Resonance frequency shift in a GaAs MEMS beam resonator induced by internal mode coupling

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Mode coupling effect in MEMS resonators is very attractive since it significantly modifies the performance of MEMS resonators. Previously, we have reported a giant enhancement in the thermal responsivity of the doubly clamped GaAs MEMS beam resonators by using the internal mode coupling effect[1,2], which indicates that the mode coupling effect is promising for realizing high-sensitivity thermal sensing, such as ultrasensitive terahertz (THz) detection at room temperature.

In this work, we have investigated the mode coupling effect by measuring the resonance frequency shift of a GaAs MEMS beam resonator when higher order resonance modes were excited[3]. Fig. 1(a) shows the measured resonance spectra for the first 6 modes by using a laser Doppler velocimeter. With a phase locked loop, the MEMS resonator was driven at the first bending mode in a self-sustained oscillation mode. Simultaneously we drove the MEMS resonator at the frequencies of higher resonance modes and measures the frequency shift of the self-sustained 1st bending mode. We have found that, when the higher modes were excited, the lower mode resonance frequency is significantly shifted, as shown in Fig. 1(b)-1(c), indicating that the higher mode is internally coupled with the first bending mode. In particular, a mode that has been barely shown any oscillation amplitude was detected by the frequency-shift scheme, as indicated by the arrows in Fig. 1(b), demonstrating the effectiveness of the mode coupling effect for detecting the higher resonance modes.

Ref. [1] Ya Zhang, et al., PR Applied 14, 014019 (2020). [2] Ya Zhang, et al., APEx 14, 014001 (2021).
[3] Atakan B. Arı, et al., PR Applied 9, 034024 (2018).

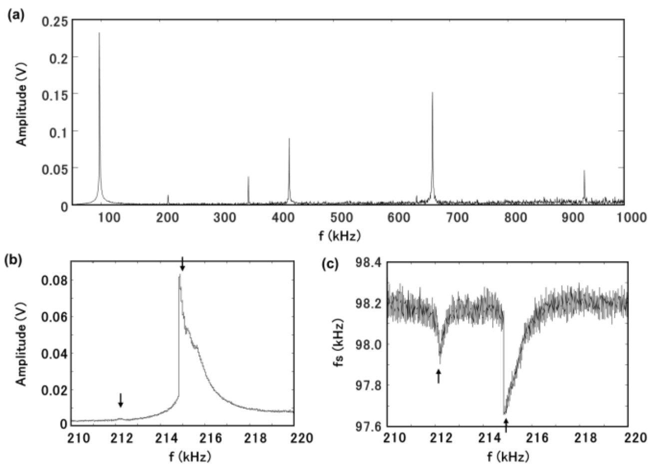

Fig.1 (a) Oscillation spectra of a GaAs MEMS beam resonator. (b)-(c) Oscillation amplitude spectra and resonance frequency shift of lower mode by driving the frequencies of higher resonance modes.