Security Level:

Initial experiment results of SOA as Pre-amplifier for 100G EPON

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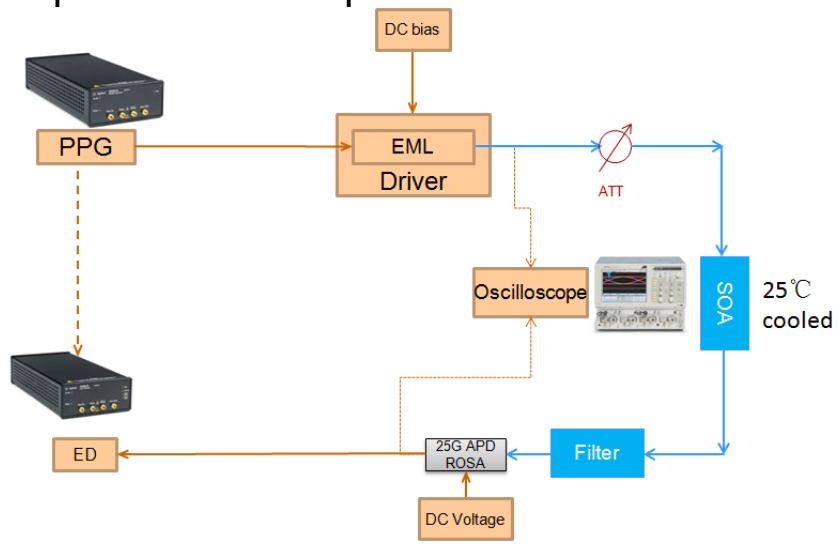
Background

- As bit rate increases, the sensitivity of APD decreases accordingly due to higher bandwidth noise. This makes the power budget of 25Gb/s is more challenging than 10Gb/s.
- Due to the extra loss of mux and demux, 100G EPON high likely needs a preamplifier in the OLT to reach the necessary receiver sensitivity .
- The bandwidth of ASE filtering after SOA is an important factor for the sensitivity gain , this contribution shows some initial experiment results of SOA as pre-amplifier for 100G EPON.

