HIGH-PRESSURE INVESTIGATION OF WAVELENGTH-TUNEABLE NANOWIRE-BASED QUANTUM LIGHT SOURCES IN TELECOM BANDS

LABORATORY : Institut Lumière Matière
IN COOPERATION WITH : LN2- IRL 3463, Université de Sherbrooke

TEAM(S) : ENERGIE

CONTACT(S) : PISCHEDDA Vittoria

CONTACT(S) DETAILS: vittoria.pischedda[at]univ-lyon1.fr / Tel. 0472431402

KEYWORD(S) : high pressure / quantum dot-nanowires / telecom bands

SCIENTIFIC CONTEXT :

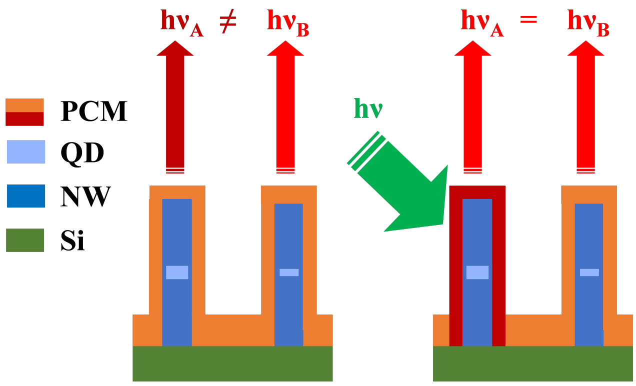

Fig.1. Schematic of single photon sources QD-NWs grown on Si and capped with an amorphous PCM.

Efficient non-classical light sources are a key element in quantum technologies such as quantum computing with single photons, quantum cryptography, quantum communication and networks. Ideally, these quantum sources should emit in the telecom bands, be integrated on chips, compatible with the silicon-on-insulator platform and the complementary metal-oxide semiconductor fabrication processes. Semiconductor quantum dot-nanowires (QD-NWs) fulfil all the requirements. However, one of the major bottlenecks, which prevent semiconductor QD from large-scale integration, resides in the fact that as they are formed via a self-assembled process, they never emit light exactly at the same wavelength. Ensuring uniform emission wavelengths is crucial for quantum devices utilizing flying qubits, such as optical quantum computers, long-range quantum communication, and quantum cryptography.

In this project we will study a wide-range wavelength-tuneable single photon sources (SPS) in the telecom band on silicon substrates. In particular hybrid nano-device with a core III-V semiconductor QD-NW embedded in a phase change material (PCM) shell. The central concept is to use the volume change associated to the crystallization of the PCM to strain the QD-NW and tune the QD emission energy (Figure 1).

MISSIONS :

The ANR project main objectives are : 1) demonstrating a wide-range wavelength tunability within the telecom bands(> 100 meV); 2) achieving in operando fine tuning at the single QD-NW level to reach a desired wavelength, 3) comprehensively elucidating the properties of these hybrid nanostructures. The PhD student will dedicate to the study of new synthesized QD-NWs under high pressure using a diamond anvil cell to extract key parameters such as the deformation potentials of these materials. These parameters are required to calculate accurately the QD shift. The student will also focus on the strain transfer between the PCM and NWs as a key parameter in the strategy of tuning the electronic properties of NW. She/he will use techniques such as in-situ Raman and photoluminescence spectroscopies. Complementary in-situ high pressure studies such as Extended X-ray Absorption Fine Structure (EXAFS) experiments will be performed using synchrotron sources to study the local structure evolution and determining asymmetry in the distribution of nearest atoms. The student will work in an interdisciplinary and international research environment including collaboration with Canada.

OUTLOOKS :

ANR Funded. Scheduled to start on October 2024, for a duration of 3 years

BIBLIOGRAPHY :

Jaffal, A. et al. Nanoscale 11, 21847-21855 (2019).