

# Semiconductorization of Photonics using Silicon Optical Interposer

PIC Conference April 2024

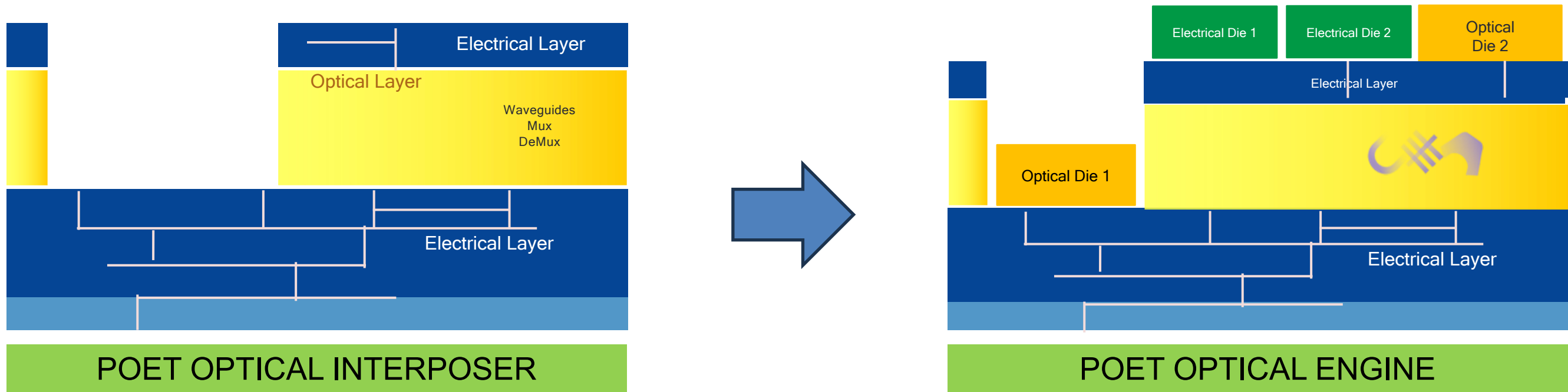
Raju Kankipati

 Optical Interposer platform

 “Semiconductorization of Photonics”

 Products in action: 10G/Lane to 200G/Lane

# Silicon Optical Interposer platform



- Integration platform that combines photonics and electronic devices in the same chip-scale package
- Two layers of low loss optical interconnects
- Multiple electrical redistribution layers with low RF insertion loss
- High throughput visually assisted passive “pick and place” assembly of electronics and photonics ICs and components
- In plane and Out of plane Optical Interfaces

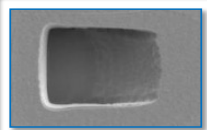
# Key features of the Interposer platform

## A proprietary technology platform for integrating photonic solutions

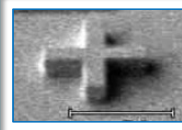
Low-cost receivers

Assy of components using std.  
pick & place equipment. Flip-chip  
bonding

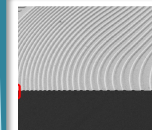
Enough margin to allow for  
passive alignment of  
components



Low loss  
Micro Mirrors  
for out of  
plane  
coupling



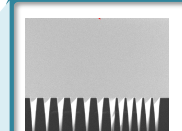
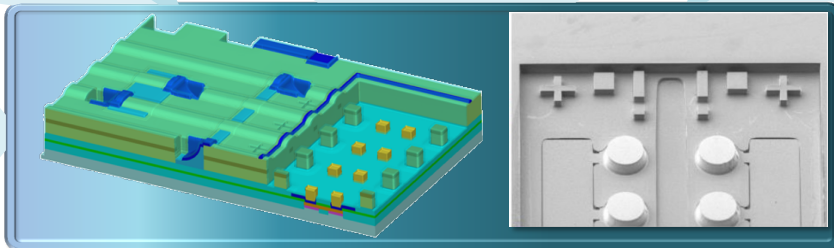
Self Aligned  
and  
Mechanically  
Interlocking  
Fiducials



