Centre de Nanosciences et de Nanotechnologies

# Soutenance de thèse

**Lundi 27 septembre**
**10h00**
**Centre de Nanosciences et de Nanotechnologies**
**10 boulevard Thomas Gobert**
**91120 Palaiseau**
**Amphithéâtre**


## Delphin DODANE


## " mm-wave generation using optical phase-locked loops for 5G applications"

Lien public :
https://us02web.zoom.us/j/87121400526?pwd=NjBvSDRNV2xLWnhHSXVaVk5SUGM2Zz09

Passcode: 352864

**Jury members :**
Président : Riad Haidar, professeur chargé de cours, Onera, Supoptique, école Polytechnique
Rapportrice : Christelle Aupetit-Berthelemot, professeure, Université de Limoges, XLIM
Rapporteur : Jeremy Witzens, professeur, RWTH Aachen University
Examinateur : Cyril Renaud, professeur, University College London
Examinateur : Guang-hua Duan, docteur, 3SP Technologies
Directeur de thèse : Laurent Vivien, directeur de recherche, CNRS, C2N
Encadrant industriel : Jérôme Bourderionnet, docteur, Thales Research & Technology


**Abstract :**
One of the key technological issues in the development of future wireless communications network like 5G is the settlement of the new frequencies higher than the classical sub-6 GHz bands, and called millimeter waves (above 30 GHz). Indeed, current frequency bands are close to saturation due to a high number of users and mm-waves represent a very wide unused bandwidth available for 5G and beyond. However, at these frequencies, electronic sources are very expensive, have a high-power consumption and occupy a lot of space, which make them unsuitable for embedded and remote applications. As a replacement optical coherent technology is in first position due to its high compatibility with the already fibered network while requiring very few elements at remote sites, like antennas for instance. Furthermore, the maturity level reached by photonic integrated circuits is now at a decisive moment when they can be used massively within coherent transmission components. This being combined with a downscale of antenna size, due to lower wavelength in millimeter wave, allows new architectures to introduce beamforming and spatial division multiplexing to increase network fronthaul capacity.

Among all optically assisted millimeter wave generation methods the one we deal with in this work is optical phase-locked loop, which compatibility with standardized photonic integrated circuits is also investigated. The working principle relies on an electronic feedback loop making optical phase variations of two independent lasers correlated, and their resulting beat note being then artificially coherent. Thus, the latter is very easy to use in order operate optically assisted frequency up- and down-conversion of a millimeter wave signal. This method benefits from strong assets like its high available optical power and its flexibility toward complex photonics architectures which makes it very suitable to supply photonic integrated circuits dedicated to signal processing, as beamforming networks for instance.

In this work we developed an optical phase lock loop based on commercially available fibered components in order to demonstrate the viability of using semiconductor lasers for coherent applications. This loop has then be implemented in several transmission schemes in the K-band (20-30 GHz) for future 5G experiments, all within the blueSPACE European project. This has led us to investigate the effect of the loop phase noise on QAM modulation formats and OFDM method, both being standards for 5G and beyond. In parallel we designed an optical phase lock loop photonic integrated circuit, which fabrication has been subcontracted to a commercial indium phosphide foundry, in order to evaluate the maturity of the process towards high complexity devices. This semi-industrial approach is validated by state-of-the-art performances for that kind of circuits.