# Passage M1000

## A 3D Photonic Interposer for AI

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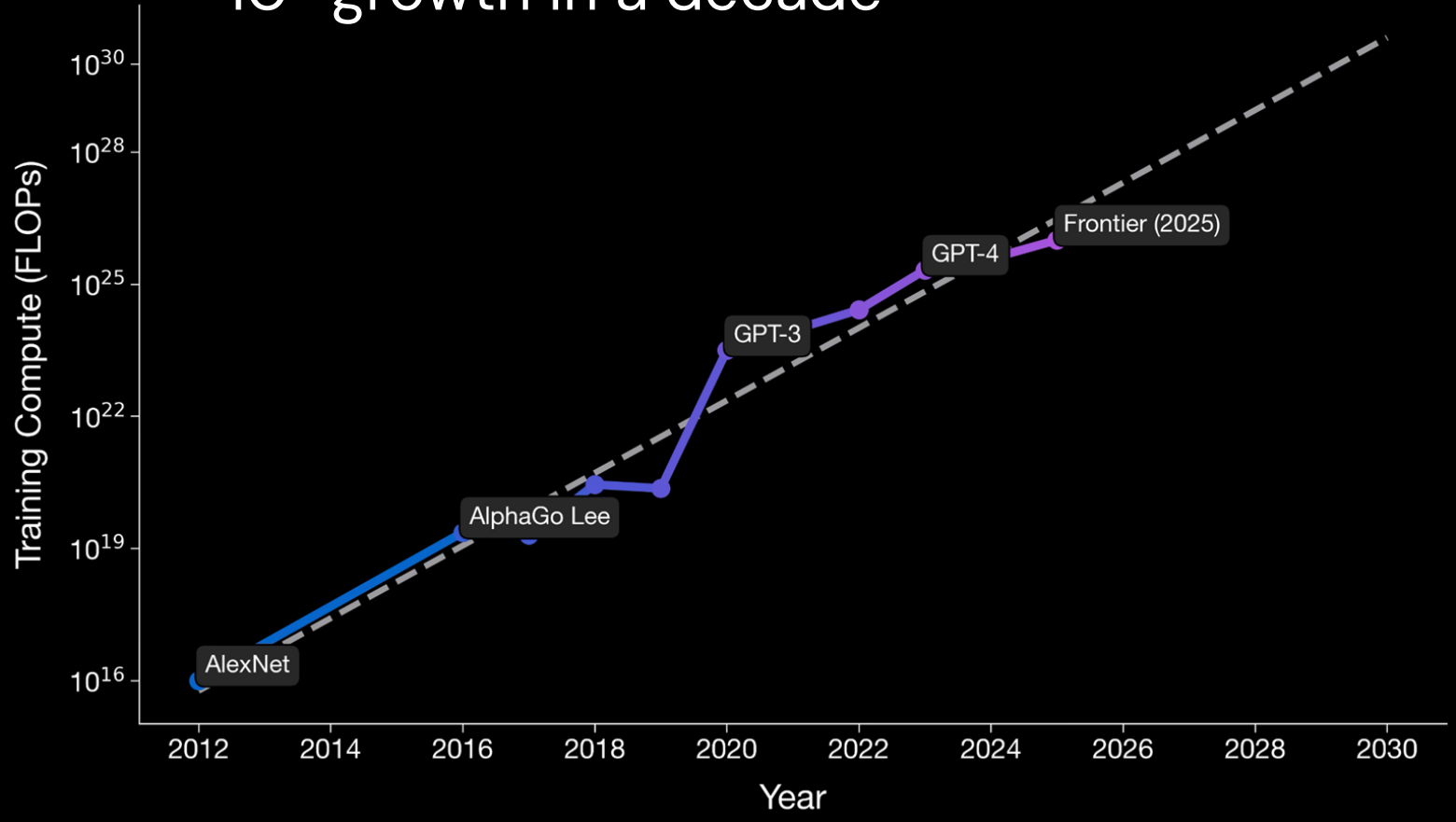
Chief Scientist, Lightmatter

