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Reliability and Emerging Capabilities of 1060nm VCSELs

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R. Lingle, Jr., OFS

IEEE 802.3 100GNGOPTX Study Group, January 2012 Interim, Newport Beach

1060nm Wavelength

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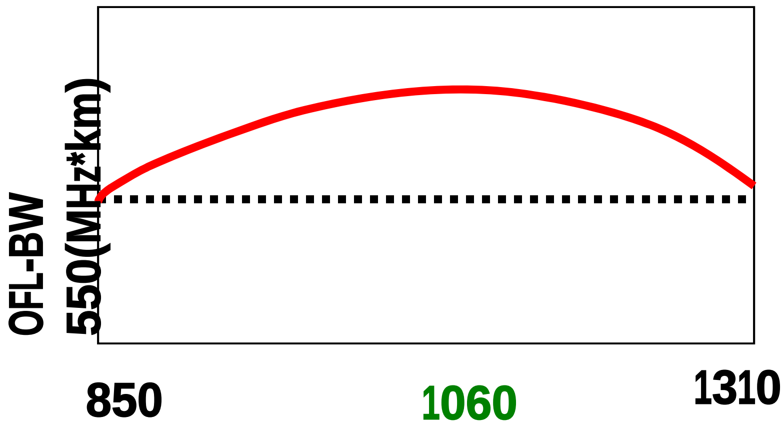
Existing OM2 fiber



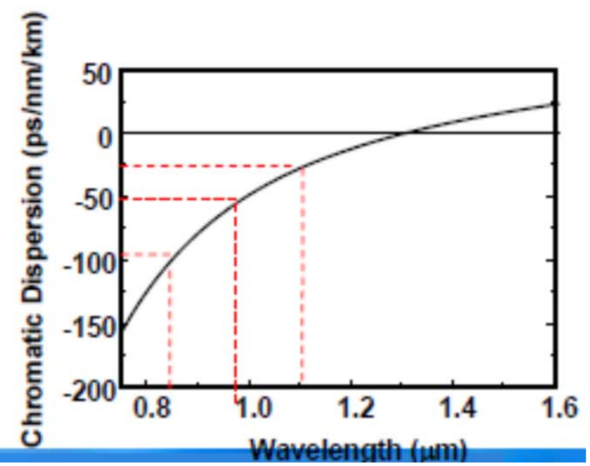
1060nm VCSELs were first developed for proprietary applications

MMF can be optimized for OM3 / OM4 performance at 1060nm

Loss		Chromatic dispersion		
2.1	dB/km	·0.85 μm	⇒	- 99.6 ps/nm/km
1.2	dB/km	• 0.98 μm	⇒	- 54.3 ps/nm/km
0.9	dB/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



