applications

With Infrasolid's patented technology and innovation it is possible to build TO-8 infrared emitters which deliver up to 10 times more IR emitting power than any other thermal TO-8 emitter on the market. The innovative thermal infrared emitters add many benefits to industrial applications, for example to NDIR gas analysis systems. Typically, such **NDIR** systems consist of three essential components:

1. A cuvette or gas chamber through which the gas mixture flows.
2. The IR detector which detects the change of radiation intensity after the absorption process.
3. The IR radiation source which emits the broadband IR signal.

With more IR signal at the detector area more accurate signals can be detected. The additional Winston cone collimator provides a more focused beam and reduces the reflections inside of the gas chamber delivering the maximum signal to the detecting element. The signal to noise ratio will be increased by typically 100%. With the availability of 4-, 8-, and even 16-channel detectors, it is most important that the infrared source delivers high optical power to the relatively small detector areas.

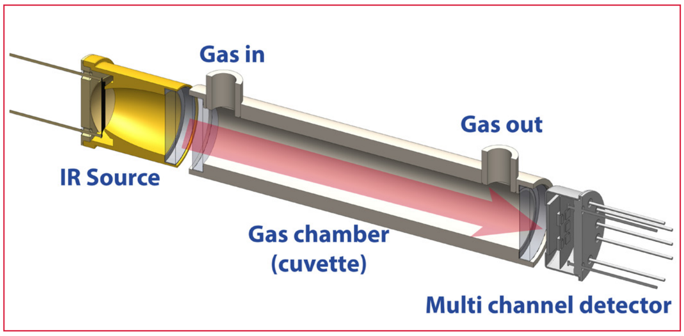


Fig. 7: NDIR gas measurement system

Fig. 7 shows a typical NDIR setup with a broadband, high-power infrared source using a focus beam Winston Cone collimator, an additional reflector at the bottom of the housing and a multichannel IR detector as an infrared sensor.

High radiation power is important because smaller detector and window areas of multi channel detectors reduce the sensitivity and detectivity.

Windows at the Emitter

Depending on the wavelength of the gases to be measured, a window with specific transmissivity is recommended between the emitter and the gas chamber. Optional windows for Infrasolid IR emitters are:
Sapphire
CaF2
BaF2
Silicon

Typical gases wavelengths are:

Gas		Absorption wavelengths (μm)
CH_4	Methane	3.2 - 3.5 / 7.7
SO_2	Sulfur dioxide	4.1
CO	carbon monoxide	4.64
CO_2	Carbon dioxide	4.26 - 4.3 / 14.9
COS	Cobalt sulfide	4.85
NO	Nitric oxide	5.2 - 5.3 / 5.5
NO_2	Nitrogen dioxide	5.5 / 6.4
N_2O	Nitrous oxide, "laughing gas"	4.47
H_2S	Hydrogen sulfide	7.5
NH_3	Ammonia	1.5 / 10.36 / 10.74
SF_6	Sulfur hexafluoride	10.6
O_3	Ozone	9 / 9.6
H_2O	Water vapour	6.4

Fig. 8: Typical NDIR absorption wavelengths

Driving circuits for easy and fast evaluation

INFRASOLIDs infrared (IR) emitter are powerful and high-efficient IR radiation sources that meet the demands for reliable and high-precision gas sensors and offer a wide range of application scenarios in IR spectroscopy. Infrasolids IR emitters are characterized by a very low temperature coefficient of electrical resistance. Therefore the hot resistance and the cold resistance are almost identical which eases the electrical control of the IR sources.

All IR sources can be driven in electrical voltage, current or power regulated mode. The application decides whether the operating mode is DC or AC (pulsed). Depending on the drive mode and the applied electrical power the electrical resistance of the IR emitter can change over time. For highest measurement accuracy a power regulated mode is always recommended for thermal IR emitters. However, it is the most complex operating mode and not suitable in all applications.

For applications that require a small and low-cost driving circuit with a maximum stability close to a power regulated mode a simple circuit with an adjustable low drop out voltage (LDO) regulator is provided by Infrasolid (Fig. 9).

