Master 2/3rd year engineer internship topic (2019)

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" Silicon-rich nanobeam cavities for on chip Four Wave Mixing in silicon photonics"

Research project description:

Integrated photonics has developed a lot in recent years in several directions. One of the major axes developed was the development of the **silicon photonics platform**, which paved the way for the possible co-integration of electronic (eg CMOS circuits) and optical functions on integrated semiconductor chips. The various applications that have been addressed have aimed to solve problems of evolution of microelectronic circuits (especially the increase in information rates, management of thermal dissipation), the realization of receivers in the optical telecommunications band (1.3µm-1.55µm wavelengths), and that of optical sensors. Passive optical functions (waveguides, junctions, dividers, multiplexers) and active optical functions (photodetectors, modulators) have been successfully developed.
More recently, new directions have developed that differ in several respects from the previous period. The integration of non-linear functions has developed because of its extraordinary potential for all-optical signal-on-chip processing [2]. The addressed wavelength window has been extended to the mid-infrared range (2µm-8µm, even 2µm-16µm) due to the very rich metrological applications available in this range (detection of many vibrational molecule resonances for gas detection, food survey, military applications, etc) [3]. As silicon remains the overall integration platform of choice, epitaxy hybridization approaches (GeSi, III/V on silicon), 2D material deposition (graphene, MoS2), or thin film deposition (Si_3N_4, silicon-rich, chalcogenides, etc) have been proposed. These different ways of optical integration on silicon for the realization of nonlinear functions, which are in competition, are currently being actively explored for application in the near and mid infrared.

In this context, our group is interested in the **use of Four Wave Mixing (FWM) processes** by the use of third order non-linear optical effects for on-chip wavelength conversion and parametric amplification in the telecommunication waveband. **The objective of the internship** is to **investigate a family of photonic cavities obtained by coupling Silicon-rich nitride waveguide optical structures, and then to study their linear and nonlinear optical properties.** Coupling three cavities enables to realize a "photonic molecule" of three states that is precisely the desired device for the enhancement of the three pump, signal, and idler wavelengths of FWM processes. The recruited student will achieve electromagnetic and optical simulation to design the structure, will participate to the design of the masks for the fabrication of structures, and to the optical characterizations in the near infra-red using both linear and nonlinear setups.
We mention that this work is achieved in collaboration with the Southampton university from UK which will be in charge of the sample fabrication using clean room fabrication processes.

BIBLIOGRAPHY:

1) "Nonlinear silicon photonics", J. Leuthold, C. Koos, and W. Freude, **Nature Photonics 4, 535 - 544 (2010).**

2) "Roadmap on silicon photonics", David Thomson, Aaron Zilkie, John E Bowers, Tin Komljenovic, Graham T Reed, Laurent Vivien, Delphine Marris-Morini, Eric Cassan, Léopold Virot, Jean-Marc Fédéli, Jean-Michel Hartmann, Jens H Schmid, Dan-Xia Xu, Frédéric Boeuf, Peter O'Brien, Goran Z Mashanovich, M Nedeljkovic, **Journal of Optics, Volume 18, Number 7 (2016).**

3) "Ultrahigh-Q photonic crystal cavities in silicon rich nitride", K. Debnath et al., Optics Express 25 (22), 27334-27340 (2017.

Send an email to eric.cassan@u-psud.fr if you are interested in these papers.

We expect you to have:
- Enthusiasm and involvement
- Taste for electromagnetism&optics
- Ability to communicate and work in a group of about 15 people (4 researchers/teacher-researchers, and arund 10-12 post-doc fellows and doctoral candidates)