Scaling Photonic Integration & Packaging of Hybrid Multi-Chip Assemblies using 3D Lithography

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CEO – Vanguard Automation

EPIC Technology Meeting @ Fraunhofer IZM, 5 June 2024

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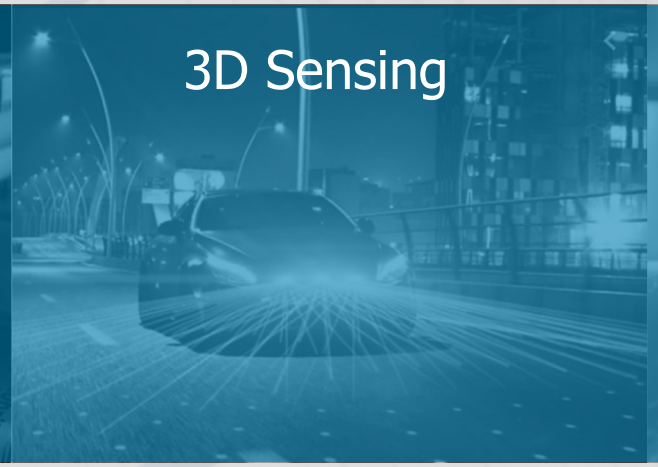
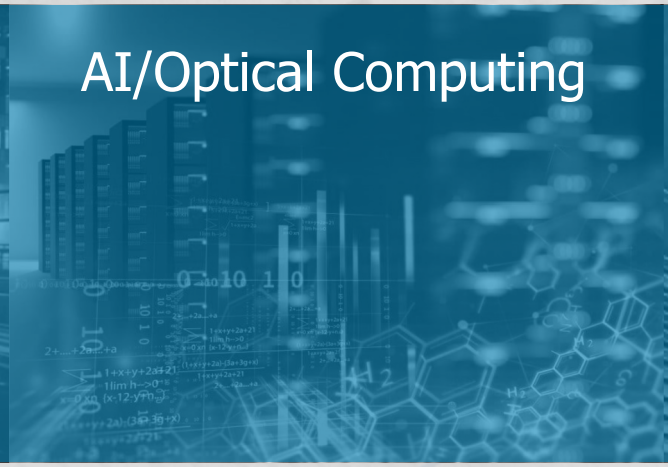
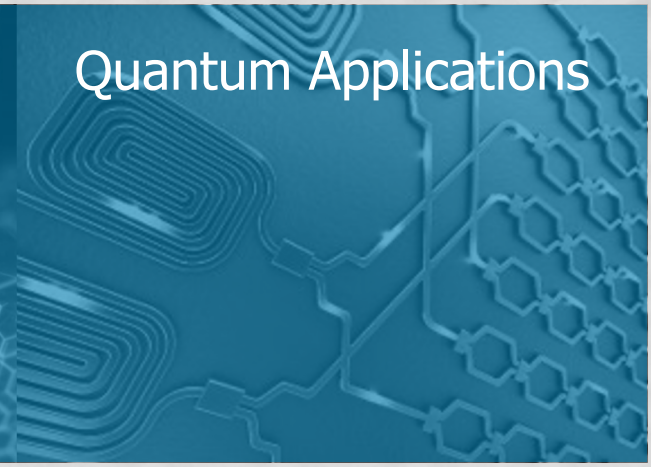
Photonics Integrated Ciruits are Growing at ≈ 25% CAGR







Mission: Enabling a *Bright* Future by Providing Scalable 3D Nano-Printing Solutions for Photonic Packaging and Integration

