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Proposal for
Very Short Reach Objective for Scale Up
Introducing 1060nm wavelength as option to meet CSD

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Contribution outline

- Objective and Proposal
- Scale Up Interconnect (Backend XPU and accelerator ASIC)
- Motivation for 1060nm wavelength
- Conclusion

Supporters

- Ali Ghiasi

Objective

- After IEEE 802.3 200G MMF CFI approval, this is a proposal to the Study Group to consider Very Short Reach objective for up to at least 10m targeting the Scale Up interconnect application (AI/ML GPU and accelerator ASICs)
  - During the preparations of the CFI, concept of VCSEL/PD arrays using longer wavelength, i.e. 1060nm and their technical benefits were introduced as option for such objective
  - The present contribution also supports the CSD that will be reviewed by the SG, specifically Broad Market Potential, Technical Feasibility, and Economic Feasibility
- Industry wide initiatives to investigate and define requirements for Scale Up interconnect (OIF, OCP, Ethernet Alliance, HoTI, Hot Chips, etc…).
  - Beyond 2028 need for very high capacity, high reliability and very low power optical interconnect for 500+ GPU/accelerator “row level” clusters
  - The IO capacities for such interconnect will quickly exceed bidirectional 50Tbps per ASIC

Motivation for 1060nm from VCSEL + PD perspective (I)

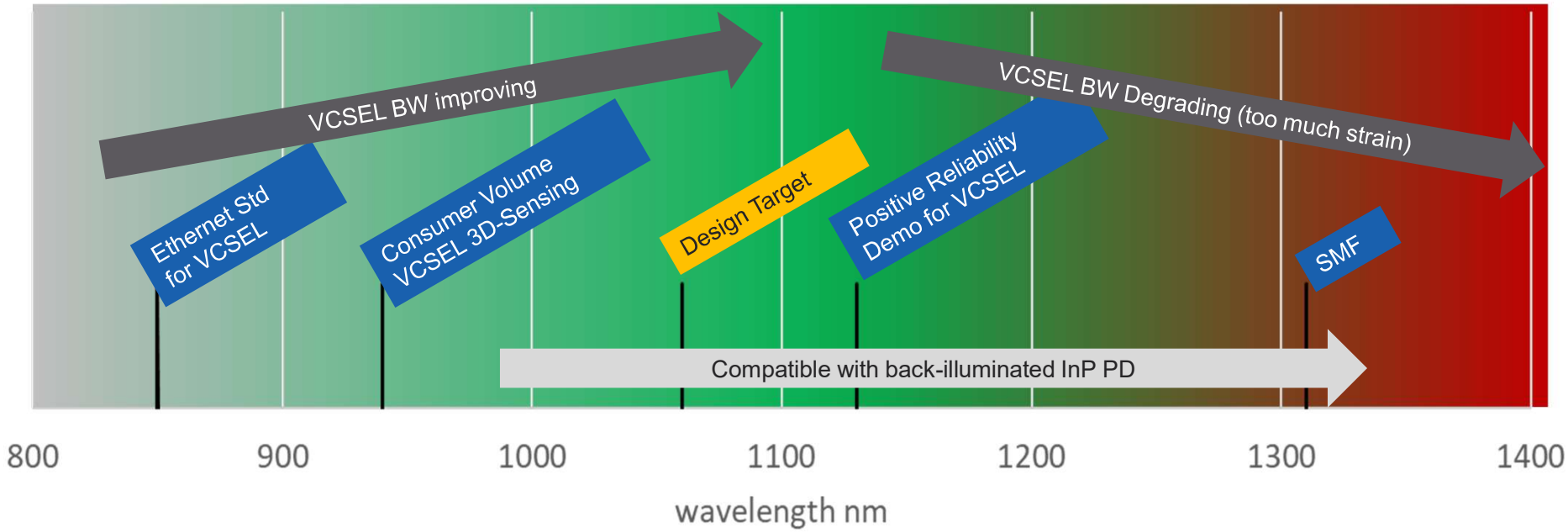
850nm
- First standard, 1999
- Set from fiber / laser technology in 90's.

