WELCOME TO PHOENIX THIRD NEWSLETTER!!

PHOENIX

FERROELECTRIC PHOTONICS ENABLING NOVEL FUNCTIONALITIES AND ENHANCEDPERFORMANCE OF NEXT GENERATION PICS

LET'S DIVE INTO OUR RECENT PROGRESS, ACHIEVEMENTS, AND UPCOMING PLANS!

We are excited to bring you the latest updates from the PHOENIX project, where ferroelectric photonics continues to unlock novel functionalities and enhance the performance of next-generation photonic integrated circuits (PICs).

Etching of thin and thick VO2 films

Our partners Universitat Politècnica de València - Nanophotonics Technology Center (UPV-NTC) and https://www.kuleuven.be/kuleuven/ KATHOLIEKE UNIVERSITEIT LEUVEN (KUL) have made significant progress in the patterning and etching of VO2 films from a few to hundred nanometers thickness. Good results have been obtained in thin film, and testing on functional devices is aimed at targeting the performance exhibited by VO2/Si fabricated by the lift-off process.

Optimization of the fabrication process to integrate VO2 onto SiN/BTO waveguides

Universitat Politècnica de València - Nanophotonics Technology Center (UPV-NTC) is also advancing in the optimization of fabrication processes to integrate VO2 onto the Lumiphase SiN/BTO photonic platform. Recent tests on SiN/BTO chips are promising for demonstrating functional VO2-based devices in the upcoming months.

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

SCIENTIFIC PUBLICATIONS TO CELEBRATE!

Ultra-high endurance silicon photonic memory using vanadium dioxide.

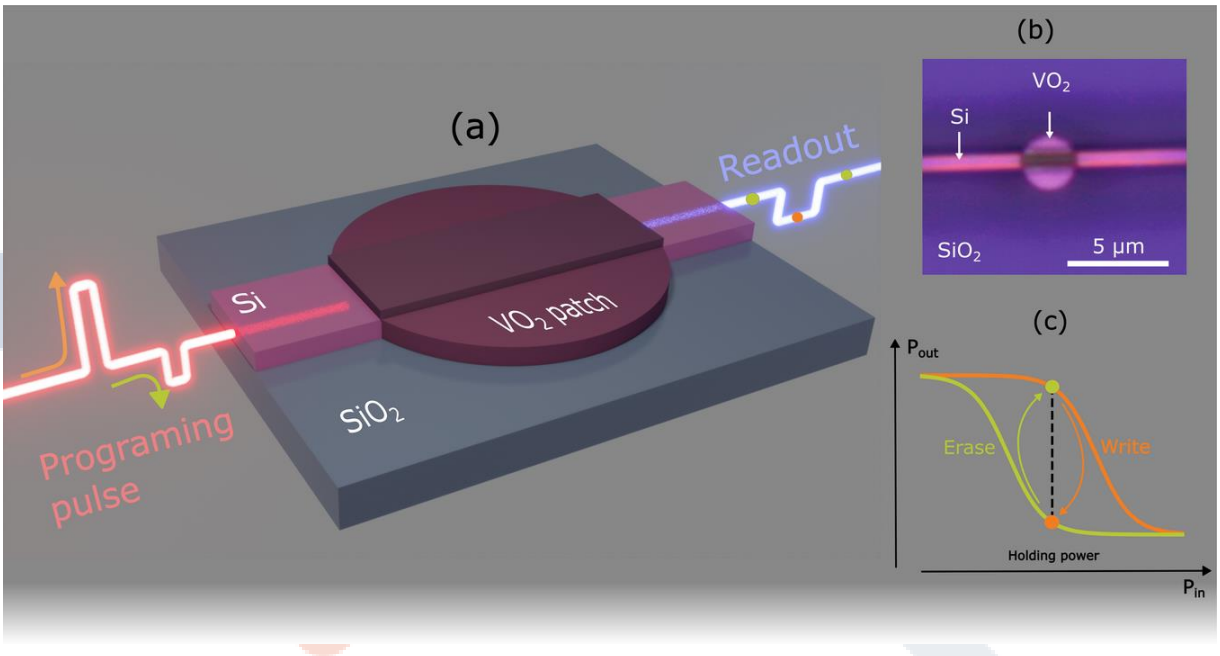


Fig: Device scheme and working principle.

a Working principle of our VO_2/Si photonic memory operated by programming (write/erase) optical pulses. b Optical image of the fabricated device. c Sketch of the memory operation between written/erased states by exploiting the hysteretic response of the VO_2 insulating-to-metal phase transition. Image From: Ultra-high endurance silicon photonic memory using vanadium dioxide

DOI: https://doi.org/10.1038/s44310-024-00038-1

Seoane, J.J., Parra, J., Navarro-Arenas, J. et al. Ultra-high endurance silicon photonic memory using vanadium dioxide. npj Nanophoton. 1, 37 (2024).