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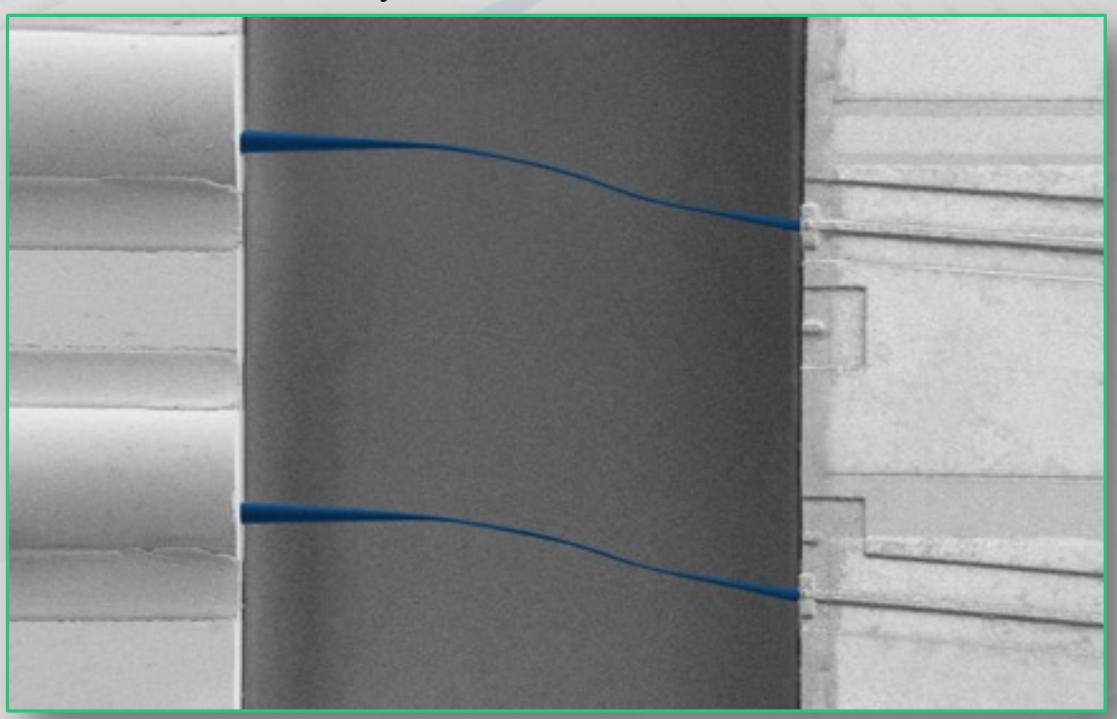
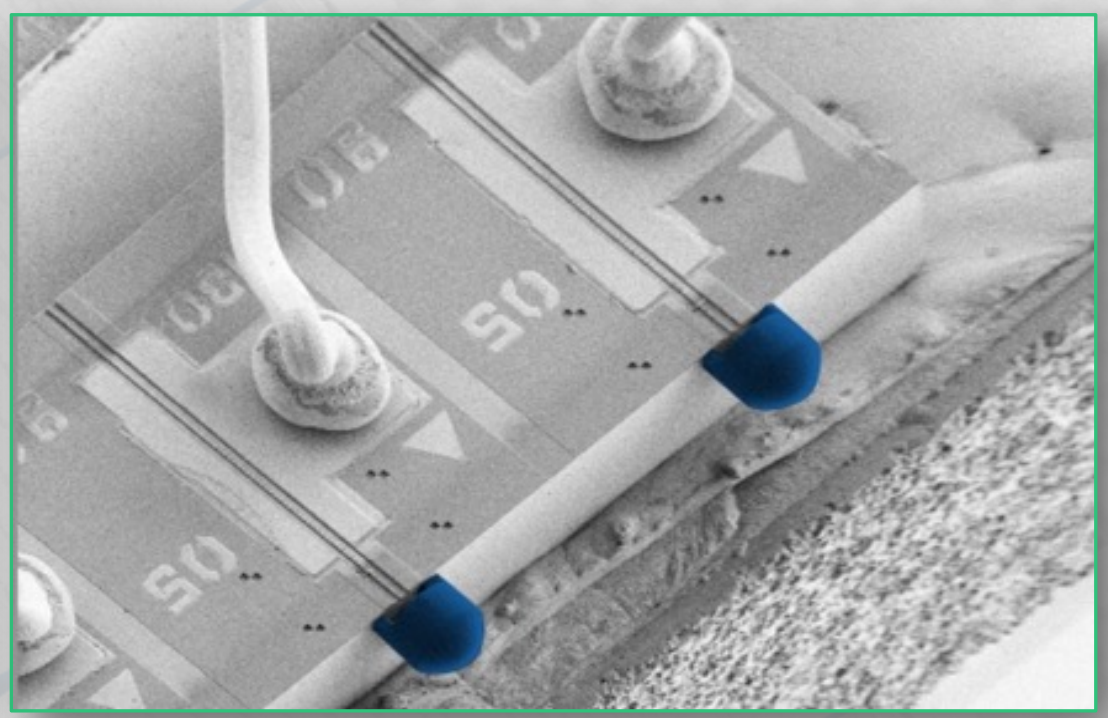
Enabling next Generation Photonic Integration and Packaging Solutions with 3D Laser Lithography Solutions

