Position Description

1. General Information

Name of the position	**Development of photonic integrated circuits for neuromorphic secure accelerators in LNOI platforms**
Foreseen enrolment date	January 2025
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • École Centrale de Lyon (EC Lyon) • Royal Melbourne Institute of Technology (RMIT)
Research Host	École Centrale de Lyon
PhD awarding institutions	École Centrale de Lyon & Royal Melbourne Institute of Technology
Locations	Primary: Ecully, France Secondary: Melbourne, Australia
Supervisors	Cédric Marchand and David Navarro (ECL) Arnan Mitchell (RMIT)
Group of discipline	Photonics, applied physics, programming

2. Research topics (only one of these projects will be funded)

Project 1: *Development of photonic devices for energy-efficient secure neuromorphic accelerators in LNOI platforms*

Context

The rising need to guarantee security at the edge has recently fostered a large amount of research and efforts into robust and lightweight hardware security approaches towards prompt integration in accelerators for edge computing and IoT. Differently from software security layers which are prone to various attacks targeting non-volatile digital memories storing secret information e.g., secret keys, hardware security layers and primitives such as physical unclonable functions can bypass this attack vector by generating secret information ad hoc once opportunely stimulated. Photonic technologies have a disruptive potential for neuromorphic computing as they can allow to process information at high speed with ultralow energy consumption and latency, while preserving similar fabrication costs to CMOS electronics.

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Thesis goal

The goal of this thesis concerns the development of devices based on LNOI and III-V materials integrated onto LNOI dies using transfer-printing approaches for building energy-efficient neuromorphic architectures. Such architecture will combine novel and robust security layers leveraging the unique performance of LNOI platforms such as low losses (< 0.5 dB/cm), high-speed modulators, and embedded phodiodes and electronics (> 50 GHz). The student will be directly involved in the fabrication of such devices, leveraging the expertise of the Integrated Photonics and Applications Centre (InPAC), as well as their design. Non-linear effects of different kinds e.g., electro-optic or opto-electronic will be investigated to find optimal trade-offs for activation functions in the case of neuromorphic architectures and randomness character in the case of security layers (e.g., physical unclonable functions).

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Research Fields: Applied science, photonics, nonlinear optics, hardware security

Project 2: *Investigation of photonic architectures for energy-efficient secure neuromorphic accelerators in LNOI platforms using novel security protocols*

Context

The rising need to guarantee security at the edge has recently fostered a large amount of research and efforts into robust and lightweight hardware security approaches towards prompt integration in accelerators for edge computing and IoT. Differently from software security layers which are prone to various attacks targeting non-volatile digital memories storing secret information e.g., secret keys, hardware security layers and primitives such as physical unclonable functions can bypass this attack vector by generating secret information ad hoc once opportunely stimulated. Photonic technologies have a disruptive potential for neuromorphic computing as they can allow to process information at high speed with ultralow energy consumption and latency, while preserving similar fabrication costs to CMOS electronics.

Thesis goal

The goal of this thesis concerns the system-level investigation of photonic integrated circuits (PICs) for energy-efficient and low-latency neuromorphic computing as well as for robust security layers. The PICs will be based on novel photonic and opto-electronic devices leveraging the thin-film LNOI platform present at RMIT as well transfer-printed high-speed III-V devices. Novel security protocols will be investigated to relax constraints such as the need for strong non-linear effects within the PICs to prevent from e.g., modeling attacks of the security layers. The student will also have the opportunity to carry out device fabrication if interested.

Supervisors: Dr. Cédric Marchand, Dr. David Navarro (ECL) / Professor Arnan Mitchell (RMIT) / Alfredo de Rossi (Thales Research and Technology)

Research Fields: Applied science, photonics, nonlinear optics, hardware security

Project 3: *Theoretical and numerical study of photonic devices and architectures for energy-efficient secure neuromorphic accelerators in LNOI platforms*

Context

The rising need to guarantee security at the edge has recently fostered a large amount of research and efforts into robust and lightweight hardware security approaches towards prompt integration in accelerators for edge computing and IoT. Differently from software security layers which are prone to various attacks targeting non-volatile digital memories storing secret information e.g., secret keys, hardware security layers and primitives such as physical unclonable functions

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can bypass this attack vector by generating secret information ad hoc once opportunely stimulated. Photonic technologies have a disruptive potential for neuromorphic computing as they can allow to process information at high speed with ultralow energy consumption and latency, while preserving similar fabrication costs to CMOS electronics.

Thesis goal

The goal of this thesis concerns the theoretical and numerical investigation of photonic integrated circuits (PICs) for energy-efficient neuromorphic computing and robust security layers. Various studies concerning different architectures and computing paradigms for neuromorphic computing as well as complex and chaotic architectures for security primitives such as physical unclonable functions and true random number generators are foreseen. For this type of architectures, several trade-offs are present e.g., when considering the required system complexity versus security strength of the proposed solutions. The possibility of using a high-performance platform featuring low losses (< 0.5 dB/cm), high-speed modulators, and embedded phodiodes and electronics (> 50 GHz) will provide a perfect play field to explore exotic concepts and architectures for PICs from first principles. Finally, the proposed PICs will be realized at RMIT in a thin-film Lithium Niobate on Insulator (LNOI) platform, leveraging the expertise of the Integrated Photonics and Applications Centre (InPAC). The student will also have the opportunity to carry out device fabrication, if interested.

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Research Fields: Applied science, photonics, nonlinear optics, hardware security

3. Employment Benefits and Conditions

Ecole Centrale Lyon offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). The employment contract includes a probation period of one month, which may be renewed once for a period not exceeding the initial duration. The total working hours per week is 35h.

The remuneration, in line with the European Commission's rules for Marie Skłodowska-Curie fellows, will consist of a gross monthly salary of EUR 2,142 in 2024. Of this amount, the estimated net salary to be received by the researcher is EUR 1,720 per month. However, the final amount to be received by the Researcher is subject to national tax legislation (approximately EUR 100 /month). This salary will increase during the thesis and should reach, on average, EUR 2,340 gross (i.e. EUR 1,870 net) per month.

Benefits include

- Becoming a Marie Skłodowska-Curie fellow and be invited to join the Marie Curie Alumni Association.
- Access to all the necessary facilities and laboratories at Ecole Centrale Lyon and RMIT, including potential access to other French research laboratories.
- Tuition fees exemption at both PhD awarding institutions.
- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events.
- 10,000 EUR allowance to cover flights and living expenses for up to 12 months in Australia.
- 27 days paid holiday leave.
- French Social security coverage.
- Sick leave.
- Parental leave.

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4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRANDE's conditions.

Applicants must hold a Master's degree that includes a research component comprised of at least 25% of a full-time academic year (or part-time equivalent) with an overall high distinction or a master degree without a research component with at least a high distinction average.

Applicants will also need to meet English proficiency requirements: https://www.rmit.edu.au/study-with-us/international-students/apply-to-rmit-international-students/entry-requirements/english-requirements.

More information on EC Lyon's requirements

Foreign degrees are examined by the doctoral schools to determine whether they are equivalent to a Master's.

Important: the authorisation of the Defence Security Officer may be required before admission. In case of denial, the enrolment will not be carried out.

Visit the website: https://www.ec-lyon.fr/en/research/doctorate/admission-enrolment-doctorate

More information on RMIT University's requirements

Visit the website: https://www.rmit.edu.au/research/research-degrees/how-to-apply

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