High symbol rate transmissions with SiP modulators

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MOPA Workshop, ECOC2024, September 22, 2024

Outline

- State-of-the-art
- Key components
- Experimental setups
- Measurement results
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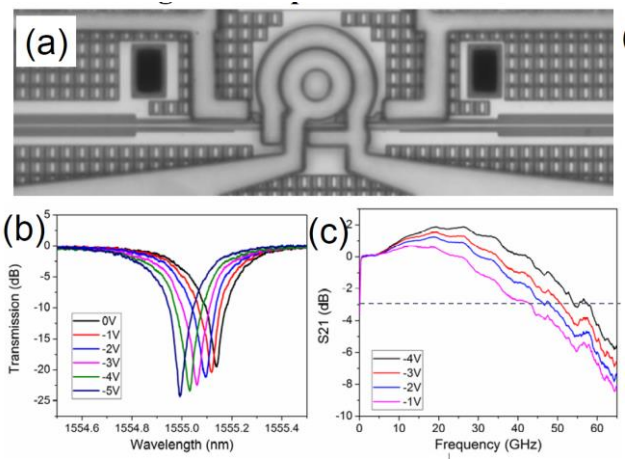
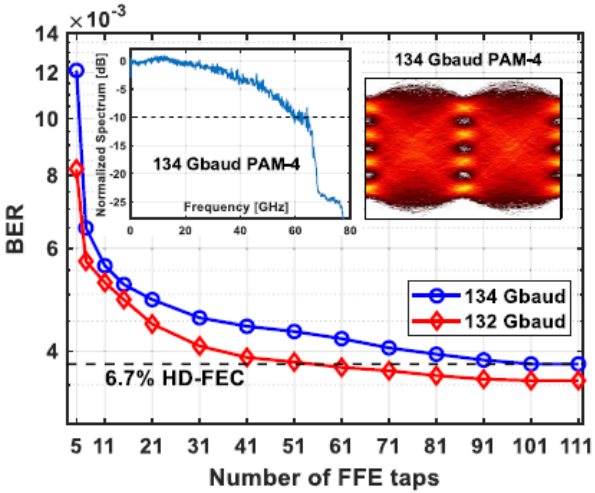
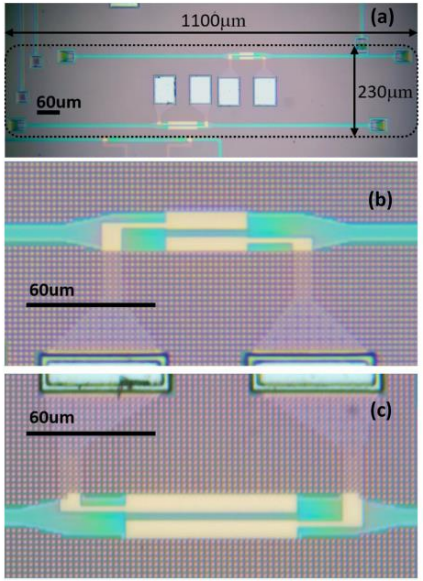
SOTA on SiP modulators



Tun-Yao Hung, et al., 300Gbit/s Si MRM, OFC 2024, W4H.4



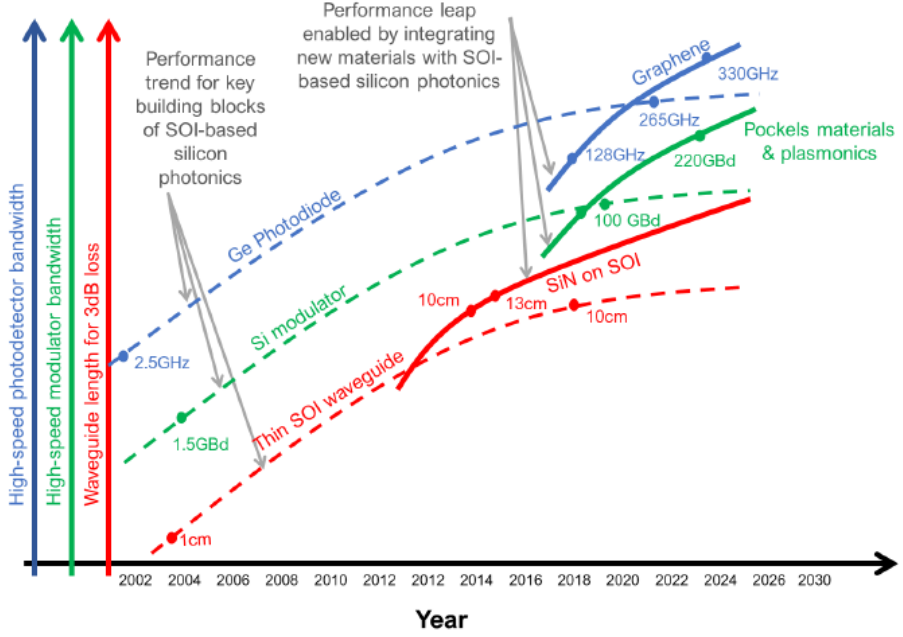
Md Samiul Alam, et al., 300Gbit/s Si MZM, IEEE Photonics Technology Letters, 2021



