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# Optical Interconnects for AI Data Centers

Matt Sysak, CTO

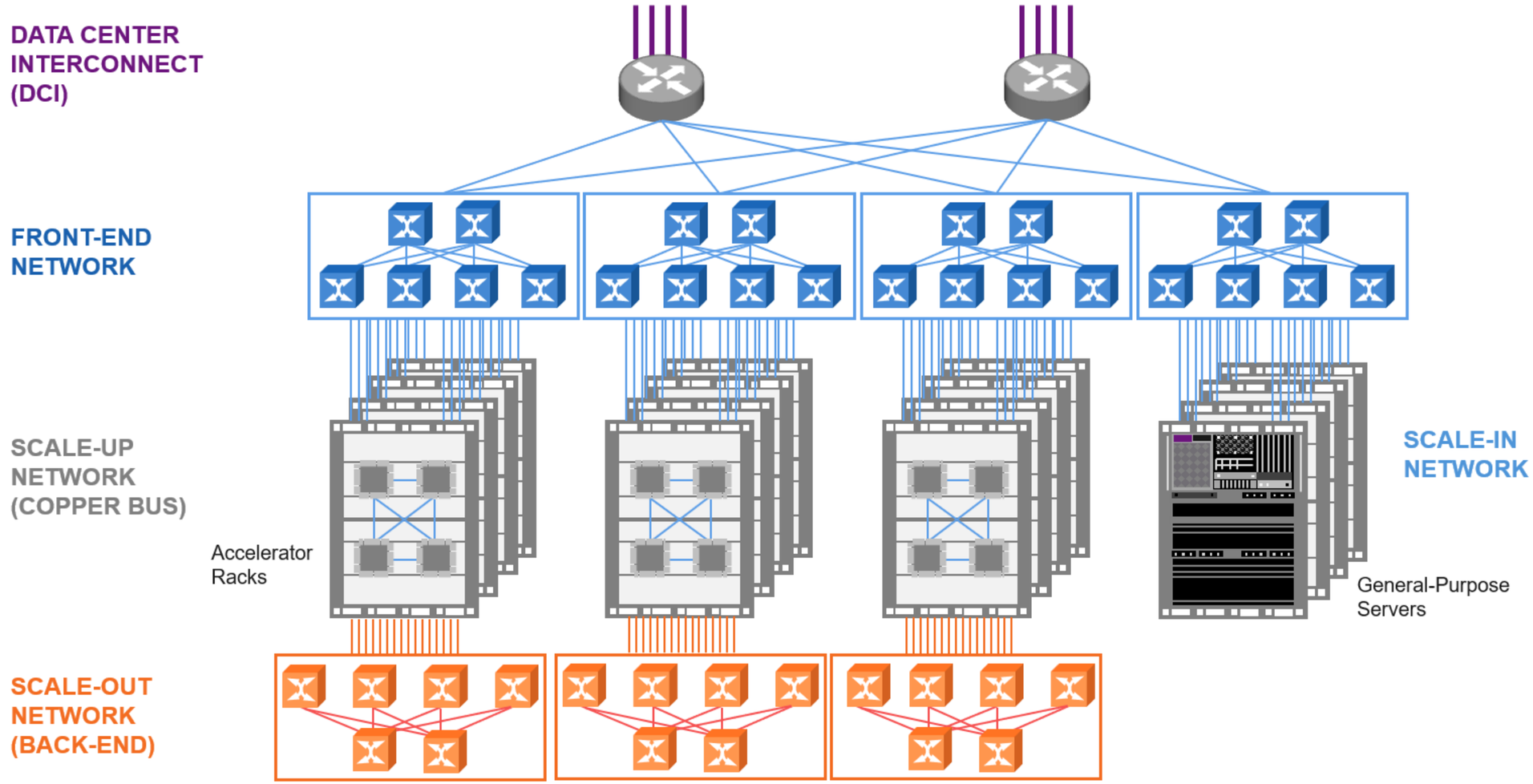
August 31, 2026

TRANSFORM TOMORROW

# The Virtuous Cycle of AI Scaling



# AI/ML Data Center



# Lumentum: Foundational AI Material Expertise

## Indium Phosphide (InP)

High-performance lasers, modulators, and transceivers for scale-out and scale-up



## Gallium Arsenide (GaAs)

High-volume lasers for scale-up and scale-in built on large scale sensing deployments



## Optical Switching Technologies

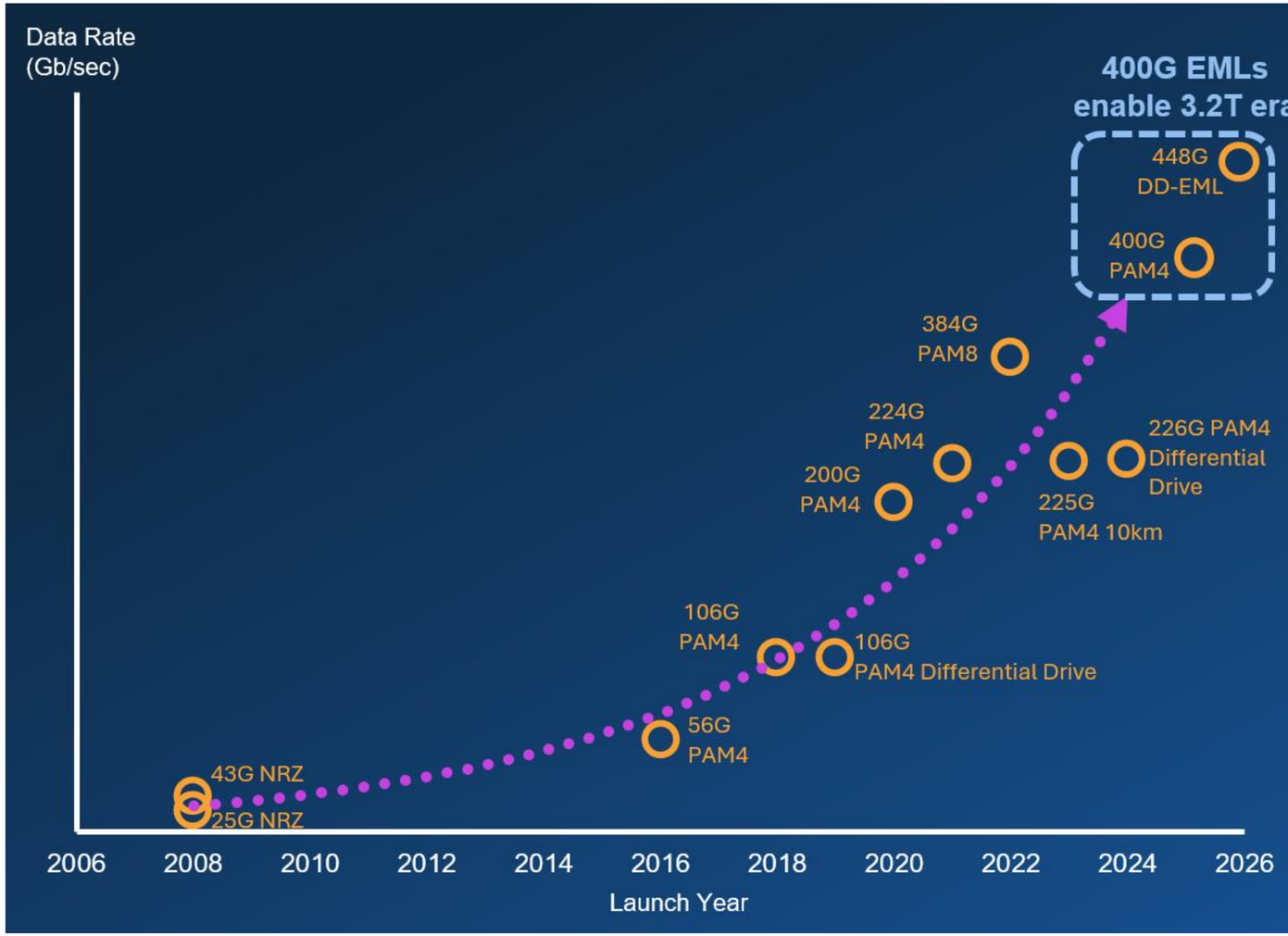
Proven MEMS and LCOS solutions supporting scalable optical switching



