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Resonant Tunneling Diode Oscillator Source for Terahertz Applications

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Resonant tunneling diode (RTD) is the fastest solid-state electronic device with the highest reported frequency at 1.92 THz [1]. RTD-based THz sources have many promising applications such as ultrafast wireless communications, THz imaging, etc. To date, the main limitation of RTD technology is the low output power. Here we report the series of nearly/over one half mW output power RTD oscillator. The frequencies range from 125 GHz to 308 GHz and the preliminary wireless communication measurement result demonstrates data rate up to 7Gbps. The details of the RTD layer-structure was described in [2]. The device sizes were 3×5, 4×4 and 5×5 μm². The measured DC characteristic is shown in Fig.1. The negative differential resistance (NDR) region exists between 1.0V-1.6V. All devices were fabricated with photolithography. The process was described in [2].

The RTD oscillator design approach presented here employs two RTDs in parallel as shown in Fig. 2(a). Each device is biased individually with its own shunt resistor Rₑ to suppress the low frequency bias oscillations and a bypass capacitor Cₑ. Inductance L is designed to resonate with RTD self-capacitances to determine the desired frequency. It is realized from an appropriate length of a coplanar waveguide (CPW) terminated in a short circuit, through capacitor Cₑ in this case. Rₑ is the load resistance which is 50-Ω, the input impedance of the spectrum analyser or power meter used. The RF equivalent circuit of the oscillator circuit is shown in Fig. 2(b). Gₐ and Cₐ are the device differential conductance and self-capacitance in the NDR region, respectively. A photograph of the fabricated oscillator with probes landing on top of CPW is shown in Fig. 3. The measurement results are summarized in Table 1. The 125 GHz oscillator provided 0.68 mW output power while the 156 GHz oscillator gave 0.47 mW output power and 308 GHz oscillator was 0.33 mW power. The spectrum of the 308 GHz oscillator is shown in Fig. 4.

The wireless communication measurement setup is as shown in Fig 5. The PRBS data was applied through bias-T. The frequency carrier was 300 GHz RTD oscillator. The receiver was composed of 300GHz antenna with schottky barrier diode (SBD) detector and oscilloscope. The measured eye diagram of 2Gbps and 7Gbps is shown in Fig 6.

The results shows great potential by using RTD oscillator as THz source for many applications such as wireless communication, imaging system etc.


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Figure 1. RTD device I-V characteristics. The NDR region is between 1.0V to 1.6V.

Figure 2. (a) Two RTD oscillator schematic circuit. Each RTD is biased individually with its own DC stabilization circuit $R_e$ and $C_e$. (b) Oscillator RF equivalent circuit excluding device parasitic elements.

Figure 3. The oscillator employed two RTDs and each device was biased individually with shunt resistor $R_e$ and capacitor $C_e$. The CPW length is $L$.

Table 1: Summary of RTD Oscillators Performance

<table>
<thead>
<tr>
<th>Device size (μm²)</th>
<th>CPW $Z_0$ (Ω) / length (μm)</th>
<th>Freq. (GHz)</th>
<th>Power (dBm/mW)</th>
<th>DC Power (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5×5</td>
<td>50/30</td>
<td>125</td>
<td>-1.7/0.68</td>
<td>415</td>
</tr>
<tr>
<td>3×5</td>
<td>50/30</td>
<td>156</td>
<td>-3.3/0.47</td>
<td>374</td>
</tr>
<tr>
<td>4×4</td>
<td>25/10</td>
<td>308</td>
<td>-4.8/0.33</td>
<td>191</td>
</tr>
</tbody>
</table>

Figure 4. Measured spectrum of the 307.8 GHz oscillator when $V_{bias}=1.65$ V, $I_{bias}=116$ mA.

Figure 5. Wireless communication by using 300GHz RTD oscillator schematic measurement setup.

Figure 6. Measured eye diagram of 2 Gbps and 7 Gbps.

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