



Hybrid Photonics Integration using the POET Optical Interposer™ Platform

Dr. Mo Jinyu
Sep. 15 2021



Presentation Outline

- Background
- POET's Optical Interposer Platform
- Summary



POET Technologies at a glance

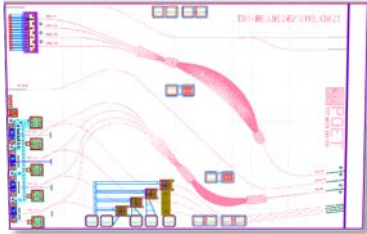
- POET Technologies has developed a unique hybrid photonics packaging platform targeting applications in high-speed data communications for the large Datacom / Telecom markets
- Built on its highly disruptive Optical Interposer Platform technology, POET's platform delivers compelling value in terms in performance, power, cost and scalability
- POET has established a "fab-lite" business model and a joint venture partnership to enable manufacturing to scale, while maintaining ownership and control over its Intellectual Property
- POET has engagements or contracts with some of the largest Datacom and Telecom Optical companies who represent a sizable market share among POET's target market segments

| | | |
|--------------------------------------------|---------------------------------------------------------------------------|-------------------------------------------------------|
| \$20B+ Data Communications Market | 5 Customer Engagements | 4+ Years of Technology and Product Development |
| 77 + 18 Patents and Patents Pending | \$46M Total Funding* <small>* Capital raised since 2015</small> | |

| | | | |
|----------------------------|--------------------------|------------------------------------------------|---------------------------------------------------|
| Target Applications | 100G CWDM4 LR4 | 400G DR1 DR4 FR4 Remote Lasers | 800G DR8 External Cavity Laser Platform |
| | 200G Custom | | CPO |

Optical Interposer Platform

| | |
|-------------------------------|--------------------------------------|
| Superior Cost and Scalability | 20-40% Lower |
| Power Consumption | 20% Lower |
| Hybrid Integration | 1/10th Lower Capex |
| Versatility | Numerous Applications |



6mm X 9mm

World's smallest TxRx "Optical Engine on a chip", integrating 4 lasers, 4 high speed photodiodes, 4 monitor photodiodes, Mux/DeMux, Taps and output fiber coupling features



Global Development and Manufacturing



ALLENTOWN, USA
Optical Engine
Product Development

TORONTO, CANADA
Corporate
Headquarters

SZHENZHEN, CHINA
Applications
Engineering

KULIM, MALAYSIA
Silterra
Interposer
Manufacturing

SINGAPORE
Interposer
Development

XIAMEN CHINA
Joint Venture
Assembly, Test, Sales



Presentation Outline

- Background
- POET's Optical Interposer Platform
- Summary

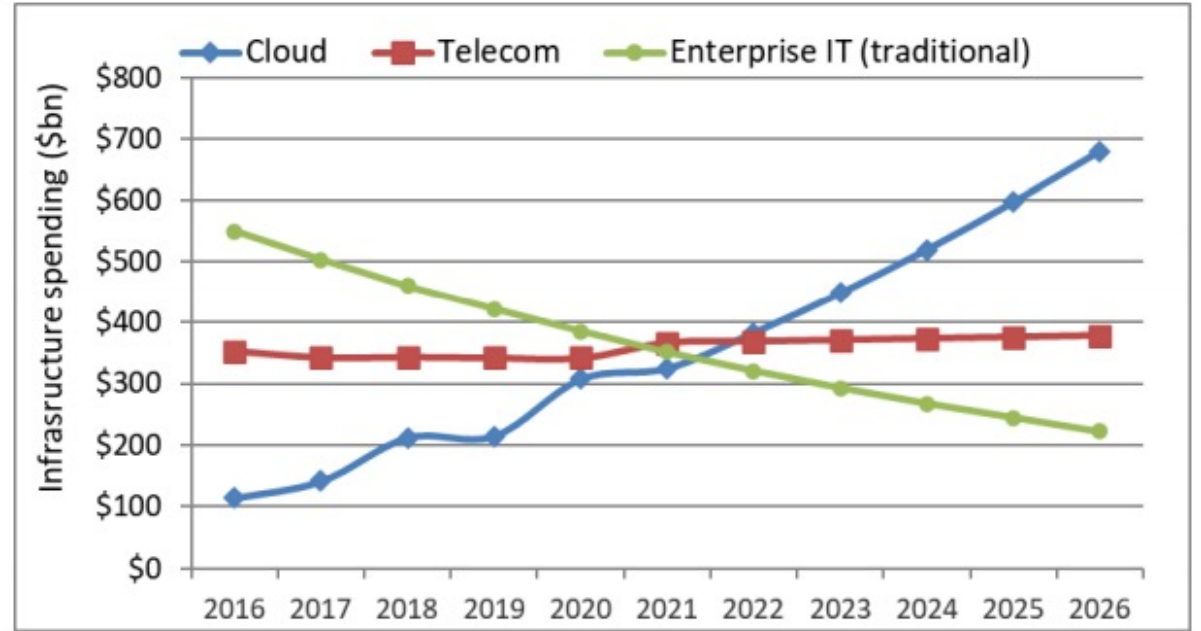


Industry Demand



Mega data centers:

- BW ↑
- Speed ↑



Cloud had the highest CAGR from 2016-2020, (+29%) vs Telecom (-1%), and Enterprise (-9%)



Challenges

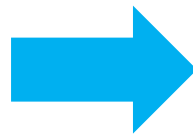
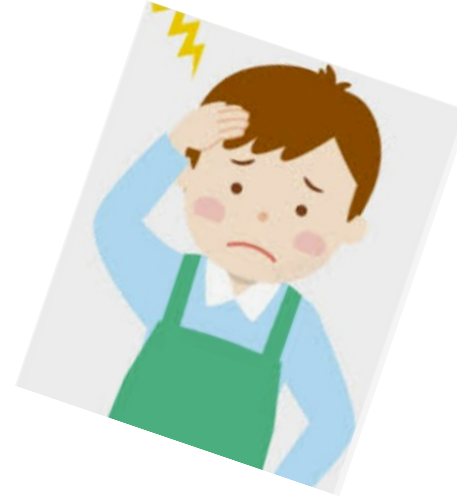
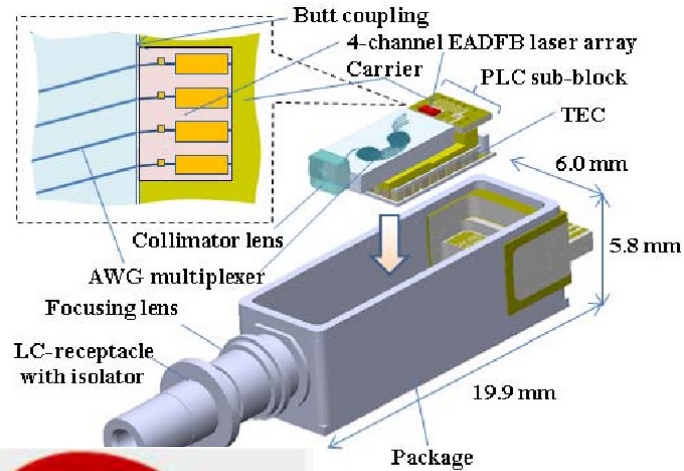
Pricing:



VS



Assembly:



Silicon Photonics Integration



Silicon photonics supply chain for optical transceivers

(Source: Silicon Photonics 2021 report, Yole Développement, 2021)



■ Coherent optical communication

Systems include servers, routers, and switches
Non exhaustive list of companies



Presentation Outline

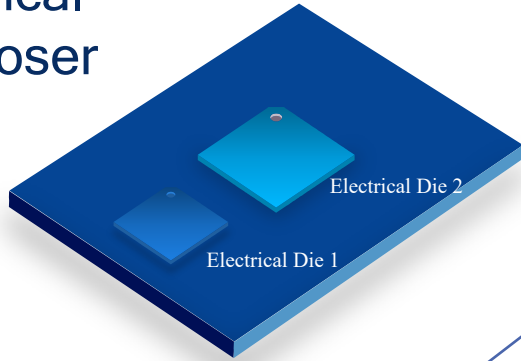
- Background
- POET's Optical Interposer Platform
- Summary



POET's Optical Interposer™ Platform

- A **unifying** hybrid optoelectronics integration platform

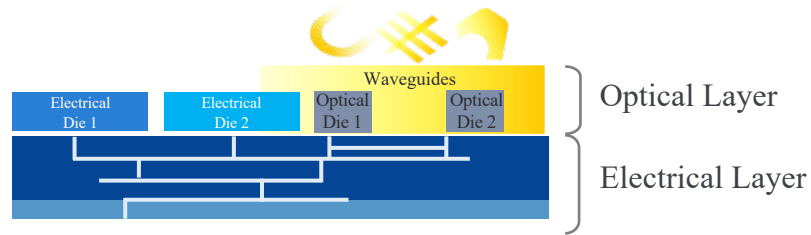
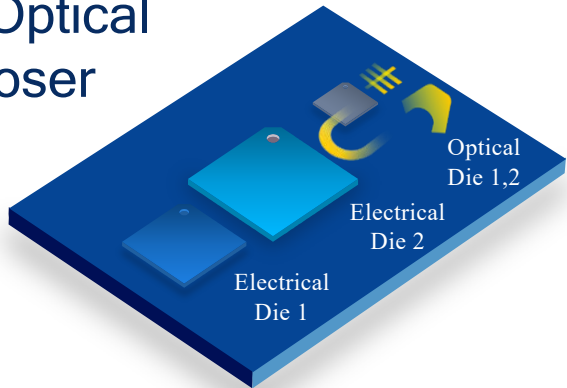
Electrical Interposer



- Typical electrical interposer with high-speed electrical connections among devices has been commonly used in devices like cell phones



