# SYMPHONY newsletter 3

*Mar-2026*

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- Gas sensing module development at Resolute Photonics
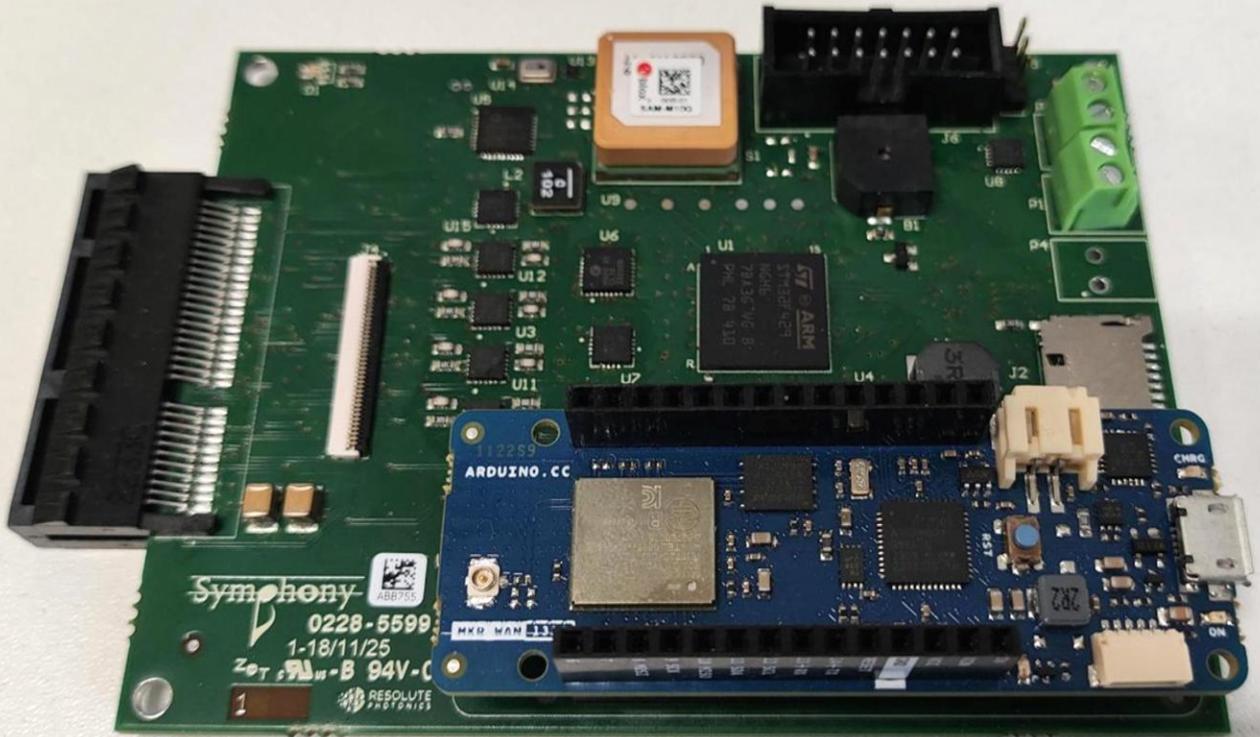
**Symphony**

*The CyRIC communication module enables low-power, long-range bidirectional connectivity between the SYMPHONY sensing system and the cloud platform using LoRaWAN technology. See p. 3-5 for more info. [Image courtesy of CyRIC.]*

More information is available on the project website
https://symphonyproject.eu

## Consortium



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*Please join the SYMPHONY LinkedIn group to keep up with project updates!*

https://www.linkedin.com/company/symphony-project

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# CNRS suspended silicon waveguides