Hot Chips 2025

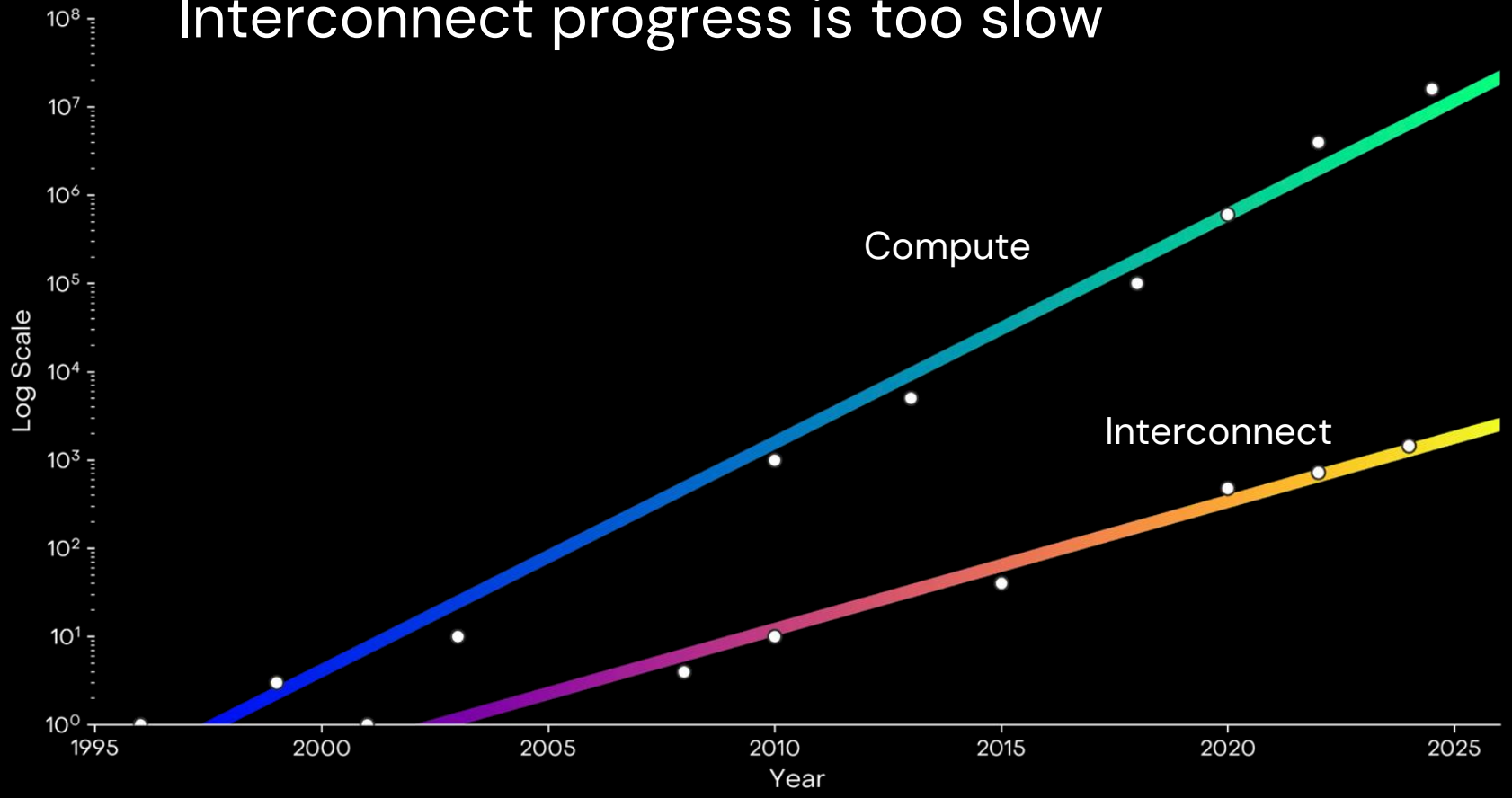
# A decade of AI breakthroughs



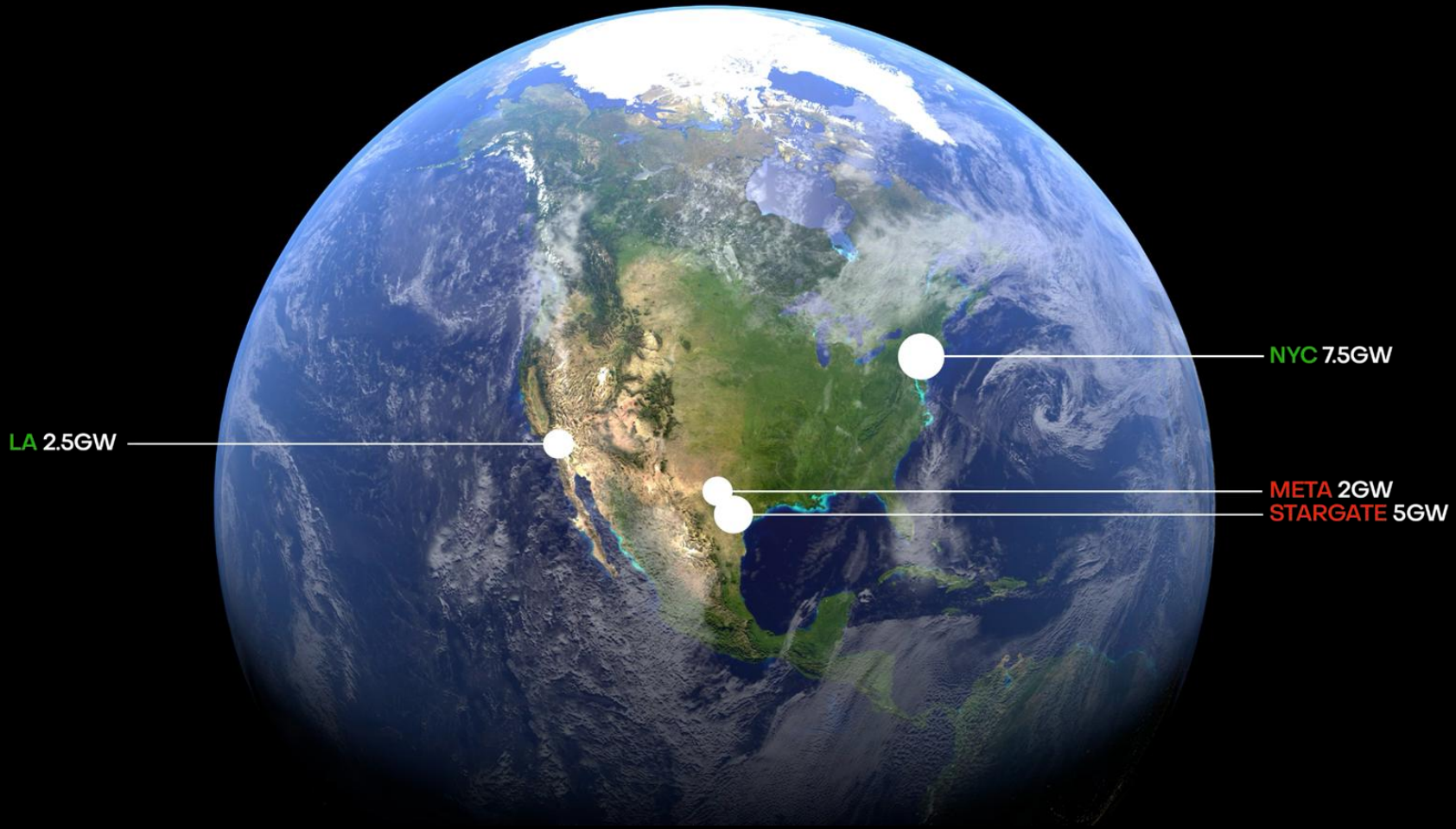
# $10^9$ growth in a decade



# Interconnect progress is too slow



LIGHTMATTER



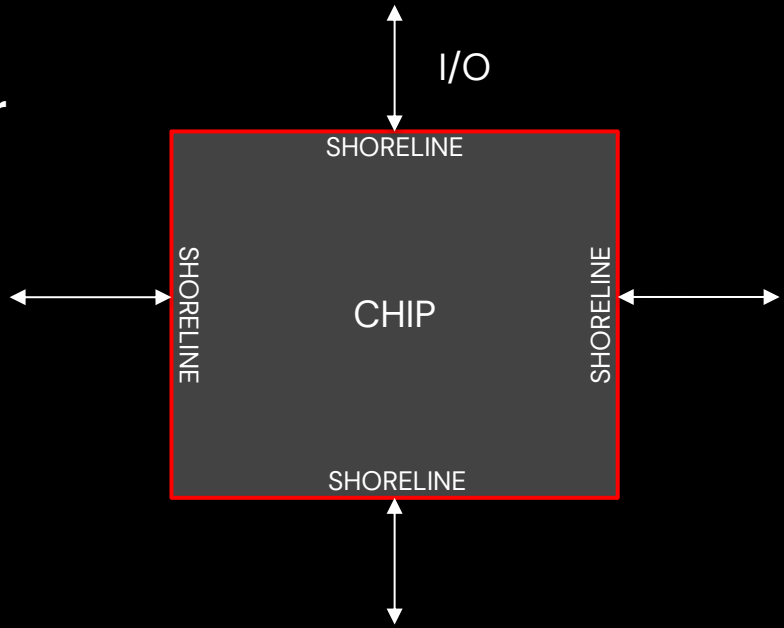
# The interconnect bottleneck

Communication happens at the chip **perimeter**

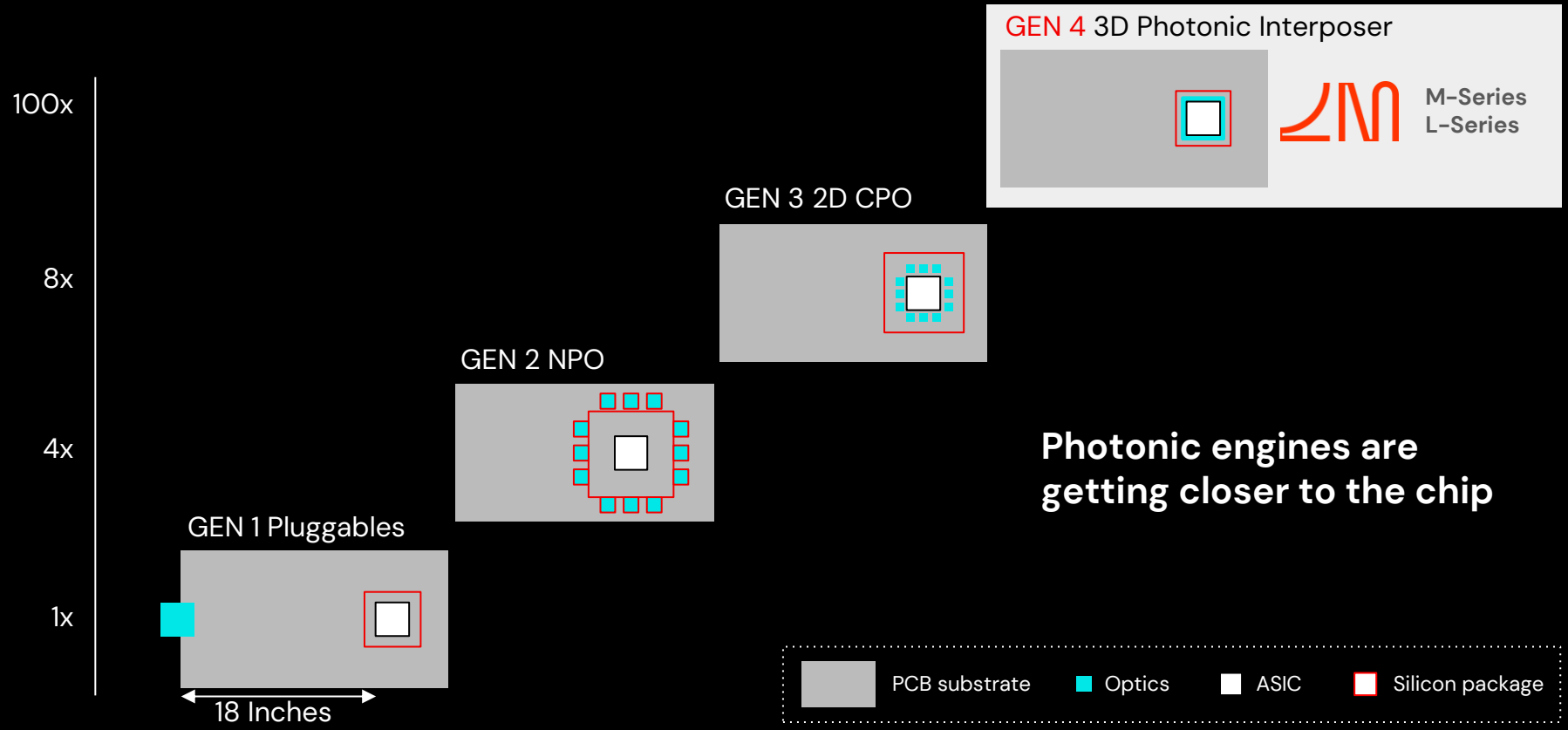
FLOPS ∝ Chip Area ($L^2$)
IO Bandwidth ∝ Chip Perimeter ($L$)

We need >100x the bandwidth.

