PhD position on integrated optics/silicon photonics

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Quantum cascade laser integrated on Ge-based photonics circuits

Mid-infrared (mid-IR) integrated photonics (i.e. with 2µm<λ<20µm) is actually a subject of increased emphasis, with a strong potential to revolutionize different application fields. As an example mid IR spectroscopy is a nearly universal way to identify chemical and biological substances, as most of the molecules have their vibrational and rotational resonances in this wavelength range. Commercially available mid-IR systems are based on bulky and expensive equipment, while lots of efforts are now devoted to the reduction of their size down to chip-scale dimensions. The demonstration of mid-IR photonic circuits on silicon chips would benefit from reliable and high-volume fabrication to offer high performance, low cost, compact, low weight and power consumption photonic circuits, which is particularly interesting for mid-IR spectroscopic sensing systems that need to be portable and low cost.

A key point for the development of applications for mid-IR integrated photonics **is the coupling of mid-IR light source with photonic integrated circuits.** In this context, the ANR project LIGHT UP project addresses the integration of an InAs/AlSb – based Quantum Cascade Laser (QCL) on a mid-InfraRed Germanium (Ge)-based photonics integrated circuit. The groundbreaking concept of the project is the direct growth of QCL devices on the Ge-based photonics circuit, to enable large-volume, wafer-level mid-IR photonic platform. The QCL active region and the SiGe waveguide will be specifically designed to optimize both the coupling strategy and the material properties, i.e., to preserve low optical losses and large optical gain.

In this context, the objective of the PhD project **is to work on the design, fabrication and characterization of the QCL integrated on SiGe waveguide.** The research activity will include:

- **theoretical study and optical simulations** (using commercial software) to optimize the light coupling from QCL active region to SiGe waveguide.

- **definition of a fabrication process flow** compatible with both the QCL and SiGe waveguide fabrication, as well as mask designs, and **clean-room fabrication**.

- **experimental characterizations** of passive and active devices within mid-IR optical bench developed in the group

The work is done in the framework of the ANR LIGHT UP, in a strong collaboration with IES (Université de Montpellier) and L-Ness lab (Politecnico di Milano).

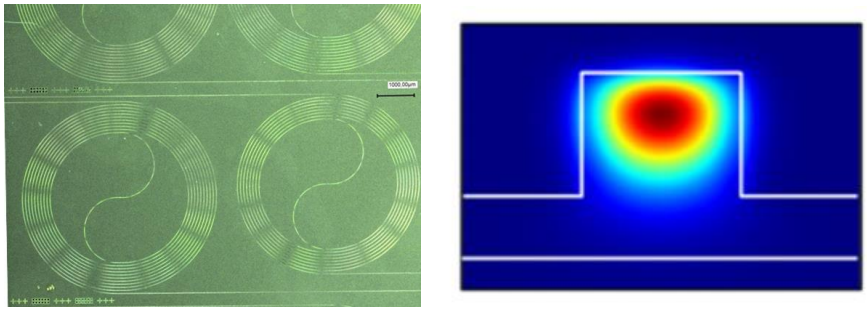

Fig. 1: left: picture of integrated mid-IR photonic integrated circuit based on Ge-rich SiGe platform / right: optical mode calculation showing the strong confinement of light in the core of a graded waveguide.

VALUED QUALITIES IN THE STUDENT

- Curiosity for novel research experiences and fields.

- Creativity and pro-activity in the search for innovative solutions and approaches.

- Capability to communicate and share results in a multidisciplinary and multi-nationality environment.

BIBLIOGRAPHY RELATED TO THE TOPIC

D. Marris-Morini, V. Vakarin, J-M. Ramirez, Q. Liu, A. Ballabio, J. Frigerio, M. Montesinos, C. Alonso-Ramos, X. Le Roux, S. Serna, D. Benedikovic, D. Chrastina, L. Vivien and G. Isella,
Germanium-based integrated photonics from near- to mid-infrared applications
Nanophotonics, (2018) invited review paper.

https://doi.org/10.1515/nanoph-2018-0113

J.M. Ramirez, Q. Liu, V. Vakarin, J. Frigerio, A. Ballabio, X. Le Roux, D. Bouville, L. Vivien, G. Isella, D. Marris-Morini
Graded SiGe waveguides with broadband low loss propagation in the mid infrared
Optics Express, 26 (2), 870, (2018)

https://doi.org/10.1364/OE.26.000870

Hoang Nguyen-Van, Alexei N. Baranov, Zeineb Loghmari, Laurent Cerutti, Jean-Baptiste Rodriguez, Julie Tournet, Gregoire Narcy, Guilhem Boissier, Gilles Patriarche, Michael Bahriz, Eric Tournié & Roland Teissier,

Quantum cascade lasers grown on silicon,

Scientific Reports 8,7206, (2018).

https://www.nature.com/articles/s41598-018-24723-2