

Greener Industry with Advanced Gas Detection

Industrial emissions significantly contribute to climate change, prompting global regulatory pressure for cleaner practices. This article discusses photonicsbased gas detection, highlighting how advanced infrared sensors and emitters support emission monitoring and leak detection, enabling industries to comply with regulations and reduce their environmental impact.

Industrialization and Its Environmental Cost

Industrialization has brought global economic growth, but led to high greenhouse gas (GHG) emissions. Key industrial sectors like power generation, chemical production, and cement manufacturing emit large volumes of CO_2 , CH_2 , and N_2O , contributing significantly to climate change.

According to the EDGAR 2024 database and the Intergovernmental Panel on Climate Change (IPCC), direct industrial emissions amounted to approximately 11,408 million tons of CO_2 equivalent (Mt CO_2e) in 2023. This represents about 21.5% of global GHG emissions, excluding land use and forestry. When indirect emissions from electricity used in industry are included, the sector's share rises to nearly 31%.^[1]

Industrial emissions are often continuous and centralized, so they can accumulate rapidly and affect regional and global climate patterns. They can also cause global temperature increases, melting polar ice, and the increased frequency of extreme weather events like droughts, floods, and hurricanes. These emissions' high volume and persistence make them challenging to mitigate without systemic change.

Regulatory Pressure to Cut Emissions

In response to the climate emergency, governments worldwide enforce stricter environmental regulations to reduce industrial emissions and promote cleaner technologies. These measures are designed to mitigate global warming and to build resilience against its impacts. Many countries have implemented updated climate laws, carbon taxes, and mandatory reporting requirements to drive industry transition toward cleaner alternatives.

For instance, China aims to raise non-fossil fuel consumption to 20% by 2025, targeting a 130 million tonne CO₂ reduction over 2024–2025. ^[2] Similarly, the EU's "Fit for 55" package mandates a 55% GHG cut by 2030 versus 1990 levels.^[3] Three such policies drive industries to adopt real-time emission monitoring technologies like advanced gas detection sensors.

Photonics: A Technological Solution for Emission Monitoring

Industries need highly sensitive, accurate, and rapid gas detection systems to comply with the demanding regulatory standards. Photonicsbased gas detection offers non-contact, real-time analysis of a variety of gases. These systems rely on the interaction of light with gas molecules, using absorption spectroscopy to identify and quantify specific gases. Continuous monitoring via these sensors provides industries with the data needed to detect leaks and adjust processes. This enables industries to measure emissions, comply with regulations, and reduce their carbon footprint.

Hamamatsu Photonics: A Leader in Infrared Detection

Hamamatsu is a leading provider of a wide range of advanced infrared detection technologies. Hamamatsu offers a comprehensive lineup of indium gallium arsenide (InGaAs) photodiodes and image sensors engineered for high-speed, high-sensitivity, and low-noise detection in the near-infrared spectrum, with spectral responses ranging from 0.5 μ m to 2.6 μ m, ideal to detect the strongest absorption peaks of the main GHGs. Their compact, integrated designs — sometimes combining photodiodes with ICs for digital output enable precise, real-time monitoring in industrial environments.^[4]

Similarly, Hamamatsu's indium arsenide antimonide (InAsSb) detectors for mid-infrared applications deliver high sensitivity at key atmospheric absorption bands $-5 \mu m$, 8 μm , and 11 μm . In these wavelength ranges, the absorption peaks of GHG such as Methane and Carbon Dioxide are well spaced, allowing for a measurement with high gas selectivity. Hamamatsu's latest models, such as the P16702-011MN, feature built-in preamplifiers for improved signal amplification and seamless integration, compact form factors, and fast response times up to 100 MHz. These detectors are valuable



Hamamatsu's InAsSb photovoltaic detector with preamp P16702-011MN.

for portable gas analyzers, allowing immediate onsite analysis of industrial exhaust gases. Moreover, InAsSb also provides a RoHS-compliant alternative to mercury-cadmium-telluride (MCT) detectors, which are restricted due to toxicity concerns.^[5]

Hamamatsu is one of few companies that manufacture both infrared photodetectors and light sources. Their QCLs and infrared LEDs integrate with detectors for high-speed, high-sensitivity measurements. Moreover, these emitters facilitate advanced spectroscopic techniques when paired with InAsSb detectors.

Applications for Emission Monitoring and Leak Detection

Hamamatsu's infrared solutions are used in several critical applications that help industries meet environmental and safety goals. For instance, Continuous Emission Monitoring Systems CEMS are a regulatory requirement in many countries for facilities that emit pollutants into the air. These systems continuously measure gas concentrations in exhaust stacks and flues to ensure compliance with environmental regulations. In this regard, Hamamatsu's infrared detectors are crucial in enabling multi-gas monitoring capabilities and accurate tracking of harmful emissions.



Similarly, Leak Detection and Repair LDAR programs are designed to detect and fix uncontrolled gas leaks before they become critical. Industries can quickly identify and localize leaks using laser scanning, optical gas imaging, and UAV-based (drone) monitoring technologies. Hamamatsu's sensors and emitters enhance the precision and range of these technologies, making leak detection more efficient and less labor-intensive.

The Impact of Photonics on Environmental Sustainability

Applying photonics technologies significantly impacts industries' ability to meet stringent environmental regulations and contributes to the fight against global warming. Photonics empowers industries to optimize their processes, reduce waste, and minimize their environmental impact by providing accurate and realtime data on gas emissions. This ultimately leads to a substantial reduction in GHG emissions, contributing to the global effort to mitigate climate change and create a more sustainable future.

References

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