Performance Improvement of THz Microbolometer by Folded - Dipole Antenna

○ Arie Pangesti Aji[13], Hiroaki Satoh[2] Catur Apriono[3], Eko Tjipto Rahardjo[3], Norihisa Hiromoto[1] and Hiroshi Inokawa[1,2]
[1]Graduate School of Science and Technology, Shizuoka University
[2]Research Institute of Electronics, Shizuoka University
[3]Department of Electrical Engineering, Faculty of Engineering, Universitas Indonesia
E-mail: inokawa.hiroshi@shizuoka.ac.jp

In a terahertz (THz) antenna-coupled microbolometer, the incoming THz waves are captured by the antenna and transferred to the load resistor (heater) to dissipate power. The voltage signal output is then obtained in the thermistor part which is thermally connected to the heater. Here the thermal or electrical conductivity of the heater and thermistor plays a key role to increase the responsivity of the microbolometer. The conductivity needs to be decreased by downscaling the structure dimensions. However, as the resistance of the heater part increases, it may cause an impedance mismatch issue with the antenna part, if a low-impedance antenna such as half-wave dipole is incorporated. Therefore, the folded dipole antenna (FDA) is advantageous to resolve this issue due to its larger characteristic impedance [1].

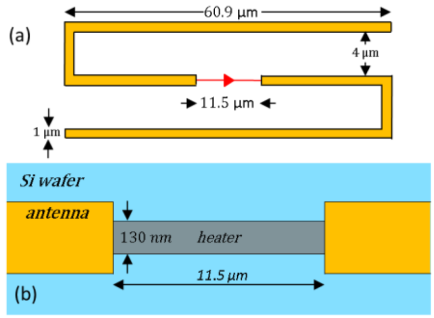

Fig. 1. (a) FDA design structure, (b) top view of the coupled heater

In this work, we assessed the improvement attained by an FDA-coupled microbolometer based on electromagnetic (EM) simulation in transmitting (Tx) and receiving (Rx) mode. Fig. 1(a) illustrates the FDA design comprising of three parallel arms with the S-parameter excitation source at its gap for Tx mode simulation. The antenna was made of 200-nm thick gold with the conductivity of 4.4×10^7 S/m. The substrate material is a high-resistivity silicon (ε = 11.7, ρ = 6.8 kΩ.cm) with semi-infinite thickness to mimic the backside radiation [2]. In Rx mode simulation, the antenna gap is filled with a 50-nm-thick titanium heater as shown in Fig. 1(b). The heater width (W_h) was designed to match with the resonant resistance (R_r) from the Tx simulation by $W_h = L_h/(\sigma \times R_r \times t_h)$, where L_h, t_h, and σ are the heater length, thickness, and conductivity (2.46×10^6S/m), respectively. A linearly polarized uniform plane wave with 4.54 mW/cm^2 intensity enters from the substrate side towards $z+$ direction.

Fig. 2(a) shows the impedance behavior of the FDA compared to the half-wave dipole antenna with the resonant at 1 THz frequency from the Tx mode simulation. The FDA has the resonant resistance of 675 Ω, which is nearly 27 times larger than that of the half-wave dipole antenna. The FDA impedance bandwidth shows a broad characteristic, which is beneficial for large variation of heater resistance. Fig. 2(b) shows dissipated power obtained on the load heater coupled to the antenna in Rx mode. The peak power dissipation is shifted from the resonant frequency obtained in the Tx simulation. Compared to the half-wave dipole antenna, the FDA has relatively lower efficiency and effective area due to higher ohmic losses on the antenna patch. However, as the responsivity of the microbolometer is proportional to the heater thermal resistance in conjunction with electrical one, a higher overall performance can be expected despite the reduced antenna effective area in receiving mode. Based on our calculation, the utilization of FDA can enhance the responsivity by 15 times compared to the half-wave dipole antenna. The proposed FDA design is currently being investigated experimentally to demonstrate the prediction.

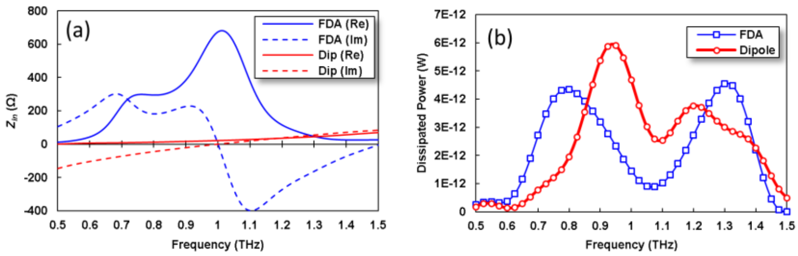

Fig. 2. (a) Impedance characteristic of FDA, and (b) dissipated power in the load heater coupled to FDA, with comparison to the half-wave dipole results

References:
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[2] J. Montero-de-Paz, et al., *IEEE T.A.P.,* Vol. 62, No. 9, p. 4870, 2014.