Centre de Nanosciences et de Nanotechnologies

Soutenance de thèse

Vendredi 1 avril
14h00
Centre de Nanosciences et de Nanotechnologies
10 boulevard Thomas Gobert
91120 Palaiseau
Amphithéâtre

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"New concepts for the development of polaritonic emitters in the mid-IR and THz range"

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Abstract :

The mid-infrared and terahetz bands of the electromagnetic spectrum have seen significant growth in applications in recent years, both in telecommunications and in the environmental and medical sciences.This interest is driving the demand for ever more compact and efficient sources and detectors. In this context, the development of coherent photon sources using the strong light-matter coupling regime is a promising avenue. Two axes of study of such sources will be explored in this thesis. First, a new approach to obtain mid-infrared photon emission through resonant optical pumping of intersubband polaritons was studied.

This type of spontaneous emission is based on the use of non-dispersive cavities, allowing in principle to increase the phonon-polariton scattering rate and thus to reach more easily the threshold intensity of the coherent emission. The demonstration of photon emission in this configuration opens up the possibility of exploring this emission in a stimulated scattering regime by populating the final state of the system with a probe beam.

In a second step, the focus will be on the THz domain. In order to overcome the thermal limitation imposed by the low energy of THz transitions, interdigitated parabolic quantum wells can be used to obtain resonant absorption up to 300K.To overcome the broadening introduced by multiple interfaces, alloy gradient wells were developed in collaboration with the University of Waterloo, Canada. This design resulted in very high quality THz transitions and an improvement in the operating temperature of the strong coupling regime by 170K. A particularity of intersubband polaritons is the possibility to obtain a high coupling constant through doping of the semiconductor. Consequently, these polaritons have been a platform of choice for demonstrating the ultra-strong coupling regime, in which the fundamental level of the system is populated by a non-negligible population of virtual photons. Theoretical studies have predicted that a non-adiabatic modulation of the ground state of the system, i.e. on a time scale smaller than the lifetime of the polaritons, this pool of light can be accessed. It is then possible to see these virtual photons being emitted as real photons. To explore this effect, three-dimensional LC cavities have been functionalised to achieve ultra-fast switching of their resonant frequency.

Their development and characterisation by time-resolved THz spectroscopy will be presented.

By using low temperature epitaxial GaAs, sub-picosecond modulation times have been achieved.

Finally, the combination of these ultrafast switches with parabolic graded alloy quantum wells has allowed the achievement of a strong light-matter coupling regime between them.

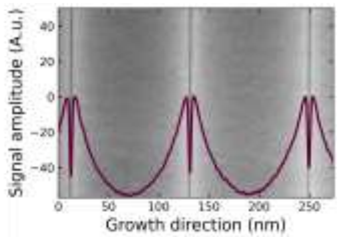

Figure 1: SEM image of a 3D LC resonator with parabolic quantum well active region in the patch. Figure 2: STEM image of a continuously graded parabolic quantum well. Overlay alloy profile extracted from the STEM signal amplitude.