940nm
- 3D sensing introduced, 2017
- Pushes industry to HVM - billions of emitters shipped

980nm
- Automotive introduced, 2021
- Forces High temperature, high reliability interconnects inside automobiles

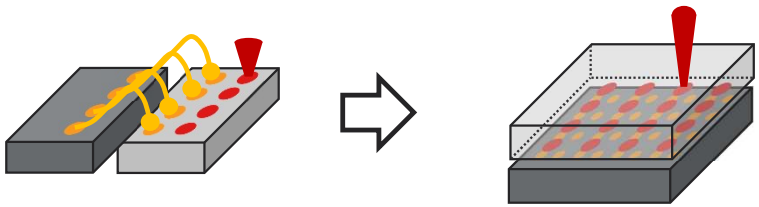
1060nm
- High density interconnect proposed, 2025
- Builds on 3Ds, Automotive, adds bandwidth, density, signal integrity, manufacturability

Motivation for 1060nm from VCSEL + PD perspective (II)



- Higher intrinsic RF bandwidth in 1000-1100nm range - best (operating) power efficiency
- Proven 940nm reliability, 1130nm showing even better reliability performance

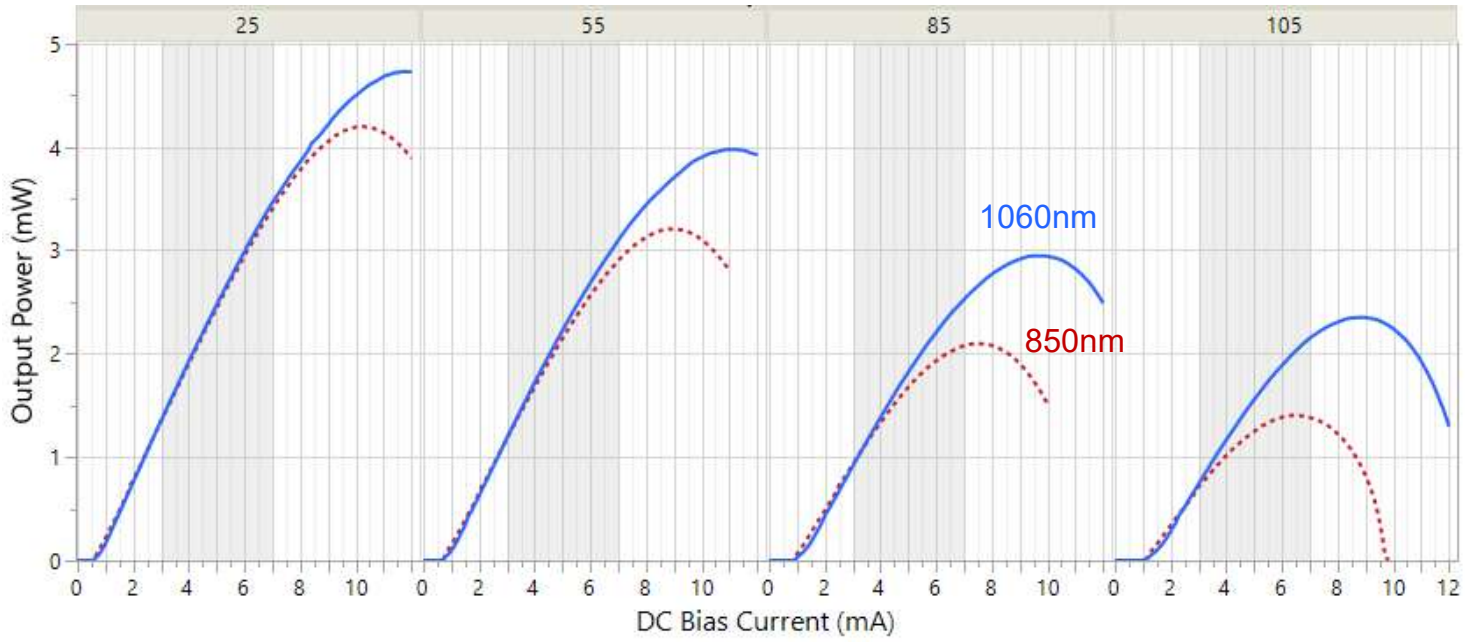
1060nm VCSEL technical benefits summary



Metric	850nm	1060nm	Context
Fiber BW	+	-	**Help needed from fiber manufacturers** to confirm reach at 1060nm
Wall plug efficiency	+	+	Roughly equivalent efficiency, slightly lower voltage at 1060nm.
Emitter BW	-	+	Strained InGaAs active layer design enables 1.3x intrinsic BW, higher differential gain and efficiency
