

Beyond CO₂: the emerging importance of multi-gas detection

Carbon dioxide (CO₂) is often the headline gas in discussions on emissions and indoor air quality, but it is far from the whole story. A host of other gases, including methane (CH₄), nitrogen oxides (NO_x), sulfur oxides (SO_x), ammonia (NH₃), and volatile organic compounds (VOCs), can have just as much of an impact on health, safety, and climate.^[1,2] Gaining an accurate picture of air quality requires gas sensing systems to go beyond CO₂ and deliver accurate, selective detection of multiple compounds. This blog explores the impact of these commonly overlooked pollutants, the role of mid-infrared (MIR) sensors in detecting them, and their applications in industries where accurate multi-gas monitoring is critical.

Silent gas pollutants and their impact

There are many gases that don't grab the pollution headlines in quite the same way as CO₂, however, several stand out because of their wide-ranging effects on the climate and human health:

- **CH₄** is a highly potent greenhouse gas, with a short-term warming effect more than 80 times greater than CO₂.^[3] Even small, undetected leaks from pipelines or storage facilities can accelerate climate change.
- **NO and NO₂** (together referred to as NO_x) are major contributors to smog, acid rain and ozone formation, harming both ecosystems and human health. NO is relatively short-lived, but rapidly converts to NO₂, which is highly regulated.^[4]
- **CO** is not a strong greenhouse gas in itself, but plays an indirect role by extending the lifetime of methane in the atmosphere. It also contributes to ground-level ozone formation and air quality issues.^[5]
- **SO₂ and SO₃** (referred to as SO_x) are released mainly from burning fossil fuels and shipping. They convert in

the atmosphere to form sulfuric acid, driving acid rain and particulate pollution.^[6]

- **HNO₃** is formed in the atmosphere from NO_x, and contributes to acid deposition that damages soils, forests, and aquatic systems.^[7]
- **H₂S** is produced in agriculture and certain industrial processes. It is toxic even at low concentrations, and when oxidized in the atmosphere it can form SO₂, adding further to acid rain.^[8]
- **NH₃** is another key agricultural emission affecting climates, ecosystems and animal welfare.
- **VOCs** are released from solvents, fuels, and industrial processes, and are linked to respiratory problems and poor indoor air quality.

Individually, these gases are dangerous; together, they create complex pollution profiles that require reliable monitoring. That is why regulators are expanding their focus beyond CO₂ alone, and why industries are seeking technologies capable of multi-gas detection.^[9] Reliable monitoring of these gases requires technologies capable of distinguishing them from one another, underscoring the need to choose the right detection approach.

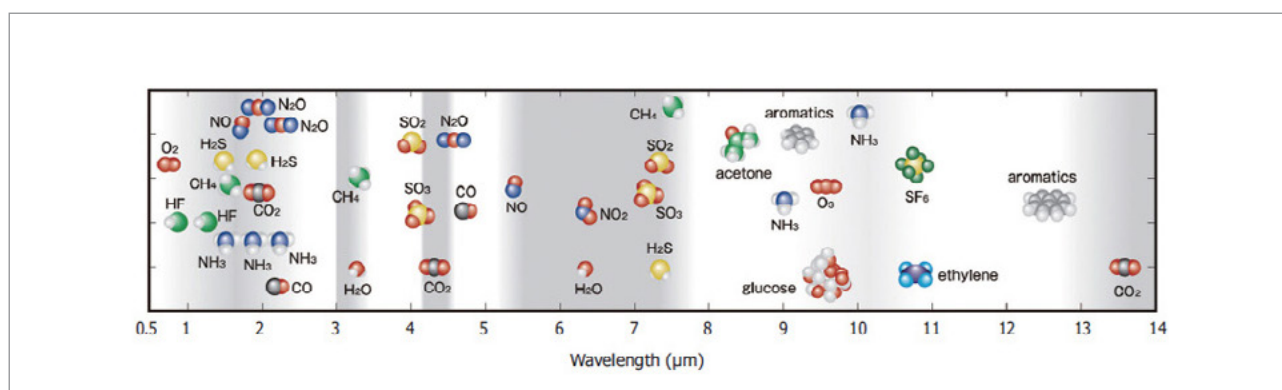


Figure 1. Examples of environmentally significant gas molecules with characteristic absorption bands in the IR spectrum.

