Use of Multi Channel Detectors and Infrared Emitters in Gas Analysis

The detection and concentration measurement of gases is a standard procedure in the medical and industrial area worldwide. But what needs to be observed for the selection of components and what do multi channel detectors and infrared emitters have to do with this?

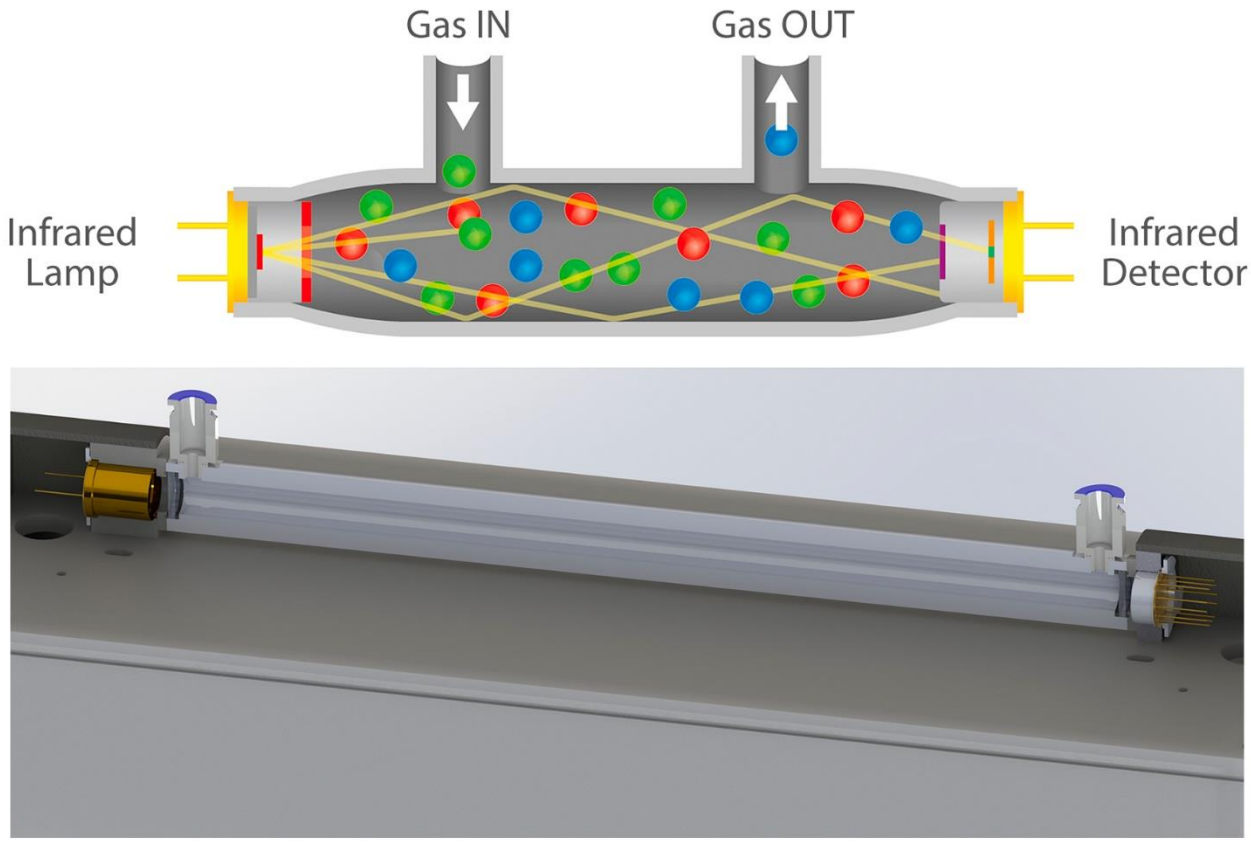

Fig. 1: Principle setup for NDIR gas analysis at the top and a practical setup at the bottom with a pyroelectric eight-channel detector from InfraTec (right) and an electrically modulated infrared source from Infrasolid (left). (Fig.: Infrasolid/InfraTec)

Almost every gas has the characteristic of absorbing radiation of specific wavelengths in the mid-infrared spectrum. This means that the radiation is specifically weakened according to the gas and the existing gas concentration. This effect is measured and visualised in non-dispersive infrared gas analysis (NDIR gas analysis). This allows gas concentrations to be determined with long-term stability and accurately as well as the reduction of cross-sensitivities to other gases. The application areas are diverse: for health ranging from pulmonary function diagnostics to the dosage of anaesthetic gases, for personal safety equipment for the mining industry, and in environmental technology - for example, the measuring of exhaust gases in chimneys and from vehicles.

