Centre de Nanosciences et de Nanotechnologies

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université PARIS-SACLAY

Postdoctoral position (2 years): Machine Learning for Enhanced Silicon Photonics Devices

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The project

The development of nanofabrication technologies has opened the door to the possibility of **precisely controlling the behaviour of light using nano-scale devices realized on chip**. In particular, **silicon-based photonics is widely considered the platform of choice for the realization of miniaturized devices** in a wide variety of application fields, including optical communications, sensors, machine learning computation, and imaging. Additionally, due to its compatibility with CMOS fabrication processes, silicon photonics holds the promise of providing ultra-compact devices that could be fabricated at large-volumes and low cost and offers the unique potential for the integration of photonic and microelectronic functionalities in a single chip.

Classical photonic devices exploit simple geometries that are designed by hand (e.g., waveguides, rectangles, rings, etc.), resulting in relatively large components and limited scale of integration. On the contrary, one of the most active research topics in the field focuses on the possibility to use non-intuitive shapes, complex material distributions, and metamaterials to achieve extremely compact devices capable of integrating multiple functions with footprints of few square microns.

The way light interact with matters in such devices cannot be easily described with commonly available models and device development requires **innovative methodologies**. **These challenges stimulated a large research effort in the direction of artificial intelligence and data-driven methodologies**. Machine learning algorithms can build complex physical models directly from a set of training data, models that can then be used to very efficiently realize novel photonic structures with desired optical properties.

In this context, the **long-lasting collaboration between our group and the Silicon Photonics group at the National Research Council Canada** allowed to pioneer the use of dimensionality reduction techniques, demonstrating devices with unprecedented performance.

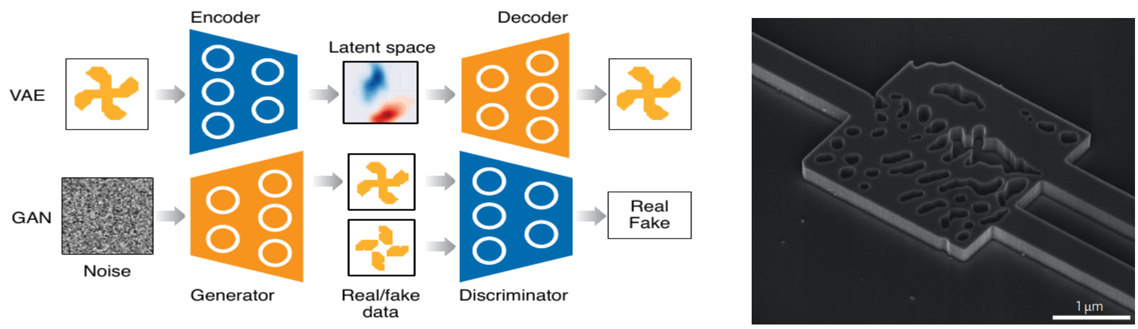

Fig.1: *(left) Representation of a Variational Autoencoder and a Generative Adversarial Neural Network (Ma, et al. Nature Photonics, 2020). (right) Metamaterial-based photonic device (Piggott, et al. Nature Photonics, 2015).*

This project stems from this ongoing collaboration and aims at developing accurate silicon photonics surrogate models using machine learning. In particular, we will address the key open challenge of modeling the impact of fabrication and operation environment on the perfromance of photonic devices. We will exploit both simulations and optical measurements in a data-efficient manner, and leverage transfer learning and active learning methods. The developed models will then be used to anticipate and pre-emptively compensate for fabrication errors, providing an innovative approach to design and calibrate large photonic circuits.

Activities and responsibilities

We are seeking a **postdoctoral researcher** with interest and experience in integrated photonics to join the Silicon Photonics team at the **Center for Nanoscience and Nanotechnology (C2N)**. The activities will be carried out in the framework of a funded collaborative project with the **National Research Council Canada (NRC)**.

The successful candidate will be responsible for the **design and layout of photonic components** and circuits to be used as test cases; **fabrication** of the devices in the C2N clean room and their **experimental characterization** to build the dataset required for neural network training; identify, implement, and train **neural network architectures** both for optical behavior prediction and inverse design purposes. Activities will be carried out in collaboration with the PI and the NRC team. **Short stays in Ottawa (Canada) are foreseen as part of the project**.

Job offer and candidate profile

This job position offers the opportunity to work within an **enthusiastic and internationally recognized team** in the outstanding environment of C2N and directly collaborate with a world-leading research group at the NRC. The contract will be for 2 years. **Gross monthly salary** will be between 3400€ and 4200€, depending on the relevant experience. We offer access to state-of-the-art fabrication and characterization infrastructures, with the **possibility to propose and investigate novel research ideas**.

The candidate should have a PhD degree in Electrical Engineering, Applied Physics or related disciplines. The candidate should be familiar with modelling, simulation, and design of photonic components and circuits and have experience with their fabrication and experimental characterization. Aptitude with machine learning is a plus. A proactive attitude and the ability to work in a diverse, multi-disciplinary, and international team with PhD, Postdocs, and students are a must.

[1] D. Melati, Y. Grinberg, M. K. Dezfouli, S. Janz, P. Cheben, J. H. Schmid, A. Sánchez-Postigo, and D.-X. Xu, 'Mapping the global design space of nanophotonic components using machine learning pattern recognition', Nat Commun, vol. 10, no. 1, pp. 1–9, Oct. 2019, doi: 10.1038/s41467-019-12698-1.

[2] D. Gostimirovic, D.-X. Xu, O. Liboiron-Ladouceur, and Y. Grinberg, 'Deep Learning-Based Prediction of Fabrication-Process-Induced Structural Variations in Nanophotonic Devices', ACS Photonics, vol. 9, no. 8, pp. 2623–2633, Aug. 2022, doi: 10.1021/acsphotonics.1c01973.