WELCOME TO PHOENIX FIRST NEWSLETTER!!

PHOENIX

FERROELECTRIC PHOTONICS ENABLING NOVEL FUNCTIONALITIES AND ENHANCED PERFORMANCE OF NEXT GENERATION PICS

Europe aims to maintain and increase Europe's industrial leadership in photonics by fostering photonics manufacturing and accelerating Europe's innovation process to reduce the time-to-market for novel products, stimulating the creation of strong and complementary value chains around photonics and facilitating access to manufacturing capabilities to highly innovative SMEs.

The creation of such an ecosystem will cement the EU leadership in photonics, stimulating private investment in research and development and business creation, resulting in jobs generation and economic growth. Furthermore, this will contribute to strengthening EUs technological sovereignty, industrial competitiveness, and independence, supporting EU industrial and digital strategies.

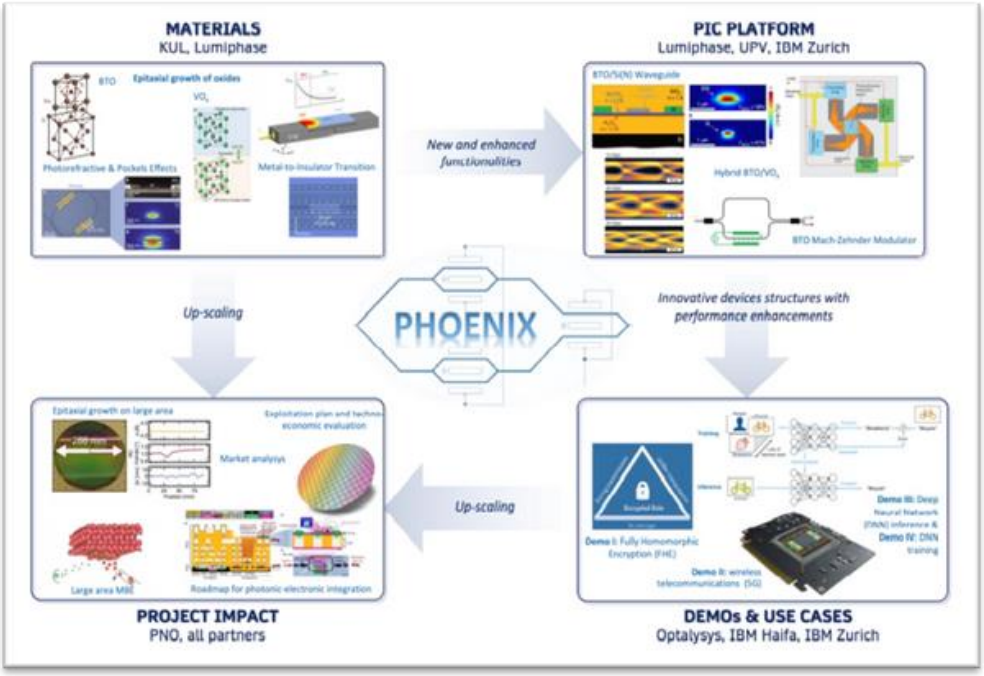
WHAT IS THE PHOENIX PROJECT ABOUT?

PHOENIX, "Ferroelectric Photonics Enabling novel functionalities and enhanced performance of neXt generation PICs", funded by the EU Horizon Europe programme, gathers a full panel of industrial, research and technology organizations from EU member states and Associated Countries, coordinated by KATHOLIEKE UNIVERSITEIT LEUVEN (Belgium), SMEs Lumiphase (Switzerland) and Optalysys (UK), IBM (Switzerland and Israel), the Nanophotonics Technology Center – Universitat Politècnica de València (Spain), and PNO Innovation (Spain).

The PHOENIX project started on the 1st of September 2022 and will run for 3 years until the 31 August 2025.

OBJECTIVES

The PHOENIX' ambition is to create the next generation of compact PICs leveraging on Lumiphase´s barium titanate (BTO) on silicon nitride (SiN) platform that will be optimized to enable novel functionalities and produce enhanced PICs.



