Wavelength-tunable single photon source in the telecom band

Highly efficient single photons sources emitting in the telecommunication bands will be key elements to enhance the capability of quantum communications.

Several approaches are currently being studied to generate single photons. In the *Institut des Nanotechnologies de Lyon* (INL – UMR CNRS 5270), we have a huge expertise in the field of nanowire-based telecom-band single photon sources. This source involves an InAs quantum dot (QD) embedded inside an InP nanowire (NW). The NW acts as a waveguide and allows a highly efficient and directional outcoupling of the photons emitted by the QD.

To be able to integrate a large number of quantum sources into a fiber-based quantum network, these sources will have to be wavelength-tunable. In this thesis, we plan to embed the semiconductor QD-NW inside a shell of a phase change material (PCM) in amorphous phase. Then, local heating will be used to progressively crystallize the amorphous PCM to strain the QD, modifying its emission energy. The use of a PCM guarantees the reversibility of the process.

In this thesis, the recruited PhD student will work on:

- The growth of InAs/InP quantum dot – nanowires by molecular beam epitaxy.
- The deposition of a PCM shell around the QD-NWs.
- The optical study by photoluminescence setups of this semiconductor-PCM hybrid nanostructure to quantify the impact of the PCM on the QD emission properties.

This work is built on existing expertise in the host laboratory on the growth and optical characterization of InAs/InP QD-NWs [i,ii,iii] and elaboration of PCM [iv,v].

The thesis is part of a project funded by the ANR (French National Research Agency), and will be hosted in the *Functional Materials and Nanostructures* team of the *Institut des Nanotechnologies de Lyon* (INL). The supervisory team will be composed of Dr. Nicolas Chauvin (CNRS researcher) and Dr. José Penuelas (Assistant Professor at EC Lyon), and the work will be assisted by other permanent researchers at the INL and the technical staff of the Nanolyon platform.

Expected Skills

The candidate should have a strong background in physics and a strong interest in semiconductor physics and/or experimental studies. Experience in epitaxy and/or in optical characterization/spectroscopy will be appreciated. She/he will have to demonstrate autonomy, quick assimilation and be capable of multinational teamwork requiring interactions in English.

Practical information

Candidates can submit their application (CV, university grades and cover letter) to Nicolas Chauvin (nicolas.chauvin@insa-lyon.fr) as soon as possible. The start date of the thesis is set for September 2024 (with a possibility of postponement depending on the circumstances) and lasts for 36 months.

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[i] « InAs quantum dot in a needlelike tapered InP nanowire: a telecom band single photon source monolithically grown on silicon », Jaffal, A. et al. Nanoscale 11, 21847-21855 (2019). https://hal.archives-ouvertes.fr/hal-02317732

[ii] « Density-controlled growth of vertical InP nanowires on Si(111) substrates », Jaffal, A., et al. Nanotechnology 31, 354003 (2020). https://hal.archives-ouvertes.fr/hal-02613439

[iii] « Highly linear polarized emission at telecom bands in InAs/InP quantum dot-nanowires by geometry tailoring », Jaffal, A. et al. Nanoscale 13, 16952-16958 (2021). https://hal.archives-ouvertes.fr/hal-03269925

[iv] « Reconfigurable Flat Optics with Programmable Reflection Amplitude Using Lithography-Free Phase-Change Materials Ultra-Thin Films », Cueff, S. et al. Advances Optical Materials 9, 2001291 (2021). https://hal.science/hal-03582587/

[v] « Ultimate phase sensitivity in surface plasmon resonance sensors by tuning critical coupling with phase change materials », Berguiga, L. et al. Optics Express 29, 42162-42175 (2021). https://hal.science/hal-03622148v1