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We2B-4

An 80 Gbps QAM-16 PMF Link Using a 130 nm SiGe BiCMOS Process

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Outline

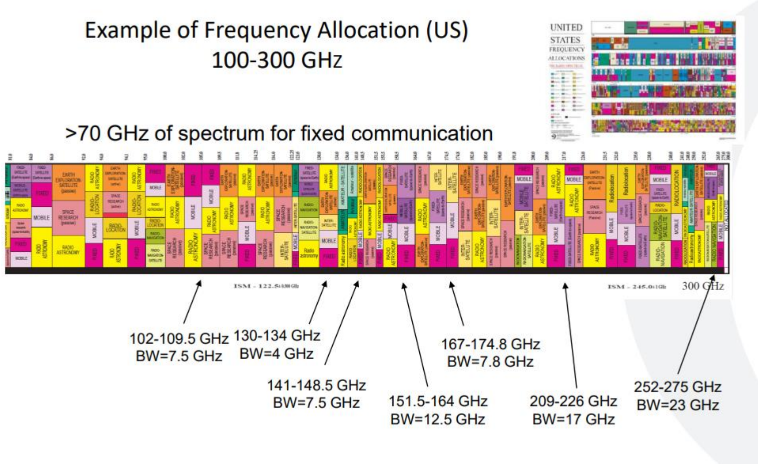
- Motivation
- Overview of the Link
- Results
- Comparison with similar work
- Conclusion

Motivation

- Why do we need high data rate short distance communication?
  - Chip-to-chip, module-to-module
  - In-cabin vehicle communication and sensor co-operation
  - Intra-box in base-stations and data centers

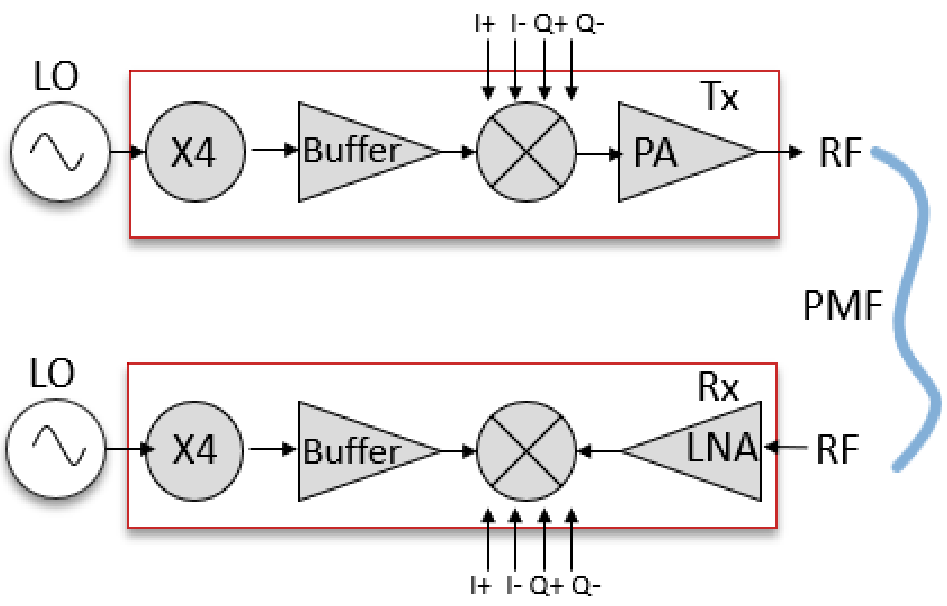
Motivation

- Why use a polymer microwave fiber (PMF)?



