

# Experimental results of SOA pre-amplification for 25G-EPON

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# ZTE

Tomorrow never waits

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# Motivation and purpose of this contribution

- It has been shown that the sensitivity of 25G APD is insufficient to meet the power budget requirements in the upstream direction. Therefore, it is necessary to have a preamplifier at the OLT
- In the Huntington Beach meeting, both simulation and experimental results of SOA in combination of PIN or APD were presented by Nokia, Huawei, ETRI, and Sumitomo. However, it was difficult to compare the results due to the wide variety of test conditions
- This contribution presents our experimental results and proposes a set of common test conditions to help compare results in the future

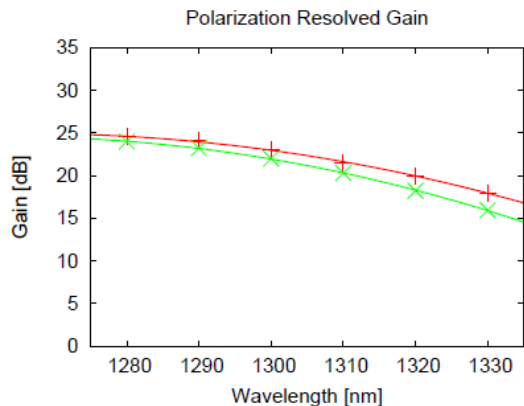
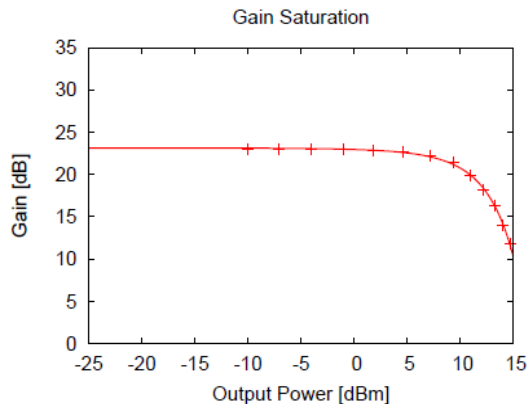
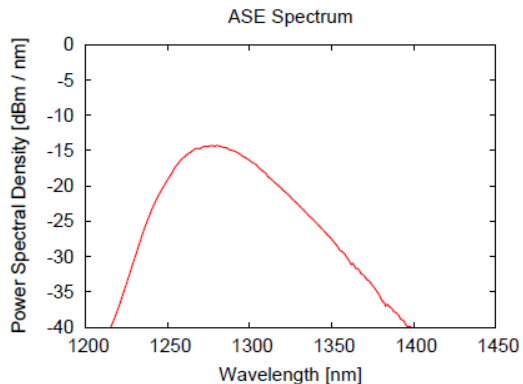
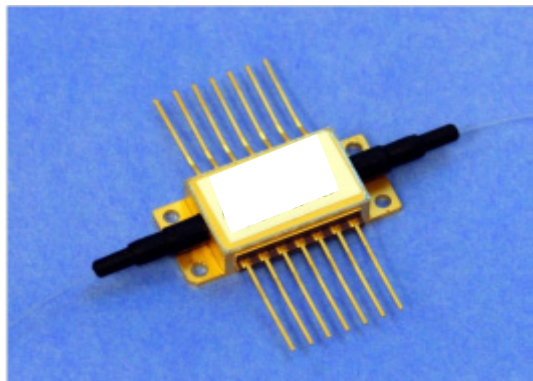
# Outline

- Experiment results of four scenarios are shown
  - a) DML+SOA+PIN
  - b) DML+SOA+APD
  - c) EML+SOA+PIN, varying ER of EML
  - d) EML+SOA+APD, varying ER of EML
- Comparison of our test results with previous reported values
- Proposal of common test conditions