# InP Technology



# Lumentum: InP Technology Leadership

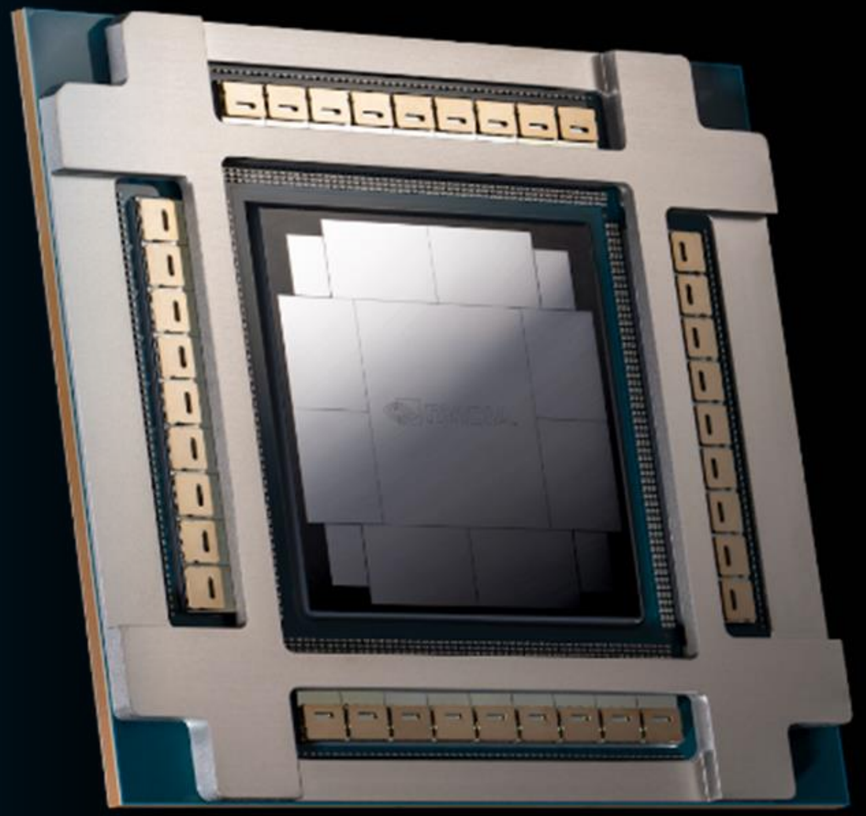



## Leadership Milestones

| | |
|---|---|
| **1997** | ▪ First to introduce a 10G DML |
| **1999** | ▪ First to introduce a 40km 10G EML |
| **2008** | ▪ First to introduce 100G CFP 25G/28G CWDM DML |
| **2018** | ▪ First to introduce a 112G PAM4 EML |
| **2023** | ▪ First to introduce a 224G PAM4 EML |
| **2025** | ▪ First to introduce a 400mW UHP Laser for CPO |
| **2026** | ▪ First demonstration of 800mW SHP CPO Laser<br>▪ First demonstration of 16-channel DWDM UHP |

# NVIDIA's Spectrum-X CPO Switch

*Enabled by Lumentum's high-reliability, ultra-high-power laser*



LUMENTUM

**NVIDIA Spectrum-X Photonics**

CPO Co-Invention Ecosystem Partners

**Technology Innovations**

New Microring Modulators (MRM)

TSMC Photonics Engine Optimizations

High Power, High Efficiency Lasers

Detachable Fiber Connectors

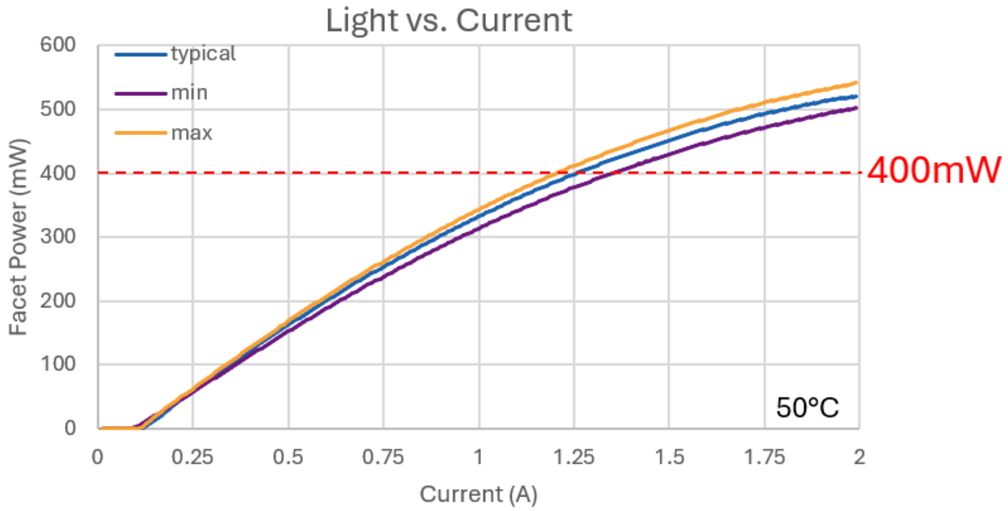
100's of Patents, Licensed to Customers

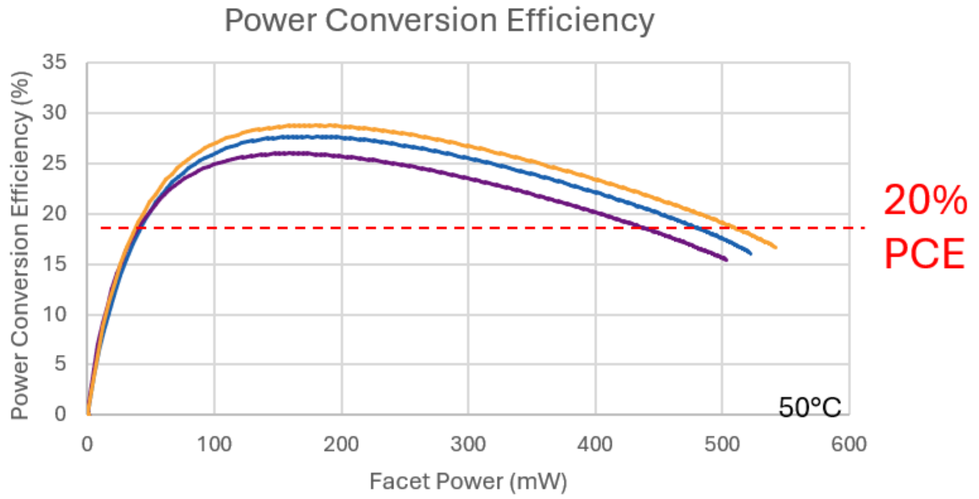
***Leveraging Lumentum Foundational Leadership in Lasers***