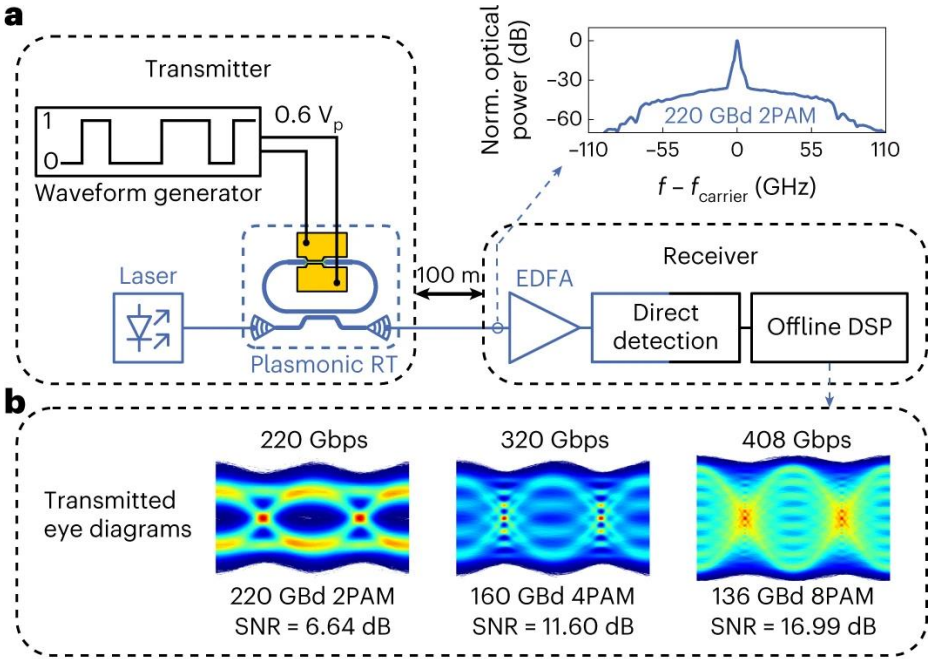
David W. U. Chan, et al., 224Gbit/s SiGe EAM, Journal of Lightwave Technology, 2022

SOTA on heterogenous integration

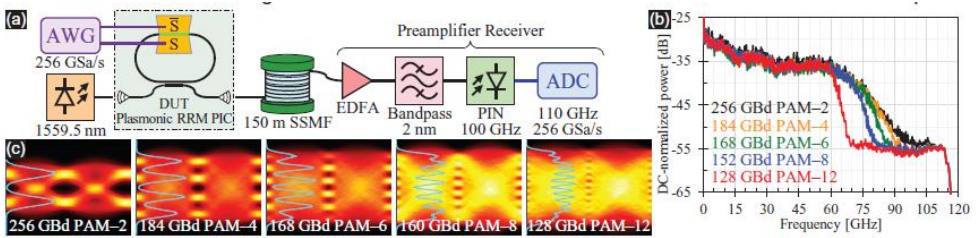
R. Baets, et al., Optical Materials Express, Dec. 2023



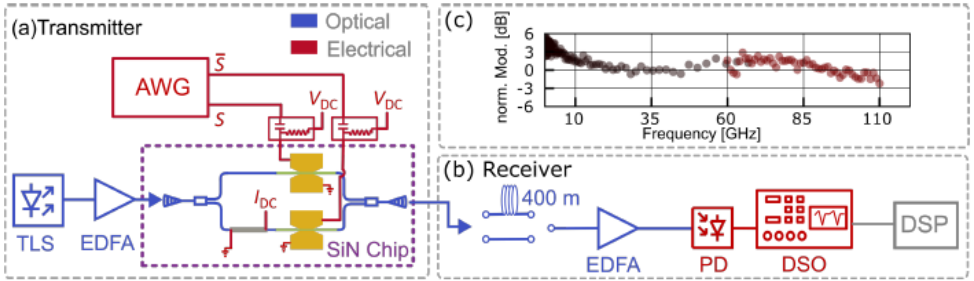
M. Eppenberger, et al., Nat. Photonics, 2023.