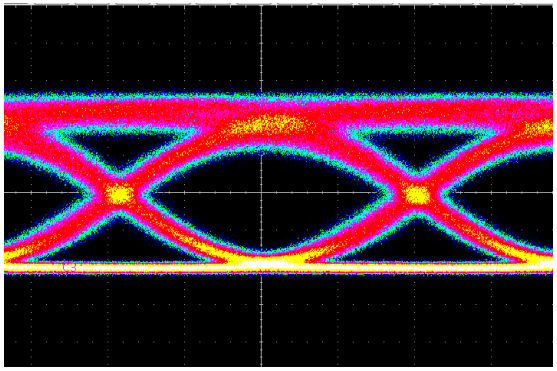
Experiment Setup

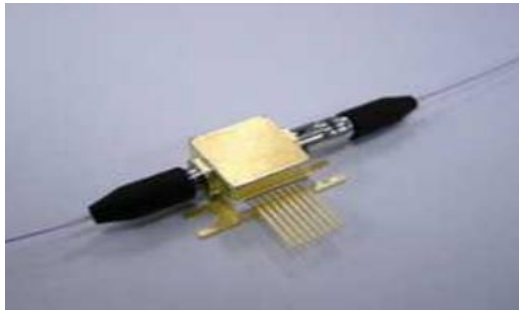
Experimental setup

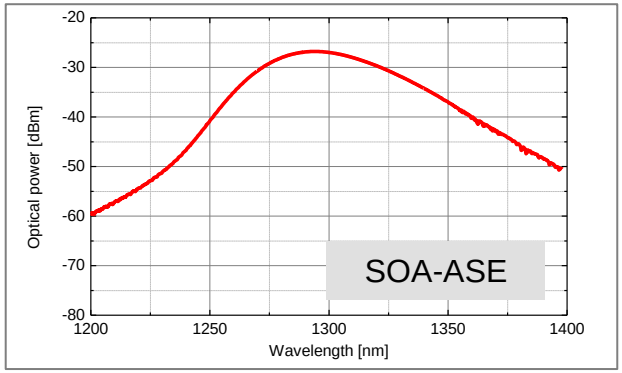


SOA Features, from 1294 nm to 1311 nm

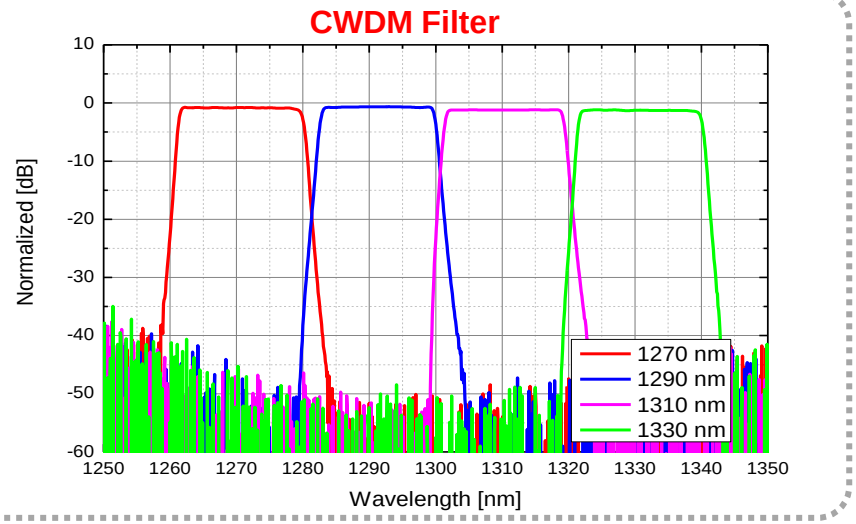
Parameter	Value			Unit
	Min.	Typ.	Max.	
Optical Gain	14	-	23	dB
Saturation Output power	9.0	-	-	dBm
Polarization Dependence Gain	-	-	1.0	dB
Noise Figure	-	-	8.0	dB
Gain Ripple	-	-	1.0	dB

