Introduction of 25 Gb/s VCSELs

IEEE P802.3.ba 40Gb/s and 100Gb/s Ethernet Task Force
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Outline

(1) Proposal

4 parallel lanes 25 Gb/s PMD based on VCSELs for objectives to reach at least 100 m over OM3 MMF

(2) Introduction of 25 Gb/s optical device

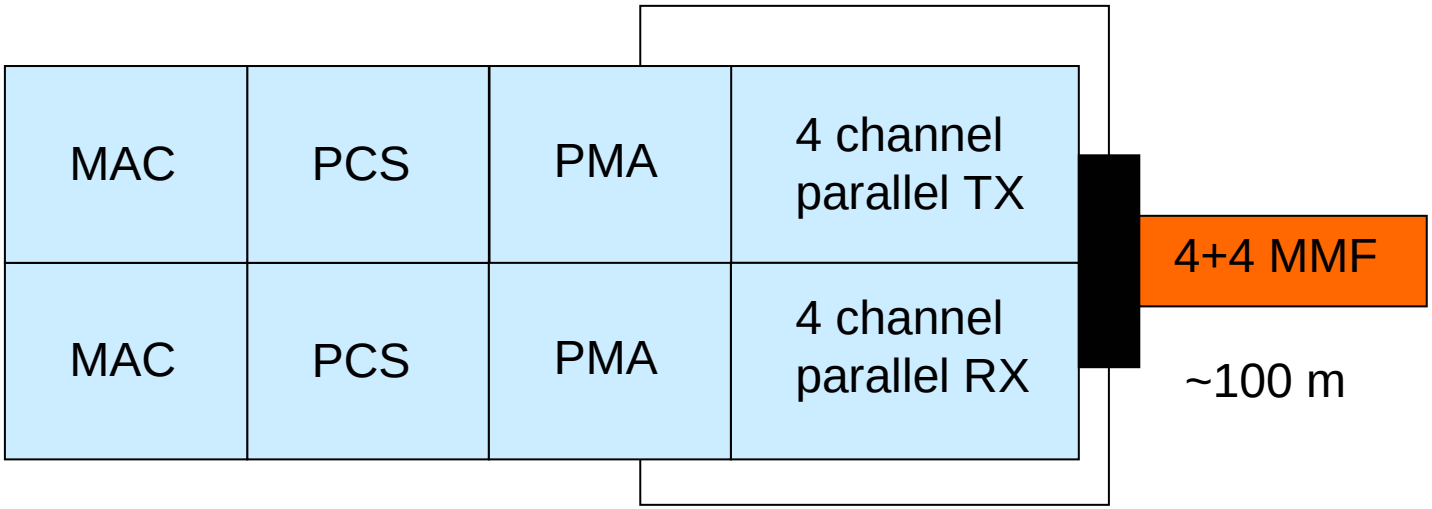
- **1-μm range VCSEL**
- **Characteristics of TX, RX, Fiber**
- **Experimental results and future work**

Proposal

- 4 parallel lanes x 25 Gb/s (100 Gb/s) for objectives to reach at least 100 m
- Over OM3 level fiber
- 4-ch VCSELs and PIN-PDs are used
- No retiming

Motivation and Configuration for 4 ch x 25 Gb/s, 100 m

- **Assembly cost reduction by decreasing the number of signal channels**
- **Same set of architecture with longer-distance efficient PMD (4 ch x 25 Gb/s, 10 km, 40 km)**
- **Lower OE/EO power consumption than edge emitters used for longer distances**