Signal Integrity	-	+	Flip chip integration removes group delay impedance issues known with wire-bonding..
Reliability	-	+	Flip chip and channel sparing takes FIT below 1. Al free active region enable high temp/high power reliability.
Detector technology	-	+	Flip chip detectors - higher speed / better responsivity than wire-bonded equivalent
Density	-	+	2D VCSEL arrays for high density interconnect including channel sparing
Thermal management	-	+	>20C lower laser junction, >20C lower ASIC temperature from flip chip driver/TIA assemblies
Manufacturability	-	+	Flip chip for mass reflow or TCB, also enables high accuracy placement for assembly
Volume	-	+	Builds on largest VCSEL deployments in history, reuses MFG partners, test, assembly supply chain

1060nm VCSEL | Example L-I Curves over Temperature (I)

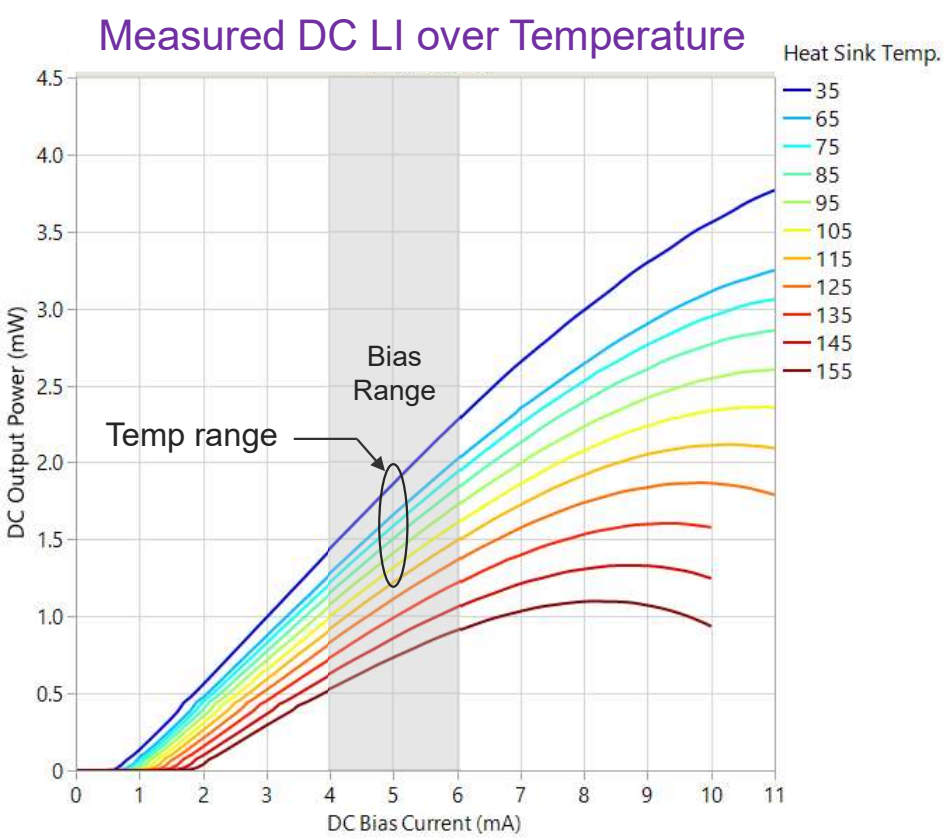
Example DC L-I Curves for Top-Emitting VCSELs
vs. Heat-Sink Temperature
similar ~5um OA and 25ºC slope eff. devices selected