POET's Optical Interposer



- By adding a layer using a novel material set and patented process, POET created the Optical Interposer that allows photonic devices to communicate seamlessly with one another and with the electronic devices at chip level
- Placement of components is done with automated semiconductor techniques without the need for “active” alignment

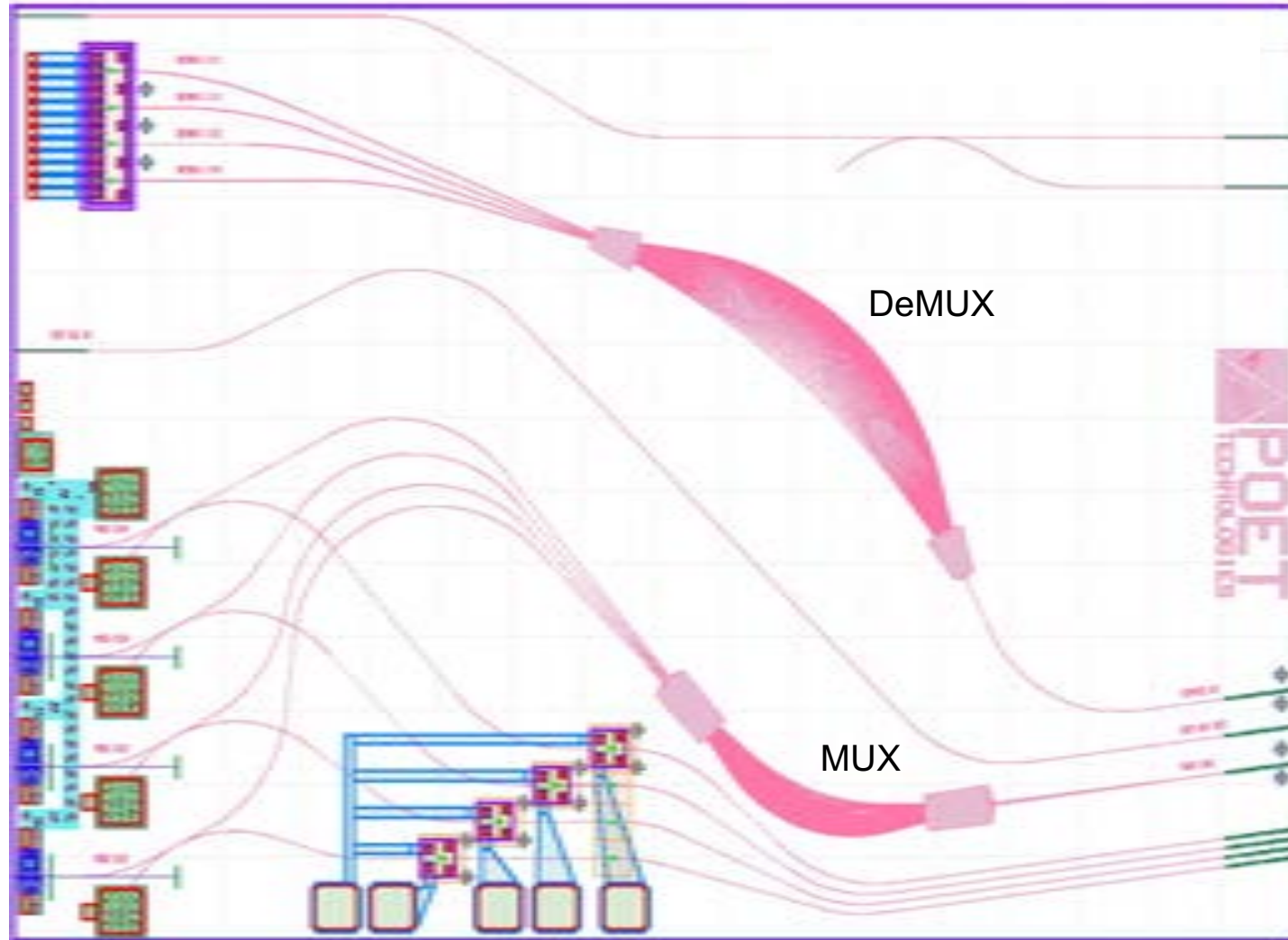
Adding a Novel, Patented Waveguide Layer on a Conventional Semiconductor Wafer Enables the Integration of Electronic and Photonic Components at Wafer-Scale



Critical Technical Blocks

- Mirrors
- PD/PD array: flip chip bonded

- Spot size convertor
- Laser chips: flip chip bonded
- BI features



- Spot size convertor
- FAU

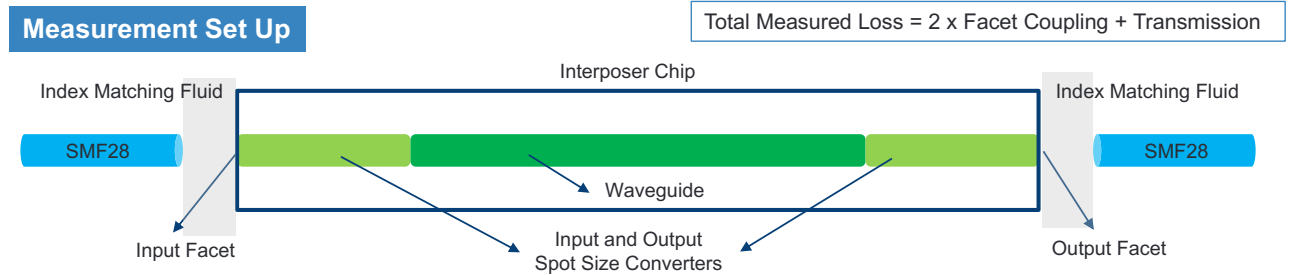
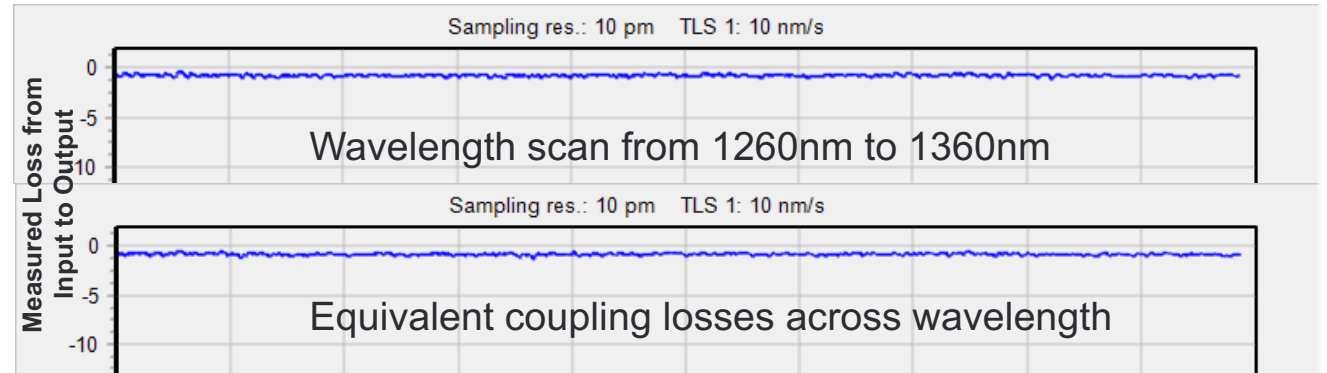
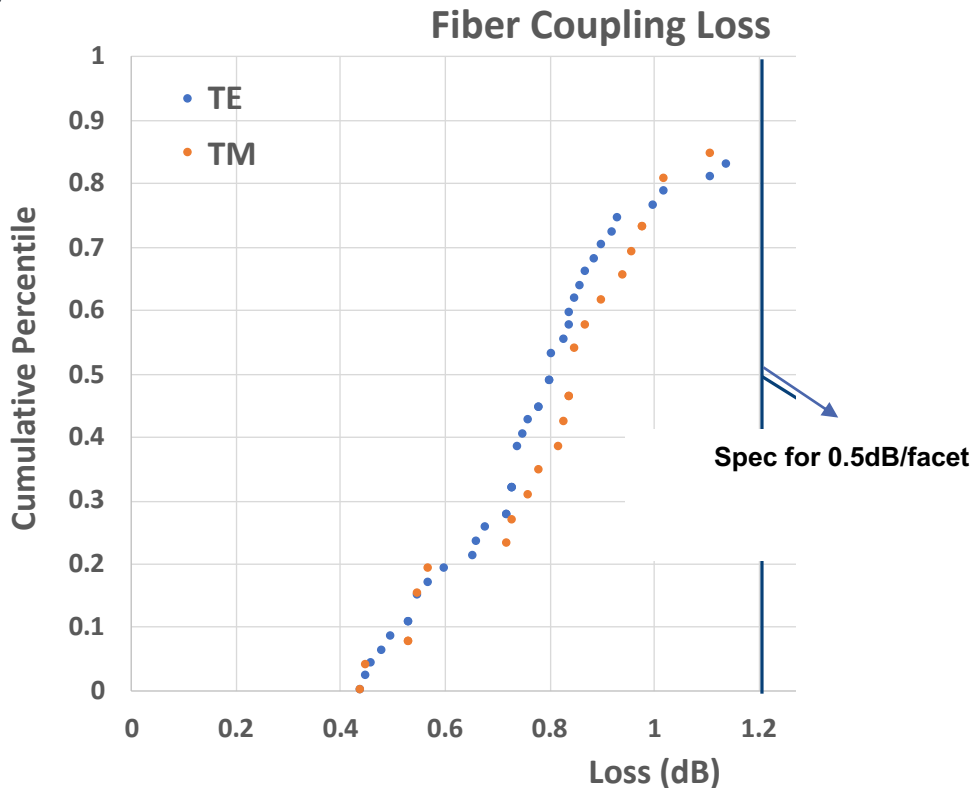


Industry-Leading Fiber Coupling Performance

Measured Fiber Coupling Optical Losses

Total loss from input to output : 0.7dB
Best measured fiber coupling loss : 0.25dB/facet

