



# WELCOME TO PHOENIX SECOND NEWSLETTER!!

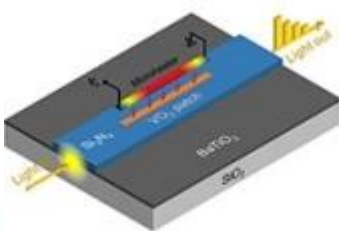


FERROELECTRIC PHOTONICS ENABLING NOVEL FUNCTIONALITIES AND ENHANCED  
PERFORMANCE OF NEXT GENERATION PICS

## PROJECT PROGRESS SO FAR...

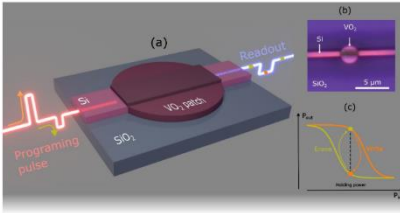
»»» The consortium has continued the project workplan execution.

The work on the integration of VOx in the **Lumiphase** BTO/SiN platform has continued. This work has resulted in the publication by partner **UPV** of the following scientific publication:



**“Enhanced BaTiO<sub>3</sub>/Si<sub>3</sub>N<sub>4</sub> integrated photonic platform with VO<sub>2</sub> technology for large-scale neuromorphic computing [Invited]” Juan José Seoane, Jorge Parra, Juan Navarro-Arenas, and Pablo Sanchis**

The integration of VO<sub>2</sub> in the SiN/BTO platform for enabling ultra-compact amplitude switching devices offers a scalar multiplication functionality with multilevel operation. An electronically reprogrammable switching device with a 5-bit amplitude encoding capability and an insertion loss of only 0.5 dB has been proposed. The device is built with a 9- $\mu$ m-long VO<sub>2</sub>/SiN/BTO waveguide structure integrated with an efficient microheater using a transparent conducting oxide to reduce energy consumption and achieve faster speeds. Results have been published as an invited paper in Optical Materials Express (<https://doi.org/10.1364/OME.501920>)



On the other hand, a VO<sub>2</sub> etching process based on ICP/RIE (Inductively Coupled Plasma/Reactive Ion Etching) is also being developed in the project. Furthermore, we have continued fabricating VO<sub>2</sub>/Si structures as reference and for demonstrating new functionalities. A photonic memory device fabricated by **UPV and KUL** has been successfully demonstrated with a record

endurance of up to 10<sup>7</sup> cycles and with potential for achieving switching times of few nanoseconds and energy consumptions of few picojoules (submitted manuscript [under review, https://arxiv.org/abs/2403.10162](https://arxiv.org/abs/2403.10162) ).

### ➤➤➤ LUMIPHASE has been working on the following actions:

- Fabrication of PIC designed by Optalysys and IBM almost completed.
- Fabrication flow of BTO/VO<sub>2</sub> hybrid devices adjusted, dummy SiN structures provided to UPV for process development.
- Test plan discussed with OPTALYSYS, a visit on Lumiphase's premises is being organized to get OPTALYSYS engineers familiar with BTO technology.

### ➤➤➤ Partner OPTALYSYS activities have been focused to:

- Working on the optimization of the TFHE PBS implementation to make it more versatile (e.g., easier to implement on different FPGAs) and expand the range of parameters that can be supported.
- Working on getting a better understanding of the requirements for CKKS (focusing on key-switching).
- Developing a Verilog / Vitis HLS module for high-accuracy FT4 reconstruction using the optical device.
- Photonics has been integrated with an FPGA Host for data processing.

#### Recent main achievements:

- Increase in the modulus size supported by our TFHE implementation to ~32 bits.
- Working reference implementation of the CKKS key-switching.

#### Future plans:

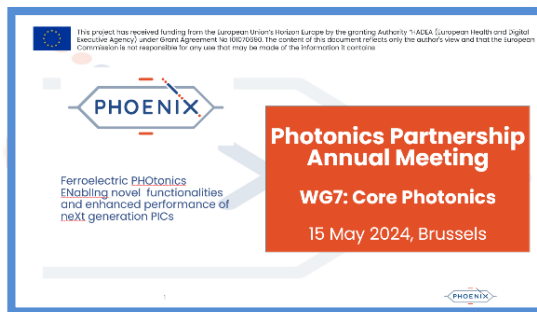
- Integration of the PBS module with the Optalysys photonic system:
- Reference implementation of the CKKS bootstrapping.
- Implementation of TFHE key-switching.



# DISSEMINATION & EXPLOITATION

Dissemination and communication activities carried out during the latest months have been reported through the website and social media, while preparing the second Press Release of the project! Here a short summary of the highlights!

## PHOENIX at the Photonics21 partnership Annual Meeting 2024



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## UPV-NTC at the IEEE Silicon Photonics Conference 2024, Tokyo, Japan



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## Joint call with Korea aims to enhance economic resilience through collaborative efforts for an inclusive and robust digital



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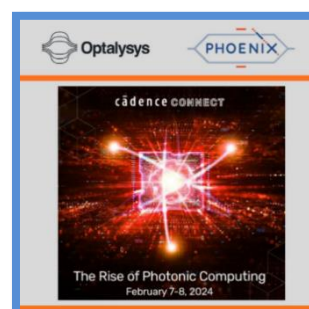
## OPTALYSYS at the Workshop on privacy enhancing technologies (ICO)



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## Optalysys being invited to speak at the Cadence CONNECT event titled "The Rise of Photonic Computing"

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# PARTNERS INTRODUCED IN THE LAST MONTHS:

## IBM ISRAEL - SCIENCE AND TECHNOLOGY LTD and NTC – UPV



IBM Israel

**PHOENIX**

**MEET PHOENIX PARTNER**  
**IBM Research - Israel**



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.



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**MEET PHOENIX PARTNER**  
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**Coming soon Lumiphase and PNO !**

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