# Comparison of test conditions and results from contributions in Huntington Beach

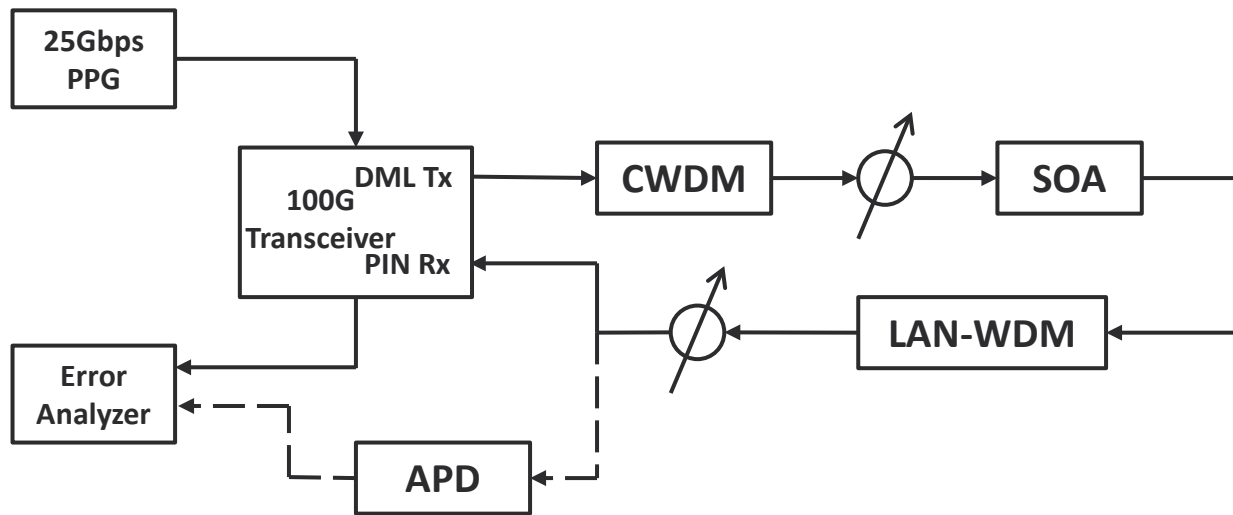
	SUMITOMO	Nokia(Simulation)	ETRI	Huawei
Tx	DML	-	EML	EML
ER	4.5dB/6.1dB	6dB	7dB	11dB
Gain <sub>SOA</sub>	16.49dB	17dB	13.9dB	14-23dB
T <sub>SOA</sub>	40°C	25°C	-	-
NF <sub>SOA</sub>	5.87dB	7dB/8dB	8.7dB	Max 8dB
Filter	LAN-WDM/CWDM/no filter	20nm/3.2nm	LAN-WDM	LAN-WDM/CWDM/DWDM/no filter
Rx	PIN	APD	APD	PIN/APD
<b>Best Sen.(@BER=1E-3)</b>	<b>-29.5dBm</b> <b>@ER=6.1dB,LAN-WDM</b>	<b>-28.4dBm</b> <b>@NF=7dB,BPF=20nm</b>	<b>-26dBm</b>	<b>-33.6dBm</b> <b>@DWDM,APD</b>

# Parameter values of the SOA used in our test



Parameter	Value	Unit
Operating Wavelength	1250-1350	nm
Peak wavelength	1277	nm
Peak Gain	24.1	dB
Gain Ripple	1.3	dB
Polarization Dependent Gain	1.8	dB
Saturation Output Power	10.8	dBm
Noise Figure	6.5	dB
Drive current	200	mA
Chip temperature	25	°C