Laser by Freedom Photonics LLC



Samples bx PIXAPP (Photonic Packaging Pilot Line)



Photonic Wire Bonding and Micro Optical Lenses

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Enabling next Generation Photonic Integration and Packaging Solutions with 3D Laser Lithography Solutions

Laser by Freedom Photonics LLC

- No need for active alignment and micro-optical structure for mode field matching.
- High interconnect density (down to 10 micron)
- High design flexibility & alignment offsets
- Current cycle times ≈20s per bond
- Yield >99% Yield (PIC to Laser)

Samples bx PIXAPP (Photonic Packaging Pilot Line)

- Flexible focal length & mode-field diameters
- Relaxed alignment tolerances at low loss
- RMS surface roughness < 10nm
- Operational range: 530 nm - 2000 nm
- Current cycle times ≈ 20s per lens
- Yield >99% (Lens on Chip)

Photonic Wire Bonding and Micro Optical Lenses

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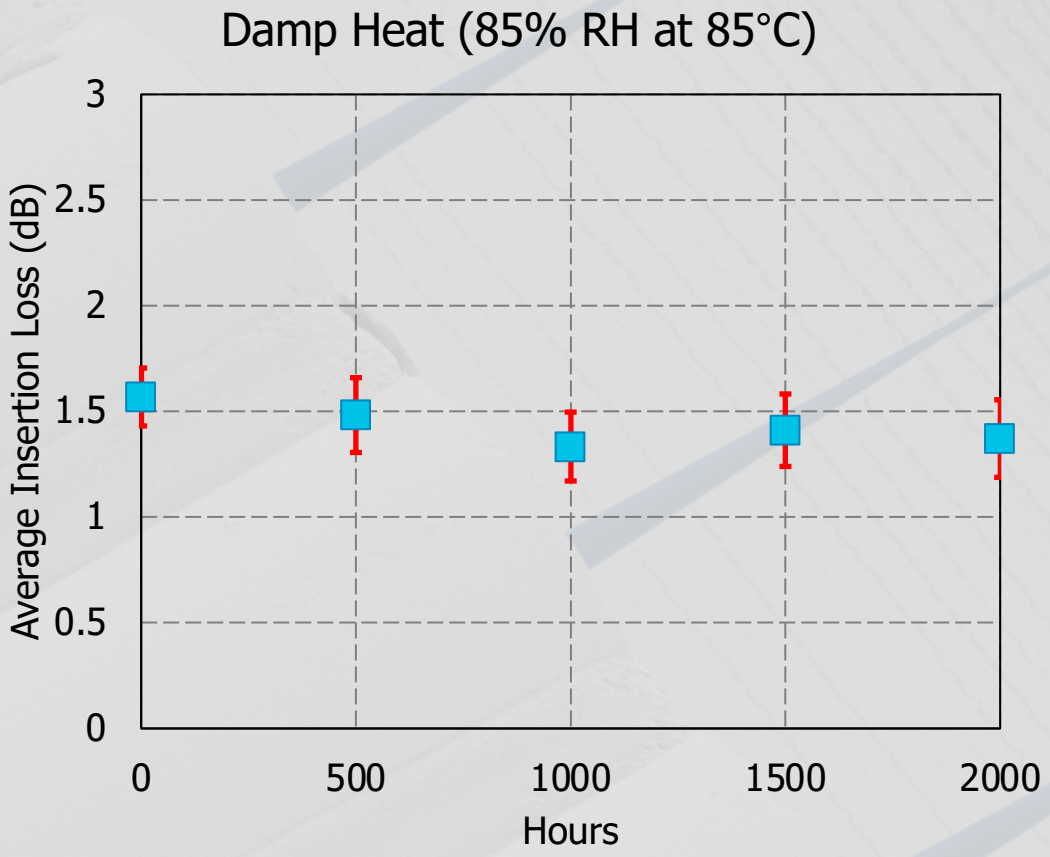
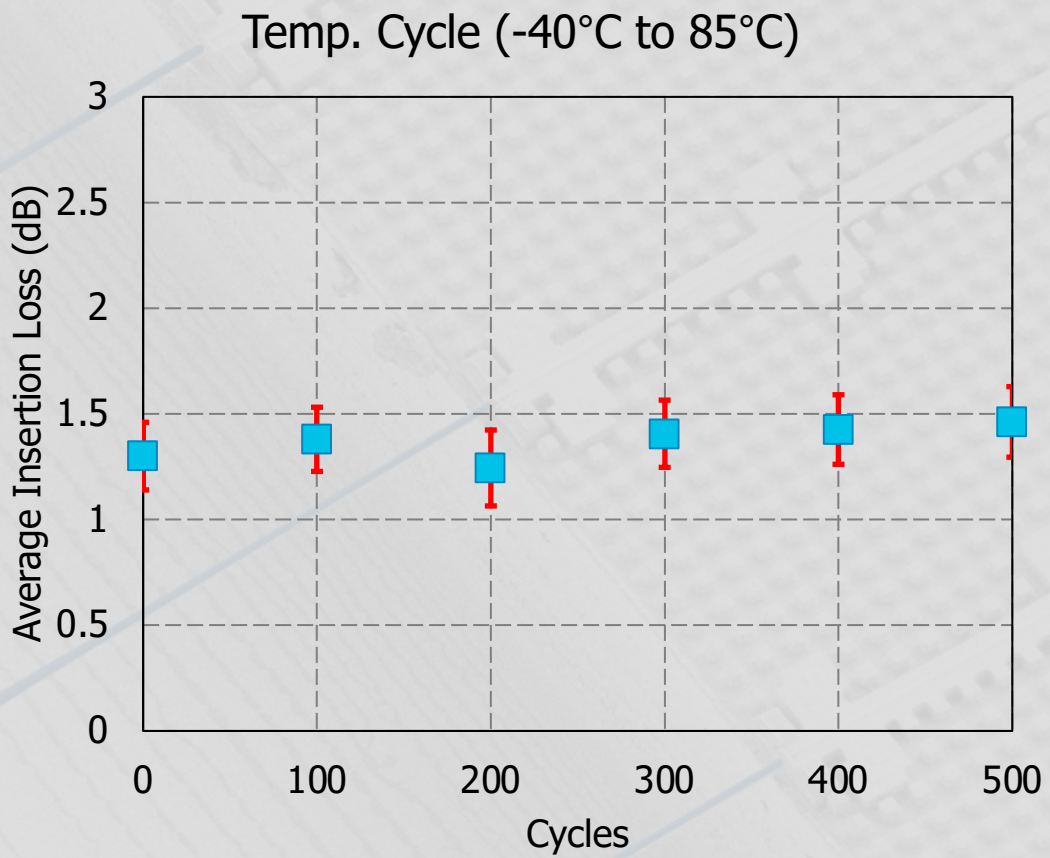
Qualified against Tele/Datacom Reliability Requirements





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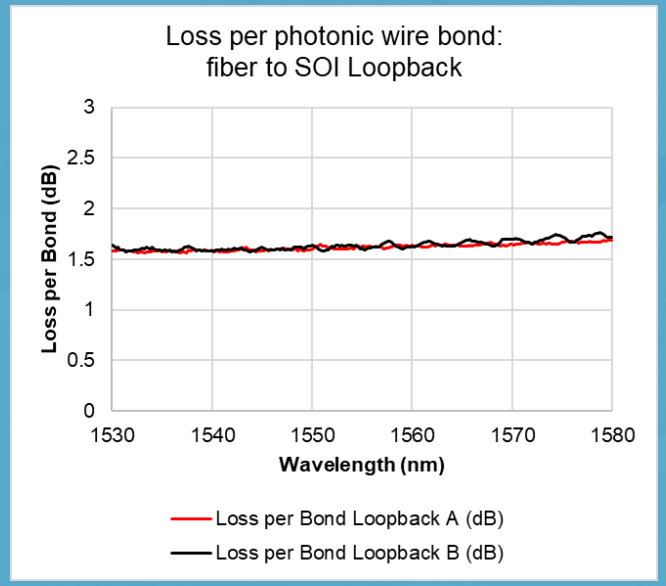
Compatability with many Material Platforms and Foundries

