Detecting sub-terahertz mechanical oscillations by a GaAs MEMS thermal sensor

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It has been known that phonon is responsible for the transmission of heat in solids. However, the phonon spectrum of the heat transport process has not been measured experimentally yet. The most related research is the coherent phonon spectroscopy by using pump-probe measurements. Local phonon modes were generated in thin film structure by femtosecond laser pulses and detected by a probe light. Although ultrafast phonon vibrations were observed, it is still not known that how these measured phonon modes carry heat.

In this research, we propose a novel method to perform phonon spectroscopy of the heat transport process. We illuminate a GaAs MEMS suspended beam structure with two light pulses from a femtosecond (fs) laser, as shown in Fig. 1(a). The generated phonons by the laser pulses propagate through the GaAs beam, and interfere with each other. We measure the phonon interference signal as the temperature rise on the beam by measuring the frequency shift of the MEMS resonator [1]. If coherent phonon transfers exist in the beam, the temperature rise will have a dependence on the time delay between two light pulses, showing a phonon interference pattern. By performing a Fourier transform for the interference signal, we will obtain the phononic spectrum of the heat transport process. Our preliminary result shows that the temperature rise increases when the two laser pulses have a zero time delay, as shown in Fig. 1(b), which is a typical feature of the phonon interference. The proposed method is very promising for realizing the ultra-fast phonon spectroscopy of heat transport process.

Ref. [1] Y. Zhang, Y. Watanabe, S. Hosono, Nagai, and K. Hirakawa, Appl. Phys. Lett. **108**, 163503 (2016).

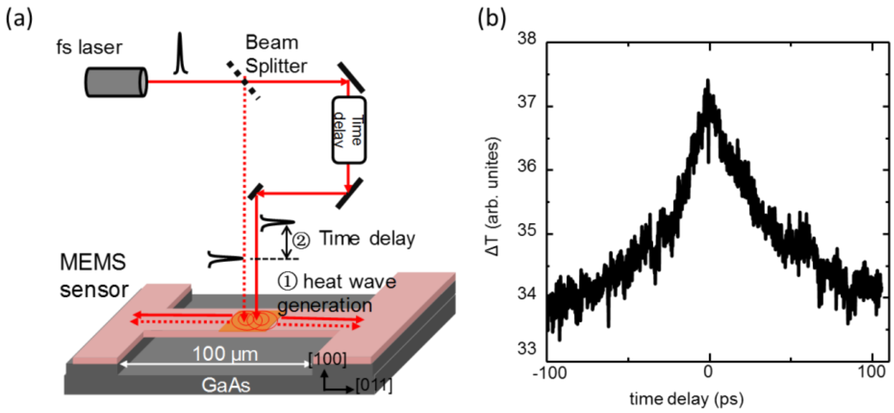

Fig.1 (a) Schematic diagram of phonon spectroscopy of the heat transport process by using fs laser heating and a MEMS thermal sensor. (b) The measured temperature rise on the beam as a function of the time delay between two fs laser pulses.