Our latest results on a photonic memory device fabricated by Universitat Politècnica de València - Nanophotonics Technology Center (UPV-NTC) and **https://www.kuleuven.be/kuleuven/** KATHOLIEKE UNIVERSITEIT LEUVEN (KUL) have been published in **npj Nanophotonics**.

In this work, the Universitat Politècnica de València - Nanophotonics Technology Center (UPV-NTC) and **https://www.kuleuven.be/kuleuven/** KATHOLIEKE UNIVERSITEIT LEUVEN (KUL) team demonstrate a record endurance of up to 107 cycles and the potential for achieving switching times of a few nanoseconds and energy consumptions of a few picojoules.

On-chip electro-optical spiking VO2/Si device with an inhibitory leaky integrate-and-fire response

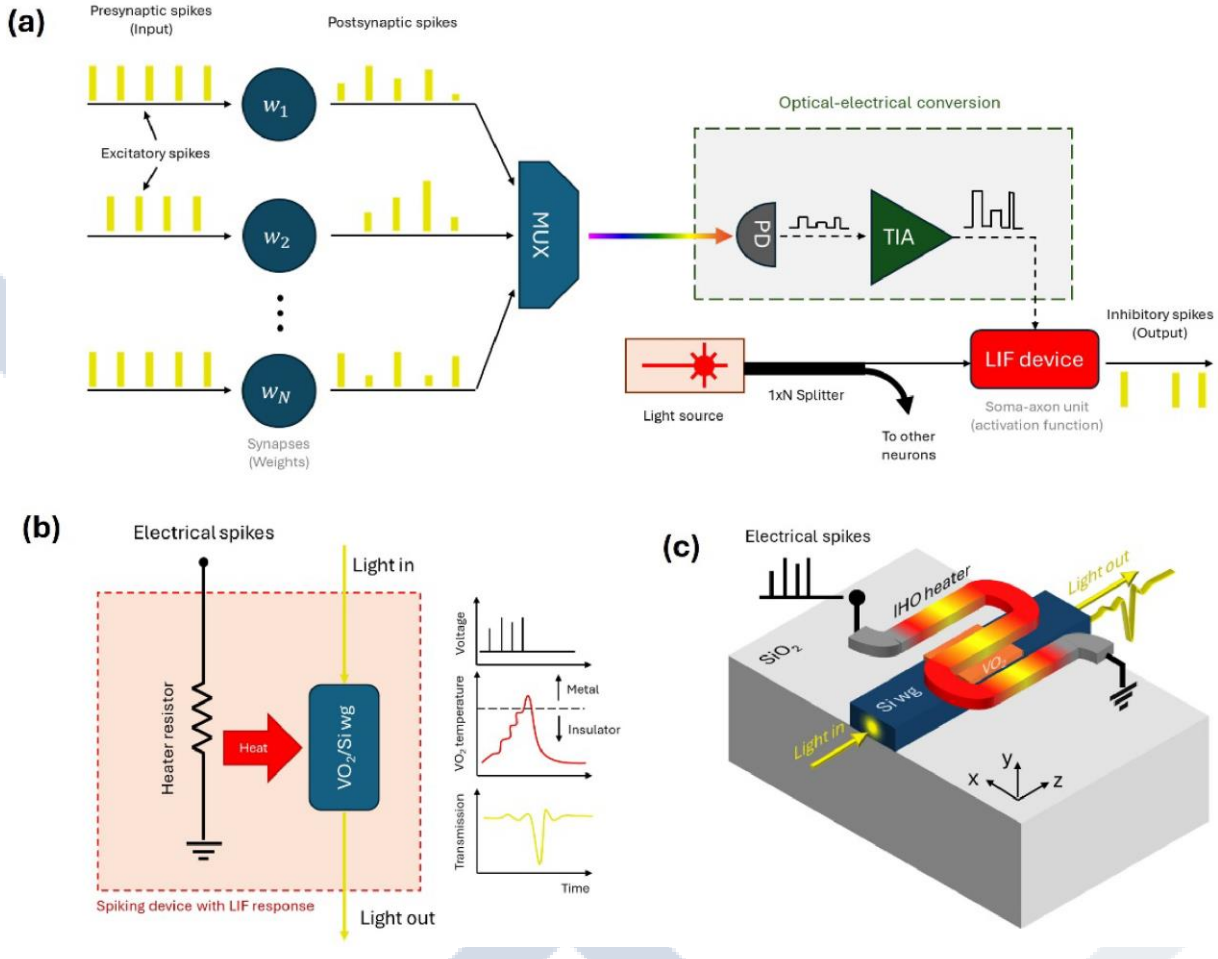


Fig. 1. Envisaged optical neuron and working principle of the proposed electro-optical VO2/Si spiking device. (a) Block diagram of the optical neuron. A set of input spikes are weighted by photonic synapses in the optical domain. The postsynaptic spikes are then combined using a multiplexer and optical-electrical converted by a photodetector (PD). The PD electrical current is trans-impedance amplified (TIA) to drive the leaky integrate-and-fire (LIF) spiking device. This device is optically fed by using a light