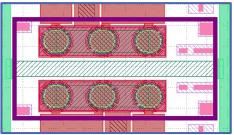
Transmission Loss : 0.2dB
Expected in Production: <0.5dB/facet



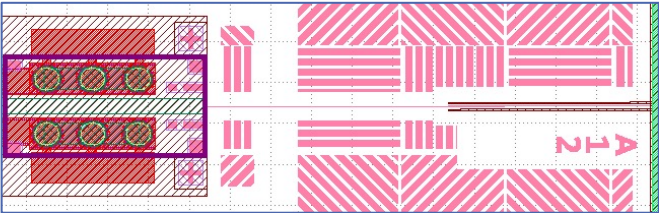


Industry Leading CW Laser to Waveguide Coupling Efficiency (>70% in manufacturing with passive placement)

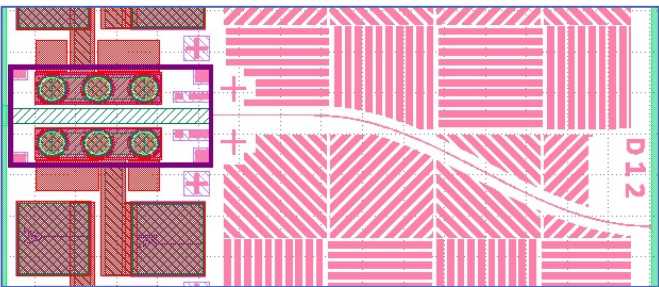
Interposer designs for wafer scale passively aligned flip chip laser mounting



No Waveguide – sub-mount only

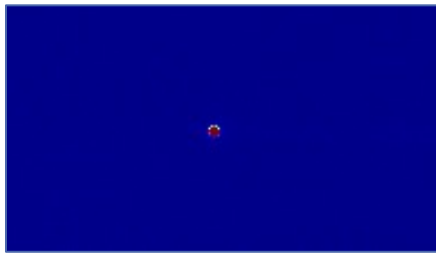
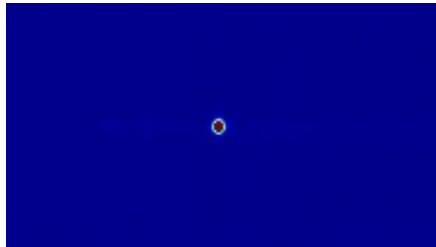


Straight WG with SSC



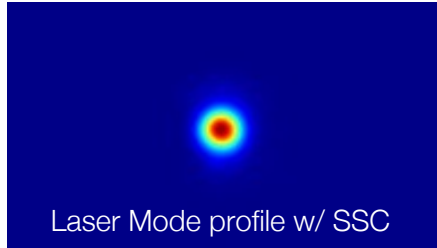
Bent WG with no SSC

Facet IR Image

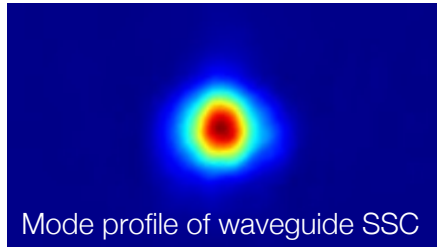


Negligible stray light observed in Facet IR images

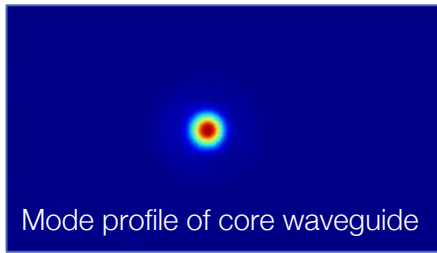
Near Field IR Image



Laser Mode profile w/ SSC



Mode profile of waveguide SSC



Mode profile of core waveguide



- Assemblies show > 90% coupling efficiency between laser mode and input waveguide mode
- Laser incorporates POET's proprietary spot size converter and waveguides tailored for good mode matching to laser modes
- Results match simulations



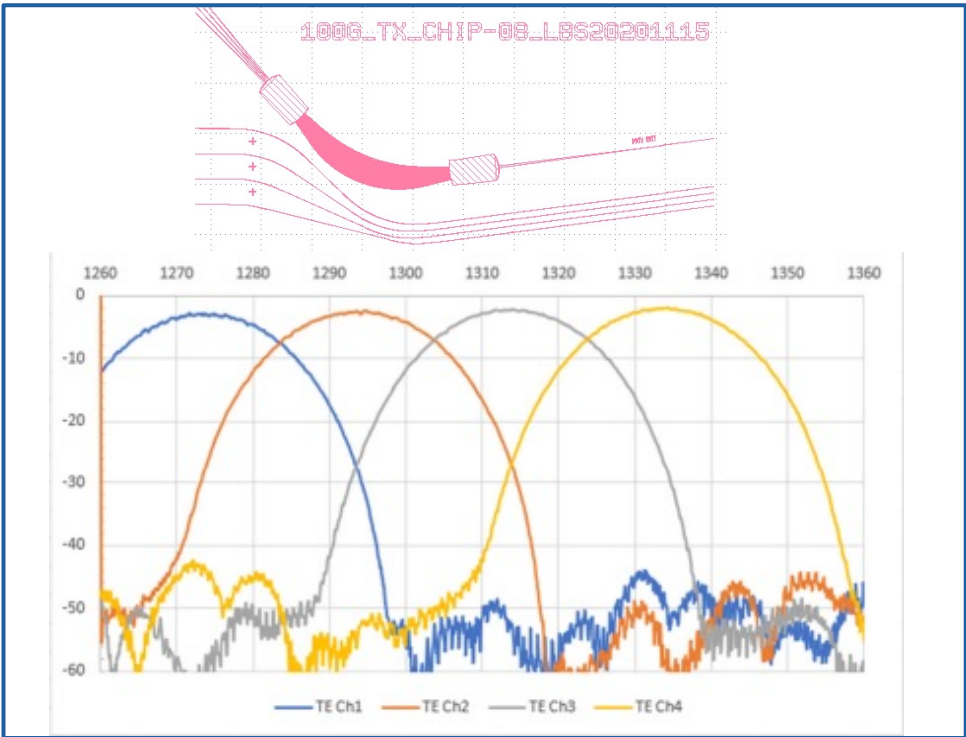
Best-in-Class Low-loss Optical Multiplexers

- Multiplexers integrated and built into waveguides in CMOS process on Optical Interposer platform

Coupling Efficiency of <1.5dB from laser at input ports and <0.5dB output to fiber; > 7nm 3dB passband