1060nm wavelength LD (VCSEL) with InGaAs active

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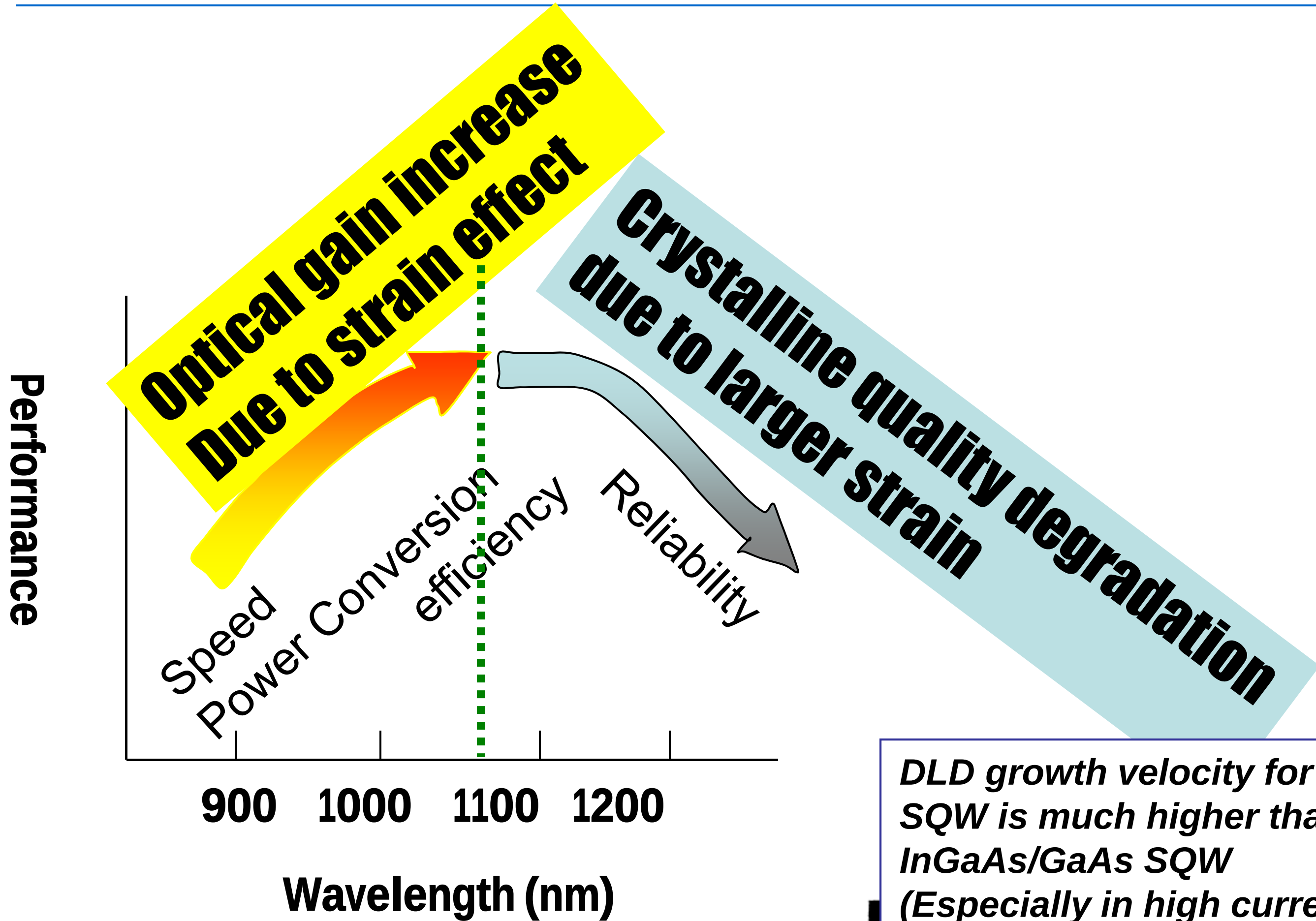
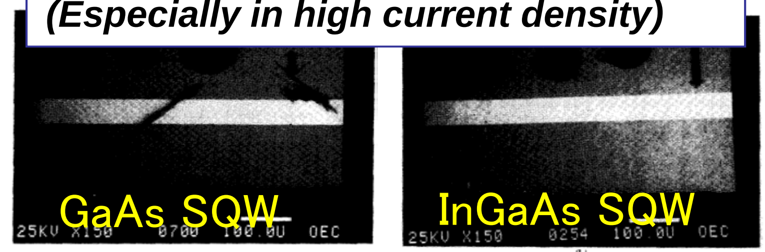


DLD growth velocity for GaAs/AlGaAs SQW is much higher than that for InGaAs/GaAs SQW (Especially in high current density)



**R.G. Waters et.al., IEEE PTL, 2, pp531-533, 1990*

Number of Optical Channels

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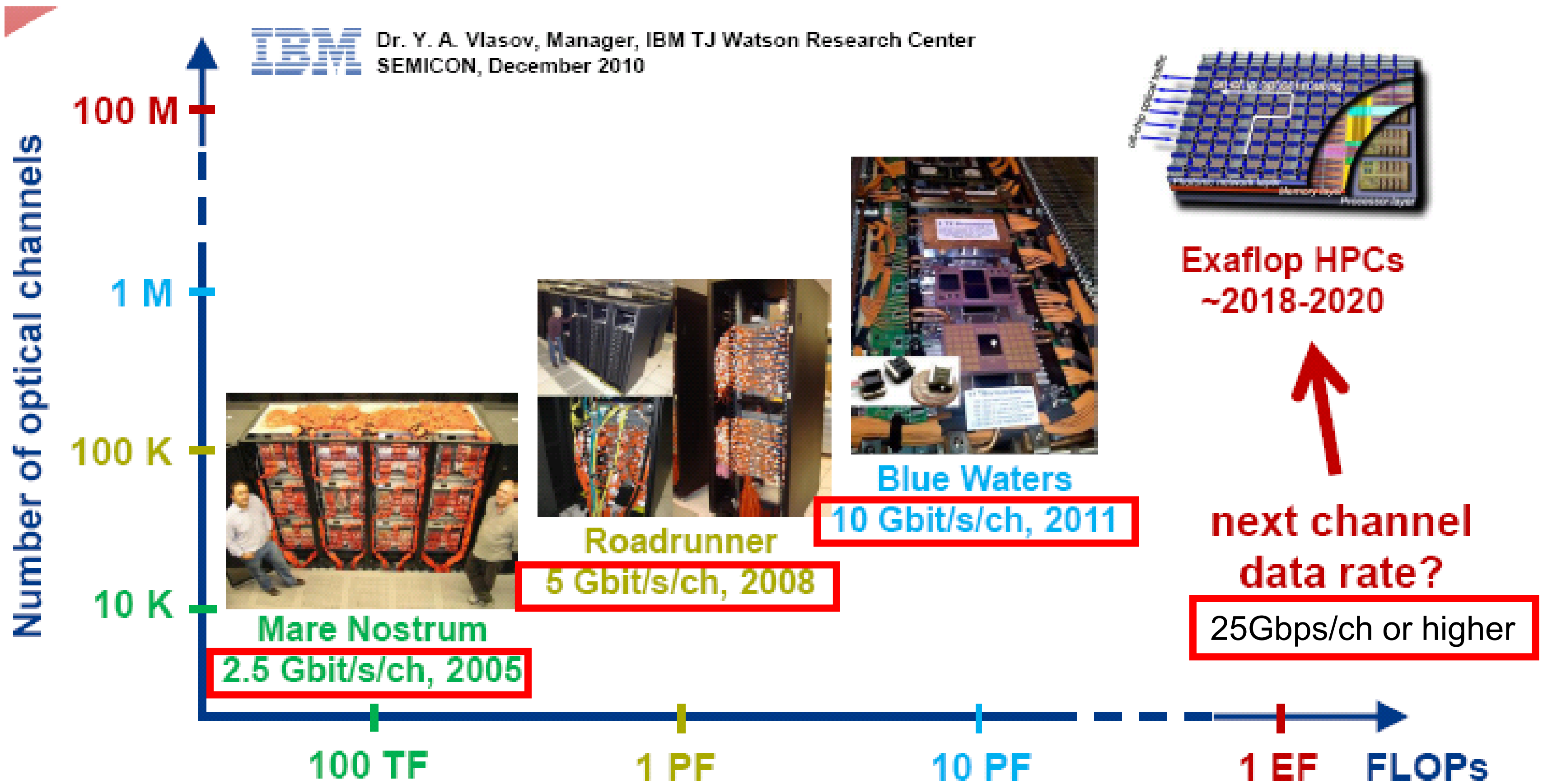

