メタマテリアルを用いた MEMS テラヘルツボロメータの吸収特性の制御

Control of absorption properties of MEMS terahertz bolometers using metamaterials

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We proposed a room-temperature operated, all electrically driving and detecting, sensitive and fast thermometer structure using a doubly clamped microelectromechanical (MEMS) resonator for bolometer applications. When a heating power is applied to a NiCr terahertz (THz) absorber film deposited on the MEMS beam surface, internal thermal stress is generated in the beam, leading to a reduction in the resonance frequency. The MEMS detects the shift in the resonance frequency caused by heating and works as a very sensitive thermometer [1]. The NiCr absorber has a broadband absorption spectrum and is good for spectroscopy. However, since its absorption efficiency is only ~20 %, it is not suitable for THz imaging applications, in which illumination sources usually have fixed, narrowband emission spectra.

To solve this problem, we propose to use metamaterials which have a metal-insulator-metal (MIM) structure [2] with rectangular patch patterns. Fig. 1 shows the structure of the metamaterial we used in this work. The metamaterial absorber consists of an array of gold rectangular patches, a SiO_2 insulation layer (thickness = h), and a bottom gold ground plane. The typical size of each rectangular patch was 23 μm×8 μm. The polarization of the incident light was set to be along the direction parallel to its long-side. We varied the thickness of the SiO_2 insulation film, h, from 600 nm to 1400 nm. Fig. 2 shows the h-dependence of the absorption spectra. At around 3 THz, the maximum absorption reaches 88% when h = 1400 nm. The observed absorption spectrum was in good agreement with theory. The present metamaterial absorber has achieved narrowband, large absorption, which is suitable for THz imaging.

Fig. 1

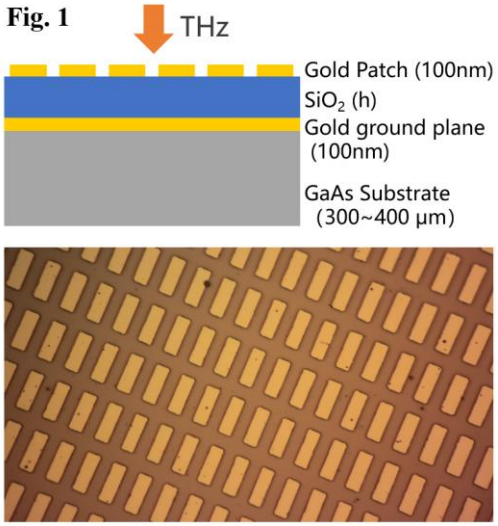
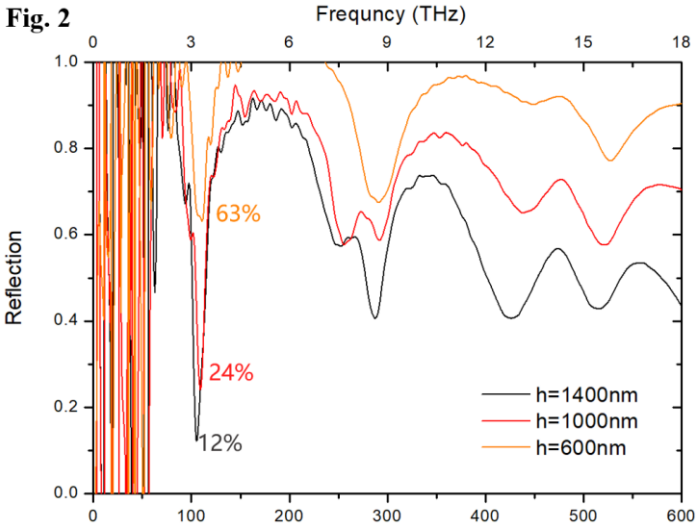


Fig. 2



Ref. [1] Y. Zhang, Y. Watanabe, S. Hosono, N. Nagai, K. Hirakawa, Appl. Phys. Lett. 108, 163503(2016).
[2] Y. Todorov, L. Tosetto, J. Teissier, A.M. Andrews, P. Klang, R. Colombelli, I. Sagnes, G. Strasser, and C. Sirtori, Optics Express 18, 13886 (2010).