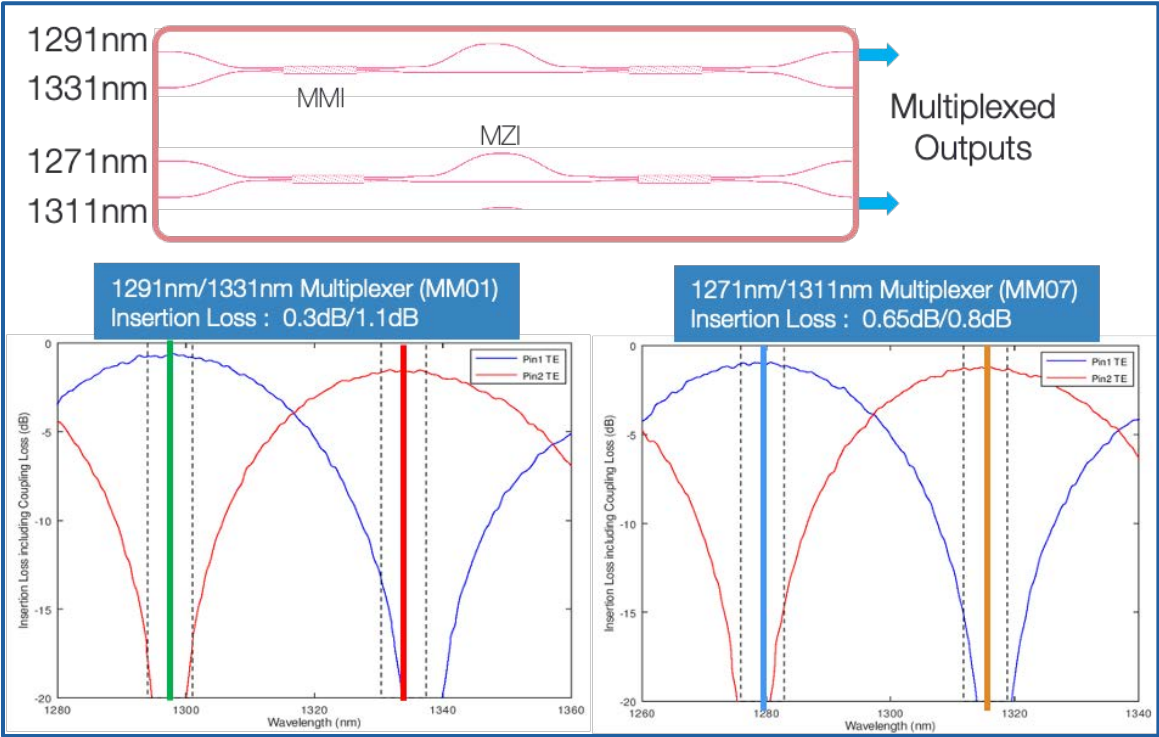
<2.5dB Insertion loss of 4 channel AWGs

AWG (4-8 ch) CWDM4 / FR4 Mux



<1.0dB Insertion loss of 2 channel MZI-MMI Mux

MZI – MMI based dual channel Mux



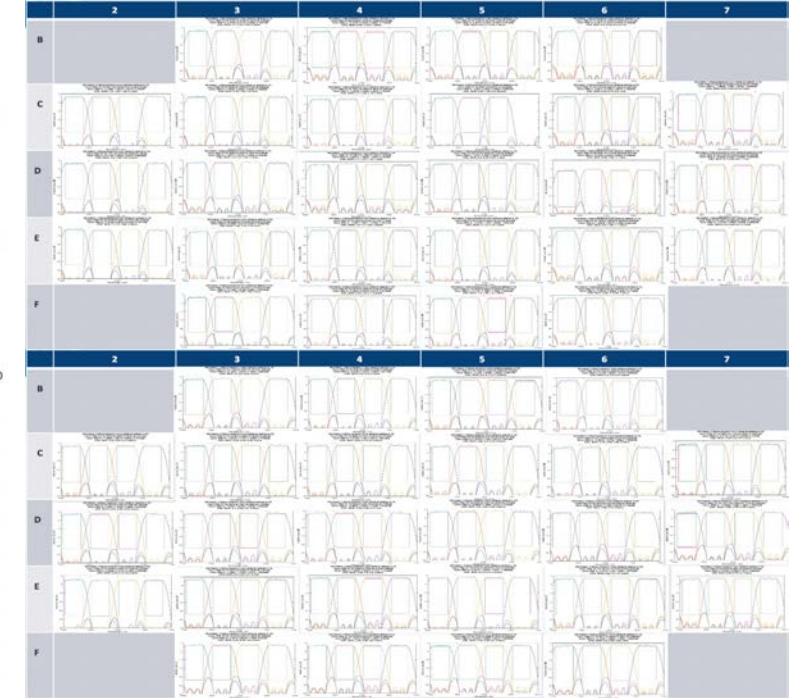
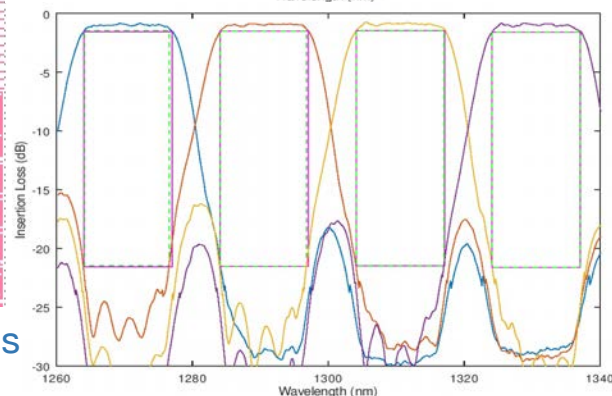
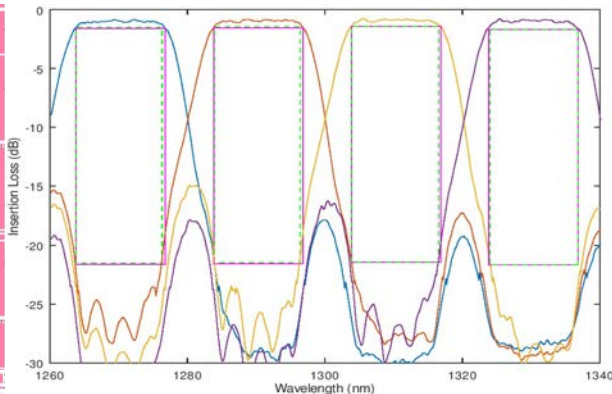
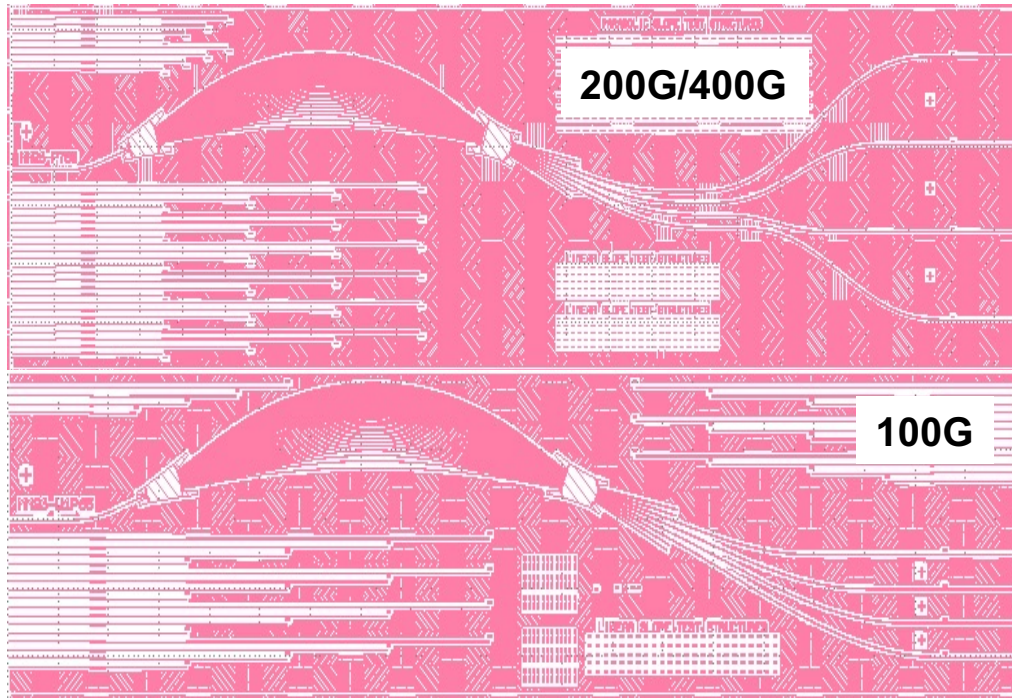


Industry-First Chip Scale Assembly compatible Optical Demultiplexers

- Demux integrated and built into waveguides in CMOS process on Optical Interposer platform

<1.5dB Insertion loss of 4 channel AWGs; <0.5dB coupling to fiber; >13nm passband for 20dB Cross talk

AWG (4 - 8 ch) CWDM4 / FR4 Demux



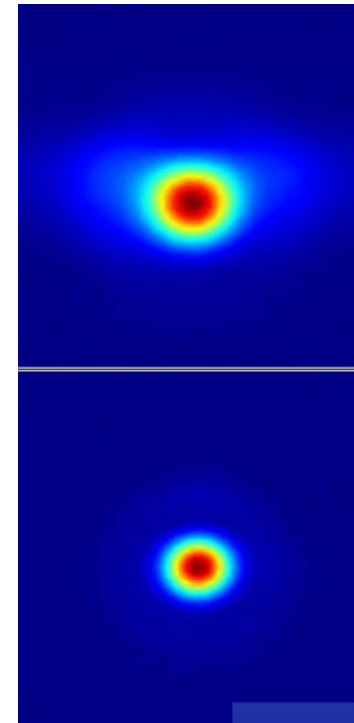
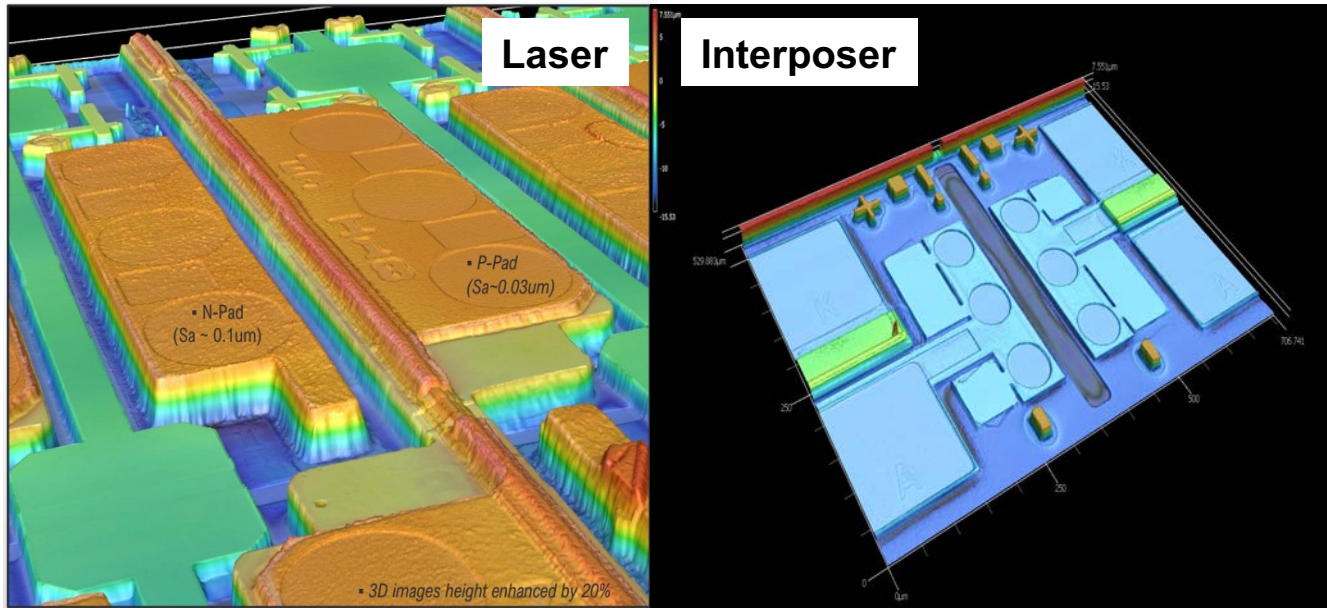
Arrayed Waveguide Gratings for 100G/200G/400G applications
Performance to support 2km and 10km applications

Excellent uniformity and yield across wafers



Industry's leading large spot size laser design for high power CW light source applications

- POET's Spot Size Converter design for CW lasers show low internal loss, large spot size and good coupling efficiency
- Laser design enables high accuracy passive placement on POET's Optical Interposer



