Self-sustained oscillation in nano-spring coupled optomechanical oscillator

NTT ﾅﾉﾌｫﾄﾆｸｽｾﾝﾀ[1], NTT 物性基礎研[2] ○田 豊[1,2], 角倉 久史[1,2],
倉持 栄一[1,2], 谷山 秀昭[1,2], 滝口 雅人[1,2], 納富 雅也[1,2]

NTT NPC[1], NTT BRL[2] ○F. Tian[1,2], H. Sumikura[1,2], E. Kuramochi[1,2], H. Taniyama[1,2], M. Takiguchi[1,2], and M. Notomi[1,2]

E-mail: Feng.Tian@lab.ntt.co.jp

Nano-optomechanics, studying the interaction between light field and mechanical systems via radiation force, is an emerging field in physics [1]. Normally, optomechanical phenomena are studied by the deformations of photonic devices themselves [2]. Here, we report a optically-driven mechanical oscillator shown in Fig. 1(a), where one of the double-coupled nanobeam photonic crystal cavities (lower side of Fig. 1(a)) is coupled with a nano-spring (folded nanobeam structure). During oscillating, the relative motions between the coupled cavities periodically happen, and the motion can be propagated outside through the nano-spring, for example, to the other pair of coupled cavities in the upper side of Fig. 1(a). The continuous wave laser without modulation is adopted as pumping. We have demonstrated that the whole coupled system exhibits self-sustained oscillation by CW pumping, when the optomechanical gain from the nanobeam compensates the mechanical damping loss. This device can be hopefully applied as a modulation tool for integrated filter or emitter with separated pump cavities.

The nano-spring has a width of 300 nm and a length of 8.5 μm for each beam. The 2nd even mode of the coupled cavities with wavelength of 1571.24 nm and Q-factor of 8000, shown in Fig. 1(b), is selected for pumping. Pump wavelength is blue-detuned at 1571.1 nm for realizing the gain. When we pumped by a CW laser, we observed oscillating signals in the RF spectrum as shown in Fig. 1(c). The major peak frequency (6.32 MHz) agrees well with the common mechanical mode (simulated as 6.22 MHz) of this nano-spring coupled optomechanical oscillator (shown in the inset). In addition, we observed side-peaks separated from the major peak and its harmonics. The separation frequency is close to the differential mode of our oscillator (simulated as 1.32 MHz). This work was supported by JSPS KAKENHI Grant Number 15H05735. Reference 1) H. Rokhsari, T. J. Kippenberg et. al., IEEE J. Sel. Topics Quantum Electron. **12**, 96-107, 2006. 2) X. Luan, C. W. Wong et. al., Sci. Rep. **4**, 6842, 2014.

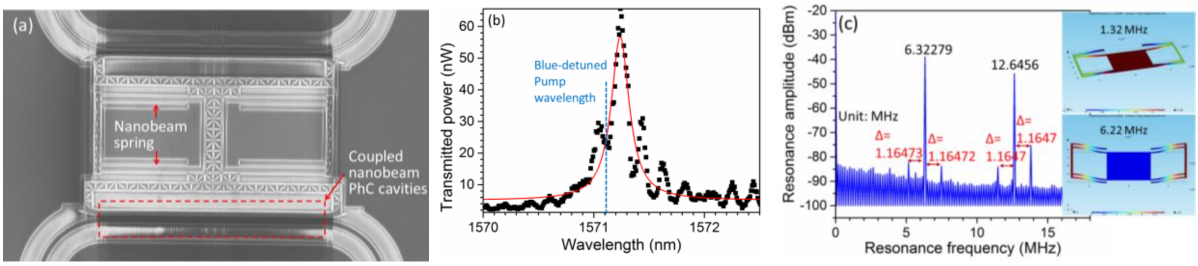

Fig.1 (a) SEM image of the device. (b) Optical transmission spectrum of selected pump mode. (c) mechanical RF spectrum with self-sustained oscillation signals.