multilab

Multi-modal, configurable optical lab-on-chip platform for low-cost multipurpose diagnostics & monitoring

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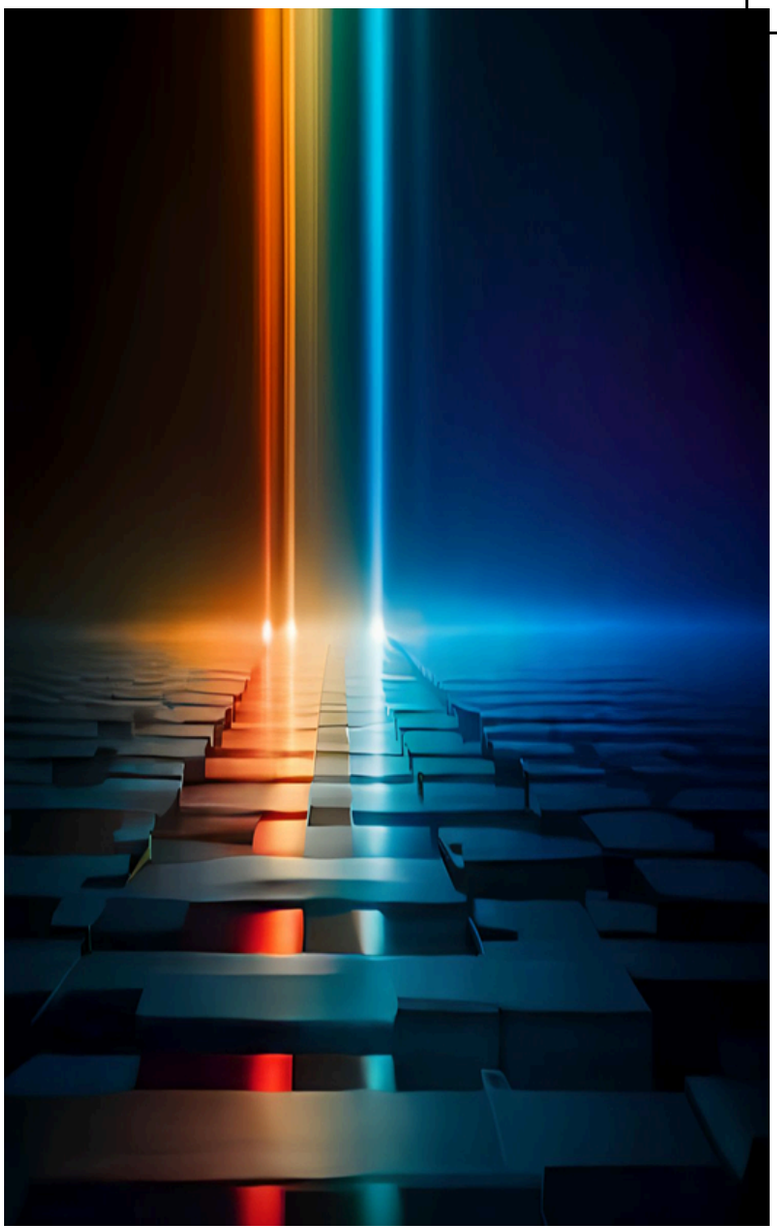
Overview

Developing a miniaturized sensing platform that integrates different detection techniques for various applications, balancing contradictory specifications.

MultiLab addresses this challenge, by developing a modular multi-sensing platform compatible with wafer scale manufacturing that will integrate multiple sensing modalities to simultaneously detect biological and chemical targets for medical diagnostics and environmental monitoring



- **Develop ECL bio-sensors for Biomarker Detection**

Fabricate enzyme-based ElectroChemiLuminescence (ECL) sensors on low-cost, all-graphite inkjet-printed 3-electrode cells for detecting biomarkers like lactate, uric acids, O_2 and H_2S.

- **Develop PA-AWG sensor**

Integrate an AI plasmonic waveguide in a Plasmonic augmented Arrayed Waveguide Grating (PA-AWG) module to enable simultaneous detection of proteins, miRNA and microorganisms with high scalability and cost-efficiency.

- **Develop mid-IR Photothermal Spectroscopy (PTS)**

Develop PTS sensors for label-free multi-component analysis in the mid-IR range, initially using Mach-Zender Interferometers (MZI) and exploring AWG integration for enhanced performance.

