DECEMBER, 2024

NEWSLETTER

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KEY FACTS

7 Partners

4 European countries

4 Years

3.6M+ EUR funding

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WELCOME TO THE PIONEAR NEWSLETTER!

Dear Reader,

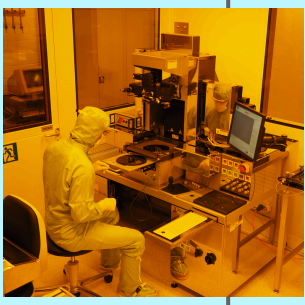
We are excited to bring you the first edition of the PIONEAR newsletter. This issue provides a comprehensive introduction to the PIONEAR project, its mission, and the unique expertise of our consortium partners.

Inside, you will find an exploration of chronometry, the foundational technology of the PIONEAR microphone.

Furthermore, we emphasise the innovation potential of PIONEAR by detailing the processes that ensure the effective exploitation of the project's key results, both for commercial and non-commercial applications.

Finally, we introduce two consortium partners – Lumiary and Tyndall National Institute – offering a closer look at their contributions to the project.

We hope you enjoy the read!
accelopment on behalf of the project consortium



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Why PIONEAR:

A sneak peak at PIONEAR's objective

Imagine having the ability to unleash the full power of acoustics with a radically new technology for detecting sounds! Imagine the endless possibilities that this could bring with an enhancement of studio-sound quality of music and sound recordings or the improved-quality conversations we could have through video calls or using our smartphones.

Figure 1. PIONEAR consortium at the kick off meeting.

To make this vision a reality, the PIONEAR consortium (Fig. 1) proposes the development of a novel photonic microphone technology that will allow for enhanced sound detection, from the faintest whispers to the loudest acoustic range imaginable!

Microphones play an increasingly important role in how we communicate and perceive our everyday lives equipped with digital and virtual technologies. They have experienced a tremendous development leap in terms of significant size and cost reductions and are now ubiquitous in industrial and professional applications. Yet, despite all this progress, the current microphone technology falls short of perceiving audio of the sensitivity limit such as that of the human ear. To date, no microphone has achieved a self-noise level of ≤0 decibels (dB) Sound Pressure Level (SPL), which corresponds to the threshold of human hearing, while also being capable of detecting sounds up to 130 dB SPL (the threshold of pain) and covering the full bandwidth of 20 kHz.

The main vision of the PIONEAR project is to design a high-resolution microphone with better-than-human-ear sound sensitivity. The PIONEAR microphone will be designed to have a similar form factor to the miniature MEMS microphones while aiming to outperform even much larger diaphragm microphones. It will be enabled by a radically new sensing technology called 'chromometry.' Chromometric sensing refers to a method which uses light instead of electrical signals to detect sound. Such a sensing technique will allow to maximise sensor resolution and dynamic range of the PIONEAR microphone which could fundamentally revolutionise optical sensing by operating at low power while replacing expensive and power-consuming analogue-to-digital converters. The technology will encompass an innovative laser design for the conversion of changes in sound pressure that can be measured with remarkable resolution - see the following page for more details.

To realise this novel photonic microphone technology, PIONEAR brings together expertise in the manufacturing of special vertical-cavity surface-emitting lasers (VCSEL), fabrication of miniature acoustic chambers and membranes, and the highest precision packaging of the device. PIONEAR experts aim to bring their microphone technology from design to a final PIONEAR proof-of-concept device. While the main focus of the PIONEAR project will be on developing a novel high-resolution microphone, the chromometric sensing technique can be applied to many other sensors too. The applications range from consumer electronics and hearing aids to environmental monitoring, and biochemical sensing.

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Chromometry:

Benefits and limits of the technology

The PIONEAR project is introducing a breakthrough in microphone technology with a unique design that redefines sound measurement. At the core of this innovation is a laser-based microphone capsule, where the laser itself serves as the sensing element. Unlike traditional lasers that emit light at a fixed colour, the laser in PIONEAR's microphone is highly responsive to environmental influences. When sound waves interact with it, subtle shifts occur in its emitted colour. These minute variations are captured by an ultra-sensitive colour meter, allowing for an unprecedented level of precision in sound measurement.