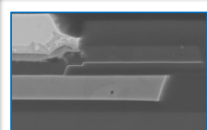
CMOS Compatible  
Low Loss  
Waveguides  
- Compatible with a  
wide range of I



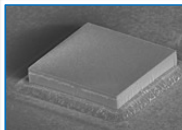
Multiple  
Eutectic Solder  
Configurations



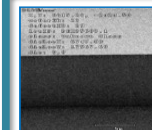
External Cavity  
Athermal Lasers  
- Low Loss  
- High Density



2.5D RF  
Interposer  
with  
Integrated  
Passives



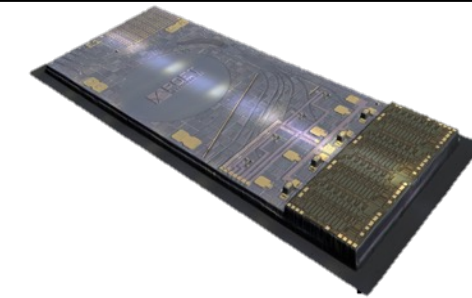
Self Aligned Z  
Referencing  
Pedestals  
- Compatibility  
with hybrid die



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

Passive placement of die  
Wafer scale assembly



- ❑ Drives down the cost of component integration and packaging
- ❑ Improves performance and lowers energy consumption
- ❑ Miniaturizes and simplifies the design and construction of complex systems
- ❑ Provides unparalleled scale through wafer level processing

 Optical Interposer platform

 “Semiconductorization of Photonics”

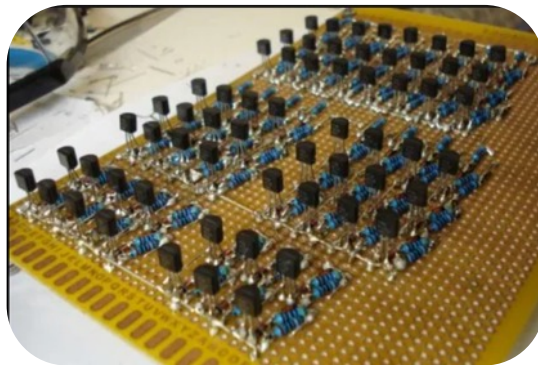
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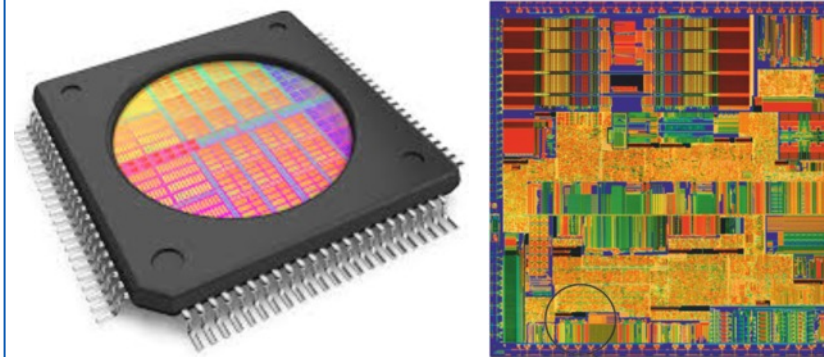
## POET does for Photonics what Integrated circuits did for electronics

### Semiconductor Electronics

#### Discrete Components



#### Integrated Circuit



#### Moore's Law

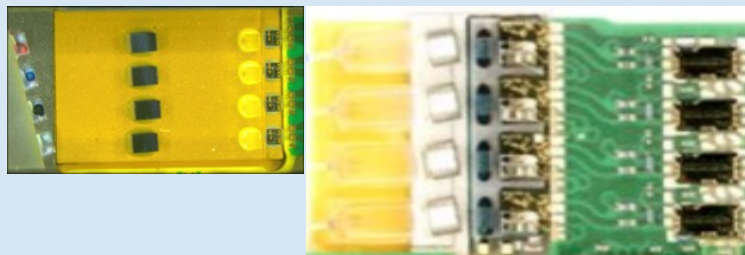
- Smaller, Faster, Cheaper, Volume
- Transformed the industry - pervasive presence of semiconductors
- Trillion dollar industry - grown over three decades of investment

