

850 nm VCSEL for Automotive Applications

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Background

850 nm 25G VCSEL reliability

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https://www.ieee802.org/3/cz/public/8_jun_2021/giovane_3cz_01_080621.pdf

980 and 850 nm VCSEL comparison

Ruben Perez-Aranda and David Ortiz

https://www.ieee802.org/3/cz/public/8_jun_2021/perezaranda_3cz_01b_080621_vcsel_reliability.pdf

Roger King, Joseph Pankert

https://www.ieee802.org/3/cz/public/may_2021/king_3cz_01a_0521.pdf

Ruben Perez-Aranda

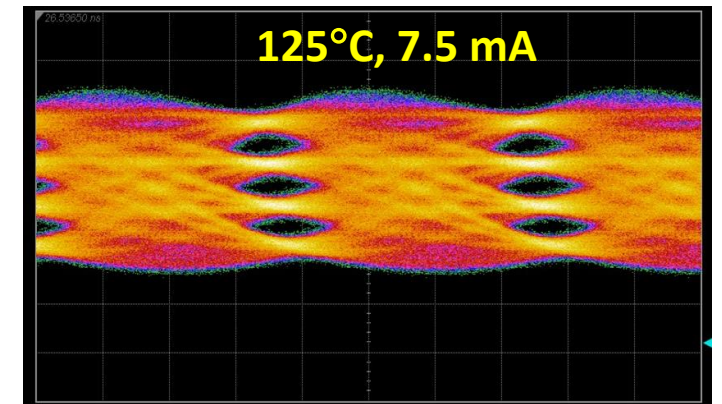
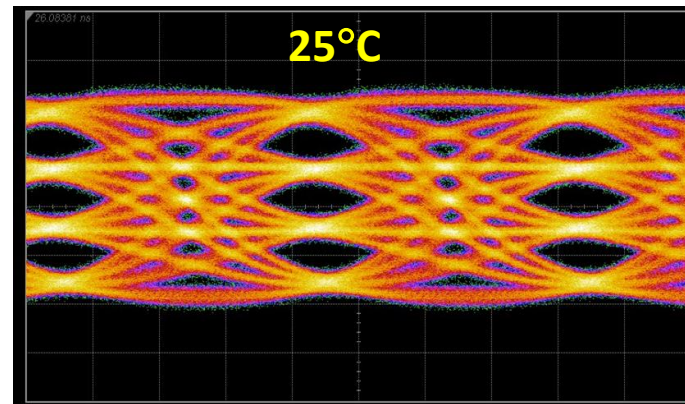
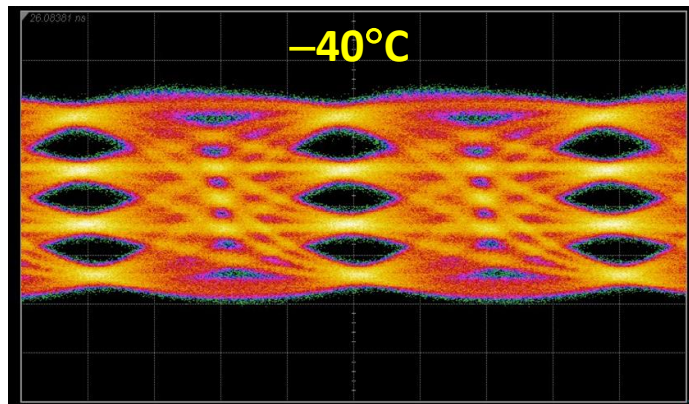
https://www.ieee802.org/3/cz/public/may_2021/perezaranda_3cz_01_0521_VCSEL_980nm.pdf