Overview of the PMF Link

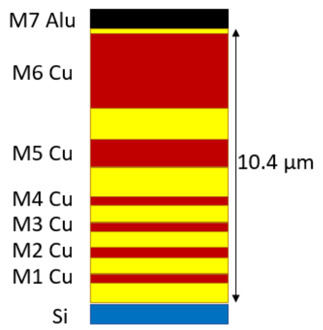
- Double-balanced Gilbert cells mixers
- Off-chip LO supplied to 2 cascaded frequency doublers
- Wideband amplifiers
  - 6-stage common emitter (Tx)
  - Balanced 2-stage cascode (Rx)
- Off-chip LO supplied to 2 cascaded frequency doublers
- 2- and 4-meter foam-cladded PMF with a 2.1 mm x 1.2 mm rectangular PTFE core (H+S)

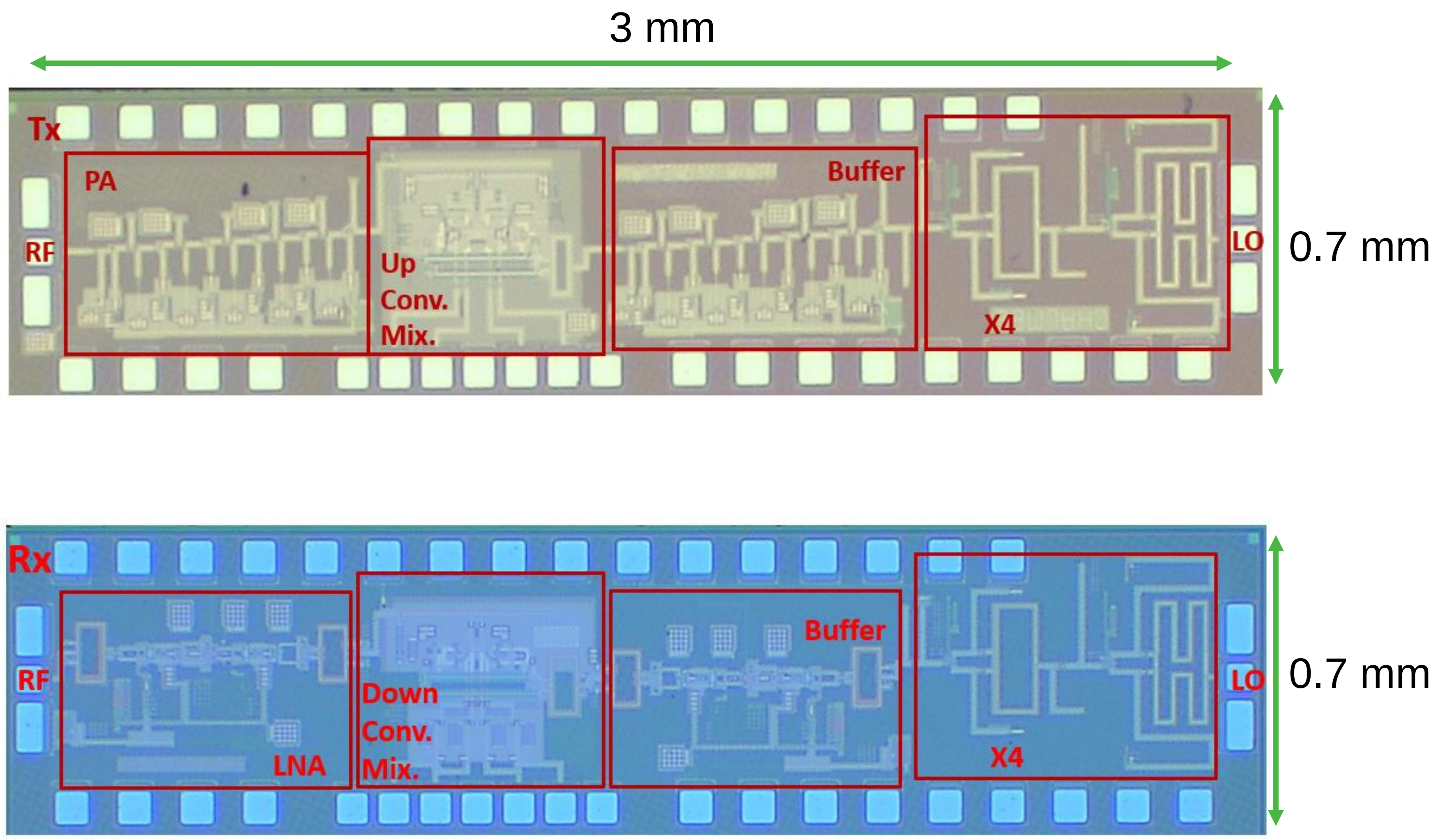


Layout of Tx and Rx

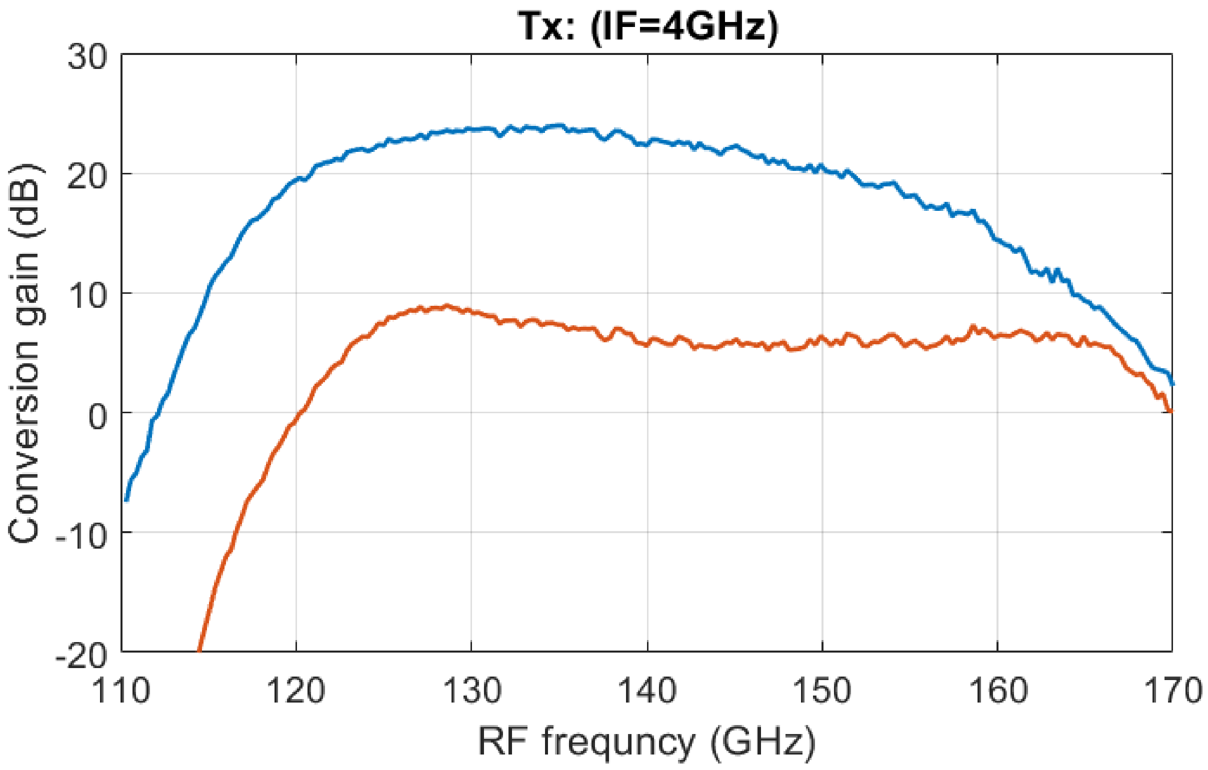
130 nm SiGe BiCMOS process by Infineon

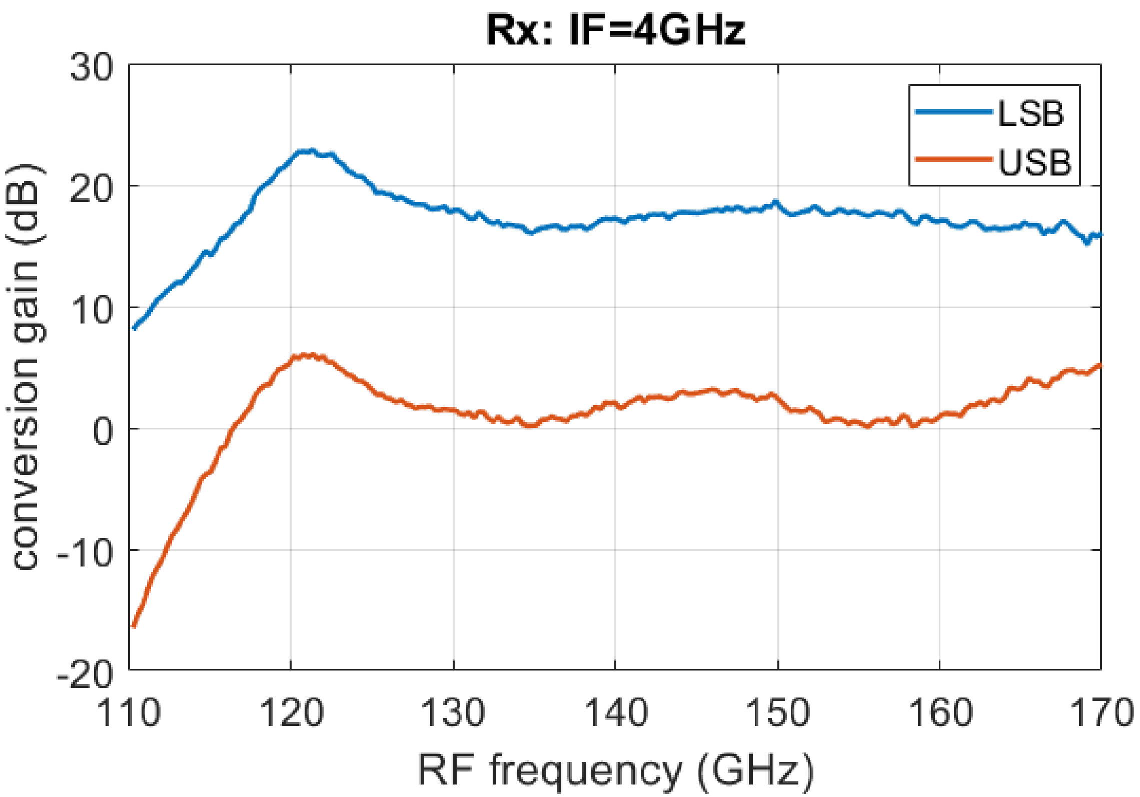