This novel sensing technique has been termed 'chromometry,' as it centres on analysing these slight colour shifts. By leveraging the exceptional purity of laser light, chromometry enables remarkably accurate sound measurements. PIONEAR's laser achieves sound sensitivity by positioning one mirror of the laser cavity on a movable membrane – similar to a traditional microphone diaphragm – while the other mirror remains fixed. When sound waves strike the membrane, it vibrates, changing the distance between the mirrors and, as a result, shifting the laser's colour.

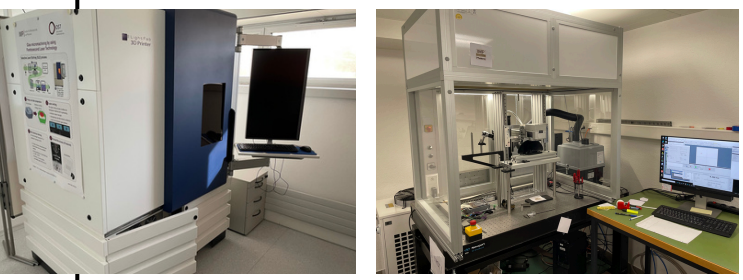


Figure 2. OST's photonics lab and equipment.

This cutting-edge microphone design also utilises an advanced Vertical Cavity Surface Emitting Laser (VCSEL), an ideal component for this application due to its compact size, high-energy efficiency, and potential for high finesse. A high-finesse laser allows photons to repeatedly bounce within the cavity, a critical feature for achieving the high degree of accuracy needed in chromometric measurements.

Human hearing operates across an astonishingly broad dynamic range, detecting everything from the faintest whisper to the piercing noise of sirens. Capturing this full range with existing microphones has been challenging, primarily due to a quantum limitation known as shot noise. Although advanced quantum techniques like squeezed light or entangled photons can overcome shot noise, these methods are complex and unsuitable for the compact, low-power requirements of modern microphones.

Figure 3. OST's Clean room.

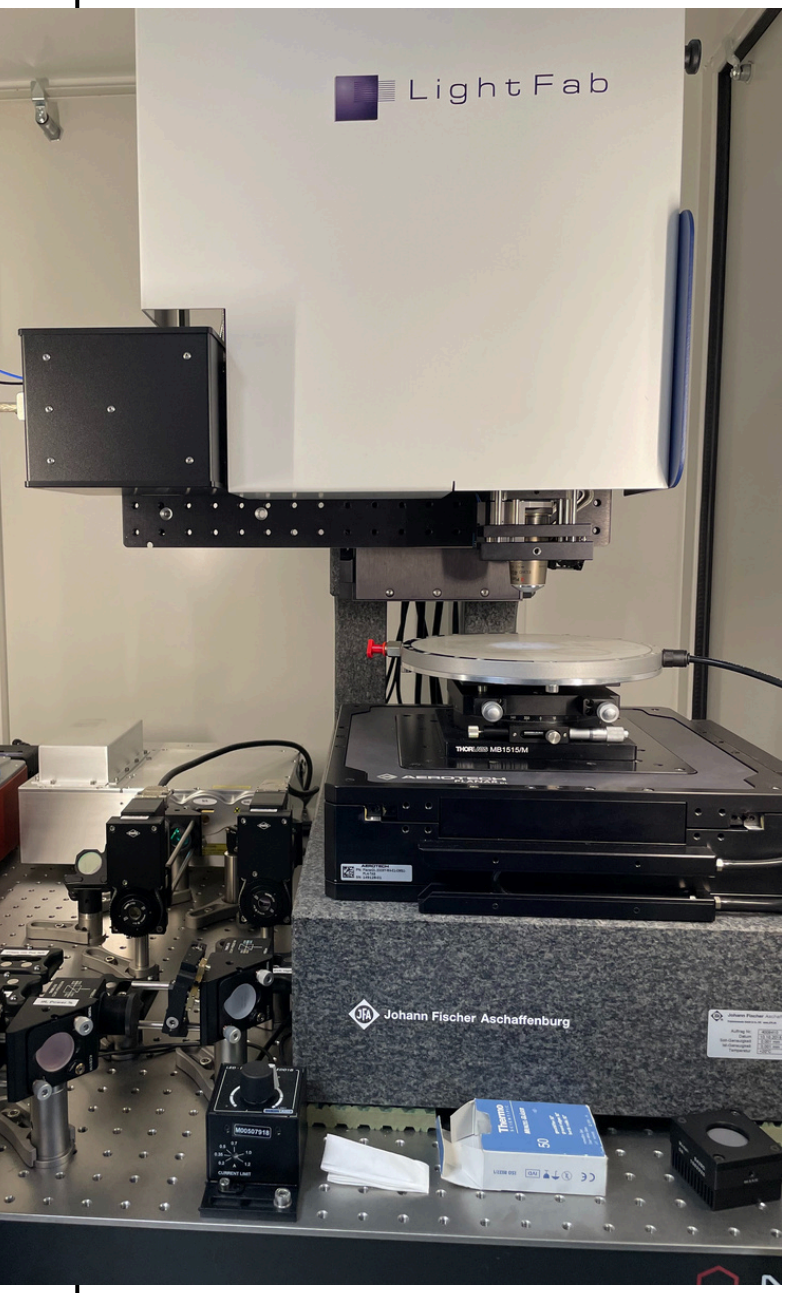
Continues on the next page...

