3D-printed terahertz integrated circuits for upcoming 6G communications

Babak Yahyapour[1], Roya Gachiloo[1], Frederique Marcotte[2], Maksim Skorobogatiy[1]

[1]*Department of Engineering Physics, École Polytechnique de Montréal, Montreal, QC H3T 1J4, Canada.*
[2]*Department of Electrical Engineering, Université Laval, Quebec City, QC G1V 0A6, Canada.*

Abstract: This study investigates the 3D printed demultiplexer by air-core grating couplers to be used in integrated photonic circuits for THz communications. To fabricate the devices, a dual-nozzle 3D printer, capable of simultaneous printing with filaments of varying sizes is utilized with larger filaments for waveguides and couplers and smaller ones for high-quality fiber Bragg gratings. Finite element numerical modeling is employed to optimize integrated circuits for operation within the 120-165 GHz frequency band. The experimental results show that fabricated devices offering significant potential for the development of linear optic transformers which are key components for energy-efficient analog data processing in forthcoming terahertz communication systems.

Proposed Experimental setup

The demultiplexer were optically characterized by an optics-based THz communication system.

In the experiments, the THz carrier wave in the 120 – 165 GHz spectral range was generated by an optical photomixer (Model: IOD-PMD-14001from NTT Electronics Inc):

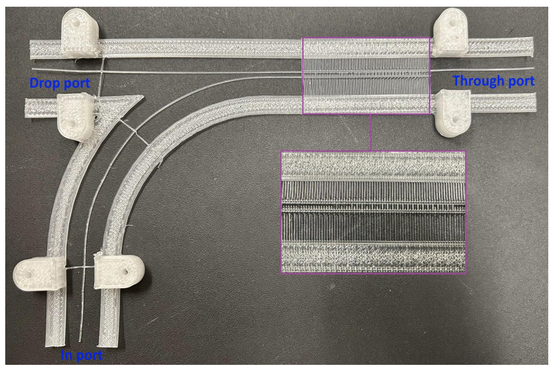

Fig. 1: 3D printed of a demultiplexer. Inset: a zoom on a grating section

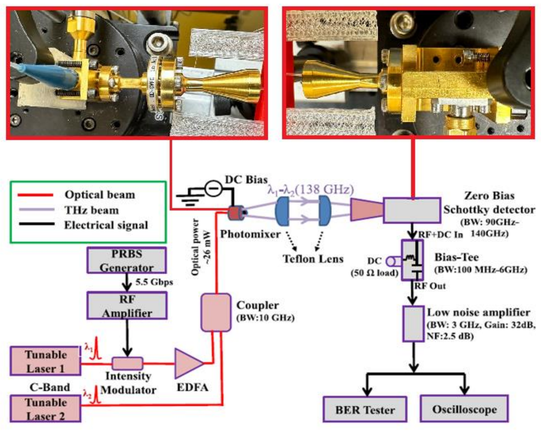

Fig. 2: Schematic of the photonics-based THz wireless communication system

Result and Conclusion

Air-core grating couplers demonstrate numerous advantages for THz circuit development, facilitating efficient demultiplexing within wavelength division multiplexing (WDM) systems.

Our study indicates that employing THz filters presents several advantages for the advancement of THz circuits.

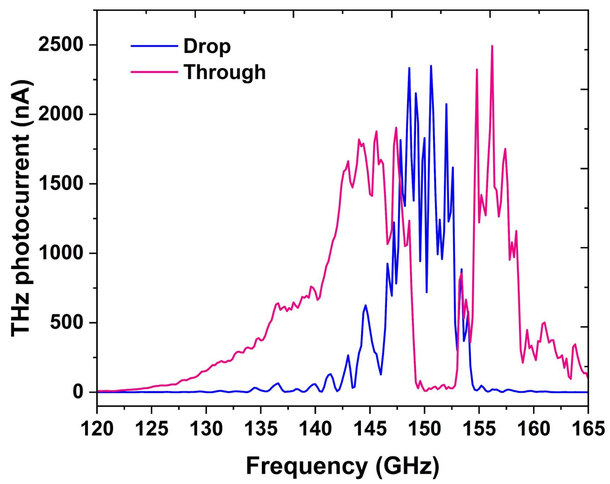

Fig. 3: Experimental drop and transmission spectra of the demultiplexer

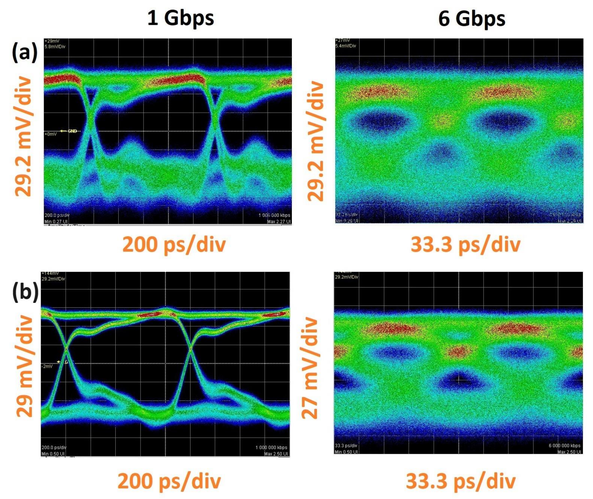

Fig. 4: Measured Bit Rate and the corresponding eye diagrams of the Demultiplexer (a) eye pattern of a Drop port with carrier at 145.61 GHz (b) eye pattern of a Through port with carrier at 149.92 GHz

The experimental results show that fabricated devices offering significant potential for the development of linear optic transformers which are key components for energy-efficient analog data processing in forthcoming terahertz communication systems.

References:

1. Xu, Guofu, and Maksim Skorobogatiy. "3D printing technique and its application in the fabrication of THz fibers and waveguides." Journal of Applied Physics 133, no. 21 (2023).
2. Cao, Yang, Kathirvel Nallappan, Guofu Xu, and Maksim Skorobogatiy. "Add drop multiplexers for terahertz communications using two-wire waveguide-based plasmonic circuits." Nature Communications 13, no. 1 (2022): 4090.