Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Mardi 16 juillet

14h00

Institut Photovoltaïque d'Île-de-France (IPVF)
30, Route départementale 128 91120 Palaiseau
Salle Amphithéâtre Edmond Becquerel

Qiankun LIU

"SiGe photonic integrated circuits for mid-infrared sensing applications"

Jury members:

Delphine MARRIS-MORINI	Professeur	Université Paris-Sud	Directeur de thèse
Gunther ROELKENS	Professeur	Ghent University	Rapporteur
Roland TEISSIER	Directeur de Recherche	Institut d'Electronique et des Systèmes	Rapporteur
Maria TCHERNYCHEVA	Directeur de Recherche	CNRS	Examinateur
Sergio NICOLETTI	Ingénieur	CEA Leti	Examinateur
Joan Manel RAMIREZ	Ingénieur	III-V Lab	Examinateur

Abstract :

Mid-infrared (mid-IR) spectroscopy is a nearly universal way to identify chemical and biological substances, as most of the molecules have their vibrational and rotational resonances in the mid-IR wavelength range. Commercially available mid-IR systems are based on bulky and expensive equipment, while lots of efforts are now devoted to the reduction of their size down to chip-scale dimensions. The use of silicon photonics for the demonstration of mid-IR photonic circuits will benefit from reliable and high-volume fabrication to offer high performance, low cost, compact, lightweight and power consumption photonic circuits, which is particularly interesting for mid-IR spectroscopic sensing systems that need to be portable and low cost. Among the different materials available in silicon photonics, Germanium (Ge) and Silicon-Germanium (SiGe) alloys with a high Ge concentration are particularly interesting because of the wide transparency window of Ge up to 15 µm.
In this context, the objective of this thesis is to investigate a new Ge-rich graded SiGe platform for mid-IR photonic circuits. Such new plateform was expected to benefit from a wide transparency wavelength range and a high versatility in terms of optical engineering (effective index, dispersion, …).
During this thesis, different waveguides platforms based on different graded profiles have been investigated. First it has been shown that waveguides with low optical losses of less than 3 dB/cm can be obtained in a wide wavelength range, from 5.5 to 8.5 µm. A proof of concept of sensing based on the absorption of the evanescent component of the optical mode has then been demonstrated. Finally, elementary building blocs have been investigated. The first Bragg mirror-based Fabry Perot cavities and racetrack resonators have been demonstrated around 8 µm wavelength. A broadband dual-polarization MIR integrated spatial heterodyne Fourier-Transform spectrometer has also been obtained. All these results rely on material and device design, clean-room fabrication and experimental characterization. This work was done in the Framework of EU project INsPIRE in collaboration with Pr. Giovanni Isella from Politecnico Di Milano.