### Photonics

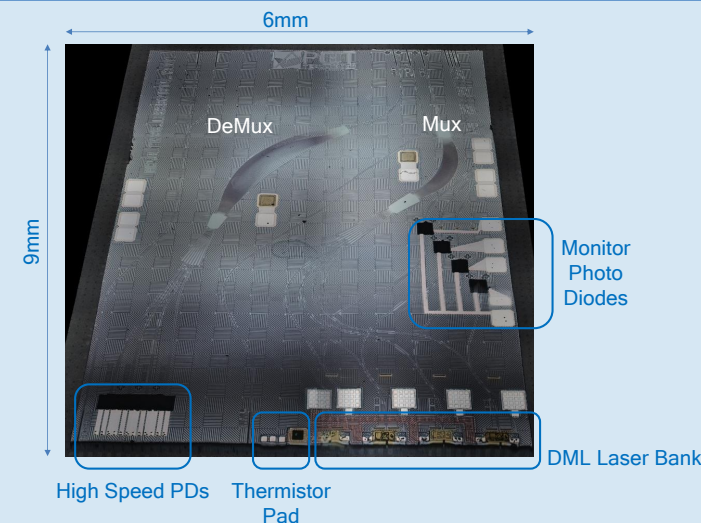
#### Discrete Transceiver Assembly

100G

400G



- ~50 individual components and sub-systems
- High labor and equipment cost - cannot scale



World's smallest optical engines for pluggable applications

#### POET Optical Interposer Platform

- Automated integration of components on a single chip
- Economies of scale comparable to semiconductors
- Transformational technology for Photonics

Wafer scale assembly. Passive alignments. Eliminate wire bonds.

## Wafer Level Packaging & Testing

- Use automated pick-place equipment to enable high speed and low-cost manufacturing
- Reduce industry assembly costs from as much as 70% to less than 20%
- Passive Laser placement with high coupling efficiency
- Significant departure from component level testing which much of the industry does

## Passive Alignments

- Eliminate active alignments of Lasers to lens, isolators and optical MUX
- Significant reduction of CapEx and OpEx by eliminating active alignments
- Enables high volume production without large investments

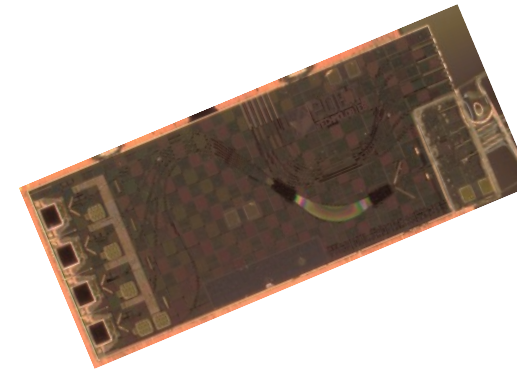
## Eliminate Wire bonds

- Achieve semiconductor type placement of Optical Engines on PCB with solder bumps (no more wire-bonds)
- Improve RF performance with high-speed trace instead of gold wire bonds
- Reduce cost

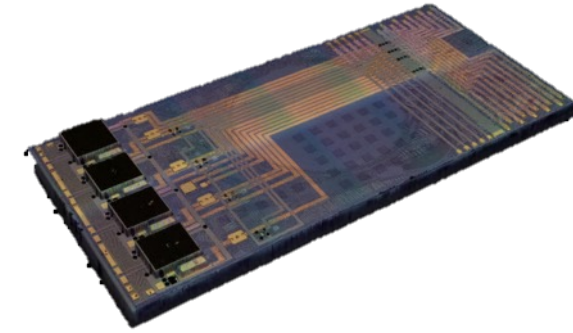
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## Scalable platform

10G/Lane to 200G/Lane with similar architecture, similar assembly process and similar chip size