The main purpose of the PHOENIX project is the integration of crystalline oxides such as barium titanate (BTO) or vanadium oxide (VOx) to expand the functionalities of the next-generation PICs.

To reach that target, we need to pursue the following objectives:

1. To demonstrate a) the photorefractive and electro-optical Pockels effects in BTO to enable fast data modulation and access to an analog optical memory, and b) the metal-insulator transition in VOx to improve amplitude modulation and device footprint.
2. To provide a BTO/SiN waveguide platform for subsequent manufacturing of Photonics Integrated Circuits (PICs), and an upgraded version of such a platform integrating VOx.
3. To integrate the developed BTO-based photonic technology into 4 demonstrators in the field of neural network inference and training, fully homomorphic encryption, and 5G.
4. To advance in the understanding, realization, and upscaling of the growth of high-quality crystalline oxide thin- films by molecular beam epitaxy (MBE).

IMPACT

PHOENIX WLL GENERATE A CREDIBLE AND SUSTAINABLE IMPACT IN VARIOUS KEY AREAS, INCLUDING SCIENTIFIC, SOCIETAL, ECONOMIC AND TECHNOLOGICAL

SCIENTIFIC IMPACT

PHOENIX will develop a set of innovative materials and technologies beyond the state-of-the-art to enhance the functionalities of next generation PICs and reduce their footprint and power consumption.

The developed materials and technologies will be demonstrated in four application use cases: neural network inference and training, fully homomorphic encryption and 5G. At the same time, the project will contribute to advance the growth of high-quality crystalline oxides by MBE on large area. The know-how and experience generated in the project will be transferred to more academic and industrial entities by dissemination under an Open Science approach.

SOCIETAL IMPACT

Photonics has emerged as a power-efficient means for communication and offers a wide set of opportunities in for example sensing and materials processing.

PHOENIX technology will build on this advantage to demonstrate low-power consumption computing alternatives and contribute to reduce the overall carbon footprint and vastly improve digital security. PHOENIX technology will also contribute to the democratization of digital infrastructure, providing access to digital content and services anytime and everywhere to everyone, and fostering jobs creation and delocalization, thus benefiting the whole value chain and ultimately EU society as a whole.

ECONOMIC AND TECHNOLOGICAL IMPACT

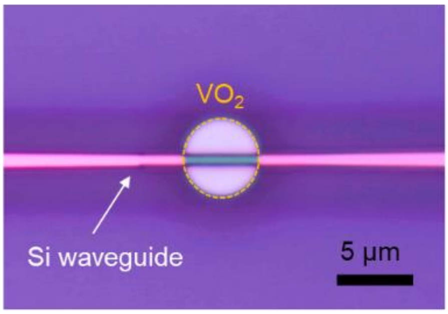
To ensure the market uptake and the economic and business sustainability of the PHOENIX technology, the project will also develop non-scientific tools such as a business model, a techno-economic evaluation, and a roadmap for the integration of the PHOENIX technology in mass volume PICs production. Other photonics industries, especially high-tech SMEs, as well as technology providers, research institutions and associations, will directly benefit from the project results, whether as adopters/users, technology, and support providers, or acting as multipliers for the evolution and use of the PHOENIX platform and the user cases demonstrators. PHOENIX will also allow the creation of employment opportunities within Europe by strengthening the EU market share in the worldwide photonics market, creating gender-equal opportunities and high-quality jobs, and facilitating SME growth by providing access to the BTO/SiN open platform.

PROJECT PROGRESS SO FAR...

In the first period of PHOENIX, the consortium has worked to define the specifications and architecture of the photonic devices, as well as the board/system hardware for those use cases.

In preparation of the first fabrication run based on BTO technology, the consortium has been working to design the circuits and building blocks (waveguides, splitters, bends, phase shifters, etc.) for each hardware platform as well as to build the setup used to confirm the presence of the photorefractive effect in BTO thin films.

