Position Description

1. General Information

Name of the position	**Hexagonal SiGe for photonics**
Foreseen date of enrolment	1 October 2024
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: Lyon, France Secondary: Melbourne, Australia
Supervisors	José PENUELAS (INL, CNRS, ECL) Sumeet WALIA (RMIT)
Group of discipline	Physics, Material Science, Photonics

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

Project 1: *Hexagonal SiGe Laser on silicon substrate*

In the field of silicon photonics, the critical missing device is a monolithic light source completely compatible with complementary-metal-oxide-semiconductor (CMOS) technologies. This is a straightforward consequence of the indirect bandgap of cubic Si semiconductor. Recently the experimental demonstration of direct band gap emission with hexagonal SiGe alloy, has attracted a strong attention to this material [1].

The objective of this PhD is to develop a laser based on hexagonal SiGe.

The method to fabricate hexagonal SiGe alloy is based on the epitaxial growth of SiGe on III-V nanowires having wurtzite crystal structure, resulting in epitaxial shell of hexagonal SiGe wrapping the nanowires [2]. Lasing has already been reported in the nanowire geometry for several semiconductors such as GaAs or ZnO. Plasmonic substrates, cavities, or nanowires with a particular geometry are among the most promising approaches to increase the light matter interaction at nanoscale and obtain lasing.

The PhD is divided in three parts.

1. Material growth and characterization using molecular beam epitaxy and electron microscopy.

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. Design and fabrication of the laser using clean room standard tools.
3. Optical Characterizations.

The project will be benefits from the expertise of INL (material growth, structural / optical characterization), and RMIT (device fabrication and characterization). Moreover the involvement of LETI as a non-academic partner will ensure a natural extension of this research towards industry applications.

[1] Fadaly et al. Nature 580, 205 (2020)

[2] Dudko et al. Cryst. Growth & Design 22, 32-36 (2022)

Supervisors: José Penuelas (ECL), Nicolas Chauvin (INSA Lyon), Sumeet Walia (RMIT)

Research Fields: Physics, Material Science, Photonics

Project 2: *Photodetector based on hexagonal Ge alloy*

Infrared photodetectors have attracted considerable research interest over the last years thanks to a wide range of applications in medical imaging, optical communication, security surveillance, and gas identification. Several materials have demonstrated efficient photodetection in the infrared range such as InGaAs, InSb or HgxCd1−xTe. However, the recent experimental demonstration of a direct band gap emission with hexagonal Ge has attracted a strong attention to this material [1]. hexagonal Ge, having a band gap of 0.35 eV, could be used as a mid-IR photodetector and for chemical sensing [2].

The objective of this PhD is to develop a photodetector based on hexagonal Ge.

The method to fabricate hexagonal Ge is based on the epitaxial growth of Ge on III-V nanowires having wurtzite crystal structure, resulting in epitaxial shell of hexagonal Ge wrapping the nanowires. In order to fabricate a photodetector a particular attention has to be given to the doping [3].

The PhD is divided in three parts.

1. Material growth and characterization using molecular beam epitaxy and electron microscopy.
2. Design and fabrication of the photodetector using clean room standard tools.
3. Optical and electro-optical characterizations.

The project will be benefits from the expertise of INL (material growth, structural / optical characterization), and RMIT (device fabrication and characterization). Moreover the involvement of LETI will ensure a natural extension of this research to industry applications.

[1] Fadaly et al. Nature 580, 205 (2020)

[2] Fontcuberta i Morral, Nature 580, 188 (2020)

[3] Dudko et al. Cryst. Growth & Design 22, 32-36 (2022)

Supervisors: José Penuelas (ECL), Nicolas Chauvin (INSA Lyon), Sumeet Walia (RMIT)

Research Fields: Physics, Material Science, Photonics

Project 3: *Light Emitting diode based on hexagonal SiGe alloy*

In the field of silicon photonics, the critical missing device is a monolithic light source completely compatible with complementary-metal-oxide-semiconductor (CMOS) technologies. This is a straightforward consequence of the indirect bandgap of cubic Si semiconductor. Recently the experimental demonstration of direct band gap emission with hexagonal SiGe alloy, has attracted a strong attention to this material [1].

The objective of this PhD is to develop a light emitting diode based on hexagonal SiGe.

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The method to fabricate hexagonal SiGe alloy is based on the epitaxial growth of SiGe on III-V nanowires having wurtzite crystal structure, resulting in epitaxial shell of hexagonal SiGe wrapping the nanowires [2]. A particular attention will be given to the doping of hexagonal SiGe in order to build the PN junction. The PhD is divided in three parts. 1. Material growth and characterization using molecular beam epitaxy and electron microscopy. 2. Design and fabrication of the laser using clean room standard tools. 3. Optical Characterizations. The project will be benefits from the expertise of INL (material growth, structural / optical characterization), and RMIT (device fabrication and characterization). Moreover the involvement of LETI will ensure a natural extension of this research to industry applications. [1] Fadaly et al. Nature (2020) [2] Dudko et al. Cryst. Growth & Design (2022)
Supervisors: José Penuelas (ECL), Nicolas Chauvin (INSA Lyon), Sumeet Walia (RMIT)
Research Fields: Physics, Material Science, Photonics

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 EC Lyon (INL) and RMIT University.
- 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.
- 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 will be 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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