50G Operation

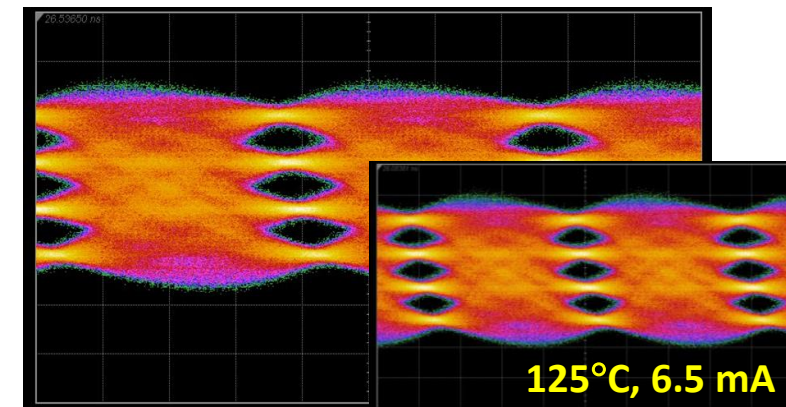
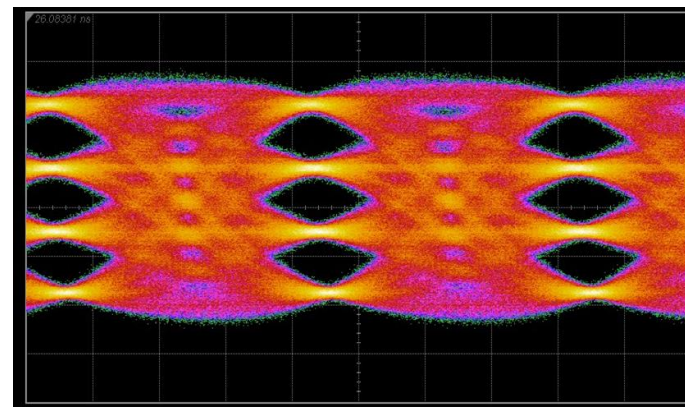
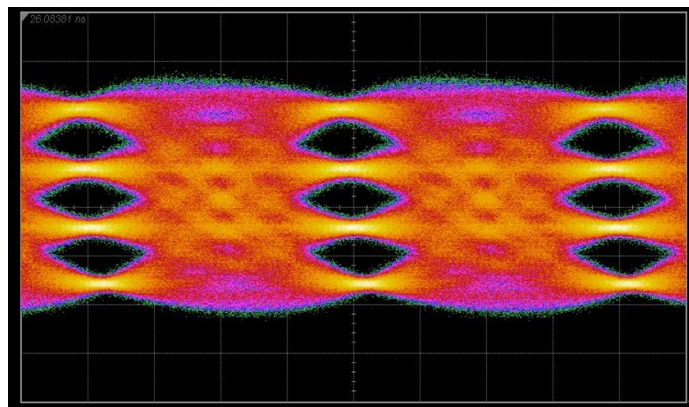
- Example of 50G operation over -40 to 125°C shown below.
- With the OM3 fiber optimized for 850 nm, minimal degradation in the eye is expected up to 40m reach at 50G [objective is 15m at 50G and 40m at 25G].

