1080P HD Video Transmission using RTD Transmitter

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***Abstract*—In this paper, we present low cost THz wireless transmission system utilizing 278GHz resonant tunneling diode (RTD) transmitter (Tx) with around 1mW output power. The demonstration shows 12Gbps error free and 1080p30 (3Gbps) HD video real time transmission over 80 cm distance. These results demonstrate very promising future of RTD Tx for next generation wireless communication system.**

Keywords—RTD, HD video, wireless communication

I. Introduction

Edholm's law predicts that the bandwidth and data rates double every 18 months since 1970s [1]. Especially with the development of multimedia technology, such as 4K even 8K high resolution video recording, 3D virtual reality (VR), etc, there is huge demand for low cost, compact ultra-high data rate wireless system. Terahertz (THz) technology, which covers spectrum from a few hundred GHz to several THz provides much higher bandwidth compared with current microwave wireless system. However low output power, poor heat handling, bulky size and high cost limit many THz sources for real life applications. The resonant tunneling diode (RTD) has received considerable attention recently for realizing THz sources [2-7]. It has the highest demonstrated oscillation frequency of 1.92 THz [2] and could potentially reach beyond 4 THz with further optimisation [3]. Other advantages of the RTD device include room temperature operation, compact size, and potential for optical control, among other devices such as field effect or bipolar transistors (MOSFETs, HEMTs or HBTs), or diode technologies (IMPATT, Gunn, etc.).

Recently, high data rate wireless transmission using RTDs has been reported by Asada's group achieved 30~34 Gbps data rates by using amplitude shift keying (ASK). Due to limited output power (26~60 µW @ 490GHz), the link distance was only a few centimetres [4][5]. Our research focus on increasing the power level of RTD Tx. 2mW@84GHz RTD Tx with 15Gbps (BER of 10^{-3}) data rate over 50 cm and record high power of 1 mW @260GHz has been reported by our group in [6][7].

In this paper we utilized developed high power RTD Tx to present the HD video (3Gbps) transmission over 80 cm distance. To the best knowledge of the authors', this is the longest distance by using RTD technology and furthermore, 12Gbps (80cm) error free wireless transmission has been demonstrated.

II. RTD Transmitter

A. RTD devices

The layer structure of the RTD wafer which was reported here was grown by molecular beam epitaxy (MBE) on a semi-insulating InP substrate. It employs a 4.5 nm InGaAs quantum well and 1.4 nm AlAs barriers as illustrated in Figure 1 (a). The RTD device was fabricated using photolithography. The central device mesa size is about 4 µm × 4 µm. The fabrication detail can be found in [7]. A scanning electron microscope (SEM) picture of a fabricated RTD device is shown in Figure 1(b).

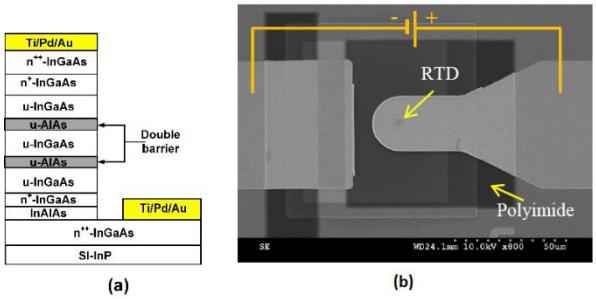

Fig. 1. (a) The schematic epitaxial layer structure of an RTD device. (b) SEM of a fabricated RTD device

The measured IV characteristic is shown in Figure 2. that the peak current density J_P is ~3 mA/µm^2 and a peak to value current ration (PVCR) is 3. The peak-valley voltage/current difference (ΔV/ ΔI) is about 0.7V and 25 mA. The estimated single RTD device maximum output power is about 3.3 mW [7].

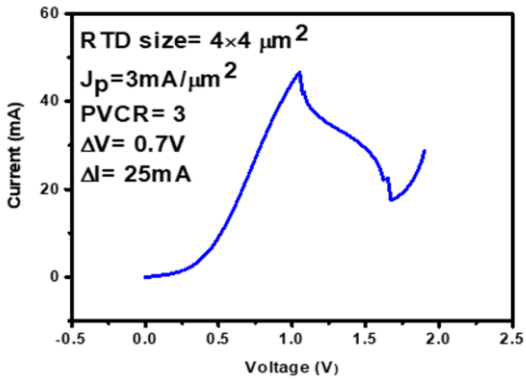

Fig. 2. Measured IV characteristics of RTD device.

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B. *RTD Tx design and measurement*

The RTD oscillator design approach presented here employs a single RTD device as shown in Figure 3. The shunt NiCr film resistor R_e is used to suppress the low frequency bias oscillations and the bypass MIM (metal-insulator-metal) capacitor C_e is used to ground the RF signal. The inductance L was realized by using a microstrip transmission line short stub. The design details can be found in [7].

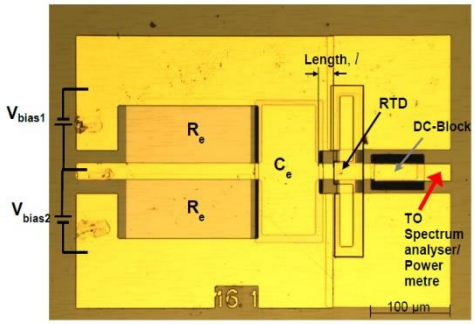

Fig. 3. Micrograph of a fabricated RTD oscillator circuit.