Speed, power consumption, reliability, and cost become crucial

Inherent Material Merit in 1060nm VCSELs with InGaAs SL-QW

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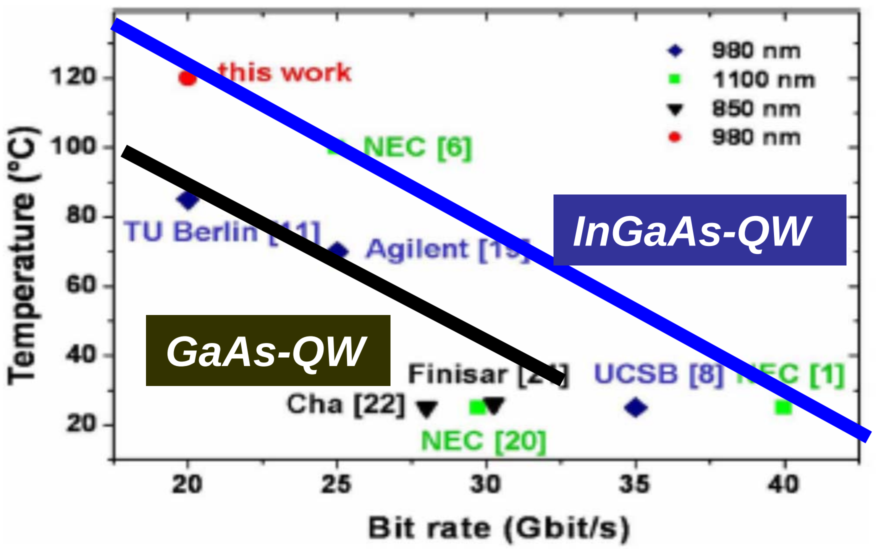
✓High Speed at high temperature, owing to high material gain

✓ Low power dissipation due to low built-in voltage, high quantum efficiency

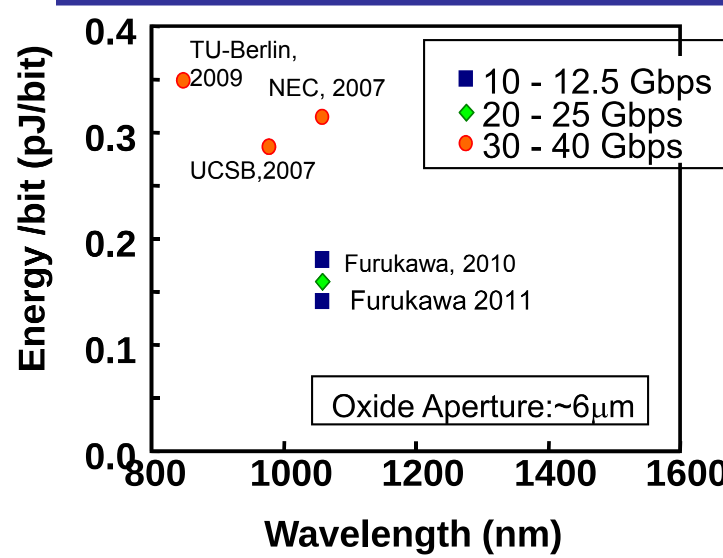
✓ High material reliability due to slow dislocation velocity