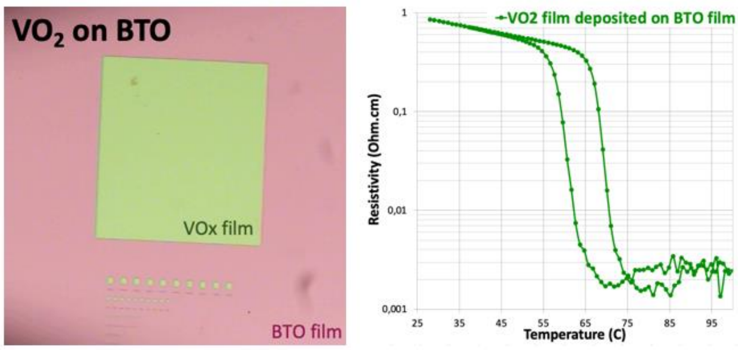
Successful work on the integration of VO_2 onto integrated photonic structures has been achieved using silicon waveguides. The hybrid structures comprise a VO_2 layer deposited on a silicon waveguide. The optical response of VO_2/Si structures relies on the optical loss of the insulator and metal state of the VO_2.



Top-view optical micrograph of a VO_x/Si structure

Switching speeds below 100 ns have been achieved. Furthermore, a record number of switching cycles have also been recently demonstrated, several orders of magnitude above the values obtained with chalcogenides. Such performance metrics are crucial in photonic artificial neural networks (ANN) and would be beneficial for building VO_2 integrated photonic devices such as optical synapses or photonic memories.

In relation to the hybrid VO_2/BTO device, which offers the possibility to build compact structures which can control the phase and the amplitude separately, the consortium has explored the deposition conditions for the growth of VO2 on BTO surfaces. We have developed a process to grow a material stack where VO2 exhibits the associated metal-to-insulator transition while preserving the BTO material integrity. The fabrication of the first hybrid device integrating both materials is currently being realized.



VO_2 film deposited on a BTO layer: left) optical microscope image, right) metal-to-insulator transition in VO_2.

In parallel, we have been preparing for the first PIC fabrication run:

PHOENIX will work on two hardware platforms. The first hardware platform has been designed for Fully Homomorphic Encryption (FHE) and 5G infrastructure. PHOENIX optical technology aims at accelerating the computations of FHE and improve its latency. For example, today one multiplication (with key switching) in CGGI programmable bootstrap takes about 5 to 15ms. Using our photonic devices, we aim to reduce these numbers by a factor 10 to 100. The requirement for the 5G demonstration focuses on using the FHE/5G system to demonstrate a 4096-point IFFT and FFT in under 4.46 ms with cyclic prefix.

The second hardware platform has been designed for inference of Deep Neural Networks (DNN) and training of DNN. In this platform a very compact tunable attenuation element can be built using the VOx absorbers. We also intend to demonstrate that we can obtain a tunable coupler by using reflection on a diffraction grating created in the BTO waveguides and using the photorefractive effect. The advantage of this approach is that the grating can be adjusted/trained optically and is non-volatile. Thus it does not need continuous electrical control to maintain the coefficient value. In the first DNN fabrication run, we will produce structures to evaluate the photorefractive effect in BTO waveguides, and produce test versions of small optical crossbars that will be used in early experiments on DNN processing.

New MBE installed

Finally, the new MBE system designed for growing metal oxide thin films on substrates up to 300 mm in diameter was purchased. The components have arrived at KU Leuven in the end of December 2024. Installation is currently ongoing (see Figure 3 below) and will be finalized in the coming weeks. After this the system will be operational and the first tests and growth runs will be performed.

The new 300 mm MBE system for growth of thin metal oxide films. Installation is in progress transition in VO_2.

