AUFRANDE

CentraleSupélec

MACQUARIE University
SYDNEY·AUSTRALIA

Position Description

1. General Information

Name of the position	**Integrated photonic circuits**
Foreseen date of enrolment	1 October 2023
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • CentraleSupélec • Macquarie University
Research Host	CentraleSupélec
PhD awarding institutions	CentraleSupélec & Macquarie University
Locations	Primary: Metz, France Secondary: Sydney, Australia
Supervisors	Delphine Wolfersberger and Marc Sciamanna (CentraleSupélec) Alexander Fuerbach and Mick Withford (MQ)
Group of discipline	Photonics

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

Project 1: *All-optical interconnects*

Photonic Integrated Circuits (PICs) offer a potential solution to overcome many of the limitations that are inherent to electronic circuits. Given the ever-increasing demand for bandwidth, the development of fibre-coupled devices for all-optical telecommunication is therefore a highly active field of research [1].

In collaboration with the company Modular Photonics, this project will investigate the design and the fabrication of complex waveguiding structures for all-optical information processing, in particular 1:N splitters for optical interconnect applications. Very recently, researchers from CentraleSupélec have demonstrated that fully controllable multichannel waveguides can be induced in photorefractive materials by counterpropagating Bessel beams [2]. The proposed project will build on this work with the ultimate aim of demonstrating a functional device. As a complementary technique, the femtosecond laser direct-write method can be used to fabricate three-dimensional waveguiding structures in transparent dielectrics [3]. Very recently, researchers from Macquarie University have developed the first designer glass

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specifically optimised for that purpose [4]. As part of this project, optical interconnects will also be designed and fabricated in this glass and the advantages and limitations of both approaches will be analysed.

[1] P. Minzioni et al.: "Roadmap on all-optical processing", J. Opt. **21**, 063001 (2019)

[2] Y. Chai et al.: "Fully controllable multichannel waveguides induced by counterpropagating Bessel beams", Scientific Reports **12**, 17566 (2022)

[3] R.R. Gattass et al.: "Femtosecond laser micromachining in transparent materials", Nature Photonics **2**, 219 (2008)

[4] T.T. Fernandez et al.: "Designer glasses—Future of photonic device platforms", Advanced Functional Materials **32**, 2103103 (2022)

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Research Fields: Photonics, nonlinear optics

Project 2: *Mode-selective optical chips*

With the ever-growing Internet data demand, single-mode optical fibers are rapidly approaching their capacity limit. Therefore in recent years significant research effort has been put into space-division multiplexing for scaling the transmission capacities of optical communication networks. Space-division multiplexing (SDM) refers to establishing multiple data channels within the cross-section of a single optical fiber [1].

In collaboration with the company Modular Photonics, this project will investigate the design and the fabrication of three-dimensional mode-selective optical components via two complementary techniques:

1) In a photorefractive material, an incident light beam excites free charge carriers, which then create a space-charge field, this modifying the refractive index distribution through the Pockels effect in the medium. Utilising multiple Bessel or Airy beams, complex waveguiding structures can thus be realised [2].
2) If femtosecond laser pulses are tightly focused into a transparent dielectric material, nonlinear absorption of the photon energy can result in a permanent and highly localised modification of the refractive index, thus providing the basis for photonic device fabrication via the femtosecond laser direct-write technique [3].

[1] D. J. Richardson: "Filling the light pipe", Science 330, 327 (2010)

[2] Y. Chai et al.: "Fully controllable multichannel waveguides induced by counterpropagating Bessel beams", Scientific Reports 12, 17566 (2022)

[3] T.T. Fernandez et al.: "Designer glasses—Future of photonic device platforms", Advanced Functional Materials 32, 2103103 (2022)

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Research Fields: Photonics, nonlinear optics

Project 3: *Photonic integrated circuits*

Photonic Integrated Circuits (PICs) offer a potential solution to overcome many of the limitations that are inherent to electronic circuits. Given the ever-increasing demand for bandwidth, the development of fibre-coupled devices for all-optical telecommunication is therefore a highly active field of research [1].

Very recently, researchers from CentraleSupélec have demonstrated that fully controllable multichannel waveguides can be induced in photorefractive materials by counterpropagating Bessel beams [2]. The integrated photonics group at

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Macquarie University on the other hand is amongst the world-leaders in the fabrication of three-dimensional fibre-coupled photonic devices via the femtosecond laser direct-write technique [3].

In collaboration with the company Modular Photonics, this project will investigate the design and the fabrication of complex hybrid devices for all-optical information processing in photorefractive materials like lithium niobate by combining both techniques for the first time. It is envisaged that the superposition of non-diffracting shape-preserving beams like Airy and Bessel beams will create a photo-induced structure that will then be modified via femtosecond laser light-matter interaction.

[1] P. Minzioni et al.: "Roadmap on all-optical processing", J. Opt. 21, 063001 (2019)

[2] Y. Chai et al.: "Fully controllable multichannel waveguides induced by counterpropagating Bessel beams", Scientific Reports 12, 17566 (2022)

[3] T.T. Fernandez et al.: "Ultrafast laser inscribed waveguides in tailored fluoride glasses: an enabling technology for mid-infrared integrated photonics devices", Scientific Reports 12, 1 (2022)

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3. Employment Benefits and Conditions

CentraleSupélec offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). There is a two months' probation period and the total working hours per week is 39h/week.

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 29,388 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,936 EUR per month. However, the definite amount to be received by the Researcher is subject to national tax legislation.

Benefits include

- Access to CentraleSupélec and Macquarie University facilities and LMOPS laboratory.
- 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 12 months in Australia.
- 25 days paid holiday leave according to the rules at CentraleSupélec.
- Social security rights.
- Parental leave.

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.

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CentraleSupélec

Applicants must hold a Master's or equivalent diploma.

More information: https://www.centralesupelec.fr/en/doctoral-studies

Macquarie University

The minimum requirement for admission to a PhD degree is:

- Completion of a Master of Research (MRes) with a grade of at least a Distinction level (75% or greater in second year; or
- A Master of Philosophy; or
- A two-year Master's degree with a major research component at Distinction level (75% or greater).

Short-listed applicants will need to demonstrate their suitability for entry to the program by:

- Providing a detailed research proposal; and
- Providing evidence of the required level of English language proficiency.

Furthermore, applicants must qualify for a Cotutelle scholarship. Macquarie University assesses applicants for the scholarship based primarily on academic merit and research experience, emphasising previous thesis outcomes. Additional information such as peer-reviewed publications, conference and poster presentations and relevant work or professional experience may also be taken into account. Applicants are rated according to the principle and process outlined in the Higher Degree Research Scholarship Rating Sheet.

Short-listed applicants will be required to submit an application to the PhD program and the Cotutelle scholarship via Macquarie University's online application system.

Successful applicants (if non-Australian citizen) will be required to:

- Meet Australian visa requirements; and
- Obtain Overseas Student Health Cover (OSHC) for the entire duration of their study in Australia.

More information: https://policies.mq.edu.au/document/view.php?id=268

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