Soutenance de thèse

Vendredi 5 Avril

14h, Amphithéâtre C2N

Developing a slow-mode nanophotonic platform for strong interaction between cold Rb atoms and guided photons

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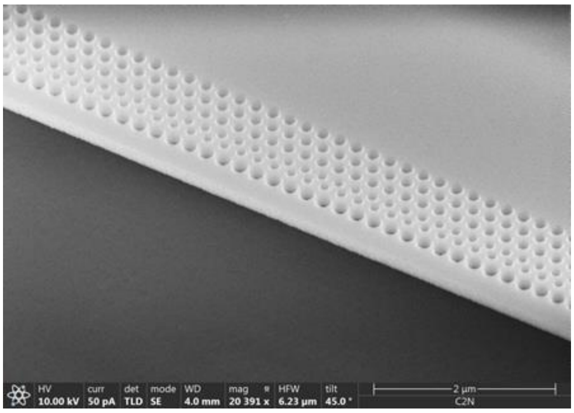
Abstract :

Light-matter interaction at the single-quanta level is the keystone of quantum information science. However, single quanta are generally weakly interacting and enhancing this coupling has been the driving force for a large community and the development of the cavity quantum electrodynamics (CQED), where single atoms and single photons can be strongly coupled via a high-finesse cavity. Very recently, integrated photonic nanostructures appeared as a promising avenue of tailoring light-matter interaction by engineering the emitter environment. Modern nanofabrication techniques have enabled the design of solid-state systems with embedded emitters, such as quantum dots in photonic crystal waveguides or nanocavities with high-quality factors, leading to Quantum Nanophotonics. In this context, we explore the waveguide QED approach by trapping atoms close to photonic crystal waveguides exhibiting slowly propagating modes, reaching strong interaction without a cavity.



Suspended slow mode Half W1 photonic crystal waveguide fabricated in GaInP during the thesis.

This thesis presents the results of PhD research on the design, fabrication, and first optical characterization of GaInP-based slow-mode nanophotonic waveguides intended for the strong interaction of guided photons with the D_2 transition (780 nm) of 87Rb atoms The approach involves coupling atoms to the guided mode of a waveguide, a concept referred to as Waveguide Quantum Electrodynamics (Waveguide QED). The selection of GaInP semiconductor material for the nanostructures is due to its wide electronic band gap below 1.85eV, which makes it transparent at the atomic resonance frequency. The photonic crystal waveguides were designed with dispersion engineering to achieve slow mode with high group indices (~30 - 50) around 780 nm. In the design, fabrication tolerance has been addressed by ensuring guided mode over a bandwidth of ~10 nm. The waveguides are intended to be suspended, allowing free space around their vicinity to facilitate the convenient transport of Rb atoms to their proximity and the easy coupling of light from an external laser source. Details on an optimized and reproducible nanofabrication process, as well as the encountered fabrication challenges and preliminary optical characterization of the waveguides, will be addressed during the PhD defense.