- Integrate and validate multi-modality optical sensing platform

Create modular PICs with CMOS-compatible Si_3N_4 photonics and interchangeable bio-sensing modules, combining them with customized microfluidics to improve sensitivity and reduce measurement time.

- Develop Machine Learning approaches

Use ML to analyze multiplexed sensor data, implementing advanced techniques.

Case studies

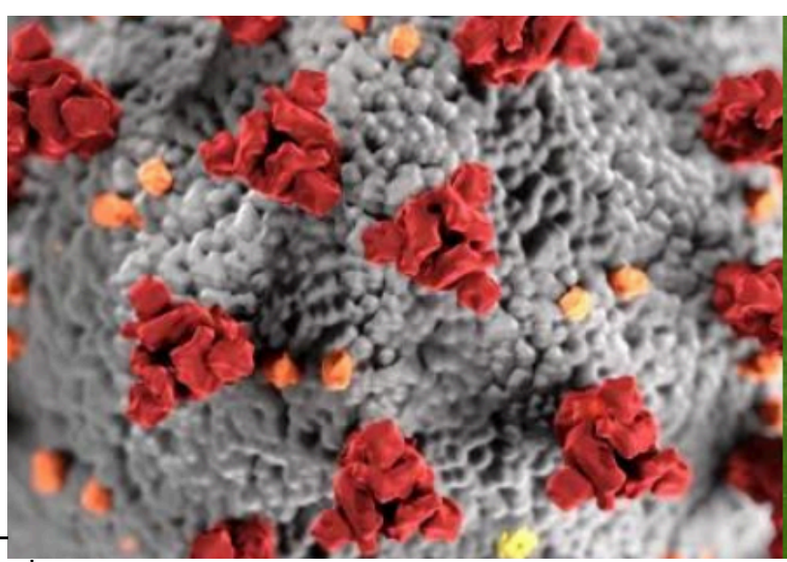
Two devices will be developed, one for each case study. Prototype A will be developed for the clinical case study and Prototype B for the environmental case study.

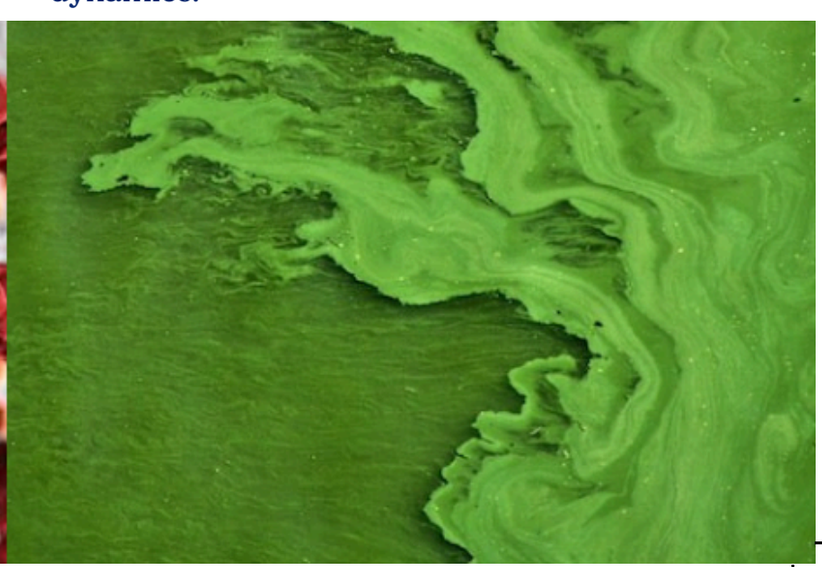
Fever is a common symptom, but distinguishing viral from bacterial infections remains challenging. Traditional diagnostic methods are slow and unsuitable for rapid point-of-care use, often leading to unnecessary antibiotic prescriptions and contributing to antibiotic resistance.

MultiLab addresses this by combining the PA-AWG module, which detects host and pathogen biomarkers, with the ECL module, which measures lactic and uric acid—key indicators of acute infection. This integrated approach enhances diagnostic accuracy, supports appropriate treatment decisions, and has the potential to reduce healthcare costs while helping combat antibiotic resistance.