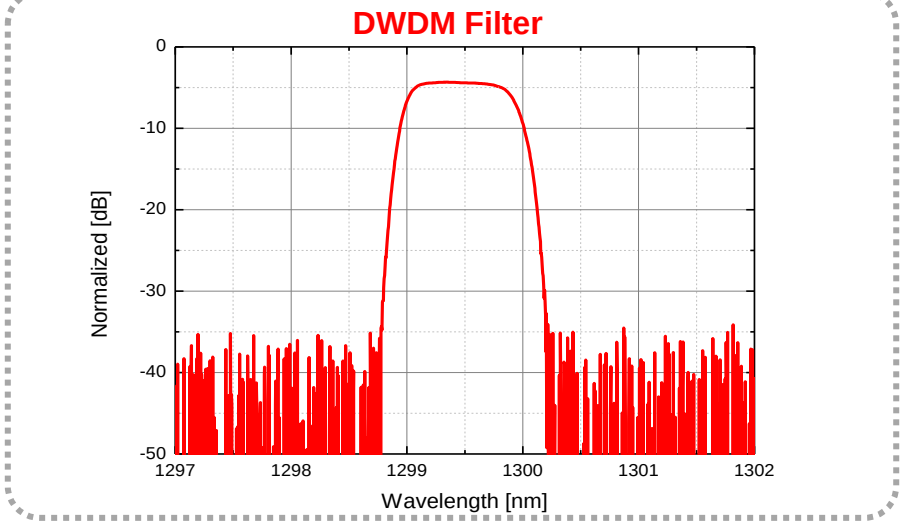


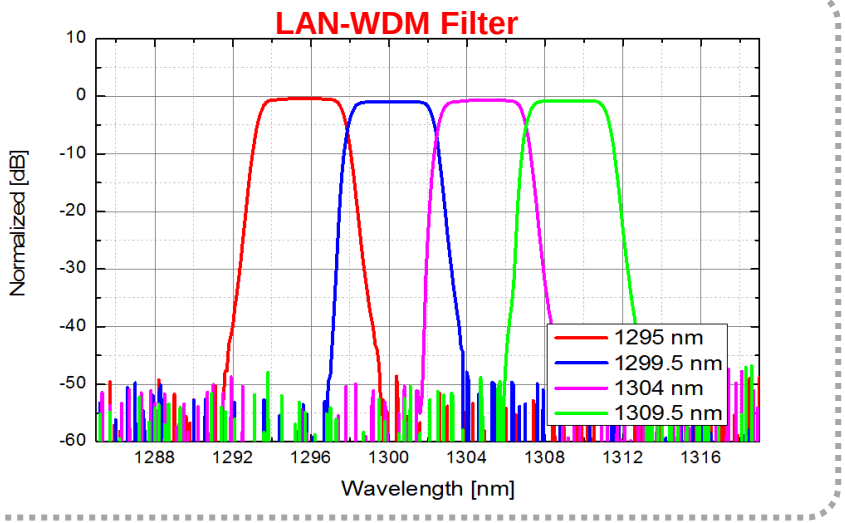




Transmission Spectra of Filters







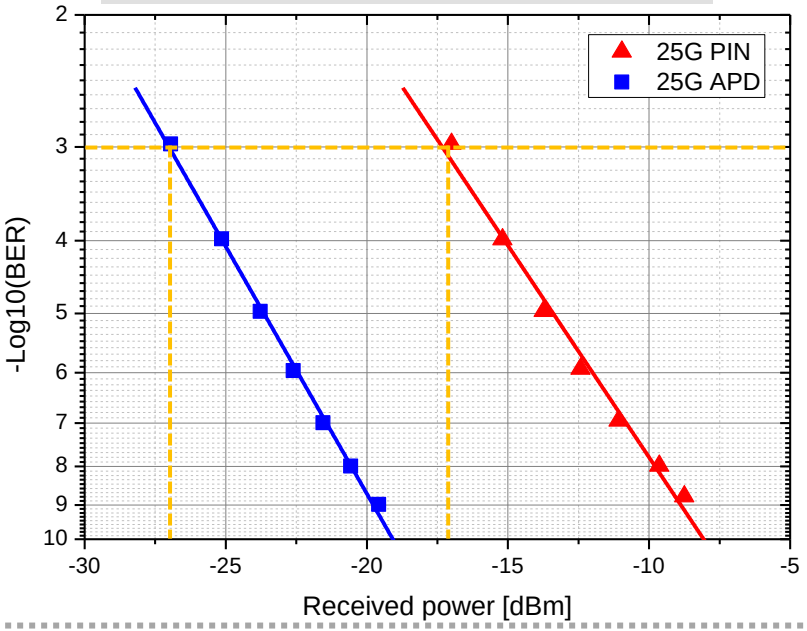
	CWDM	LAN-WDM	DWDM
Insertion loss	0.70 dB (1310 nm)	1.0 dB (1299.5 nm)	4.5 dB (1299.5)
3-dB bandwidth	16.8 nm	4.09 nm	0.9 nm

- For CWDM case, a CWDM MUX from *Vendor C.*
- For LAN-WDM case, a LAN-WDM MUX from *Vendor D*.
- For DWDM case, using a commercial tunable optical bandpass filter instead, from *Vendor E*.

Performance of APD vs. PIN

- 25G O-band EML Tx at ONU and 25G APD/PIN Rx at OLT.
- Test conditions: back-to-back, NRZ, PRBS=2^31-1.
- 10dB differences between 25G PIN and 25G APD.

