**Centre de Nanosciences et de Nanotechnologies**

# Soutenance de thèse

**Vendredi 24 septembre**
**14h00**
**Centre de Nanosciences et de Nanotechnologies**
**10 boulevard Thomas Gobert**
**91120 Palaiseau**
**Amphithéâtre**

## Christian LAFFORGUE

## “ Nonlinear optics for silicon photonics”

Lien public :
https://us02web.zoom.us/j/87102803431?pwd=T0cxTVVlQUltWGJOOTBTcUNWUzd5UT09

**Jury members :**

Camille-Sophie Brès, Associate professor, EPFL : Rapporteure, examinatrice
Arnaud Mussot, Professeur des universités, Université de Lille : Rapporteur, examinateur
Béatrice Dagens, Directrice de recherche,C2N : Examinateur
Bart Kuyken, Associate professeur, Université de Ghent : Examinateur
Thibaut Sylvestre, Directeur de recherche, Université Bourgigne Franche-Comté : Examinateur
Sébastien Tanzilli, Directeur de recherche, Université Côte d'Azur : Examinateur
Quentin Wilmart, Ingénieur chercheur, CEA LETI : Invité
Laurent Vivien, Directeur de recherche, Université Paris-Saclay : Directeur de thèse

**Abstract :**
Nowadays, communication networks are becoming more and more important, with the massive emergence of social networks, "streaming" platforms, or even the "Internet of things" for example. In this context where the demand in terms of communications continues to grow, it is necessary to find new technological solutions to overcome the limitations posed by current systems. The emergence of silicon photonics meets all the requirements relating to these needs: this technology allows the creation of ultra-fast communication systems (thus making it possible to transmit more data on the same channel) and reduces the energy consumption of the components of the entire transmission chain. In addition, the use of silicon as the basis for these new systems makes it possible to take advantage of the great maturity of manufacturing processes already established in the microelectronics industry. During my thesis work, I dedicated my efforts to the exploration of nonlinear optical effects in photonic components compatible with silicon technology. The first objective was to study the possibility of exploiting Pockels effect (a second order nonlinear effect) in silicon to produce ultra-fast and power-efficient electro-optical modulators. Due to the centro-symmetry of the crystal lattice of silicon, this effect is absent in this material. The solution envisaged in this work is to apply a stress on the waveguide in order to deform it and therefore break the crystalline symmetry. Thus, Pockels effect becomes theoretically possible. Modulation experiments in static regime as well as in hyper-frequency regime were carried out. The results show the difficulty of separating the different effects responsible for the observed electro-optical modulation. Indeed, semiconductor effects behave similarly to the Pockels effect, making interpretation of experimental results particularly difficult. Numerical models were set up to establish the contribution of each effect in the electro-optical modulation results.
The second axis approached in my thesis concerned the realization of broadband light sources that can work in classic telecommunication windows. Silicon nitride waveguides (a material compatible with silicon technology) were excited with a pulsed laser. By the combination of nonlinear effects and dispersion during propagation, the initial spectrum of the source is drastically broadened, forming what is called a supercontinuum. This type of source is very interesting for producing broadband frequency combs, useful for advanced communication systems, but also in spectroscopy, in imaging, or for chemical and biological sensors for example. In my work, several platforms for manufacturing silicon nitride waveguides were studied. Each platform showed extremely low propagation losses, and their nonlinear properties are compared through pulsed laser light experiments. The generation of supercontinuum as well as two-photon absorption were analyzed in order to conclude on the nonlinear performances of these platforms.