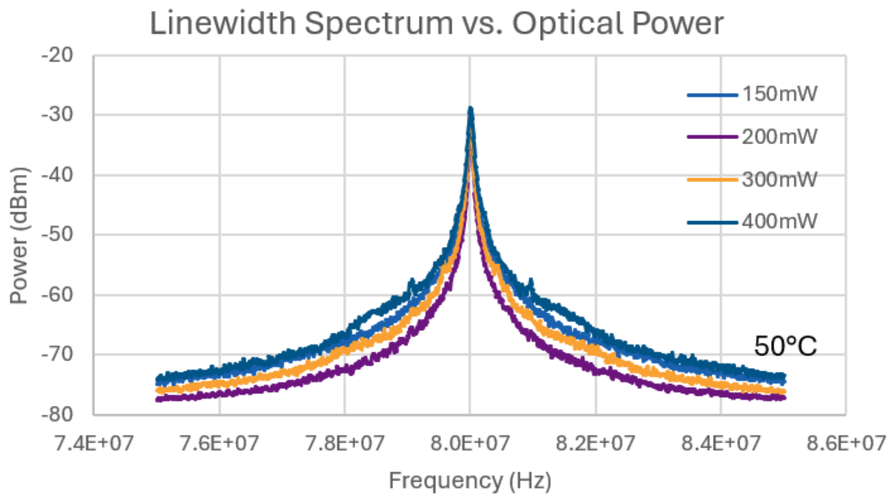
© 2026 Lumentum Operations LLC 

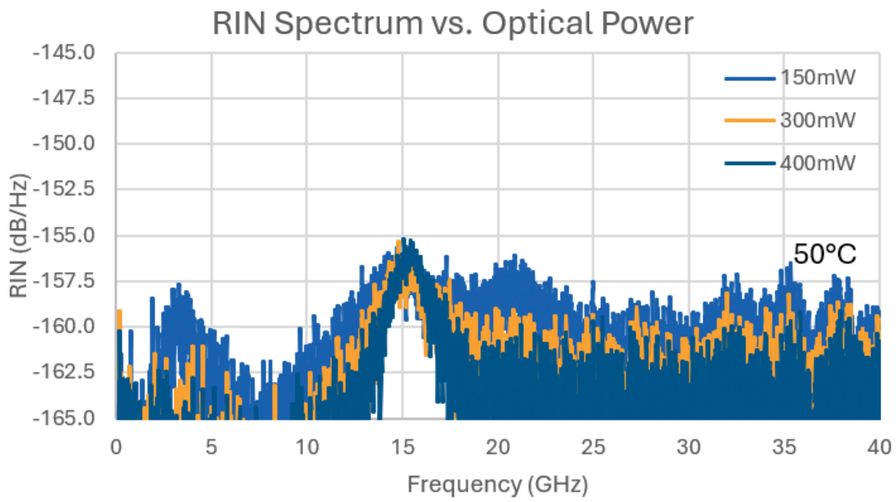
LUMENTUM

# Class-leading CPO Laser Performance



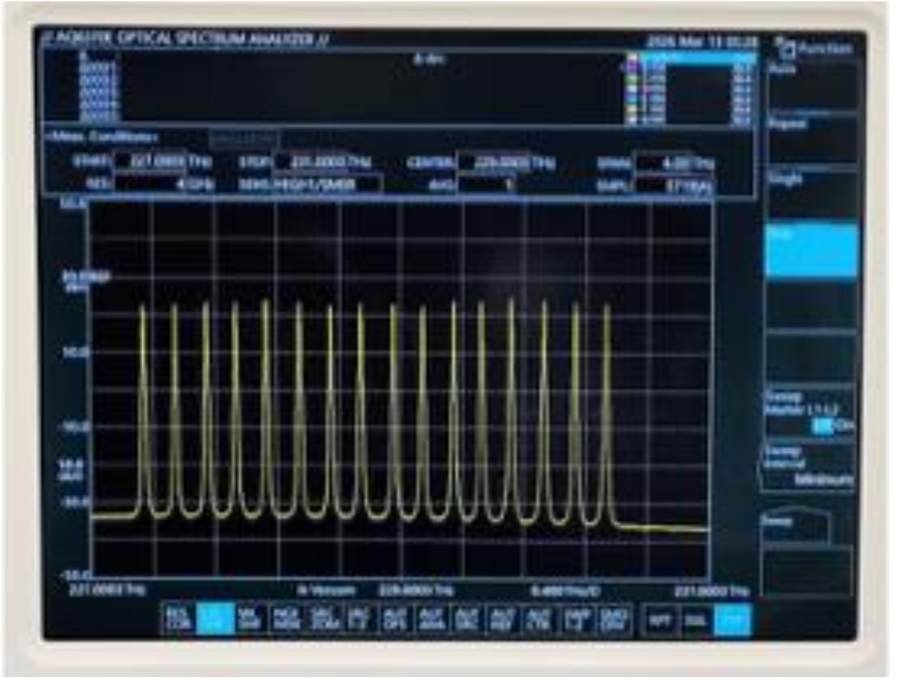



# Class-extending CPO Laser Performance

## Multi-Wavelength UHP Features and Benefits

- **16 DWDM channels** – For power efficient high-density links
- **350 mW per laser / 23–24.5 dBm per fiber** – High efficiency
- **Wavelength control within ±25 GHz** – Tight spacing control
- **Pluggable ELSFP architecture** – Compatible with ELSFP

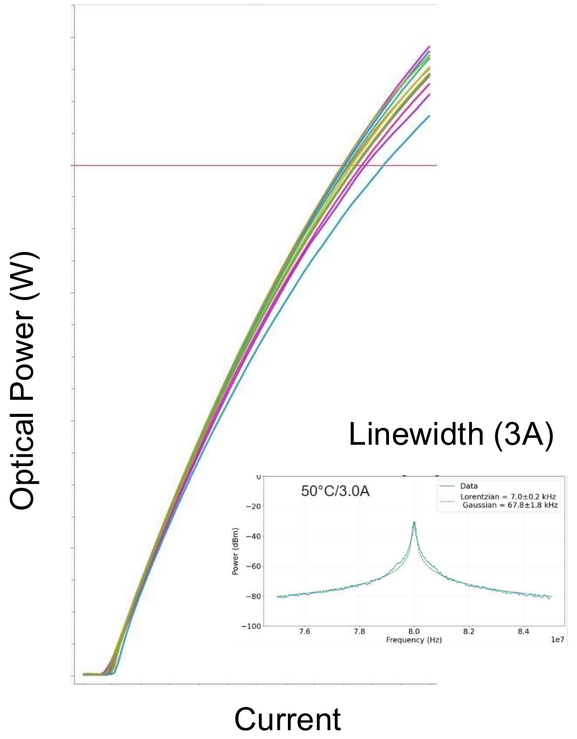


**16 wavelength ultra high-power lasers for power efficient interconnects**

# Class-extending CPO Laser Performance

## 800mW SHP Features and Benefits

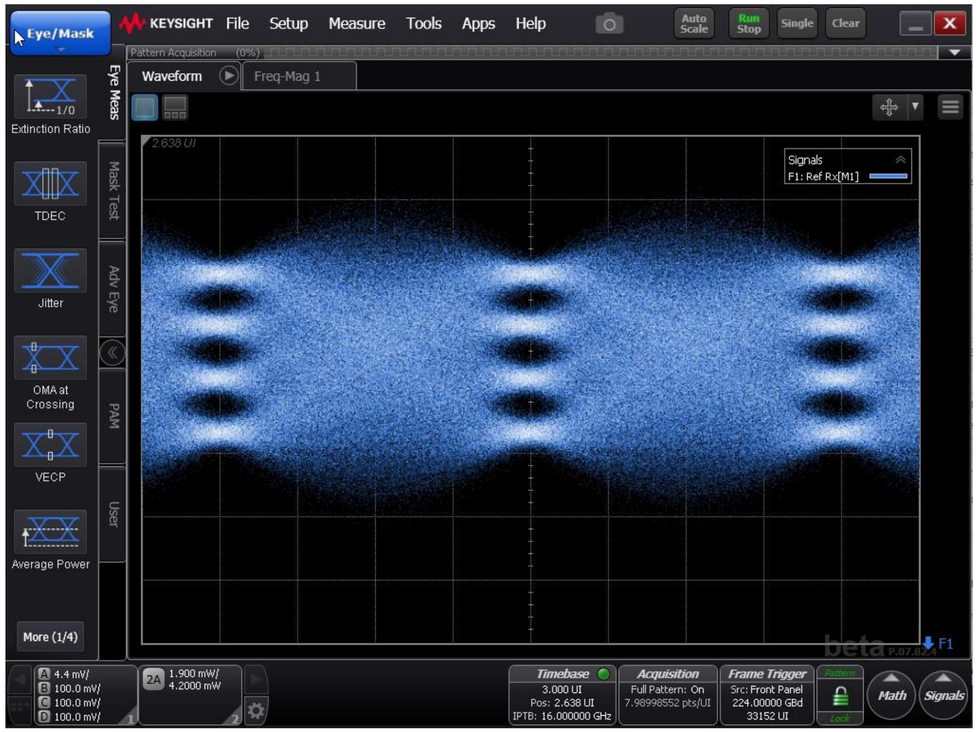
- **>1.0 W at 25°C / >0.8 W at 50°C -** For higher power budget
- **1310 nm O-band -** Aligned with SiPh and CPO architectures
- **<100 kHz linewidth -** Delivers high spectral purity
- **Low RIN and >40 dB SMSR -** Improves signal integrity
- **Mode-hop-free single-mode operation –** Wide operating range
- **Compact ELSFP implementation –** compatible with ELSFP