# Experiment setup DML



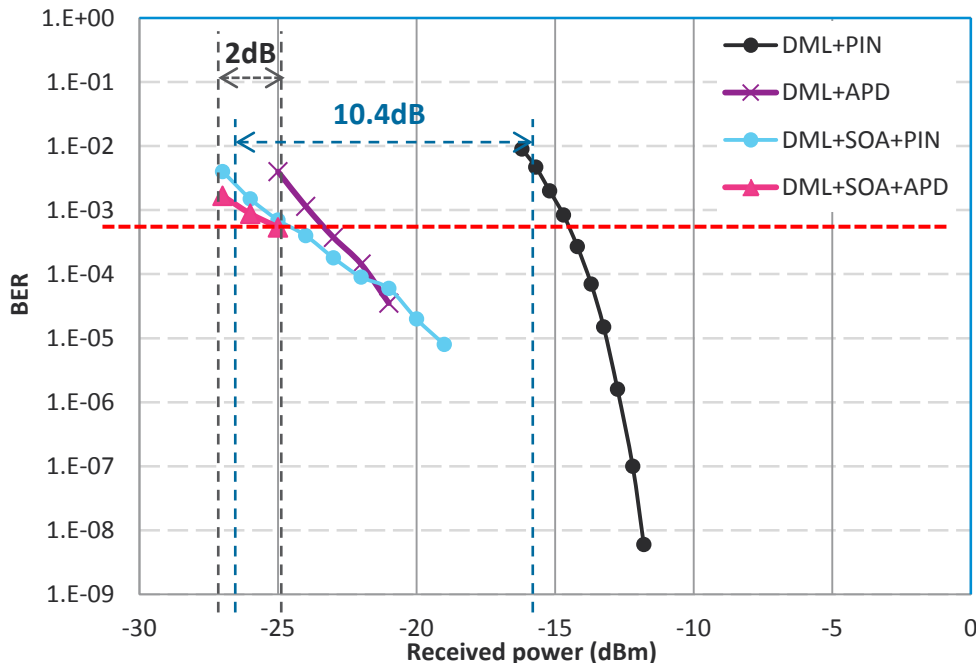
100G QSFP28 CWDM Optical Transceiver

Parameter	Value	Unit
Wavelength	1291	nm
SMSR	30	dB
Launch power	-6.5 ~ +2.5	dBm
ER	3.5	dB
Tx bit rate	25	Gbps
PIN Rx sens. @ 5e-5	-10	dBm

- A 100G QSFP28 CWDM Optical Transceiver is used to test SOA+PIN, it has 4 DML Tx and 4 PIN Rx
- CWDM filter to select just one lane of the optical module, LAN-WDM as ASE filter
- Test conditions : Back-to-Back, NRZ, PRBS7, 25°C
- Test 1: real time PIN receive
- Test 2: off-line processing calculating BER for APD receive (dash line)