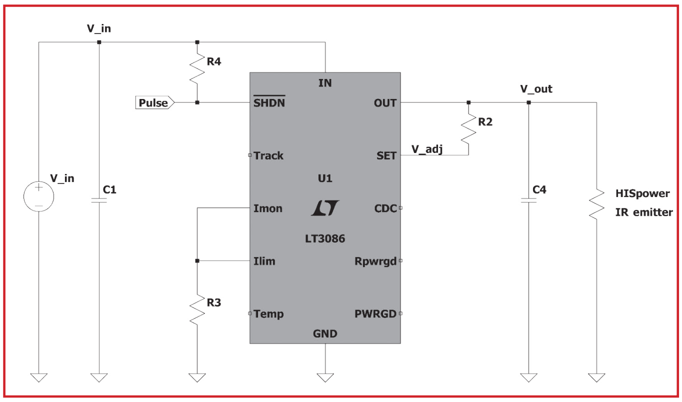


Fig. 9: Example circuit to drive HISpower TO-8 IR emitters from Infrasolid

Tool box with current source

Infrasolid offers a complete evaluation kit for IR emitters. The kit includes an adjustable current source and power supply together with an easy connection cable and holder for TO8 emitters. The holder is a special design, where variable emitters (i.e. with and without Winston cone) can be easily changes. The driving current can be easily adjusted to best fit the detector sensitivities. The current source can be triggered and synchronized with the sensor modulation frequency through the trigger input at the current source for synchronizing the complete setup.

Fig. 10: Emitter Toolbox with samples from Infrasolid

TOC (total organic compound) analysis is a non-specific test, which means it is simply a measure of the carbon found in any organic compound in the water. All EPA (environmental protection agency) approved methods for organic carbon analysis require NDIR methods. Typical emitters are:

HIS2000R-A300-6 / -A300-9 - lowest measurement range 0 ….. 40ppm
HIS2000R-CWC300 - lowest measurement range 0 ….. 20ppm
Warm-up times max. 3 minutes (full specification)

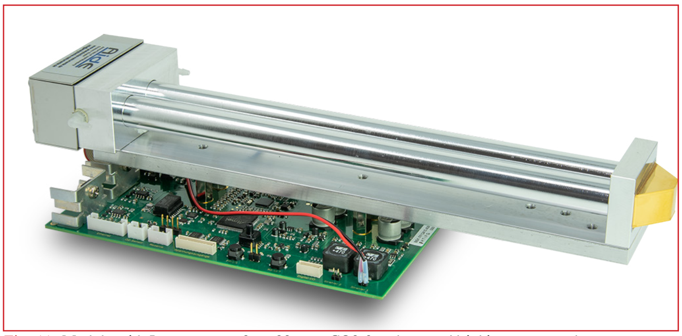


Fig. 11: Module with Lowest range 0 … 20 ppm CO_2 for ultrapure/drinking water analyzers
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Fuel gas, biogas analysis

With multi channel sensors and two independent gas sampling cells the IR gas sensor bench is used for simultaneous measurement of CH_4, CnHm (C_3H_8), CO and CO_2.

Emission monitoring (CEMS)

Best results and a wide dynamic range in emission monitoring and analysis is reached with TWIN IR gas sensors for simultaneous measurement of CO, NO, SO_2 and CO_2. Typical emitters (SO_2 requires higher wavelengths) are:

HIS2000R-C300-9 /-C300-6

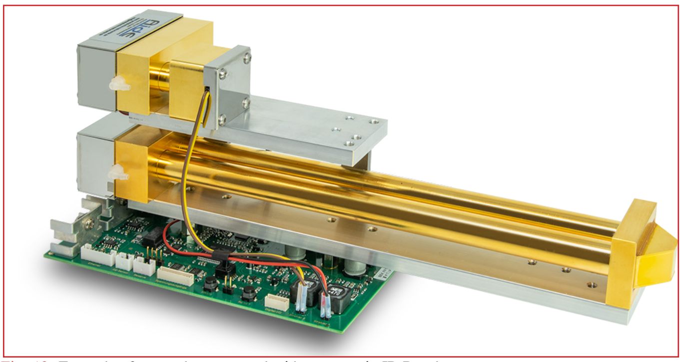

Fig. 12: Example of a very low ppm and wide range twin IR Bench
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Transformer gas diagnostics

Modern optical sensors support applications in monitoring transformers and for fault gases. Carbon monoxide, methane and ethylene (acetylene) and SF_6 are detected online in low concentrations. Best emitters are:

HIS2000R-CWC300
HIS2000R-BWC300

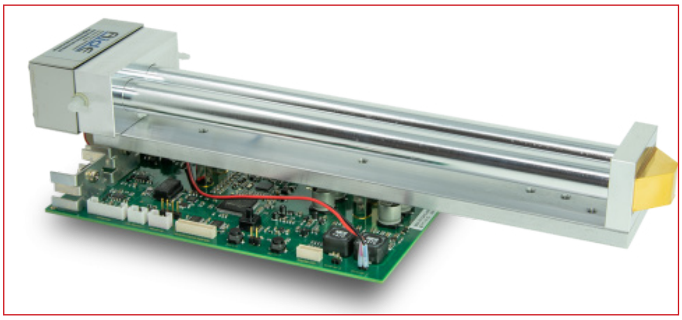

Fig. 13: Multi-channel system for the simultaneous measurement of up to 6 gases
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Respiratory gas diagnostics

Modern respiratory gas analyzers (e.g. for lung function diagnostics) need fast response times and high resolution for CO and CO_2. They use CH_4 in lowest concentrations as reference gas. Therefore, no additional sensor, e.g. for He is necessary. Typical emitters are:

HIS2000R-A300-6 / -A300-9

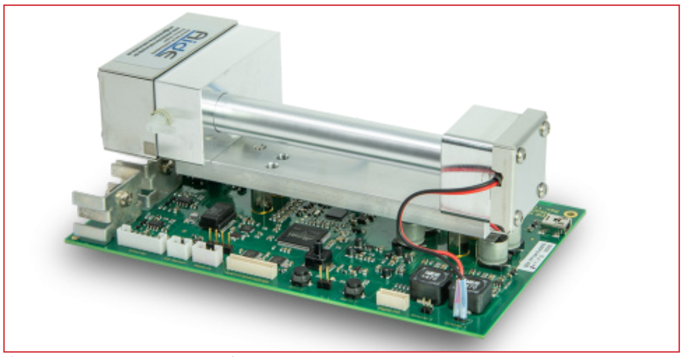

Fig. 13: Example of a modern respiratory gas analyzer module
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Fuel gas, biogas analysis

With multi channel sensors and two independent gas sampling cells the IR gas sensor bench is used for simultaneous measurement of CH_4, CnHm (C_3H_8), CO and CO_2. With typicalIR emitters:

HIS2000R-A300-6 / -A300-9

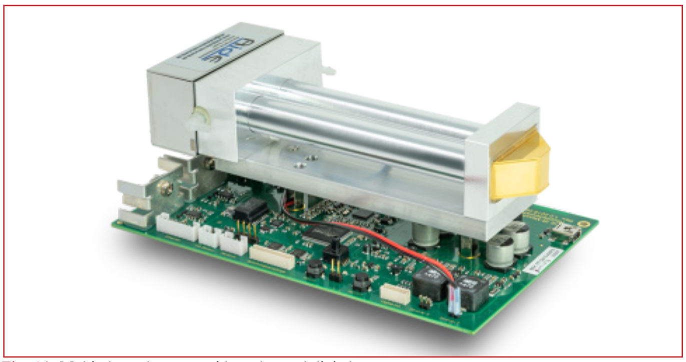

Fig. 14: Multi-channel system with analog and digital output
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C/S elemental analysis

Modern combustion analyzers are ideal for rapid and precise, simultaneous determination of carbon and sulfur in a large variety of solid materials. Typical emitters need a high emission above 7 μm:

HIS2000R-C300-9 /-C300-6
HIS2000R-CWC300
HIS2000R-BWC300

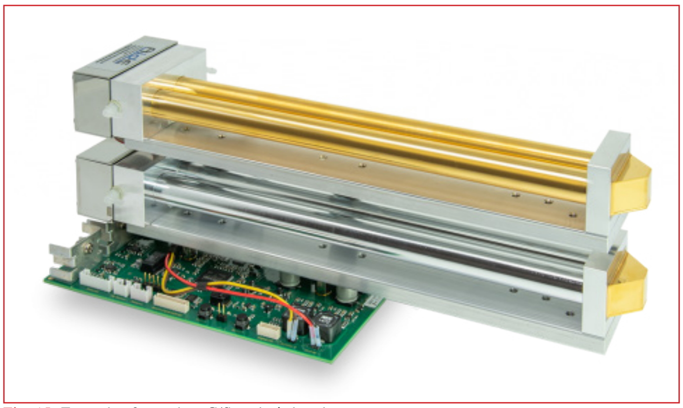

Fig. 15: Example of a modern C/S analysis bench
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