26.88 GBd PAM4 (53.76 Gb/s) ER 4 dB SSPRQ Reference equalizer defined in 802.3cd

Optical
waveform

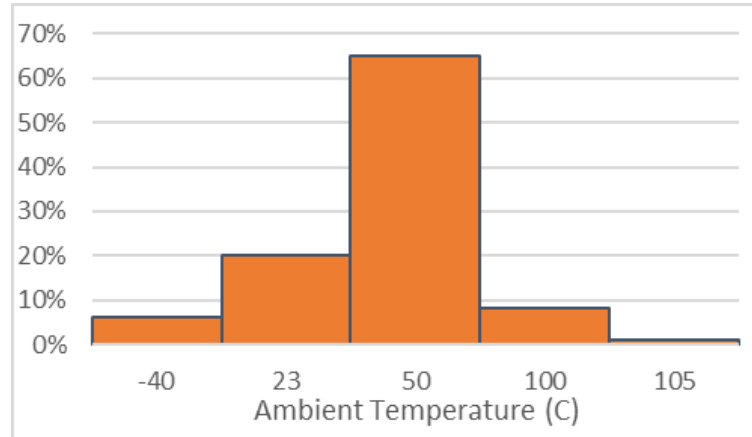


After Rx
equalization



850 nm VCSEL Lifetime

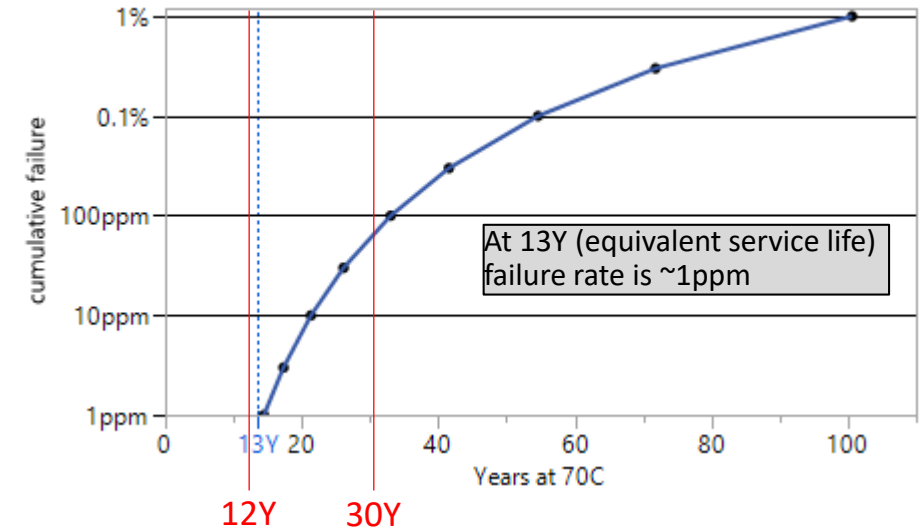
Automotive mission profile



ΔT = difference between ambient and VCSEL substrate

Operating Condition	Equivalent number of years at 70°C
$\Delta T = 10K$, Bias 7.5 mA	13 years
$\Delta T = 20K$, Bias 7.5 mA	30 years
$\Delta T = 20K$, Bias 6.5 mA	12 years

