



HAL
open science

200 Gbit/s terahertz tunneling demultiplexer in 300 GHz band

Daniel Headland, Withawat. Withayachumnankul, Masayuki. Fujita, Tadao Nagatsuma, Pascal Szniftgiser, Guillaume Ducournau

► **To cite this version:**

Daniel Headland, Withawat. Withayachumnankul, Masayuki. Fujita, Tadao Nagatsuma, Pascal Szniftgiser, et al.. 200 Gbit/s terahertz tunneling demultiplexer in 300 GHz band. 2023 48th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), Sep 2023, Montreal, Canada. pp.1-2, 10.1109/IRMMW-THz57677.2023.10299212 . hal-04277435

HAL Id: hal-04277435

<https://hal.science/hal-04277435>

Submitted on 23 Nov 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

200 Gbit/s terahertz tunneling demultiplexer in 300 GHz band

Daniel Headland^(1,2), Withawat. Withayachumnankul⁽³⁾, Masayuki. Fujita⁽²⁾, Tadao Nagatsuma⁽²⁾, Pascal Szriftgiser⁽⁴⁾ and Guillaume. Ducournau^(5*)

¹Optoelectronics and Laser Technology Group, Department of Electronics Technology, Universidad Carlos III de Madrid, 28911 Leganés, Spain

²Graduate School of Engineering Science, Osaka University, 560-8531 Toyonaka, Japan

³Terahertz Engineering Laboratory, The University of Adelaide, SA 5005, Australia

⁴PhLAM Laboratoire de Physique des Lasers, Atomes et Molécules, 59650 Villeneuve d'Ascq, France

⁵Univ. Lille, CNRS, Centrale Lille, ISEN, UPHF, UMR 8520 - IEMN, F-59652 Villeneuve d'Ascq, France.

*Email: guillaume.ducournau@univ-lille.fr

Abstract—We showcase here the experimental demonstration of demultiplexing terahertz channels with up to 200 Gbit/s aggregated data-rate, using 4 carrier frequencies. The demonstration is carried out in the 300 GHz band. Best error vector magnitude obtained values are in the range 6-9%, with 50 Gbit/s per channel, enabled by a recently-reported novel substrateless integrated passive demultiplexer, which was developed specifically to serve the particular requirements of terahertz waves.

I. INTRODUCTION

Terahertz (THz) technology is receiving rapidly increasing attention for an envisioned application in the communications field. Specifically, the frequency range around 300 GHz is very attractive from a good compromise of technology performance and atmospheric window between 250 and 320 GHz. Significant advances have been achieved for transmitters, receivers and related lab demonstrations. Among the multiple challenges of THz communications [1], passive functions as filtering, multiplexer/demultiplexer, duplexing, antennas are also mandatory to consider. Here we showcase the use of a recently developed THz multiplexer [2] in the 300 GHz band, thoroughly characterize its frequency differentiation and dispersion properties, and demonstrate that it is able to support a 4-channels signal with 200 Gbit/s aggregated data-rate.

II. TRANSMISSION AND DISPERSION ANALYSIS

The THz demux deployed here is described in detail in [2]. This device is implemented in a broadband substrateless all-silicon platform that offers freedom to define arbitrary guide curvatures [3], which the demux exploits for tailored wave-tunneling from a curved guide into an adjacent slab in order to achieve a frequency-scanning focused beam. The demux is shown in the Fig. 1.

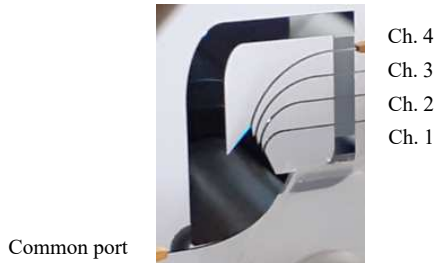


Fig. 1. Photograph of the 4 channel tunneling demultiplexer.

