Loading Effect of W-band Resonant Tunneling Diode Oscillator by using Load-Pull Measurement

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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. Many efforts had been made to increase the power level by such as optimizing the layer structure [2], employing more devices in an array [3], matching impedance by displacing the device in circuit [3], etc. Here we report the loading effect by using E/H impedance tuner. We found that the maximum power is over 20dB higher than the worst impedance matching and the frequency shift is within 14% range of the central frequency. The load-pull measurement provides a convenient way to investigate the power/frequency variation versus the impedance change. Further work will benefit from the measurement results to design corresponding impedance matching network. The power level of RTD oscillator will be increased.

The details of the RTD layer-structure was described in [2]. The device size was $3\times3\ \mu m^2$. The DC characteristic with negative differential resistance (NDR) between 1.0V-1.6V is shown in Fig.1. The inset of Fig1 shows the fabricated device. The plateau-shape in NDR is because of the bias oscillation. Due to the DC instability, it is very difficult to extract the device model to use in the design of the impedance matching network.

Here the loading effect of RTD oscillator was investigated by load-pull measurement. The oscillator as shown in Fig.2 employed two RTDs and each device was biased individually with shunt resistor R_e and capacitor C_e. The design details were given in [2]. The measurement setup is shown in Fig.3. A W-band E-H tuner was placed between W-band probe and mixer. By tuning the E-H plane micrometers, the load impedance will be shifted seeing from the mixer. The frequency and power change due to impedance changing was investigated experimentally. Fig.4 and Fig.5 shows the frequencies and output power change with E/H tuner position. This technique provides a new method to determine the optimum load for RTD oscillator experimentally.

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[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, 2016, pp. 1-2.

[3] S. Suzuki, M. Shiraishi, H. Shibayama and M. Asada, "High-Power Operation of Terahertz Oscillators With Resonant Tunneling Diodes Using Impedance-Matched Antennas and Array Configuration," in IEEE Journal of Selected Topics in Quantum Electronics, vol. 19, no. 1, pp. 8500108-8500108, 2013.

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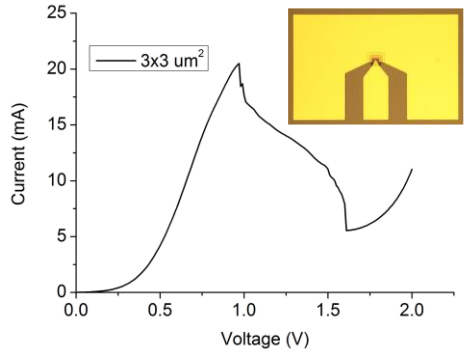

Figure 1. RTD device I-V characteristics. The device size was 3×3 μm² with NDR region between 1.0V to 1.6V. The inset shows the fabricated device.

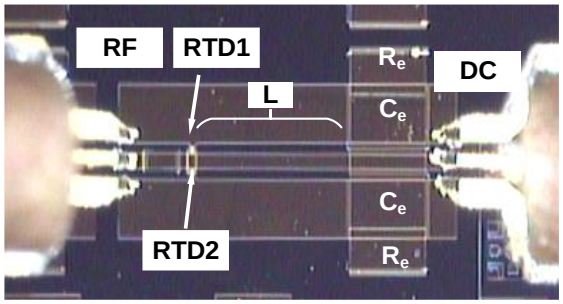

Figure 2. The oscillator employed two RTDs and each device was biased individually with shunt resistor R_e and capacitor C_e. The CPW length is L.

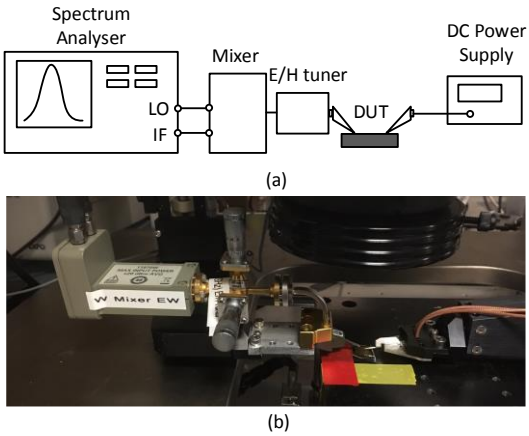

Figure 3. (a) shows the measurement setup diagram. The E/H tuner was placed between the RF probe and the mixer to change the impedance seeing from the mixer. (b) The actual measurement setup.

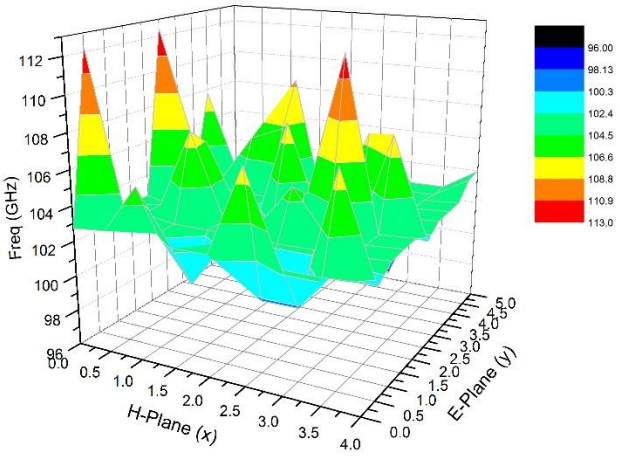

Figure 4. By changing the E/H plane micrometer position, the frequency of the oscillator shifted between 98GHz to 112GHz.

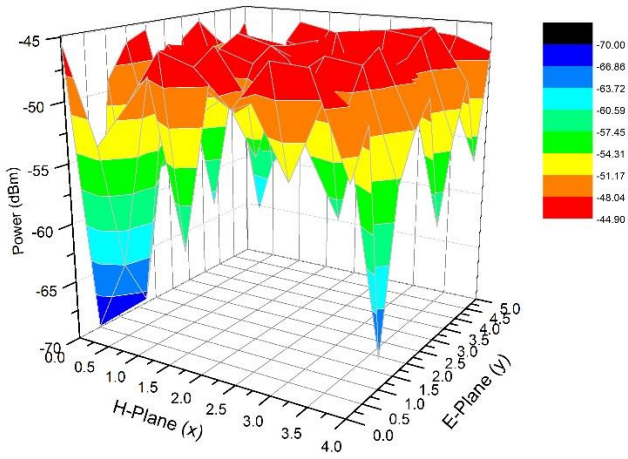

Figure 5. By changing the E/H plane micrometer position, the power of the oscillator shifted between -44 dBm to -68 dBm. Considering the mixer loss which is about 38 dB, the maximum available power is about 250 μW for W-band RTD oscillator.

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