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The role of gas sensing in climate strategies

Climate change is a global issue, and tackling it requires a reduction in greenhouse gas emissions across the globe throughout all sectors, from agriculture and energy to waste and transport. Many greenhouse gases – including methane (CH_4) and carbon dioxide (CO_2) – are invisible to the naked eye, yet even small leaks or undetected emissions can have major impact on our atmosphere. This is especially the case for CH_4, which is over 80 times more potent as a greenhouse gas than CO_2 in the first two decades after emission, before it is removed from the atmosphere.[1]

Monitoring these emissions in real time, at the source, is essential for effective climate change mitigation, and this is where optical gas sensing – in particular mid-infrared (MIR) sensors – can provide great value. This technology can be used in both fixed installations and mobile platforms, or even integrated into compact field instruments, allowing organizations to gather accurate, real-time data to support environmental policy compliance. This blog explores how MIR non-dispersive infrared (MIR NDIR) gas sensors can ensure accurate, long-term greenhouse gas measurements in the field.

Monitoring greenhouse gases CO_2 and CH_4

The most critical greenhouse gases to monitor are CO_2 and CH_4, as they are both abundant and persist in the atmosphere, making them major contributors to climate change. CO_2 is primarily released through fossil fuel combustion and cement production, as well as by deforestation, which also reduces the planet's ability to absorb the gas. CH_4 enters the atmosphere from various sources – such as livestock, landfills, wastewater, and natural gas infrastructure – accounting for the majority of radiative forcing and remaining in the atmosphere long enough to cause lasting impact.[2]

Various sectors may also benefit from tracking other trace gases and volatile organic compounds (VOCs). Many of these molecules absorb infrared (IR) light at characteristic wavelengths in the MIR range (around 3-8 µm),[3] making them good candidates for optical detection. The advantage of MIR sensing lies in the spectral separation between gas absorption peaks that reduces cross-interference, which reduces cross-interference, a key consideration in complex environments such as industrial emissions stacks or petrochemical plants.

How MIR NDIR sensing works

MIR NDIR systems measure gas concentration by shining infrared light through a sample and detecting how much is absorbed.

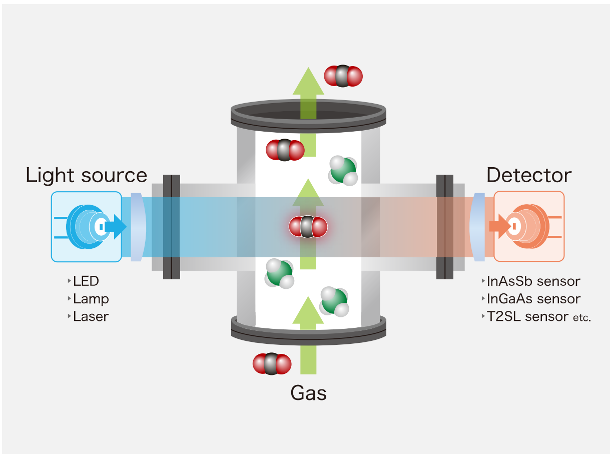
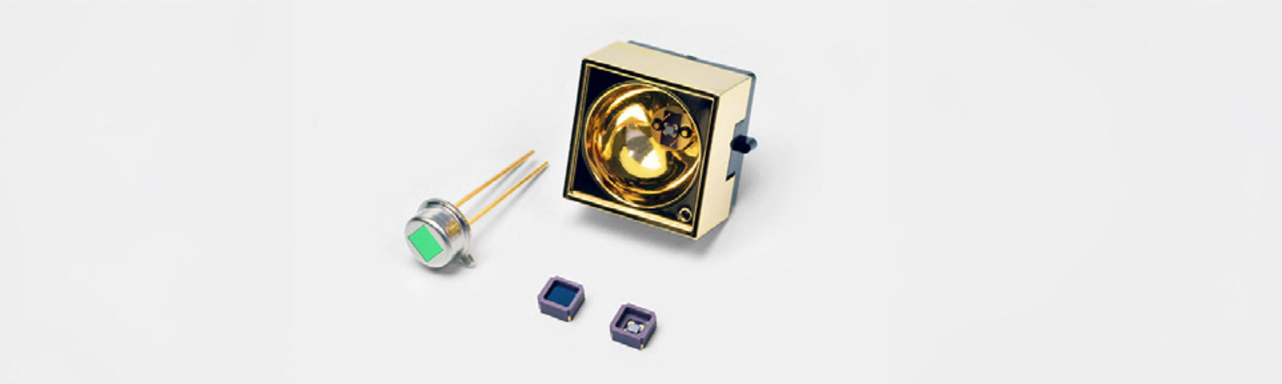