**A new paradigm is needed.**



# The promise of silicon photonics



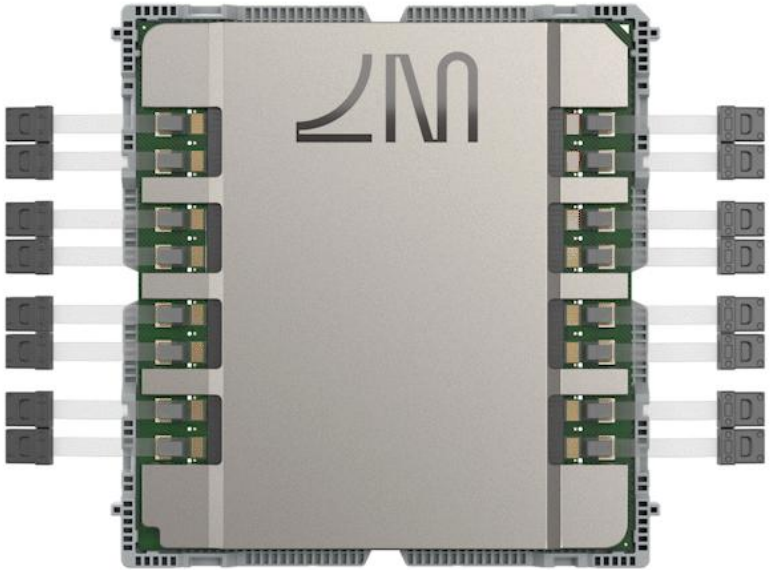

**Photonic engines are getting closer to the chip**

# Our Solution

Passage M1000
3D Photonic Interposer

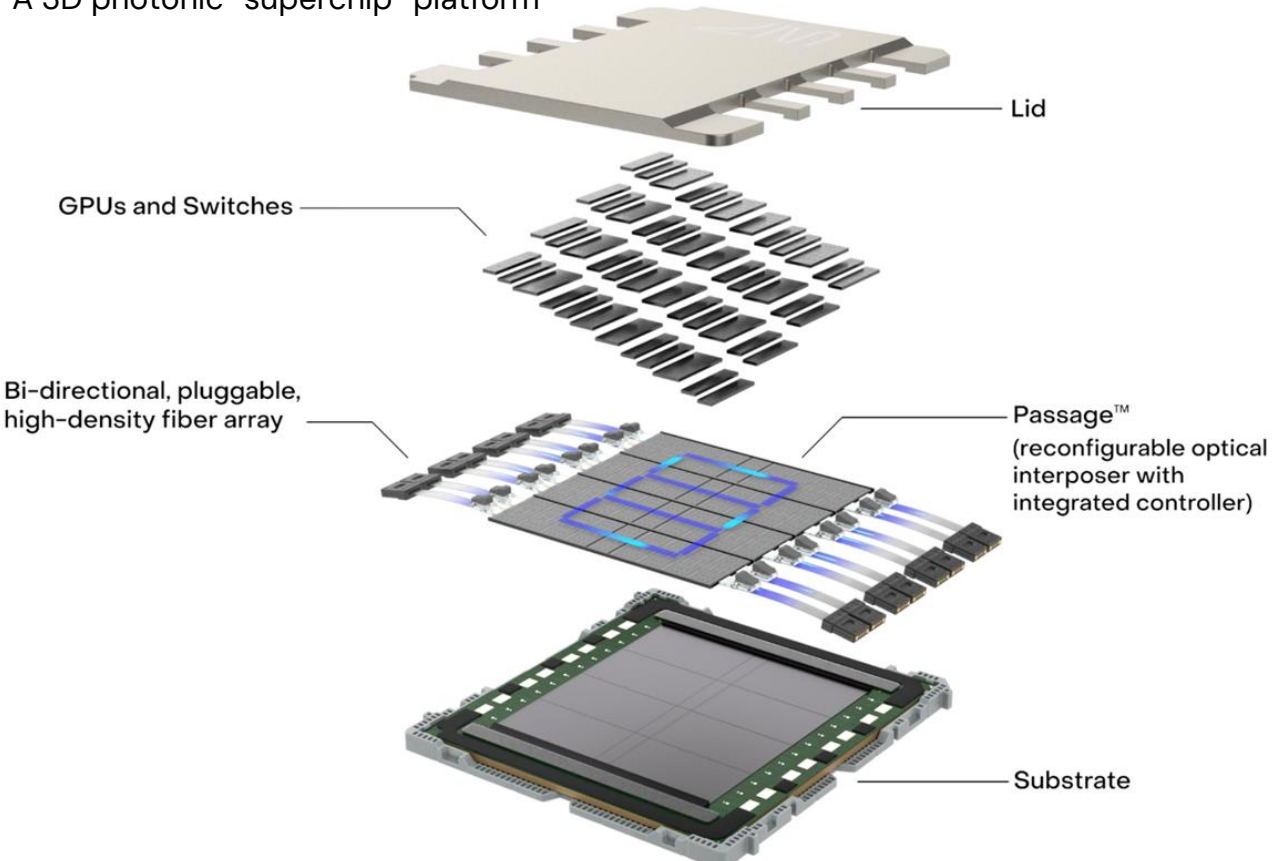
# Passage M1000

A 3D photonic “superchip” platform

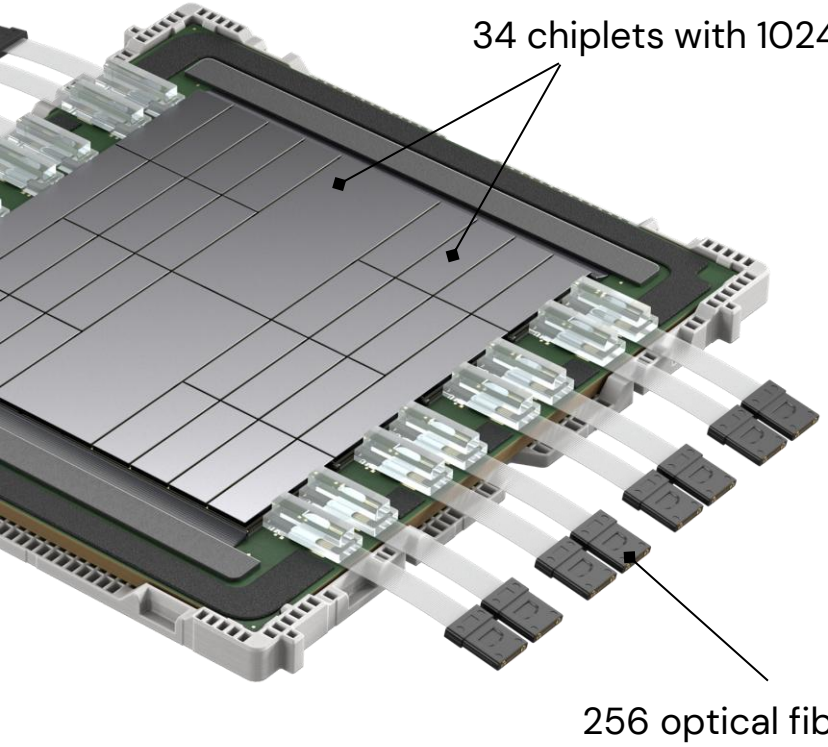


# Passage M1000

A 3D photonic “superchip” platform



# Unprecedented performance and scale

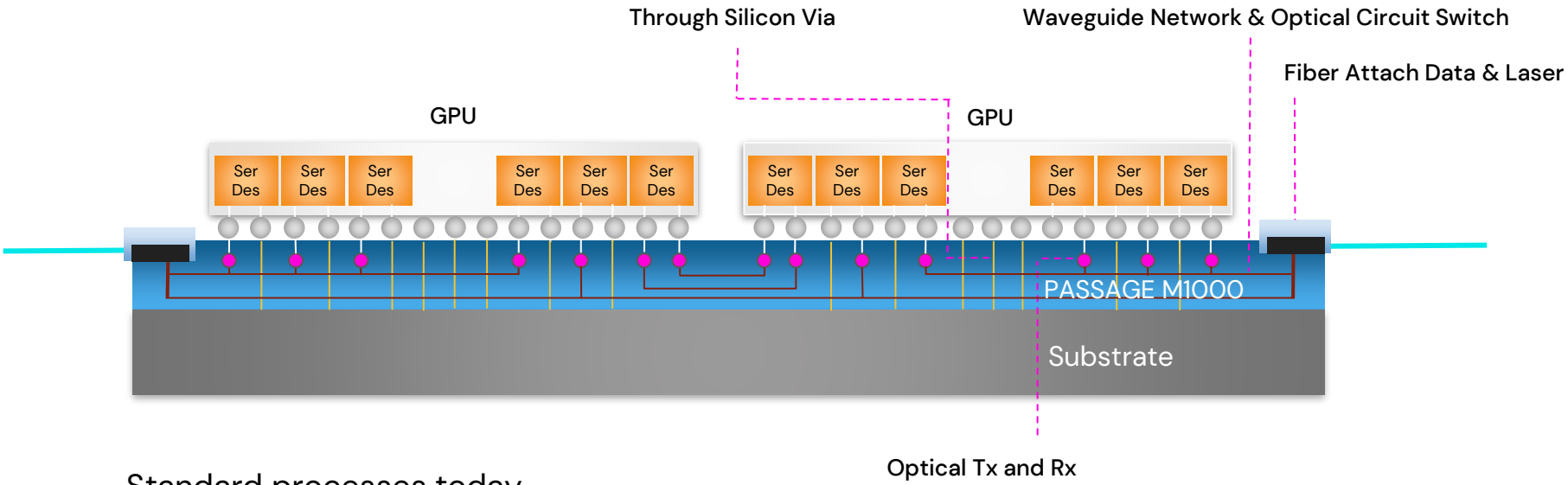



| Specifications | |
|---|---|
| Bandwidth (Tx + Rx) | Up to 114 Tbps |
| # of SerDes | 1024 |
| Silicon die Complex | 4,000 $mm^2$ |
| Power delivery | >1.4 $W/mm^2$ density |
| Fibers | 256 |
| Redundancy | Optical circuit switching |

# Platform deep dive

Architecture, performance,
and key features.