POET's Spot Size Converter

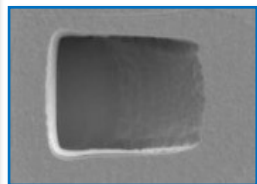
FF Angles @ 14 degrees

Conventional DFB Laser with no expanded Spot Size

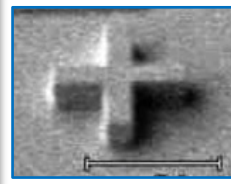
FF Angles @ 25 degrees



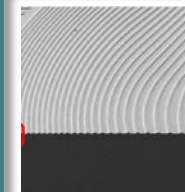
Design Flexibility Drives Competitive Advantage



Low loss
Micro Mirrors
for out of
plane
coupling



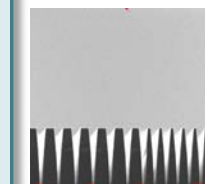
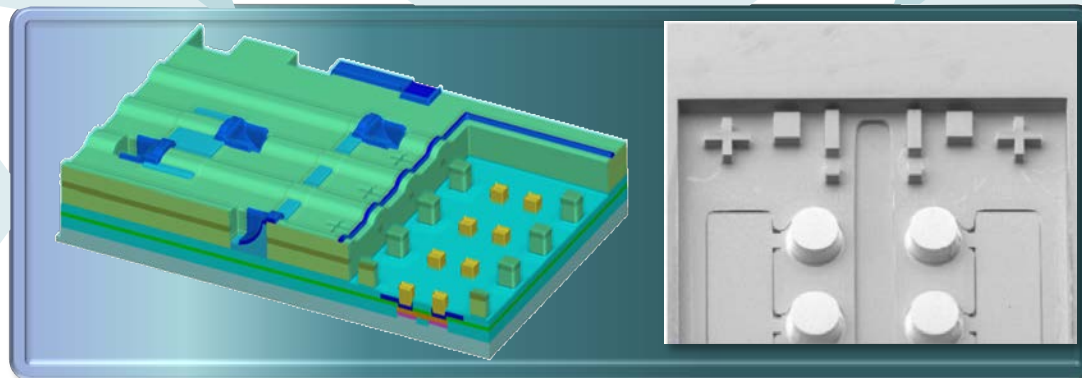
Self Aligned
and
Mechanically
Interlocking
Fiducials



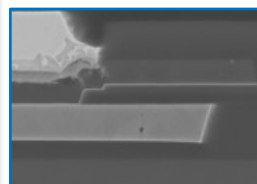
CMOS
Compatible Low
Loss Waveguides
- Compatible with a
wide range of I



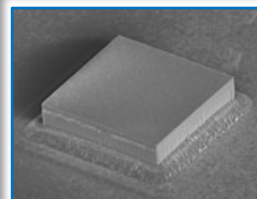
Multiple
Eutectic Solder
Configurations



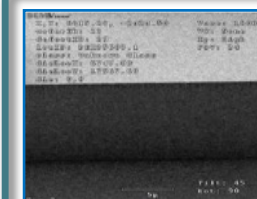
External Cavity
Athermal Lasers
- Low Loss
- High Density



2.5D RF
Interposer
with
Integrated
Passives



Self Aligned Z
Referencing
Pedestals
- Compatibility
with hybrid die



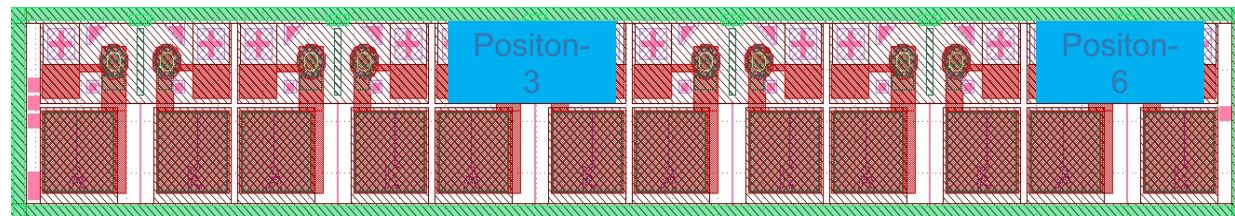
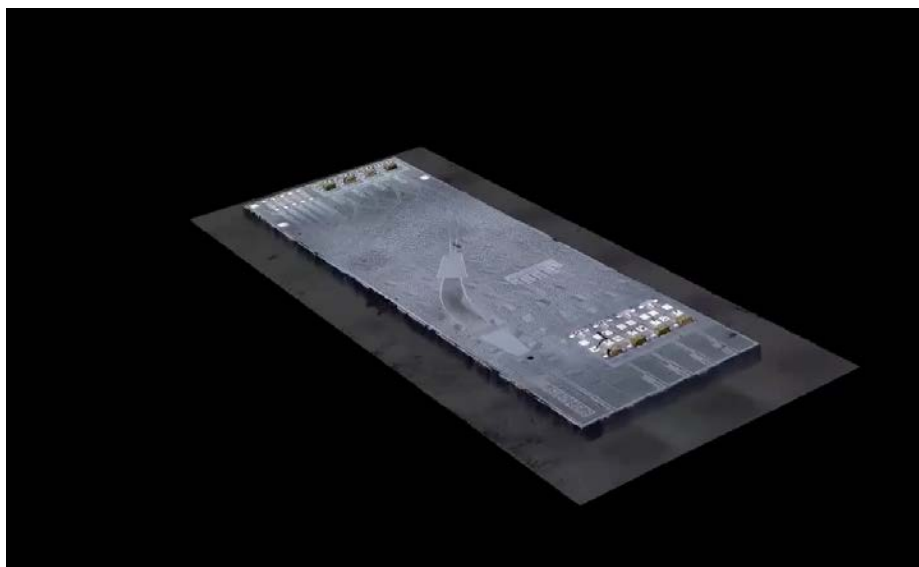
Mirror finish
etched facet
technology
- Lowest coupling
loss in industry

POET's Optical Interposer Platform is the most versatile photonics packaging platform in the Industry

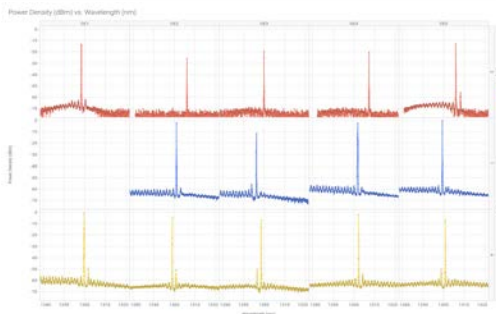


Industry's first flip-chipped DML laser technology with POET's Integrated Optical Engines