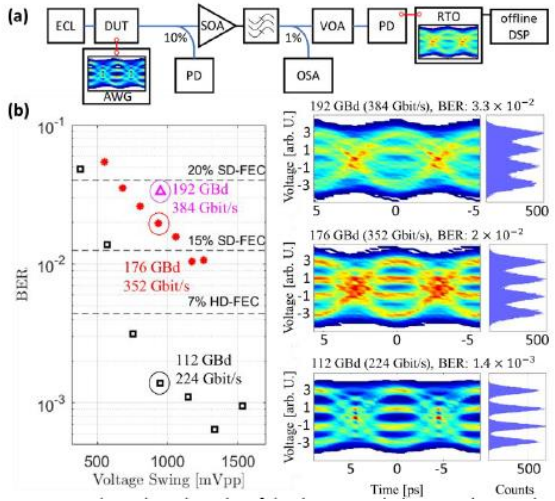
SOTA on heterogenous integration



Qian Hu, et al., 373 Gbit/s Plasmonics RRM,
ECOC 2023, Th4B.6

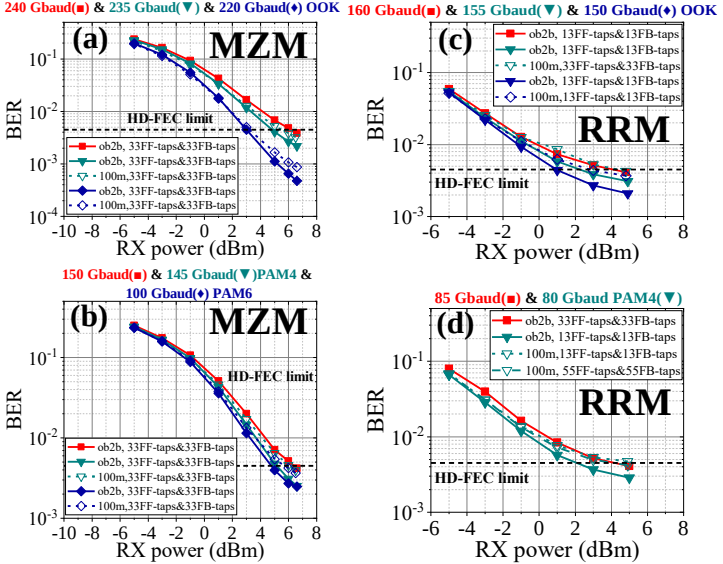


Manuel Kohli, et al., 340 Gbit/s BTO MZM,
OFC 2024, M3K.5

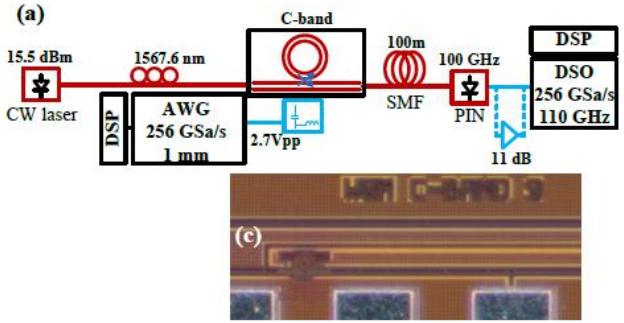


A. Schwarzenberger, et al., 384Gbit/s SOH MZM, OFC 2024, Th4B.6

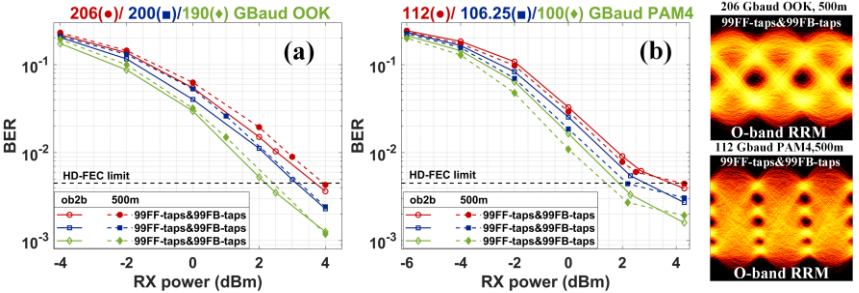
Our contributions to SOTA



A.Ostrovskis, et al., 300/160 Gbit/s Si MZM/RRM, SiPhotonics 2023, PD.3



A.Ostrovskis, et al., 280 Gbit/s Si C-band RRM, Advanced Photonics Congress 2024



A.Ostrovskis, et al., 224 Gbit/s Si O-band RRM, CLEO-PR 2024

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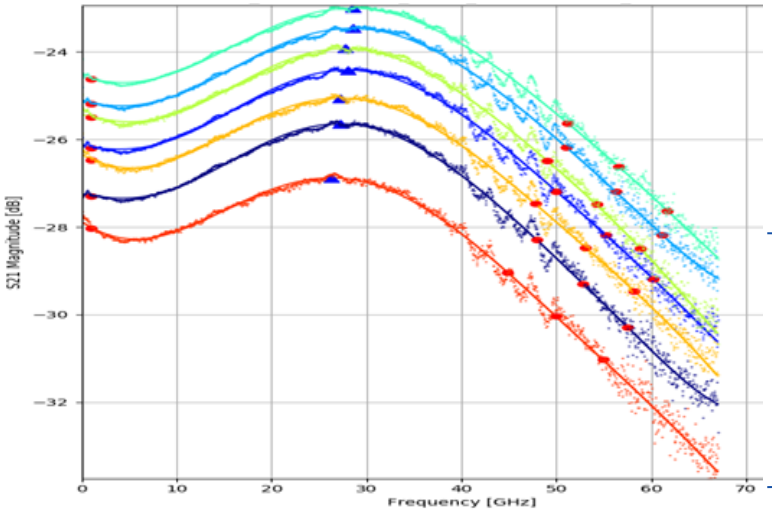