100G CWDM4: 25G/Lane

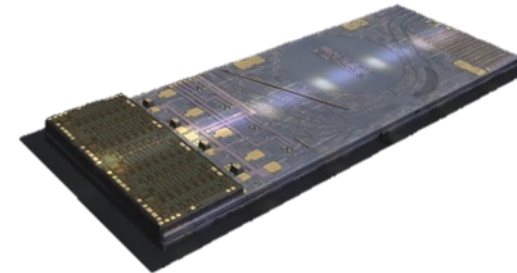


800G FR4: 200G/Lane

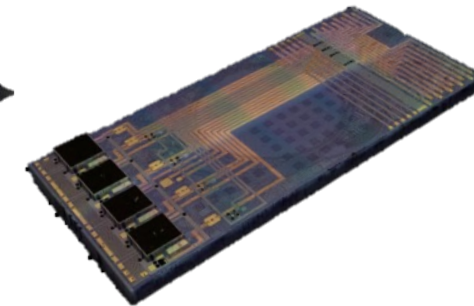
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## Hybrid Integration

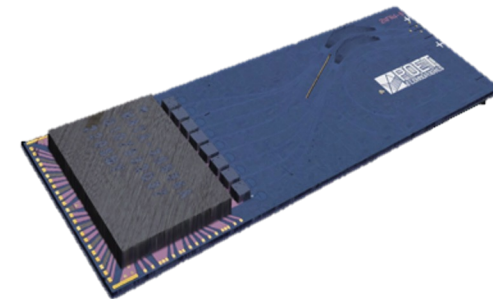
Use best of breed components & material systems: InP (EML, DML, PDs), Silicon Photonic modulators, TFLN



100G DML Platform



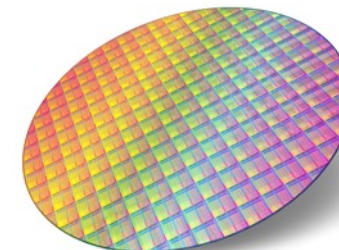
200G EML Platform



TIA+PD Platform

3

## Passive Alignments



Wafer scale assembly & testing for high volume production with lower CapEx



# Example of platform versatility

## Step 1- 3D printed elements



### *Collaboration to incorporate 3D-lithography technology into POET's Optical Interposer™*

POET's Optical Interposer™, integrates electronic and photonic devices into a single multi-chip module

Micro-optics printed to products with passively aligned lasers

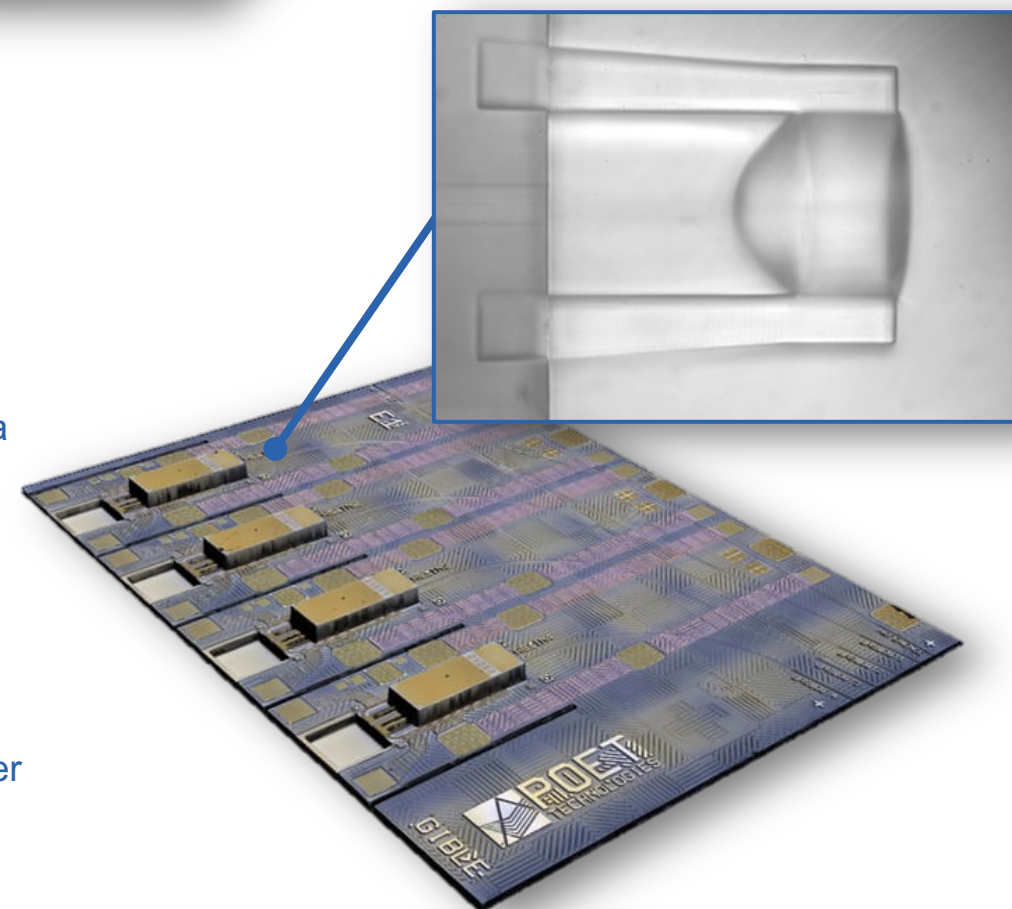
- Maximize coupling efficiency
- Improved coupling efficiency shall reduce power consumption