25G PIN Receiver & 25G APD Receiver

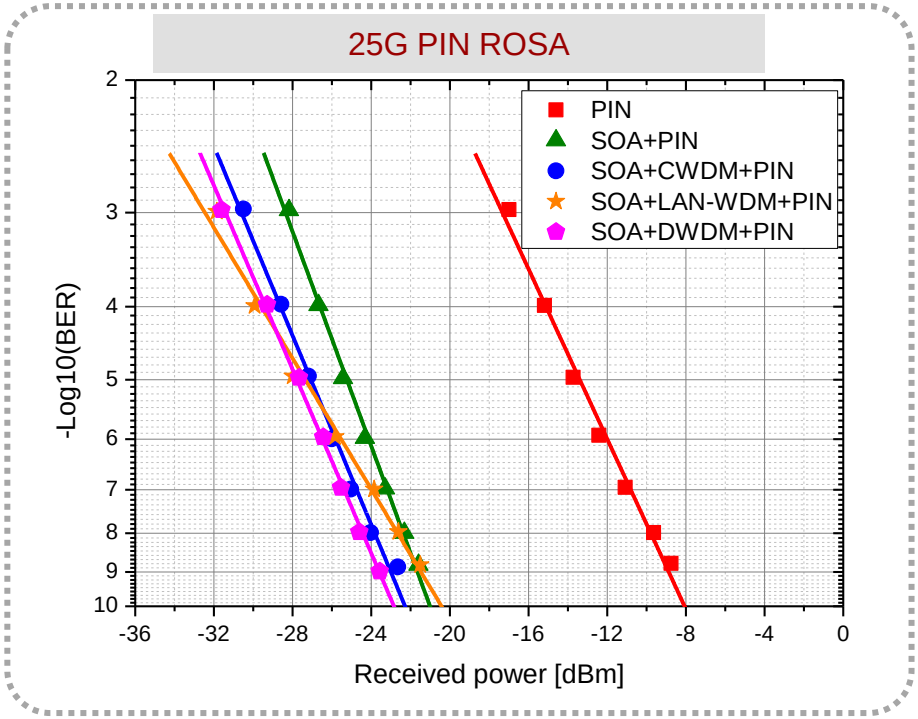


Parameter	Value	Unit
Tx bit rate	25.78125	Gb/s
Tx wavelength	1309.5	nm
Tx output power	4.5	dBm
Tx ER	11	dB
Rx responsivity	APD: 3~6	A/W
	PIN: 0.75	
Rx sensitivity (@BER=1E-3)	APD: -27	dBm
	PIN: -17	

25G PIN, Vendor A

25G APD, Vendor B

Rx1: 25G PIN with SOA and filter

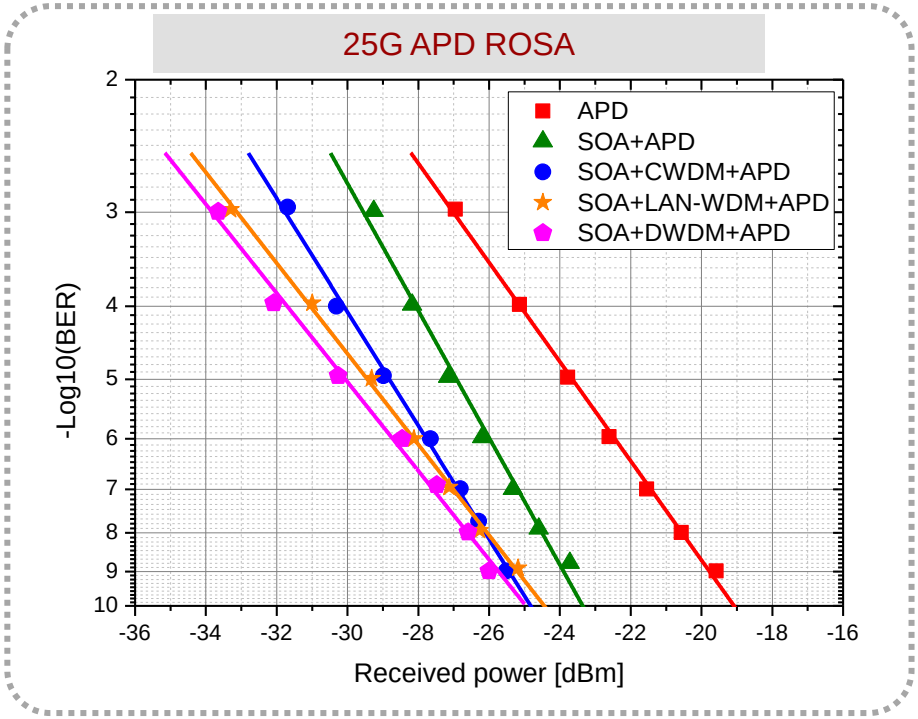


- Compared with 25G PIN, only using SOA as pre-amp., Rx. Sen. increased 11.2 dB.
- Using SOA and CWDM filter, Rx. Sen. increased 13.4 dB.
- Using SOA and LAN-WDM filter, Rx. Sen. increased 14.8 dB.
- Using SOA and DWDM filter, Rx. Sen. increased 14.5 dB.

