Multi-frequency terahertz quasi-MIM absorber for integrating with thin-film MEMS bolometer

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Terahertz (THz) thermal detectors utilizing microelectromechanical systems (MEMS) resonators[1-2] have attracted significant interests owing to their advantages of room-temperature operation, high sensitivity, rapid response, and miniaturization. In such MEMS detectors, a metallic film is typically employed as a THz absorber, but its low absorption coefficient (typically 10-20%) prevents further improvements in the optical sensitivity of MEMS detectors. An alternative, the metal-insulator-metal (MIM) metamaterial based plasmonic absorber, is promising for achieving high THz absorption. However, the MIM absorber generally features a multi-layer structure with a thickness of several micrometers, which is considerably thicker than the thin-film beam structure of MEMS detectors. It is therefore very challenging to integrate MIM absorbers with MEMS detectors.

We present a novel THz absorber with a quasi-MIM structure for improving the THz absorption coefficient of a THz bolometer based on a doubly clamped MEMS beam resonator. The quasi-MIM absorber is formed by etching the silicon substrate to create a groove structure, followed by metallic film deposition on both the etched and non-etched parts of the substrate. The silicon substrate is used as the dielectric structure instead of introducing extra dielectric materials. Consequently, this quasi-MIM structure offers a notable advantage over conventional MIM structures due to its reduced thickness, making it suitable for integration with MEMS bolometers. An example for the geometry design of the quasi-MIM absorber is shown in Fig. 1(a), which is designed for the resonance frequency of 5.1 THz. Fig. 1(b) shows the simulated absorption spectrum when THz wave is incident from the Si substrate of the structure. As seen, the absorber features absorption levels of up to 98%, indicating that our quasi-MIM absorber can work as an almost perfect THz absorber. Furthermore, by composing multiple groove structures in the absorber, we have realized THz absorber of multiple absorption peaks, as shown in Fig. 1(c). These results indicate that the quasi-MIM absorber is promising for realizing both narrow and broad band THz absorbers.

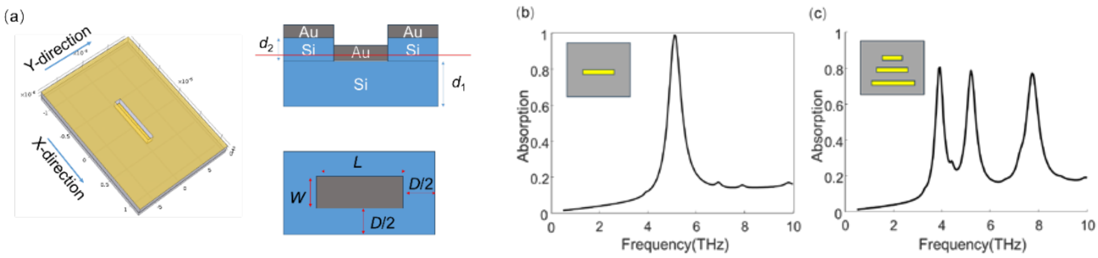

Fig. 1(a) An example of the unit structure of the MIM absorber. The vertical cross-section of the unit structure with d_1 = 1 μm and d_2 = 1.6 μm. The top view with L = 8 μm, W = 1 μm, D = 16 μm. (b) The calculated absorption spectrum of the absorber shown in Fig. 1(a). (c) The absorption spectrum of the sample composed of three rectangles grooves with L = 5 μm, 8 μm, 11μm.

Reference

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