Chip based THz emitter for ultra-high speed THz wireless communication

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***Abstract*— By using a monolithically integrated dual-distributed feedback (DFB) laser chip attached to a photomixing uni-travelling carrier photodiode (UTC-PD) with a THz antenna, single-channel THz photonic-wireless transmission system with a net rate of 131 Gbit/s over a wireless distance of 10.7 m has been achieved.**

Keywords*— *THz wireless communication, generic foundry, DFB laser, frequency comb, UTC-PD

I. INTRODUCTION

THz wireless communication (TWC) with large available bandwidth is a promising technique to fill the data rate gap between fiber optic network and wireless network. Therefore, the exploration of wireless communication in the THz band (>300 GHz) is a time-being necessity and can pave the way towards 5G networks and beyond 5G networks. Using photonic technologies is a promising path to generate high-quality THz signals to carry 100s of Gigabits/s of data, and additionally has the great advantage of being compatible with the fiber-optic network, providing a way to distribute wireless-on-fiber over long distances [1]. Apart from the mobile data streams, many other bandwidth-hungry applications are expected to be facilitated by the TWC, such as supercomputing, ultra-fast intra-board interconnection, fast restoration of link connections in disaster areas and so on [2].

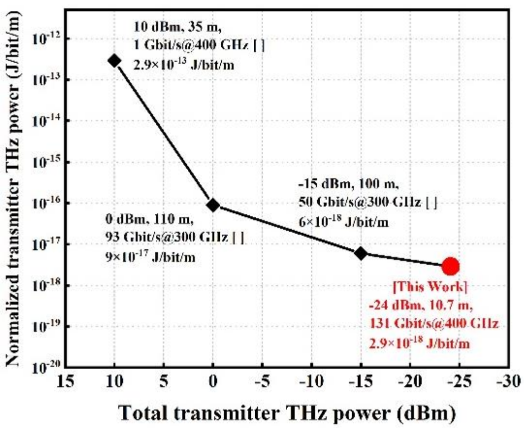

Fig.1. The comparison of the normalized transmitter THz power of the reported demonstrations with long reach.

In terms of THz wireless commutations, the carrier frequencies ranging from 350-910 GHz have been recommended for indoor communications with the 10-100 m range [3]. Extensive research has been conducted to achieve high data rates transmissions at these frequencies [4-19]. Using photonic schemes, high data rates have been achieved by frequency division multiplexing techniques often yielding data rates of 100 Gbit/s and above. However, these multiplexing techniques based on bulky components increase the system cost and complexity. Single-channel THz wireless transmission with a data rate beyond 100 Gbit/s has recently been demonstrated over a very short distance. Fig. 1 shows reported long-distance (>10 m) THz wireless transmission in different THz bands revealing the relation of data rate, distance and emitted THz power [17, 19-21].

II. INTEGRATED DUAL-DFB LASERS BASED THZ TRANSMITTER

Photonic integrated circuits (PIC) based THz synthesizer has the advantages of low cost, small footprint and low power consumption. Moreover, facilitated by continuous development of semiconductor fabrication technologies, the open-access InP generic foundry photonic integration approach has allowed active and passive components to be monolithically integrated on the same substrate [22]. The integrated dual-DFB lasers are fabricated in a generic foundry approach. Two DFB lasers are placed in parallel and combined through a MMI coupler. Each DFB laser is controlled with heater current and injection current. Each standardized DFB laser building block contains a GSG CPW along with an internal heater for thermo-optic tuning. Injection currents are injected onto the GSG CPWs, and heater currents are fed onto the heater pads. The wavelength spacing between the two CWs is controllable within the range of 0-10.7 nm, resulting in a continuously tunable beat note from microwave to THz frequencies (up to ~1.4 THz).

III. CHIP-BASED THZ WIRELESS COMMUNICATION SYSTEM

Fig.2 shows the schematic of the chip-based THz wireless communication system. Two continuous waves (CWs) with a frequency spacing of 408 GHz are generated by the dual-DFB laser chip, which are injection locked by a mode-locked laser based frequency comb, thus these two CW tones are phase coherent. One tone is used as an optical local oscillator (LO) for heterodyne mixing in order to generate the THz wave. The other tone is used to carry data and launched into an in-phase (I) and quadrature (Q) optical modulator (IQM). The modulated 16-QAM-OFDM (quadrature amplitude modulation-orthogonal frequency-division multiplexing) optical signal and the optical LO are combined before launching into the broadband UTC-PD. At the output of the UTC-PD, a THz signal with carrier frequency centered at 408 GHz are generated and emitted into a 10.7-m line-of-sight (LOS) wireless link, as shown in Fig. 2(d). A pair of THz lenses with a 100-mm diameter and 200-mm focus length is used to collimate the THz beam. At the receiver, the THz signal is down-converted to an intermediate frequency (IF) by a sub-harmonic Schottky mixer. The IF signal is digitally sampled by a 160 GSa/s real-time digital sampling oscilloscope (DSO). The digital signals are processed and analyzed offline with a digital signal processing (DSP) routine. The BER below the FEC threshold (2.7 e-2, 20%-OH) has been achieved for the 16-QAM-OFDM signal with a total bandwidth of 44.43 GHz, which corresponds to a gross bit rate of 157.46 Gbit/s (subtracting the pilot overhead) and a net rate of 131.21 Gbit/s after subtracting the FEC overhead.

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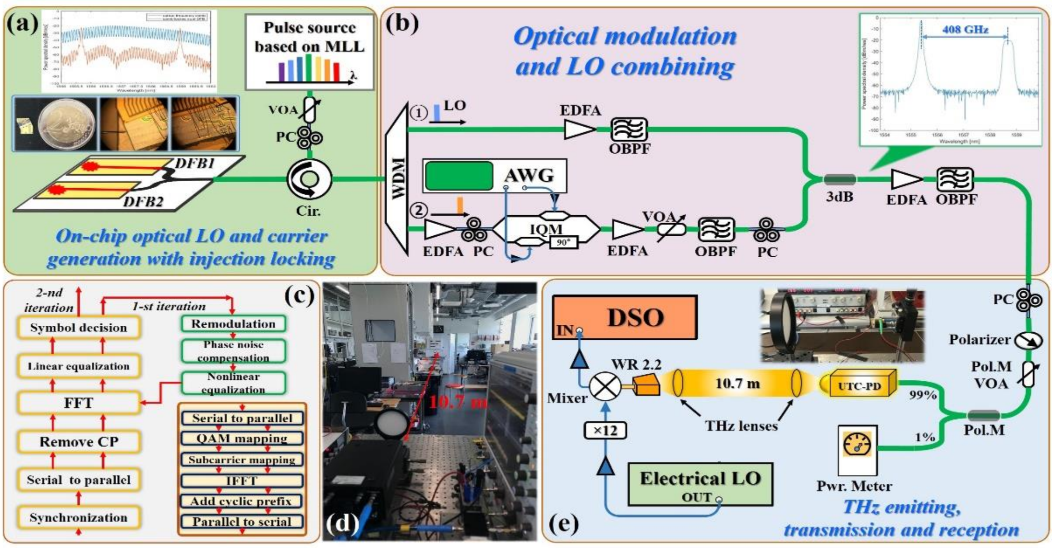

Fig. 2. Experimental configuration of 131.21 Gbit/s single-channel photonic-wireless 16-QAM-OFDM transmission system over 10.7 m: (a) On-chip optical LO and carrier generation with injection locking. (b) Optical modulation and LO combining. (c) The structure of the DSP routine. (d) The picture of the actual THz link. (e) THz emitting, transmission and reception.