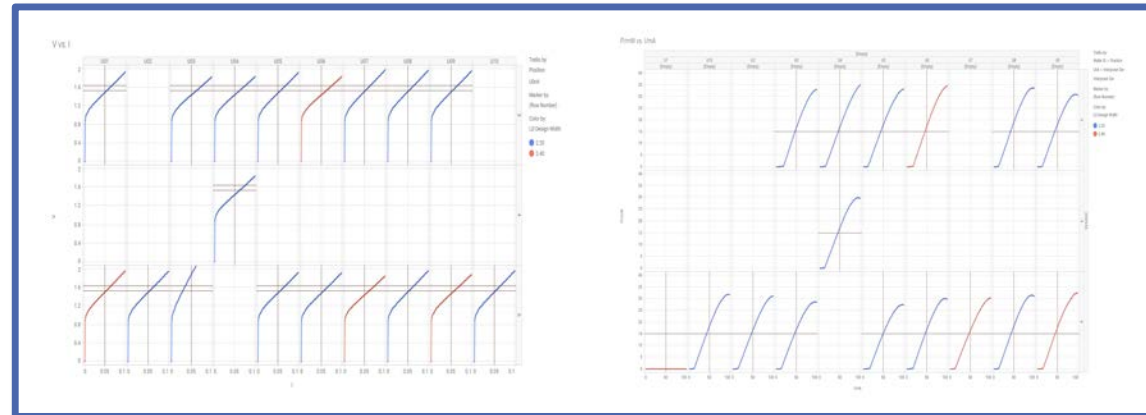
DML's mounted to Optical Engines



Excellent Mechanical, Electrical and Optical Performance



POET solves SMSR issues with flip chip ridge laser technology

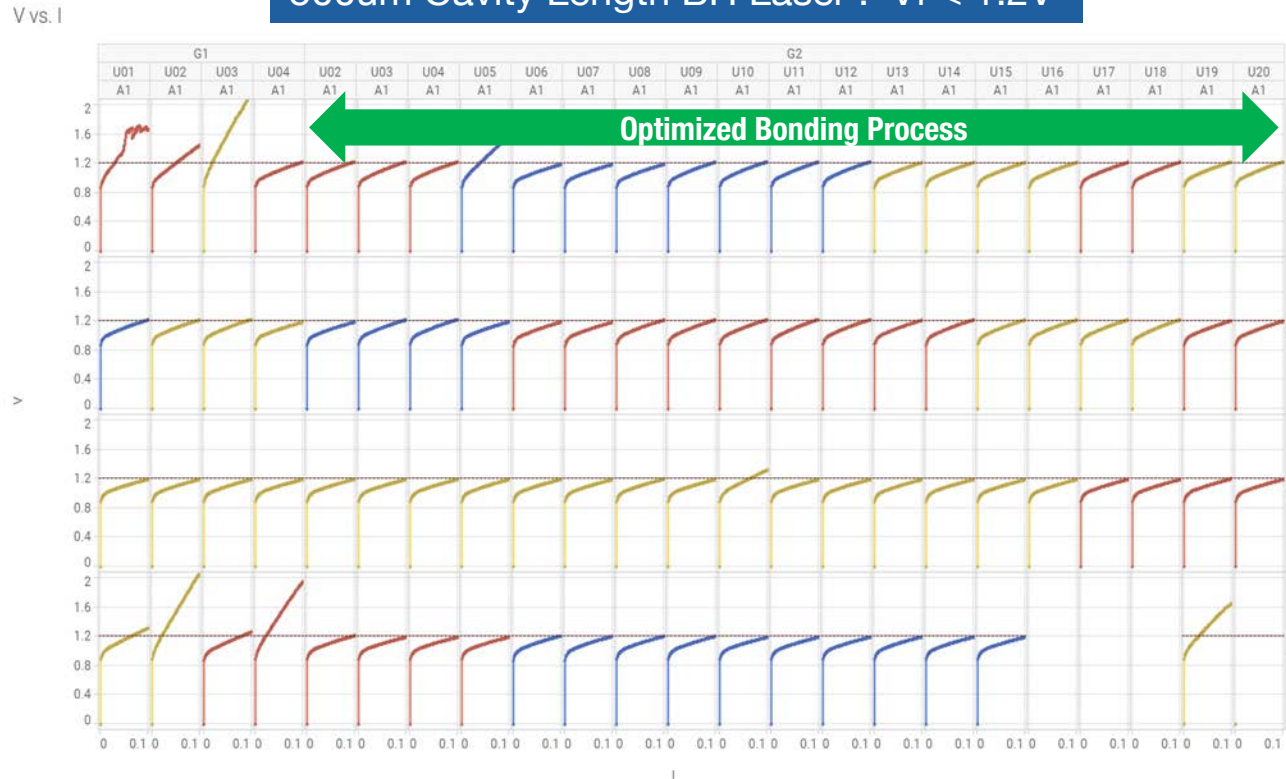


 No degradation in performance of SMSR or RIN

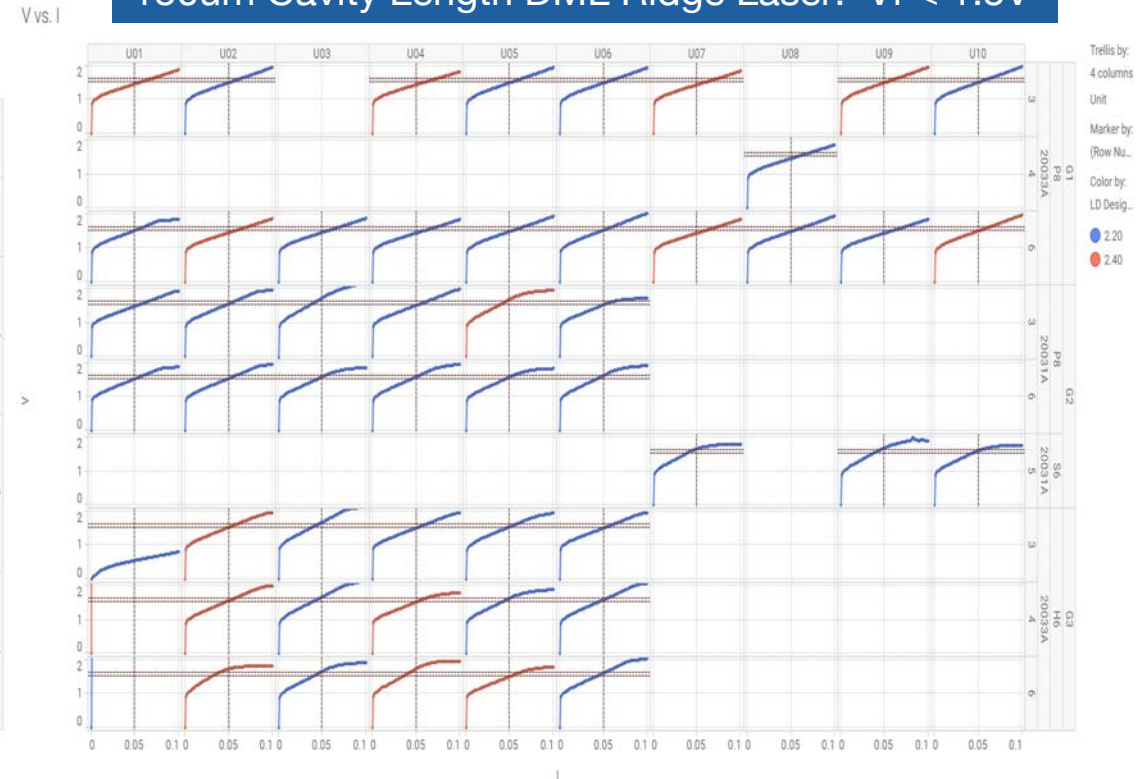


High Repeatability Bonding Process

500um Cavity Length BH Laser : $V_f < 1.2V$



150um Cavity Length DML Ridge Laser: $V_f < 1.5V$

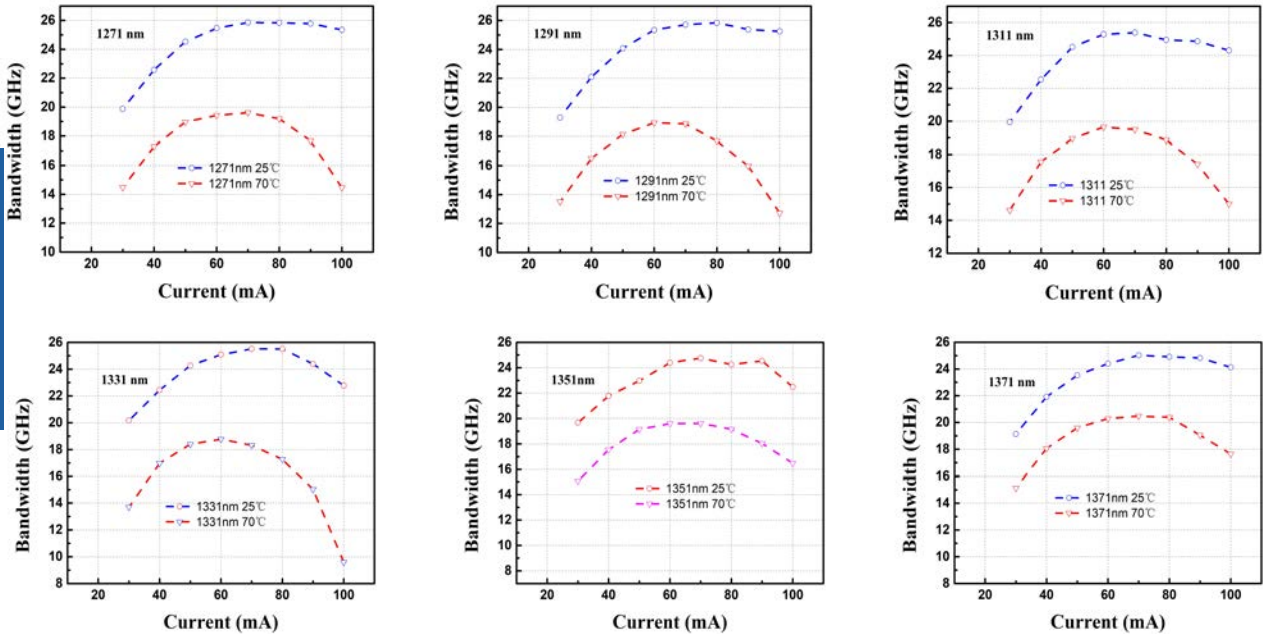


Consistency in bonding process (with high accuracy placement) established over 100's of bonded lasers