Depending on the design, the RTD Tx frequencies cover from 270GHz to 310 GHz. One of the measured spectrum is shown in Figure 4. The central frequency is 278.8 GHz. As the conversion loss of external mixer is about 70 dB, the estimated output power is around 1 mW.

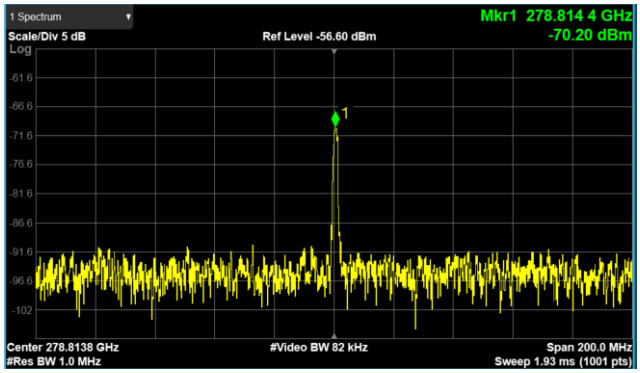

Fig. 4. Measured 278GHz RTD Tx spectrum.

III. HD Video Wireless Transmission System

The block diagram of the wireless system is illustrated in Figure 5. As the fundamental frequency of RTD Tx is 278 GHz, no external mixer/multiplier is required which greatly simplify the Tx design. The PRBS or HDMI data input is superimposed over DC bias through a bias tee. The modulation scheme is ASK modulation. As the output power of RTD Tx is high in mW range, no PA is employed. On the receiver (Rx) side, the signal is demodulated by a Schottky barrier diode (SBD) envelope detector and the output baseband signal is amplified by a low noise amplifier (LNA).

A pseudo-random binary sequence (PRBS) generator was first connected through a bias-T to the RTD Tx. Figure 6 shows 12Gbps error free wireless data transmission through 80 cm distance. This measurement demonstrate the capability of current wireless link. Next the PC with 1080P30 HD video (3Gbps) HDMI output was connected to the bias-T and the output of the Rx LNA was connected to the LCD monitor. The measurement setup is shown in Figure 7. It demonstrated real time HD video transmission by using RTD Tx through 80 cm distance.

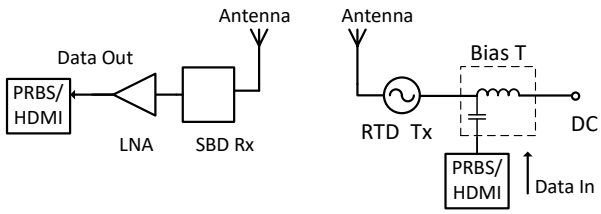

Fig. 5. Block diagram of the wireless system architecture.

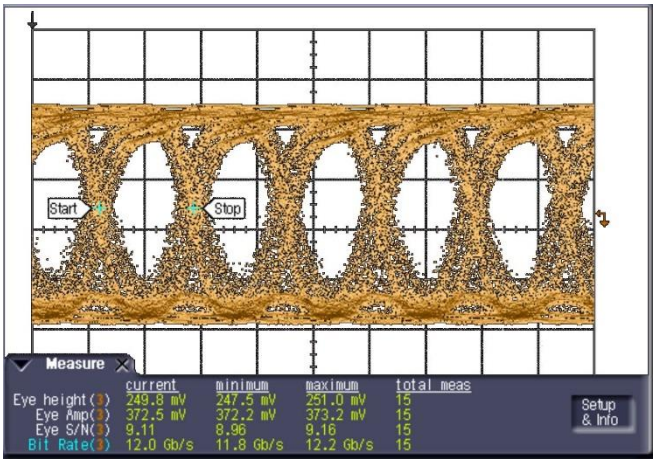

Fig. 6. 12Gbps error free eye diagram of the wireless transmission system. The Tx is 278GHz RTD . The Rx is zero bias SBD. The link distance is about 80 cm.

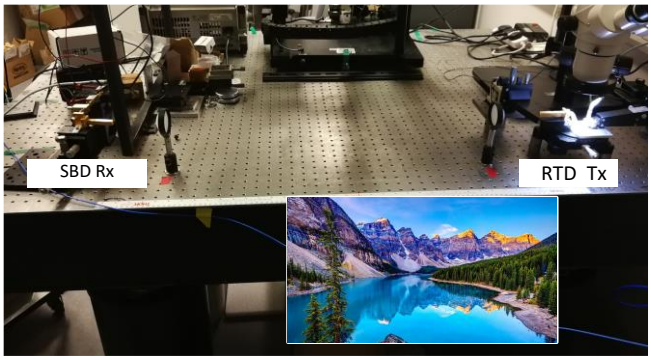

Fig. 7. 1080P30 (3Gbps) 80 cm distance HD video wireless transmission demonstration.

IV. Conclusion

12Gbps error free 80 cm distance wireless system has been demonstrated in this paper. The system utilize high-power J-band RTD Tx. 1080P HD video real time transmission has also been demonstrated. The results shows RTD Tx very promising future as simple, low cost, compact transmitter for future ultra-fast wireless communication systems. With further optimization of the system, such as high gain antenna, better alignment, the link distance is expected to reach as far as tens of meters.

Acknowledgment

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