9dB link margin gain using a Quantum Dot SOA in an 8-wavelength DWDM 50 Gbps NRZ CPO link

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OFC 2026 M1B.1

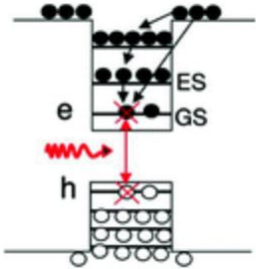
DWDM Data-SOA Application

Problem	Rx optical power increases with data rate
? More laser power	Damage fiber / Tx Nonlinear Tx penalties Worse reliability
✓ Data SOA	Lower power in Tx lane Share laser to more ports
✓ This paper	8 x 50 Gb/s DWDM NRZ SOA penalty ≪ SOA gain 9 dB net gain

Lightmatter
Passage L-Series
3D CPO

QD-SOA for DWDM

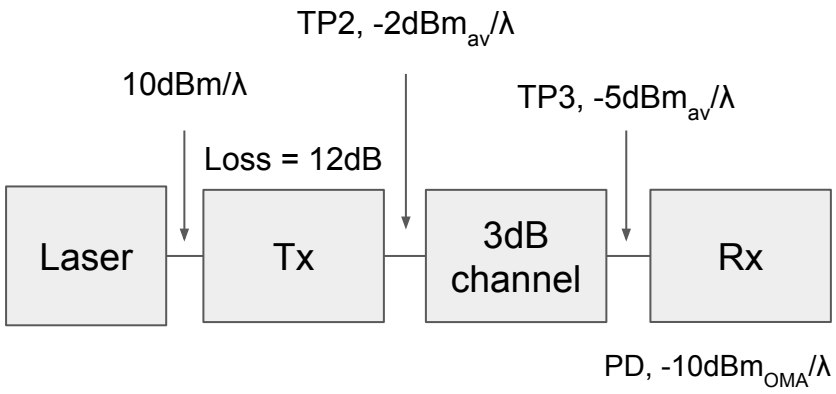
Literature	Perception that SOA's are poor for DWDM Very little literature on DWDM SOA link penalty
Single wavelength penalties	ASE Saturation Finite carrier lifetime → Pattern-dependent ISI
Cross-wavelength penalties	Finite carrier lifetime + fast carrier thermalization → XGM High $\chi 3$, small mode, high power → FWM
QD-SOA	Discrete energy states Minimize wavelength-to-wavelength interaction



