50-Gbit/s Terahertz Communication using a Valley Photonic Crystal Waveguide

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Abstract— **High speed inter-chip communications are required to operate despite multiple waveguide bends. Valley photonic crystal waveguides can be implemented with near-zero losses. Here we demonstrate a 50 Gbit/s terahertz communication with a bit error rate of 2×10^{-7} using a VPC waveguide with 10 bends.**

I. INTRODUCTION

INTER-CHIP communication requires to support for high bandwidths with low-loss and low-dispersion despite the routing with several sharp bends. Terahertz communications have a potential to achieve very high throughput. However, conventional waveguides suffer from significant losses with sharp bends. Topological valley photonic crystal (VPC) waveguides has shown near-unity transmission in the photonic band-gap for sharp bends. We have demonstrated a 11 Gbit/s transmission over a 10-bend VPC waveguide using on-off keying (OOK) modulation at 0.3-THz band [1]. In this work, we investigate the potential for higher data rates using 16-level quadrature amplitude modulation (QAM-16) modulation. The VPC consisted of ten sharp bends (zero radii of curvature) that is five 120 degree and five 60 degree turns as shown in the photograph of Fig. 1(a). The VPC is made from high resistivity silicon with a thickness of 200 µm. The graphene-like periodic structure is composed from the period $a = 242.5$ µm as shown in Fig. 1(b). A unit-cell of the lattice consists of an equilateral triangle hole of edge-length $l_1 = 0.65a$ and a similar inverted equilateral triangle of edge-length $l_2 = 0.35a$ as depicted in Fig. 1(c). The communication experimental set-up is shown in Fig. 2.

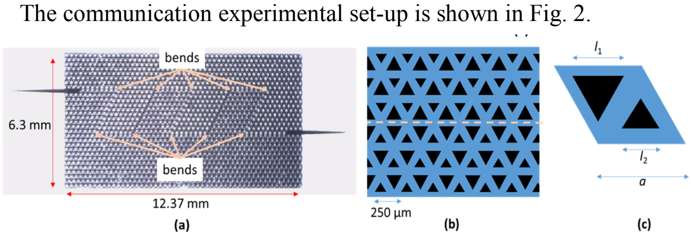

Fig. 1. VPC waveguide with 10 bends (a) photograph, (b) section schematic with waveguide (dashed line) (c) unit-cell schematic.

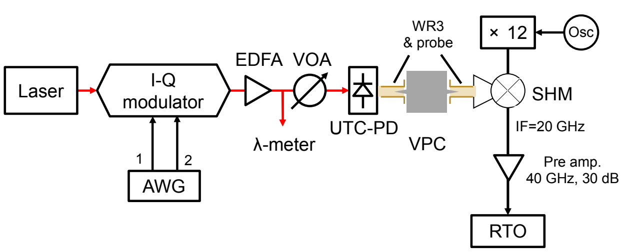

Fig. 2. Block diagram of communications experiment

Complex data signals were generated by an arbitrary waveform generator (AWG) and modulated on to a light signal using an I-Q modulator. The optical signal was then amplified by a fiber amplifier (EDFA) to about 18.5 dBm, passed through a polarization controller, voltage controlled attenuator, and THz waves generated using a uni-traveling-carrier photo-diode (UTC-PD). The 10-bend VPC was inserted between the UTC-PD and sub-harmonic mixer (SHM) receiver with WR3 hollow-waveguides and probes at each end. The SHM was pumped to operate at 317 GHz and the down-converted signal was centered at an intermediate frequency (IF) of 20 GHz. The signal was post-amplified using a 40 GHz bandwidth pre-amplifier, then converted to baseband from IF using digital signal processing software running on a real-time oscilloscope (RTO).

II. RESULTS

The error-vector magnitude (EVM) and bit error rate (BER) performance results were recorded. The EVM increased from about 4.6% to 5.3 % as the symbol rate was increased from 7.5 Gbaud to 12.5 Gbaud. The I-Q constellation for 12.5 Gbaud signaling after software equalization is shown in Fig. 3. The intensity scale provides an indication of the 3D distribution of I-Q points resulting from the collection and plotting of data from multiple frames. The highest symbol-rate was 12.5 Gbaud with QAM-16 modulation corresponding to 50 Gbit/s data-rate. This was achieved with 2×10^{-7} BER and well below the forward-error correction-recoverable rate of 2×10^{-3}. The usable bandwidth appeared limited to around 12.5 GHz and this was also consistent with the maximum data-rate achieved using OOK signaling of 11 Gbit/s in an earlier experiment [1].

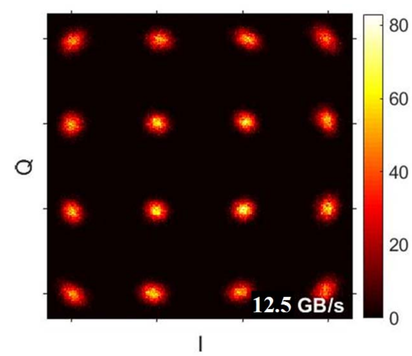

Fig. 3. Constellation diagram at 50 Gbit/s, using QAM-16 and 12.5 GBaud.

We have demonstrated that 50 Gbit/s communication at 2×10^{-7} BER can be achieved using 10-bend VPC. The usable bandwidth appeared limited to around 12.5 GHz. The future work will make efforts to increase this bandwidth.

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