The demux is incorporated in two THz testbeds. The first one is used to measure the transmission characteristics and the dispersion characteristics using a set of 2 frequency extenders coupled to vector network analyzer (VNA). In this case,

injection is done at the common port, and signal is extracted from each individual channel port. The measured transmission characteristics are shown in Fig. 2.

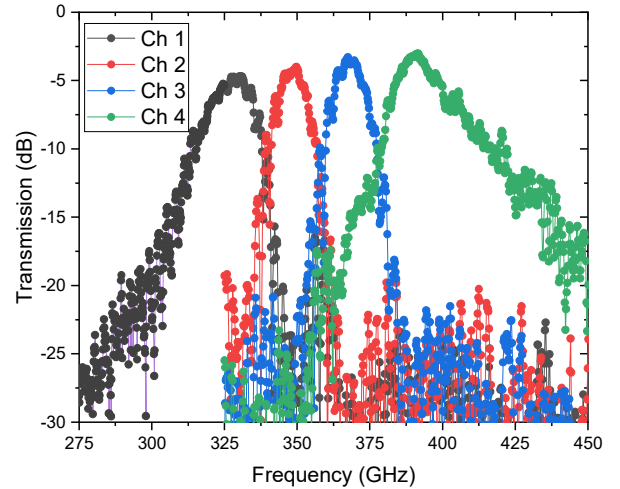


Fig. 2. Transmission characteristics of the THz demultiplexer. VNA measurement is done in the 220-325 GHz/325-500 GHz bands (CH1), and 325-500 GHz band for CH2-4.

The 4 channels were well identified, and centered at 330, 350, 370 and 390 GHz. One important feature is also a flat group delay (GD) performance of the device, which is of critical importance to avoid signal degradation due to dispersion. An example (channel 2) is shown in Fig. 3, and the flat GD in-band is clearly visible.

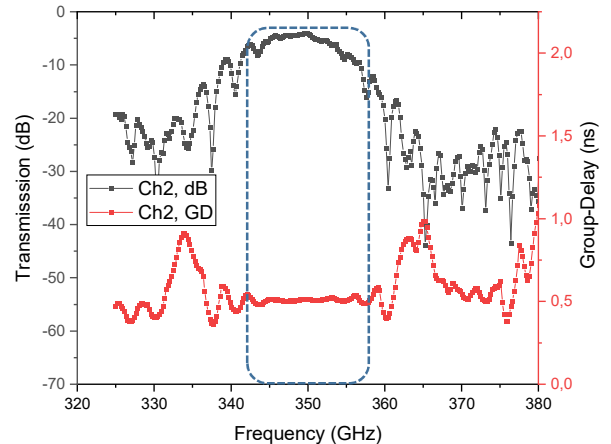


Fig. 3. Transmission characteristics of the 350 GHz channel and measured group delay, found to be flat and close to 0.51 ns.

III. THZ COMMUNICATION DEMONSTRATION

The THz demultiplexer was then tested in a data communication setup. A 16-QAM with 12.5 GBaud was successfully transmitted in all the channels, resulting in a $4 \times 50 = 200$ Gbit/s aggregated data-rate. The constellations for the reference and transmitted 16-QAM signals are shown in Fig. 4, and a clearly defined pattern of symbols can be observed, and corresponding EVM for all channels, in the range 5.6~8.5%.

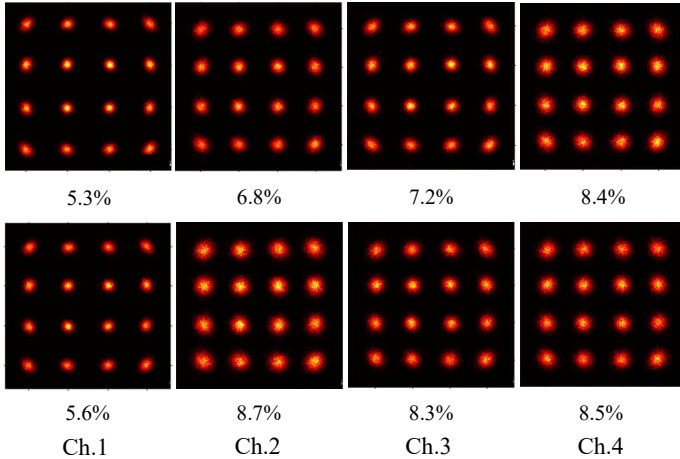


Fig.4 16-QAM transmission in all channels (up: references, down, after demultiplexing).