High Speed characteristics



A. Muting et al.,
IEEE Journal of Selected topics in Quantum Electronics, vol.15, No. 3, pp 679, 2009

Power consumption characteristics



S. Imai et al.,
IEEE Journal of Selected topics in Quantum Electronics, vol.17, No. 6, pp1614, 2011

In-plane lasers with InGaAs active layer
Proven "Telecom grade" Reliability

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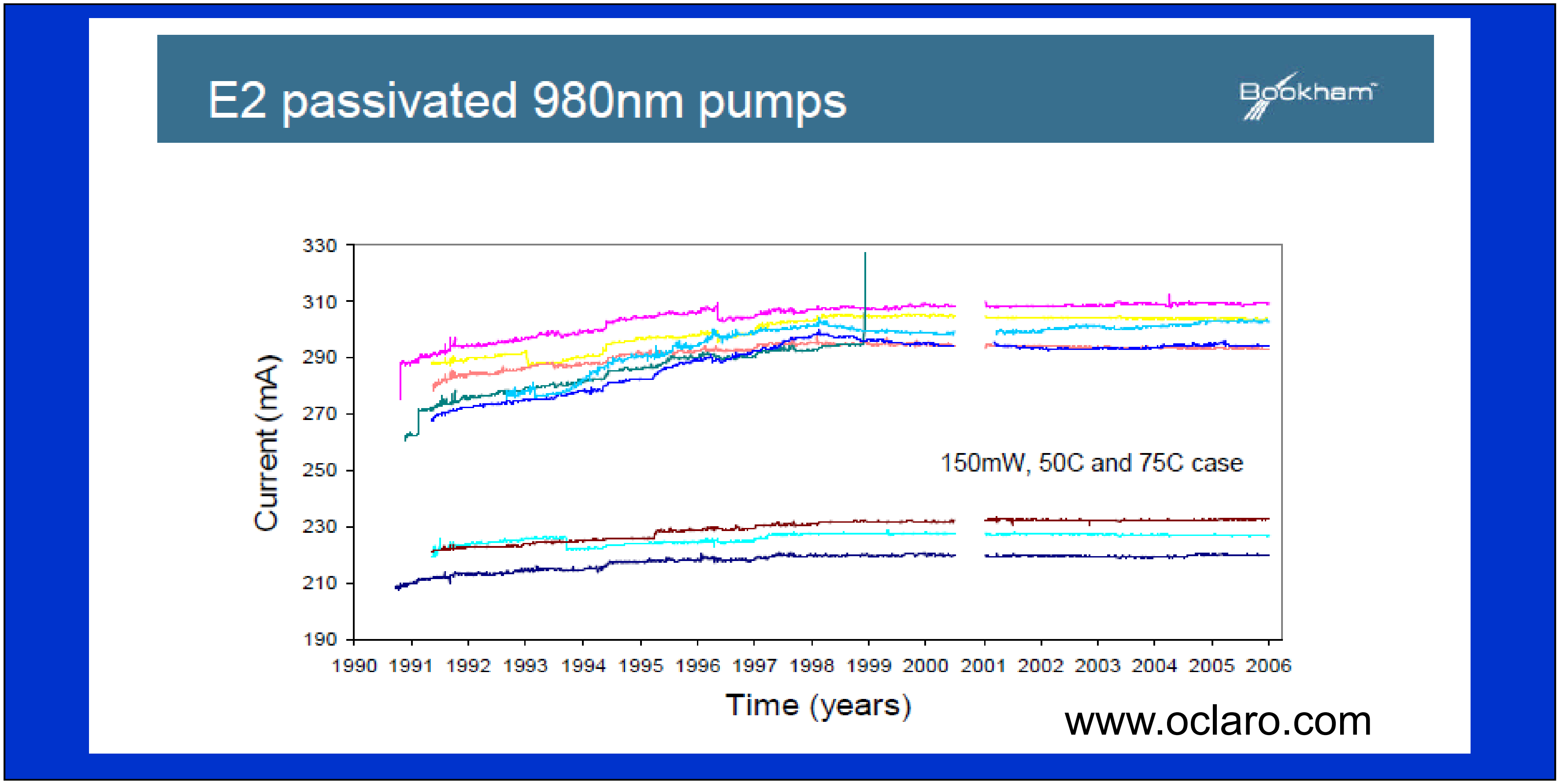

Encouraging aging result for highly reliable operation (16-year).
Never reported for GaAs-active lasers.
Lots of terrestrial and under-sea usage.