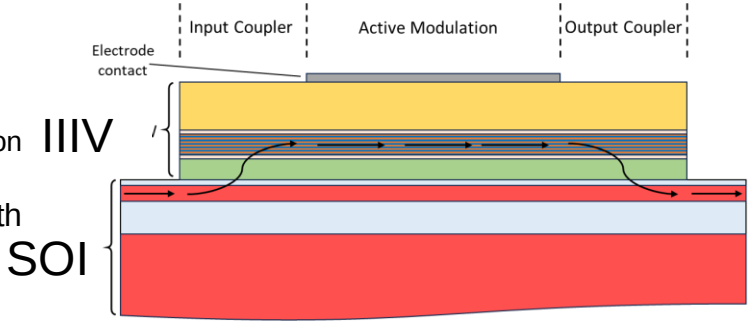
Heterogenous IIIV EAM on Silicon

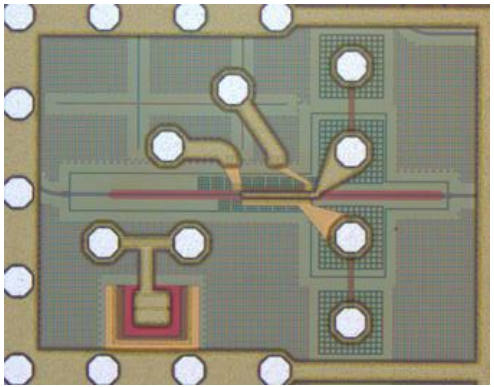
- IIIV-EAM on Silicon fabricated at Tower Semiconductors
  - Design available in open market PDK
  - PDK/Process also includes integrated IIIV lasers and full suite of silicon photonics components
- EAM designed for either single ended or differential drive, with on-PIC resistive and inductive termination
- EAM bandwidth >60GHz



Different bias values



Schematic cross-section of IIIV on Si



Optical image of fabricated EAM on Si

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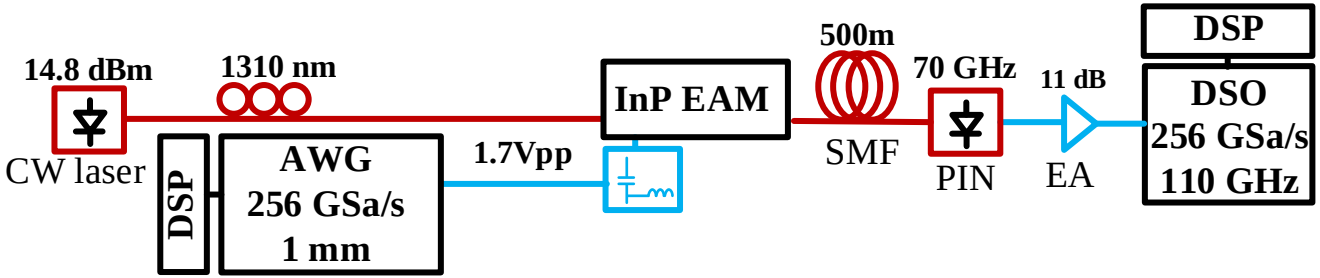
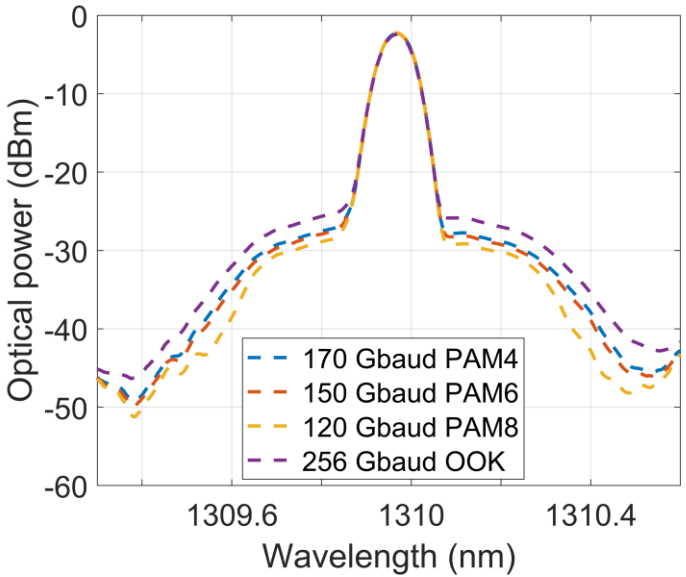
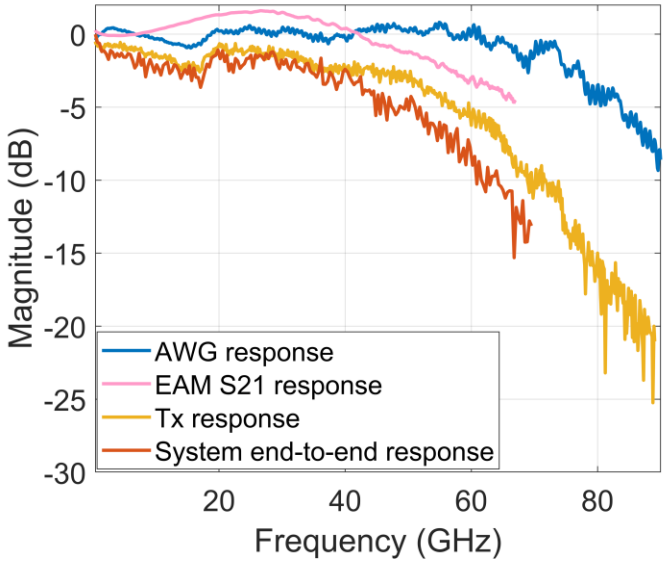
Experimental setup