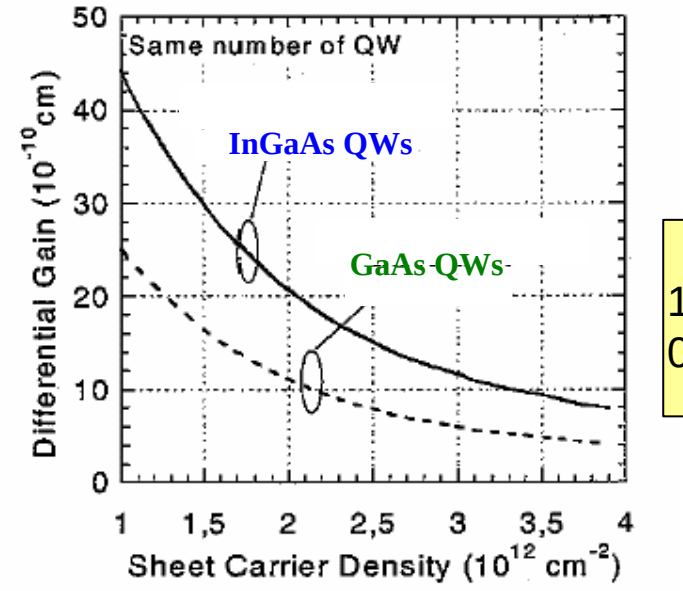


Introduction of 25 Gb/s optical device

1-μm Range VCSEL for High Speed Direct Modulation

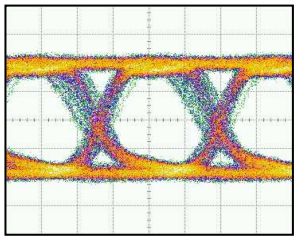
- 1-μm range VCSELs (**InGaAs QWs**) have **higher differential gain** than 0.85 μm VCSELs (**GaAs QWs**).
- 1-μm range VCSELs have **the same oxide-confined structure with 0.85 μm VCSELs**

High differential gain



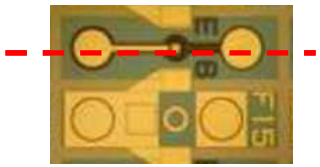
(T.Aggerstam *et al.*, SPIE vol.4649 pp.19 2002)

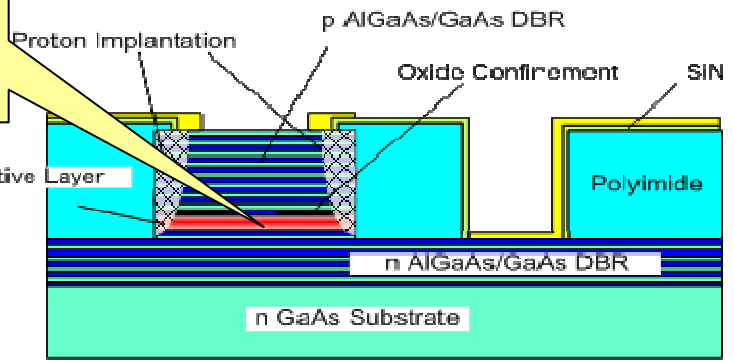
Over 25 Gbps operation was demonstrated



Eye-diagram of 30 Gbps operation

1 μm : InGaAs QWs
0.85 μm :GaAs QWs





VCSEL top view and cross section

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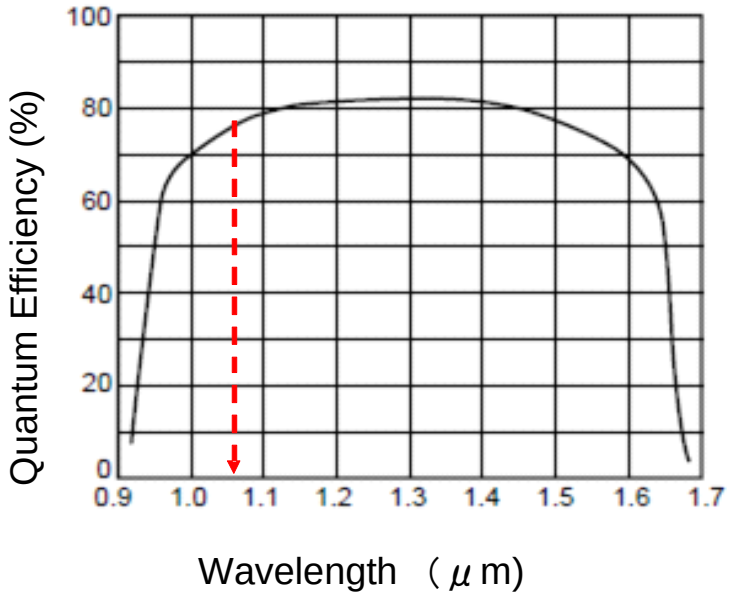
PIN-PD