source, which can be shared by the rest of the optical neurons. Hence, the LIF device can fire inhibitory optical spikes. (b) Sketch of the working operation of the proposed LIF spiking device based on a VO2/Si waveguide driven by a heater resistor. The electrical spikes (pulses) produce Joule heating, raising the temperature of the VO2 with a cumulative process. Once the insulator-metal transition (IMT) temperature is surpassed, the VO2/Si waveguide suffers a reduction in the optical transmission. (c) Illustration of the spiking device implemented on a silicon-on-insulator (SOI) waveguide with a small thin patch of VO2 on top. The heater resistor is implemented by using an IHO microheater with a meander shape. Between the microheater and the VO2/Si waveguide, there is a SiO2 gap (not shown)

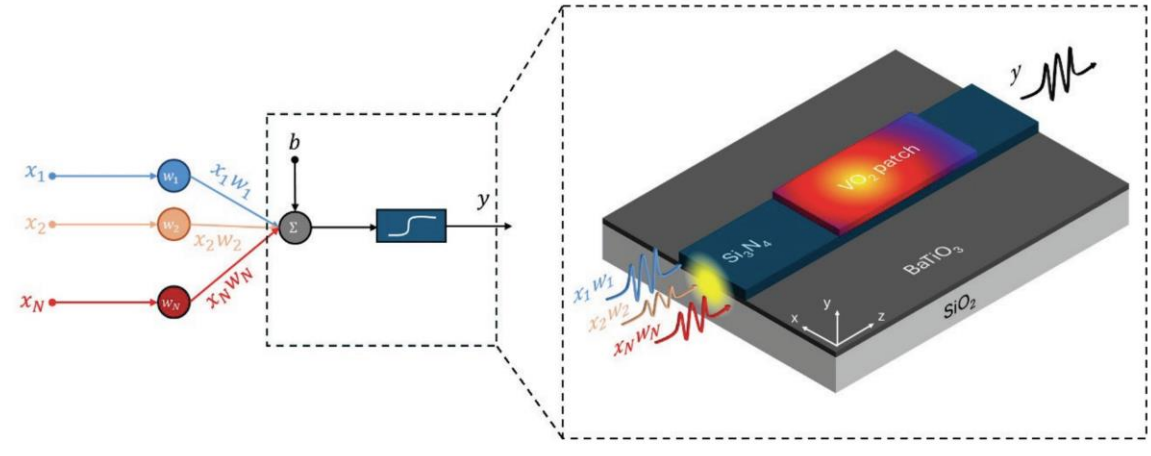
Juan-Francisco Morcillo, Pablo Sanchis, and Jorge Parra, "On-chip electro-optical spiking VO2/Si device with an inhibitory leaky integrate-and-fire response," Opt. Mater. Express 14, 2681-2693 (2024)

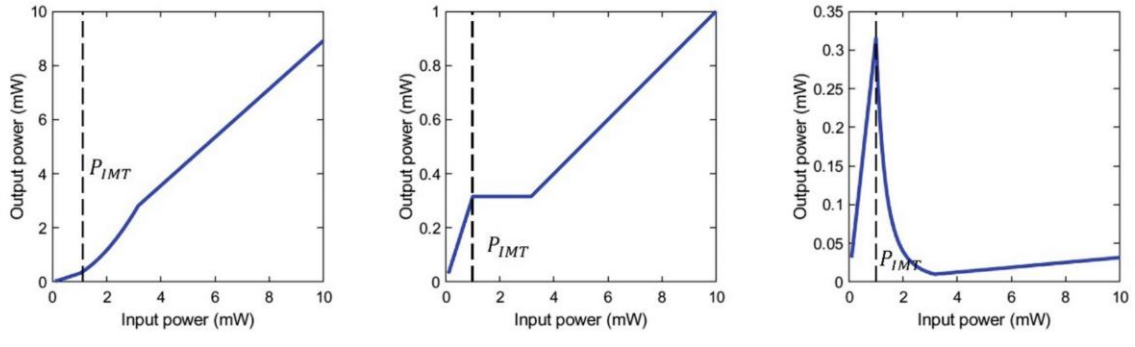
DOI : ***https://doi.org/10.1364/OME.537717***

Open Access Scientific publication by Universitat Politècnica de València - Nanophotonics Technology Center (UPV-NTC) funded by PHOENIX project.

