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 μm^2. 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 R_e to suppress the low frequency bias oscillations and a bypass capacitor C_e. 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 C_e in this case. R_L 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). G_n and C_n 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.

[1] T. Maekawa, H. Kanaya, S. Suzuki, and M. Asada, "Oscillation up to 1.92 THz in resonant tunneling diode by reduced conduction loss," Appl. Phys. Express 9, p024101, 2016.

[2] J. Wang, A. Khalidi, K. Alharbi, A. Ofiare, H. Zhou and E. Wasige, "G-Band MMIC resonant tunneling diode oscillators," 2016 Compound Semiconductor Week, Toyama, pp. 1-2, 2016.

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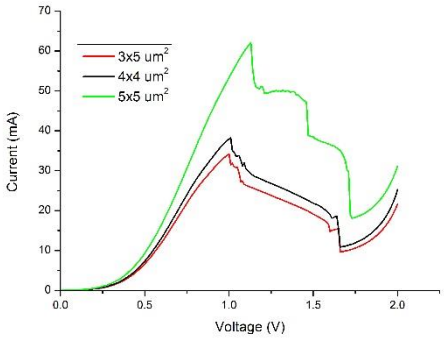

Figure 1. RTD device I-V characteristics. The NDR region is between 1.0V to 1.6V.

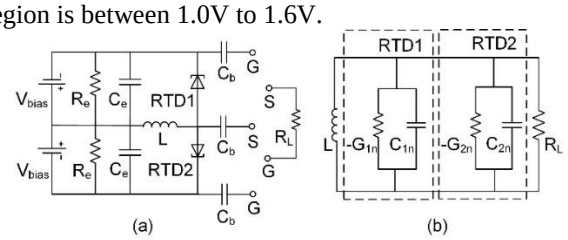

Figure 2. (a) Two RTD oscillator schematic circuit. Each RTD is biased individually with its own DC stabilization circuit R_e and C_e. (b) Oscillator RF equivalent circuit excluding device parasitic elements.

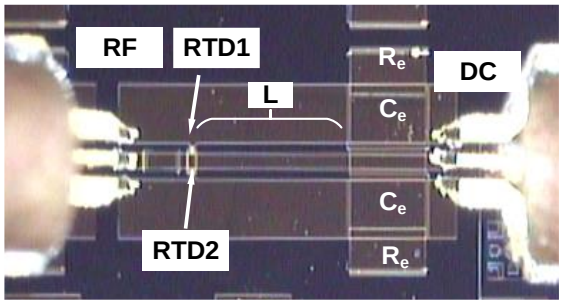

Figure 3. The oscillator employed two RTDs and each device was biased individually with shunt resistor R_e and capacitor C_e. The CPW length is L.

TABLE 1 SUMMARY OF RTD OSCILLATORS PERFOMANCE

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

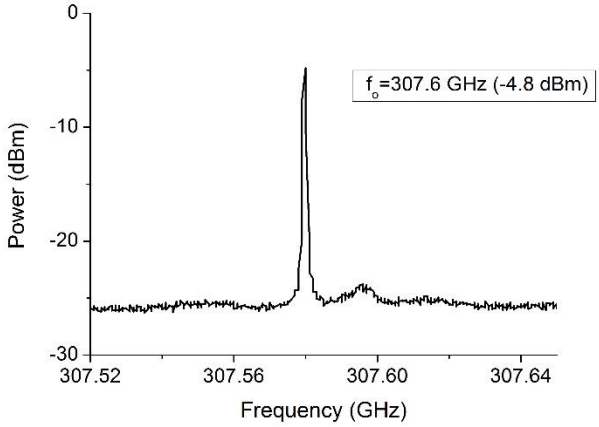

Figure 4. Measured spectrum of the 307.8 GHz oscillator when V_{bias}=1.65 V, I_{bias}=116 mA.

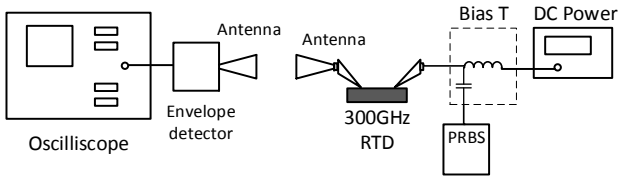

Figure 5. Wireless communication by using 300GHz RTD oscillator schematic measurement setup.

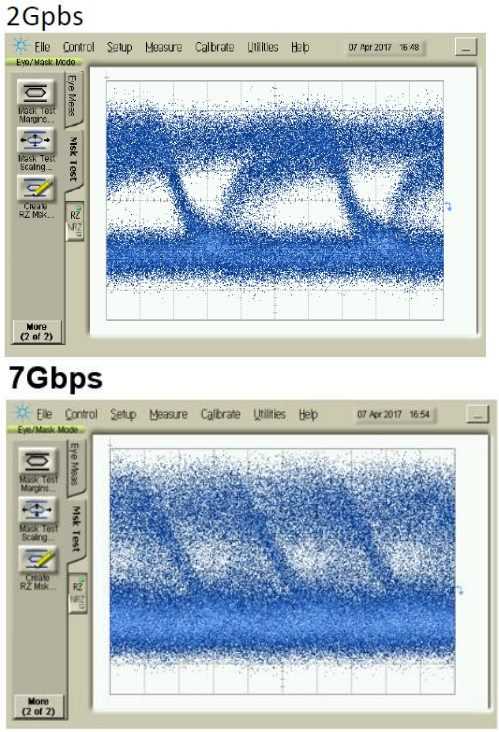

Figure 6. Measured eye diagram of 2 Gbps and 7 Gbps.

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