Initially micro-lenses shall be 3D-printed to the POET's LightBar™ product to validate the power efficiency improvements and the viability of chip scale wafer level manufacturing

## Step 2- passive alignment



## Step 3- PWBs with relaxed alignment tolerances

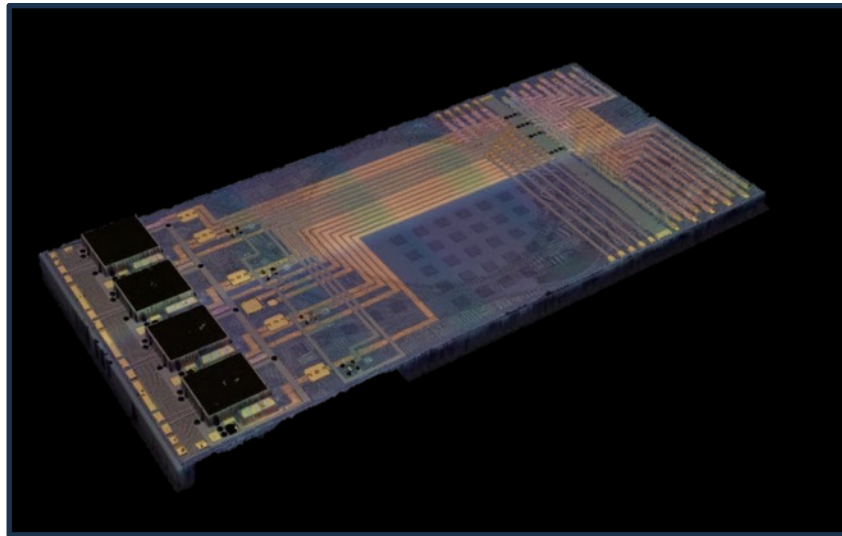


 Optical Interposer platform

 “Semiconductorization of Photonics”