Infrared gas detection: near-infrared versus mid-infrared

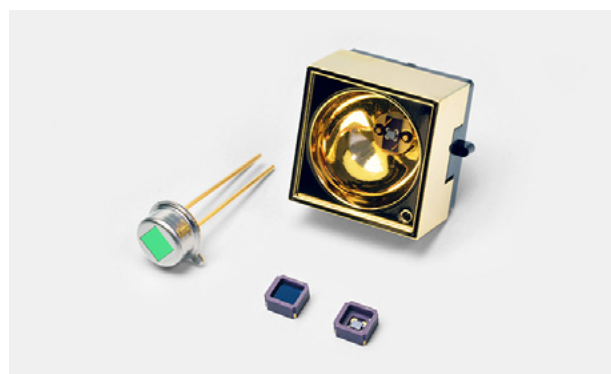
Both near-infrared (NIR) and MIR approaches are used in gas detection, but they differ in performance and suitability. NIR LEDs emit light in the 0.83 to 1.55 μm range and are efficient, reliable, and capable of very fast responses, making them attractive for applications where low power consumption is critical. Detectors operating in this range are also highly sensitive, a benefit that stems from decades of development in the telecoms industry, where indium gallium arsenide (InGaAs) devices were optimized for fiber-optic communications. The drawback is that the absorption peaks of many gases in the NIR region are weaker and lie close together, which makes it more difficult to distinguish multiple gases in a complex mixture. MIR systems, on the other hand, operate between 3 and 11 μm , where many gases exhibit strong and distinct absorption bands. This greater spectral separation reduces interference and makes MIR the preferred option for multi-gas detection, allowing individual gases to be identified more clearly.^[9,10]

Aligning the components for multi-gas detection

Designing a reliable gas sensing system, however, depends on more than just choosing the right wavelength range. The light source and detector must also be carefully matched, since performance depends on how well the emitter's output overlaps with the detector's sensitivity. Most modern multi-gas instruments are based on non-dispersive infrared (NDIR) sensing and tunable diode laser absorption spectroscopy (TDLAS), which measure the amount of infrared light absorbed by a gas at specific wavelengths. The choice of emitter and detector is therefore crucial to ensure accurate, selective detection.

Advanced light sources for optical gas sensing

Traditional emitters, such as tungsten filament lamps and blackbody sources, are still used in some systems because they are cheap and broadband. However, they draw more power, generate heat, and lack the selectivity needed for high-precision applications. MIR LEDs represent a modern alternative, as these solid-state sources can be tuned to match the absorption peaks of specific gases, for example, 3.3 μm for CH_4 and 4.3 μm for CO_2 .^[9] When paired with the right detectors, they can deliver ppm sensitivity with proper calibration.^[10] Their long lifetimes, high reliability, and low power demands make them especially suitable for portable instruments and distributed sensor networks. For applications that require even higher selectivity, quantum cascade lasers (QCLs) are sometimes employed. Their extremely narrow emission bands enable precise targeting of individual gases within complex mixtures. In practice, this often means that several QCLs – each tuned to a different absorption line – must be combined for true multi-gas detection. This adds to their cost, lowers their efficiency, and creates integration challenges, which is why they are typically reserved for specialized analytical or process-control settings rather than mainstream portable devices.^[9]

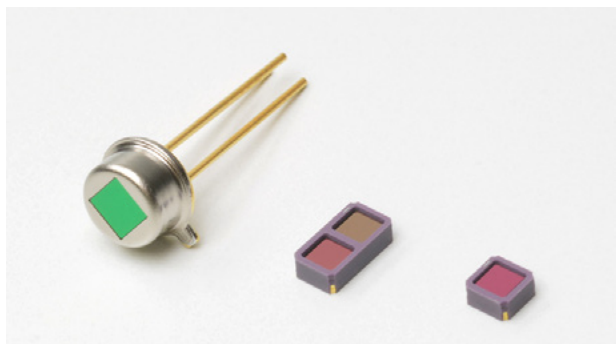


Hamamatsu Photonics' Mid-infrared LEDs L1589X series.