# Performance of DML+SOA+PIN vs DML+SOA+APD

## 25G DML+SOA+PIN/APD performance

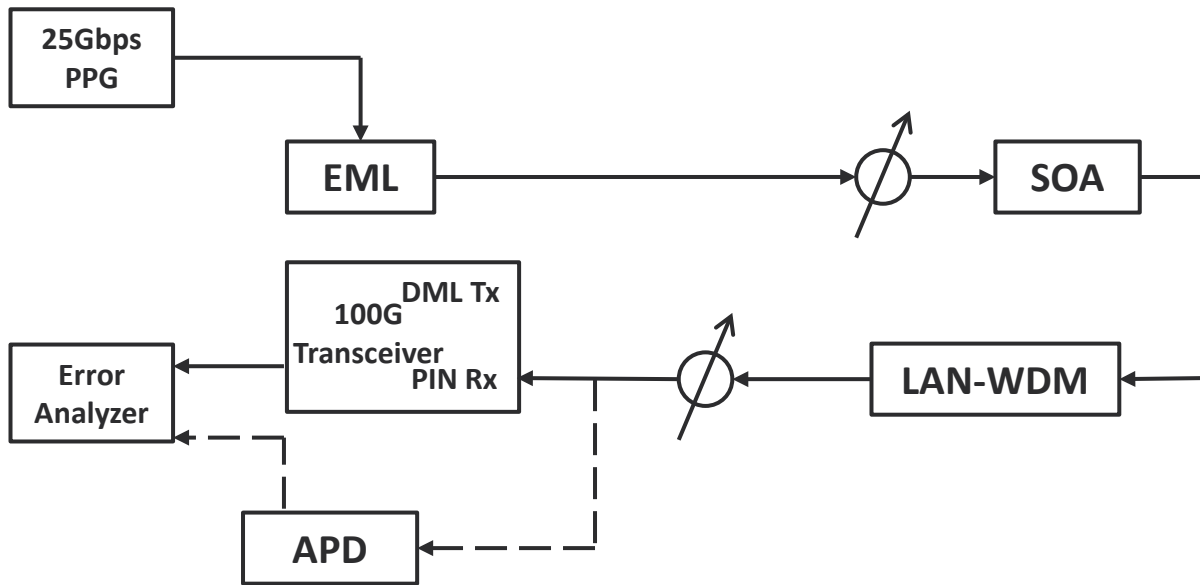


Rx Sensitivity (BER@1E-3):

	DML	PIN	APD	SOA+PIN	SOA+APD
ZTE ER=4.1dB		-14.8dBm	-24dBm	-25.2dBm	-26dBm
SUMITOMO ER=4.5dB		-18dBm	-	-28.4dBm	-

- Both results show DML+SOA+PIN can improve the receiver sensitivity by **10dB**.
- DML+SOA+APD can improve receiver sensitivity by only **2dB**.

# Experiment setup EML



25G EML TOSA

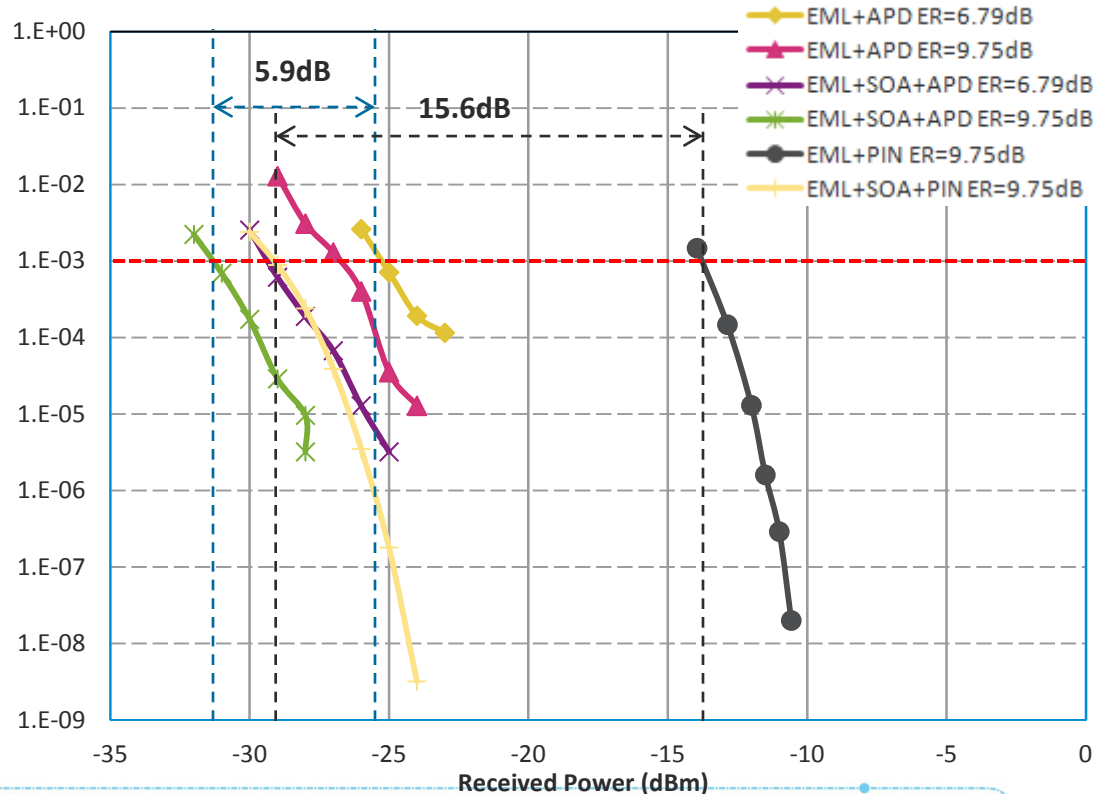
Parameter	Value	Unit
Wavelength	1295.56	nm
SMSR	35	dB
Launch Power	0~3	dBm
ER	6~10	dB
Tx bit rate	25	Gbps

