25G APD performance updates (IEEE 802.3ca 100G EPON Sep meeting)

2016-9-6

(Presented by Yong Guo)

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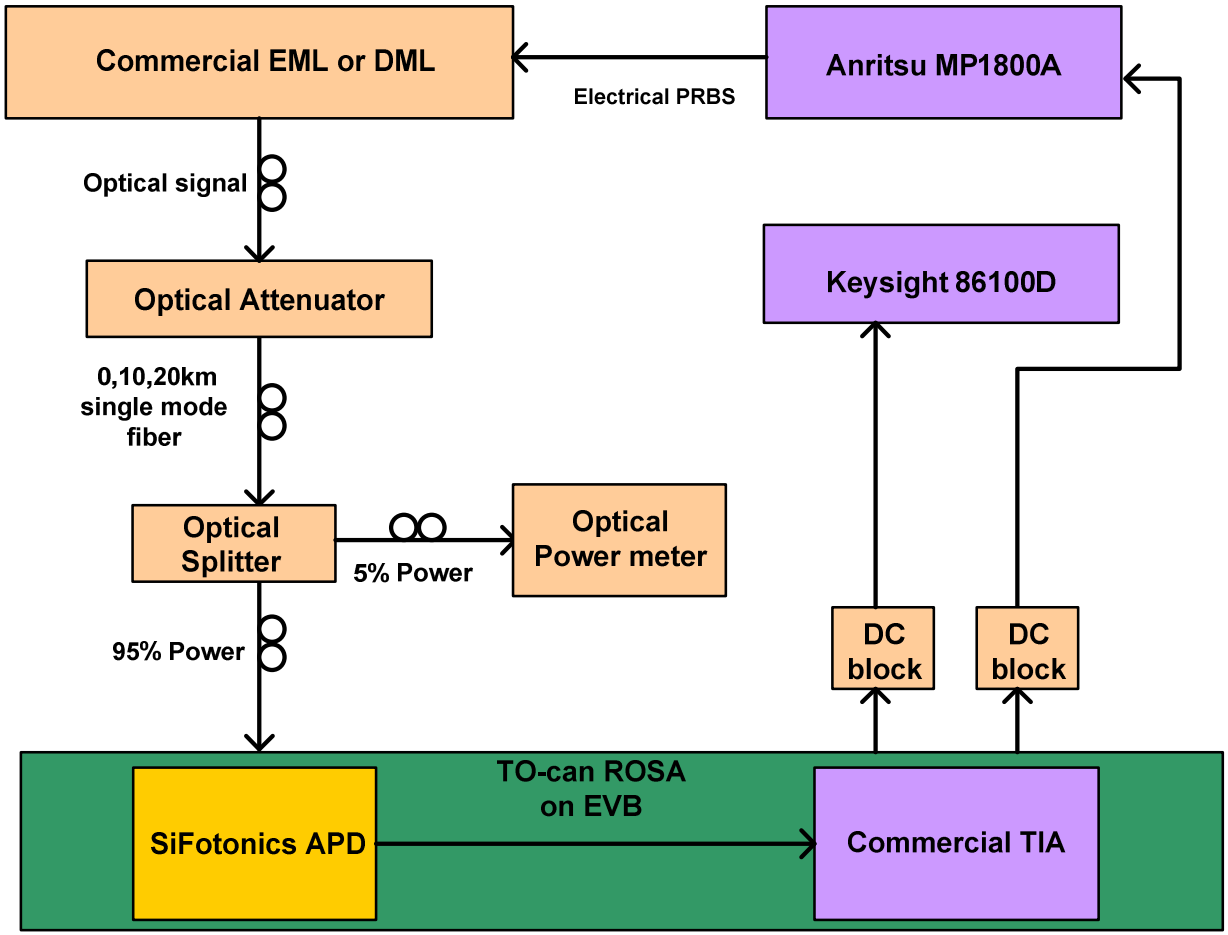
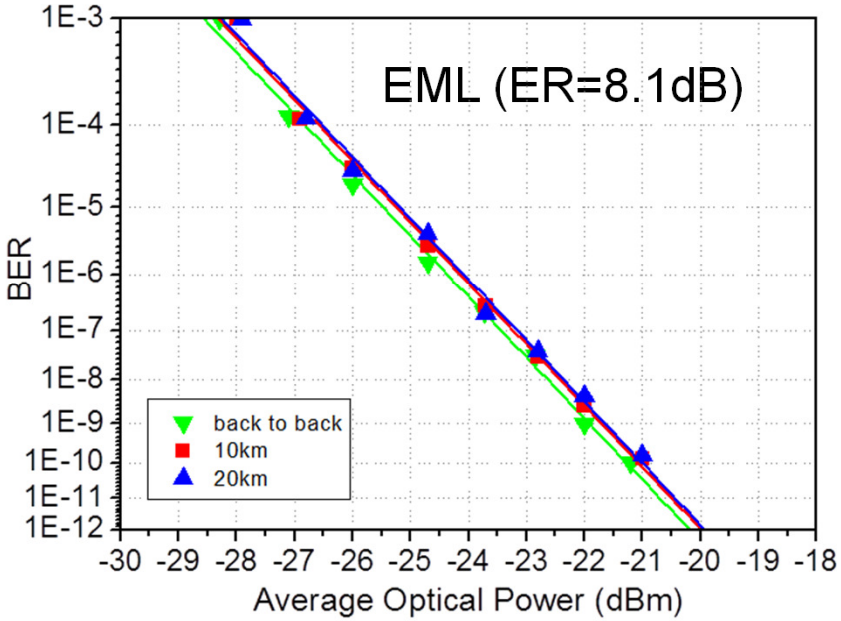
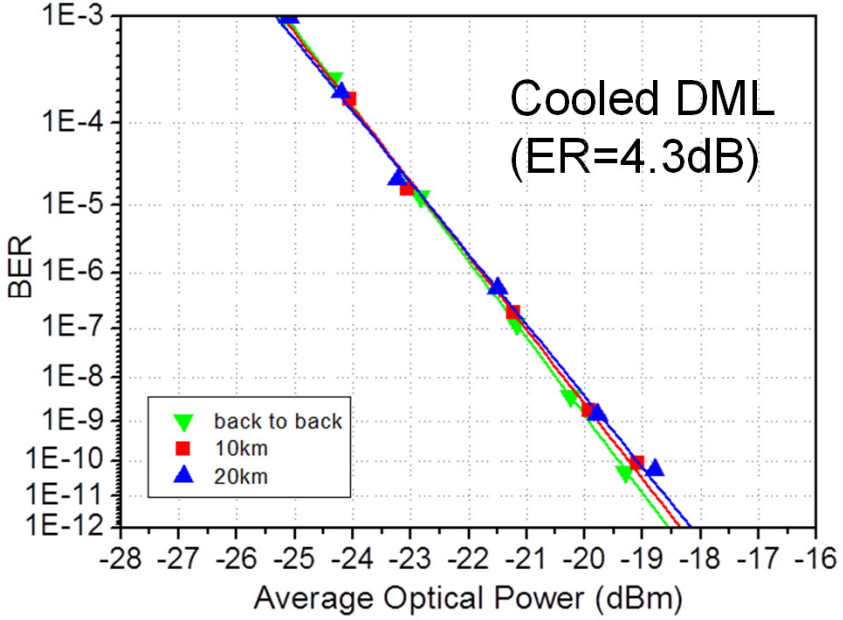
Test setup