An electro-optical VO2/Si spiking device for integrated photonic-based spiking neural networks has been proposed and published in Optical Materials Express. The main feature of this device is the ability to mimic the leaky integrate-and-fire response found in some cell brains in a very simple, compact, and energy-efficient way without requiring complex electronic circuitry that hinders the scalability and performance of implementing photonic hardware for neuromorphic computing.

Sub-milliwatt threshold power and tunable-bias all-optical nonlinear activation function using vanadium dioxide for wavelength-division multiplexing photonic neural networks





ELU **Clipped ReLU** **Radial basis**

Preprint publication: [Submitted on 23 Jul 2024] by Jorge Parra, Juan Navarro-Arenas, Pablo Sanchis from Universitat Politècnica de València - Nanophotonics Technology Center (UPV-NTC) An all-optical nonlinear activation function device is proposed based on VO2 is proposed for the SiN/BTO platform. Different types of activation functions such as ELU, clipped ReLU, and radial basis could be achieved in such a device by harnessing the insulator-metal transition (IMT) of VO2. Through numerical simulations, a sub-milliwatt activation power with bias tunability is predicted. The performance of the device was assessed using the CIFAR-10 dataset, confirming its potential for convolutional neural networks (CNN).

arXiv:2407.16472

https://doi.org/10.48550/arXiv.2407.16472

The work is under review, and the preprint is available.

Recent Achievements and Future Plans

M-24 Meeting

Successfully M-24 General Meeting hosted by NTC-UPV in Valencia, Spain, where partners discussed project progress and upcoming deliverables .

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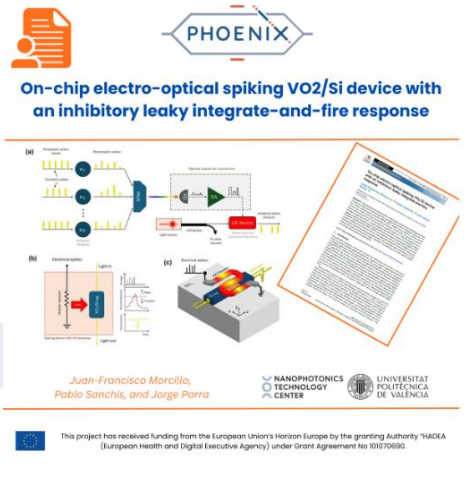
Upcoming Events

- PHOENIX will be attending the European Conference on Integrated Optics (ECIO 2025) in Wales from June 23–25, 2025.
- Final PHOENIX Conference (venue TBC).

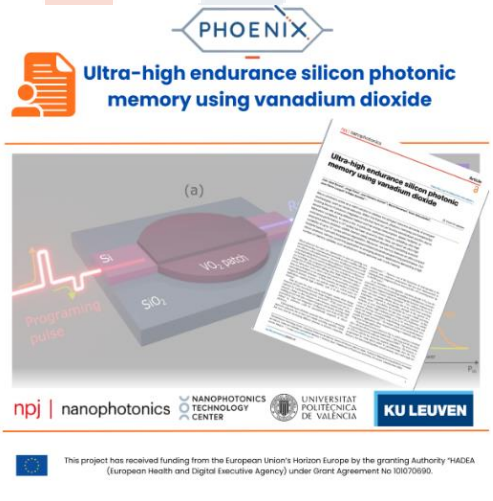
DISSEMINATION & EXPLOITATION

Dissemination and communication activities carried out during the latest months have been reported through the website and social media. Here is a short summary of the highlights!



New Publication from NTC -UPV : On-chip Electro-Optical Spiking Device for Neuromorphic Computing

READ MORE →



Announcing the Latest Publication

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IBMH at the PETS 2024

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The Ministry of Digital Transformation and Public Function has launched a process for Expressions of Interest on Semiconductor Competence Centers.

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Meet PHOENIX partners!

Throughout the "Meet the PHOENIX Partners" campaign, we had the pleasure of introducing the organizations behind the PHOENIX project. Each partner brings unique expertise, driving forward our mission to advance photonic memories and integrated technologies

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www.heu-phoenix.eu/

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