The Fig. 5 shows the EVM evolution with the relative received power, corresponding to the lowest EVM obtained for the channel 1 (329 GHz).

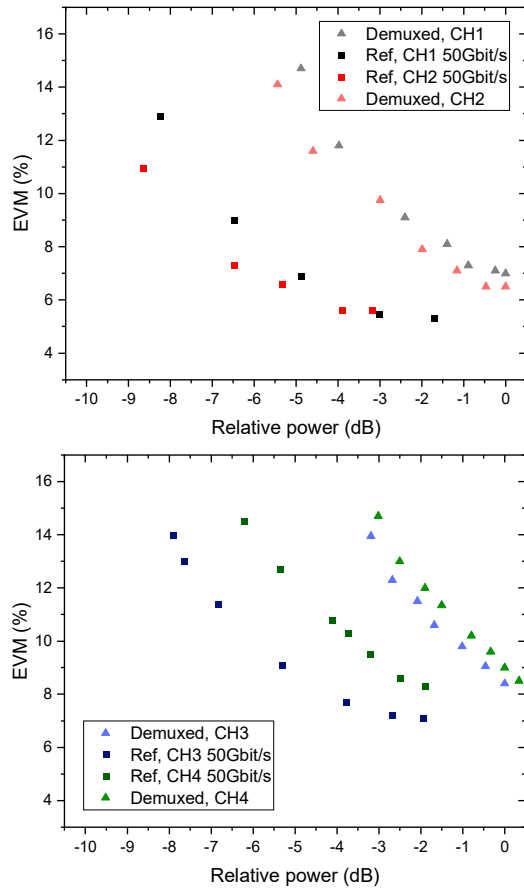


Fig.5 EVM performances curves for all channels.

IV. CONCLUSION

We have thoroughly characterized the transmission and dispersion of a recently reported passive four-channel terahertz demux [2]. The device is shown to support an aggregate data rate of 200 Gbit/s using a 16-QAM modulation format. This clearly illustrates the potential for practical applications of terahertz waves. The channel characteristics will be shown in greater detail at the conference.

ACKNOWLEDGMENT

The characterization work conducted at IEMN, France, was supported by the ‘Contrat de Plan Etat Region’ (CPER) WAVETECH @HdF project and Haut-de-France Regional council, IEMN UHD flagship project, and MEL-I-site TERIL-WAVES project. The characterization testbed are also supported by the PEPR project ‘FUNTERA’ funded by ANR (Agence Nationale de la Recherche) and France 2030, grant ANR-22-PEEL-0006, dedicated to THz converters.

REFERENCES

- [1] H. -J. Song and N. Lee, "Terahertz communications: challenges in the next decade," *IEEE Trans. THz Science and Tech.*, vol. 12, no. 2, pp. 105-117 (2022), doi: 10.1109/TTHZ.2021.3128677.
- [2] Daniel Headland, Withawat Withayachumnankul, Masayuki Fujita, and Tadao Nagatsuma, "Gratingless integrated tunneling multiplexer for terahertz waves," *Optica* 8, 621-629 (2021).
- [3] D. Headland, W. Withayachumnankul, X. Yu, M. Fujita and T. Nagatsuma, "Unclad Microphotonics for Terahertz Waveguides and Systems," in *Journal of Lightwave Technology*, vol. 38, no. 24, pp. 6853-6862, 15 Dec.15, 2020, doi: 10.1109/JLT.2020.3021681.