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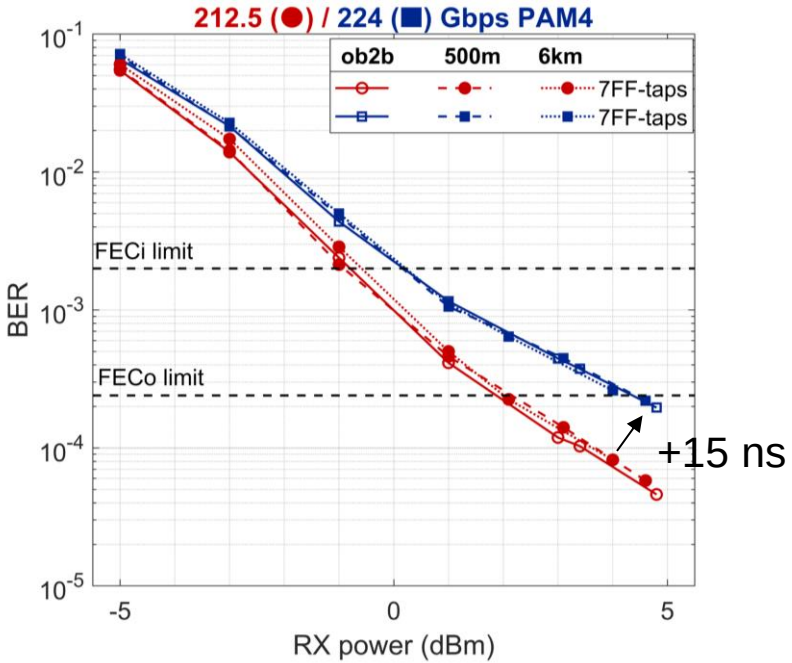
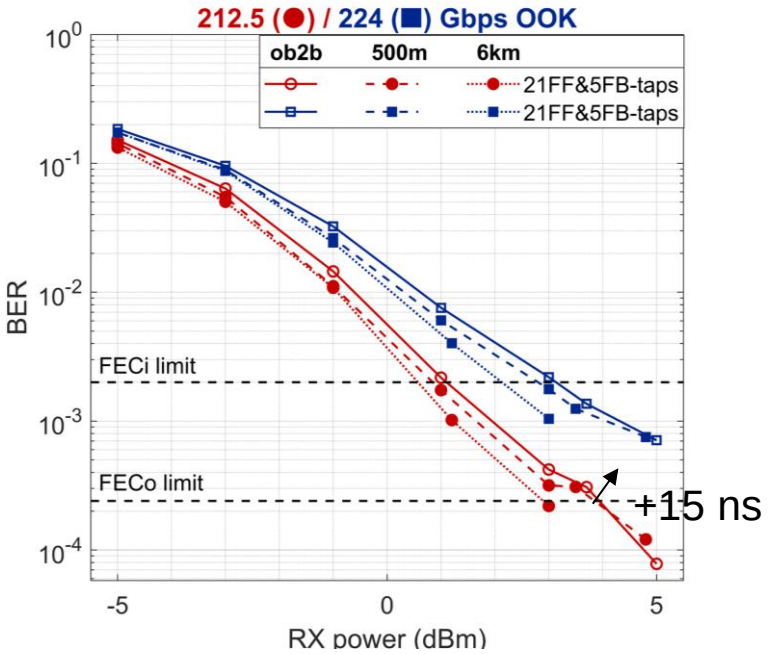
200 Gb/s per lane investigation