Optical power @BER=1E-3		
	After SOA	**After Filter**
CWDM	1.8 dBm	-8.4 dBm
LAN-WDM	1.8 dBm	-5.4 dBm
DWDM	1.8 dBm	-18.9 dBm

	25G PIN	**w. SOA**	**w. SOA+CWDM filter (16.8 nm)**	**w. SOA+LAN-WDM filter (4.09 nm)**	**w. SOA+DWDM filter (0.9 nm)**
Rx. Sen. (@BER=1E-3)	-17 dBm	-28.2 dBm	-30.4 dBm	-31.8 dBm	-31.5 dBm

Rx2: 25G APD with SOA and filter

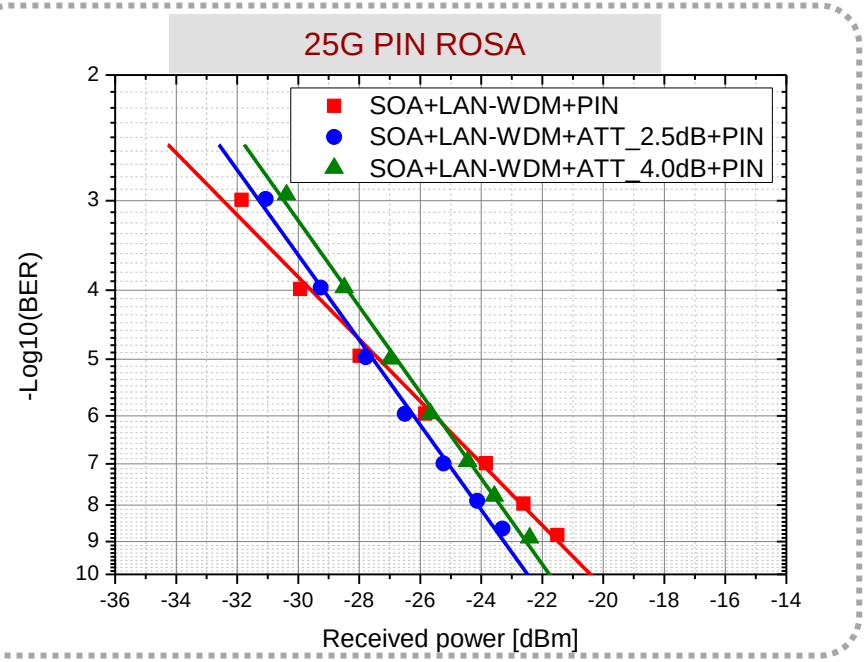


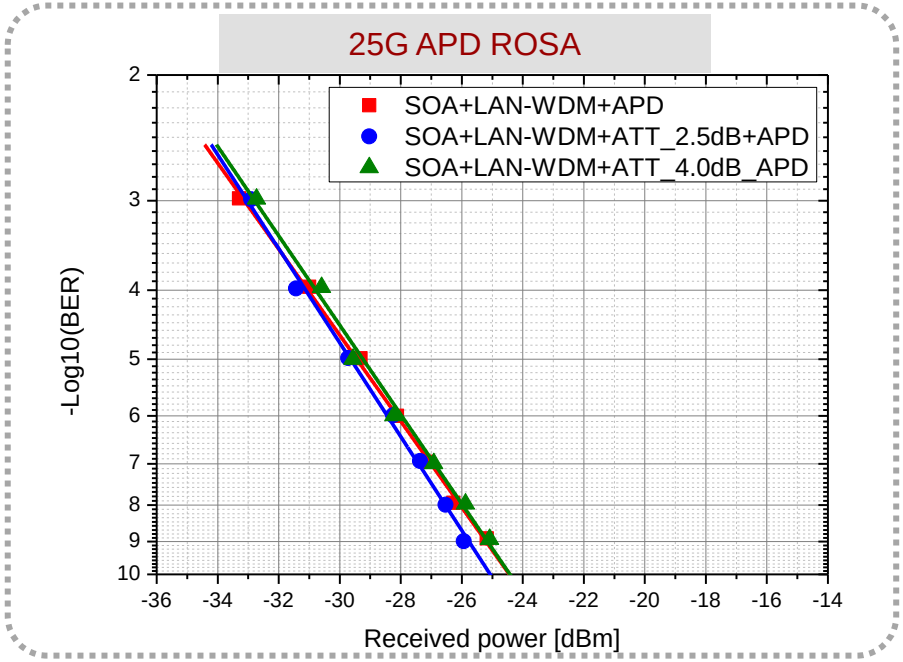
- Compared with 25G APD, only using SOA as pre-amp., Rx. Sen. increased 2.2 dB.
- Using SOA and CWDM filter, Rx. Sen. increased 4.6 dB.
- Using SOA and LAN-WDM filter, Rx. Sen. increased 6.1 dB.
- Using SOA and DWDM filter, Rx. Sen. increased 6.6 dB.