VALUE CHAIN OVERVIEW FOR DISSEMINATION & EXPLOITATION

During the first year of the PHOENIX project lifecycle, dissemination and communication activities have included the launch of the website, press releases, creation of the LinkedIn and Research Gate channels, promotional material, publishing several Scientific papers, attending related events and congresses, shared news and publications and had its first-year project review.

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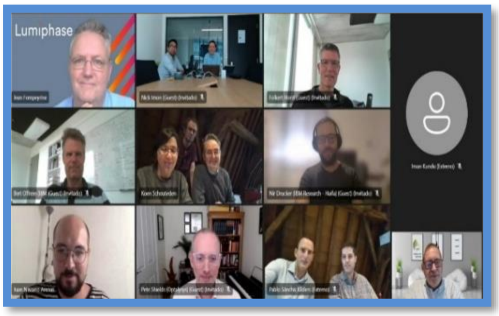
PHOENIX Kick-off Meeting



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PHOENIX's first project review, 13th Sept 2023.

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PHOENIX project at the ACM-CCS 2023

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Optalysys attending Kisaco PET Summit Asia-Pac, Nov 9-10, 2023.

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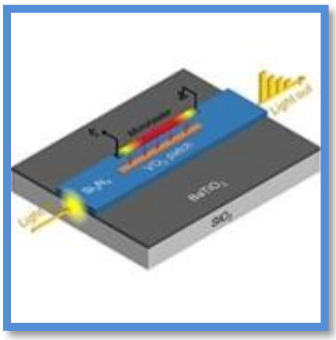
A new paper published on 20th Nov 2023: Enhanced BaTiO3/Si3N4 integrated photonic platform with VO2 technology for large-scale neuromorphic computing under PHOENIX PROJECT.



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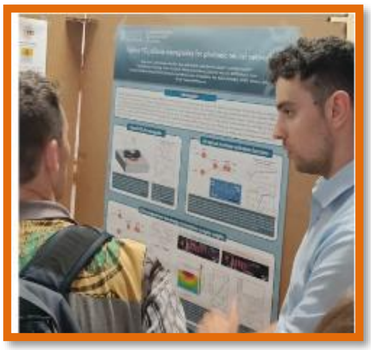
Nanophotonics Technology Center at the Universitat Politècnica de València (UPV) participated in the Spanish Conference on Nanophotonics CEN2023 from June 12-14, 2023.



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PHOENIX funds article on V2O3 thin films on Si(111) by Alberto Binetti et al. from KU Leuven in Results in Physics, Vol.49, 2023.


Results in Physics

Epitaxial growth of V_2O_3 thin films on Si(111) by molecular beam epitaxy

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Prof. Dr. Pablo Sanchis Kilders and Bert Jan Offrein participated in the E-MRS Symposium on June 1, 2023. They gave two talks on the advances brought by PHOENIX

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Valentin Polo from PNO Innovation (Spain) attended Photonics 21 annual meeting last 26th and 27th of April 2023

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Paper "Photonic memory based on VO2/Si technology", presented in the frame of the European Conference on Integrated Optics (ECIO) by UPV-NTC

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HERE ARE THE PARTNERS WE HAVE INTRODUCED SO FAR!

Coming soon NTC-UPV, IBMH, PNO Spain, and Lumiphase!

KATHOLIEKE UNIVERSITEIT LEUVEN (Belgium)

OPTALYSYS (UK)

IBM Research Europe – Zurich

MEET THE CONSORTIUM

THE PROJECT IS RUN BY A CONSORTIUM OF **7 PARTNERS** FROM **5 EUROPEAN COUNTRIES.**

THE PROJECT **COORDINATOR KATHOLIEKE UNIVERSITEIT LEUVEN** (BELGIUM) OVERSEES THE PROJECT'S IMPLEMENTATION PLAN OF **FIVE WORK PACKAGES** (WP) FOR DURATION OF **36 MONTHS.**

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This project has received funding from the European Union's Horizon Europe by the granting Authority "HADEA (European Health and Digital Executive Agency) under Grant Agreement No 101070690.