f_t / f_{max} of 250/370 GHz





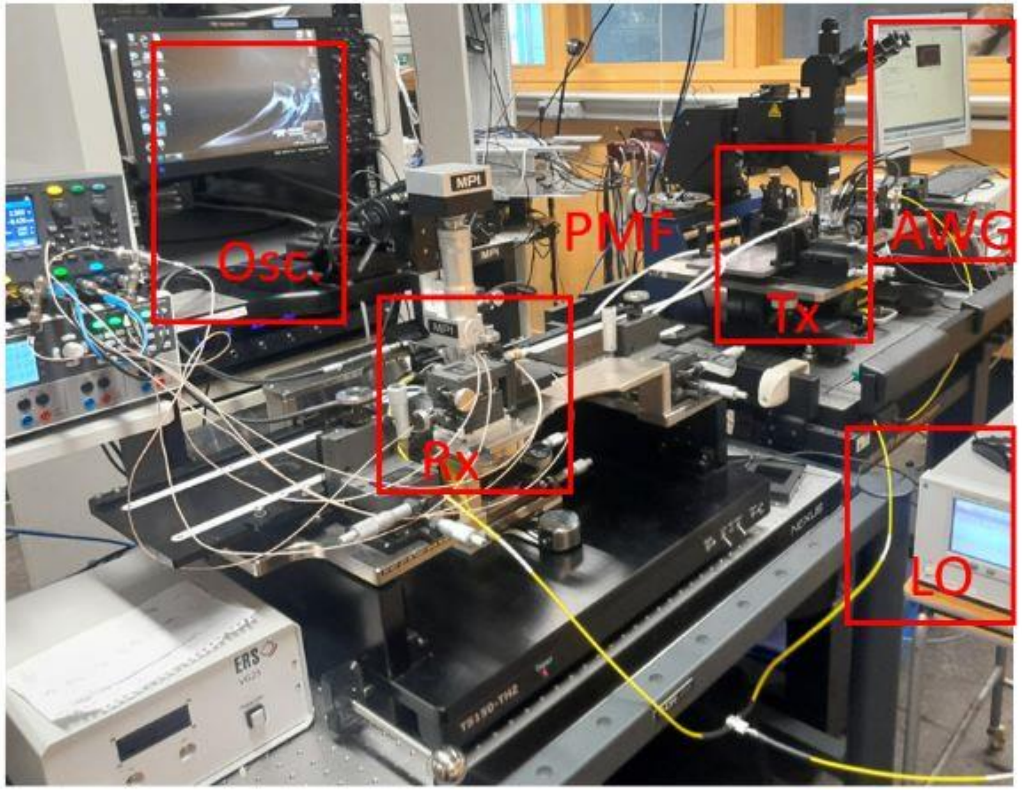
Frequency domain measurements





Link measurement setup

- On-wafer using 2 probe stations
- Data provided by an AWG to Tx
  - Direct modulation
- Output from Rx captured by an oscilloscope