Functioning Principle of NDIR Multi Gas Analysis with Eight Spectral Channels

A measuring chamber is illuminated with infrared radiation for the analysis of gases. A gas measuring module consists of an electronically or mechanically modulated infrared radiation source, a sample cell through which the gas to be measured flows, and a pyroelectric detector with one or more spectral channels that measures the impinging radiation intensity. One of the measuring channels in the detector often serves as a reference channel on which the radiation meets, unaffected by the gases to be measured. Depending on the concentration of the gases to be

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measured in the chamber, the change in intensities generates corresponding signals on the channels of the detector and sets them in relation to the reference signal. The reference channel also levels drift effects which could occur due to the ageing of the infrared radiation source or due to contamination in the optical path of the infrared source in the course of the device's life. With the world's first eight-channel detector from InfraTec, eight different spectral channels can be used for gas measurement.

Fig 2: First eight-channel detector LRM-278 from InfraTec; recognisable are the 8 different narrow bandpass filters. (Fig.: InfraTec)

Physical Principles of Gas Analysis

Many gases absorb infrared radiation at different wavelengths, meaning that a gas can be identified by the evaluation of the unique spectral absorption. An NDIR gas analyser uses this principle. A narrow bandpass filter is integrated in each channel of the detector which corresponds to the absorption wavelength of the target gas. The more channels, the smaller the sensor area of each individual channel and the greater the importance of having a powerful infrared radiator.

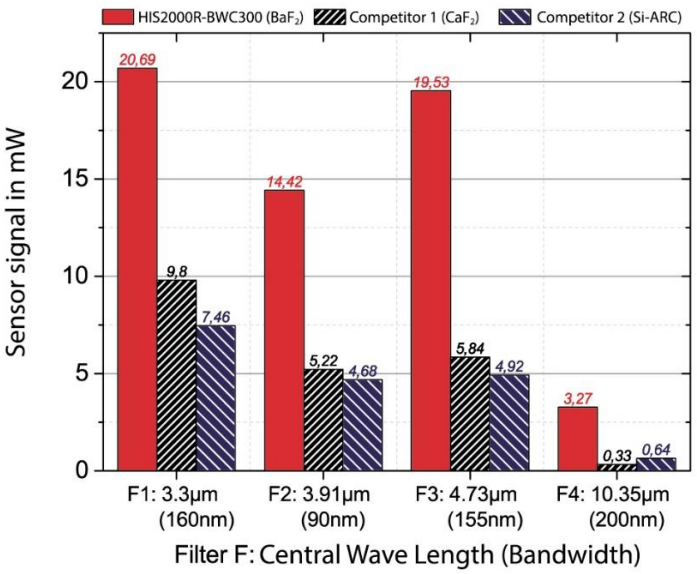

Fig. 3: Signal gain through the Infrasolid emitter in comparison with other thermal infrared emitters in TO-8 housing. More than 500% signal gain is attained, at different wavelengths. (Fig.: Infrasolid/InfraTec)

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How are the Infrared Detectors Selected

Pyroelectric detectors enable measurement over a large wavelength range and therefore achieve a clearly straightforward, long-term stable, cost-effective and constantly operating measuring procedure on the instrument side for gas analysis.

The simultaneous identification of many gases with the exclusion of cross-sensitivities in gas mixtures requires several spectral channels. InfraTec offers components with patented designs, in which the radiation enters through one aperture in the detector and illuminates up to eight channels to achieve this purpose. In this way, a great deal of radiation reaches the elements, which, in turn, have a high signal-to-noise ratio and offer benefits for the electronic reinforcement on the user side.

