Optomechanical Dynamics of Resonant Microcavities

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In this work, we present a numerical method to show the optomechanical dynamics in resonant microcavities. A rigorous model is proposed to solve the electromagnetic/mechanical system. The model is tested by means of analysing optomechanical performance of a corrugated Si-based nanobeam.
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1. Introduction

In the recent years, the bridge between the high-Q optical cavities and mechanical systems attract immense attention due to the major practical development of on-chip photonic based phononic circuits [1-2]. The purpose of an optomechanical system is to study the interaction of light with a mechanical oscillator. Owing to its phonon generation and propagation, optomechanical resonator cavities offer attractive applications further to standard available technologies [3-4]. Moreover, optically propelled coherent phonons have been demonstrated up to few GHz in frequency range. Such a frequency spectrum provides a direct manipulation over radio-frequency (RF) signals. In this work, the microwave phonons behave as a surface acoustic waves (SAWs) mainly useful for sensing applications [5]. Exploiting the additional phonon degree of freedom will open new possibilities in scaling of RF devices. The high sensitivity of optomechanical cavity system to mechanical waves could be very useful for signal processing at micrometric scale, in the GHz range of frequencies, as well as modulation and conversion between microwaves and optics [6,7].

2. Theoretical background

Optomechanics is described by the fusion between the continuum mechanical physics and classical electrodynamics. The basics of this theory relies on the Brillouin scattering relation

$$\omega_1 = \omega_2 \pm \Omega; \qquad (1)$$

where Ω is the mechanical frequency and $\omega_{1,2}$ are the optical frequencies of two interacting light beams. The above relation expresses the exchange of energy between the electromagnetic radiation and the mechanical motion.

Table 1 Opto-mechanical Cavity

Parameter	Meaning	Values
Q_o	Optical QF	$\approx 10^4$
λ_o (nm)	Optical wavelength	[1530 - 1580]
Q_m	Mechanical QF	$[10^2\text{-}10^3]$
f_m (GHz)	Mechanical frequency	[1.9-2.1]

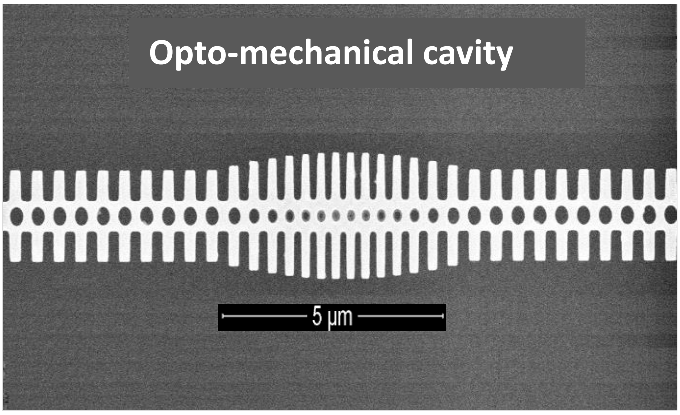

Fig. 1 Opto-mechanical cavity: silicon suspended beam of 200 nm thickness.

In this contribution, we perform rigorous full-wave simulation of EM and mechanical interaction, by means of multiphysics solvers. Specifically, the table 1 summarizes the quality factors (QF) of the optical and mechanical modes resonating in the cavity, laying in the respective considered frequency bands. Figure 1 shows the designed optomechanical cavity. Experimental characterization is currently in progress.

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