**Super high power laser for high speed and improved ELSFP density**

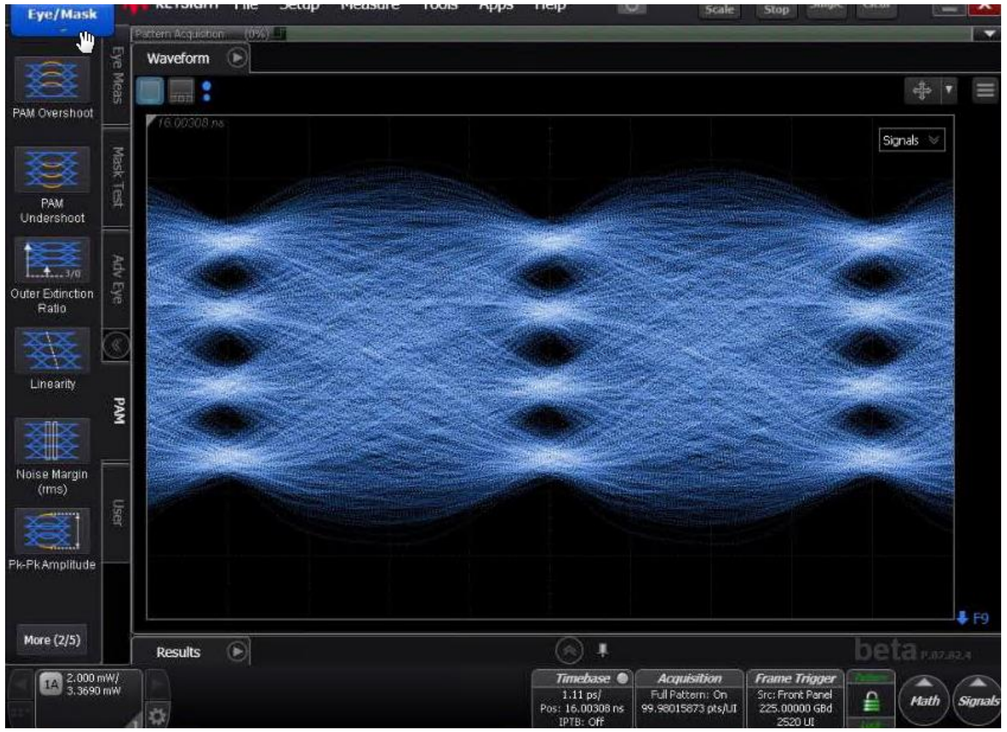
# InP EML 400G Performance (OFC ’25)

## 448G InP EML




***Partner announcement:*** *“Keysight, NTT Innovative Devices, and Lumentum Achieve New Benchmark 448 Gbps Data Transmission for AI”*

## 450G InP DFB-MZI

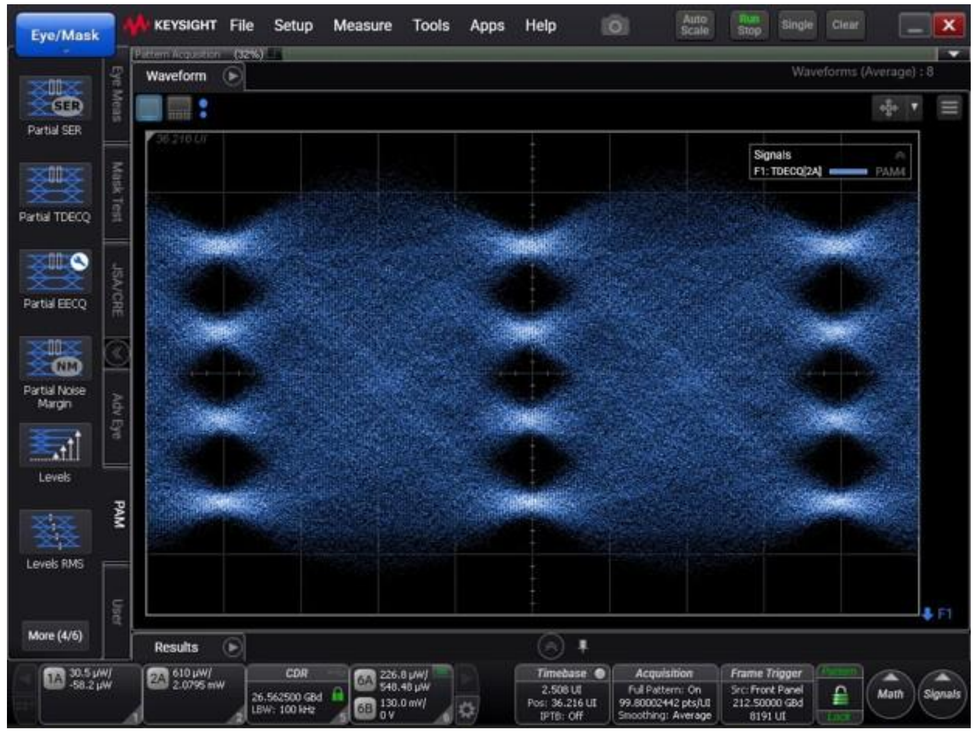



***Live demonstration in Lumentum’ s booth at*** OFC 50

**Debut of 400G+/lane high-performance InP technology**

# OFC ’26 – Intercepting the Market

## 400G+ InP EML




## 1.6T Optical Module



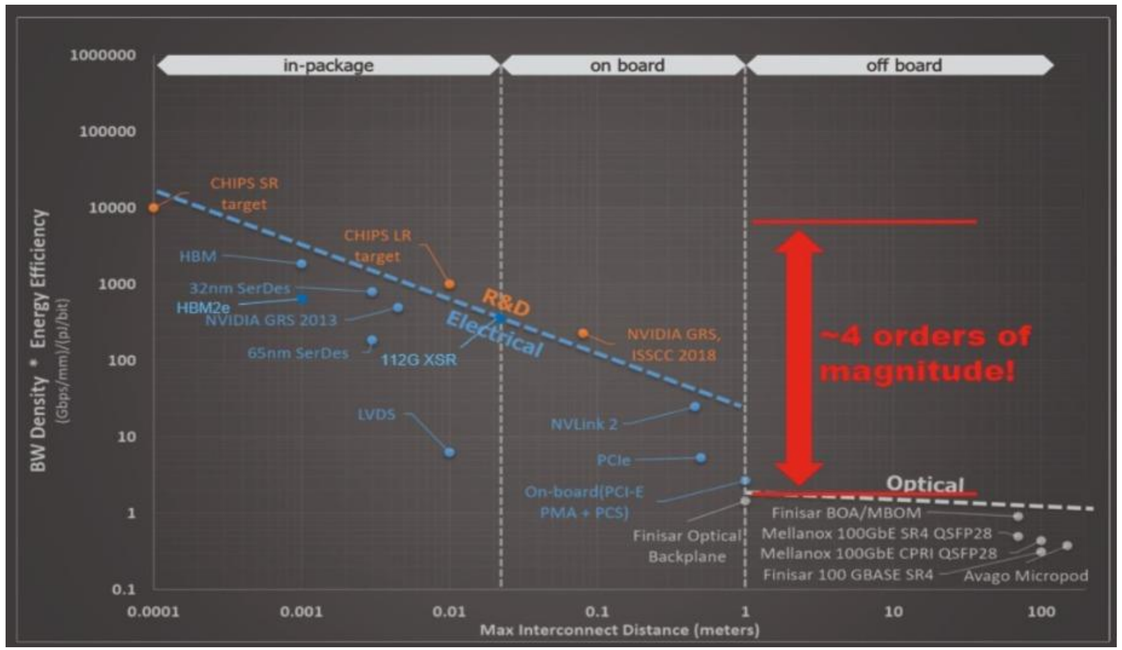
*Live demonstration in Lumentum’ s booth at* OFC