## Study, design, and fabrication of metamaterial grating-clad silicon waveguides for mid-infrared sensing applications
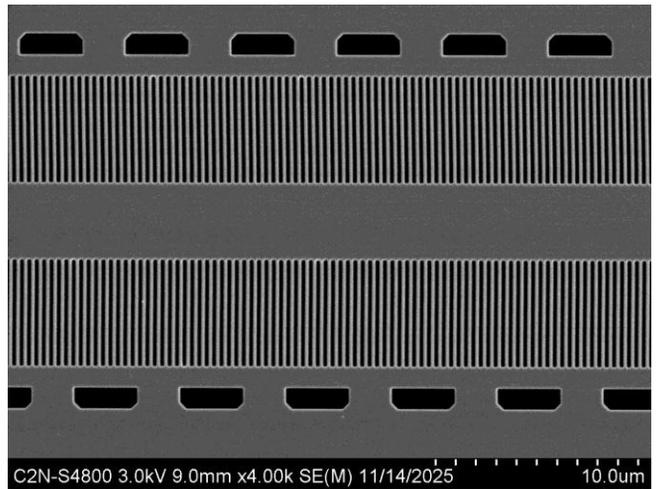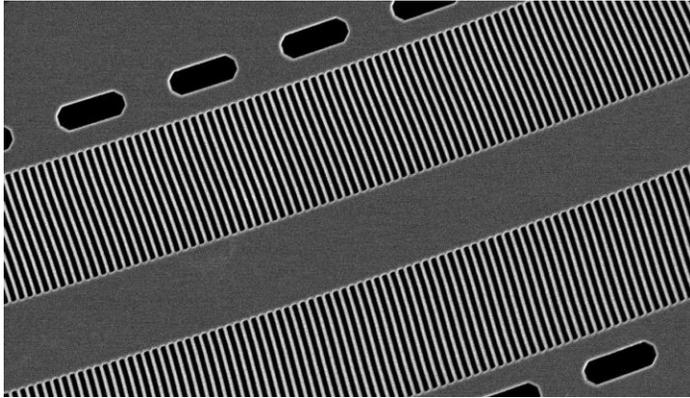


*Two micrographs of sub-wavelength gratings for SYMPHONY fabricated by CNRS with design inputs from several SYMPHONY partners.*

C2N-S4800 3.0kV 9.0mm x4.00k SE(M) 11/14/2025          10.0um

One of the core technologies in **SYMPHONY** is the subwavelength grating (SWG) cladding fabricated at **CNRS**. This technique not only contributes to the mechanical stability of the suspended structure and provides the effective lateral refractive index contrast required for optical mode confinement, but also enables the removal of the silica under-layer, giving access to the full transparency window of silicon (~1.1 to 8 μm), essential for mid-IR operation.



*SYMPHONY Coordinator Carlos Ramos presenting his invited paper, "Silicon nanostructures for the mid-IR" at Photonics West 2026 (San Francisco, USA).*

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# Control subsystem development

The **SYMPHONY** project is developing smart, autonomous sensing systems for environmental pollution detection and biogas monitoring by combining silicon photonics, microelectronics, machine learning (ML) models and cloud connectivity. The project targets scalable, low-power sensor platforms capable of operating reliably in real-world conditions.

## CyRIC-led contributions in SYMPHONY

**CyRIC** is leading the design and development of the control circuitry, communication module and energy harvesting modules. A modular architecture was specified to interconnect photonic sensors, signal conditioning, embedded ML, and wireless communication. The control circuitry was designed as a modular, multi-MCU system. This architecture separates time-critical sensor control and data acquisition from higher-level data handling and machine learning inference. The application MCU manages photonic sensor interfacing, including photodetector biasing, signal conditioning through transimpedance amplifiers, LED modulation and temperature stabilisation. Processed data are forwarded to auxiliary and deep-learning MCUs, enabling efficient task partitioning and scalability.

## Control module

The SYMPHONY control subsystem was developed following a structured systems engineering approach, translating high-level requirements into clear, measurable system specifications covering sensing performance, data acquisition, processing, communication, and power constraints. These specifications guided the design of a modular system architecture centred on a multi-MCU control module,



*Photo of the CyRIC SYMPHONY multi-MCU control module.*

separating photonic sensor interfacing, embedded machine learning, data handling, communication and power management into dedicated functional blocks. This architecture enables efficient signal conditioning, synchronised sensor control, local data buffering and robust data flow from photodetectors to edge intelligence and onward to LoRaWAN communication. The design was implemented on a compact, four-layer control PCB based on an STM32 microcontroller, integrating analogue front-end circuitry, temperature control, high-speed data acquisition and standard interfaces, while maintaining low noise, manufacturability, and cost efficiency.

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## Machine learning model

The ML component of the SYMPHONY system performs on-device classification of gas absorption patterns derived from short-time Fourier transform (SHFT) spectrometer interferograms. It processes multi-dimensional spectral data and produces a compact multi-class output indicating gas type or concentration level. The models have demonstrated promising accuracy on both synthetic and noisy datasets, including methane absorption scenarios, as validated in earlier project work. They are specifically designed for edge deployment, using lightweight architectures with limited layers, low-bit precision weights, and hardware-friendly constraints to minimise memory and power requirements. The current model has been deployed on an Arduino Nano 33 BLE (nRF52840), enabling early validation of real-time inference, duty-cycled operation and energy impact. Initial tests show minimal memory usage, leaving significant headroom for future model enhancements while more advanced SoC solutions are under development.