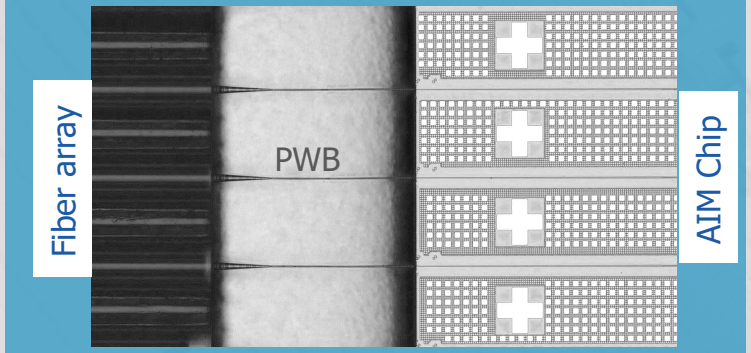
Silicon (AMF, SGP)

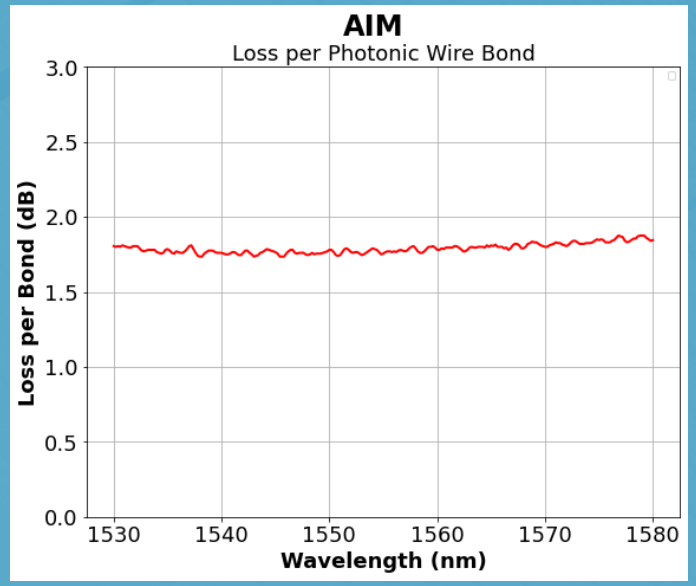
- ~1.5dB loss



Silicon Nitride (AIM, USA)