**4x400G, 1.6T optical modules based on differential drive EML**

# GaAs Technology



# The Scale-Up Challenge






*Sources: Nvidia*

| GPU | Scale-Up BW (Tbps) | Scale-Up Size (GPU) | Rack Power (kW) |
|---|---|---|---|
| Blackwell | 7.2 | 72 | 120 |
| Rubin | 14.4 | 144 | ?? |
| Feynman | 28.8 | ?? | ?? |

**High-volume optics required to break reach, power, and bandwidth constraints**

# Scale-up technology options

| Metric | VCSEL | SiPh | InP | TFLN | Context |
|---|---|---|---|---|---|
| Speed | + | + | + | + | Wide parallel approaches do not require significant bandwidth. |
| Volume | + | + | - | - | No technology with higher deployment than 3DS VCSEL. |
| Cost | - | - | - | - | InP and TFLN are expensive; SiPh requires external laser. VCSEL requires fiber. |
| Power | + | - | - | - | External laser drives power, InP, and TFLN require external drivers. |
| Reliability | + | + | - | - | VCSELs offer redundancy and sparing to reach <1 FIT. SiPh has external laser. |
| Reach | - | + | + | + | VCSEL reach challenging with standard fiber (new fiber possible). |
| Density | + | + | - | - | InP and TFLN are not dense enough to meet scale-up interconnect requirements. |

**Scale-up requires new fundamental optical technology**

# What Kind of VCSEL?

**850nm**

- First standard, 1999
- Set from fiber/laser technology in ’90s

**940nm**

- 3D sensing introduced, face ID, 2017
- Pushes industry to high-volume manufacturing – **billions of emitters shipped**

**980nm**

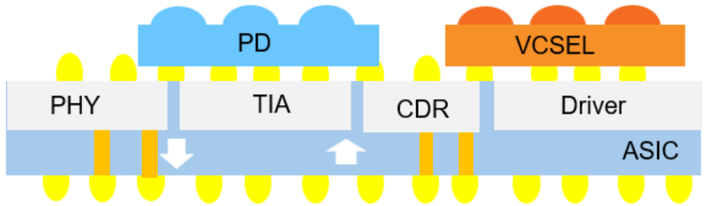
- Automotive introduced, 2021
- Forces **high-temperature, high-reliability** interconnects inside automobiles

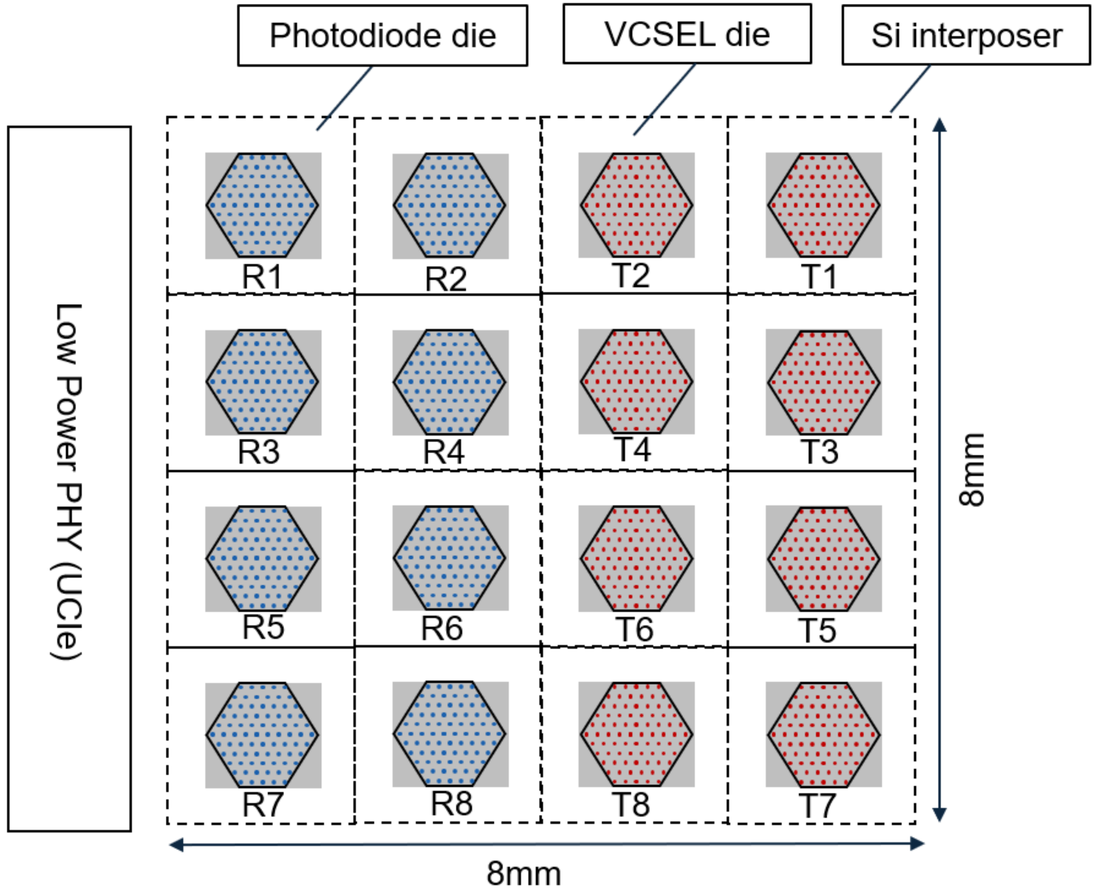
**1060nm**

- High-density interconnect proposed, 2025
- Builds on 3DS, automotive, **adds bandwidth, density, signal integrity, manufacturability**

