

State of the Art Microsensors at Industrial Scale

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Summary:

Sensirion develops and manufactures microsensors based on CMOSens® technology, integrating sensing elements and readout electronics on a single chip or within highly integrated sensor modules. This enables scalable, high-volume production of precise and reliable sensors for environmental, medical and mobility applications. Key sensing principles, including capacitive, chemoresistive, thermal and optical methods, are implemented in miniaturized systems. Each sensor is individually calibrated during production, ensuring high accuracy out of the box. The article highlights how industrial R&D translates microscale sensing concepts into robust, mass-produced solutions.

Keywords: CMOSens, MEMS, gas sensing, environmental sensing, high-volume manufacturing

Innovative and Reliable Microsensors at Industrial Scale

Microsensors are key enabling technologies for addressing challenges in climate action, energy efficiency, and healthcare. Applications range from indoor air quality monitoring to medical ventilation and industrial process control. Sensirion, founded in 1998 as an ETH Zürich spin-off, produces around 200 million sensors annually. The heart of each sensor is a combined MEMS structure with integrated electronics enabled by the company CMOSens® technology. Fig. 1 shows an overview of the sensing principles.

Sensing Principles: MEMS core

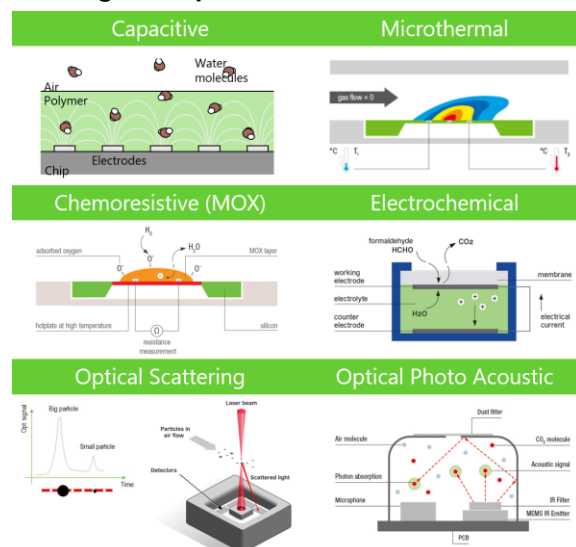


Fig. 1. capacitive, microthermal, MOX, electrochemical and optical (including scattering for particulate matter).

CMOSens® integrates sensing elements and CMOS electronics either monolithically or in highly integrated modules. Key sensing principles include capacitive humidity sensing, chemoresistive MOX gas sensing, microthermal sensing (thermal flow and thermal conductivity), optical absorption (NDIR and photoacoustic), and optical scattering for particulate matter. These technologies enable highly selective and scalable sensing solutions across a wide range of applications.

Products and Applications

These sensing principles are implemented across a broad portfolio of products.

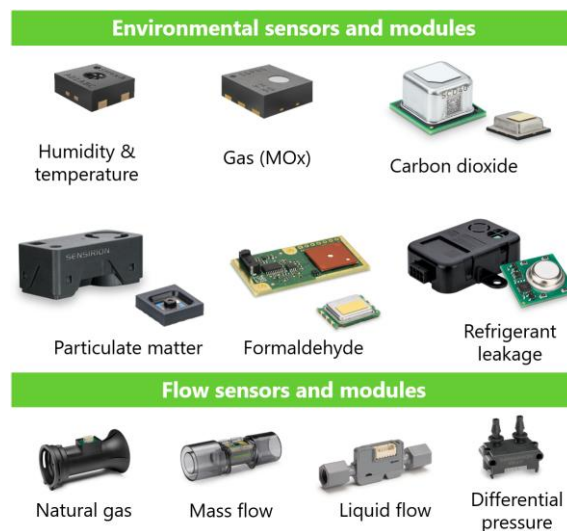


Fig. 2. Sensirion product portfolio overview across application domains.

These products serve a wide range of applications across environmental monitoring, mobility

and automotive, medical, life sciences and diagnostics, industrial, and consumer markets. Typical use cases include indoor air quality monitoring, HVAC systems (e.g. refrigerant leakage), gas metering, climate control in vehicles, medical ventilation and anesthesia monitoring [1]. An overview of the product portfolio and application domains is shown in Fig. 2.

Industrialization and Manufacturing

Scaling microsensor technologies from concept to millions of units requires not only robust design but also a deep integration of development and manufacturing processes, including MEMS and ASIC design, cleanroom fabrication, packaging, automated testing, and system integration. A key differentiating element is the individual calibration of every sensor during production, performed using dedicated automated calibration systems. This ensures high accuracy, reproducibility, and interchangeability, enabling reliable “out-of-the-box” sensor deployment at scale. Product development follows iterative design–test cycles over several years, bridging the gap from prototype to industrialization while maintaining a strong pace of innovation.

A representative example of technology evolution is the miniaturization of carbon dioxide sensing. Earlier solutions based on non-dispersive infrared (NDIR) absorption required relatively large optical paths, limiting their use in compact devices. The transition to photoacoustic sensing enabled a significant reduction in size by detecting pressure waves generated by modulated infrared absorption in a confined cavity. This approach allows highly compact sensor modules while maintaining high accuracy and stability, demonstrating how new sensing concepts can be successfully industrialized and scaled.

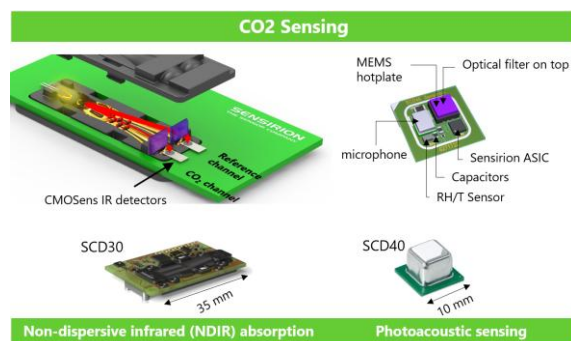


Fig. 3. Evolution of CO₂ sensing technologies: from NDIR to photoacoustic miniaturized modules.

Bridging Academia and Industry

Industrial microsensor development differs from academic research by emphasizing scalability, reproducibility, and cost efficiency in addition to sensitivity. Interdisciplinary collaboration and strong integration between R&D and operations

are essential. Approximately 20% of revenue is invested in R&D, supporting continuous innovation. This approach has enabled the transformation of a university spin-off into a global company, with more than 1,150 full-time equivalents across three continents, and an interdisciplinary research and development team of more than 300 employees.

From Sensor to System Solutions

A strong focus on customer needs drives the evolution from discrete sensor components to complete system solutions. Modern sensing solutions increasingly integrate:

- Advanced packaging enabling system-in-package integration
- Sensor modules as hardware platforms
- Embedded signal processing
- Connectivity and data analytics

Such integration enables the transformation of raw sensor data into actionable information. Examples include refrigerant leakage detection modules, which provide ready-to-use sensing solutions, and methane emissions monitoring systems, where sensor data is transmitted, processed, and analyzed to enable real-time detection, localization, and quantification of leaks. These developments illustrate the growing importance of combining sensing technologies with system-level integration and digital capabilities.

Conclusion

CMOSens® technology and highly integrated modules enable scalable, high-performance sensing across environmental, medical and mobility applications. Individual calibration, advanced manufacturing, and interdisciplinary development are key to transforming scientific concepts into mass-produced solutions.

References

- [1] Sensirion AG, “Applications and Products,” available at: <https://www.sensirion.com/en/applications> and <https://www.sensirion.com/en/products>, accessed May 2026.