Chromometry offers a simpler, more feasible approach to bypassing shot noise. In the PIONEAR microphone, only essential optical components are required – a laser, passive optical pathways, and photodetectors – enabling the device to be miniaturised to just a few cubic millimetres. This design is not only compact but also cost-effective compared to other miniature microphones. Additionally, the high-finesse laser used by PIONEAR requires only about 1% of the photons typically needed by traditional interferometric sensors, further enhancing power efficiency. Combined with the low power usage of the VCSEL laser, the PIONEAR microphone is well-suited for battery-powered applications.

While the initial focus of PIONEAR is on audio applications, chromometry's potential extends well beyond sound sensing. This versatile technology can be adapted to measure various physical phenomena, including acceleration, rotation, and even chemical concentrations in gases and liquids.

Developing a chromometric microphone is a complex undertaking, requiring significantly more effort than designing conventional capacitive microphones. However, this technology is unique in its ability to rival the dynamic range of human hearing in a miniaturised form. PIONEAR is committed to advancing this technology and is working toward a fully functional prototype to demonstrate the vast potential of chromometric sensing.

The project's efforts include the meticulous design and fabrication of a specialised VCSEL laser, a responsive microphone membrane, and an acoustic chamber, each tailored to meet exacting performance standards. Furthermore, the integration of an ultra-sensitive colour metre and other components presents significant technical challenges due to the high precision required for successful assembly.



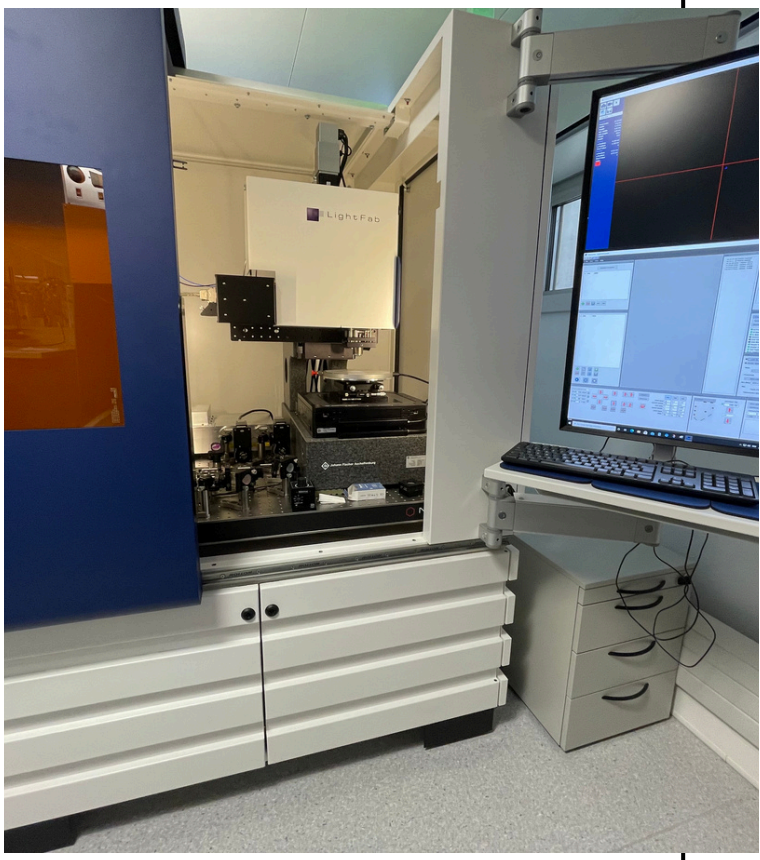


Figure 4. OST's 3D Laser Printer: Close-up view (left) and full view from a distance (right).