Summary for large scale reliability test

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Test procedure

High temperature: 70, 90 and 120°C,   Bias current: 6 mA

Package: commercial 20pin DIP (**air ambient; non-hermetic**)

Failure definition: 2 dB power degradation at 25°C and 6 mA

Adopted acceleration factor: Ea = 0.35 eV, n = 0

Condition	Quantity (number of chips)	Maximum aging duration (hours)	Device hours @40°C, 6 mA	Number of failures
70°C, 6 mA	1,075	5,000	8.0×10^6	0
90°C, 6 mA	1,121	5,000	1.6×10^7	0
120°C, 6 mA	2,702	2,000	5.4×10^7	0
Total	4,898		7.8×10^7	0

30 FIT/ch with confidence level of 90%

Over 20,000h   Life test at 70C, 90C (I=6mA)

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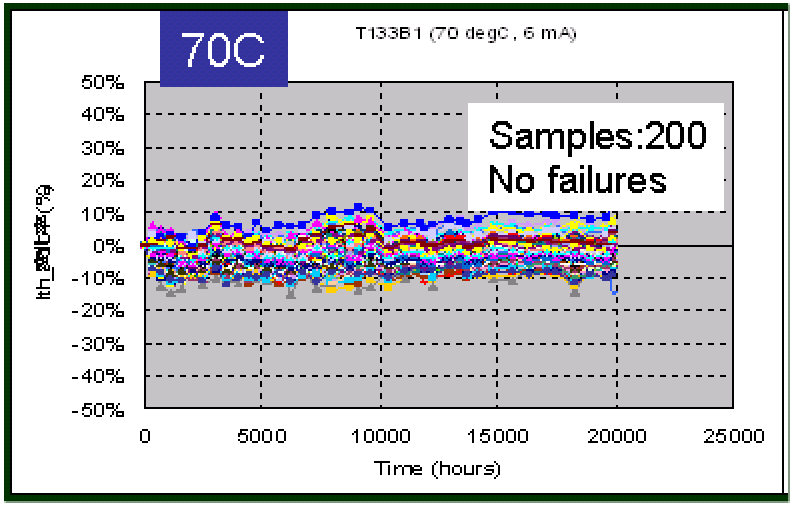
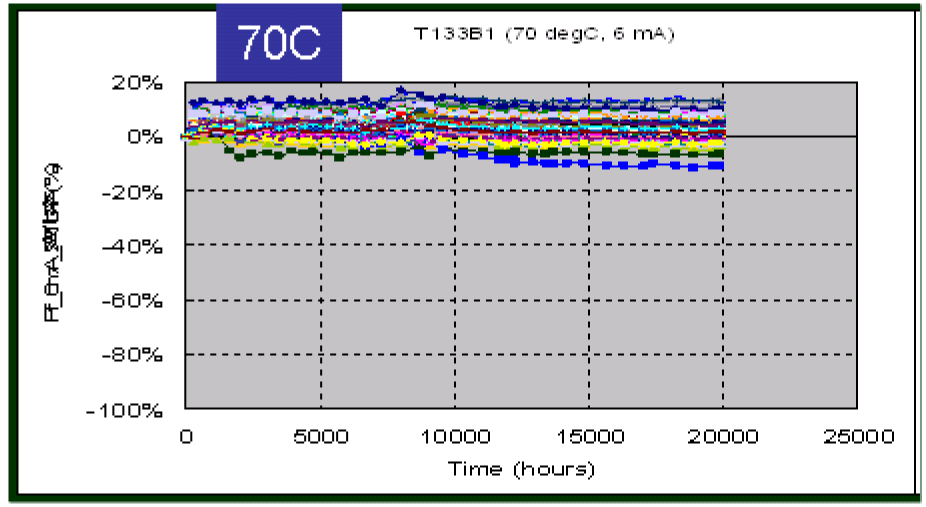
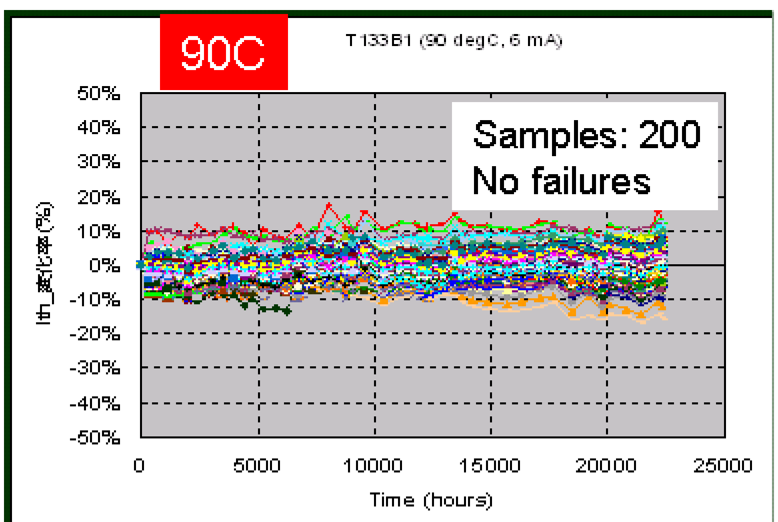
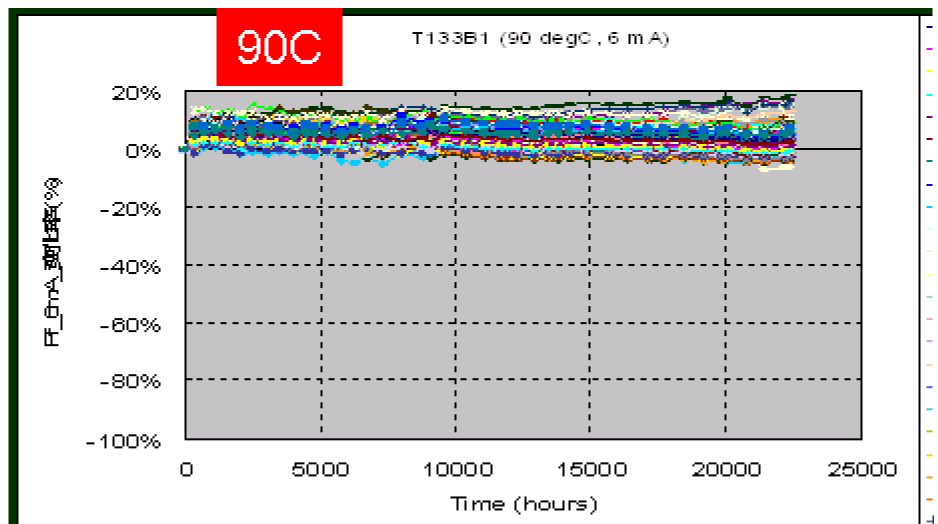




