Spécialité de Master « Optique, Matière, Paris »

Stage de recherche (4 mois minimum, à partir de début mars)

Proposition de stage (ne pas dépasser 1 page)

Date de la proposition :

Responsable du stage */ internship supervisor*:

Nom / *name*: CASSAN   Prénom/ *first name* : Eric

Tél : 01 69 15 78 52   Fax :

Courriel */ mail*: eric.cassan@u-psud.fr

Nom du Laboratoire :

Code d'identification : UMR 9001   Organisme : CNRS / UPSud

Site Internet / *web site*: http://silicon-photonics.ief.u-psud.fr/

Adresse / *address:* Rue de la Vauve, Palaiseau

Lieu du stage / *internship place*: C2N site Palaiseau (quartier IOGS/Polytechnique/Danone/Horiba)

Titre du stage / *internship title* : **Nonlinear pulse propagation in photonic integrated waveguides: modelling and application to supercontinuum generation**

Résumé / ***summary***

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 (Si3N4, 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 supercontinuum, i. e. the generation of a broad spectrum optical source by the use of third order non-linear optical effects. This theme, which is a key area for the realization of multiple spectral sources by generating a supercontinuum and multiple filtering, has a very rich potential for application in optical metrology on a chip. To make concrete progress in this direction, a good understanding of the physical effects present in the materials and a judicious design of the guiding structures (dilution of optical power along the propagation, realization of phase agreements, etc) are necessary.

The proposed internship aims to actively contribute to this research theme. The aim will be to learn about the state of the art, to synthesize it, and to get involved in the development of models to simulate the non-linear propagation of waveguide waves. The recruited student will use a software to simulate the non-linear Schrödinger equation (python code), adapt it to several geometries of hybrid waveguides on silicon, and seek to optimize the design of photonic structures and circuits for supercontinuum on-chip generation. Through several collaborations with STMicroelectronics (France) and MIT (USA), our research group has access to technologies for the realization of Si3N4 and chalcogenides waveguides on silicon. In a complementary way, the recruited student will participate in non-linear optical characterizations of the samples available at the time of the internship and will compare the results of his/her model with the experimental results.

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) "Octave-spanning coherent supercontinuum generation in a silicon nitride waveguide", Adrea R. Johnson, Aline S. Mayer, Alexander Klenner, Kevin Luke, Erin S. Lamb, Michael R. E. Lamont, Chaitanya Joshi, Yoshitomo Okawachi, Frank W. Wise, Michal Lipson, Ursula Keller, and Alexander L. Gaeta, Optics Letters Vol. 40, Issue 21, pp. 5117-5120 (2015)

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)

Ce stage pourra-t-il se prolonger en thèse ? *Possibility of a PhD* **? : OUI**

Si oui, financement de thèse envisagé/ *financial support for the PhD*: **Convention industrielle ou ED**

Lumière, Matière, Interactions	**oui**	Lasers, Optique, Matière	**oui**