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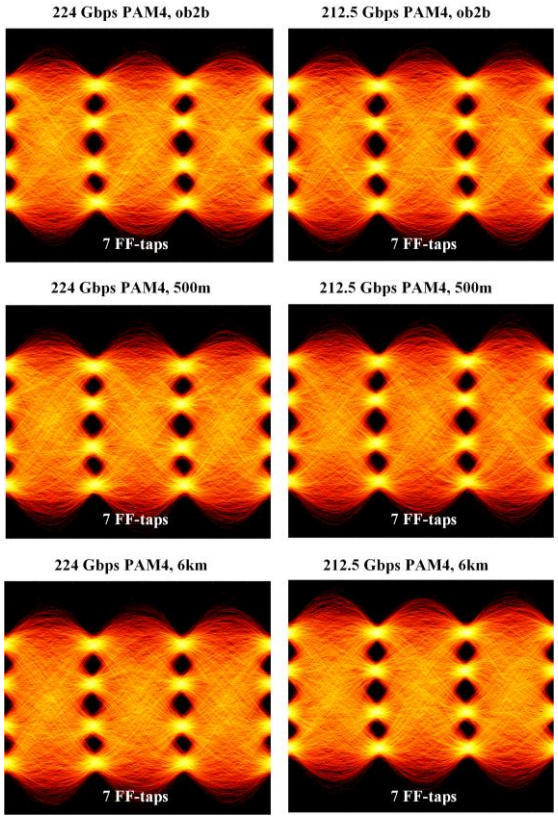
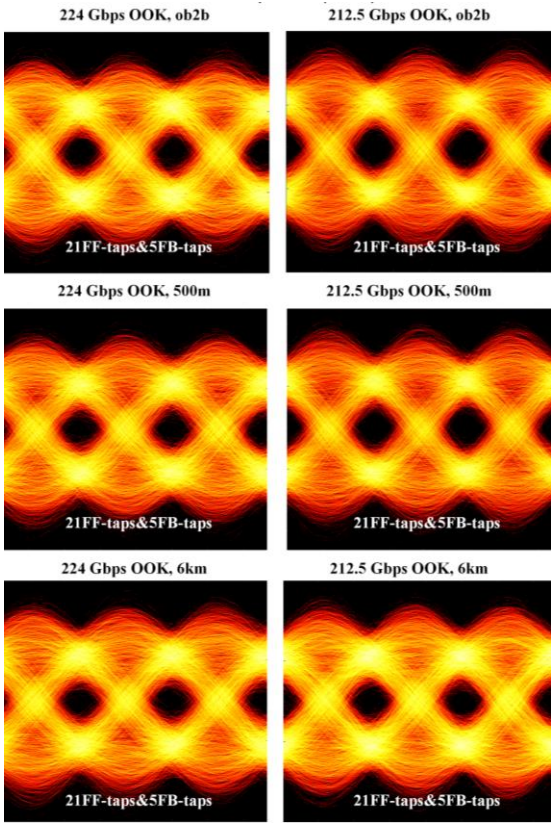
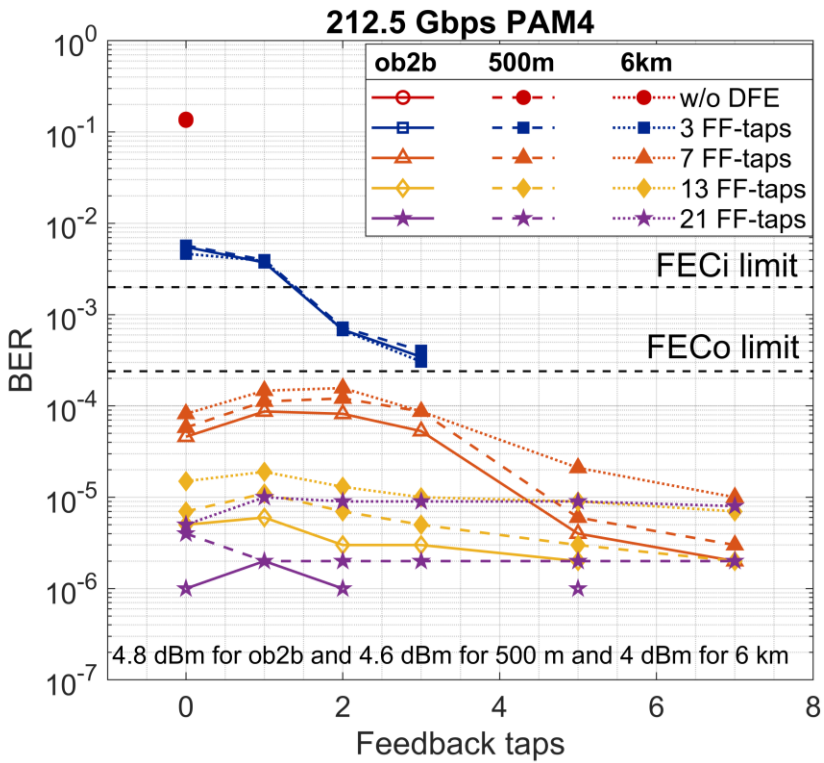
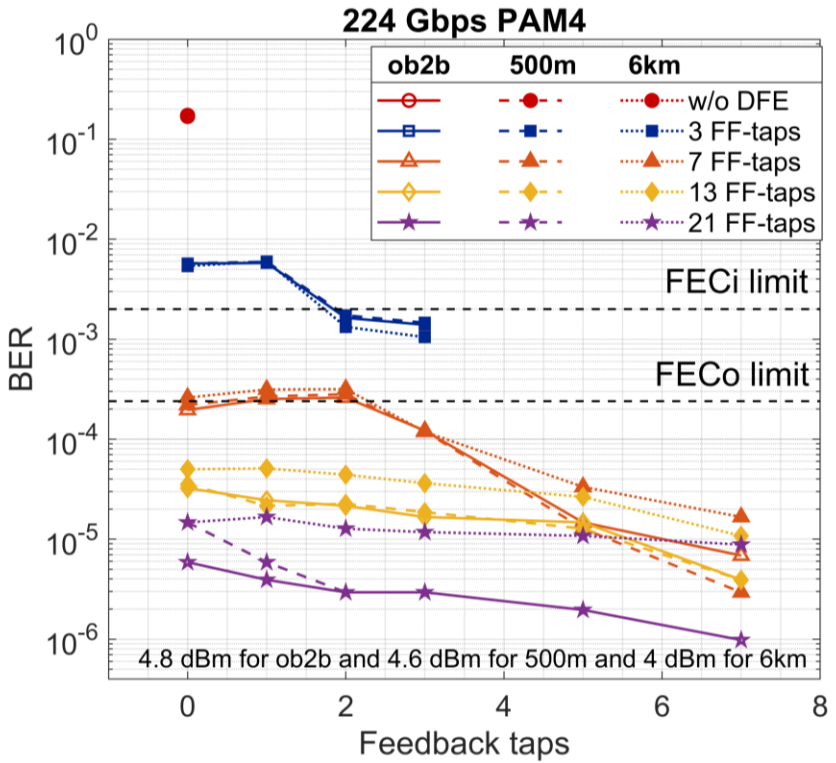