# UCIe-A Chiplet Concept

LUMENTUM

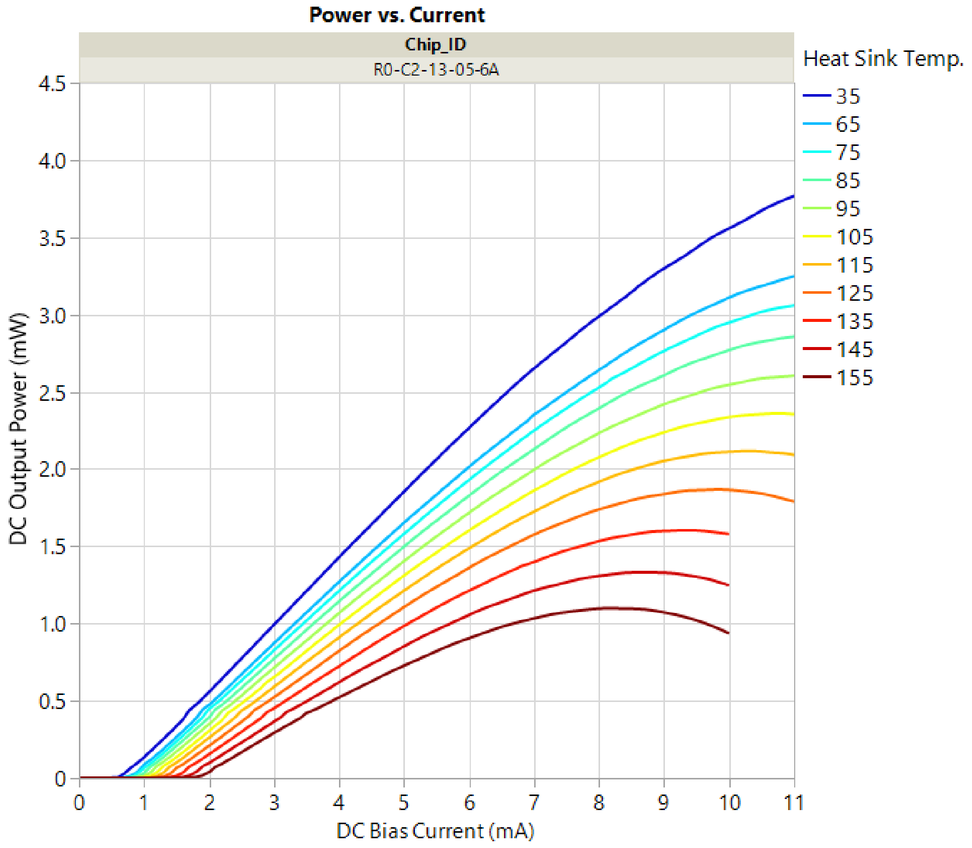


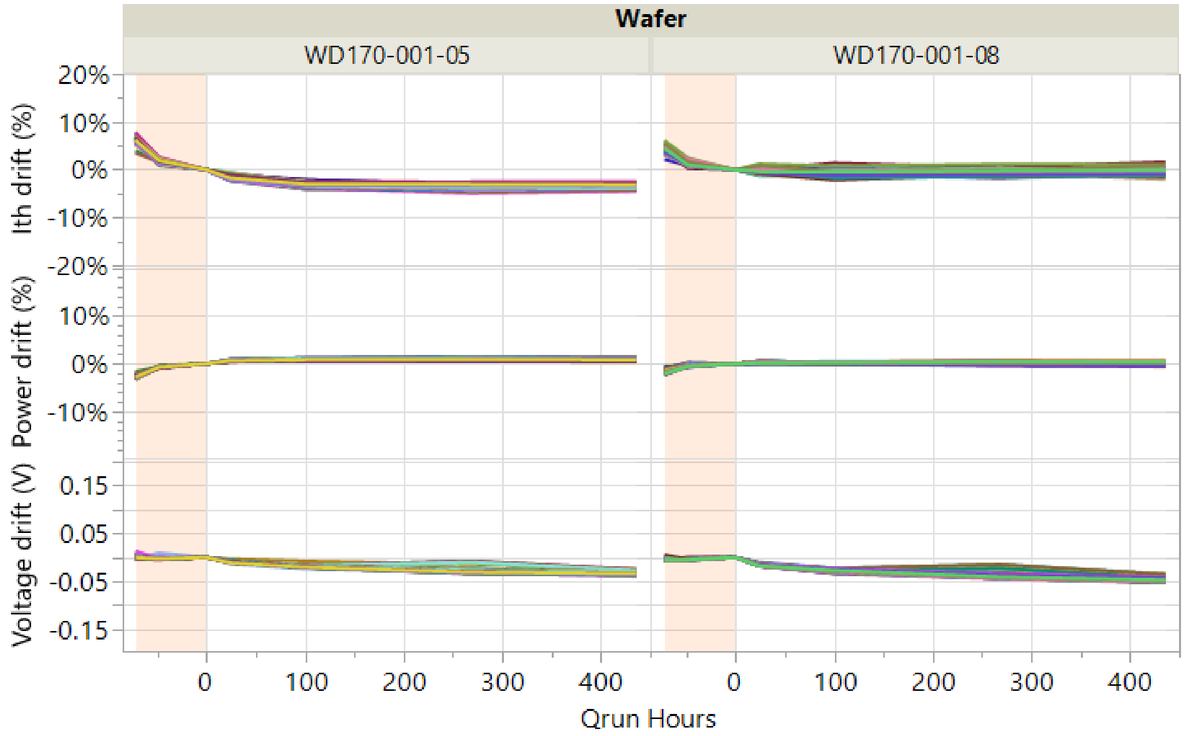

**32 Tbps bidirectional bandwidth (8 bundles x 32Gbps x 64 data channels)**

# Core Technology: GaAs VCSEL

*Measured DC LI Over Temperature*

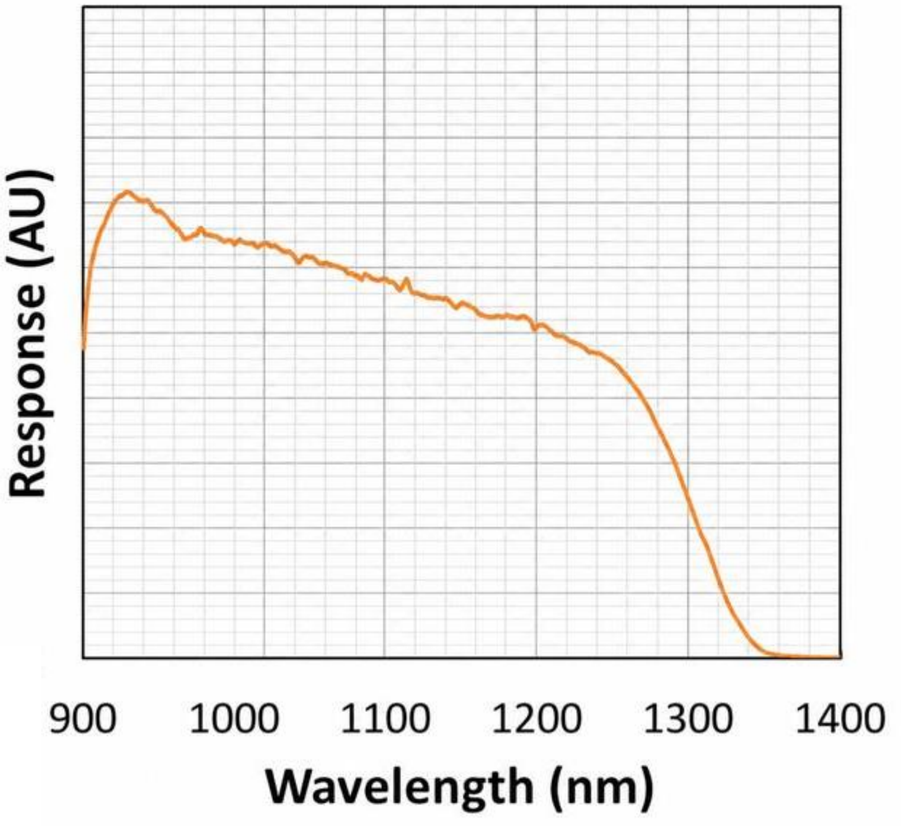


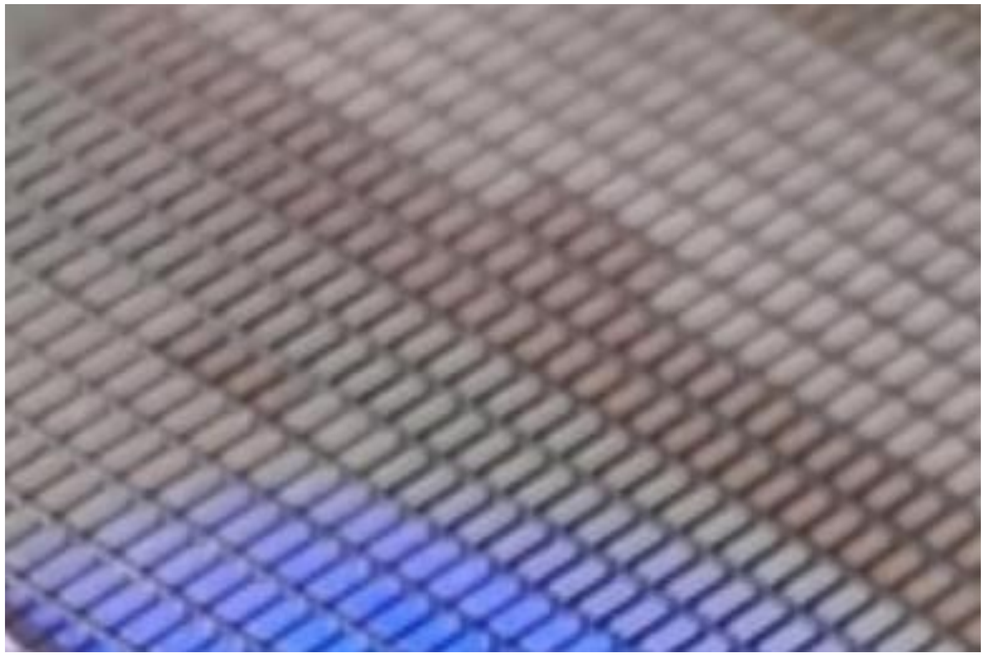

*Reliability Testing*




**High Volume VCSELs with unmatched performance and reliability**

# Core Technology: GaAs Photodiode



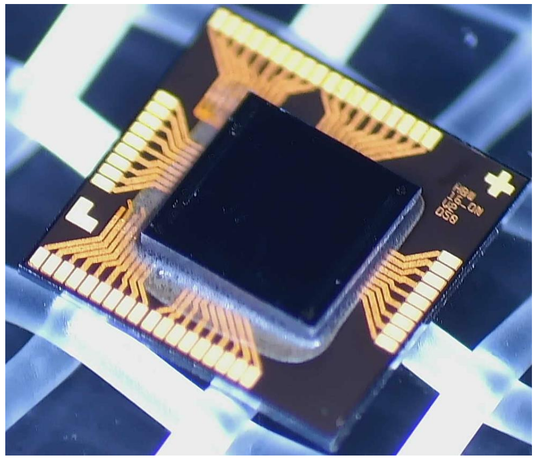



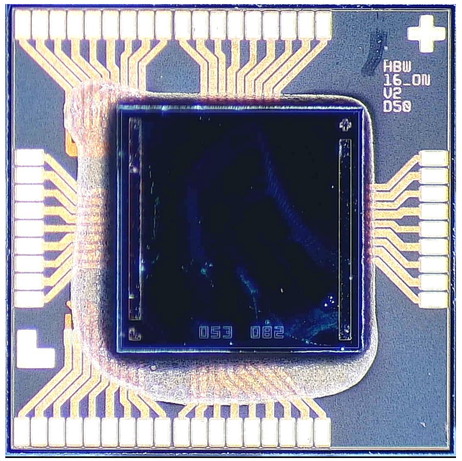
PD arrays

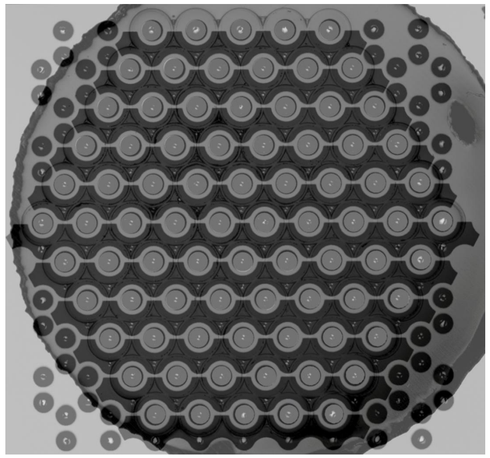
**High volume Photodiodes leveraging GaAs supply chain**

# Core Technology: VCSEL on Interposer

Backside emitting VCSEL on Si interposer

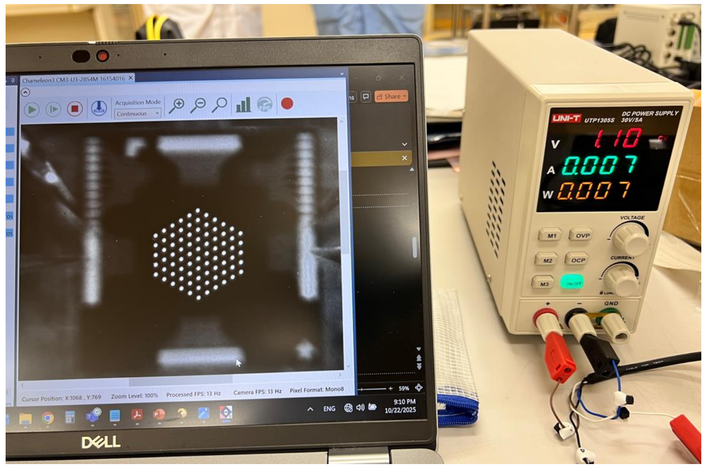




80 emitter fiber array/VCSEL

VCSEL array power on




