**Mid-IR frequency combs**

**Name of the hosting institution in France**: CNRS Centre National de la Recherche Scientifique

**Name of the host laboratory / research team**: Institut des Nanotechnologies de Lyon

**Address**: INL – UMR 5270 Ecole Centrale de Lyon – 36 av Guy de Collongue 69134 Ecully Cedex, France

**Website**: https://inl.cnrs.fr/

**Name of the supervisor**: Christian Grillet

**Function**: CNRS - Head of Mid-IR group

**Email**: Christian.grillet@ec-lyon.fr

**Phone number**: +33 4 72186253

**Internship offer**

**Topic of the internship (title)**: Mid-IR frequency combs

**Proposed dates of the internship**: Start 01/10/2023, End 31/03/2024

**Scientific and academic objectives of the internship:**

Research conducted at the beginning of the millennium on optical frequency comb generation was crowned in 2005 by the Nobel Prize in Physics awarded to John Hall and Theodore Hansch. The need for more compact, robust, and energy efficient sources offering high repetition rates (> 1 GHz) has favored the emergence of a different approach to comb generation, based on nonlinear chip-based microresonators [1,2] that are manufactured by leveraging microelectronics processes and infrastructure. These “MicroCombs” have recently led to an explosion of record demonstrations, e.g. optical clocks on a chip [3], LIDAR [4], data transmission [5], neural networks [6], mostly using the Si3N4 or Hydex platform. INL/CEA-Leti contributed to these efforts, with the development of Si3N4 dispersion engineered waveguides with very low loss [7], making possible the co-integration of combs with silicon optoelectronics [8] and the demonstration of an integrated Si3N4 comb source pumped by a butt-coupled DFB III-V laser (InGaAsP/InP) [9]. All these demonstrations are mainly centered around 1550 nm at telecom wavelength whereas many applications such as spectroscopy, gas detection, environmental surveillance, free space communication etc require combs in the mid-infrared (mid-IR - in the molecular fingerprint region beyond 3 μm).

**Our first objective** is to demonstrate the first "Micro-comb" on a CMOS compatible platform to cover the actual mid-IR region. We will exploit the SiGe and Ge platform to create highly nonlinear resonators in the mid-IR with high Q-factor, suitable dispersion and repetition rate (from tens GHz to few GHz FSR as required for direct gas sensing). The initial focus will be to determine the best trade-off architecture, in terms of nonlinear enhancement, dispersion engineering, coupling strategy and loss reduction.

**Our second objective** is to demonstrate an on-chip dual-comb spectrometer operating in the mid-IR. We will aim at demonstrating the usefulness of these compact spectrometers for sensing applications such as pollution monitoring, breath analysis.


**Industrial partner**

**Does the project involve a French industry partner?** Yes

**Name**: Thales

**Role of the industrial partner in the internship project**: collaborators
### Main contact
[Insert here]

### Email
[Insert here]

### Main contact industrial partner’s branch in Australia
[Insert here]

### Email
[Insert here]

#### Australian partner

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<thead>
<tr>
<th>Question</th>
<th>Answer</th>
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<tbody>
<tr>
<td>Is the internship project proposed in the framework of an existing collaboration with an Australian partner university?</td>
<td>Yes</td>
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<tr>
<td>Name of the Australian partner institution</td>
<td>RMIT</td>
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<tr>
<td>Lab/department/team involved in the collaboration</td>
<td>InPaC</td>
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<tr>
<td>Main contact in the Australian partner institution</td>
<td>Arnan Mitchell</td>
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<td>Email</td>
<td><a href="mailto:arnan.mitchell@rmit.edu.au">arnan.mitchell@rmit.edu.au</a></td>
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#### Outside of this ongoing collaboration, will students from other Australian universities be considered by the hosting institution in France?

Yes

### Expected profile of applicant

#### Level of study
Master

#### Discipline
Photonics

#### Prerequisite knowledge, qualities and skills
The required skills for the intern will be a good knowledge and a solid background in the field of optics, nonlinear optics, solid-state physics, and semiconductor devices. S/he should work towards one of these areas. An experience in photonics, clean-room fabrication, material deposition or optical modeling and characterization will be strongly appreciated.

#### Other specific eligibility criteria
[Insert citizenship requirements, language requirements or other preferences here]