# 3D stacking requires compact optical Tx and Rx

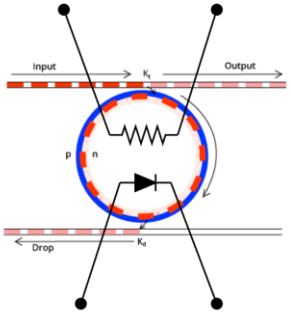



Standard processes today

- Bump pitch: ~120 µm
- Bump size: ~80 µm
- Area for a transmitter/receiver: 0.015 mm²

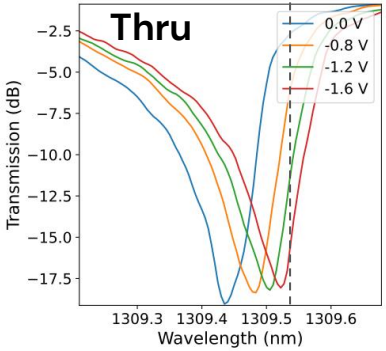
# The heart of the engine: silicon microrings

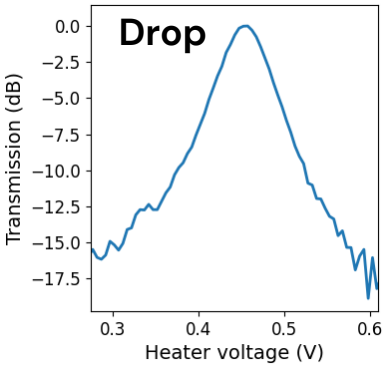
Ultra-compact, high-speed, WDM-friendly

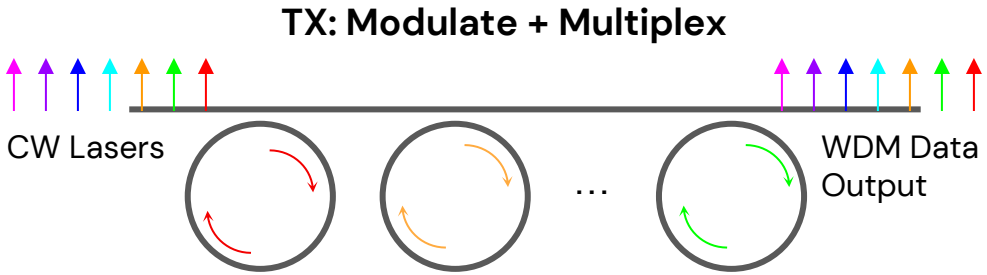


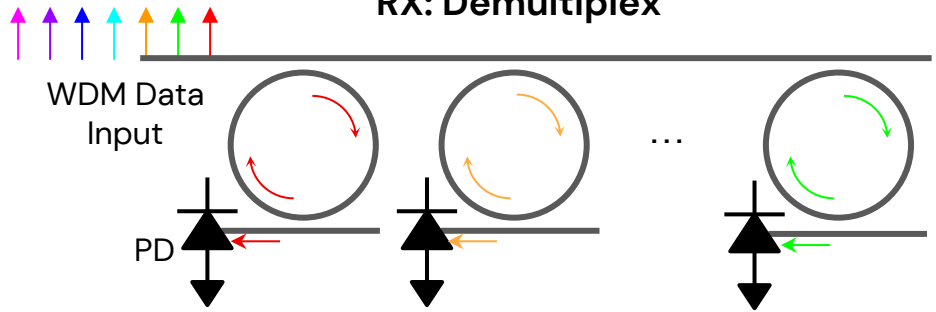

Diameter ~ 15um

Resistive heater
for tuning
Depletion PN junction
for modulation



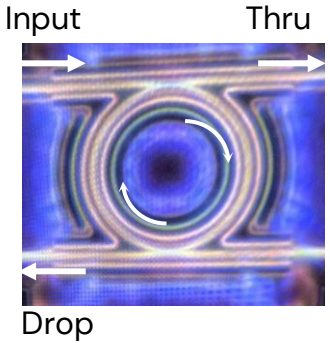



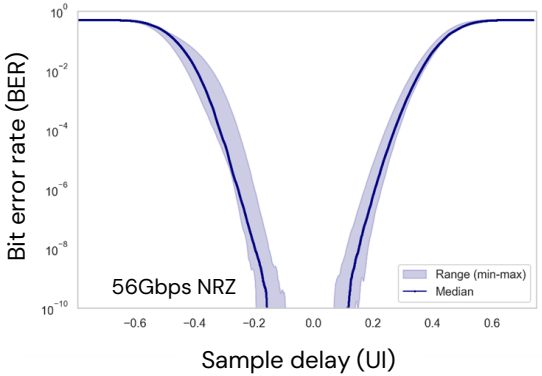



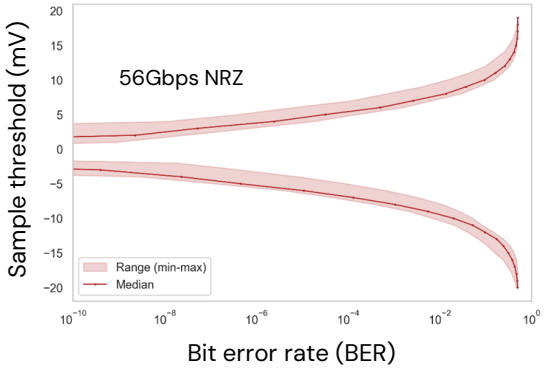



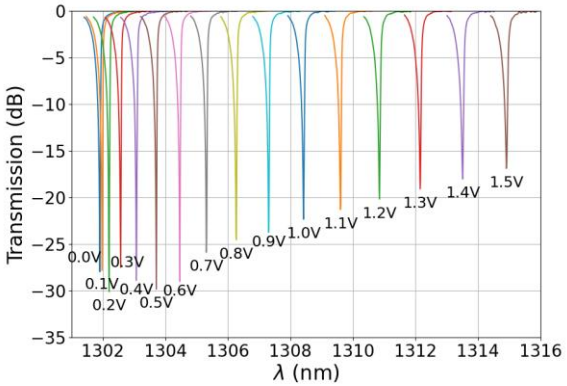
# Ultracompact transmitter and receiver

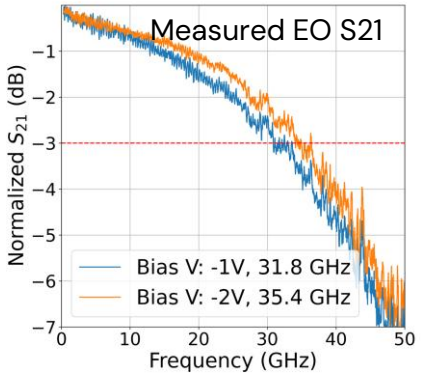
Microrings with inductorless driver and analog front end enable **0.006 mm²** Tx + Rx area.



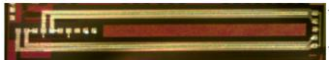



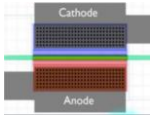



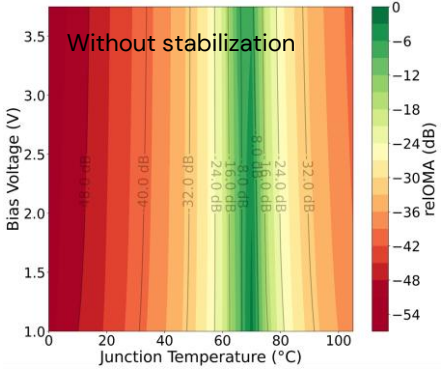



# Why rings are revolutionizing photonics

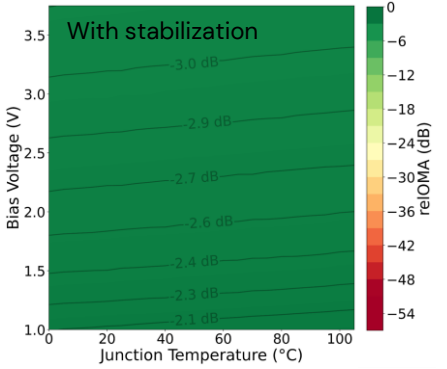





| Metric | MZM [1] | SiGe/Ge EAM [2, 3] | MRM [4] |
|---|---|---|---|
| **3D-CPO compatible?** | No, too large. >1000μm | No, too large. 50–100μm | Yes, ~15μm in diameter. |
| **Need another multiplexer?** | Yes | Yes | No, already a multiplexer |
| **Thermal stability** | Stable, only thermal gradient between the two arms affect. | Stable with feedback loop. Modulation is temperature dependent. | Stable with feedback loop. Transmission depends on ring resonance. |
| **Power consumption [5]** | ~50 mW | ~10 mW | ~1 mW |
| **Transmitter penalty** | <5 dB | <10 dB | <5 dB |
| **Optical bands** | O-band & C-band | C-band only | O-band & C-band |




*Feedback control loop gives the MRM a wide operating range: 0°C–105°C*




[1] M. Streshinsky, et al. Opt. Express 21, 30350-30357 (2013).
[2] J. Fujikata, et al., Opt. Express 31, 10732-10743 (2023).
[3] Y. Liu, et al., PRJ 8, 1474 (2023).
[4] E. Timurdogan, et al. Nature Communications 5, 4008 (2014).
[5] DAB Miller, et al. Opt. Express 20, A293-A308 (2012).