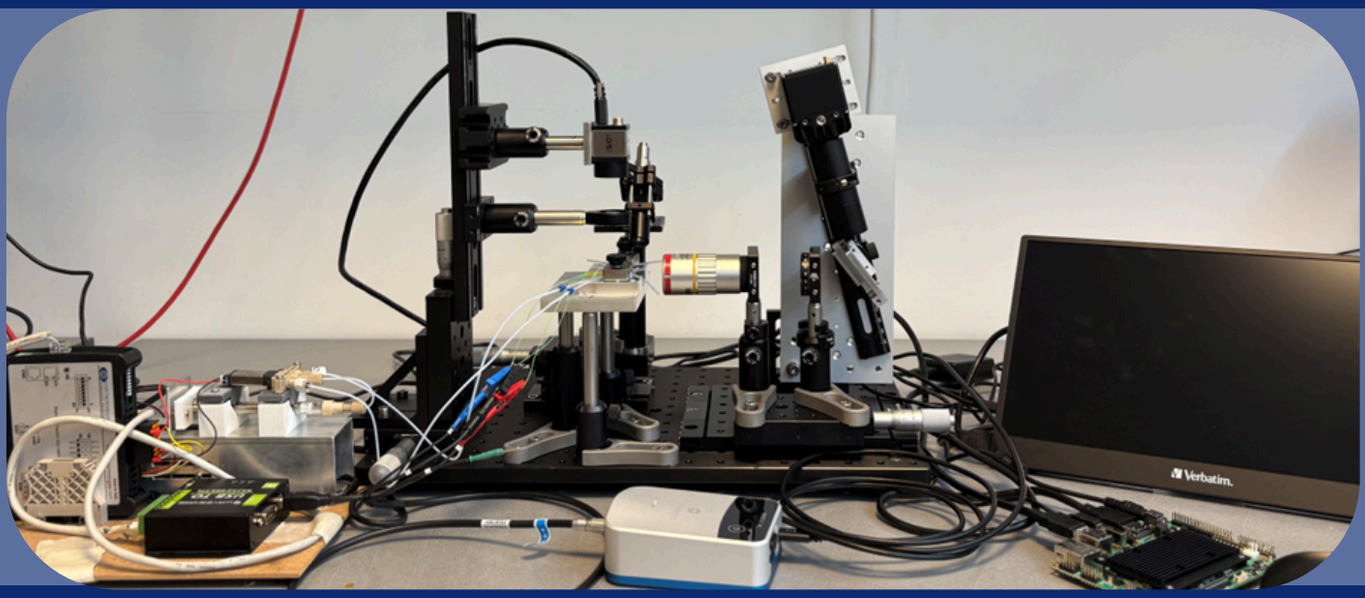
Surface water eutrophication can trigger Harmful Algal Blooms (HABs), compromising water quality and threatening human health and aquatic ecosystems. Traditional monitoring methods are often slow, providing limited early-warning capabilities and leaving water resources vulnerable.

MultiLab offers an IoT-enabled, cost-effective, and reliable solution for early HAB detection. By analyzing key water parameters—nutrients (nitrate, ammonium, phosphate), dissolved oxygen, and hydrogen sulfide—MultiLab supports predictive models for timely warnings. Its precise nutrient quantification, validated against standard methods, enhances monitoring practices and improves understanding of nutrient-bloom dynamics.





First results



1 Development of the core sensing modules

- ECL biosensors detecting lactic and uric acids, dissolved oxygen and hydrogen sulphide with limits of detection already below target values (<1 µM for acids, >10% O_2 saturation, <0.01 µg/L H_2S)
- PA-AWG sensor supporting multiplexed detection with six clinically relevant biomarkers identified (proteins, RNA transcript, pathogen biomarkers)
- PTS sensos demonstrated promising results with water/caffeine tests

2 Integration progress of the multi-modal platform

- First chip layouts designed for medical (AWG + ECL) and environmental (PTS + ECL) applications.
- Microfluidics modules developed for sample delivery, with customised Y-shaped designs for PTS, and shared modules for AWG/ECL
- A sample delivery system based on syringe pump was adapted for all sensors

3 Laser source innovation

- A novel External Cavity Quantum Cascade Laser (EC-QCL) gain chip was grown and tested, showing expected broadband emission.
- Dual frequency, software-controlled modulation was introduced, eliminating the need for mechanical choppers, making a key innovation for PTS

4 First system-level steps

- Initial prototype components were shipped for mid-project testing (M18-M20), with integration into the first demonstrator system underway
- Preliminary in-silico datasets for machine learning training were generated for PA-AWG, ECL, and PTS sensors, enabling early AI model development for multiplexed classification.