Figure 1: A schematic of a gas sensor

Since many gases absorb IR light at distinct wavelengths, this method offers high selectivity and the ability to detect gases in diverse environments. The system typically consists of a MIR LED source, a gas cell, and a



Hamamatsu's Mid-infrared LEDs L1589X series

photodetector. Tuning sensors to the specific absorption wavelengths of target gases allows accurate concentration measurements as the amount of light absorbed by a gas is directly proportional to its concentration:

$$A=\varepsilon lc$$

Where 'A' is absorbance, 'ε' is the molar extinction coefficient, 'l' is the path length of the light, and 'c' is the concentration.

Combining indium arsenide antimonide (InAsSb) photodiode detectors with MIR LEDs is popular for greenhouse gas sensing, as this set-up has a strong spectral overlap for the absorption bands of key gases, such as CH_4 and CO_2.[3]

Emission monitoring in the field

Sensors based on InAsSb detectors and MIR LEDs can provide high sensitivity in a compact, rugged design, and their low power requirements make them ideal for extended deployment in challenging environments. They can be mounted on drones for aerial surveys, integrated into vehicles for mobile measurements, or installed at remote sites where regular maintenance is difficult.[4,5] These capabilities make them central to robust climate strategies, as the ability to measure and verify greenhouse gas emissions is key to both national inventories and corporate environmental, social and governance (ESG) reporting.

One critical application is in continuous emission monitoring systems (CEMS), which are fixed installations on industrial stacks or vents that measure pollutant concentrations in real time to ensure regulatory compliance, optimize processes, and track long-term emission trends.[5] These systems are commonly used in complex environments – such as petrochemical or power plants – taking advantage of advanced simulation tools help to deconvolute overlapping spectra to isolate target compounds.

Similar technology is used in fence-line monitoring, where networks of sensors around a facility's perimeter detect fugitive emissions escaping into surrounding areas. This not only helps with pinpointing leaks but also provides transparency for local communities and supports environmental reporting. In the oil and gas sector, optical sensors are widely applied for methane leak detection, with multi-sensor networks capable of triangulating leak locations – and even reconstructing plume movement in 3D – to give a high-resolution picture of real-time emissions.[4] Beyond industry, these sensors are used in climate research campaigns to measure specific gases in situ, providing accurate quantification of emissions directly at the source to inform mitigation strategies.

Other gas sensing technologies

Applications that require measuring more complex gas mixtures often use quantum cascade lasers (QCLs) to accurately identify and quantify individual gases within the mix. These offer exceptional spectral precision, making it easier to isolate individual gases, even when multiple compounds are present. For certain gases like ammonia (NH_3), UV-based detection systems – typically using xenon lamps and UV photodetectors – are preferred over infrared methods. Though not a greenhouse gas, NH_3 contributes to secondary particulate formation and is under growing regulatory scrutiny, particularly in maritime emissions and agricultural environments, where new European legislation may soon require its continuous monitoring in settings such as barns.[4]

Summary

Greenhouse gases may be invisible, but their impact on the climate is not. As expectations around accountability, traceability, and climate transparency grow, MIR NDIR gas sensors are becoming an essential part of climate action strategies. EU regulations for methane monitoring in the energy sector are already in force, and NH_3 and CH_4 measurements in agriculture may soon follow. In all these settings, accurate and reliable sensing will be essential for compliance and effective action.[4]

Advances in solid-state components like MIR LEDs and InAsSb photodiodes mean that modern gas sensors are smaller, more efficient, and better suited to for long-term, decentralized deployments. This enables direct measurements at the source, providing organizations with actionable data. At Hamamatsu, we continue to develop environmentally friendly, high-performance sensing technologies that support accurate greenhouse gas monitoring. Our commitment to using non-toxic materials and reducing power requirements ensures that these innovations contribute to climate goals not only through their applications, but through their design.

For more information, or to discuss how we can help with your gas sensing project, please visit www.hamamatsu.com or contact us at info@hamamatsu.eu

To learn more, watch our webinar[4] on how MIR technologies are shaping the future of intelligent gas sensing.

References

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