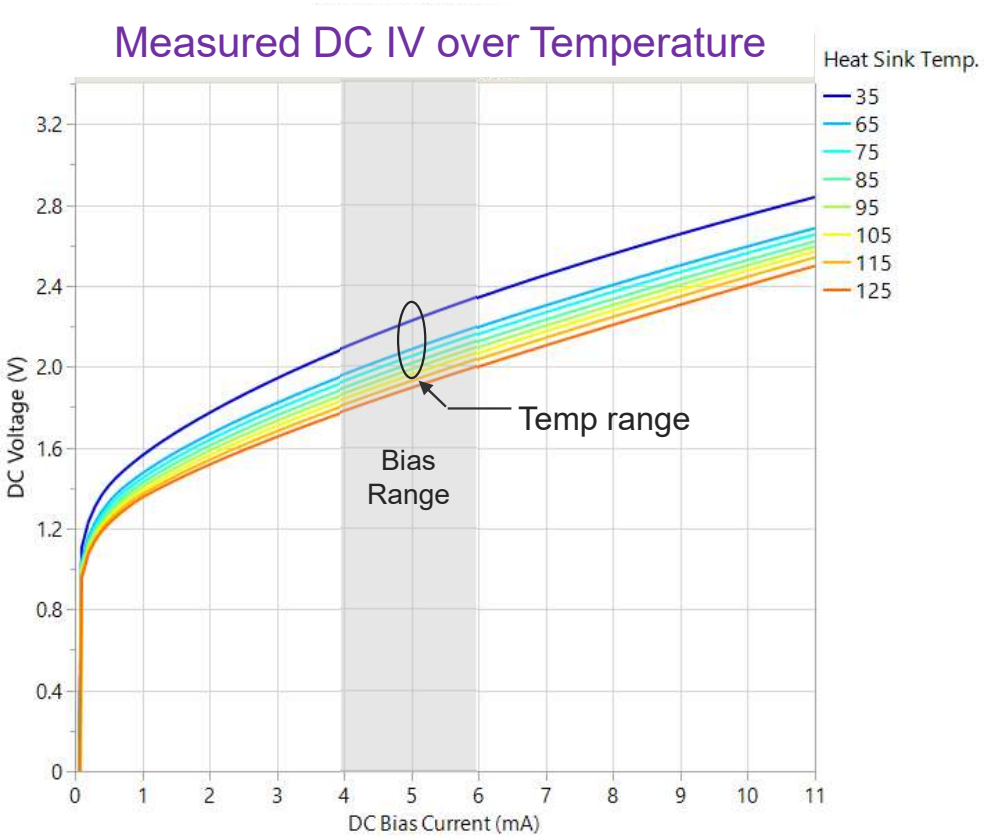


Typical bias range 5±2mA

- 1060nm device with higher strain and deeper wells are more linear at higher current and temperature

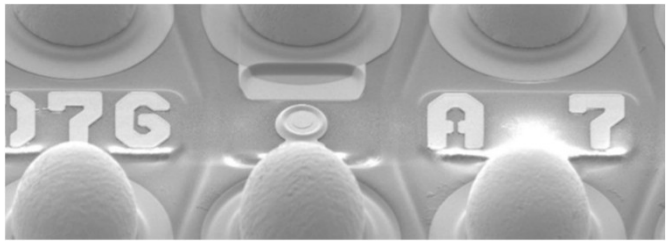
1060nm VCSEL | Example L-I Curves over Temperature (II)