Commercial EML or DML
Electrical PRBS
Anritsu MP1800A
Optical signal
Optical Attenuator
Keysight 86100D
0,10,20km
single mode
fiber
Optical
Splitter
5% Power
Optical
Power meter
95% Power
DC
block
DC
block
TO-can ROSA
on EVB
SiFotonics APD
Commercial TIA

TO-can APD ROSA with EML (ER=8.1dB) and DML (ER=4.3dB)



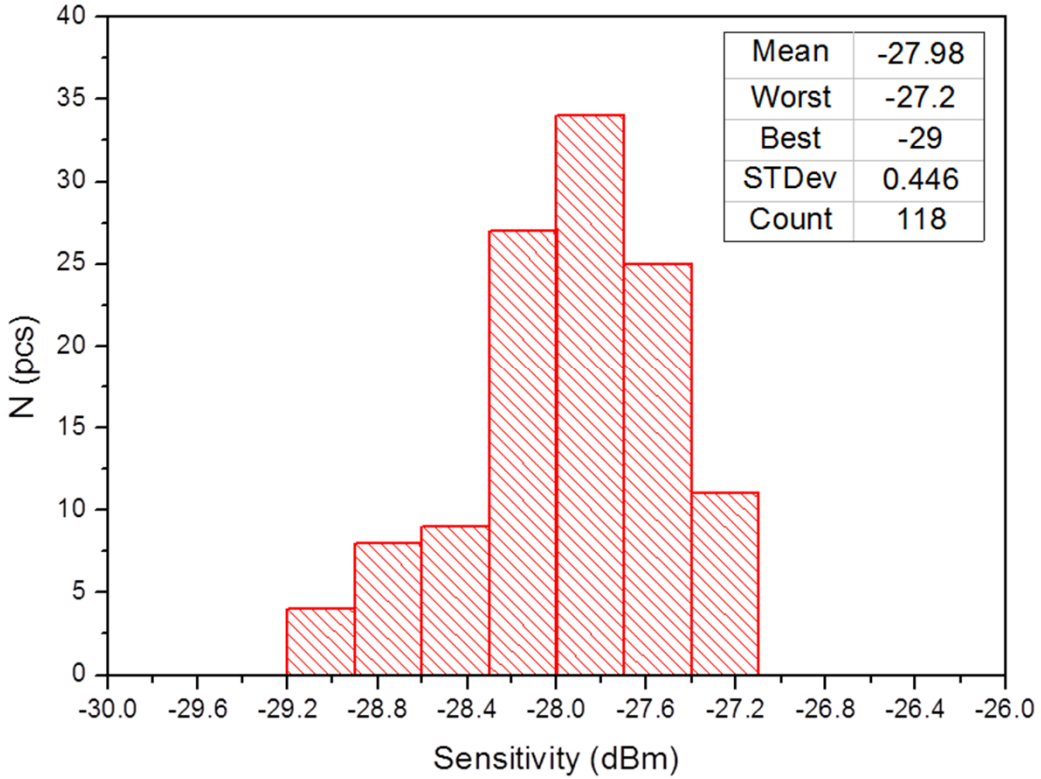


Test conditions: 1304nm, NRZ, PRBS=2^31-1, 25.78Gb/s, RT

AOP (dBm)	EML(ER=8.1dB)	Cooled DML (ER=4.3dB)
Back to Back	-28.3	-25.2
10km	-28.0	-25.1
20km	-27.9	-25.1

Statistical data of TO-can APD sensitivity

Statistical sensitivity data of 25G TO-can type APD ROSA (assembled by commercial packaging house)



Test conditions: 1304nm, ER=8.1dB(EML), 25.78Gb/s, NRZ, BER=1e-3, 2^31-1, back-to-back, RT

Theoretical calculation of 25G APD sensitivity

APD ROSA sensitivity can be calculated by:

$$Sensitivity(OMA) = i_{ROSA} \cdot SNR / R_{APD}$$

Here, *SNR* is signal to noise ratio, R_{APD} is APD ROSA responsivity, i_{ROSA} is APD ROSA total noise current, which is given by:

$$i_{\mathrm{ROSA}} = \sqrt{i_{APDshot}^2 + i_{TIA}^2}$$

Here, i_{TIA} is TIA input referred RMS noise; $i_{APDshot}$ is APD shot noise, which is given by:

$$i_{\mathrm{APDshot}} = \sqrt{2q(I_{\mathrm{dark}} + I_{\mathrm{photo}})FM^2B}$$

Here, q is electron charge, I_{dark} is dark current (@gain=1), I_{photo} is average photo current (@gain=1), M is APD gain, B is APD bandwidth, F is excess noise factor. The excess noise factor is related to APD gain (M) and ionization coefficient ratio (k) as following equation:

$$F = kM + (2 - 1/M) \cdot (1 - k)$$

Theoretical calculation of 25G APD sensitivity

Si based APD has much lower k value (<0.2), which is the fundamental reason that Ge/Si APD can perform ultra high performance at high data rate. Following table lists the calculation results of different 25G APD performance:

Parameter at 25^{0}C	Ge/Si APD (now)	Ge/Si APD (improved TIA)
BER	1.00E-03	1.00E-03
Q factor	3.09	3.09
Extinction ratio (dB)	8	8
Dark current @M=1 (nA)	60	60
Responsivity @M=1 (A/W)	0.7	0.7
Ionization coefficient ratio @M=12	0.13*	0.13*
Bandwidth @M=12 (GHz)	22	22
25G TIA input RMS noise (μA)	2	1.4
APD shot noise (μA)	1.83	1.65
Receiver total RF noise (μA)	2.71	2.16
25G AOP Sensitivity (dBm)	-28.6	-29.6

*Only calculation data.

Discussion

- Advantages of 25G APD TO-can ROSA for 100G PON
  - High performance: -28dBm (typical), this performance can be further improved by adopting TIA with lower noise current;
  - Provide similar cost structure to 10G APD ROSA in large volume, smoothly upgrade from 10G PON to 25/100G PON;
  - Suitable for compact package such as BOSA;
  - Reduce Tx power: +2dBm for single channel 25G PON and +4dBm for each channel of 100G PON , which can be realized by current commercial 25G EML;