Fabrication of terahertz quasi-MIM absorbers for integration with thin-film MEMS bolometers.

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Metal-insulator-metal (MIM) metamaterial absorbers [1] are promising for achieving high terahertz (THz) absorption, which is crucial for the development of high sensitivity THz detectors. Here, we have fabricated a quasi-MIM absorber on high-resistivity silicon substrate, for improving the optical sensitivity of a THz detector using a SOI MEMS resonator [2]. The fabrication process is schematically shown in Figure 1(a). The quasi-MIM absorber is formed by etching a high-resistivity silicon substrate by using reaction ion etching (RIE) to form a groove structure. Then we deposit a 200nm-thick Al film on the top surface of the substrate by thermal evaporation, and the etched and unetched parts naturally become two metal layers, forming the MIM structure together with the silicon substrate as the dielectric layer. A short wet etching process is performed for the Al film to completely separate the two Al layers. This structure features a notable advantage that no extra dielectric layers are introduced, thus is very compact, and very easily fabricated on SOI MEMS beam resonator.

Figure 1(b) shows the microscope images of two fabricated quasi-MIM structures (sample A/B). Figure 1(c) shows the reflection (black) and transmission (blue) spectra of a sample A, measured by using a THz time-domain spectroscopy, when THz electromagnetic wave incident from the Si substrate. The reflection of the bottom surface of the silicon substrate has been removed in the data analysis. As seen, the reflection spectrum shows a valley at ~1.8 THz, indicating that there is a plasmonic resonance at this frequency. The absorption spectrum(A) is calculated by $A=1-T-R$, which is shown as the red curve in Figure 1(c). As seen, the peak absorption is over 95%, demonstrating the effectiveness of the proposed quasi-MIM structure for achieving a high THz absorption coefficient. The transmission, reflection and absorption spectra of sample B is shown in Figure 1(d). Sample B has the sample design for the resonant pattern, but with a smaller separation between two patterns. As seen, it seems sample B shows two absorption peaks at ~1.6 THz and ~4 THz, suggesting that the interactions between resonant patterns may play an important role in such structures. These results indicate that the quasi-MIM absorber is promising for realizing both single frequency and multi-frequency THz absorbers.

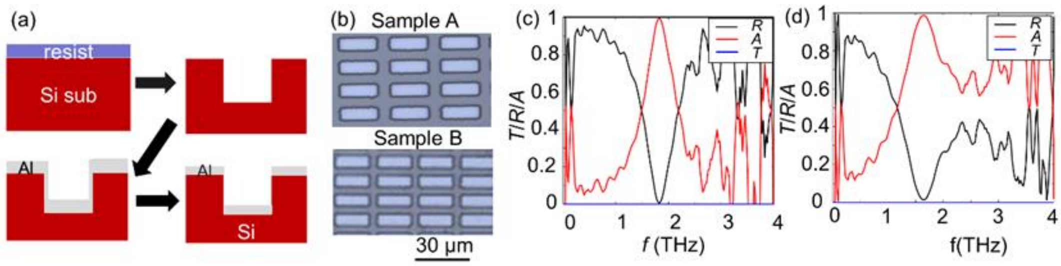

Fig. 1 (a) Schematic fabrication process of quasi-MIM absorber. (b) microscope images of two fabricated quasi-MIM absorbers (sample A/B). (c) Measured reflection (black) and transmission (blue) spectra of the fabricated sample A. The absorption spectrum (red) is calculated from the reflection and transmission spectra. (d) Reflection (black), transmission (blue), and absorption (red) spectra of sample B.

Reference

[1] J. Zhu, Z. Ma, W. Sun, et al. Appl. Phys. Lett. 105, 021102 (2014).

[2] K. Ebata, et al., the 71st JSAP Spring Meeting 25a-11E-7 (2024)