Master 2/3rd year Engineer internship topic (2023)

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"Reverse design methodology to control nonlinear optical effects on a chip"

Research project description:

Silicon photonics is a key field that has developed considerably in recent years [1]. For many applications, an important tool in the **panel of possible physical effects** consists of exploiting **non-linear phenomena**, for example of the third order, which can be applied to the realization of optical sources for a broad set of applications [2]. The dynamics of these effects is yet intrinsically difficult to control. Indeed, the cascade of nonlinear optical processes (Kerr broadening, effects of free carriers, solitons, etc) that can occur often depends on a competition between them, which itself depends on the input light source pulse properties as well as on the dispersion regime of the optical waveguides.

In this context, there is clearly a **need to develop approaches for a reverse design methodology to control nonlinear effects on a chip**. The objective of this internship is to study the propagation of optical beams in guided optics in two or three model configurations at most, in order to deeply understand their physical mechanisms. In a second step, it is a matter of **proposing and exploring appropriate methods for the design of waveguiding structures responding to a targeted nonlinear function (inverse design)**. The first configuration chosen will be that of **supercontinuum generation** (see **Fig. 1**) by injecting a short and high peak power pump beam into a waveguide. Analytical and/or numerical approaches will be proposed and studied.

Depending on the progress, the student recruited will be involved in the design of the mask sets useful for the exposure of structures by electron lithography, and will follow the fabrication steps of structures at the C2N clean room, then will characterize them optically at the Minaphot research group labs.

https://minaphot.c2n.universite-paris-saclay.fr

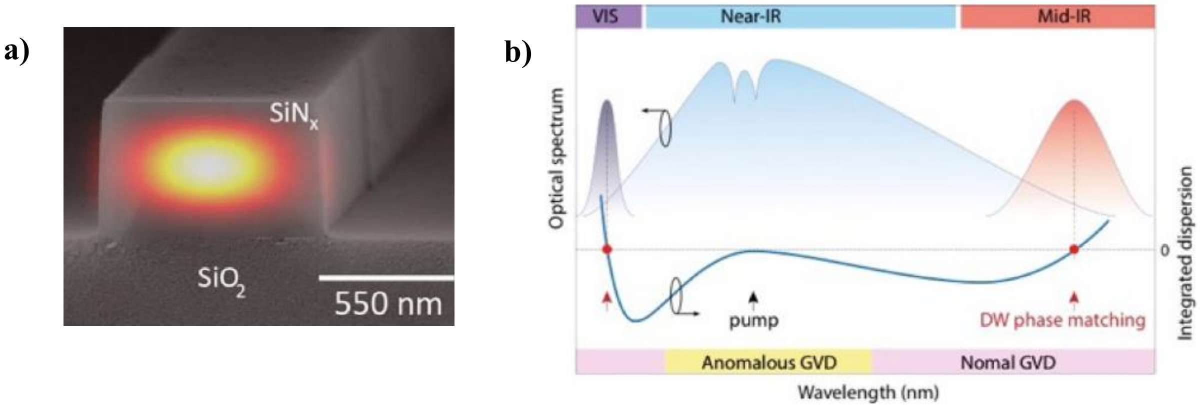

Fig. 1: **a)** Strong optical confinement in a $SiNx/SiO_2$ waveguide; **b)** Principle of the supercontinuum generation process seen in the frequency domain.

References:

[1] **"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, et al.
Journal of Optics, vol. 18 (7), 73003 (2016)

[2] **"Nonlinear silicon photonics"**
J. Leuthold, C. Koos, W. Freude
Nature Photonics, vol. 4, 535 (2010)