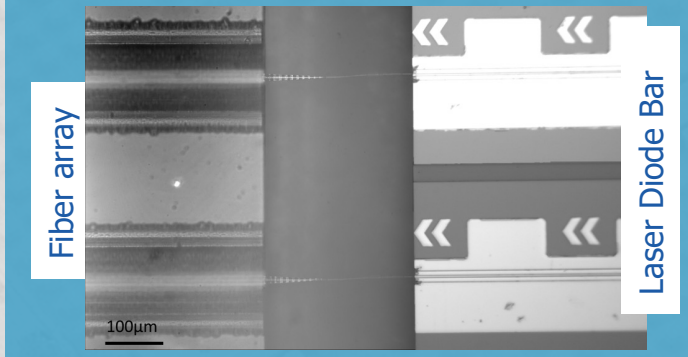
- ~1.7dB loss

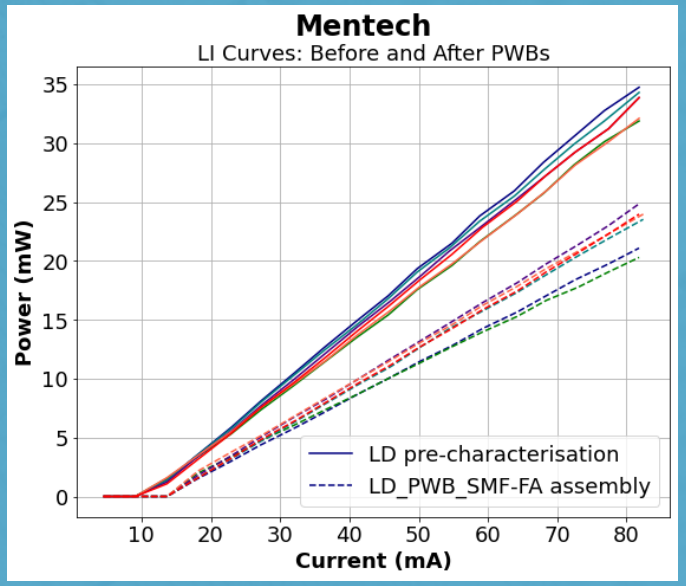




Indium Phosphite (Mentech, CHN)

- ~1.5dB loss





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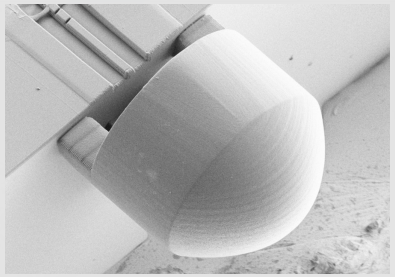
Path to Implement Photonic Integration with 3D Lithography

Step 1: Lense / Active Alignment

3D Printed Elements



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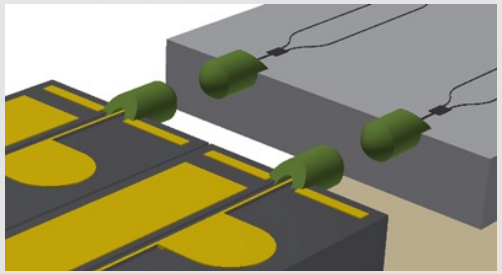
Active alignment

- Improve coupling and yield
- No major changes to production process steps

Step 2: Lenses / Passive Alignment

FaML



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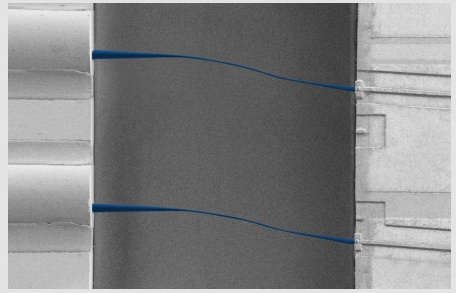
Passive alignment (±10µm)

- Passive assembly is a viable process

Step 3: PWBs / No Alignment

PWBs



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Relaxed Pick & Place (±30µm)

- Ensuring compact coupling
- High yields
- High package density

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3D Nano-Printed Facet-Attached Micro Lenses

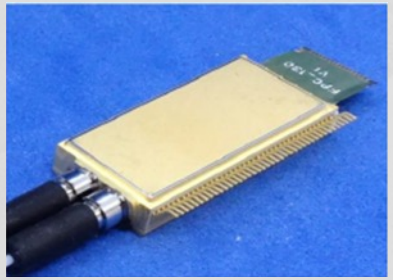
SUMITOMO: Micro-Optical Lens on InP-Based Modulator

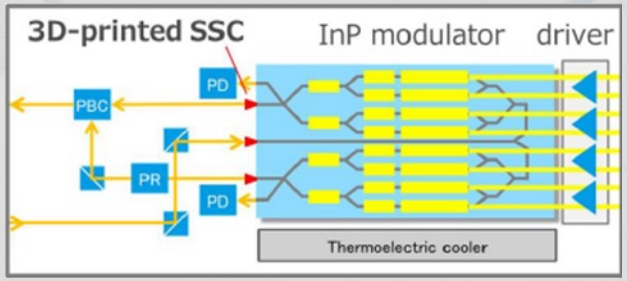
Step 1:
Lense / Active Alignment

Step 2:
Lenses / Passive Alignment

Step 3:
PWBs / No Alignment

128-Gbaud HB-CDM





First

First demonstration of commercial optical modules benefitting from 3D nano-printed optical components.

