Position Description

1. General Information

Name of the position	**Rare earth doped microstructures for integrated optics made by pulsed laser deposition**
Foreseen enrolment date	1 October 2024
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • University Claude Bernard Lyon 1 (UCBL) • RMIT University (RMIT)
Research Host	University Claude Bernard Lyon 1
PhD awarding institutions	University Claude Bernard Lyon 1 & RMIT University (RMIT)
Locations	Primary: Lyon, France Secondary: Melbourne, Australia
Supervisors	Alban Gassenq (UCBL) and Arnan Mitchell (RMIT)
Group of discipline	Photonics, Integrated Optics, Opto-electronics, Nano and micro-technology

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement № 101081465

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

Project 1: *On chip mid-Infrared convertor*

The mid-infrared (Mid-IR) wavelength range is extremely interesting for sensing applications between 2 and 15 um wavelength, but Mid-IR systems are bulky and expensive. Integrated Mid-IR optics are promising for miniaturizing such devices. However, integrating an on-chip source for a fully integrated system is very complex, especially for wavelengths above 2.3 µm [1]. For that purpose, the rare earth wavelength conversion strategy from IR to mid-IR is relevant.

This project aims to create on-chip Mid-IR sources using rare earth down conversion processes in an Al_2O_3 [2,3] host with Dy doping [4]. Figure 1 presents the envisaged devices. A standard photonic chip using both SiN and LNOI will be designed with waveguides which can support infrared and mid-infrared light respectively. A ring in the middle will be formed using doped Al_2O_3 formed using pulsed laser deposition (PLD) [5]. The project will explore direct fabrication of waveguides from the doped Al2O3 material at UCBL and will also explore hybrid integration of this doped material with waveguides fabricated from SiN and $LiNbO_3$ devices realised at RMIT.

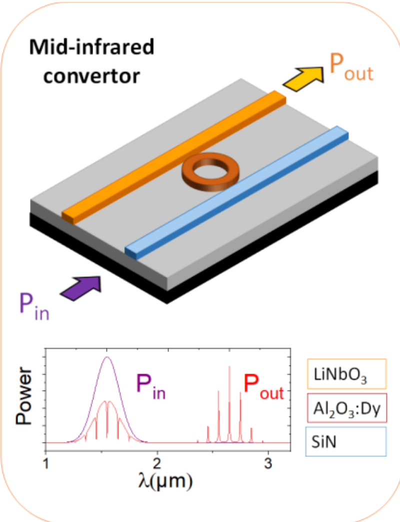

Figure 1 : Visible to Mid-Infrared light Integrated wavelength convertor

Devices requirements and state of the art comparison for sensing applications will be studied in strong collaboration with Hemara company.

References:

[1] Ruijun Wang et al. Optica, 2017 https://doi.org/10.1364/OPTICA.4.000972
[2] Gassenq et al., Appl. Phys. A, 2023, https://doi.org/10.1007/s00339-023-06549-6
[3] Hendriks et al., Adv. Phys. X, 2021, https://doi.org/10.1080/23746149.2020.1833753
[4] Gassenq et al., Opt. Express, 2021, https://doi.org/10.1364/OE.416450
[5] Heuer et al., Opt. Mate. Express, 2018, https://doi.org/10.1364/OME.8.003447
[6] Boes et al. Science 2023 https://doi.org/10.1126/science.abj4396

Supervisors:

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Research Fields: Photonics, Integrated Optics, Opto-electronics, Nano and micro-technology, Mid-Infrared

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Project 2: *Rare earth tunable laser*

Detection of chemical species is of interest in a wide range of applications, from biosensing to environmental monitoring. For such a task, precise measurements are made using tunable wavelength sources for spectroscopic evaluations, but equipments are bulky and expensive. Photonic integrated circuit (PIC) aims to miniaturize and combine multiple optical devices on a planar substrate to create compact, energy-efficient and complex on-chip functionalities [1]. In this area, ring resonator designs can be used for chemical sensing [2].

In this project, we want to design, fabricate, and characterize integrated tunable infrared sources based on micro-heaters integrated into doped ring resonators coupled to a SiN waveguide. Figure 2 presents the concept. The Al_2O_3 doped laser [3] is coupled to a SiN waveguide. The laser is integrated by pulsed laser deposition and lift-off processing [4], [5]. Since a micro-heater is placed in the center of the ring, the resonance can be electrically tuned to control the emitted wavelength for spectroscopy applications.

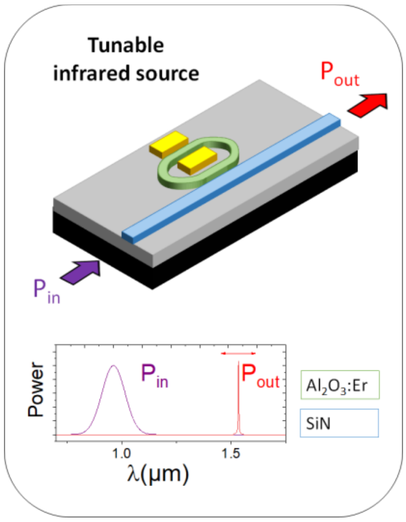

Figure 2 : Integrated tunable source coupled to a SiN waveguide

Devices requirements and state of the art comparison for sensing applications will be studied in strong collaboration with Hemara company.