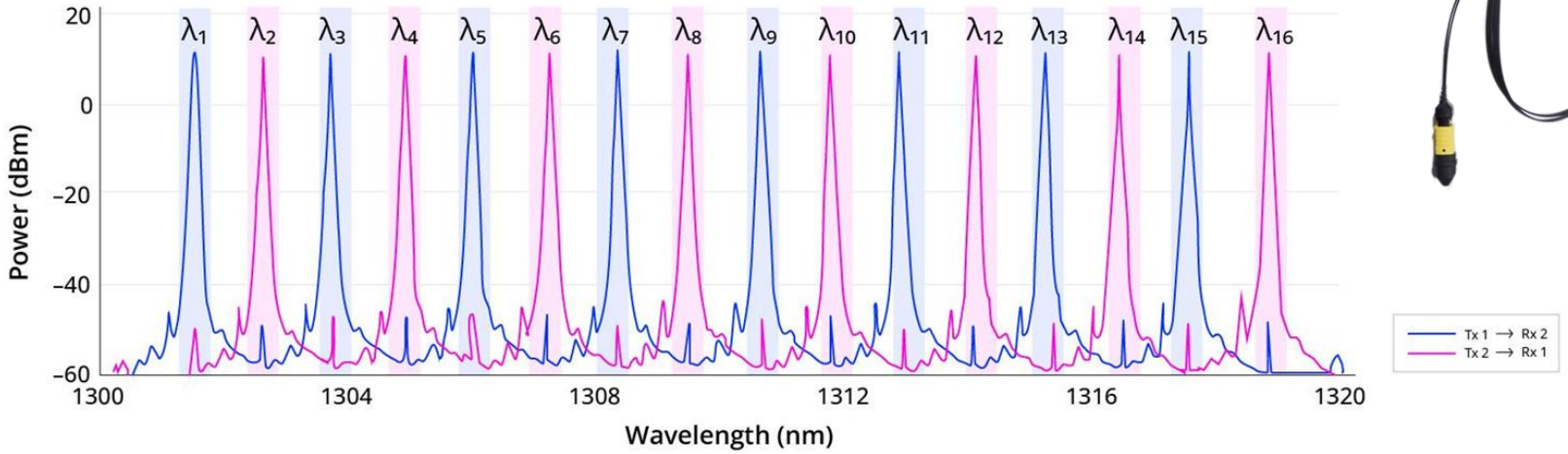
Note: "Relative OMA" (relOMA) is relative to 1 mW laser into the MRM.

# Guide™: External WDM laser

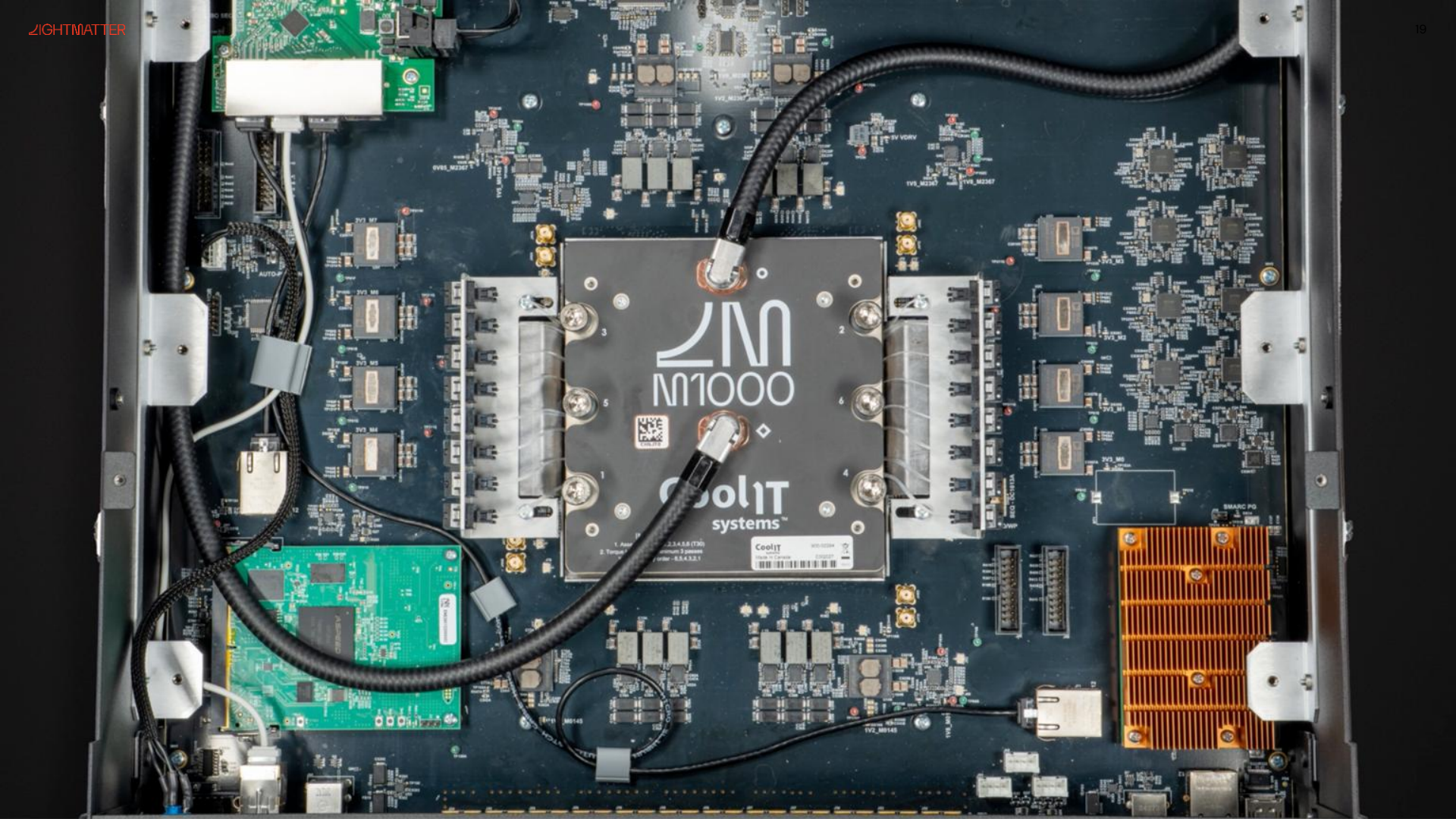
Up to 16 wavelengths per fiber, 200 GHz grid