Threshold change

Power change





Eye patterns before and after aging at 120C, 6mA

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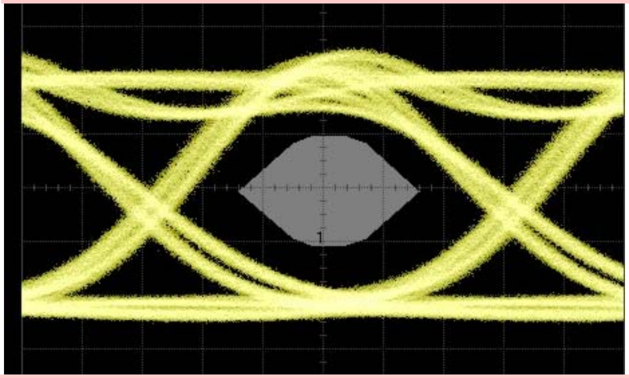
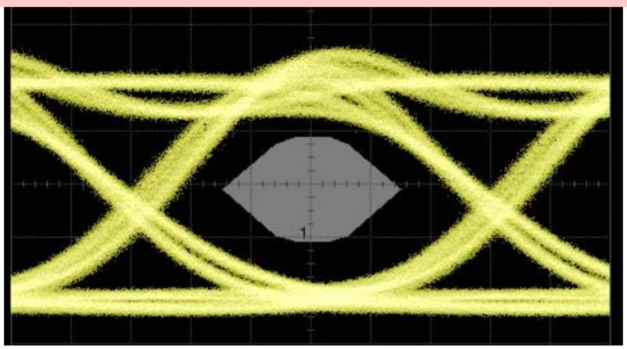
10Gbps

Eye diagram before aging test



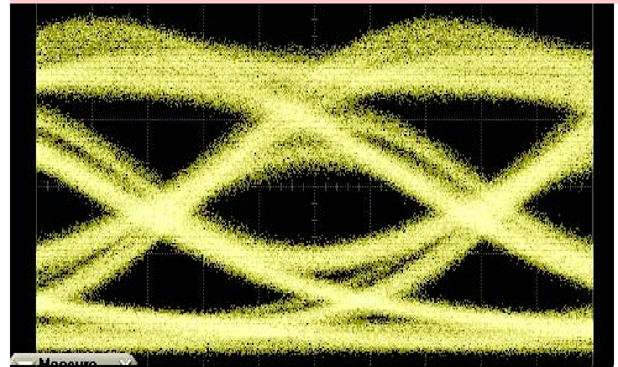
Eye diagram after aging test (5000hrs)



