Impedance matching method in high-power RTD THz oscillator integrated with rectangular-cavity resonator

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Oscillators using resonant tunneling diodes (RTDs) are major candidates for THz wave sources, because of their operation at room temperature and compactness. Although we achieved a high power oscillation of around 0.7 mW by an arrayed RTD oscillator [1], the output power of single RTD oscillator is relatively small, in the order of 10 μW around 1 THz. For higher output power, novel RTD THz oscillators with cavity resonators and bow-tie antennas was proposed [2]. In this work, we propose and simulate an impedance matching method between RTD and antenna in the novel oscillator to extract maximum output power from RTD.

The device structure is shown in Fig. 1. The oscillator is composed of a line-shaped RTD mesa, a rectangular cavity resonator, and a bow-tie antenna. The RTD has a negative differential conductance in the current-to-voltage characteristics, which is utilized for the THz oscillation. The rectangle cavity is expected to reduce the conduction loss and inductance, and the large-area RTD can be used even at high frequency in this oscillator, which results in high output power. The oscillation frequency is basically determined by the inductance of cavity resonator and RTD capacitance. A part of generated THz signal passes through the MIM capacitor and is radiated to air by the bow-tie antenna. We analyzed the admittance of cavity resonator and antenna using 3D electromagnetic simulation, and established an equivalent circuit model for this structure. The radiated output power can be estimated by calculating power consumption at the antenna.

A control of antenna impedance is required to extract the maximum output power from RTD with an impedance matching between antenna and RTD. The right-hand-side MIM capacitor as shown in Fig. 1 is connected in parallel with the bow-tie antenna. Therefore, the impedance of antenna can be changed by the MIM capacitor, and the impedance matching condition will be satisfied. The output power dependence on MIM capacitor is shown in fig. 2. The assumed RTD characteristics and cavity structure are also shown in Fig. 2. A relatively high output power of ~2 mW can be achieved at around 1 THz with an optimum MIM capacitor of ~50 fF.

References:

[1] K. Kasagi, S. Suzuki, and M. Asada, J. Appl. Phys. **125**, 151601 (2019).
[2] H. Tanaka, Y. Aoyama, R. Izumi, S. Suzuki, M. Asada, SSDM, PS-4-24, Tokyo, 2018.

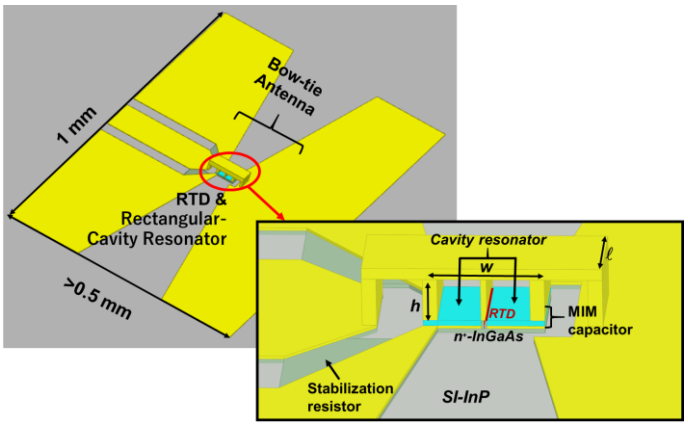

Fig. 1 Schematic structure of RTD oscillator with rectangular cavity resonator.

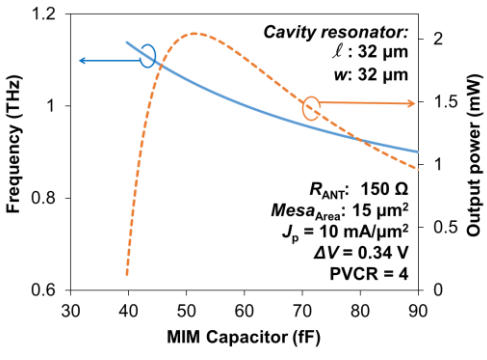

Fig. 2 Dependence of estimated output power on MIM capacitor