Pyroelectric detectors are suitable for gas analysis because the pyroelectric crystals of lithium tantalate (LiTaO3) installed in the detector change their polarity with a change in temperature. To reinforce the pyroelectric effect, a highly absorbent black layer is applied to the pyroelectric material LiTaO3. If infrared radiation impinges on this layer, the pyroelectric material heats up and surface charges result. If the radiation is switched off, charges of reverse polarity result. However, the charges are very low. Before they can balance out again through the final internal resistance of the crystal, extremely low-noise and low leakage current field-effect transistors (JFET) or operational amplifiers (OpAmp) convert the charges to a signal voltage. Detectors with OpAmp (current-mode operation) can be operated very quickly. Their high output signal can be processed without problems and virtually without interference.

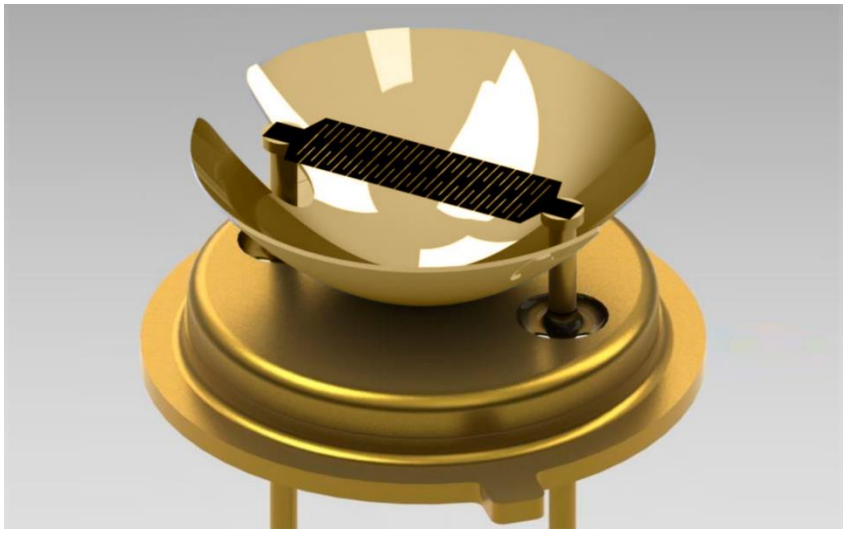

Fig. 4: Principle structure of an infrared emitter from Infrasolid with gold-plated reflector. (Fig.: Infrasolid/InfraTec)

First Eight-Channel Detector Worldwide

The LRM-278 from InfraTec combines eight measuring channels for the first time in a TO8 housing with a diameter of 15.2 mm. In comparison with conventional quad channel detectors, the number of gases that can be encompassed by one single detector of this size is doubled.

When looking at the design of the detector, two details become clear, which make a significant contribution towards ensuring that such a powerful solution fits into such a small space. On one hand, there is a central built-in window in

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the detector cap. This makes the detector more resistant to outside impacts and enables high radiation on the pyroelectric elements to achieve a positive signal-to-noise ratio. It especially protects the sensitive narrow bandpass filter and can also fulfill further spectral requirements such as the blocking in areas outside the absorption bands.

The second detail is concealed inside the detector. There, on special frames, the sensitive pyroelectric elements for thermal compensation as well as the IR Filters are stacked directly on top of each other. Eight channels and all further components can be accommodated in one compact TO-8 housing thanks to this stacking design.

The measuring of the temperature in direct proximity to the IR filters is essential for instrument calibration. The compact design of the detector LRM-278 also integrates a temperature sensor for the first time and makes external temperature measuring redundant.

