テラヘルツ帯 GaAs ベース MEMS ボロメータにおける梁部へのリン添加効果
Effect of introducing phosphorous in the GaAs-based terahertz MEMS bolometers

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Terahertz (THz) detector is one of the crucial components in the THz technologies. Recently, we reported an uncooled, all electrical driving and detecting, very sensitive thermometer using a GaAs doubly clamped microelectromechanical (MEMS) beam resonator for bolometer applications [1,2]. Fig. 1(a) shows schematic of the device. When the MEMS beam is heated by THz radiation, thermal expansion is induced in the MEMS beam and its resonance frequency decreases. The present device detects the frequency reduction induced by heating and works as a very sensitive thermometer. According to a simple theory, longer beams are expected to have higher thermal responsivities. However, we found that the measured responsivities of GaAs MEMS beam resonators deviates from theory due to initial deflection of the MEMS beams.

In this work, we have introduced a preloaded tensile strain in the MEMS beams in order to reduce the initial deflection of the beam. We use a lattice mismatch between GaAs and GaAsP. Fig. 1(b) shows the wafer structure. We have prepared samples with doubly clamped MEMS beam resonators by using GaAs and strained $GaAs_{1-x}P_x$ (x = 0.01) as the beam materials on GaAs substrates. Measured resonance frequencies of the samples of various beam lengths show a good agreement with theoretical expectation (Fig. 1(c)). This indicates that, by using the GaAsP beam structure, we have successfully applied a tensile strain in the MEMS beam. Fig. 1(d) shows the thermal responsivities of the samples. For the GaAs beams, the thermal responsivity deviates from theory for the beams longer than 150 μm. On the other hand, thermal responsivity of the GaAsP samples keeps increasing with increasing beam length, indicating that, by introducing tensile strain, the initial deflection of the MEMS beam is efficiently suppressed and high responsivities can be realized.

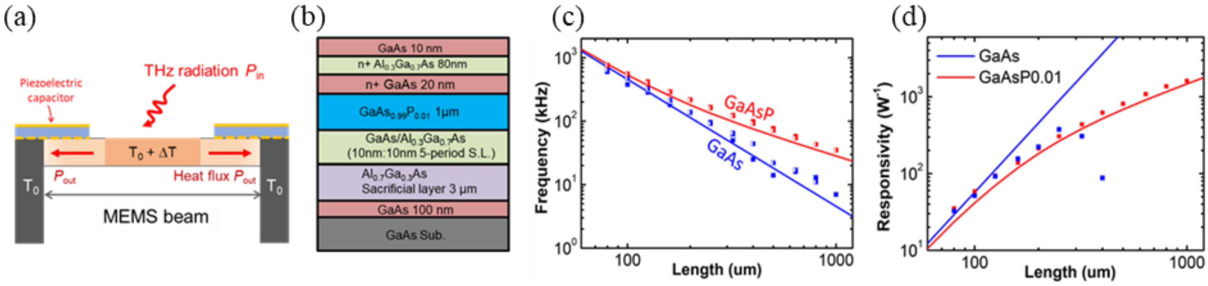

Fig.1 (a) Schematic of MEMS resonator as THz bolometer. (b) The wafer structure of an $GaAs_{1-x}P_x$ MEMS resonator. (c) Resonance frequency and (d) responsivity as function of the beam length. Dots: experiment data, lines: theory.

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