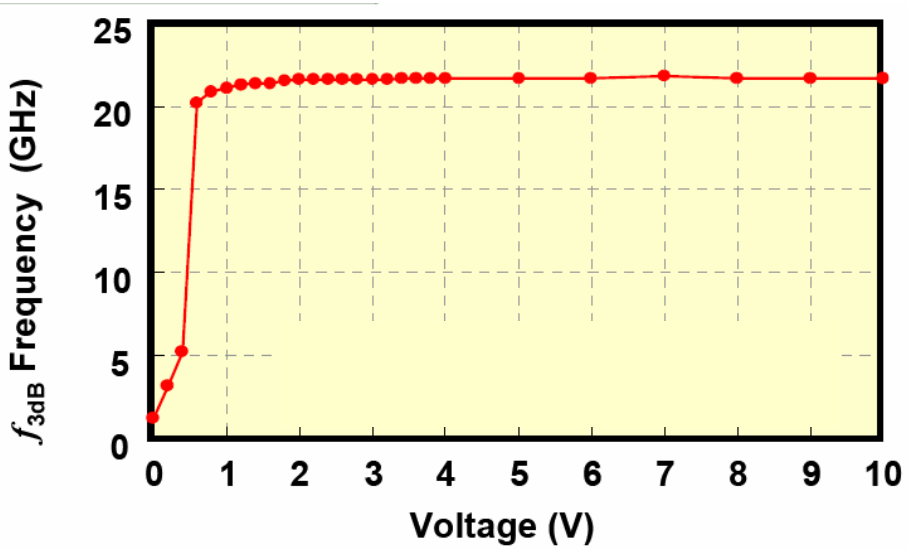
= feature for 25 Gbps operation =

- Conventional structure used at 1.3 / 1.55 μm range is available for 1-μm range
- Bandwidth is > 20 GHz at a detector diameter of 30 μm
- Insertion of an InP capacitance reduction layer

Wavelength dependence of Q.E.



Bandwidth of Φ30 μm PIN-PD.



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Transmitter and Receiver Characteristics

TX

Description	Value	Unit
Signal speed	25	Gb/s
Center wavelength (range)	980-1100	nm
RMS spectral width	1.6*	nm
Average Launch Power (max)	1.5	dBm
Extinction ratio (min)	TBD	dB
RIN12OMA (max)	TBD	dB/Hz

*Smaller amount of Chromatic dispersion at 1-µm range accepts wider RMS.

RX

Description	Value	Unit
Min Bandwidth	20	GHz
Average Receiver Power (max)	TBD	dBm
Average power at receiver input (min)	TBD	dBm

Link and Cable Characteristics

- **Amount of Chromatic dispersion of 1-μm range is smaller than half that of 0.85 μm**

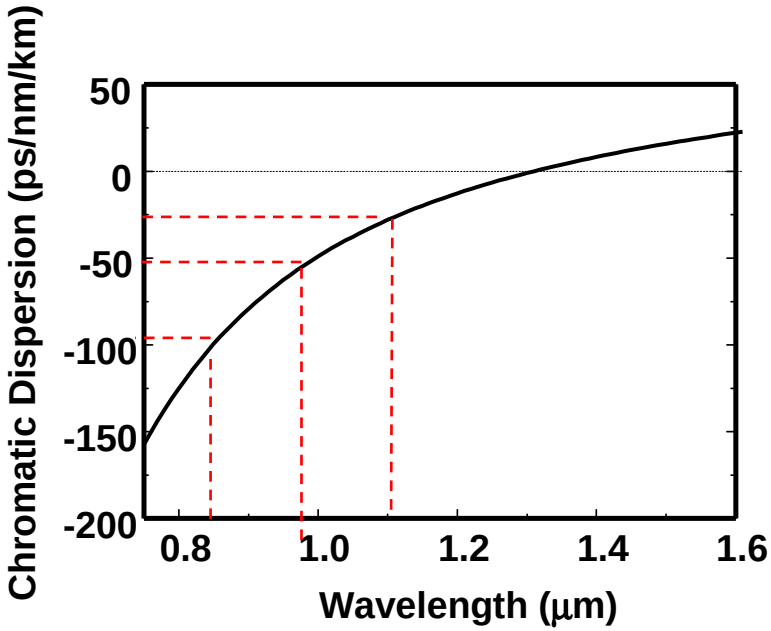
Chromatic dispersion

- 0.85 μm ⇒ - 99.6 ps/nm/km
- 0.98 μm ⇒ - 54.3 ps/nm/km
- 1.1 μm ⇒ - 28.1 ps/nm/km

$$D(\lambda) = \frac{S_0}{4}\lambda\left(1 - \frac{\lambda_0^4}{\lambda^4}\right)$$

In here, S_0=0.101

λ_0 =1310



- **1-μm range MMF can be prepared from commercial MMF by using 1-μm range light source**

parameter	Value	Unit
Effective Modal Bandwidth	2000 (OM3)	MHz*km
Power Budget	TBD	dB
Operating Range	0.5-100	m