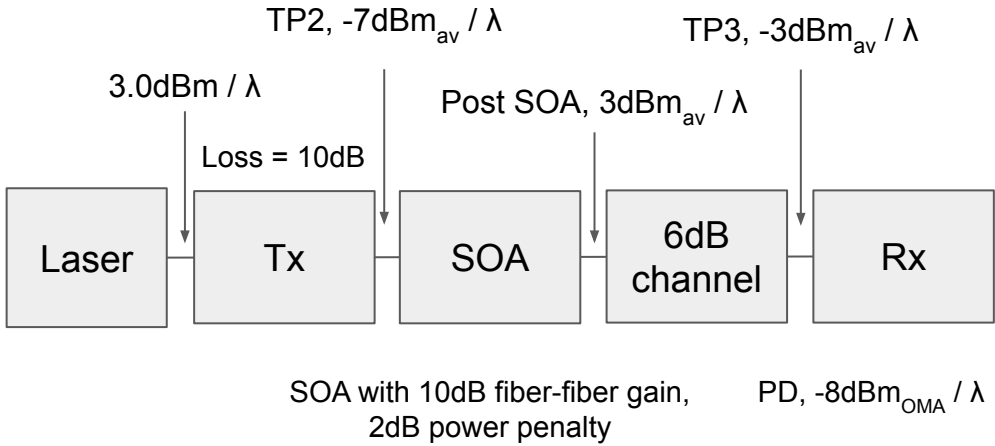
Link-budget Comparison

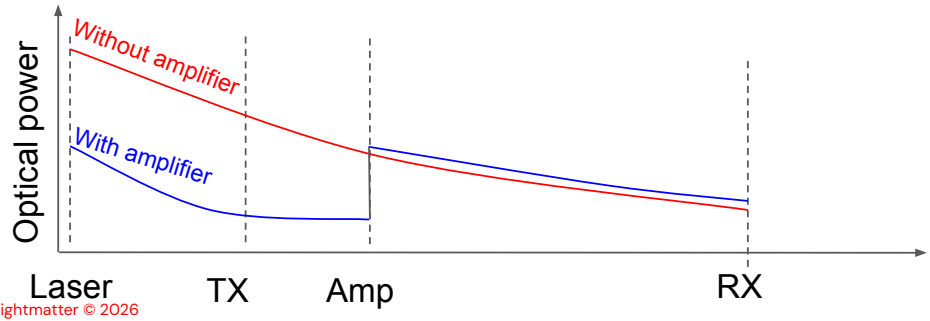
8λ 50Gb/s NRZ

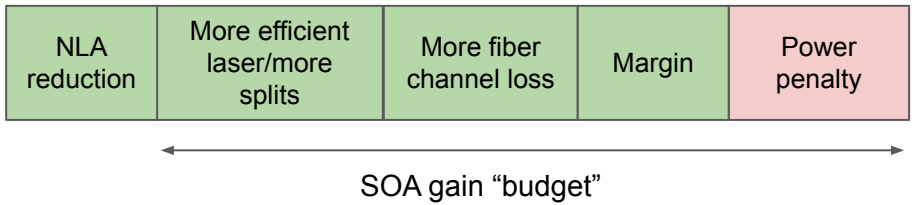
Powerful laser, modest fiber channel, no SOA



