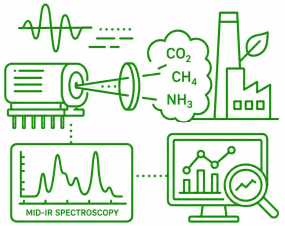
Mid-infrared photonic technologies based on quantum cascade lasers for advanced industrial process monitoring and greenhouse gas emission detection



Project Idea / Expertise	The project focuses on the development of advanced mid-infrared photonic technologies based on Quantum Cascade Lasers (QCLs) and Interband Cascade Lasers (ICLs) for applications in: • industrial emission monitoring, • optimization of technological processes, • supporting the transformation of industry towards climate neutrality.
Organization name, town and country	**Łukasiewicz Research Network – Institute of Microelectronics and Photonics** al.Lotników 32/46, 02-668 Warsaw, Poland
Addressed topic(s)/area(s)	**CID-02 / Clean Technologies for Climate Action** • Clean energy in energy-intensive manufacturing processes • Zero-emission integrated energy systems

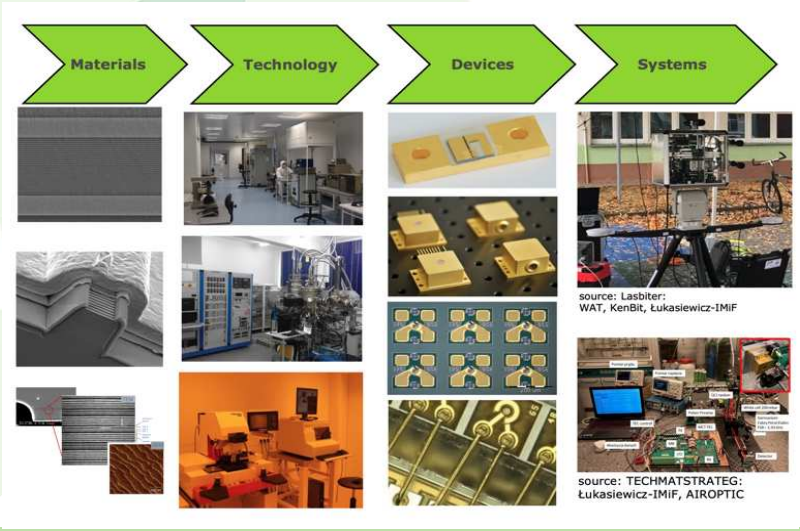
Łukasiewicz – Institute of Microelectronics and Photonics

The Łukasiewicz Research Network is one of the leading European organizations dedicated to applied research and R&D activities; it currently comprises 22 research institutes**.**

Łukasiewicz IMIF: approximately 400 highly qualified employees and 4 technological lines, including a complete III-V semiconductor technology platform:

- **Epitaxy Laboratory for Photonic Device Structures** (3× MBE reactors and MOCVD reactor)
- **Photonic Device Technology Laboratory** (complete III-V semiconductor processing line)
- **Photonic Device Design and Characterization Laboratory**

Comprehensive in-house capabilities covering the entire value chain — from semiconductor heterostructure design and epitaxial growth to device fabrication, electro-optical characterization, and system-level integration.



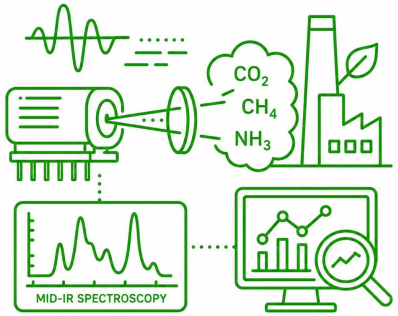
Many years of experience in national and international R&D projects in the field of infrared photonics, III-V semiconductor technologies, and optoelectronic devices.

Participation in projects funded by:

- Horizon Europe,
- European Defence Fund (EDF),
- IPCEI Microelectronics and Communication Technologies,
- EIC Pathfinder,
- European Chips Act,
- National and regional programs.

Concept: Development of advanced mid-infrared photonic technologies for highly sensitive gas detection, real-time industrial process monitoring, and CCUS-related applications.

IMIF competences: design of III-V semiconductor heterostructures, epitaxial growth using MBE and MOCVD methods, MWIR/LWIR laser technologies, integrated photonics, and comprehensive electro-optical characterization.



Why Quantum Cascade Lasers?

Compact semiconductor radiation sources operating in the mid-wave and long-wave infrared ranges (MWIR/LWIR) — precisely where strong absorption lines of key industrial and greenhouse gases are located:

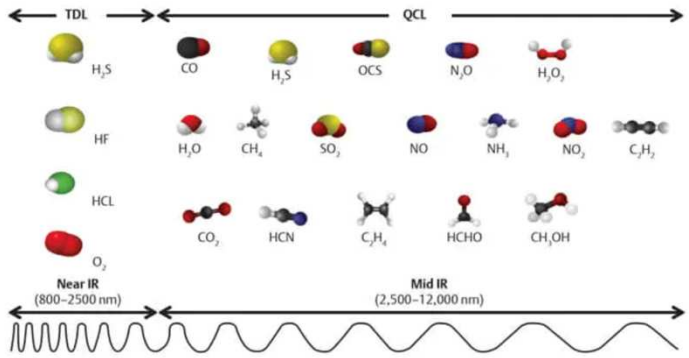
- **CO_2 / CH_4 — greenhouse gases**
- **NH_3 / NOx / SO_2 — industrial emissions**
- **BTEX (benzene, toluene, xylene)**

This technology enables:

Higher sensitivity and selectivity at ppm/ppb levels,

Real-time monitoring,

Operation in harsh industrial environments.

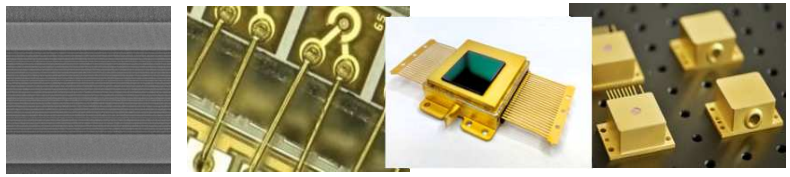


Technological advantage of the project

From Epitaxy to Integrated Systems

We offer **unique competencies** covering the entire technological chain — from semiconductor heterostructure design, through MBE growth, to integration into compact measurement systems ready for industrial deployment.

This is a rare combination of materials science, laser technology, and system-level expertise within a single research team/project consortium.



Technology Partners

System integrators and companies developing hardware and software solutions enabling the construction of complete industrial monitoring platforms, particularly in the fields of:

- integration of measurement and sensor systems,
- industrial software and data analysis platforms,
- integration of photonics with electronic circuits and automation systems,
- development of comprehensive gas detection systems for industrial and energy applications

Industry and Infrastructure Operators

Steelworks, refineries, chemical plants, gas network operators, and energy companies interested in pilot implementation of emission monitoring technologies and industrial process diagnostics

Universities and Research Institutions

Research institutes, universities, and RTO organizations with complementary competences in:

- modeling and optimization of industrial processes,
- energy technologies and net-zero systems,
- environmental monitoring and emission analysis,
- AI and data processing,
- system validation under operational conditions,
- standardization, certification, and industrial deployment c clean-tech technologies.

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