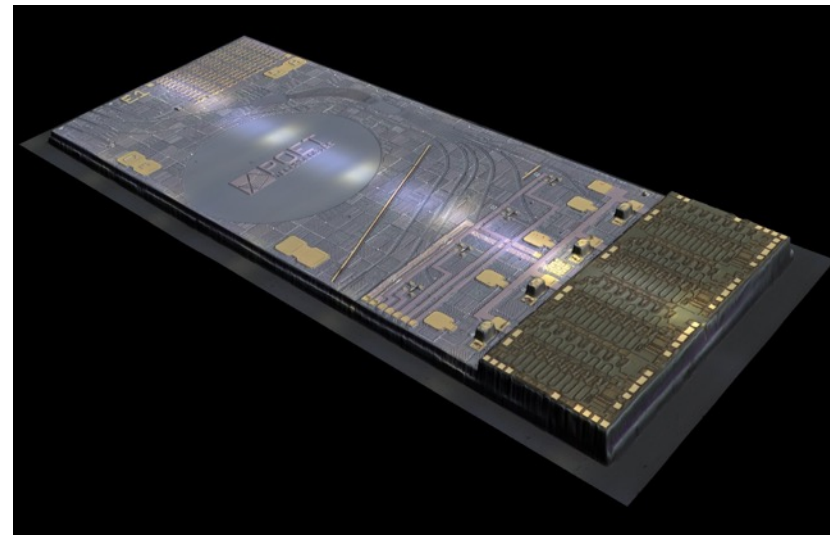
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## Optical Interposer based solutions



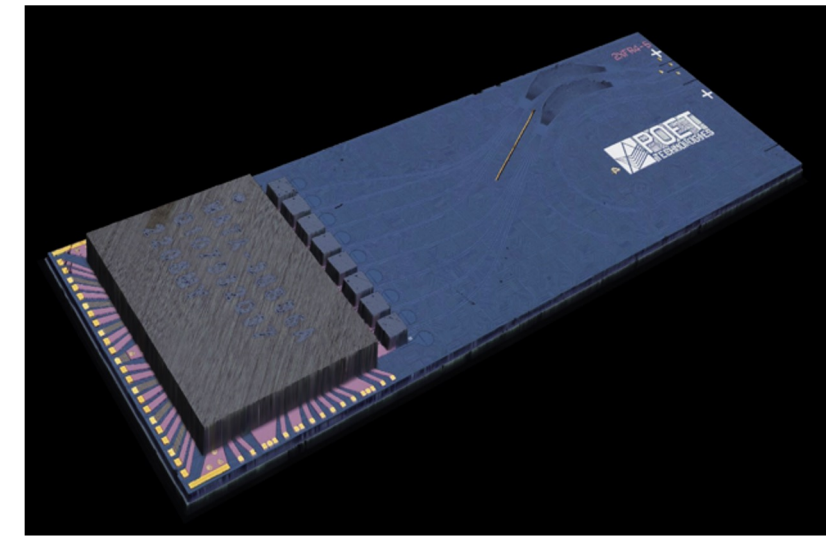
### 800G FR4 Transmitter

- Integrated EMLs and EML Driver
- Integrated MUX
- Monitor PDs & Thermistors
- Chiplet architecture to support 800G/1.6T



### 2X400G FR4 Transmitter

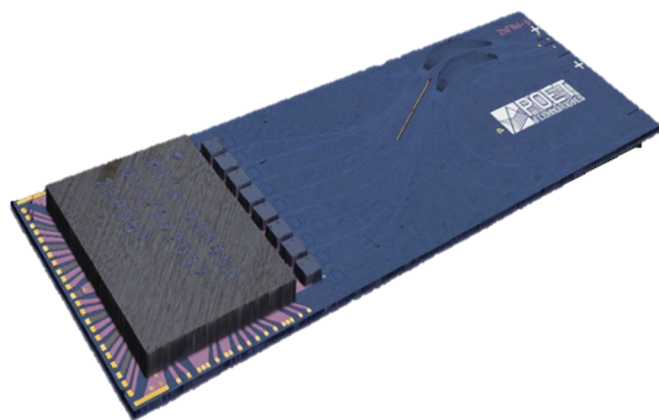
- Integrated EMLs and EML Driver
- Integrated MUX
- Monitor PDs & Thermistors
- Chiplet architecture to support 400G/800G



### 800G 2xFR4 Receiver

- 8xHighspeed PDs
- Integrated TIA
- Integrated DMUX
- TSVs coming soon!