Efficient laser, larger fiber channel, with data SOA



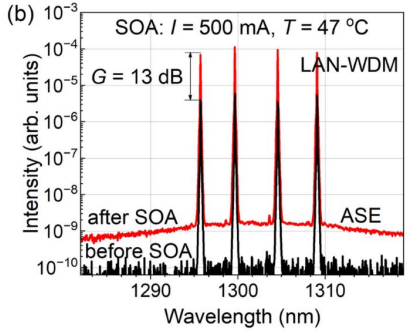


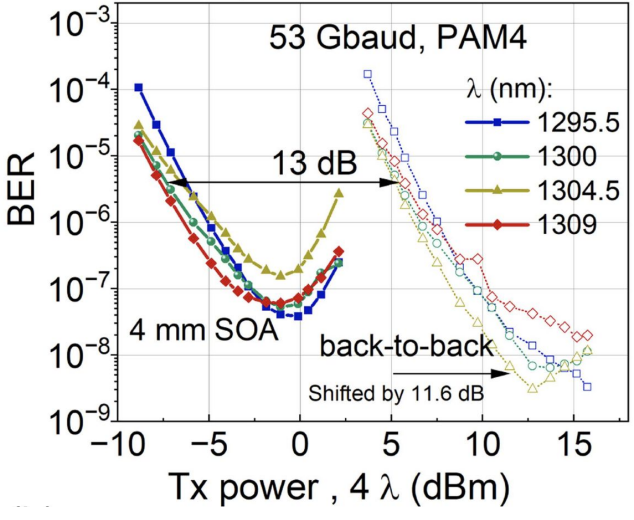


Previous Reports

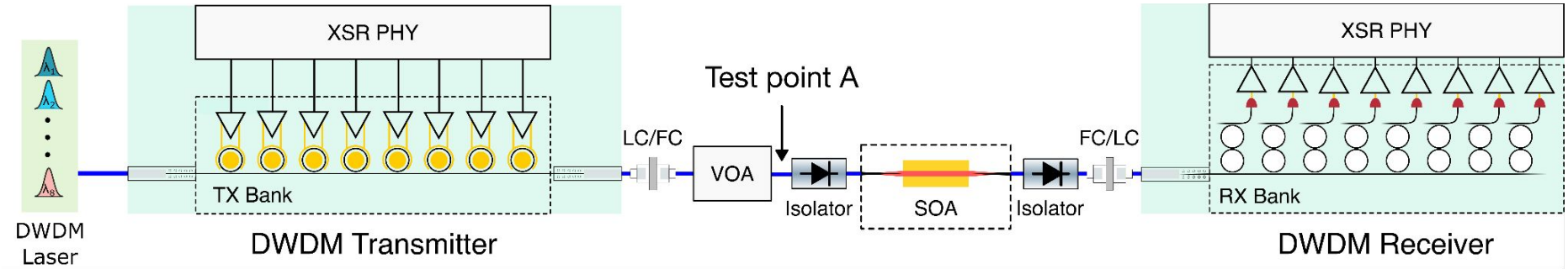
- V. Belykh, et al, JLT 2025. reports the use of a QD-SOA in a WDM link
  - They demonstrate a 9.5dB (13dB) improvement of Tx launch power at 26 Gbaud NRZ (53 Gbaud PAM4)
- However, this prior art demonstrated 4λ x 800GHz WDM
- In this work, we apply similar analysis to our 8λ x 400 GHz DWDM CPO systems at 50 Gbaud NRZ

Bit Error Rate in WDM Data Transmission Links With Semiconductor Optical Amplifier





Data-SOA in DWDM CPO Links

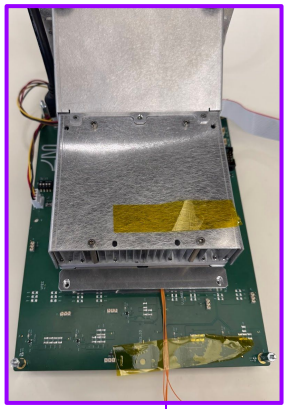


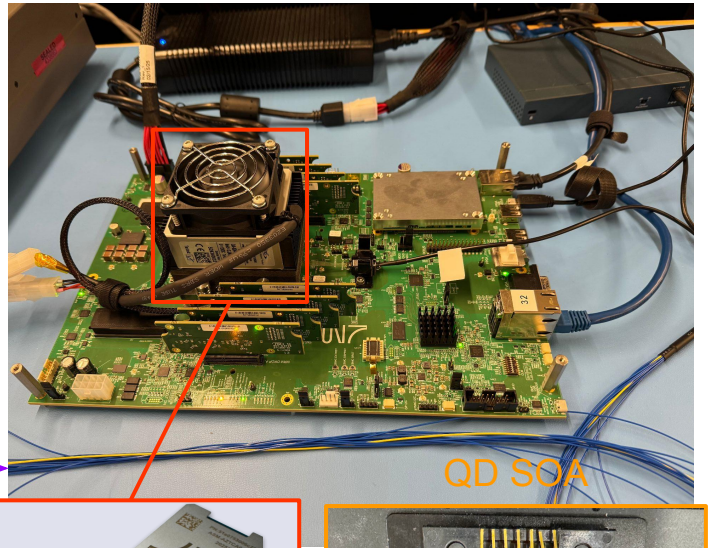
Laser + TRx reported in OFC 2026 M4B.3 ↔ bidirectional
In this SOA paper we use half the elements → unidirectional

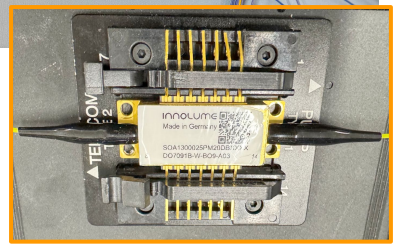
Test Hardware

Lightmatter Passage CPO optical engine (OFC 2026 M4B.3)
Commercial QD-SOA

8λ Laser







28 Gbaud NRZ

Lane	A0(0)	A1(1)	A2(2)	A3(3)	A4(4)	A5(5)	A6(6)	A7(7)
Mode	NRZ	NRZ	NRZ	NRZ	NRZ	NRZ	NRZ	NRZ
Link Status	RDY	RDY	RDY	RDY	RDY	RDY	RDY	RDY
Eye 1 (mV)	263	211	223	167	248	263	230	253
Eye 2 (mV)	-	-	-	-	-	-	-	-
Eye 3 (mV)	-	-	-	-	-	-	-	-
PRBS Timer (sec)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
PRBS Count	0	0	0	0	0	0	0	0
PRBS BER	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00