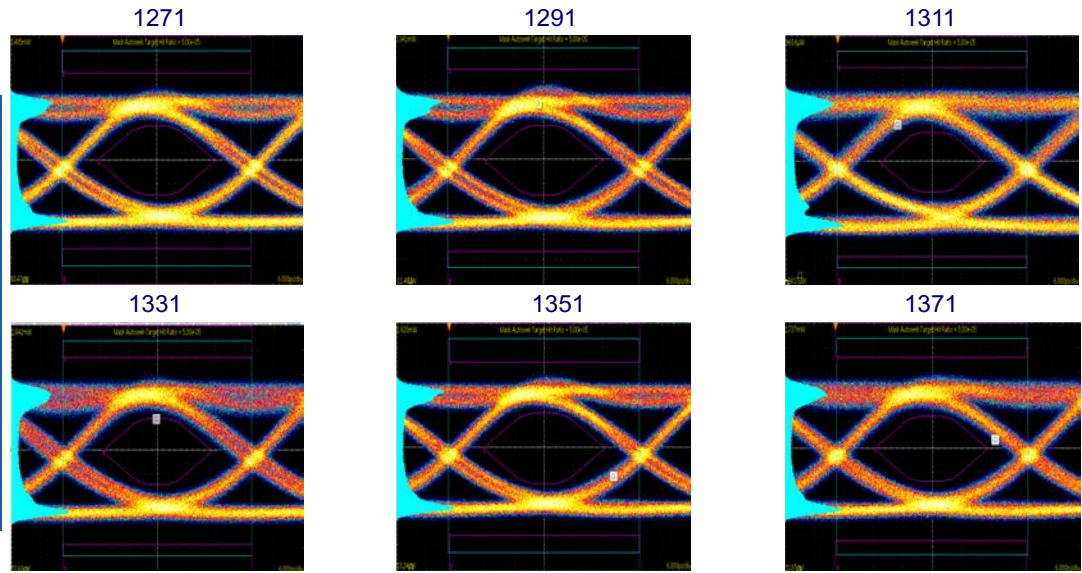


Optical Engine performance: 100G NRZ & 200G PAM4

S21 Bandwidth

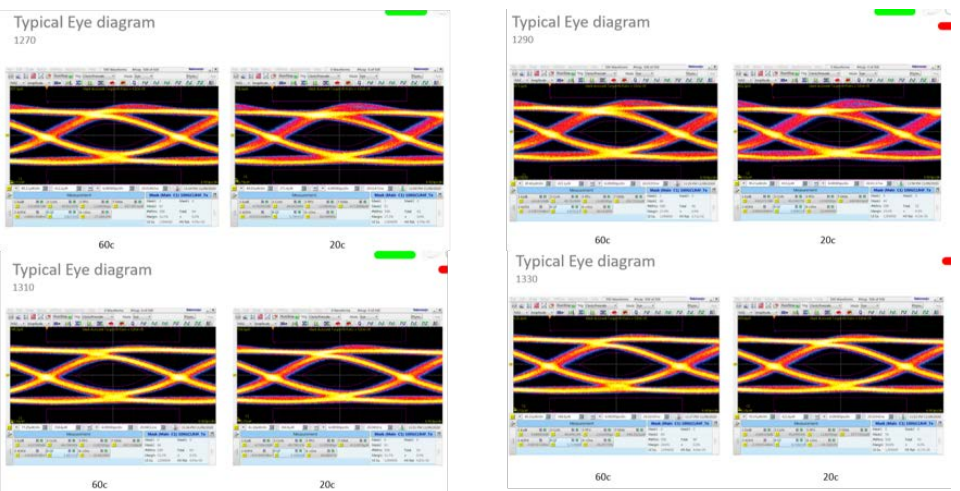


100G C Temp NRZ CWDM

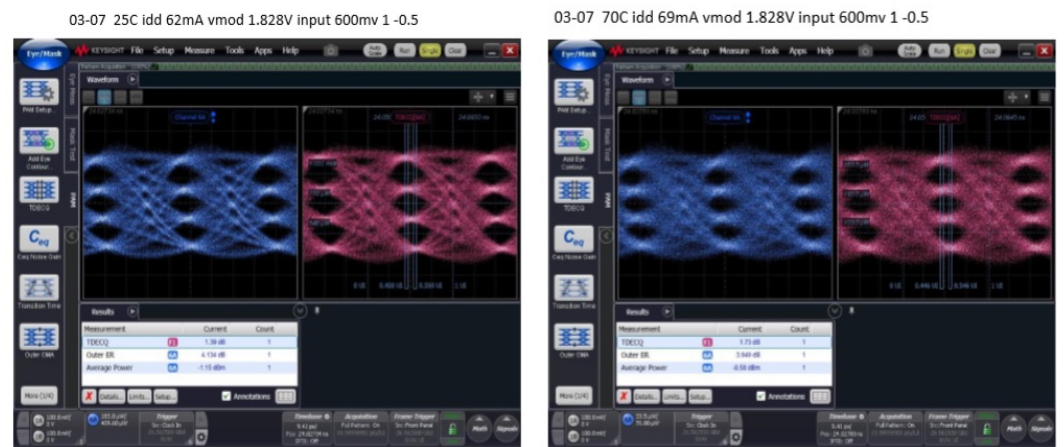


XCE19B120002-03-07 PAM4 eyediagram

10km Operation



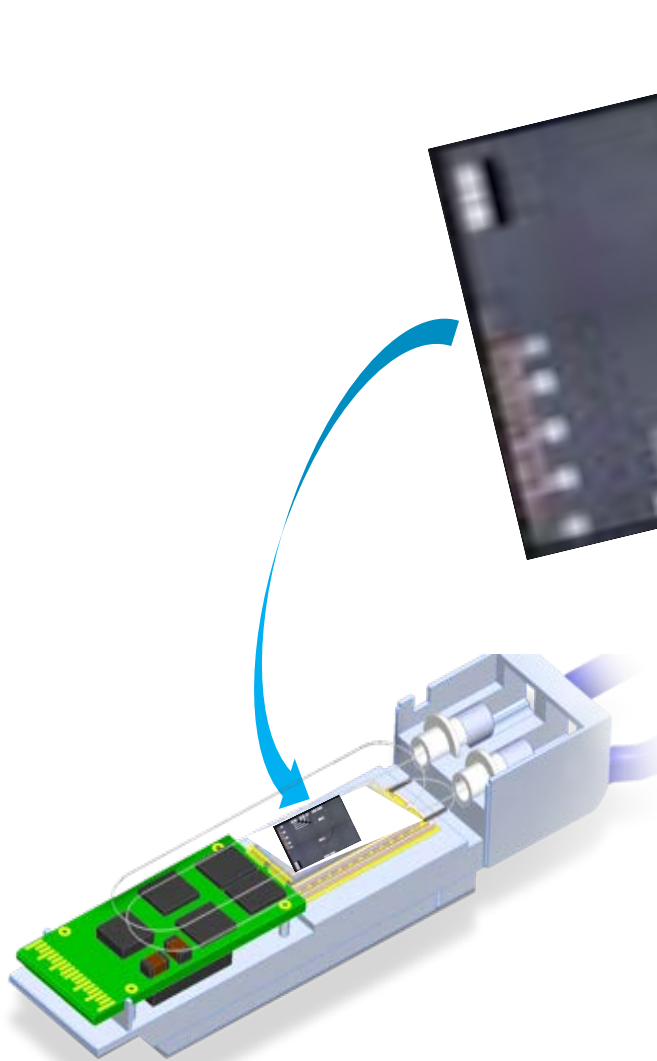
200G C Temp PAM4 CWDM



Note: Ld BIAS is around idd - 12mA



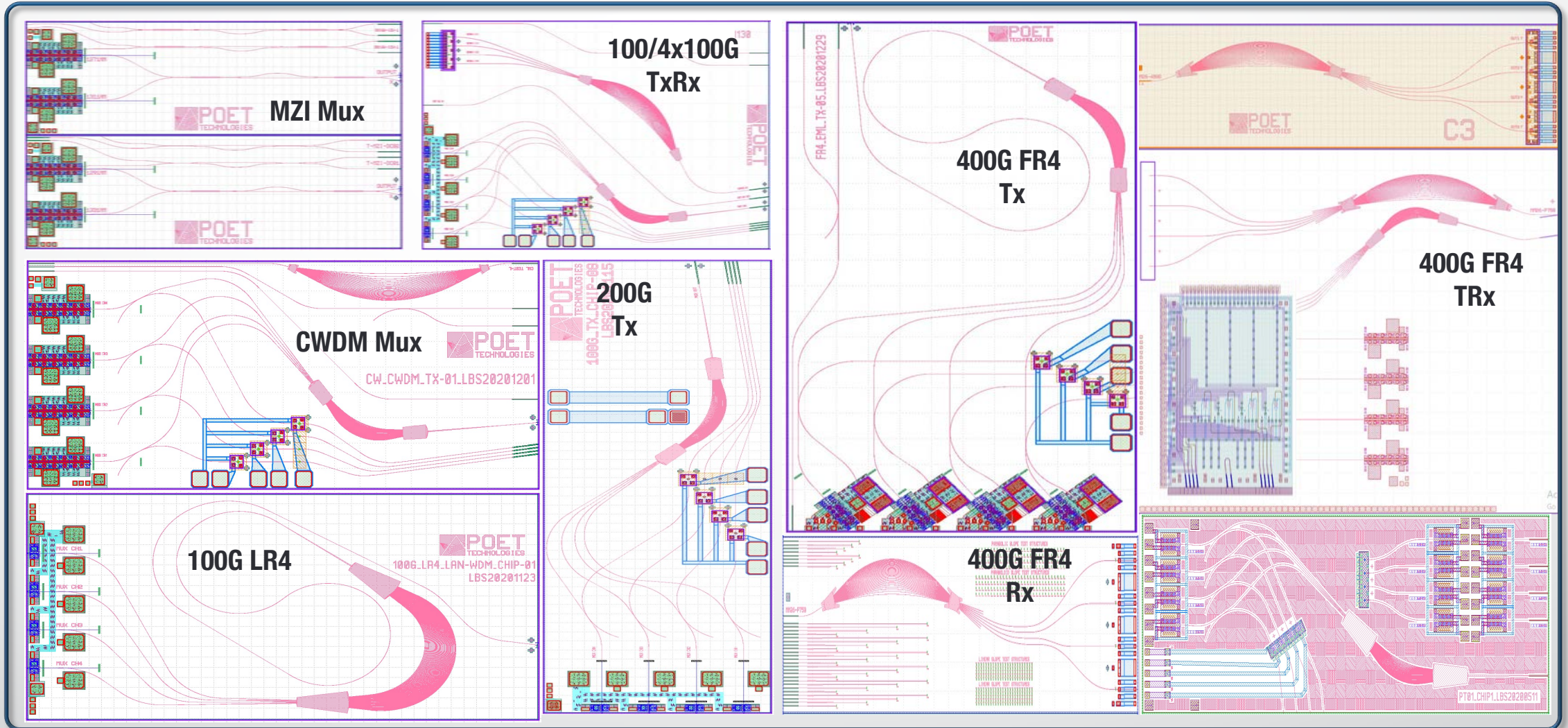
Integration Platform used in Optical Module



- The POET Optical Interposer™ platform for hybrid component integration, test and packaging – **at wafer-level**
- Utilizing the highest performance components from different material sets (Si, InP, GaAs, GaN, Ge)
- Built on a 200mm CMOS wafer incorporating passive optical and electrical components, optical interconnects (waveguides) and electrical interconnects
- Flip-chip assembly of photonics and electronics with passive alignment enables automated, chip-scale packaging