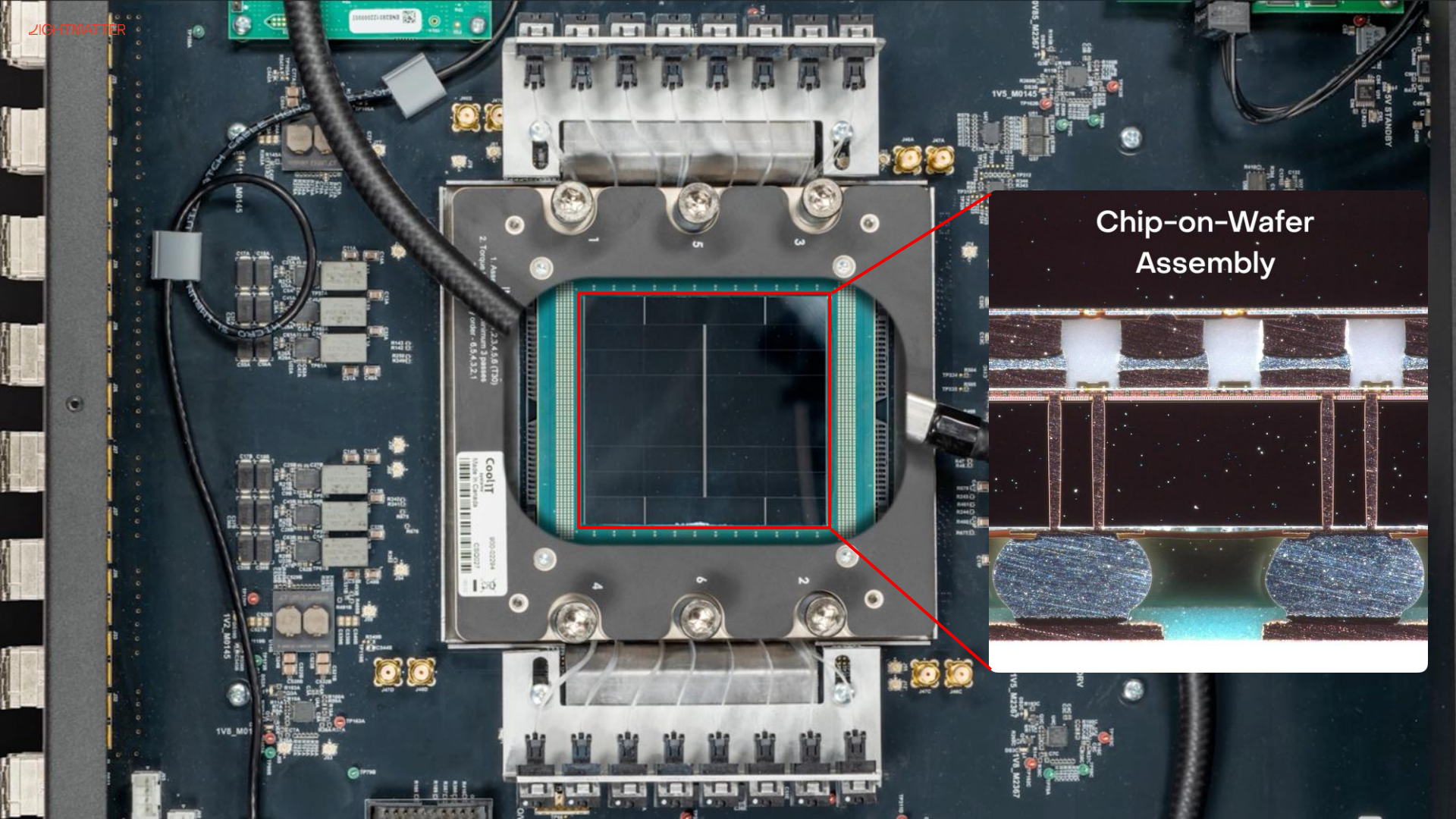
16 fiber output

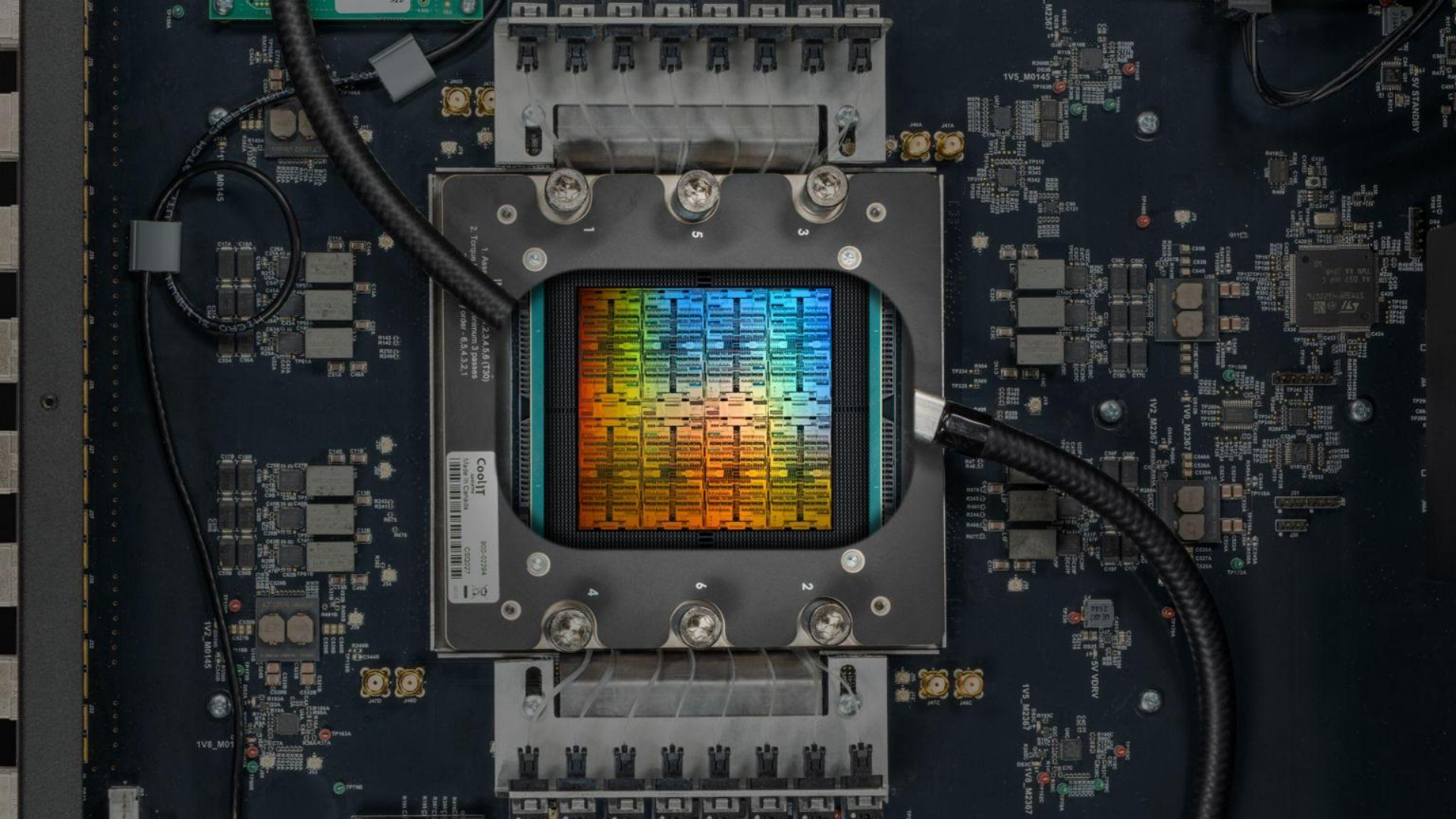
Optimized for microring modulator Tx architectures

