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

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" Si_3N_4 on SiO_2 and chalcogenide on Si photonic resonators for frequency comb generation"

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 **generation of optical frequency combs** by the use of third order non-linear optical effects. Optical frequency combs indeed emerge as a very promising approach enabling highly sensitive on-chip spectroscopy with a high resolution. **The objective of the internship** is to **carry out the most complete state of the art possible** of the solutions already proposed in silicon photonics in the broad sense (i.e. taking into account the hybrid platforms: III/V on Si, Si_3N_4 on SiO_2, chalcogenides on Si, etc.) **and to design structures** exploiting the materials and technological processes accessible to our research group. Through several collaborations with STMicroelectronics (France) and MIT (USA), our team has access to technologies for the realization of Si_3N_4 and chalcogenides waveguides on silicon. The design of structures for the generation of frequency combs using these two approaches will therefore be favored. **In a complementary way, the recruited student will participate in non-linear optical characterizations of the samples** available at the time of the internship.

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) "Kerr optical frequency combs: theory, applications and perspectives", Y. K. Chembo, **Nanophotonics 5(2), 214-230 (2016).**

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
- Taste for simulation (python, electromagnetic softwares)
- 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)