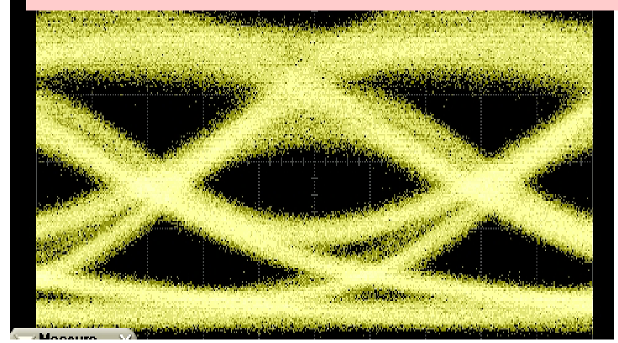
Ib=5mA ER=360mV(ER=6dB)

25Gbps

Eye diagram before aging test



Eye diagram after aging test (2000hrs)



Ib=5mA Vpp=400mV (ER=6dB)

No eye pattern degradation was observed **in both for 10Gbps and 25Gbps after long-term aging.**

Preliminary reliability test

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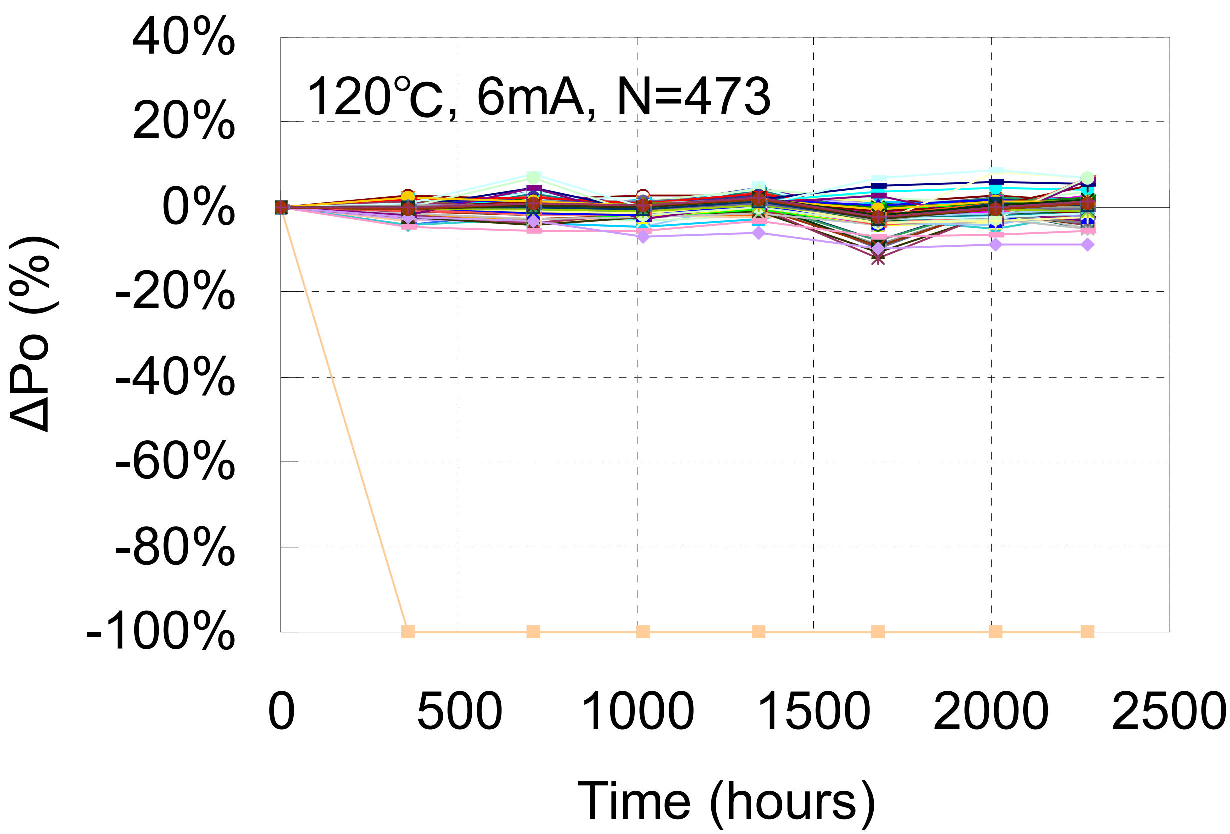
Promising result, comparable to those for 10Gbps was obtained.



One failure was infant failure

-→ Screening condition was not adjusted for 25Gbps device.