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Impact:

PIONEAR pathway towards the market

In the rapidly evolving world of technology, the PIONEAR project stands at the forefront of technological innovation, with the goal of creating long-lasting change in the way sound is detected, allowing for an overall better miniature microphone sound quality for our day-to-day use devices. Under the guidance of the PIONEAR partners Lumiary and accelopment Schweiz, the consortium has joined forces to bring the innovation potential of the project to a higher level.

Assessing the innovation potential

A critical factor in PIONEAR's journey towards market success lies in recognising the innovation potential of its proposed microphone technology. Led by accelopment and supported by the entire consortium, project partners have assessed the initial key exploitable results developed during the project's first months. This evaluation focused on several aspects of innovation, including the type of innovation (e.g., product, service, or process), the current Technology Readiness Level (TRL), the anticipated TRL at the project's conclusion, as well as insights into its application and market potential.

Identifying the broader ecosystem

Once potential innovations were identified and assessed, a stakeholder analysis was performed to identify and engage key target groups who stand to benefit significantly from PIONEAR 's technological advancements. The identified stakeholders include the scientific community, to promote further research into sensing technologies; the European electronics industry, to drive the development and adoption of products using the PIONEAR microphone technology; policymakers, to support the creation of a harmonised framework for microphone and acoustic regulations; and the general public, as the ultimate end users of the proposed microphone technology.

The Plan for the Exploitation Activities

The Plan for the Exploitation Activities plays a pivotal role in shaping the project's exploitation trajectory. Developed by Lumiary and accelopment Schweiz, this document provides a detailed roadmap for utilising PIONEAR's results in both commercial and non-commercial contexts. It outlines a step-by-step plan of actions to be implemented during the project and beyond, ensuring the continued use of PIONEAR’s results. The plan also identifies relevant markets, analyses the EU research and innovation (R&I) landscape in photonic technologies, and evaluates current competitors and regulatory frameworks that could impact the project’s pathway to the market.

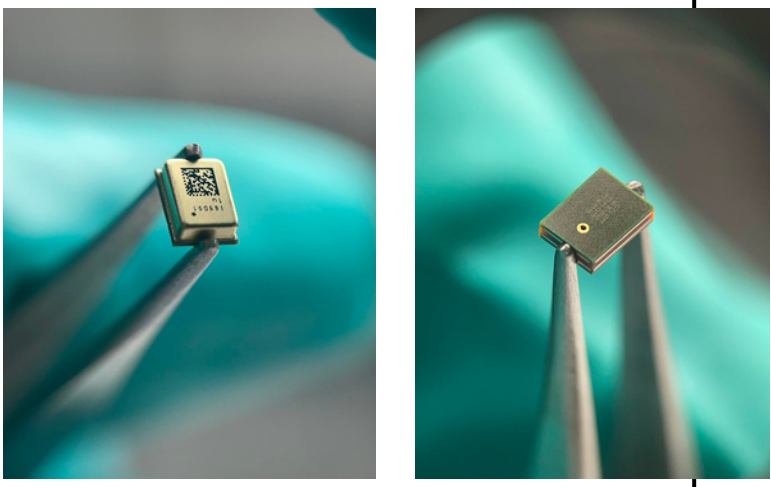

Figure 5. Example of miniature microphones.

What are the next steps?

By fully understanding and maximising market potential, the project aims to benefit a broad range of stakeholders and foster technological advancements within the European electronics industry. Moving forward, PIONEAR will continue to assess and monitor both current and emerging results, guided by Lumiary and supported by accelopment Schweiz. These efforts will be comprehensively detailed in the final version of the Plan for the Exploitation Activities, which is scheduled for completion by the project's conclusion in January 2028.

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PIONEAR's GA:

Consoritum meets in Warsaw for the third General Assemly

From 1st to 3rd October, the third General Assembly (GA) of the PIONEAR project took place in Warsaw, Poland. Hosted by the Łukasiewicz – Institute of Microelectronics and Photonics (Ł-IMIF), it saw the participation of 19 representatives from the seven consortium partners.

Figure 6. PIONEAR partners in Ł-IMIF's clean room.

