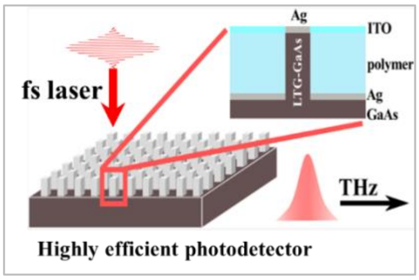
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2022-2023

Optoelectronic THz source for Solid-State Quantum Electronics

General Scope: The association of Terahertz (THz) optoelectronics and solid-state quantum electronic opens the way to a new branch of electronic quantum studies. Indeed, using femtosecond laser and ultrafast photodetectors allows for the generation of sub-picosecond, THz, electrical pulses that can be used to excite and coherently control single electrons propagating in a semiconductor-based quantum circuit. This allows for the measurement of fundamental properties of the electron wave-packet such as coherence length, velocity and damping. Moreover, the single electrons can also act as electronic flying qubits, and THz optoelectronic allows to perform quantum operations during their time of flight.
Such challenging physics relies on the development of smart electronic and optoelectronic circuits where both quantum electronics and ultrafast optoelectronic components are co-integrated. Among the different possible technologies, III-V semiconductor and especially GaAs allow for the fabrication of components with outstanding performances thanks to the very high electron mobility of 2D electron gases (AlGaAs/GaAs heterostructures) and the ultrafast carrier trapping time of Low Temperature Grown GaAs layers.
In order to keep the optical power budget as low as possible, it is mandatory to design very highly efficient THz photodetectors. For that, we have designed different nanophotonics detectors based on electromagnetic resonances (see figure). These structures have now to be investigated experimentally and optimized in order to render possible the optoelectronic excitation of single electrons and demonstrate in-flight manipulation of electronics flying qubits.



Research topic: The aim of the proposed M2 internship is to participate in the design, the fabrication and the test of an original optoelectronic component (see reference and figure) dedicated to the excitation of flying qubit using ultra-short single-electron charge pulses. The work will be done in close collaboration in between Institut Néel (fabrication of the device, time resolved quantum experiment) and IMEP-LAHC (design and test of the THz photodetector).

References:

- G. Georgiou, C. Geffroy, C. Bäuerle, and J.-F. Roux, ACS Photonics 2020 7 (6), 1444-1451 , https://arxiv.org/abs/2001.01341; Edlbauer et al., EPJ Quantum Technology 9: 21 (2022); in COLLECTION ON "QUANTUM INDUSTRY", REVIEW ARTICLE; https://doi.org/10.1140/epjqt/s40507-022-00139-w

Possible collaboration and networking: This project is part of the priority projects of the French National Strategy on Quantum Technologies. This project is realized in close collaboration in between the QuantECA team at Neel (C. Bäuerle), the THz group of IMEP-LaHC at USMB (J.F. Roux), and the theory group of CEA (X. Waintal).

Possible extension as a PhD: we are looking for a candidate who is motivated to pursue the M2 internship towards a PhD; (PhD fellowship can be obtained)

Required skills:
The candidate should have a good background in optics, electromagnetism and solid-state physics. Strong interest in experimental science is mandatory. Programming skills in Python would be a plus.

Starting date: open (preferentially beginning 2022)

Contacts:

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