20Gbps transmission over OM2 MMF using 1060nm VCSEL

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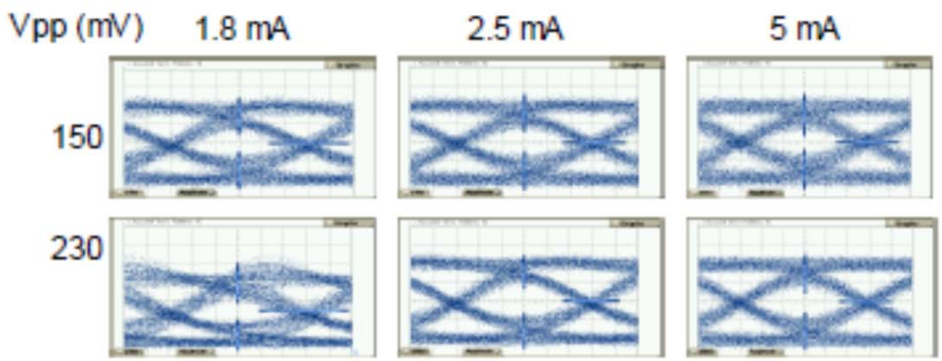

Fig. 6: Eye patterns after transmission over a 100m OM2 optical fiber.

Possibility to extremely low power consumption optical link ~1.5mW/Gbps

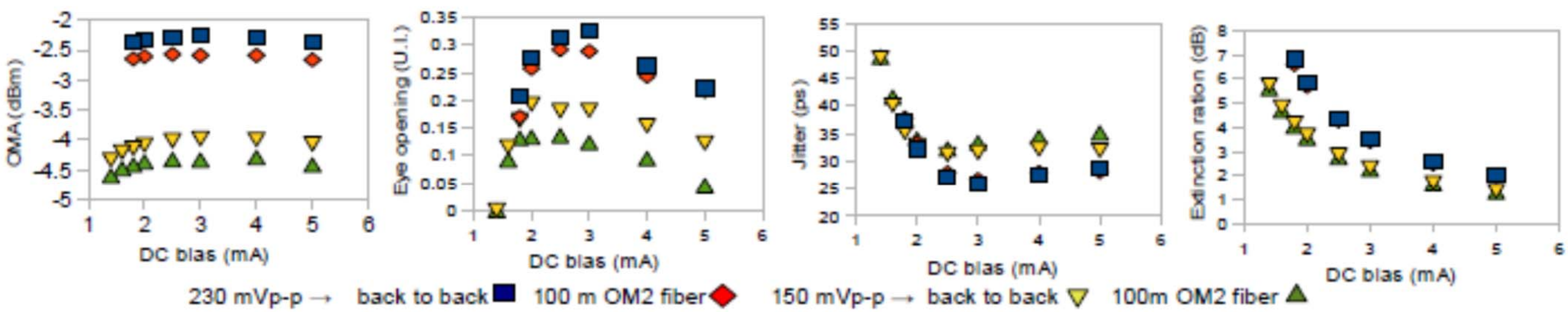

Fig. 5: Measured OMA, eye opening, total jitter and extinction ratio as a function of the VCSEL DC bias at 20 Gbps.

20 Gbps optical link with high efficiency 1060 nm VCSEL
Jean Benoit Héroux[*a], Keishi Takaki[b], Masao Tokunari[a], Shigeru Nakagawa[a]
Optoelectronic Interconnects and Component Integration X, edited by Alexei L. Glebov, Ray T. Chen, Proc. of SPIE Vol. 7944, 79440A · © 2011 SPIE

Conclusions

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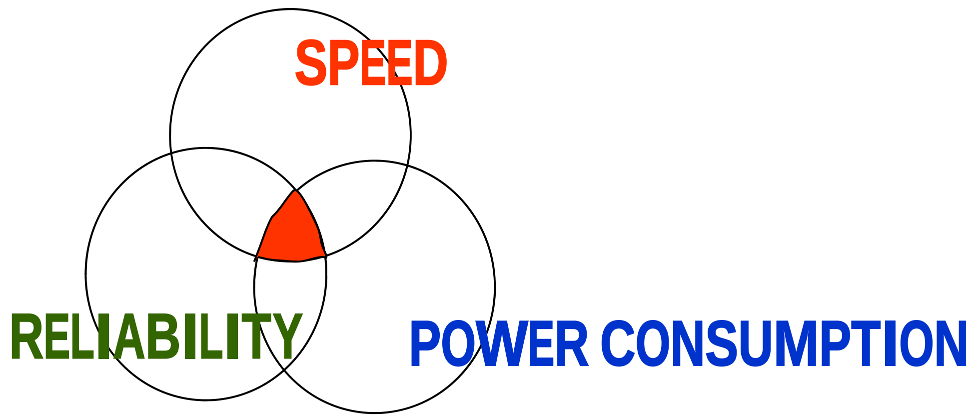
1060nm VCSELs can provide following features simultaneously:

- ✓ High Speed data transmission
- ✓ Low power dissipation
- ✓ High material reliability



Promising candidate for high speed, low power consumption, high reliability. In development for 28 Gbps applications