The GA kicked off on October 1st as participants arrived. The day began with an Executive Board meeting, during which the project coordinator, Lumiary, alongside accelopment, provided updates on management and the overall project status. Following the executive board meeting, partners were treated to a tour of the Ł-IMIF facilities. During the tour, participants had the opportunity to enter the Ł-IMIF clean rooms. After putting on appropriate lab gear (Figure 6) and entering the clean room through a dedicated sluice, they were introduced to the state-of-the-art VCSEL processing facilities including instruments for atomic layer deposition, plasma etching, and photolithography.

On the second day (Figure 7) of the meeting, the focus shifted to evaluating the progress of the project's different work packages. The morning sessions delved into the design and fabrication of both the membrane and acoustic chamber, along with VCSEL design and processing, microphone assembly, and device testing. The afternoon was dedicated to discussions on communication, dissemination, and exploitation strategies, as well as on the technological challenges encountered thus far. The day ended with a consortium dinner in central Warsaw, providing attendees an opportunity for informal interactions and networking.

Finally, on day three PIONEAR project partners convened at VIGO photonics, in the outskirts of Warsaw. During the visit to VIGO's facilities, partners explored two crucial areas for the development and manufacturing of VCSELs. The tour began in the laboratory, dedicated to R&D, where new materials and photonics components, including VCSELs, are innovated, prototypes crafted, and initial testing conducted. Following this, the partners proceeded to the production and assembly site for infrared detectors. This area focuses on the physical production, assembly, and precise packaging of the components. This site also hosts final product testing, which verifies the functionality and reliability of the photonics devices before they are ready for shipment.

Figure 7. PIONEAR's consortium during the 3rd GA.

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Meet the partners:

Lumiary

Lumiary is a Swedish start-up at the forefront of developing an innovative microphone based on chromometry, a cutting-edge laser sensor technology. The company is poised to market these microphones and their components across various sectors, including professional audio, hearing aids, defence, and consumer electronics.

Revolutionising audio across Industries

Lumiary's photonic microphone technology is set to transform audio capabilities across multiple industries by providing innovative solutions to age-old challenges. For the professional audio sector, these microphones aim to reduce noise and distortion whilst enhancing directionality. This is crucial for sound engineers who demand impeccable sound quality.

In the field of security and defence, Lumiary's technology is designed to offer superior drone detection capabilities, featuring extended range and precision. This positions it as a potential cost-effective alternative to traditional radar systems.

The Sweden-based start-up is also expected to make significant strides in hearing aid technology, achieving 'better-than-human' sensitivity. This breakthrough is set to expand the limits of assisted hearing, substantially improving the quality of life for those with hearing impairments.

Finally, in consumer electronics, Lumiary aims to revolutionise sound quality and reliability in devices such as smartphones and smart home systems. The goal is to make voice control the primary mode of interaction, unaffected by environmental noise.

Leading the PIONEAR project

Within the PIONEAR project, Lumiary plays a pivotal role as the coordinator, steering the project's vision with a committed team of two employees. The company's scientific efforts within PIONEAR are concentrated on integrating photonic, electronic, and digital signal processing techniques to boost the performance and functionality of the microphone signal.

Meet the Lumiary team

Per Grön
CEO

Andreas Lundström
Developer & Engineer

Meet the partners:

Tyndal National Institute

Figure 8. Tyndall National Institute's campus in Cork, Ireland

Tyndall National Institute (Fig. 8) is a premier Irish ICT research institute. As part of University College Cork, it houses 400 staff and students. It is divided into Microelectronics and Photonics Centres, the latter being the larger of the two. In the Photonics Centre, Tyndall Institute has broad expertise: from theory, semiconductor growth and fabrication to systems design, testing, packaging, and integration. It operates mainly in the telecommunications and biomedical sectors, however, it is close to nascent and future technologies.

The Photonic Packaging Group is operating in the Photonics Centre. The group remit covers a wide range of activities related to the packaging of photonic integrated circuits. With 25 members, it has a strong research core that investigates new technologies and processes, including novel materials (e.g. glass substrates), methods (e.g. pluggable photonic devices) and integration methods (utilising, for example, transfer printing or 3D printing). This expertise is essential to deliver PIONEAR prototypes as well as securing a viable scalable manufacturing pipeline for resultant devices.

Meet the Tyndal team

Kamil Gradkowski
Researcher

Sini Nandath Shibu
Postdoc Researcher

PIONEAR

Developing a photonic microphone with better-than-human-ear sound quality.

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Lumiary

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takes you further