PhD position (3 years) at CEA Grenoble, laboratory: PHELIQS

# Single-phonon quantum acoustics with a quantum dot - nanomechanical hybrid system

**Background.** Quantum hybrid optomechanical systems are composite devices, which couple an optically-active two-level system (qubit) to a mechanical resonator. Besides applications in sensing or in quantum information technologies, these devices have also been proposed to explore the quantum/classical boundaries, by coherently mapping non-classical states of the qubit onto the "macroscopic" resonator. Leveraging the assets of a hybrid system based on a semiconductor quantum dot (QD) that is strain-coupled to a vibrating microwire, the host team has already made pioneering contributions to the field [1-4]. However, the optical generation of long-lived quantum states of motion – a considerable challenge – calls for a new generation of devices, with massively improved performance.

**Project.** This PhD project proposes to demonstrate strain-mediated hybrid systems that operate deep in the quantum regime. To enable coherent optical manipulation, both the mechanical frequency and the coupling strength will be brought above the radiative decay rate of the QD (~160 MHz). Our strategy will be twofold: (a) Evolving the current generation of systems, in which a new electrostatic actuation technique (see figure, [5]) has recently revealed low-loss mechanical modes approaching the GHz limit. (b) Developing a new, ultra-low dissipation double cavity nanowire heterostructure operating in the 10 GHz range. The proposed device built on a recent proposal [6] that will be combined with a novel photonic structure concept for optimal light extraction [7]. As a first step into the realm of quantum acoustics, we will prepare single-phonon states. Thanks to a built-in phonon-photon transduction, the quantum nature of this mechanical state will be directly evidenced using established quantum optics techniques.

**Profile of the candidate.** The PhD candidate will be in charge of the optics experiments and their analysis. She/he will have a background in condensed matter physics and/or in quantum technologies as well as good communication skills and a taste for team work.

**Collaborators.** Néel Institute: O. Arcizet, B. Pigeau and J.-P. Poizat; Lumin: P. Verlot.

**Starting date and duration.** October 2023, 3 years duration.

**Host laboratory.** Quantum Photonics, Electronics and Engineering Laboratory (PHELIQS, website)

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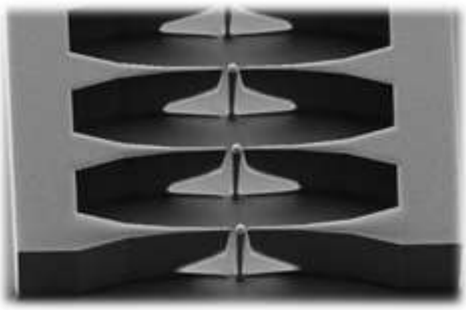

*20-µm-high conical microwires equipped with pairs of electrodes for the excitation of high-frequency vibration modes (SEM image).*

**References**

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[2] Munsch *et al.*, Nat. Communications **8**, 76 (2017).
[3] Artioli *et al.*, Phys. Rev. Lett. **123**, 247403 (2019).
[4] Kettler *et al.*, Nat. Nanotechnology **16**, 283 (2021).
[5] Finazzer *et al.*, to appear in Nano Letters (2023).
[6] Garcia-Sanchez *et al.*, Phys. Rev. A **94**, 033813 (2016).
[7] Kotal *et al.*, Appl. Phys. Lett. **118**, 194002 (2021).