High-sensitivity detectors for gas monitoring

The detector side of the system is just as critical as the light source. Early gas sensors made use of lead-salt or mercury-based detectors, but these materials are now restricted under RoHS regulations. Pyroelectric detectors remain in use for some lower-cost applications, but their slower response and lower precision make them less suitable for environments where multiple interfering gases are present.

The shift is now toward indium arsenide antimonide (InAsSb) photodiodes, which are highly sensitive in the 3-11 μm spectral range, fully RoHS-compliant, and far more stable over time than electrochemical alternatives. When paired with MIR LEDs, they provide a compact, energy-efficient combination capable of reliable, interference-resistant measurements. This solid-state pairing is central to the ongoing miniaturization of gas sensors, enabling broader adoption across multiple industries.



Hamamatsu Photonics' InAsSb photovoltaic detectors P16112 series and others (with BPF).

Mid-infrared sensing applications

Advances in solid-state light sources and detectors now provide the foundation for practical multi-gas sensing. These technologies make it possible to move beyond lab-based instruments and deploy reliable sensors in real-world environments – from transportation and agriculture to smart buildings and urban monitoring – helping to track climate-relevant emissions and protect human health.

Transportation

Shipping companies are under increasing pressure to monitor emissions as vessels enter harbors, particularly SO_x and NO_x , which contributes heavily to coastal air

pollution. Meanwhile, in the oil and gas sector, MIR sensors are central to detecting CH_4 leaks.^[9] Fence-line monitoring networks equipped with MIR detectors can triangulate leak locations and even reconstruct gas plume movement, helping operators prevent fugitive emissions.^[11]

Agriculture

Livestock farming is another major source of CH_4 and NH_3 , both of which affect climate and animal welfare. Farms can also emit H_2S , which poses odor and toxicity risks, and can oxidize in the atmosphere to form SO_2 . MIR sensors enable continuous, non-intrusive monitoring in barns and storage facilities, giving farmers data to reduce their environmental footprint and comply with emerging regulations, including proposed EU requirements for NH_3 monitoring.^[9,12]

Smart buildings

Indoor air quality is increasingly monitored as part of building management systems and, while CO_2 is often the primary target, VOCs also affect comfort and productivity. Integrating MIR sensors into HVAC systems enables continuous tracking of these gases, creating safer, more responsive working and living spaces.^[13]

Urban and public health

In cities, MIR sensing can support air quality networks that monitor hotspots of CH_4 , NO_x , and CO . NO_x and CO are particularly problematic in urban areas, with traffic and heating systems being major sources. Both contribute to ground-level ozone and respiratory issues, while HNO_3 , formed in the atmosphere from NO_x , plays a role in acid deposition that damages infrastructure and ecosystems. Portable MIR instruments can even be deployed in response to emergencies, helping to detect hazardous leaks or identify unsafe conditions after an industrial incident.^[14]

Moving towards smarter gas sensing

Air quality and emissions cannot be understood by looking at CO_2 alone, as CH_4 , NO_x , CO , HNO_3 , NH_3 , H_2S , SO_x , and VOCs all contribute detrimentally to health, safety, and climate. Advances in solid-state light sources and detectors are making it possible to track these multi-gas emissions with greater accuracy, stability, and efficiency than ever before. At Hamamatsu Photonics, we offer the components that make this

possible; our MIR LEDs, InAsSb photodiodes, and other solid-state solutions are designed for precise, long-term gas detection, enabling reliable multi-gas monitoring. With decades of expertise in photonics, we continue to advance sensor technology that helps industries and communities measure, manage, and ultimately reduce harmful emissions.

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^{\[9\]}](#)
to hear experts in the field explore
the potential of advanced MIR
detection technology.

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