

Radio frequency to optical transducer based on a soft-clamped membrane

F. Marzioni^{1,2}, G. Novelli¹, R. Natali^{1,2}, M. Bonaldi^{3,4}, A. Borrielli^{3,4}, E. Serra^{4,5}, B. Morana⁵,

F. Marin^{6,7,8}, F. Marino^{6,7}, N. Malossi^{1,2}, D. Vitali^{1,2,6}, G. Di Giuseppe^{1,2}, P. Piergentili^{1,2}

1. University of Camerino, School of Science and Technology, Section of Physics, Via Madonna delle Carceri 9b, 62032 Camerino (MC), Italy

2. INFN, Sezione di Perugia, 06123 Perugia (PG), Italy

3. Institute of Materials for Electronics and Magnetism, Nanoscience-Trento-FBK Division, 38123 Povo, TN, Italy

4. Istituto Nazionale di Fisica Nucleare, TIFPA, 38123 Povo, TN, Italy

5. Microelectronics Department, EEMCS Faculty, Delft University of Technology, 2628 CD Delft, The Netherlands

6. CNR-INO, L.go Enrico Fermi 6, 50125 Firenze (FI), Italy

7. INFN, Sezione di Firenze, Via Sansone 1, I-50019 Sesto Fiorentino, Italy

8. Dipartimento di Fisica e Astronomia, Università di Firenze, Via Sansone 1, I-50019 Sesto Fiorentino, Italy

Abstract: We present the characterization of an 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.

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, achieving coherent conversion between optical and microwave/radio frequency (mw/rf) photons is one of the primary tasks of a transducer.

In this talk we present a complete characterization of a nanomechanical oscillator, which might be used for the realization of a novel electro-optomechanical 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.

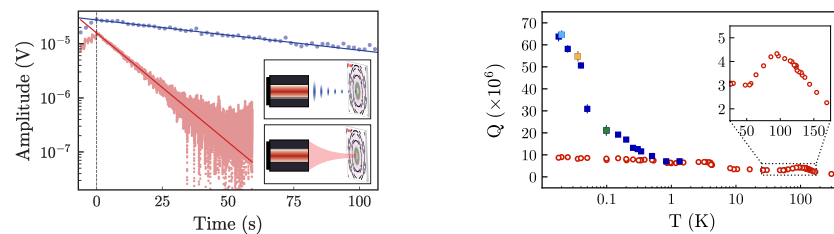


Fig. 1 Typical ring-down measurements at 20mK (left) and mechanical quality factor of the metalized membrane as a function of the temperature of the cryostat plate (right). The red circles show the quality factor measured by continuously reading out the motion of the membrane, while the blue markers 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 [5]. Moreover, the shift of the fundamental mode of the oscillator and the electro-mechanical induced transparency as a function of the potential difference between the device electrodes are reported as evidence of the presence of the electro-mechanical coupling.

References

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