References:
[1] Baets et al., APL Photonics, 2016, https://doi.org/10.1063/1.5120004
[2] Kazanskiy et al., Micromachines, 2023, https://doi.org/10.3390/mi14051080
[3] Rönn et al., Nat. Commun., 2019, https://doi.org/10.1038/s41467-019-08369-w
[4] Gassenq et al., Opt. Express, 2021, https://doi.org/10.1364/oe.416450
[5] Gassenq et al., Opt. Lett., 2023, https://doi.org/10.1364/OL.486893

Supervisors:

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Research Fields: Photonics, Integrated Optics, Opto-electronics, Nano and micro-technology, Tunable source

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Project 3: *Multiple source integration*

Integrated optics merges the advantage of optics and electronics in a single chip for many applications like communication or sensing. However, the fabrication process for the manufacturing is expensive and complex, especially for the laser source integrations. For that field, Pulsed Laser Deposition (PLD) is a promising technique since it can provide high-quality materials and micro-structuration without etching [1].

In this topic, we want to fully explore the potential of this method by integrating different PLD materials [2] and doping [3] on the same chip. Integrated ring lasers will be studied mainly with Al_2O_3 host [4,5] but with different doping. Using lift-off based processing, several lasers with different wavelengths will be integrated on the same waveguide with a grating coupler for the light injection (Figure 3). Indeed, lift-off based PLD processing offers the possibility to integrate both doped rings at the same level without etching and complex integration. This project will highlight thus the high potential of this method for multiple micro-devices integration on the same chip mainly for sensing applications.

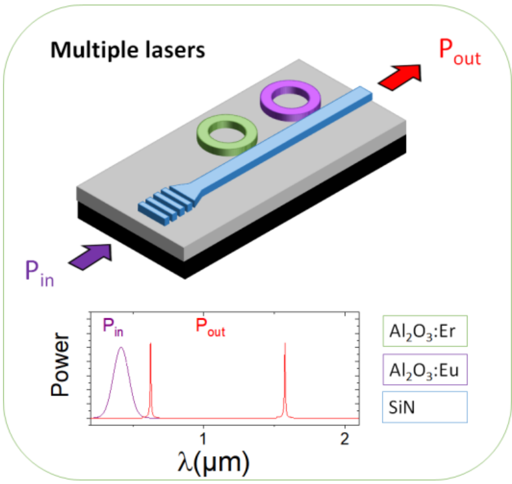

Figure 3 : Double integration using both Er and Eu doped ring resonators coupled to the same waveguide

Devices requirements and state of the art comparison for sensing applications will be studied in strong collaboration with Hemara company.

References:

[1] Gassenq et al., Opt. Express, 2021, https://doi.org/10.1364/oe.416450
[2] Jelínek et al., Laser Phys., 2009, https://doi.org/10.1134/s1054660x09020194
[3] Gassenq et al., Appl. Phys. A, 2023, https://doi.org/10.1007/s00339-023-06549-6
[4] Hendriks et al., Adv. Phys. X, 2021, https://doi.org/10.1080/23746149.2020.1833753
[5] Rönn et al., Nat. Commun., 2019, https://doi.org/10.1038/s41467-019-08369-w

Supervisors:

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Dr. Stephan Guy (Lyon, ILM)
Dr. Arnan Mitchell (Melbourne, RMIT)
Rachid MOUFLIH (Meylan, HEMERA company)

Research Fields: Photonics, Integrated Optics, Opto-electronics, Nano and micro-technology, sources integration

3. Employment Benefits and Conditions

The Université Claude Bernard Lyon 1 offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months). The total number of worked hours per week is 37h30.

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The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of an estimated gross annual salary of 28,080.00 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,870.00 EUR per month. However, the definite amount to be received by the Researcher is subject to national tax legislation.

Benefits include

- Becoming a Marie Skłodowska-Curie fellow and be invited to join the Marie Curie Alumni Association.
- Access to both universities educational resources, as well as ILM and UNSW research facilities and laboratories.
- Tuition fee waiver 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.
- 47 days paid holiday leave.
- Sick leave.
- 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.

Applicants must hold a Master's degree or a diploma that confers the Master grade (5 years).

Applicants must demonstrate an English language proficiency equivalent to an overall IELTS Academic score above 6.5 and no band below 6. Note that the test needs to be completed no more than two years before enrolment. For more information about the tests accepted and scores required, visit: https://www.rmit.edu.au/study-with-us/international-students/apply-to-rmit-international-students/entry-requirements/english-requirements/english-language-proficiency-tests

More information on UCBL's requirements

Visit the website: https://phd-physics.universite-lyon.fr/ed-52-phast/site-francais/navigation/pendant-la-these/inscriptions-reinscriptions/ and the website of the doctoral school.

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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