**High Volume VCSELs in stacked die packaging**

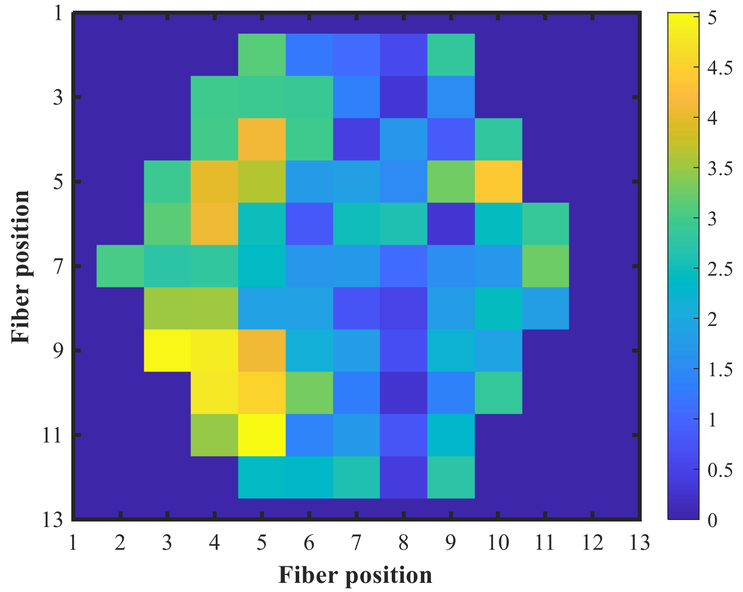
# Core Technology: High Density Fiber

- Fiber core position error relative to a perfect 125 μm hex grid < 5 μm
- Fiber average pitch was close to 125 μm
- Up to 80m / 80 core fiber array prototypes fabricated

CORNING



CORNING




CORNING

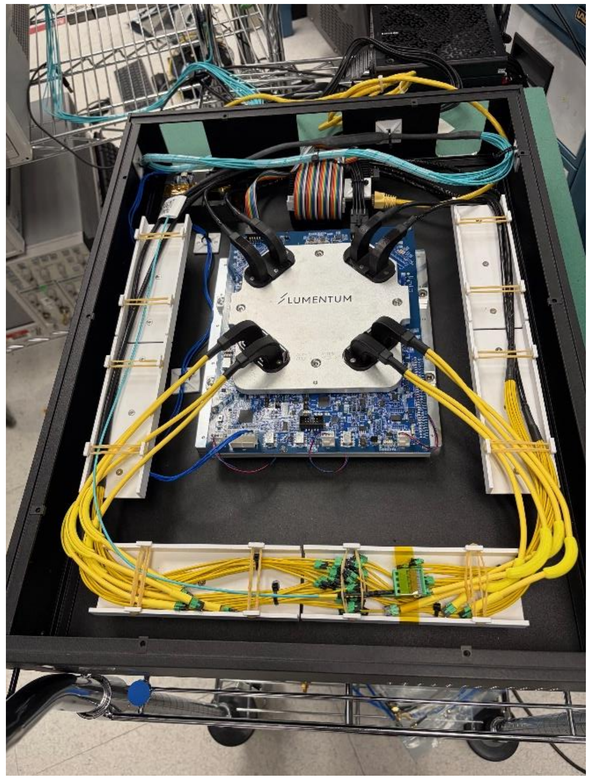


**High density 80 element fiber bundles with 30m reach**

# VCSEL/CMOS Integration




OFC




*Live demonstration in Lumentum's booth*

## VCSEL/Advanced CMOS Integration

- High-density 1060nm VCSEL and photodiode arrays
- Leverages high-volume 3DS supply chain
- Compatible with standard SMT (no fiber compatibility issue)
- 32 Gbps / channel consistent with UCIe-S and UCIe-A
- >80 Tbps bi direction optical bandwidth capability
- >1.5 Tbps/mm (path to >4 Tbps/mm)
- Capable of <2.5 pJ/bit
- Error-free operation (1e-12 BER)