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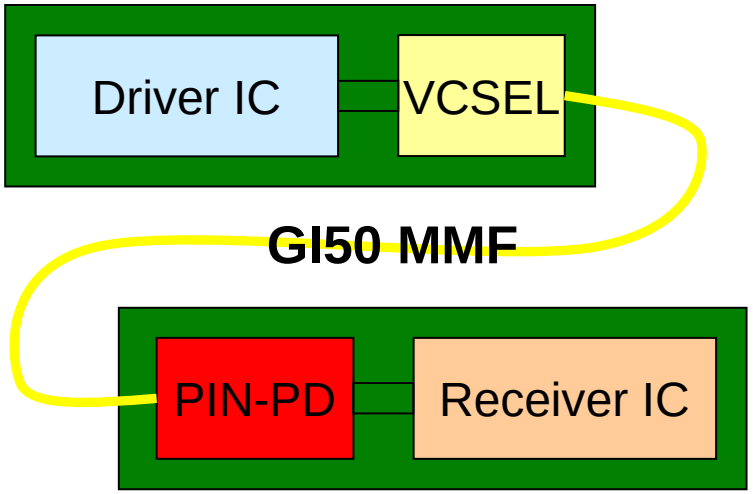
Experimental results

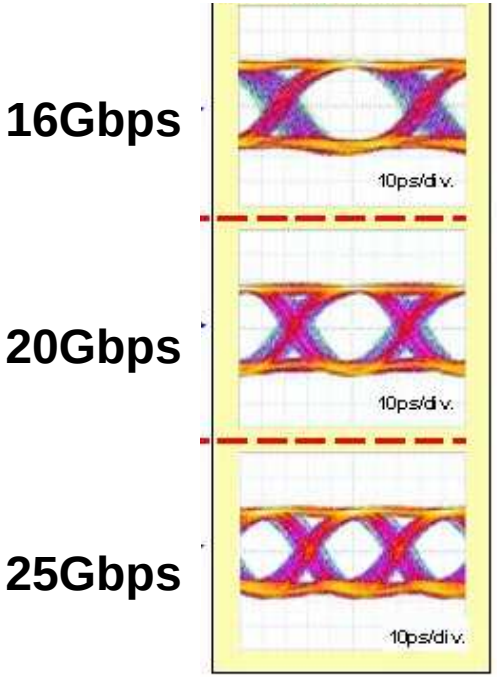
- **up to 100 m 25 Gb/s error-free transmission**

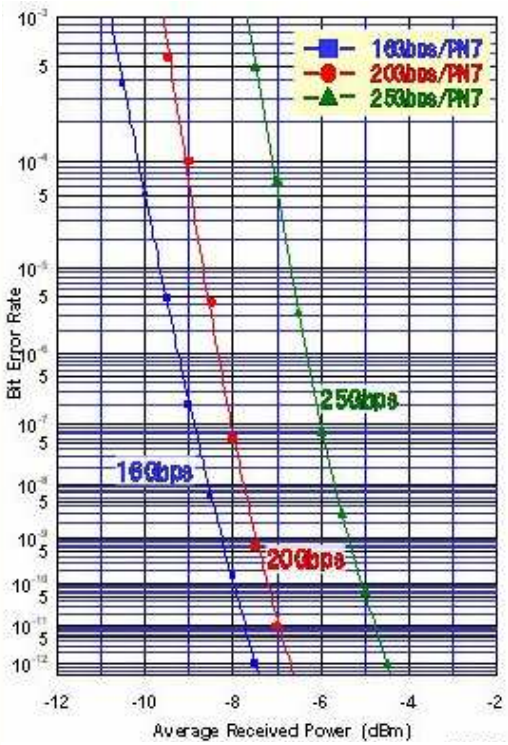


Setup for HPC

- **GI50 MMF 100 m**
  (sorted from OM2 fibers)
- **PRBS 2^7-1**
  (compatible to 8B10B)
- **no retiming**
- **Driver / TIA SiGe BiCMOS**
- **λ = 1.07 μm**

Reciever IC output





***Minimum received power will be more improved by tuning ICs for Ethernet in the future**

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Future work

- Finely tuning device* parameters for link budget for 25 Gb/s 100 m transmission
- Jitter
- Crosstalk
- Fiber specs for 1-μm range (transmission demonstration with various bandwidth MMF)

*optical devices and ICs

Conclusion

- We propose no-retimed PMD to address objectives to reach 100 m over OM3 at 100 Gb/s (4 ch x 25 Gb/s) with VCSELs

- 1-μm range directly modulated VCSELs meet the objectives

Thank you!