

Frequency increase in resonant-tunneling diode THz oscillator by simulation-based structure optimization

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Terahertz (THz) radiation, in the range between the light waves and millimeter waves, has gained much attention because of its applications, such as imaging, spectroscopy, high resolution radars and high-capacity wireless communications [1]. Among the electron devices, resonant tunneling diodes (RTDs) are one of the major candidates for THz wave sources, because of their operation at room temperature, compactness, and undemanding system requirements. Recently, oscillation frequencies up to 1.98 THz were achieved for RTD THz oscillators with slot antenna, and a novel RTD oscillator integrated with cavity resonator was proposed for further increment in frequency [2]. In present work, we analyzed oscillator structure with cavity resonator and optimized the cavity structure to reach higher frequencies.

The oscillator is composed of an RTD mesa structure, a circular cavity resonator and bow-tie antenna as shown in Fig. 1. The RTD mesa is located at the center of the cylindrical cavity. The oscillation occurs in the cavity, and output power is supplied to the bow-tie antenna and radiated into the substrate side.

To achieve high oscillation frequency, optimization of the oscillator structure parameters is essential. By using 3D electromagnetic simulation for the device parameters and solving oscillation condition equations, we obtained dependences of oscillation frequency limit on cavity height for various cavity radiuses (Fig. 2).

It's revealed that there is an optimum cavity height for each radius value where frequency limit reaches its maximum. On the other hand, similar behavior could be seen for dependences of oscillation frequency on cavity radius, i.e. there is an optimum cavity radius for each height value, where oscillation frequency reaches maximum value. Combining both series of the results, optimum resonator cavity dimensions to achieve maximum oscillation frequency of the RTD oscillator structure could be found. Analysis of the calculation results has shown that fundamental oscillation up to 2.77 THz could be expected for the RTD device considered in the present study.

References:

- [1] M. Tonouchi, Nat. Photonics **1**, 97 (2007).
- [2] R. Izumi, T. Sato, S. Suzuki, and M. Asada, AIP Advances **9**, (2019) 085020.

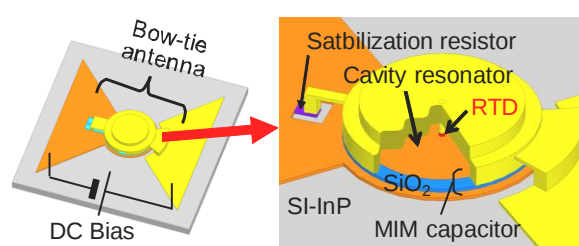


Fig. 1 Schematic structure of RTD oscillator with cavity

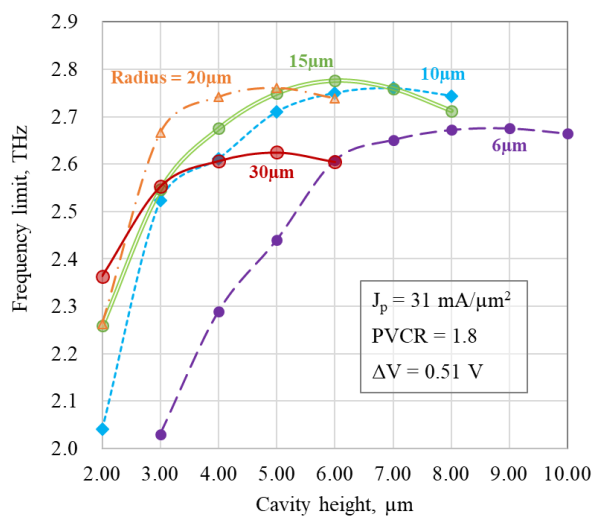


Fig. 2 Upper limit of oscillation frequency in dependence on the cavity height for various radiuses