## Communication module

The communication module enables low-power, long-range bidirectional connectivity between the SYMPHONY sensing system and the cloud platform using LoRaWAN technology. Sensor data processed at the edge, including gas classification results produced by the embedded machine learning model. The data are packaged into compact payloads and transmitted via a LoRaWAN transceiver integrated within the control module. These payloads are received by gateways and forwarded to the network server and delivered to the cloud infrastructure over standard IP links. In addition to uplink data transmission, the LoRaWAN link supports downlink communication for system configuration, allowing parameters such as transmission rate and reporting intervals to be updated during operation or at system start-up, enabling flexible and remote device management.



*Photo of the CyRIC SYMPHONY multi-MCU control module including the integrated ML processing module.*

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# Energy harvesting

The energy harvesting module is a key enabler of SYMPHONY's autonomous operation, allowing sensor nodes to function for extended periods without manual recharging. Based on a low duty cycle operating concept, the system activates sensing, processing and communication tasks only during short, scheduled intervals, significantly reducing average power consumption. A preliminary power budget estimates a daily energy demand of approximately 9 Wh. To meet this demand, a solar-based architecture has been defined, combining a high-efficiency monocrystalline photovoltaic panel, MPPT-based power management with power-path control, and a battery pack sized for multi-day autonomy. This approach decouples energy generation from peak power demand, ensuring reliable, continuous operation under variable outdoor conditions and supporting long-term deployment of SYMPHONY sensor nodes.

## Partner contributions and collaboration

The work reported here was developed in close collaboration with the other SYMPHONY consortium partners. Inputs from photonic sensor developers and algorithm providers ensured alignment between hardware interfaces, signal characteristics, and data processing requirements. Partners including **CNRS**, **AUTH**, and **RESOLUTE** contributed to architecture alignment, model



*CyRIC is a key part of the SYMPHONY team, shown here at one of the plenary meetings. The control system is a great example of collaborative work within the project.*

development, and system validation planning. This coordinated effort ensures that subsystem-level innovation translates into a coherent system.

## Design progress

The first version of the SYMPHONY control PCB has been successfully designed and manufactured and is currently undergoing laboratory testing. This initial prototype validates the core system architecture, including photonic sensor interfacing, signal conditioning, embedded processing, and communication pathways. Building on these results, the development effort is now transitioning toward a second, more integrated PCB version, which will consolidate functionality and address additional technical requirements identified during system integration and testing. This iterative approach supports risk reduction while accelerating convergence toward a fully integrated and deployment-ready hardware platform.

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# SYMPHONY gas sensing module development

**SYMPHONY** project partner **Resolute Photonics** designs and develops electro-optic subsystems for photonic integrated circuits (PICs) targeting a variety of diverse applications including WDM switching networks for hyperscale and AI, disaggregated quantum communication and space communication. Resolute Photonics recently demonstrated quantum PIC subsystems and a disaggregated quantum platform on the UK government funded **EQUINOX** project.

On the SYMPHONY project, Resolute Photonics is applying its expertise to the design of portable low-power, low-cost PIC gas sensing modules, in which neuromorphic networks and AI are deployed by the consortium partners to enhance detection of a range of gases including carbon dioxide, methane and nitrous oxide. Based on broad experience and expertise in integrated photonic sensing systems, Richard Pitwon and his team at Resolute Photonics will be designing the electronics and the bespoke mechanical housings for the SYMPHONY modules.



*Above and below: Resolute Photonics developed and exhibited quantum PIC subsystems and a disaggregated quantum communication platform on the Innovate UK EQUINOX project.*
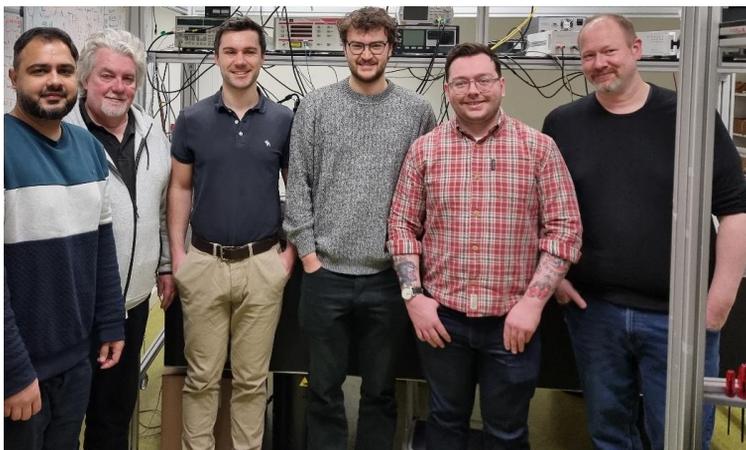




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*Resolute Photonics engineering team (from left to right: Muhammad Shafiq, Ken Hopkins, Aidan Harkin, Tom Beards, Rian Kane and Richard Pitwon).*

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