ウェーハー接合技術により作製した高抵抗 Si 基板上 GaAs ベース MEMS テラヘルツボロメータ

GaAs-based MEMS terahertz bolometers fabricated on high-resistivity Si substrates using wafer bonding technique

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We proposed and realized a room-temperature operated, all electrically driving and detecting, sensitive and fast thermometer structure using a doubly clamped microelectromechanical (MEMS) resonator for bolometer applications [1]. When a THz radiation is incident on a NiCr terahertz (THz) film absorber deposited on the MEMS beam surface, thermal stress is generated in the beam due to the thermal expansion, leading to a reduction in the mechanical resonance frequency. The MEMS detects the shift in the resonance frequency caused by heating and works as a very sensitive thermometer [1]. However, since THz radiation is absorbed/reflected in the thick GaAs substrate, the responsivity spectrum of the MEMS bolometer is strongly affected by the phonon properties in GaAs and, in particular, loses its sensitivity in the Reststrahlen band, which is not suitable for detector applications.

To get around this problem, here, we fabricate the MEMS bolometer on a high-resistivity Si substrate using the wafer-bonding technique. Different from polar GaAs, non-polar Si has a very small phonon absorption/reflection in the THz range. Figure 1(a) shows a wafer structure grown on a GaAs substrate by MBE. It was bonded to a high resistivity Si substrate by using adhesive FOx-15. Then the GaAs substrate was selectively etched by H_3PO_4 and citric acid, and the $Al_{0.7}Ga_{0.3}As$ layer was removed by HF. The wafer bonded sample used for fabrication is shown in Fig. 1(b). The inset in Fig. 1(c) shows the schematic of MEMS bolometer fabricated on Si substrate. The beam vibration is piezoelectrically driven and detected by the capacitors at the two ends of the beam. We used a phase locked loop to measure the shift in the resonance frequency of the beam, Δf [2]. As shown in Fig. 1(c), the wafer-bonded MEMS sample shows a large responsivity even in the Reststrahlen band of GaAs, where the responsivity vanishes in the standard MEMS bolometers fabricated on GaAs substrates. The wafer bonded samples successfully filled the responsivity gap in the standard MEMS bolometer and it becomes a very good candidate for far-infrared detection.

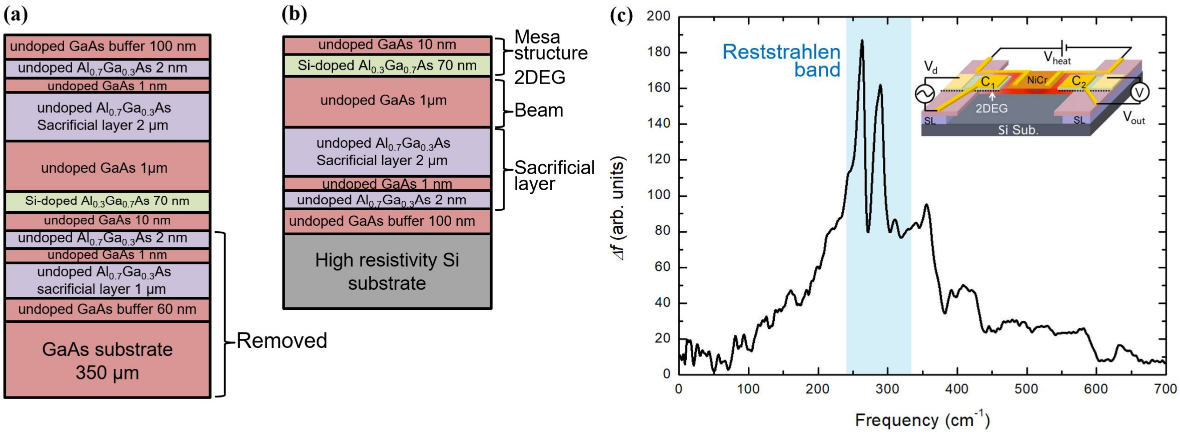

Fig.1. (a) GaAs wafer structure grown by MBE. (b) Wafer-bonded structure. (c) Response spectrum of a MEMS on Si substrate. The blue region indicates Reststrahlen band in GaAs. The inset shows the schematic sample structure.

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