Optical power @BER=1E-3		
	After SOA	After Filter
CWDM	1.8 dBm	-8.1 dBm
LAN-WDM	1.8 dBm	-5.9 dBm
DWDM	1.8 dBm	-18.9 dBm

	25G APD	w. SOA	w. SOA+CWDM filter (16.8 nm)	w. SOA+LAN-WDM filter (4.09 nm)	w. SOA+DWDM filter (0.9 nm)
Rx. Sen. (@BER=1E-3)	-27 dBm	-29.2 dBm	-31.6 dBm	-33.1 dBm	-33.6 dBm

Impact of Filter Insertion Loss (for LAN-WDM case)

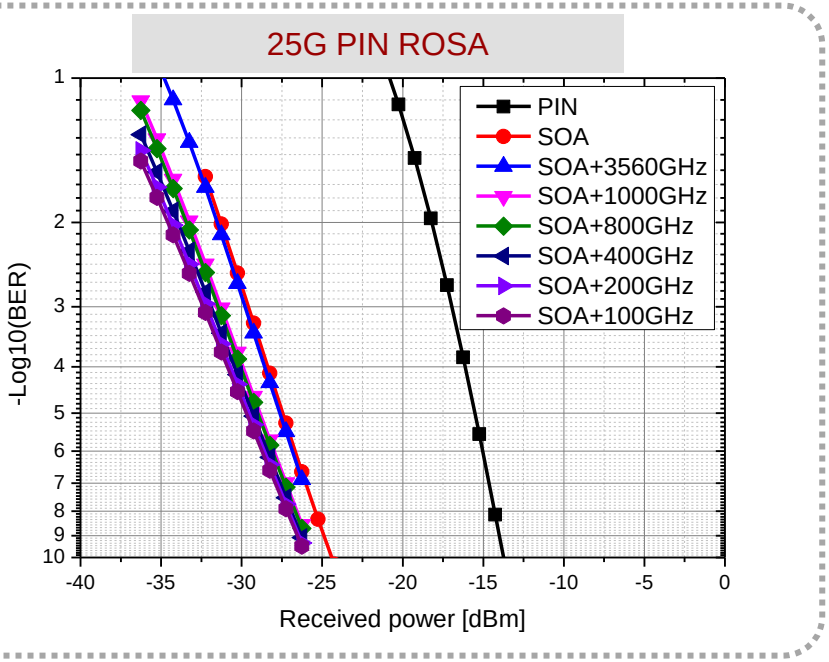


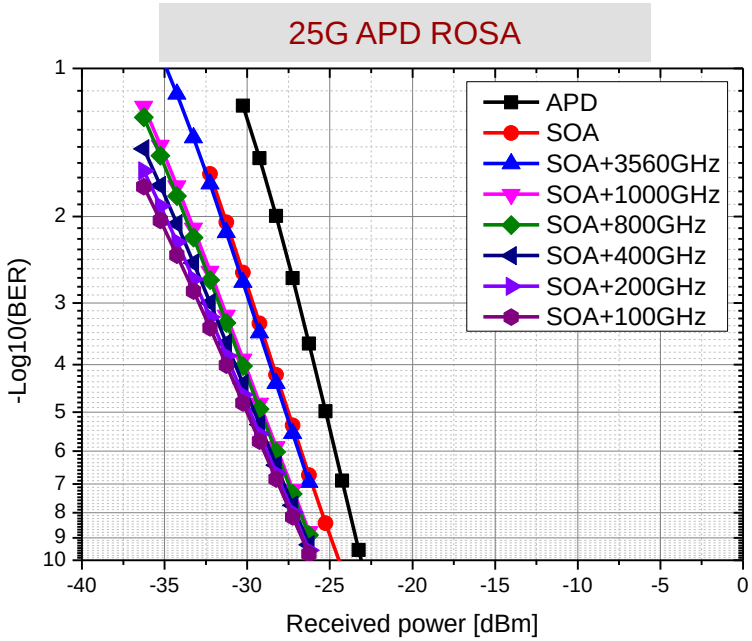


	SOA+LAN-WDM+PIN	SOA+LAN-WDM+ATT_2.5dB+PIN	SOA+LAN-WDM+ATT_4dB+PIN
Rx. Sen. (@1e-3 BER)	-31.8 dBm	-31.1 dBm	-30.3 dBm
	SOA+LAN-WDM+APD	SOA+LAN-WDM+ATT_2.5dB+APD	SOA+LAN-WDM+ATT_4dB+APD
Rx. Sen. (@1e-3 BER)	-33.1 dBm	-32.9 dBm	-32.7 dBm

Insertion Loss has a significant impact on Rx. Sen. in PIN-ROSA case.

Simulation Results (with SOA as pre-amp. & filter)





	PIN	w. SOA	w. SOA +1000GHz	w. SOA +800GHz	w. SOA +400GHz	w. SOA +200GHz	w. SOA +100GHz
Rx. Sen. (@BER=1E-3)	-16.94 dBm	-29.58 dBm	-31.28 dBm	-31.45 dBm	-31.89 dBm	-32.18 dBm	-32.39 dBm
	APD	w. SOA	w. SOA +1000GHz	w. SOA +800GHz	w. SOA +400GHz	w. SOA +200GHz	w. SOA +100GHz
Rx. Sen. (@BER=1E-3)	-26.86 dBm	-29.65 dBm	-31.52 dBm	-31.71 dBm	-32.24 dBm	-32.62 dBm	-32.92 dBm

Overview comparison

- Experimental results

	25G PIN	w. SOA	w. SOA+CWDM filter (16.8 nm)	w. SOA+LAN-WDM filter (4.09 nm)	w. SOA+DWDM filter (0.9 nm)
Rx. Sen. (@BER=1E-3)	-17 dBm	-28.2 dBm	-30.4 dBm	-31.8 dBm	-31.5 dBm