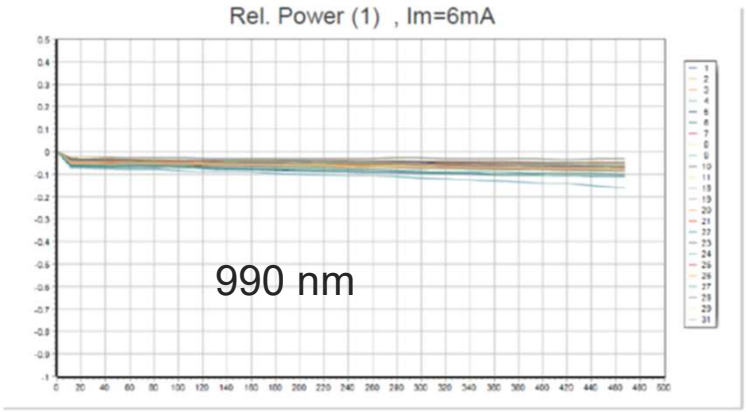


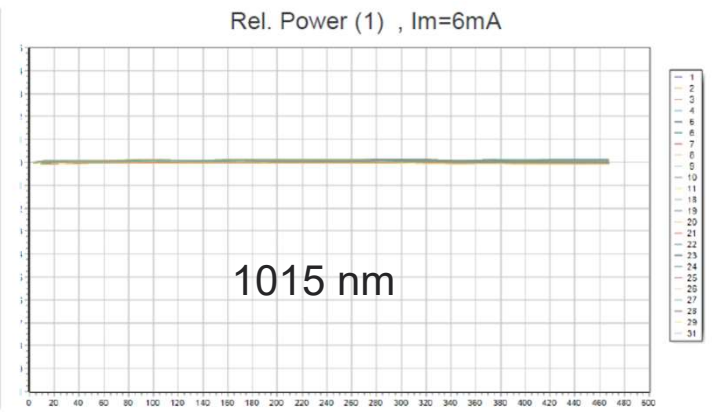
- Excellent performance with >155C operating temperature

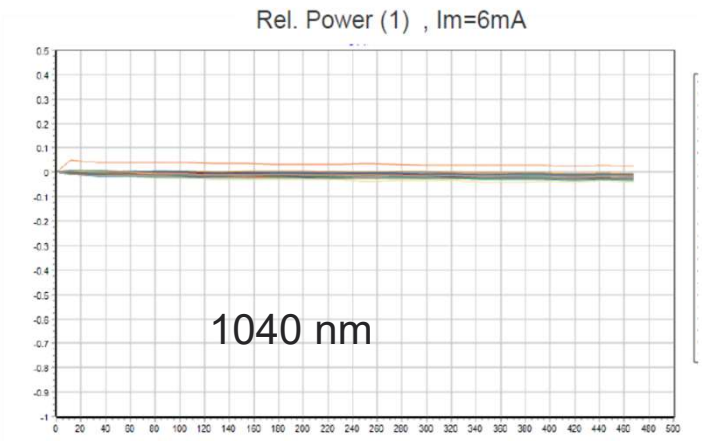
Industry Example – High Reliability to 1065nm and Bottom-Emitting