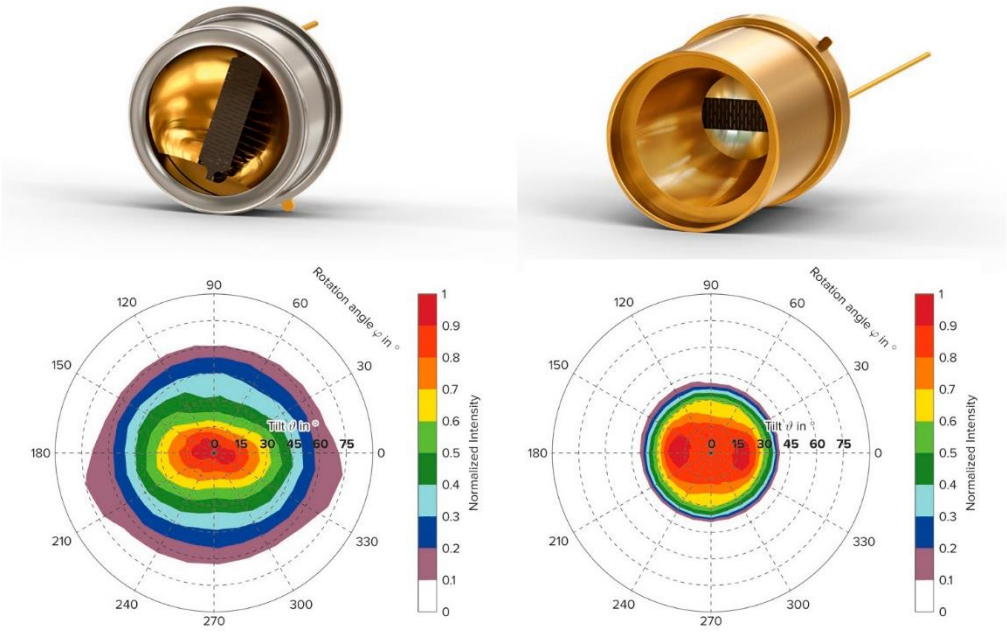

Fig. 5: Emitter in TO8 housing with reflector (left) and with reflector and Winston Cone collimator (right), the optimised bundle of rays is well captured in the diagram on the right. (Fig.5: Infrasolid/InfraTec)

The Right Infrared Emitter

The modulating emitters from Infrasolid supply a broadband radiation. The electrical modulation means that a mechanical chopper can be omitted. This implies that the structure of the complete sensor can be more compact and the systems are more robust due to the omission of mechanical parts. The patented design of the radiating filament in the form of a double meander guarantees the high mechanical stability and simultaneously increases the electrical resistance, meaning that the emitter can be operated with a lower current. The high electric resistance is constantly maintained throughout the entire operation and leads to extremely high efficiency and even heating of the entire filament. The filaments are coated on both sides by a special process in order to increase the radiation power significantly.

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The TO8 infrared emitters from Infrasolid deliver the highest sensor signal in comparison with other thermal infrared radiation sources that are currently available on the market. Fig. 3 compares the signal gain of the Infrasolid emitter with conventional infrared emitters in TO8 housing in a typical NDIR structure with a quad-channel detector and a cuvette length of 200 mm. It can be clearly detected that the infrared emitters from Infrasolid in comparison with other thermal TO-8 emitters deliver a factor of 2 to 4 times higher signal in the wavelength range from 3 µm to 5 µm and even a 5 times higher signal in the long-wave range at 10.35 µm. This can be ascribed to the high temperature, the large radiating area, and the high emission degree of the radiating filament. Moreover, by means of a gold-plated reflector mounted on the TO base, the radiation emitted on the rear side is additionally thrown reflected out of the cap opening and therefore utilised (fig. 5), leading to an additional signal gain on the detector. The use of Infrasolid emitters can increase the resolution of gas measuring instruments up to factor of 5. This leads to a significant performance enhancement in classical NDIR structures.

Additional reflections inside the gas cuvette have a particularly interfering impact if water vapour partially condenses on the inside wall. To reduce the reflections, the emitters from Infrasolid can also be set up with a so-called Winston Cone collimator. This bundles the radiation emerging from the emitter and reduces the reflections on the cuvette wall up to the impingement on the detector. Fig. 5 shows the radiation performance measured depending on the angle of radiation.

Fig 6: A potential application area for IR emitters and reflectors could be in the medical field, e.g. monitoring anaesthetic gases.
(Fig.: Fotolia/beerkoff)

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Source:
https://www.all-electronics.de/elektronik-entwicklung/nutzen-von-mehrkanaldetektoren-und-infrarotstrahler-in-der-gasanalyse-124.html

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