50 Gbaud NRZ

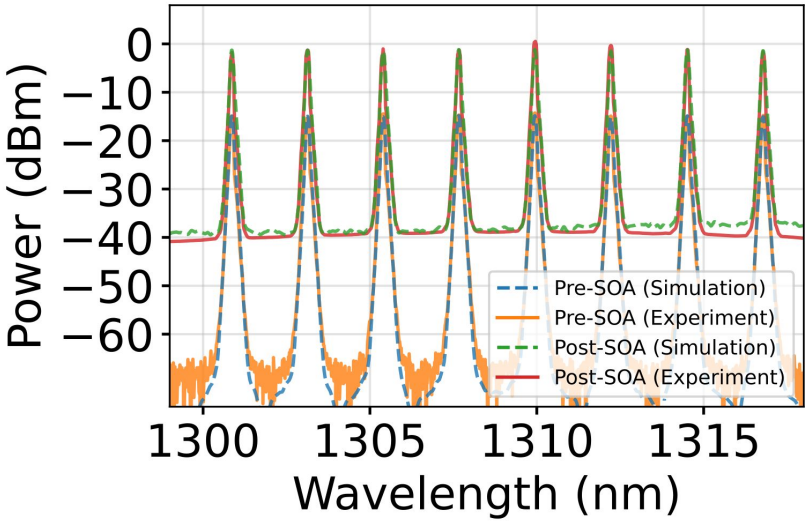
Lane	A0(0)	A1(1)	A2(2)	A3(3)	A4(4)	A5(5)	A6(6)	A7(7)
Mode	NRZ	NRZ	NRZ	NRZ	NRZ	NRZ	NRZ	NRZ
Link Status	RDY	RDY	RDY	RDY	RDY	RDY	RDY	RDY
Eye 1 (mV)	214	199	183	151	159	154	285	215
Eye 2 (mV)	-	-	-	-	-	-	-	-
Eye 3 (mV)	-	-	-	-	-	-	-	-
PRBS Timer (sec)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
PRBS Count	0	0	0	0	0	68	0	0
PRBS BER	0.00e+00	0.00e+00	0.00e+00	0.00e+00	0.00e+00	2.72e-10	0.00e+00	0.00e+00

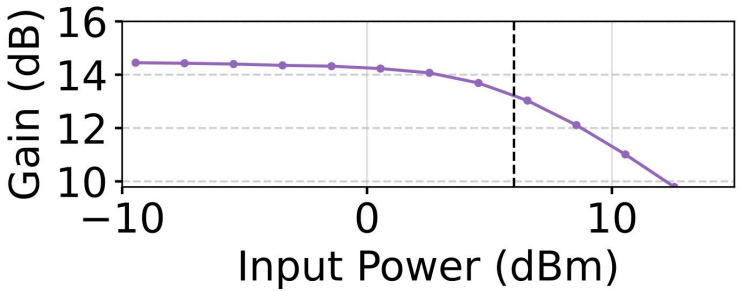
Data-SOA Characterization

14dB fiber-to-fiber gain, <1.7dB gain variation over wavelength

1dB input (output) P_{sat} of 6dBm (19.5dBm)

