Self-sustained coherent phonon generation in optomechanical crystals

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Miniaturized self-sustained coherent phonon sources, also known as "phonon lasers", are interesting for applications such as mass-force sensing, intra-chip metrology and intra-chip time-keeping among others. We will review several mechanisms and techniques that can drive a mechanical mode into the lasing regime by exploiting the radiation pressure force in optomechanical cavities. We will specifically focus on a novel and efficient strategy for achieving the "phonon lasing" regime in optomechanical (OM) crystals [1] using the radiation pressure as the driving force of the motion. The mechanism is based on a self-pulsing limit cycle, which is a spontaneous process triggered within the optical cavity that modulate the intracavity radiation pressure force in resonance with a mechanical mode [2]. Self-sustained mechanical oscillations of modes up to 0,2 GHz are achieved if one of the low harmonics of the modulated force is resonant with a mechanical eigenstate (see Figure 1). We will discuss how it will be possible to further speeding up of the self-pulsing dynamics to reach the GHz regime, where the lack of good quality and miniaturized sources is a severe issue.

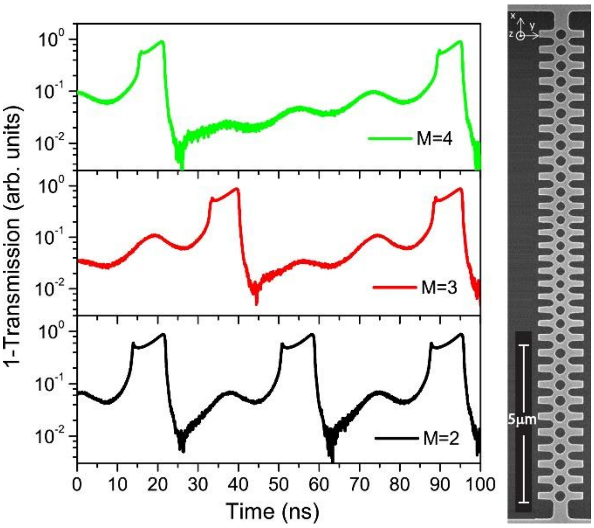

Figure 1. *Dynamic behavior of the inverted transmitted optical signal for three different values of the self-pulsing frequency. In the three cases, the self-pulsing is frequency-entrained with the coherent mechanical oscillation of a flexural mode at* Ω_m*=54 MHz, which was activated by the anharmonic modulation of the intracavity radiation pressure force. The bottom, medium and top panels correspond to M=2, M=3 and M=4 situations, M being the order of the harmonic used to pump the mechanics. The sinusoidal-like oscillations correspond to the mechanical coherent oscillation while the strongly asymmetric peaks are dominated by the self-pulsing. On the right, we show a SEM picture of one of our optomechanical crystals.*

References

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