- 2- and 4-meter long PMF connecting the Tx and Rx RF probes through a waveguide adaptor



Measurement setup limited to 18 GHz bandwidth for data due to cables and probes

2 meter PMF link demonstration

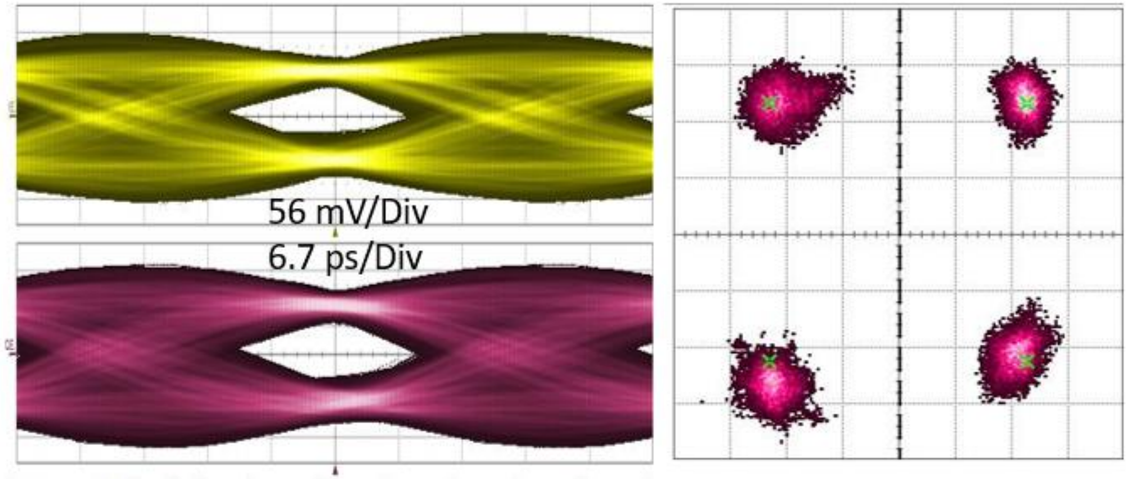
Received eye diagram and I/Q constellation