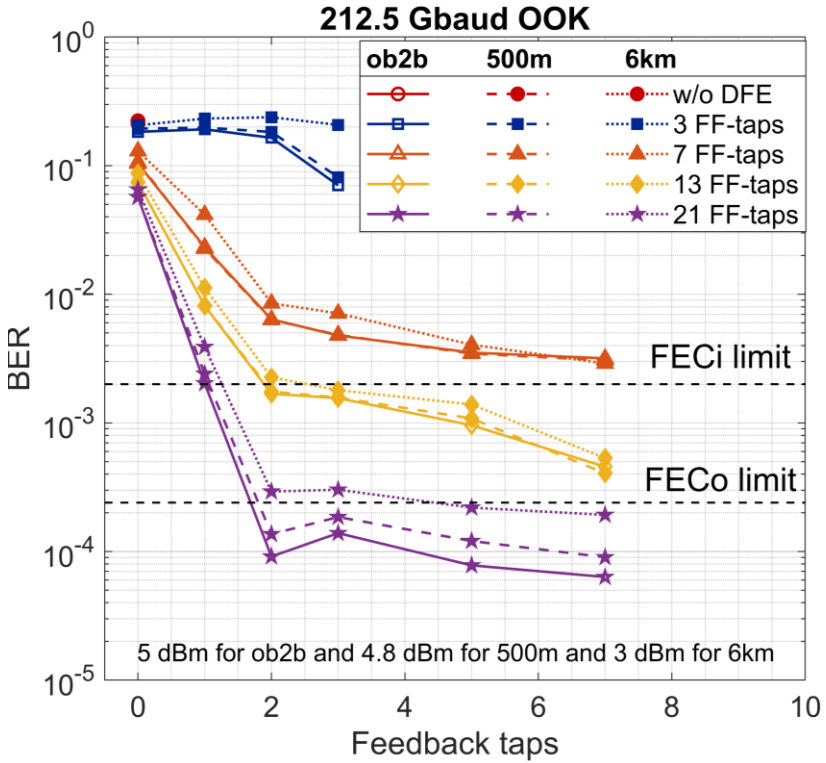


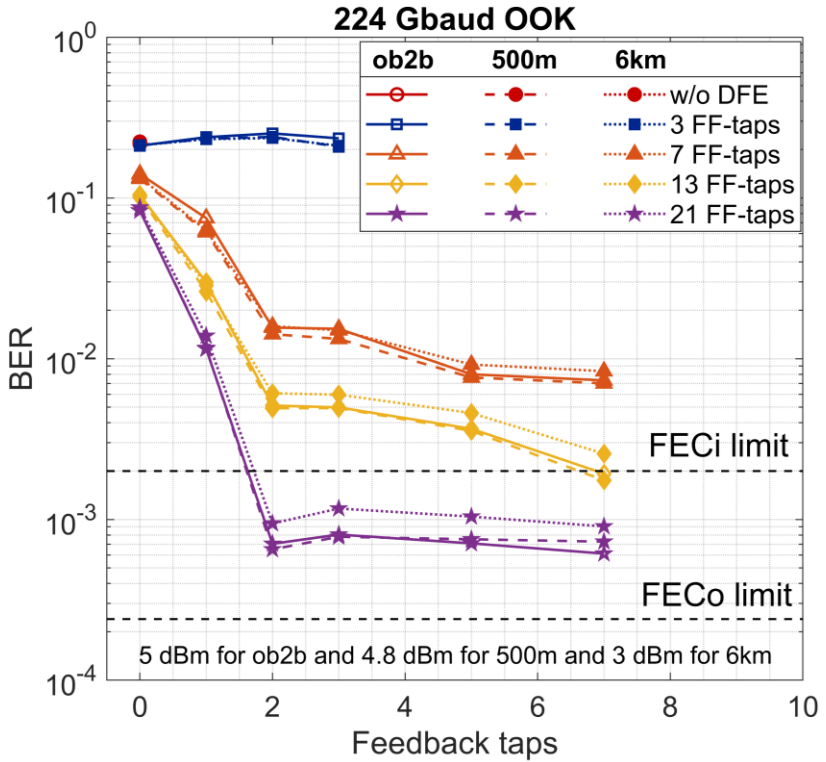
212.5 Gbps vs 224 Gbps PAM4 DFE





212.5 Gbps vs 224 Gbps OOK DFE





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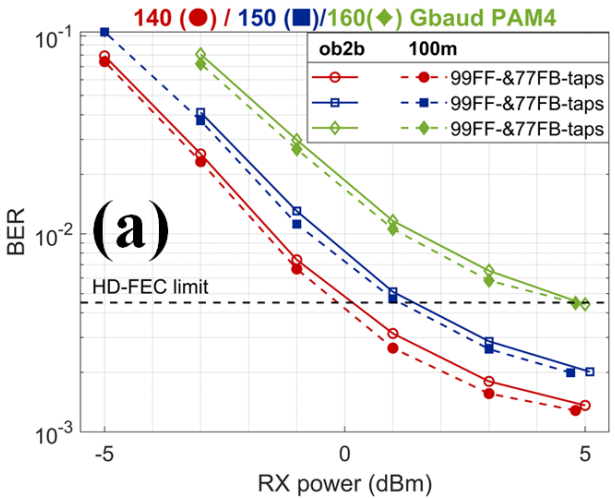
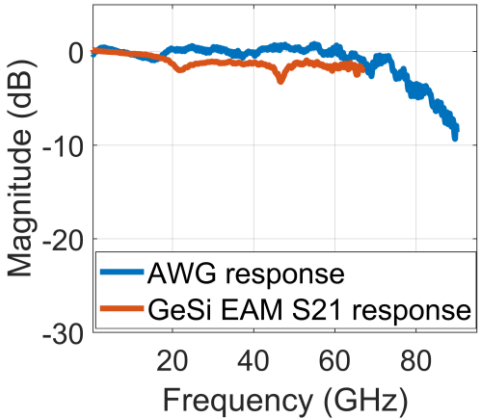
Conclusions

- In this work, we investigate **212.5 Gbps** and **224 Gbps** PAM4 and OOK signals at IEEE 802.3dj FECi and FECo thresholds at distances up to **6 km**.
- Use of concatenated FEC schemes allows to increase power budget significantly at expense of additional **+15 ns** of latency.
- In investigated, PAM4 signals can reach same performance level as OOK signals with small equalizer complexity. Due to timing recovery constraints OOK requires decision-feedback equalizer to achieve performance specified by IEEE 802.3dj.
- We don’t observe dispersion power penalty in case transmission of PAM4 signals over 500m and 6km SMF, however we observed negative dispersion power penalty in case of OOK signals.

Advertisement break





Armands Ostrovskis, et al., **Silicon Photonics GeSi Electro Absorption Modulator for Beyond 300 Gb/s Per λ Links ,** ECOC 2024, Tu1D: Intra-Data Center Systems **Tuesday 9:45, Harmonie 4**

Acknowledgement: EQUIPMENT

We thank **OpenLight Photonics** and **Tower Semiconductor** for the chips and components. The complete components list including on-chip lasers are available to the open market for the design of 200G/Lane heterogeneous silicon photonics PIC (DR and FR PIC) through **Tower Semiconductor PH18DA process design kit (PDK)**.

We also thank **Keysight Technologies** in Böblingen, Germany for hosting the experiment and for loaning the **N7776C-013 High Power Tunable Laser Source,** the **M8199B Arbitrary Waveform Generator** and the **UXR1104A Infiniium UXR-Series Oscilloscope.**

Acknowledgement: FUNDING

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- Swedish Research Council (VR) project 2019-05197 and 2022-04798
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Thank you for attention!

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