Project facts

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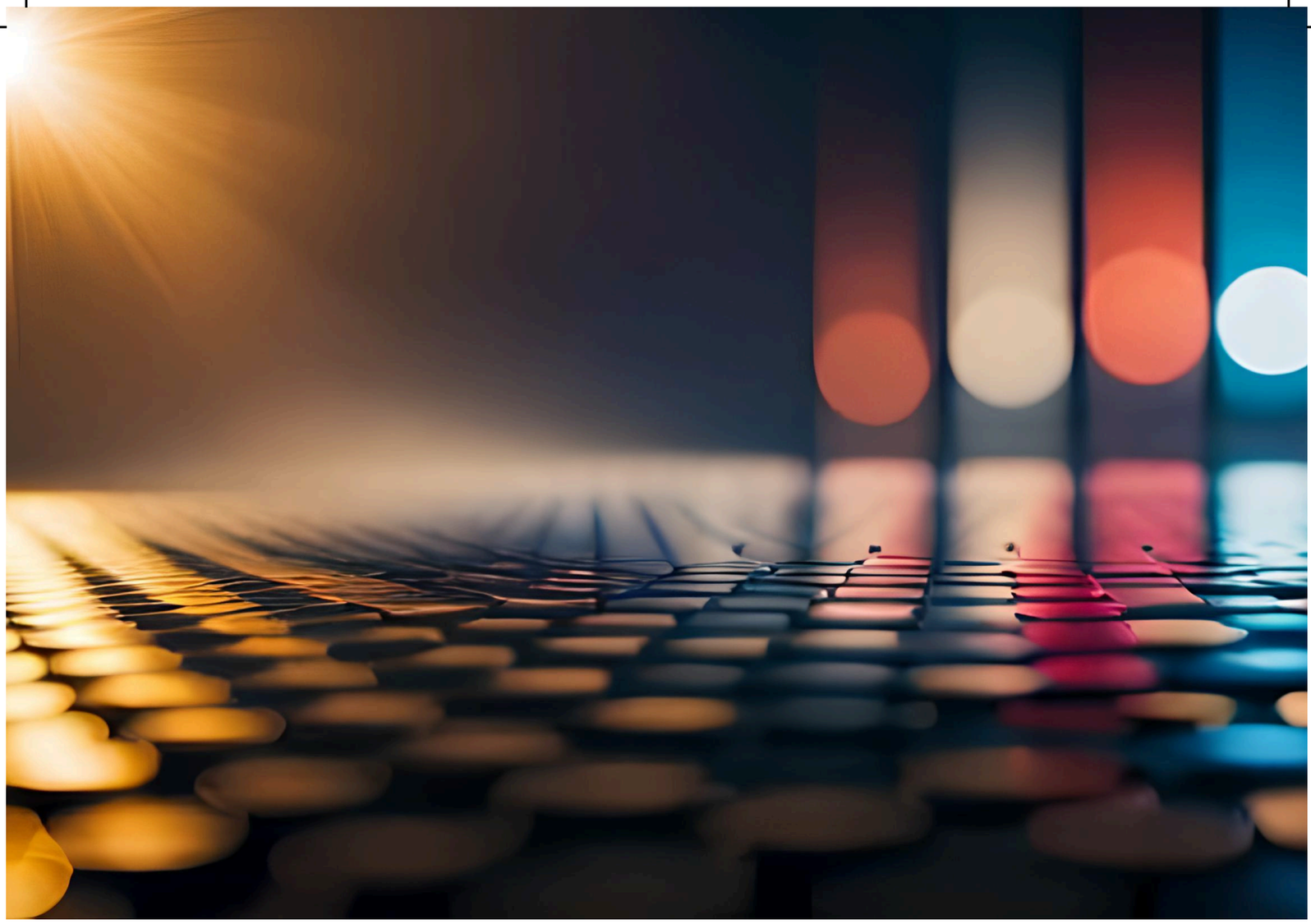

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