Characterization of a soft-clamped membrane for quantum transducers

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Abstract: We present the mechanical characterization of a novel electro-optomechanical modulator, based on an ultra-high quality Si_3N_4 mechanical oscillator. This device constitutes the building block for an RF-to-Optical transducer in Quantum Technologies.

The transduction of quantum signals at different energy scales plays a crucial role in Quantum Technologies [1,2]. Since optical spectrum is well-suited for long-distance communication, while lower frequencies of the electromagnetic field prove advantageous for precise local quantum operations employing superconducting and other solid-state processors, achieving coherent conversion between optical and microwave/radiofrequency (Mw/RF) photons is one of the primary tasks of the realization of a quantum transducer.

In this talk we present a complete characterization of a nanomechanical oscillator, which might be used for the realization of a novel electro-opto-mechanical device that can be implemented for the sympathetic cooling of the LC circuit [3], and as building block of an RF/Mw-optical transducer [4]. The key element of the device is a mechanical resonator based on a metal coated (TiN) circular Si_3N_4 membrane, which is optically coupled by radiation pressure, and capacitively coupled to an electrical circuit by placing the metal coated membrane in front of two electrodes. Since a primary thermodynamical cooling of the device is employed for achieving a quantum regime, the quality factor of the mechanical oscillator has been characterized at room and cryogenic temperatures, as shown in Fig. 1, by means of homodyne detection and ring-down technique.

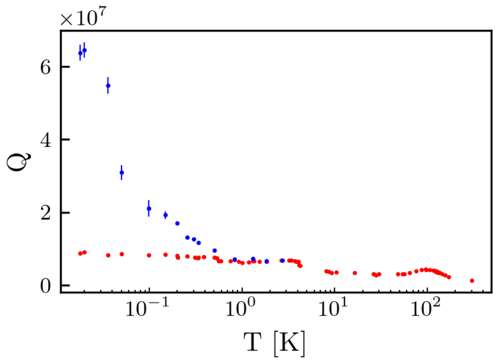

Fig. 1 Mechanical quality factor of the metalized membrane as a function of the temperature of the cryostat plate. The red circles show the quality factor measured by continuously reading out the motion of the membrane and the blue circles stand for stroboscopic readout.

For mechanical frequencies in the MHz range, a quality factor of 10^6 and over 6×10^7 at room temperature and below 100 mK, respectively, is measured by means of stroboscopic technique, which is necessary for avoiding any heating effect due to the probe beam. Moreover, the shift of the fundamental mode of the oscillator as a function of the potential difference between the device electrodes is reported as evidence of the presence of the electro-mechanical coupling.

References

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