5.5dB Noise Figure estimated



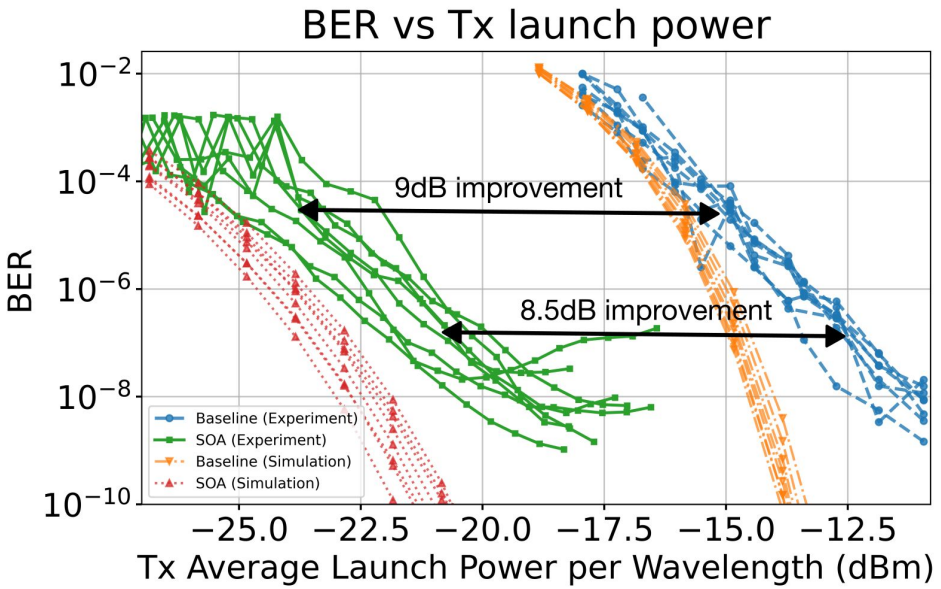


9dB Improvement at 50G 8λ PRBS31

9dB improvement at $2.4*10^{-4}$ BER
8.5dB improvement at 10^{-7} BER

~9dB improvement can be estimated as Gain – Power penalty – added component loss = 14.6–2–3.8

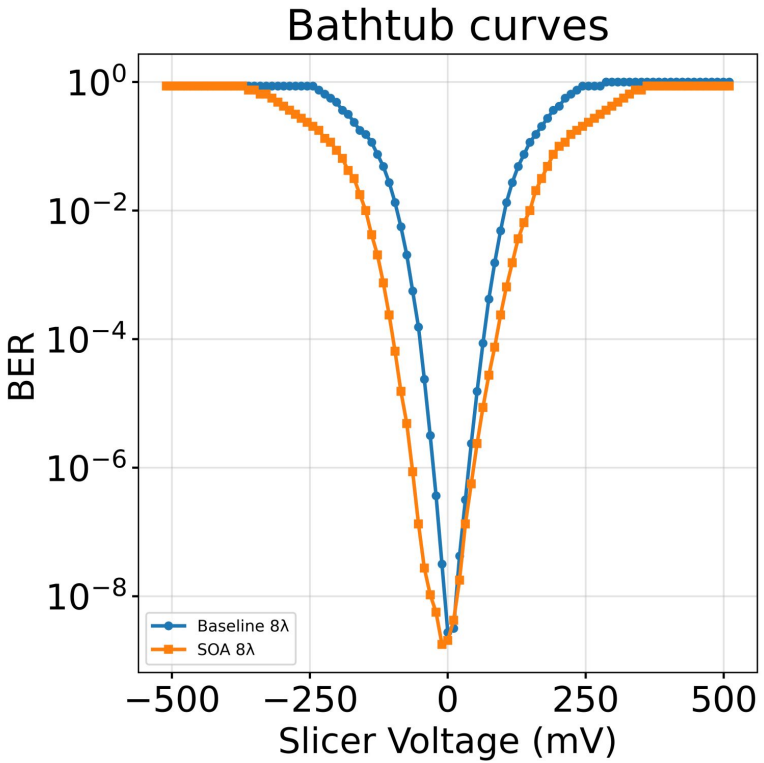
Some saturation observed in SOA curves, likely caused by saturation of Rx electrical circuits, not SOA



9dB Improvement at 50G 8λ PRBS31

We can also infer a Rx side power penalty from the bathtub curves at the slicer

Taking the bathtub curve right, a noise at the slicer can be inferred of 28.7mV$_{rms}$ (39.2mV$_{rms}$) for baseline (SOA)



Conclusion

- Lightmatter 8λ 50 Gb/s NRZ DWDM 400 GHz grid CPO unidirectional link
- Commercial Quantum Dot SOA
- With SOA vs baseline no-SOA
  - Substantial Tx output power reduction
    - 9 dB @ BER 2.4E-4
    - 8.5 dB @ BER 1E-7
      - This net-gain can be spent on more efficient lasers, larger fiber channel loss
  - Rx power penalty 1.35 dB for 1λ, 2dB for 8λ