# A complete reference platform

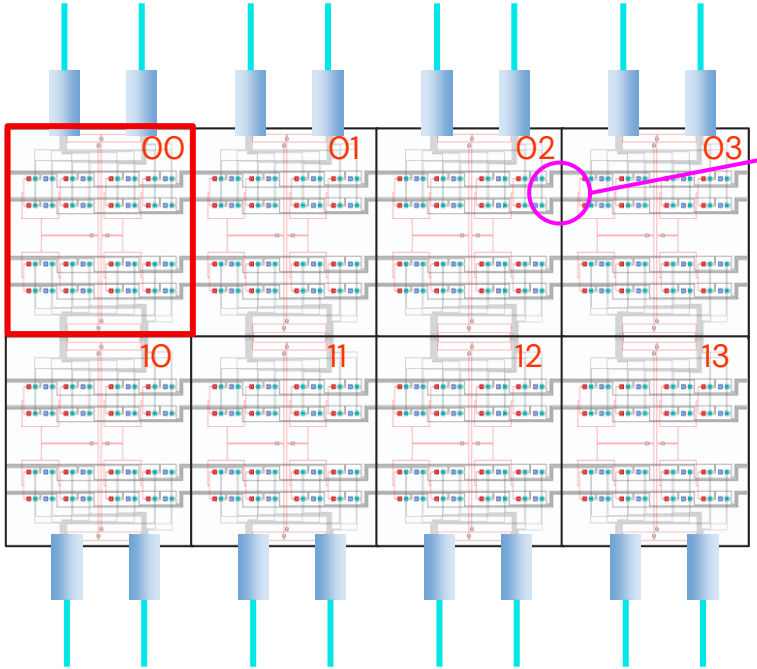

M1000
CoolIT
systems


Chip-on-Wafer
Assembly

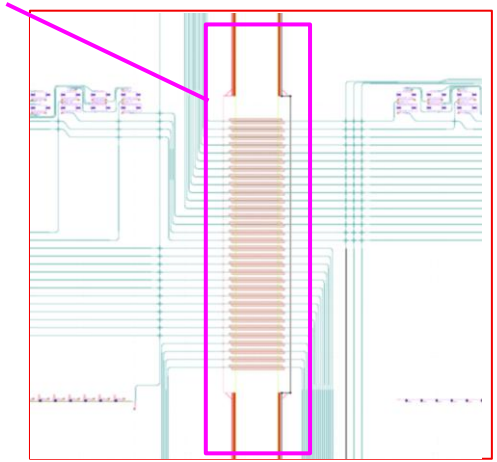

1V5_M0145
5V STANDBY
1V2_M0145
1V8_M0145
5V VDRV
1V8_M2367
1V5_M2367
1V2_M2367
CoolIT
800-02204

# Reconfigurable connectivity

A dynamic, programmable optical fabric in the 2x4 tile design



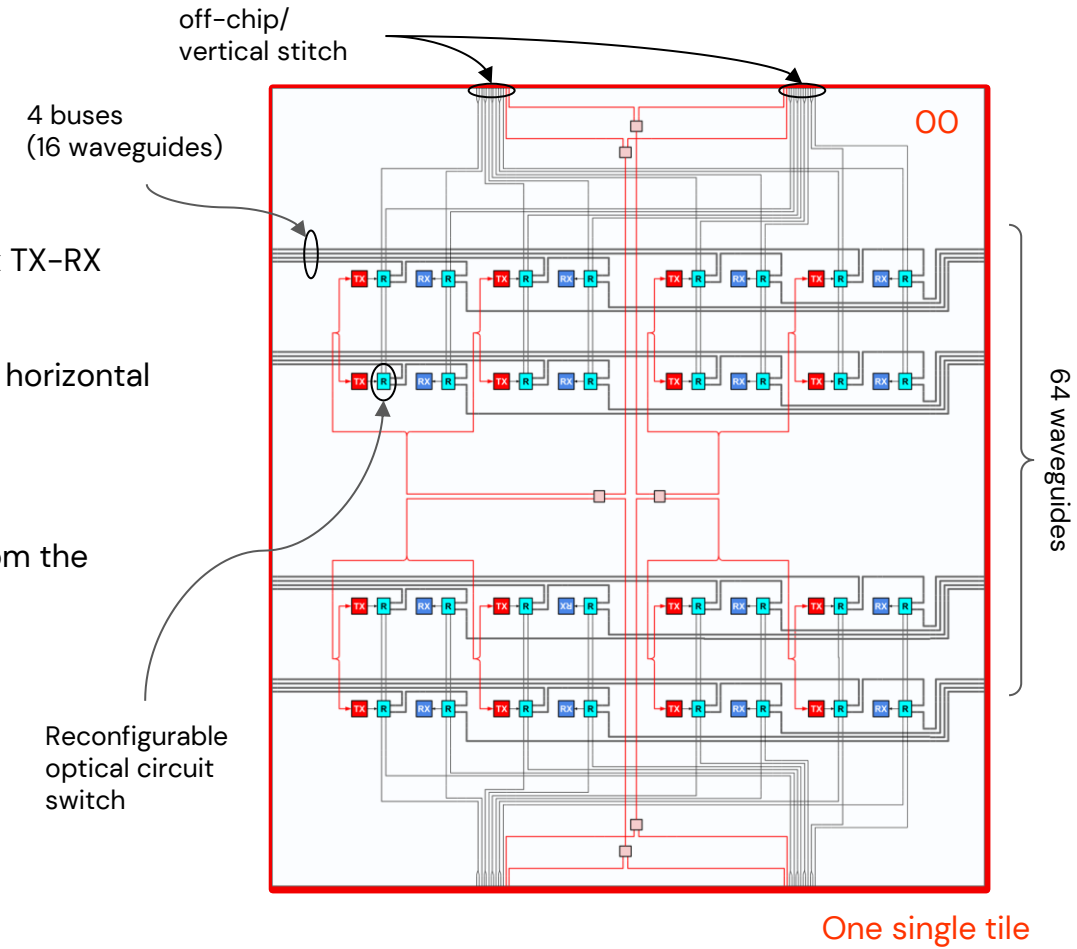

Photonic cross-reticle stitching



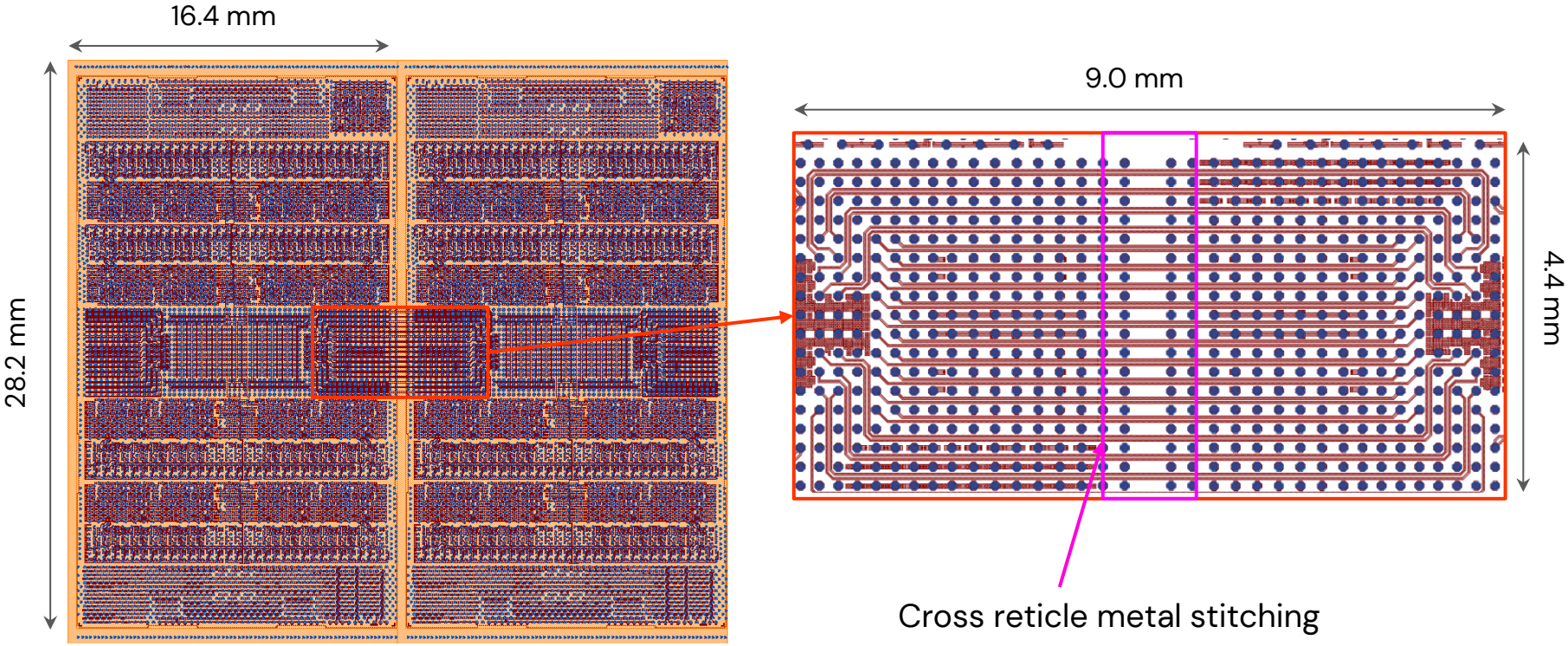
Passage M1000
2x4 tile

# Tile design

- 16 horizontal buses
- Each bus supports up to 2 full-duplex TX-RX links:
  - 8λ @ 56Gbps/λ per link
- Each TX bank can also talk across the horizontal tile edge to:
  - RX bank on adjacent tile
  - Off-chip
- Each RX bank can receive off-chip from the horizontal tile edge



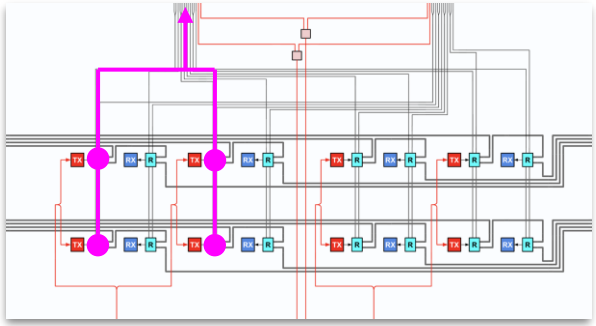
# Neighboring tiles can also communicate electrically

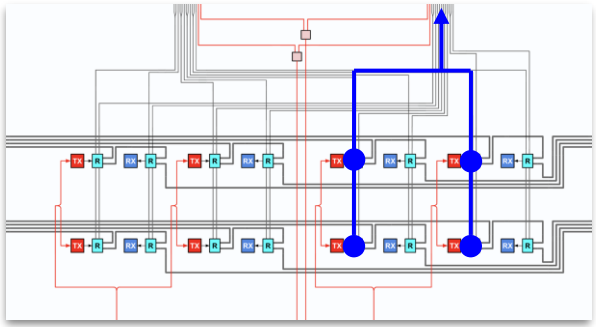


# Resilience through optical circuit switching

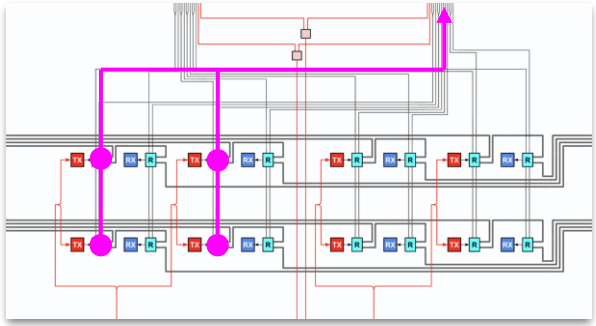
Fiber attach redundancy allows users to route around failures

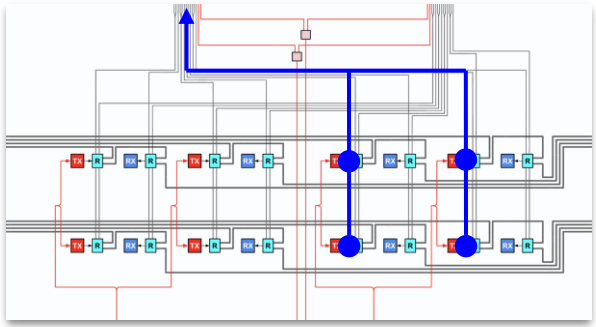
Option A (default):



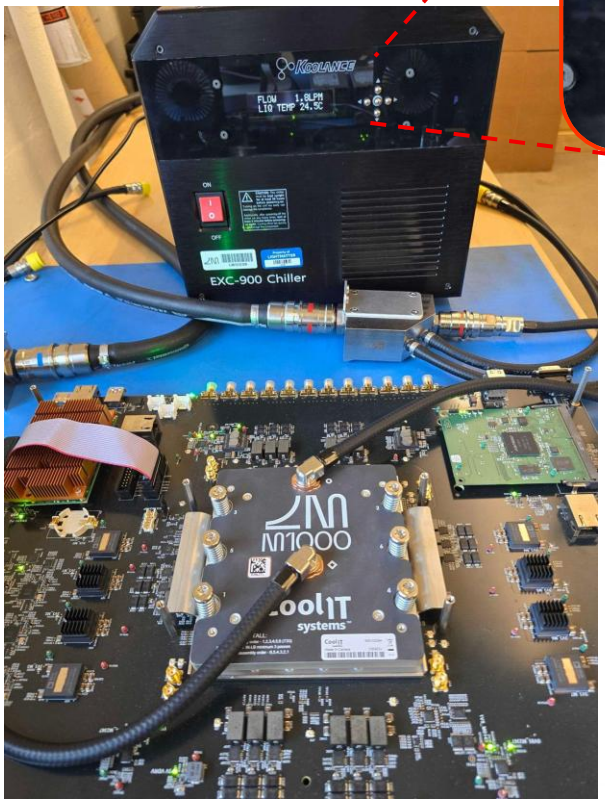


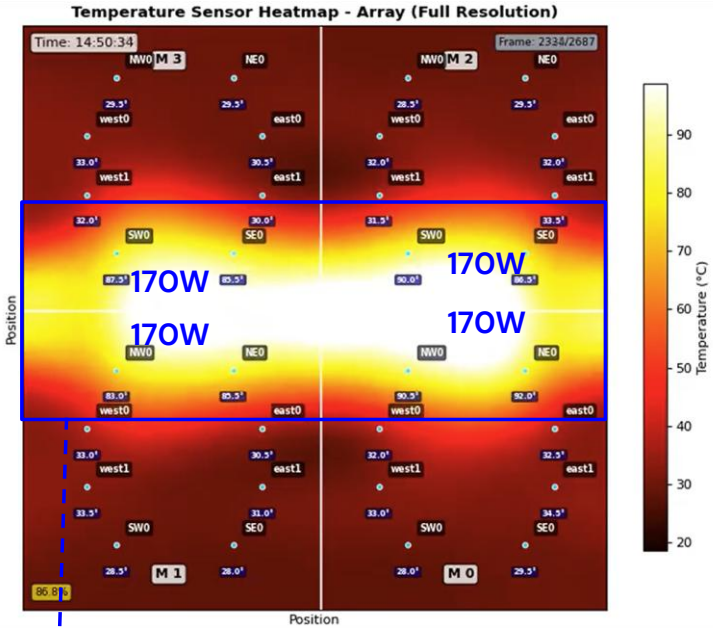
Option B (backup):





