Room temperature, very sensitive terahertz bolometer using doubly clamped mechanical oscillators

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We have proposed room temperature, all electrical driving and detecting, sensitive terahertz (THz) bolometers using doubly clamped mechanical oscillators. We fabricated GaAs MEMS doubly clamped beam oscillators, which were excited and detected both by piezoelectric effect [1]. Fig. 1(a) shows an SEM image of a fabricated sample (120L×30W×1.5H μm^3), which has an oscillation frequency around 380 kHz with a Q-factor of about 3,000. When a heating power is applied to a NiCr film placed on the MEMS beam surface, an internal thermal stress is generated in the beam and decreases the oscillation frequency, as shown in Fig. 1(b)-1(c). The present device detects the shift in the resonance frequency caused by heating and works as a very sensitive bolometer . When the oscillator is driven slightly below the nonlinear regime for the mechanical oscillations, the bolometer shows a voltage responsivity > 3000 V/W, while keeping low noise spectral density of about 60 $nV/Hz^{-1/2}$, demonstrating a noise equivalent power (NEP) of about 20 $pW/Hz^{-1/2}$ even at room temperature, as shown in Fig. 2. Further improvement in NEP is expected by optimizing the sample structure.

[1] I. Mahboob and H. Yamaguchi, Nat. Nanotech., 3, 275 (2008) .

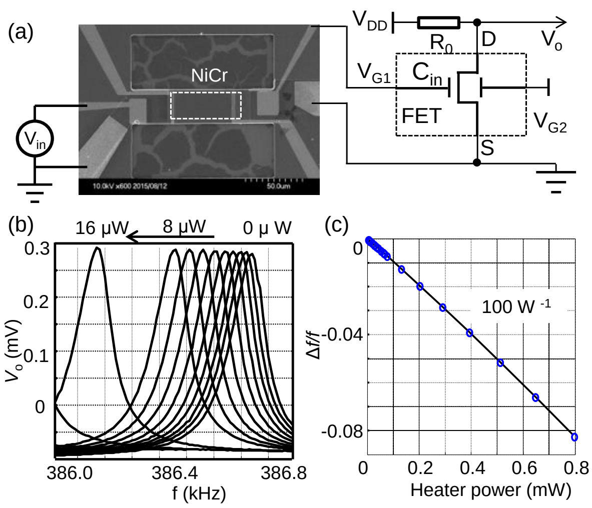

Fig.1 (a) Top view of a fabricated oscillator. (b) The shifts in the oscillation frequency with increasing heating power. (c) Normalized frequency shift plotted as a function of the heating power.

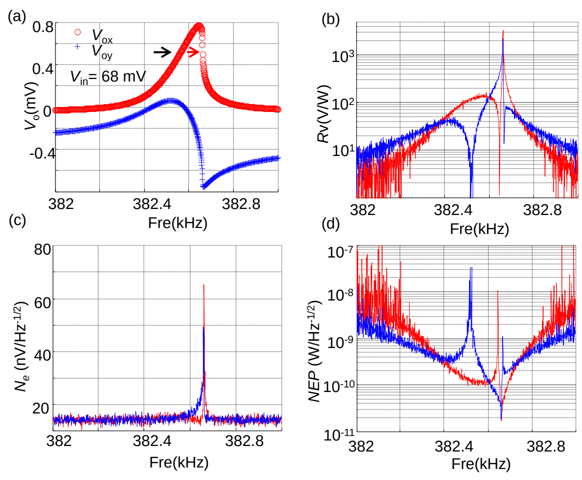

Fig.2 (a) Oscillation at the threshold amplitude. (b) Voltage responsivity as a function of the driving frequency. (c) Noise spectra at the threshold amplitude. (d) Obtained noise equivalent power (NEP) as a function of the driving frequency.