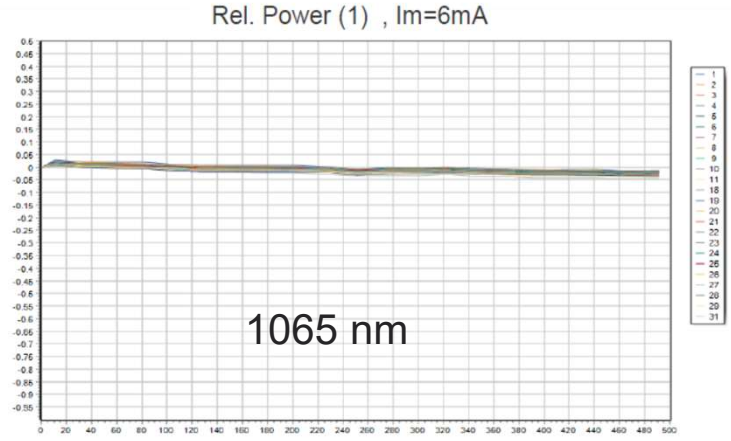


- 170ºC (high acceleration) 8mA stress
- Flip-chip bottom emitting







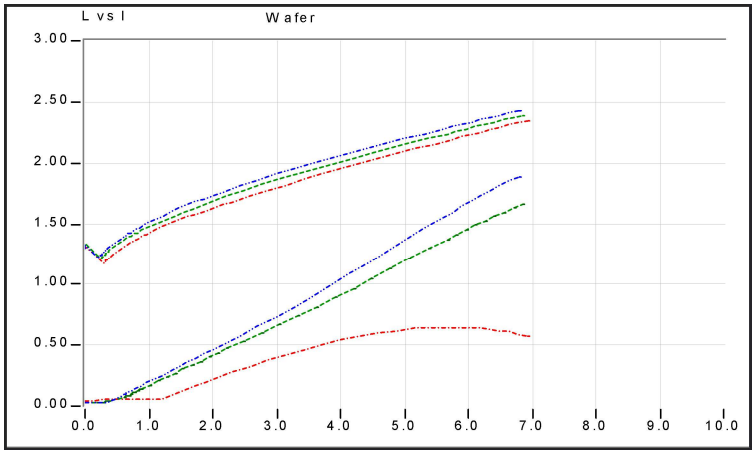


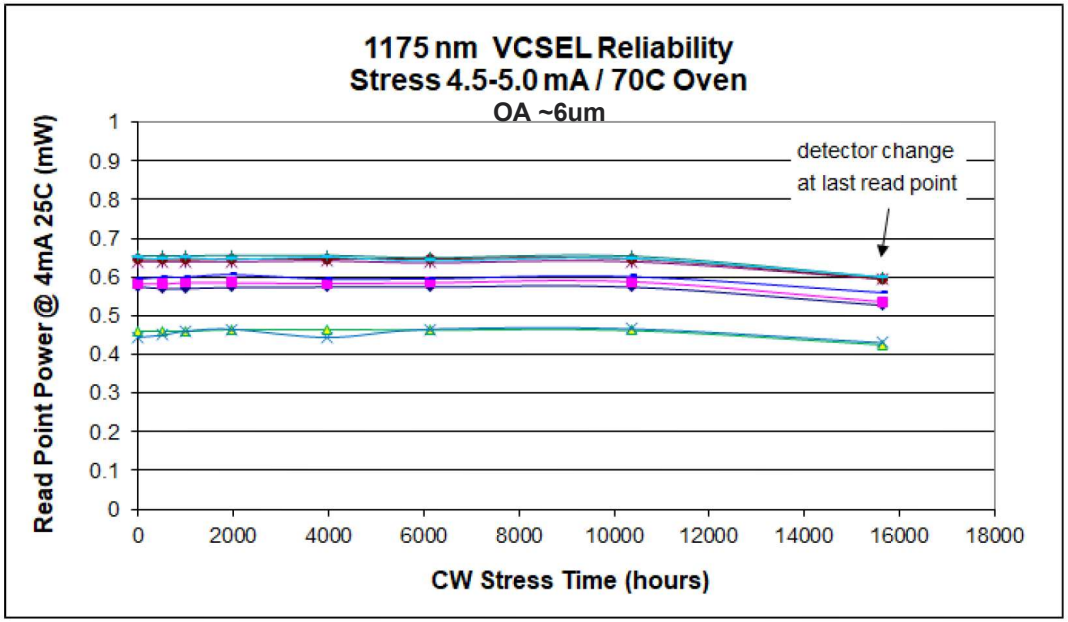
- Samples from 4 different wafers (4 different EPI designs): 0 fails after 500hrs