# Power delivery and thermal load




369mm$^2$ thermal test chip, power density 1.47W/mm$^2$.
Passage TSVs support >2.5A/mm$^2$.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systems

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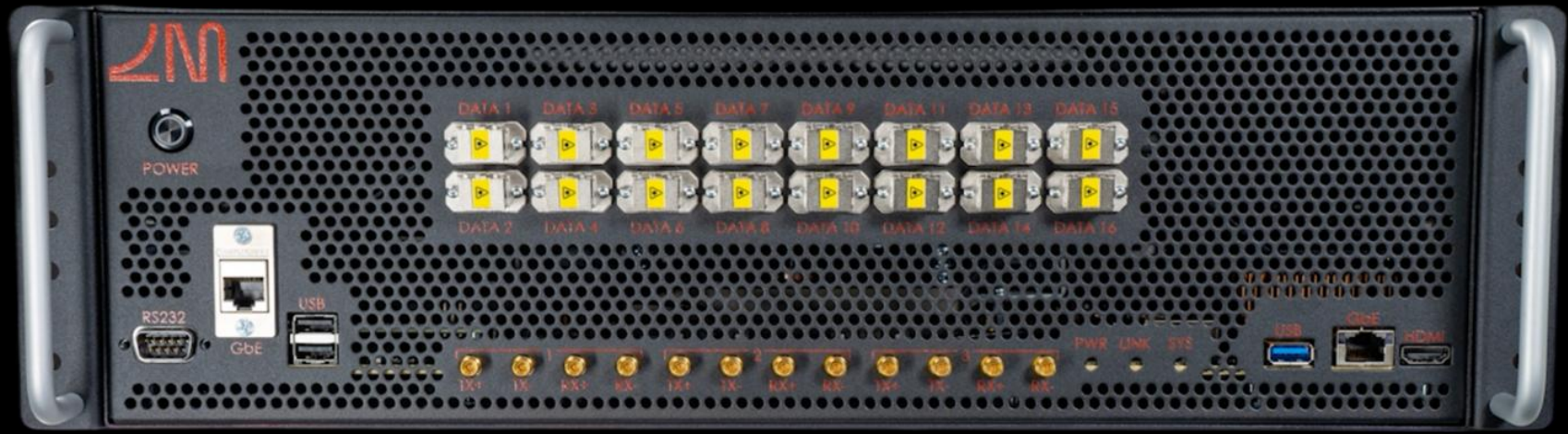

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# Bandwidth density leadership

SerDes eye diagrams

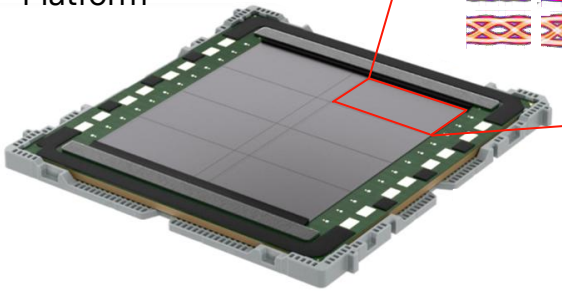
PAM4 also enabled

112 Gbps, TDECQ = 0.83 dB

56 Gbps, NRZ

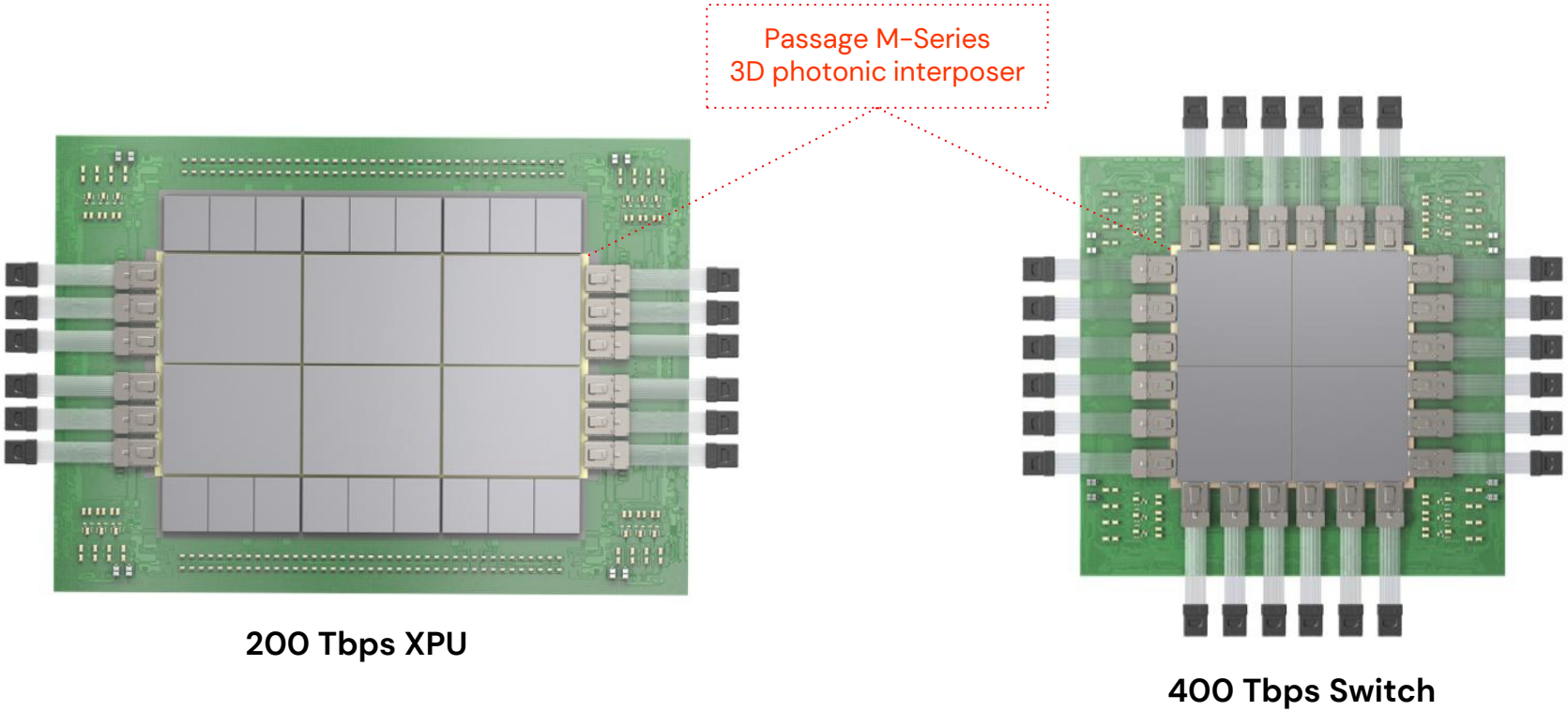
128 SerDes per tile

Passage M1000 Platform



# 3D Interposer scale-up and out to 1M nodes

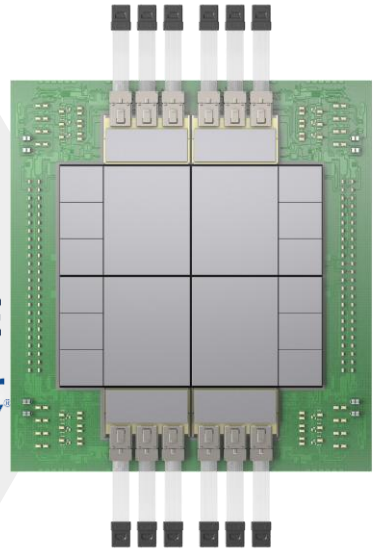
The M1000 revolution



# Optimized end-to-end and production-ready

| | |
|---|---|
| Customer ASIC with UCIe IP | **Multiple fabs** |
| Passage EIC | tsmc |
| LIGHTMATTER Passage PIC | tsmc, Tower Semiconductor |
| Pluggable fiber coupler | **Strategic partner** |

tsmc
ASE
Amkor Technology



Laser module

16λ
100 mW/fiber