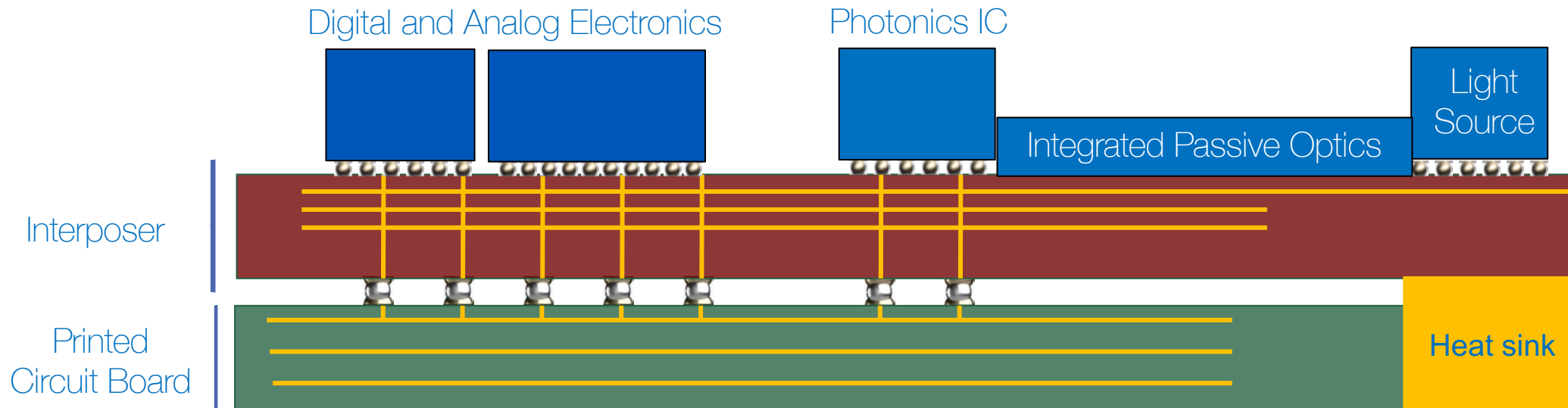


Interposer Platform Leads to Many Different Products





Interposer Architectures for Co-packaged Optics Applications



- 1.6Tbps & 3.2Tbps as defined by Facebook and Microsoft
- Coarse Through Silicon Vias (TSV) for power and low speed IO
- Dense interconnects on interposer for 2.5D high speed routing
- Integrated Light sources and passive optics

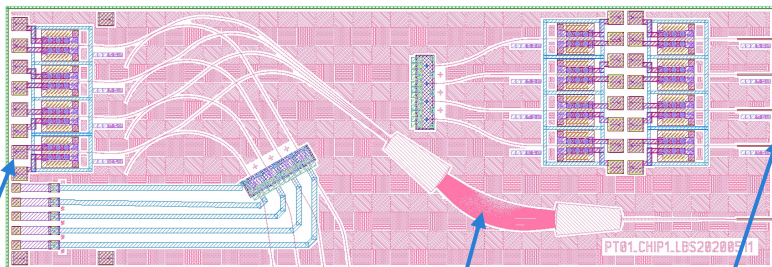


LightBar™ TOSA for 400G, 800G and CPO

For use as a remote light source for 400G, 800G transceivers or for Co-packaged optics

4 and 8 channel AWG Multiplexed LightBar

~ 10mm

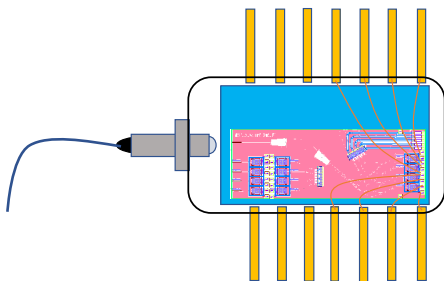


~ 4mm

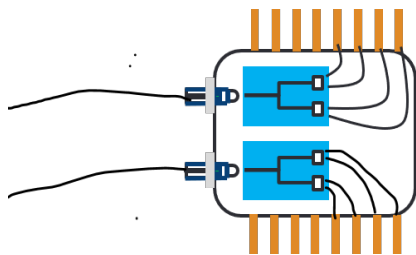
High Power CW Lasers in the O or C Band up to 8 channels

Optical FR4/FR8 AWG Mux

Angled Output for reducing back-reflection



4X1 AWG for O Band Interposer-Integrated in a Package with PM fiber and isolator



2x2 MZI Integrated in Butterfly Package with High Power CW PM fiber and isolator

Two by 2 channel MZI LightBar

~ 8mm



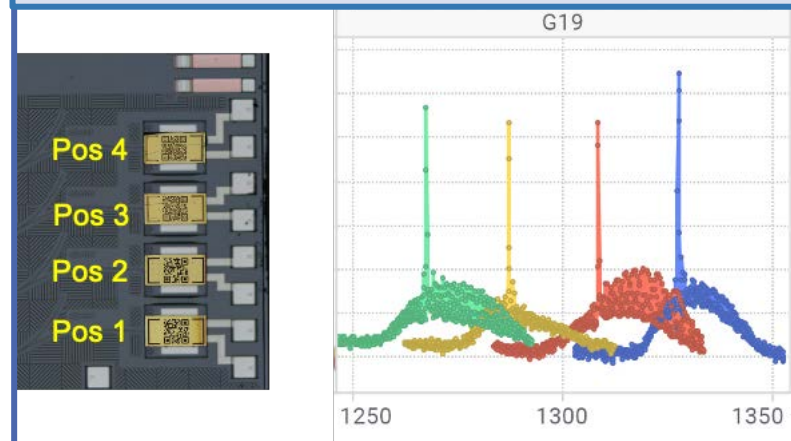
~ 1.5 mm

High Power CW Lasers in the O Band

Optical 2x2 MZI Mux

Angled Output for reducing back-reflection

Output Spectra of 4ch AWG LightBar





Presentation Outline

- Background
- POET's Optical Interposer Platform
- Summary



Summary

- POET's Optical Interposer platform is a unifying hybrid optoelectronics integration platform, which demonstrates superior performance :
 - World's smallest TxRx "Optical Engine on a chip", integrating 4 lasers, 4 high speed photodiodes, 4 monitor photodiodes, Mux/DeMux, Taps and output fiber coupling features
 - Superior cost and scalability: 20-40% lower
 - Power consumption: 20% lower
 - Hybrid Integration: 1/10th lower capex
 - Versatility: numerous applications

欢迎莅临：讯石研讨会 POET 400G Live Demo 专场 (会议室1)

2021年9月14日~2021年9月15日

&

POET深圳实验室 Live Demo 专场

2021年9月16日~2021年9月18日



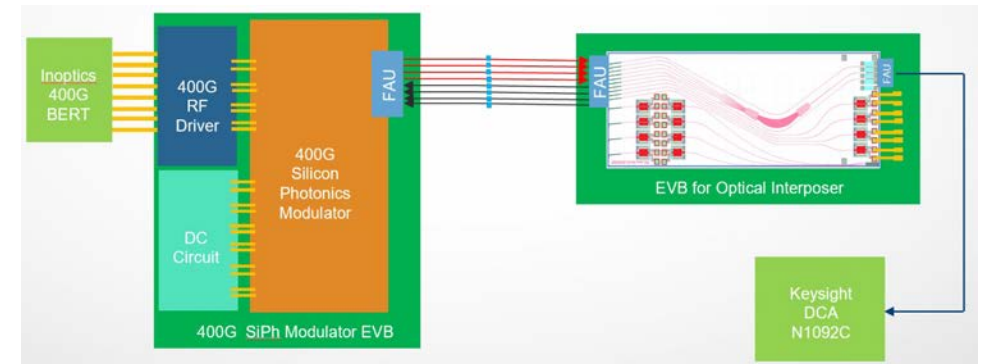
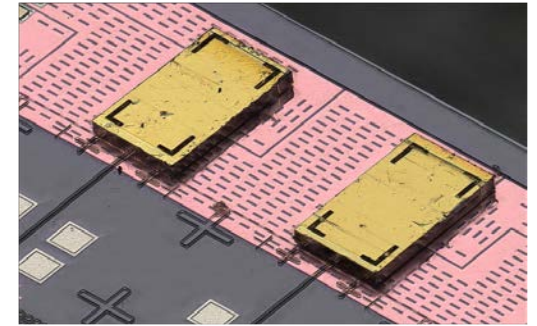
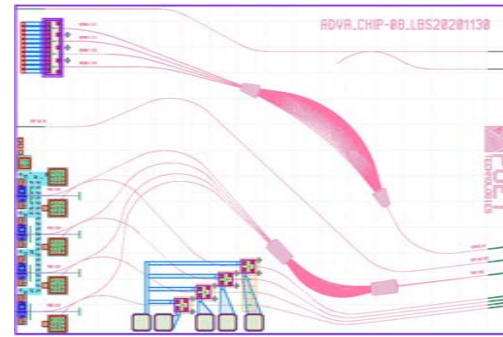
扫一扫了解更多信息

波亿光电子深圳有限公司
地址：深圳市南山区科兴科学园A4栋1002
电话: 0755-86544502
邮箱: xu.xianwen@poet-technologies.com
网址: www.poet-technologies.com

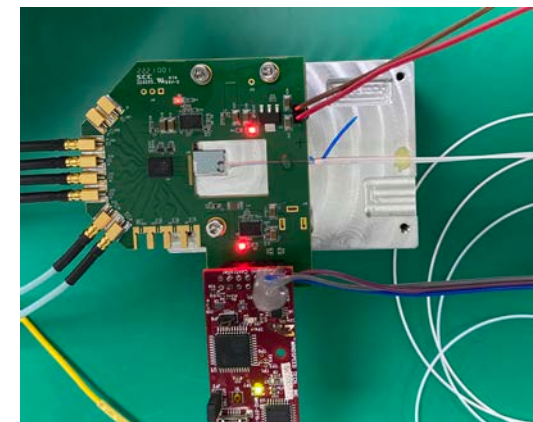
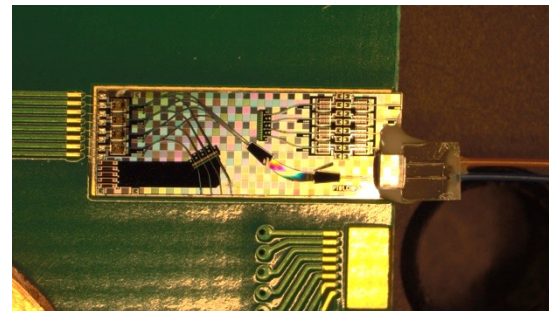


Live Demos

- Demo 1: 400G Tx OE
- Demo 2: 100G Tx OE
- Demo 3: 200G Rx OE
- Demo 4: LightBar, 4 channel CW lasers
- Demo 5: MZI
- Demo 6: MCF



And there are many more ...





POET
Technologies