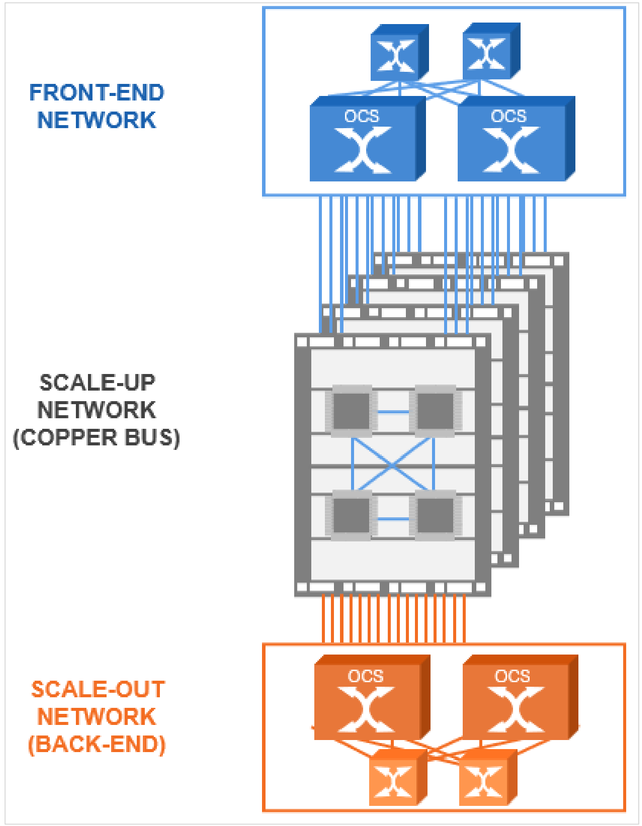
**First demonstration of 1060nm VCSEL integration with advanced Si CMOS**

# MEMS Technology



# Optical Circuit Switch: Breakthrough Power Savings

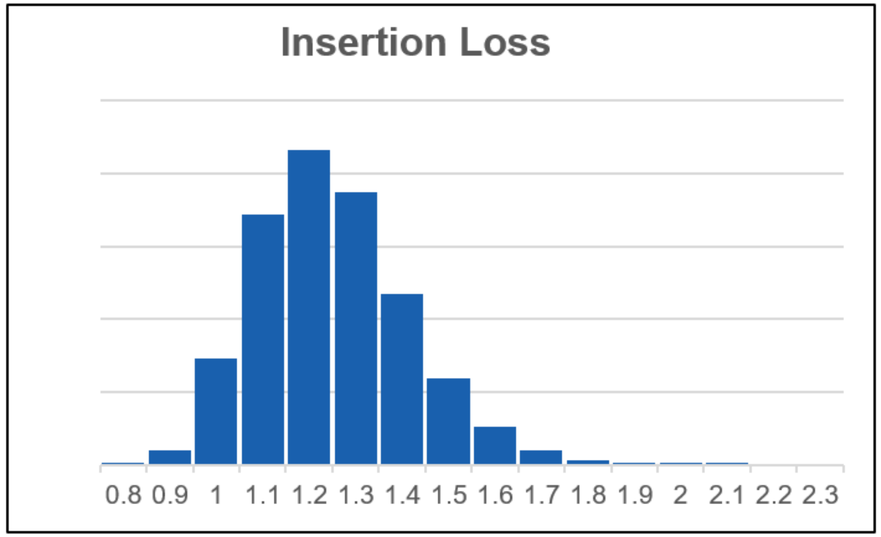


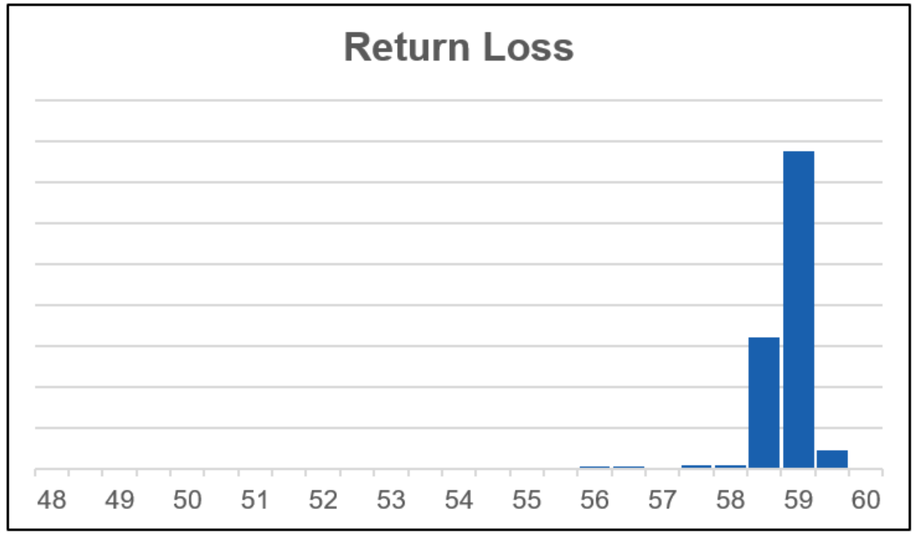



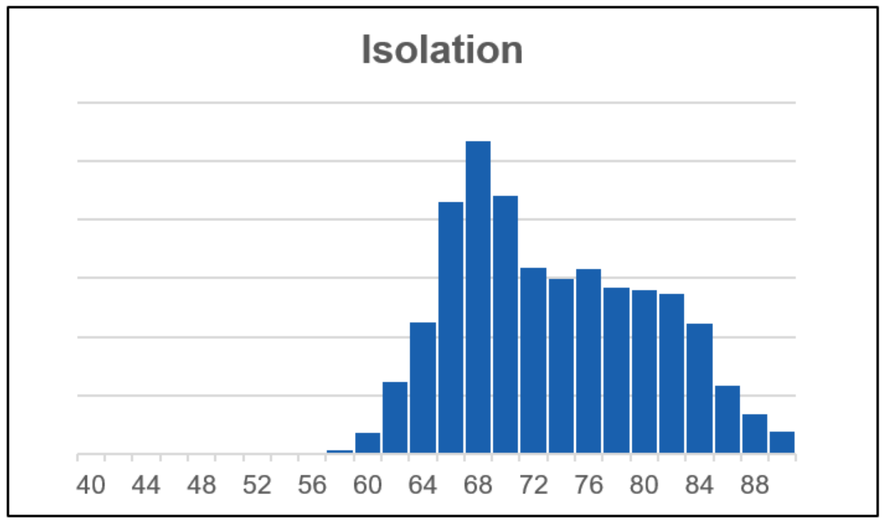

- 300x300 passive optical switch based on MEMs
- Spine switch replacement and network redundancy / network failover
- >65% front-end and scale-out network power reduction in 100K-scale GPU deployments*

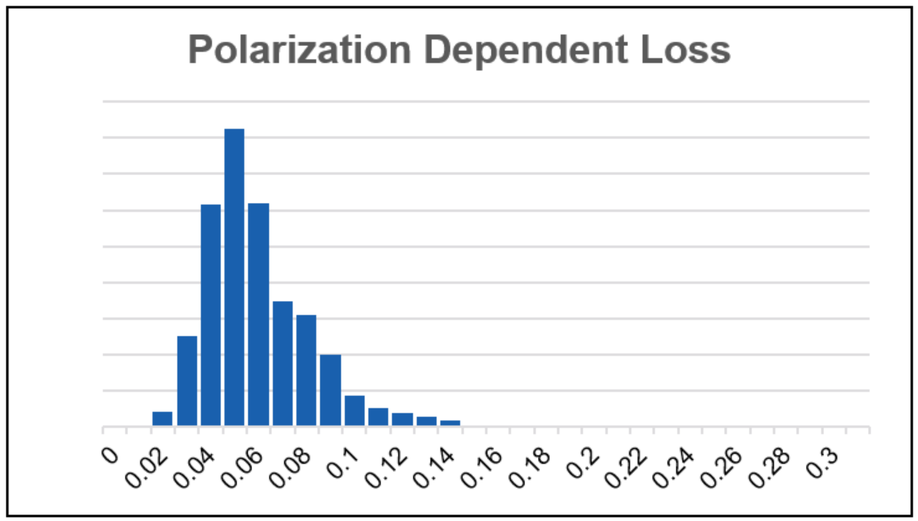
*Sources: Lumentum: Energy-Efficient AI Networks Lead to Dramatic Reduction in Environmental Impact, 2024; Cignal AI: The Optical Circuit Switching Market Report, 1Q25*

# Optical Circuit Switch Performance




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Thank you
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