LO at 148 GHz

24 Gbd = 48 Gbps

QPSK

BER<10^{-12}

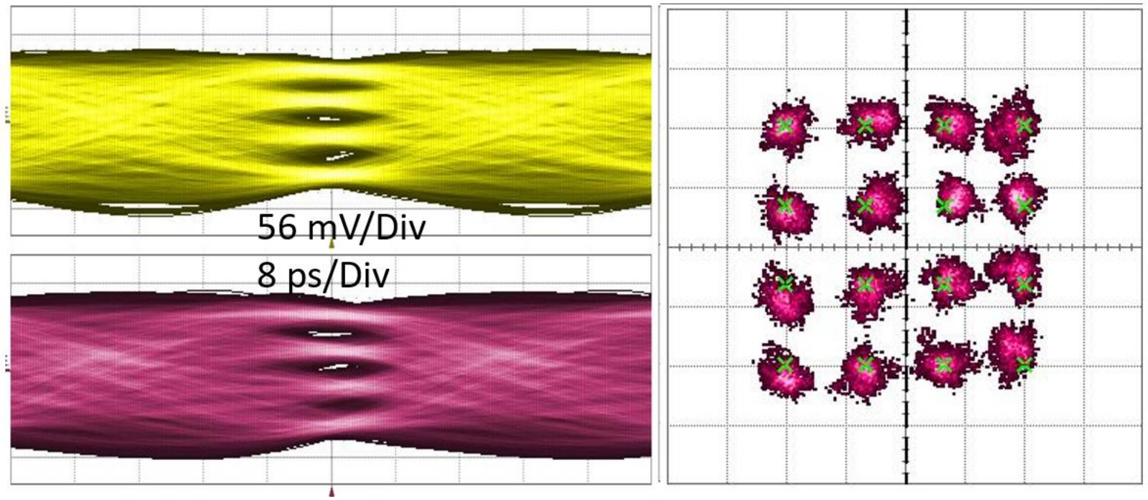


LO at 148 GHz

20 Gbd = 80 Gbps

QAM-16

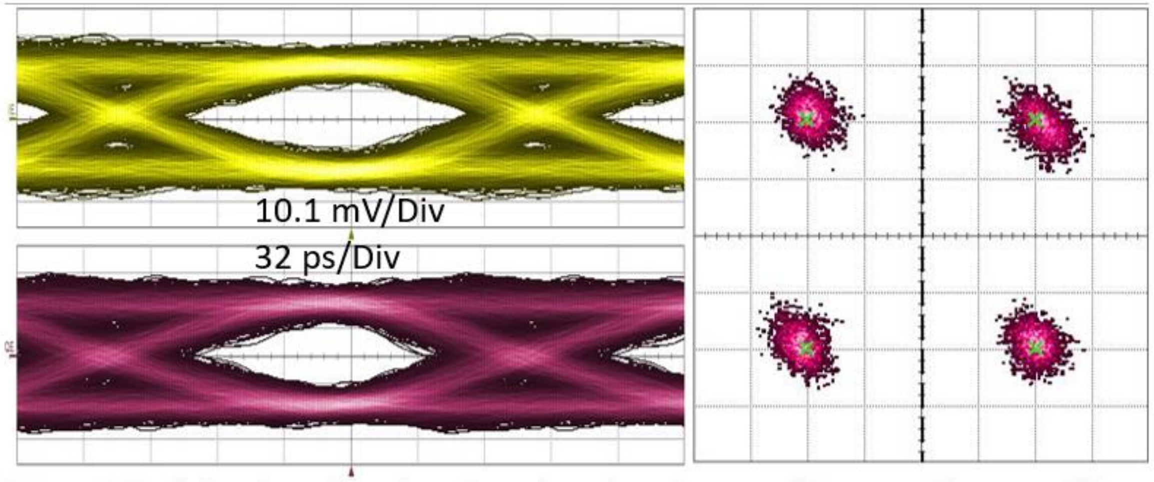
BER=8×10^{-4}



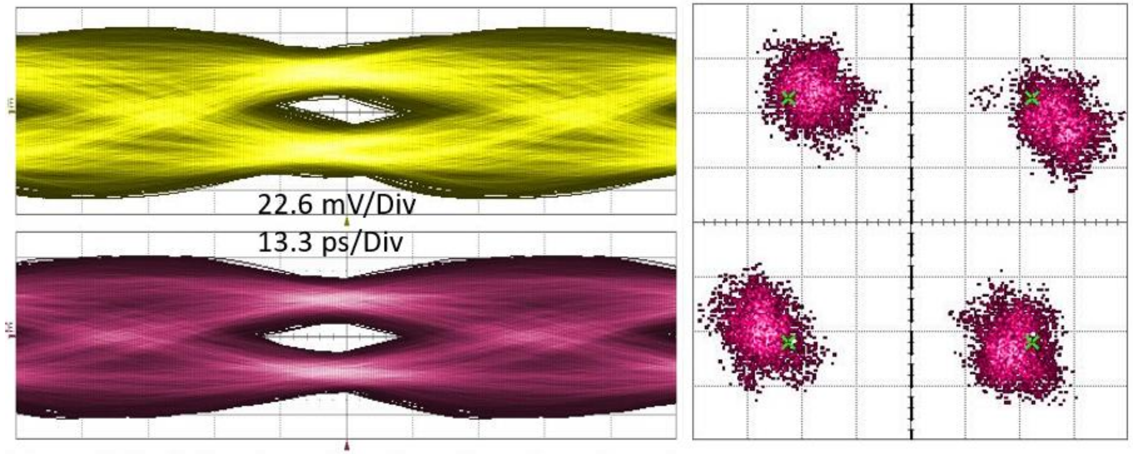
4 meter PMF link demonstration

Received eye diagram and I/Q constellation

LO at 148 GHz
5 Gbd = 10 Gbps
QPSK
BER<10^{-12}



LO at 148 GHz
12 Gbd = 24 Gbps
QPSK
BER=$8x10^{-6}$



Comparison with similar work

Table 1. Comparison with other D-band PMF links, with BER $< 10^{-12}$.

Reference	[4]	[5]	[7]	**[this work]**
Technology	28 nm CMOS	28 nm CMOS	250 nm InP DHBT	**130 nm BiCMOS**
Modulation	CP-FSK	ASK	PAM-2	**QPSK**
Frequency (GHz)	140	135	131	**148**
Data Rate (Gbps)	12	27	30	**48**
Fiber Length (m)	1.0	1.0	1.0	**2.0**
Total chip area (mm^2)	2.31	1.94	0.83	**4.2**
Peak output power (dBm)	6	-3	3	**5**

[4] M. De Wit, Y. Zhang, P. Reynaert, "Analysis and Design of a Foam-Cladded PMF Link With Phase Tuning in 28-nm CMOS", *IEEE Journal of solid-state circuits*, vol. 54, no. 7, pp. 1960-1969, July 2019.
[5] K. Dens, J. Vaes, S. Ooms, M. Wagner and P. Reynaert, "A PAM4 Dielectric Waveguide Link in 28 nm CMOS", *ESSCIRC 2021 - IEEE 47th European Solid State Circuits Conference (ESSCIRC)*, pp. 479-482, 2021.
[7] F. Strömbeck, M. Bao, Z. S. He, and H . Zirath,"Transmitter and Receiver Circuits for a High-Speed Polymer Fiber-Based PAM-4 Communication Link", *Sensors*, vol. 22, no. 17.

Conclusion

- A high data rate short distance PMF link at D-band in 130 nm SiGe BiCMOS
- Highest error free (BER<10^{-12}) data rate demonstrated compared to other D-band PMF links (48 Gbps)
- 4-meter PMF link demonstrated with 10 Gbps error free