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A 1.25Gbps Radio-on-fiber Transmission in 60GHz band using an InP Heterojunction Phototransistor

Chang-Soon Choi[1*], Jae-Young Kim[1], Hong-Seung Kim[2], Eun-Soo Nam[2] and Woo-Young Choi[1]

[1]Department of Electrical and Electronic Engineering, Yonsei University, Seoul, Korea
[2]Electronics and Telecommunications Research Institute (ETRI), Daejun, Korea

***Abstract* — We present 60GHz radio-on-fiber systems for 1.25Gbps downlink transmission using InP heterojunction phototransistor (HPT). Since a HPT can combine the functions of photodetection, amplification and frequency mixing in a single device, it is possible to realize simple and cost-effective antenna base station architecture in 60GHz radio-on-fiber systems.**

I. INTRODUCTION

Recently, markets for wireless access networks are rapidly growing, which gives rise to much attention in gigabit wireless transmission. Millimeter-wave frequencies around 60GHz are attractive for these applications because of their wide transmission bandwidth and efficient frequency reuse capability, however, the generation and the transmission of millimeter-wave still remain as severe obstacles for their practical uses. Radio-on-fiber technologies have emerged as a solution for these problems, which also gives us efficient way to incorporate wireless networks with previously deployed fiber-optic networks. Since millimeter-wave radio-on-fiber systems inherently use micro-cells or pico-cells in order to compensate high transmission loss, simple antenna base station is inevitable for their practical implementation [1].

Three-terminal phototransistors are useful devices for these applications because they can be used as not only phototransistors but also optoelectronic mixers that perform the frequency up-conversion of optically transmitted data into desired frequency bands [2]. Compared to HEMT-based phototransistors, HBT-based phototransistors (HPTs) having vertical PIN structures exhibit high optical responsivity and wide photonic bandwidth. In this work, we present the characteristics of an InP heterojuction phototransistor. Utilizing it as an optoelectronic mixer, 60GHz radio-on-fiber downlinks for 1.25Gbps downlink transmission is demonstrated.

II. HETEROJUNCTION PHOTOTRANSISTOR

The device structure of InP/InGaAs HPT can be found in our previous works [3]. Fig. 1 shows the collector current (I_C) as a function of collector-emitter voltage (V_{CE}) of HPT under dark and -12dBm optical illumination. The high optical responsivity of 44.3A/W was obtained.

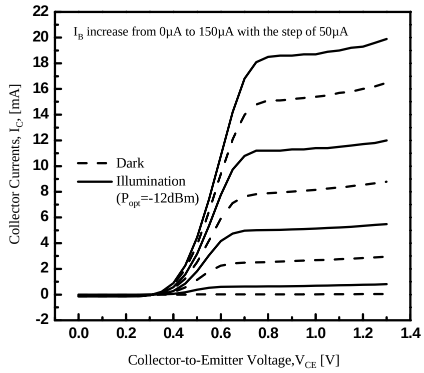

Fig. 1. I_C-V_{CE} characteristics of HPT under dark and optical illumination..

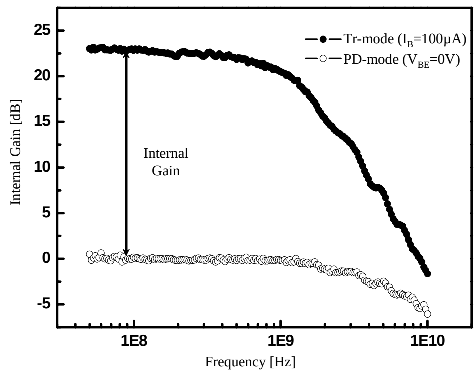

Fig. 2. Optical modulation responses of InP HPT under Tr-mode and PD-mode

The optical modulation responses of the HPT are shown in Fig. 2. Under the PD-mode where V_{BE} is 0V, HPT operates as a photodiode without internal gain. The Tr-mode indicates the HPT is actively biased, $V_{BE}>0$, which provides internal gain by the transistor operation. The internal gain is defined as the output power ratio of Tr-mode to PD-mode. The fabricated HPT exhibits the internal gain of 23dB at 100MHz optical modulation frequency. Since HPT should be operated at Tr-mode for the applications of phototransistors and optoelectronic mixers, the optical modulation response determines the