	25G APD	w. SOA	w. SOA+CWDM filter (16.8 nm)	w. SOA+LAN-WDM filter (4.09 nm)	w. SOA+DWDM filter (0.9 nm)
Rx. Sen. (@BER=1E-3)	-27 dBm	-29.2 dBm	-31.6 dBm	-33.1 dBm	-33.6 dBm

- Simulation results

	PIN	w. SOA	w. SOA +1000GHz	w. SOA +800GHz	w. SOA +400GHz	w. SOA +200GHz	w. SOA +100GHz
Rx. Sen. (@BER=1E-3)	-16.94 dBm	-29.58 dBm	-31.28 dBm	-31.45 dBm	-31.89 dBm	-32.18 dBm	-32.39 dBm
	APD	w. SOA	w. SOA +1000GHz	w. SOA +800GHz	w. SOA +400GHz	w. SOA +200GHz	w. SOA +100GHz
Rx. Sen. (@BER=1E-3)	-26.86 dBm	-29.65 dBm	-31.52 dBm	-31.71 dBm	-32.24 dBm	-32.62 dBm	-32.92 dBm

Summary

- Some initial experiment results of SOA as pre-amplifier for 100G EPON are shown:
  - SOA can dramatically increases the sensitivity of PIN receiver, the sensitivity gain of APD receiver by SOA are much smaller .
  - SOA+APD has about 1~2dB sensitivity advantage compared with SOA+PIN
  - The bandwidth of pass band filter has an important impact on the sensitivity gain for SOA+APD
  - Without ASE pass band filtering , SOA can only provide ~2dB sensitivity gain for APD; With a narrow band ASE filter, it can provide more than 6dB sensitivity gain.
- Further works needed in future:
  - SOA gain for DML laser in O-band
  - Temperature impact on sensitivity gain
  - Impact on overload and dynamic range

Thank you

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