Extrapolation of lognormal at 70°C



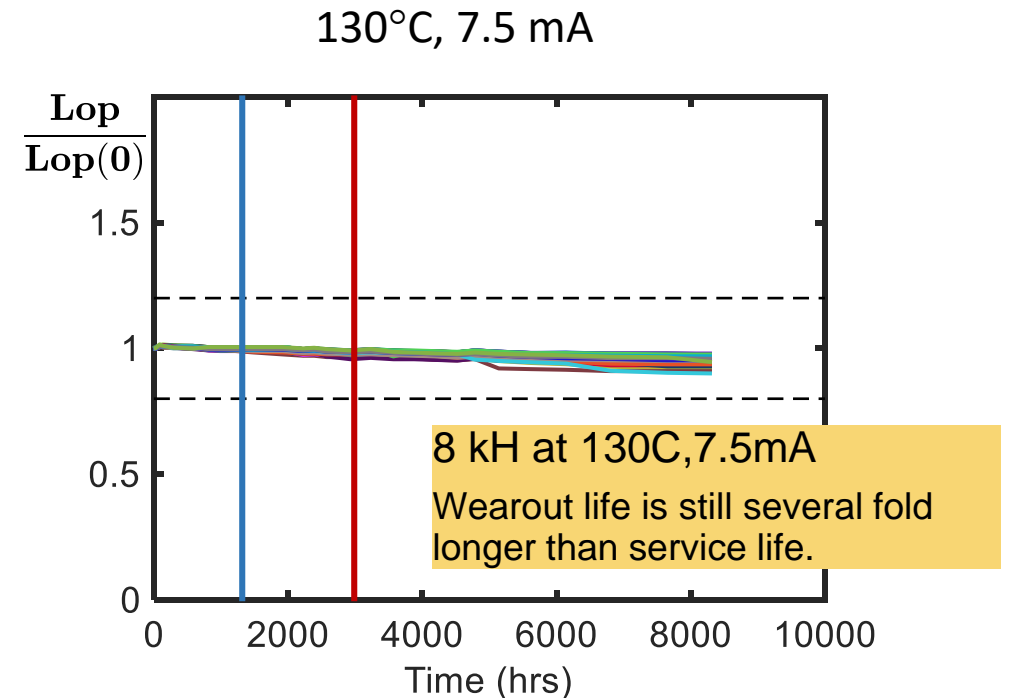
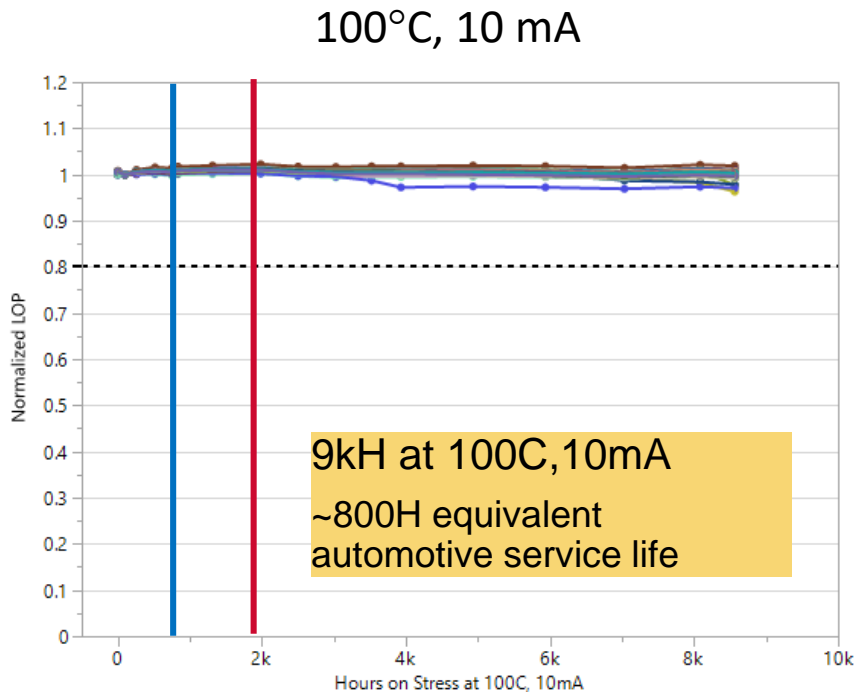
Forward voltage, light emission and device thermal resistance are considered a function of temperature when calculating failure rate.

Stress Tests

- Long term aging tests show that the wear out life is several fold longer than automotive service life.

— $\Delta T = 10K$, Bias 7.5 mA, automotive mission profile service life

— $\Delta T = 20K$, Bias 7.5 mA, automotive mission profile service life



Failure Rate

850 nm 25 GBd VCSELs are widely deployed in data centers.

- Field experience: Over 100M 850nm 25GBd VCSEL channels deployed for Data Centers

Field experience

< 1 DPPM (channel)

< 1 FIT (channel)

- Wear out failure mode is not observed in the field.
- Accelerated aging tests determine the parameters of the wear out failure mode.

Low random failure rate is more important in the field. How do you establish low random failure rate?

1. Failure modes have low activation energy; not easy to accelerate in a lab test (GR-468 $E_a = 0.35$ eV)
2. Demonstrating values below 10 FIT requires massive testing, or many years of field experience.

Summary

850 nm VCSELs have been proven in the field and are available today.

- 25 GBd VCSELs have sufficient bandwidth to operate over the automotive temperature range.
- Low field FIT rate in data center applications over 7 years.
- Using 850 nm VCSELs for automotive application will leverage the established high volume, multi-vendor manufacturing eco-system.