Example – Demonstrating High Reliability to 1175nm

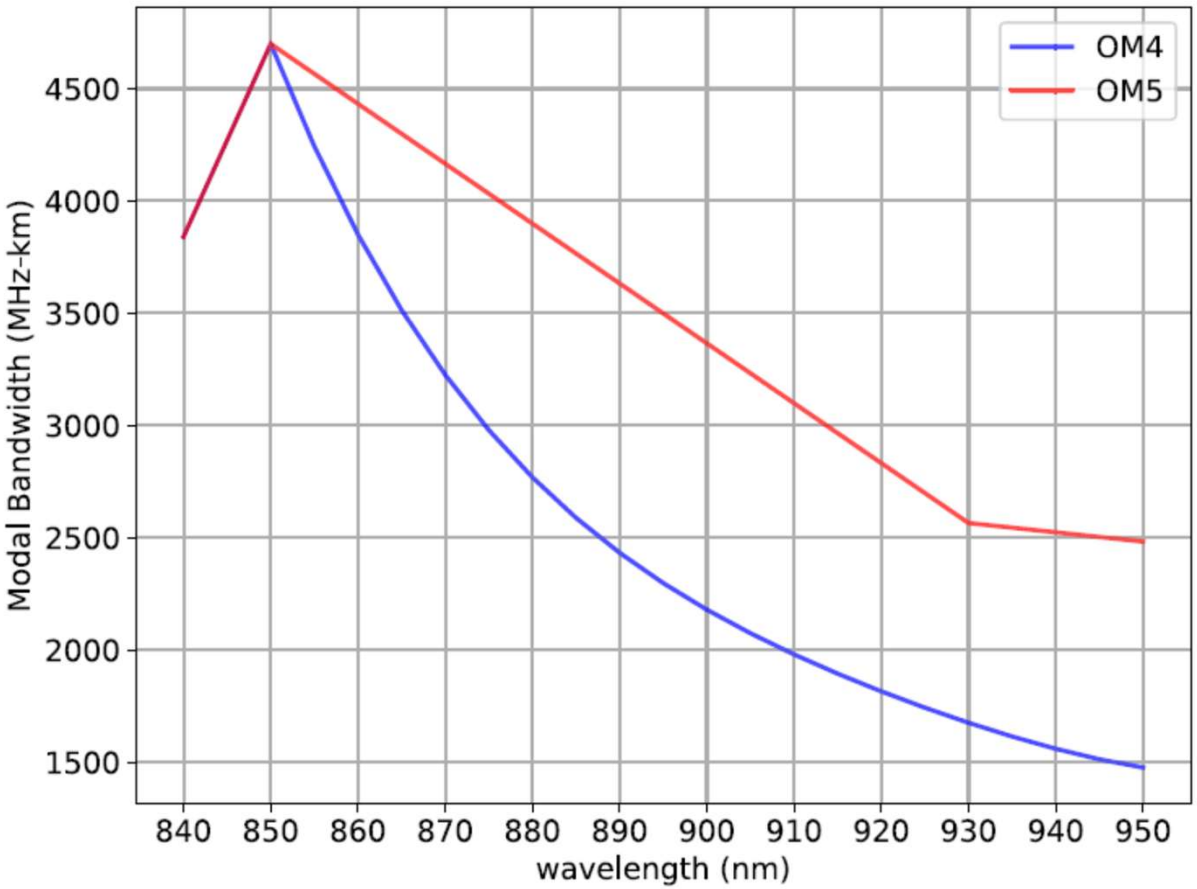
- Early reliability of designs targeting datacom applications
- VCSELs run for ~16k hours with no significant degradation
  - Provided confidence in reliability of Lumentum InGaAs based active region design. Excellent reliability for 1060nm or below was proven

Example 1175nm Datacom CW LIV
Test Temperatures 5, 25 and 70°C





> 950nm VCSEL OM4 and OM5 fiber constraints



- Need to specify OM4/OM5 fiber EMB beyond 950nm vs achievable reach for “–VSR”

Conclusion

- We demonstrated industry need for optical interconnect targeting next gen AI/ML clusters and the opportunity to leverage new technologies including advanced packaging
- Proposing IEEE802.3 200G MMF SG to approve the objective at a minimum reach of 10 m (VSR) and technical benefits of 1060 nm wavelength VCSEL and the ability to enable the proposed VSR objective
  - We also recommend objectives for up to 30 m and up to 50 m reaches. We believe these longer-reach objectives will be best met with 850 nm wavelength VCSELs
- The proposal assumes using broadband PDs designed to support 850 to 1100nm wavelengths
- Calling for assistance from fiber manufacturers to provide EMB guidance on existing OM4/OM5 fibers at 1060nm wavelengths
- Adding such objective with set IEEE802.3 for next gen AI interconnect needs. The project should not be restricted ‘transceiver focused’ 850nm

Proposed Objectives (using IEEE802.3db and .df objectives as a template)

- Define a physical layer specification that supports 200 Gb/s operation over 1 pair of MMF with lengths up to at least 10 m
- Define a physical layer specification that supports 400 Gb/s operation over 2 pairs of MMF with lengths up to at least 10 m
- Define a physical layer specification that supports 800 Gb/s operation over 4 pairs of MMF with lengths up to at least 10 m
- Define a physical layer specification that supports 1.6 Tb/s operation over 8 pairs of MMF with lengths up to at least 10 m

Thank you