# 800G 2xFR4 Receiver Optical Engine



- ❑ Integrated 8 channel TIA, high-speed Photodiodes, Optical DMUX and Fiber Array Unit
- ❑ TIA and PDs flip-chip attached: No wire-bonds between TIA and PD
- ❑ DMUX monolithically integrated on the interposer
- ❑ Small chip size: 5.1 x 14.8 mm (W x L)



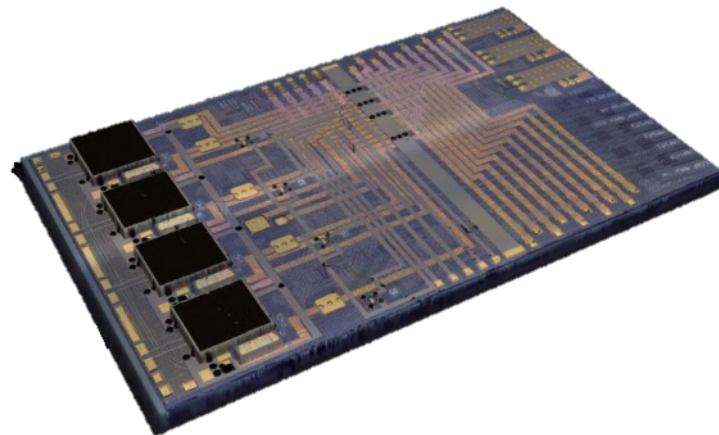
Excellent pre-FEC BER performance



# 1.6T Pluggable transceiver using POET Engines

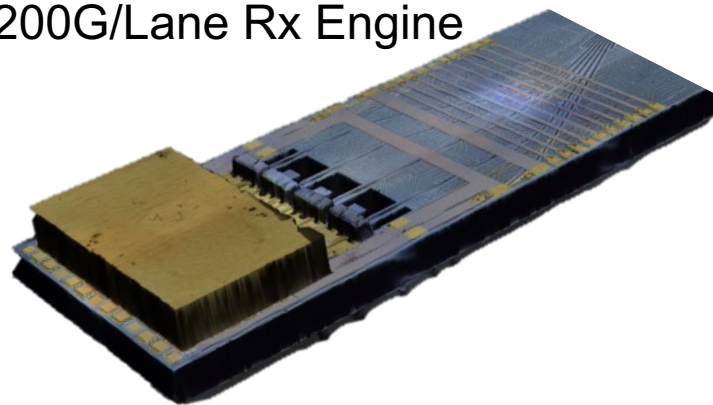
## 1.6T DR8 & 2xFR4 Solution

### 200G/Lane Tx Engine

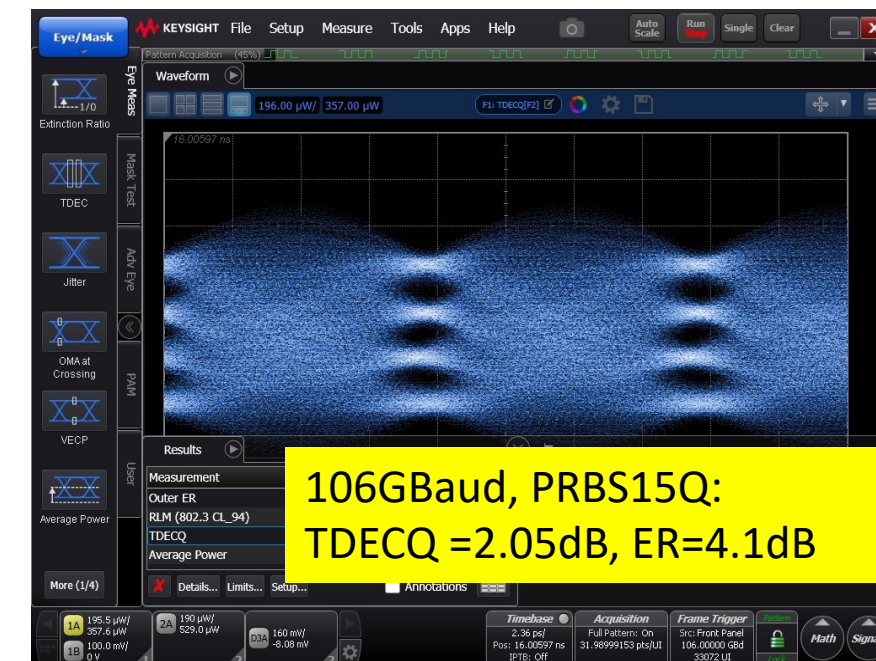
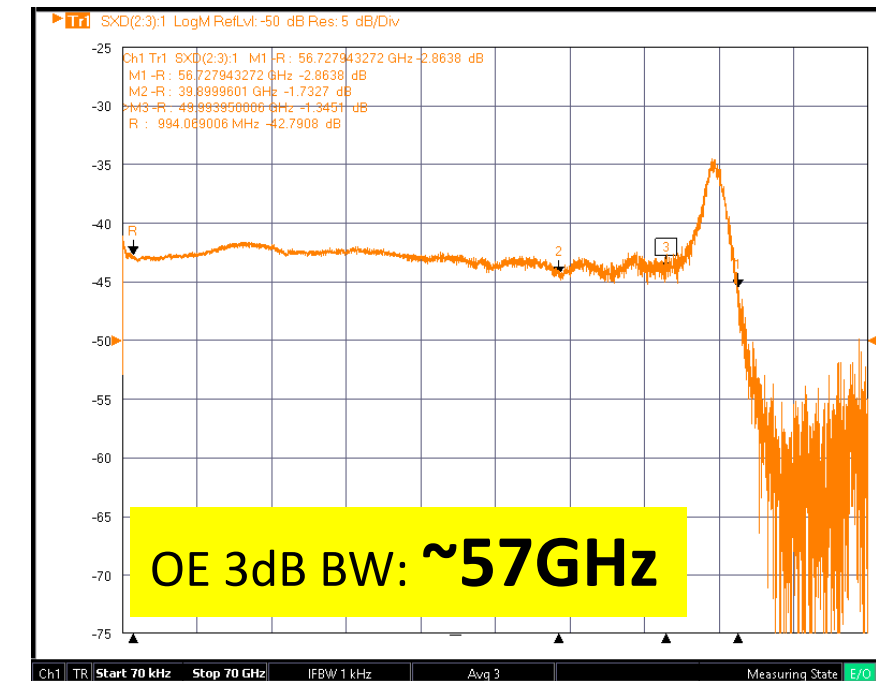


- EML Lasers (1310nm)
- Integrated EML Drivers
- SMF mode matched SSC for easier fiber alignment
- Integrated MPDs & thermistor
- Integrated MUX (for FR4)
- Chip size: 4.75 x 7.7 mm

### 200G/Lane Rx Engine



- PIN-PDs
- Integrated Quad TIA
- SMF mode matched SSC for easier fiber alignment
- Integrated DMUX (for FR4)
- Chip size: 3.75 x 7.7 mm



- Higher speed communication requires high level of integration between electronics and photonics

The Optical Interposer provides high speed RF trace on the platform and eliminates the use of wire-bonds

- Limiting to one material system (like silicon photonics) may not offer the best cost and performance solution

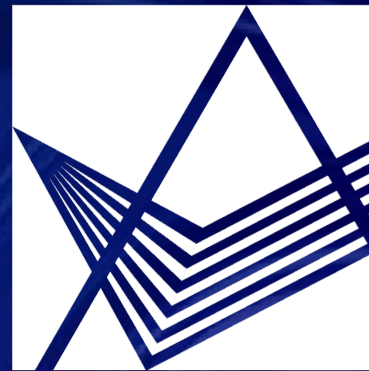
Using best of breed and known-good components accelerates time to market and provides best cost and performance

- Scaling to high volume with lower CapEx requires “Semiconductorization of Photonics”

The Optical Interposer uses passive attachment process for photonics and enables wafer scale assembly



**GO OPTICAL  
INTERPOSER!!**



**APOET**

T e c h n o l o g i e s