Frequency Increase in Resonant-Tunneling Diode Cavity-type Terahertz Oscillator

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Terahertz (THz) radiation, in the range between the light waves and millimeter waves, has attracted much attention because of its applications [1]. Oscillators using resonant tunneling diodes (RTDs) are major candidates for THz sources, because of their operation at room temperature and compactness. To achieve oscillation frequencies more than 2 THz, new RTD THz oscillator structure based on low conduction loss cavity resonator was proposed [2]. In the first fabrication trial, oscillation frequencies only up to 1.79 THz were obtained due to a parasitic capacitance around the RTD mesa. To optimize structure parameters and reach higher frequencies, oscillation frequency limitations and structure dependences were analyzed [2, 3]. In this work we report results of the devices with improved structure and fabrication process.

Oscillator is composed of an RTD mesa structure, cylindrical cavity resonator and a bow-tie antenna on a semi-insulating InP substrate (Fig.1a). Top contact layer of the RTD is connected to the upper electrode of the cavity with a metal pillar. For the resonator height of 2 μm, optimization technique [3] allows us to expect oscillation frequencies up to 2.55 THz with radius of the resonator around 30 μm and RTD mesa areas around 0.2 μm^2. In previous work [2] parasitic capacitance (C_p) was formed around the RTD mesa, as shown in left inset on Fig. 1b. To eliminate C_p, we used new fabrication technique which allow to form cone-type pillar on top of the RTD mesa (Fig.1b right inset).

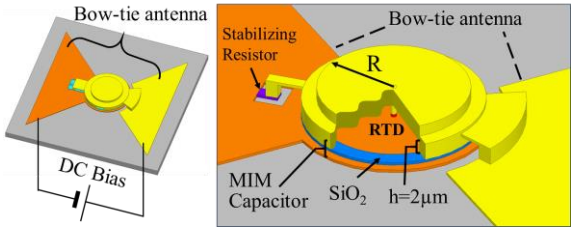

Fig. 1a Schematic structure of RTD oscillator with cavity

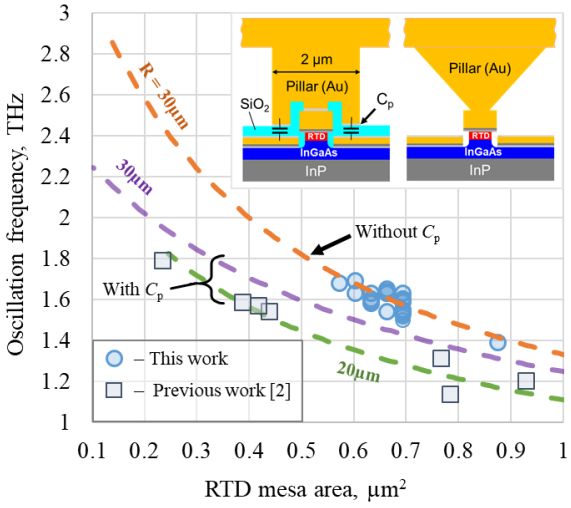

Fig. 1b Oscillation frequency versus RTD mesa area. Experimental results shown as blue circles (this work) and grey squares (previous work). Dashed curves show calculation results for oscillator structure with and without C_p in present work (purple and orange), and with C_p for previous work (green). The inset shows previous pillar structure with parasitic capacitance C_p (left) and new pillar structure without C_p (right).

Figure 1b shows measured dependencies of oscillation frequency on RTD mesa area. In this work fundamental oscillations up to 1.7 THz were obtained. Oscillation frequency deviations could be attributed to unevenness of the mesa sizes across the wafer. Dashed curves in Fig. 1b show calculated dependencies of oscillation frequency on mesa area for current (orange, purple) and previous (green) works. Good agreement between experimental and calculation results allow us to conclude that parasitic capacitance was eliminated, and optimized device shows increase in oscillation frequency of more than 250 GHz at frequencies around 1.5 – 1.7 THz in comparison with previous work [2]. We plan to continue fabrication of the devices with smaller mesa areas to reach higher frequencies

References:

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