Optical readout of coupling between a nanomembrane and an LC circuit at room temperature

Optical readout of coupling between a nanomembrane and an LC circuit at room temperature
Summary form only given. Opto- and electromechanical systems have separately shown great progress in reaching ultrasensitive displacement readout and manipulation of nano- and micromechanical resonators at the quantum level [1,2,3]. Besides that, combining optical and electrical degrees of freedom via a mechanical interface is of potential interest, as it would allow for low noise optical detection and laser cooling of weak electrical excitations. In a recent paper [4], a scheme was proposed for room temperature applications where a membrane converts rf electrical excitations in an LC circuit to optical excitations in a high finesse cavity. In this work, we have experimentally realized both optical and electrical detection of coupling in a room-temperature electromechanical system composed of an LC circuit and a 100-nm thick SiN nanomembrane coated by 50 nm Aluminum. We follow an approach similar to the one described in [4] (cf. Fig 1a): The displacement of the high Q membrane is capacitively coupled to a plate capacitor that is connected in parallel to a ferrite inductor. A change in capacitance alters the LC resonance frequency, thereby creating coupling between the membrane and the LC circuit. A DC bias voltage applied to the capacitor amplifies the coupling. We confirm two-way coupling by observing broadening in the membrane vibrations via optical readout (Doppler vibrometry, Fig. 1b) and an MIT (Mechanically Induced Transparency) dip in the electrical probe (Fig. 1c). The two different methods show fairly good agreement. We note that a similar phenomenon (EMIT) was reported recently in an electromechanical system [5], however at cryogenic temperatures with a superconducting circuit. At 60V DC bias voltage, we extract a promising cooperativity parameter (C) of around 50, corresponding to a coupling strength of roughly g/2π=1 kHz, whereas the LC decay rate is around 7 kHz. Our setup serves as a sensitive optical loudspeaker [4] for rf excitations circulating in the LC circuit which may eventually compete with cryogenic amplifiers. With an optimized design, strong electromechanical coupling is within reach. Furthermore the electromechanical part can be placed in an optical cavity for simultaneous readout and laser cooling of electrical excitations in an LC circuit.

General information
State: Published
Organisations: Department of Micro- and Nanotechnology, Nanoprobes, University of Copenhagen, National Institute of Standards and Technology
Contributors: Bagci, T., Simonsen, A., Zeuthen, E., Taylor, J. M., Villanueva Torrijo, L. G., Schmid, S., Sørensen, A., Schliesser, A., Usami, K., Polzik, E. S.
Number of pages: 1
Publication date: 2013

Host publication information
Keywords: Instrumentation, Atomic and Molecular Physics, and Optics
DOI: 10.1109/CLEOE-IQEC.2013.6801215
Source: FindIt
Source-ID: 2198993026
Research output: Research - peer-review » Conference abstract in proceedings – Annual report year: 2013