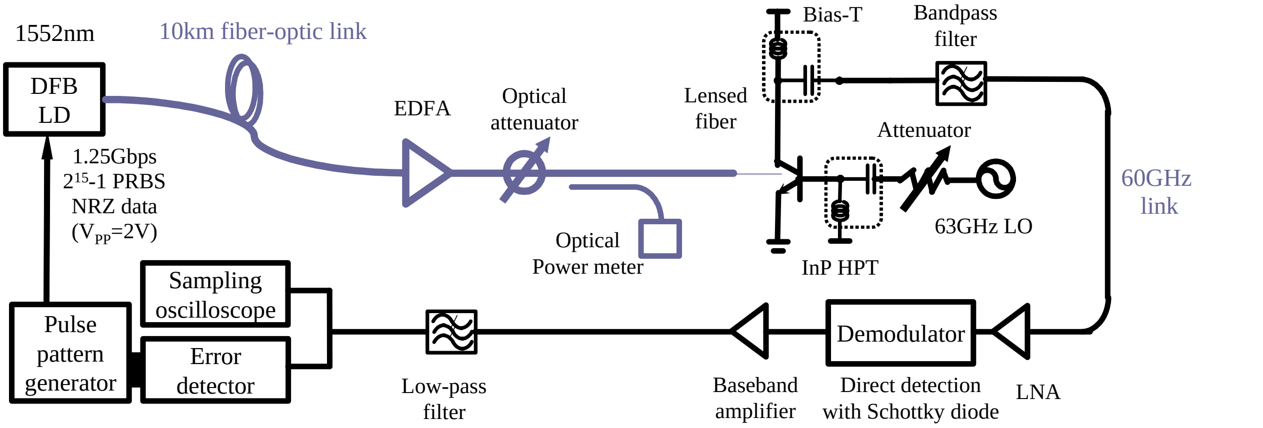

Fig. 4. Experimental setup for 60GHz radio-on-fiber system using InP HPT optoelectronic mixer

photodetection bandwidth of optically transmitted data signals. It can be seen from the figure that photodetection 3dB bandwidth is about 1.4GHz with high internal gain, which is sufficient for receiving 1.25Gbps optical signals in our investigation.

IV. 1.25GBPS, 60GHZ RADIO-ON-FIBER SYSTEM

HPT can be also used as optoelectronic mixer, which can eliminate a frequency mixer in antenna base station of radio-on-fiber systems. By applying 63GHz local oscillator signals to base port, we achieved the frequency up-conversion of 100MHz optical signals into 60GHz band. Fig. 3 shows the schematic illustration of HPT optoelectronic mixer and its 60GHz band output spectrum measured at the collector port after low-noise amplification.

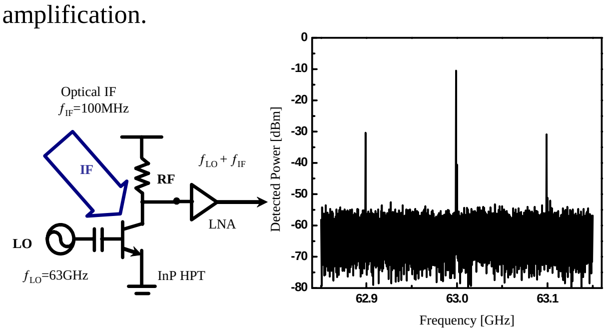

Fig. 3. 60GHz InP HPT optoelectronic mixer and its output spectrum under applying 63GHz LO and optical 100MHz signals.

60GHz radio-on-fiber system depicted in Fig. 4 was constructed in order to investigate the feasibility of HPT as a millimeter-wave optoelectronic mixer. The optically transmitted data signals were frequency up-converted to 60GHz band with the optimum bias conditions of I_B=250μA and V_{CE}=0.7V. After bandpass filtering, the 60GHz band output signals were amplified by LNA and demodulated using the direct detection technique with a Schottky diode. The recovered signals were filtered and connected to a sampling oscilloscope and an error detector. Fig. 5-(A) shows the eye-diagram for recovered 1.25Gbps data signal when incident optical power is 7dBm. The constructed link performance was evaluated by measuring BER as a function of incident optical power to HPT, shown in Fig. 5-(B).

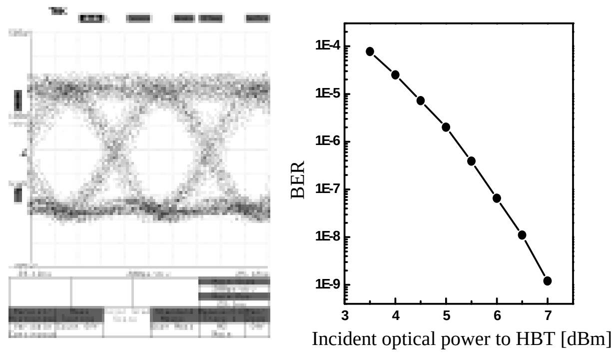

Fig. 5. (A) Eye diagram for recovered 1.25Gbps data from 60GHz radio-on-fiber system (B) Bit-error rate as a function of incident optical power to HPT

IV. CONCLUSION

We fabricated and characterized InP/InGaAs HPT having high optical responsivity of 44A/W at 1.55μm and wide photonic bandwidth of 1.4GHz. Utilizing it as an optoelectronic mixer, a 1.25Gbps data transmission in 60GHz radio-on-fiber link is successfully demonstrated.

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