- EML can be adjusted to have different extinction ratio
- Test conditions : Back-to-Back, NRZ, PRBS7, 25°C
- Test 1: real time PIN receive
- Test 2: off-line processing calculating BER for APD receive (dash line)



# Performance EML+SOA+PIN vs EML+SOA+APD

## 25G EML+SOA+PIN/APD performance



## Rx Sensitivity (BER@1E-3):

	ER	PIN	APD	SOA+PIN	SOA+APD
ZTE	6.79dB		-25.5dBm		-29.4dBm
ETRI	7dB		-24.5dBm		-26dBm
Nokia	6dB		-27.2dBm	-28.4dBm	
ZTE	9.75dB	-13.8dBm	-26.8dBm	-29.4dBm	-31.4dBm
Huawei	11dB		-27dBm		-33.1dBm

- For the performance of EML+SOA+PIN, with EML ER=9.75dB, sensitivity can be improved 15.6dB up to -29.4dBm.
- For the performance of EML+SOA+APD, the ER of EML higher, the improvement of sensitivity of using SOA is better. When ER=9dB, SOA can improve the sensitivity by 5.9dB, sensitivity is -31.4dBm.

# Summary of test results comparison

	PIN	APD	SOA+LAN-WDM+PIN	SOA+LAN-WDM+APD
ER= 4.1dB (ZTE)	-14.78dBm	-24 dBm	-25.2 dBm	-26 dBm
ER=4.5dB (SUMITOMO)	-18 dBm	-	-28.4 dBm	-

EML	PIN [dBm]	APD [dBm]	SOA+LAN-WDM+PIN [dBm]	SOA+LAN-WDM+APD [dBm]
ER=6.79dB (ZTE)		-25.5		-29.4
ER=7dB (ETRI)		-24.5		-26
ER=6dB (Nokia)		-27.2		-28.4
ER=9.75dB (ZTE)	-13.8	-26.8	-29.4	-31.4
ER=11dB (Huawei)	-17	-27	-31.8	-33.1

# Experimental set of parameters proposition

We propose to use the following parameters as the common set of test condition:

- 25G TOSA:
  - DML ER=6dB
  - EML ER=8dB
- O band SOA: Gain=20dB, NF=7dB
- Filter: LAN-WDM
- 25G ROSA: Commercial PIN/APD

# Summary

- Experiment results of DML+SOA+LAN-WDM+PIN show that when extinction ratio of DML is 4dB, this configuration can improve receive sensitivity by 10dB to about -25dBm.
- Experiment results of EML+SOA+LAN-WDM+APD show that extinction ratio of EML has influence on the performance of sensitivity. When the extinction ratio is 6.79dB, this configuration can improve receiver sensitivity by 4 dB to about -29dBm.
- The 25G PON power budget can be achieved with the use of SOA. For 100G PON, the additional WDM filter will bring challenges on the power budget. Higher gain of SOA and better OSNR will be needed. SOA sharing and dynamic range issues also need to be considered.
- Propose reference experimental test parameters to help have a more meaningful comparison of all the experimental results.
- Next steps
  - Compare burst and continual mode amplification performance
  - Test SOA dynamic range performance

# Thank you



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