メッシュフォノニック構造を用いたテラヘルツ MEMS センサの熱感度の向上

Improvement of the thermal sensitivity of MEMS thermal sensors with mesh nanostructures

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In this study, we aim to improve the sensitivity of the MEMS bolometer by introducing a porous mesh phononic (PnC) structure into the beam of MEMS resonator[1-2]. The PnC has a low density and high phonon scattering rate, thus can significantly reduce the thermal conduction and improve the thermal sensitivity of the MEMS bolometer[3]. Figure 1(a) shows the fabricated PnC structure. A square mesh was drawn on the GaAs MEMS beam by electron beam lithography and through holes were formed by reactive ion beam etching. The size of the through-mesh holes is 1μm ×1μm. After that, the sacrificial layer was selectively removed by diluted HF, and the MEMS beam structure was released by supercritical drying.

The fabricated MEMS resonator was mechanically driven by a piezoelectric element, and the vibration signal was detected using a laser Doppler vibrometer and the resonance frequency was monitored with a phase locked loop. Then a modulated laser beam was used to heat up the MEMS beam at various heat frequencies, and the resonance frequency shift was plotted as a function of heat frequency, as shown in Fig. 1(b). We have determined the thermal decay times, and the thermal conductance of the MEMS beams with PnC structures, as shown in Fig. 1(c). We have found that the mesh PnC structure could significantly reduce the thermal conductance of the MEMS beam by over 90%, thus is very promising for realizing high sensitivity MEMS thermal sensors.

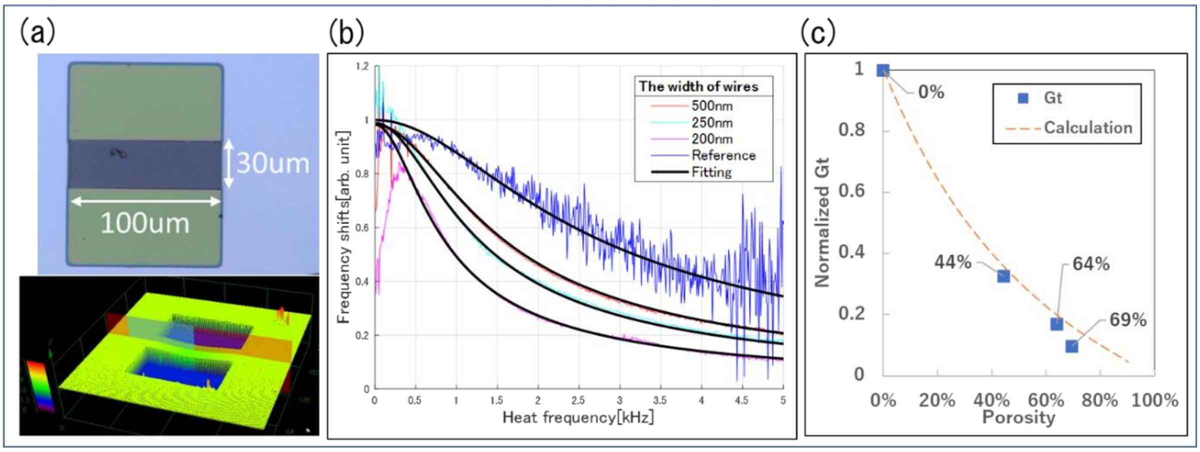

Fig. 1: (a) Microscope image of a fabricated MEMS beam with mesh PnC; (b) Resonance frequency shift as a function heat frequency. (c) Normalized thermal conductance as a function of porosities of PnC structures. The red dotted line shows the calculation result.

Reference
[1] Y. Zhang, et al., APL 108, 163503 (2016). [2] Y. Zhang, et al., JAP 125, 151602 (2019). [3] Y. Zhang, et al., AIP Advances 9, 085109 (2019).