Increased Coupling Efficiency

Reduction of insertion loss by 1.5dB per lane.

Relaxed Alignment Tolerances

1.6µm with 1dB penalty

25% Chip Reduction

InP-Chip becomes 25% smaller as coupling structures for mode field matching become redundant.

Fully Qualified (Telcordia GR468)

according to industry required reliability and mechanical shock testing.

SUMITOMO ELECTRIC
Connect with Innovation

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** (Y. Mizuno et al., 2023 OFC, San Diego, CA, USA, 2023, pp. 1-3, doi: 10.1364/OFC.2023.Th2A.8)*

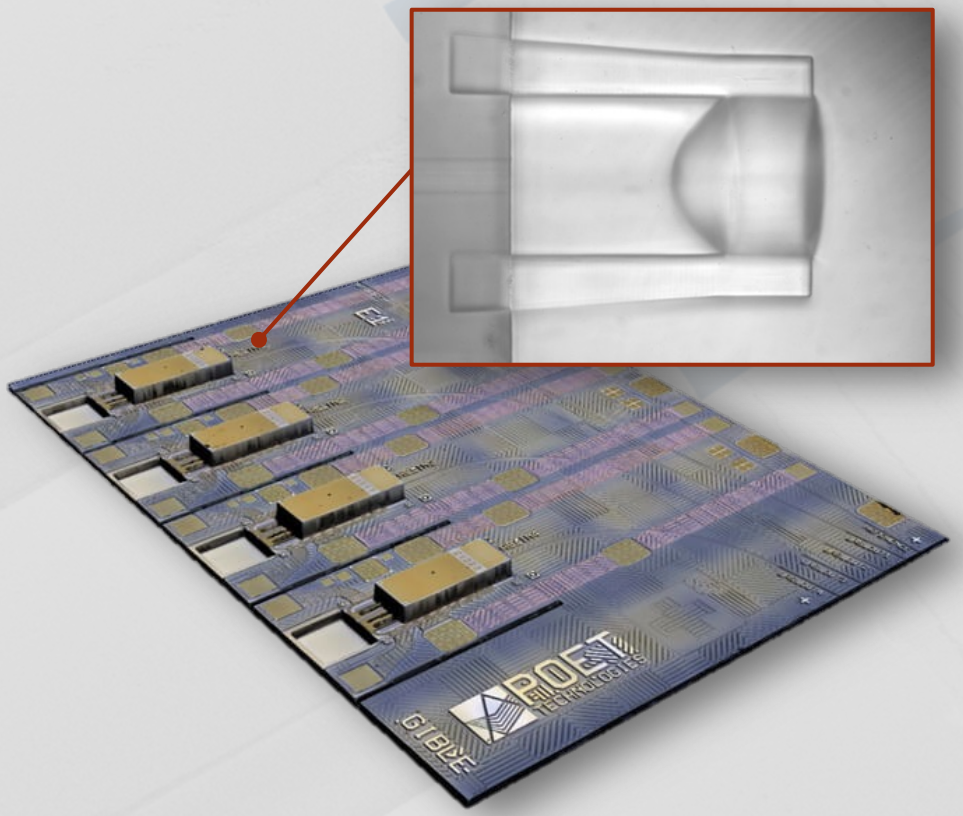
3D Nano-Printed Facet-Attached-Micro Lenses

POET Technologies: Micro-Optical Lens on Optical Interposer

Step 1:
Lense / Active Alignment

Step 2:
Lenses / Passive Alignment

Step 3:
PWBs / No Alignment



Collaboration

Collaboration to incorporate 3D-lithography technology into POET's Optical Interposer™ platform.

Increased Efficiency

Reduction of coupling efficiency and reduced power consumption.

Cost Reduction

Reduction of cost per optical interconnect through increased throughput and reduced material cost.

Wafer level scaling

Micro-lenses shall be fabricated onto POET's LightBar™ product to validate the power efficiency improvements and the viability of chip scale wafer level manufacturing.

POET Technologies

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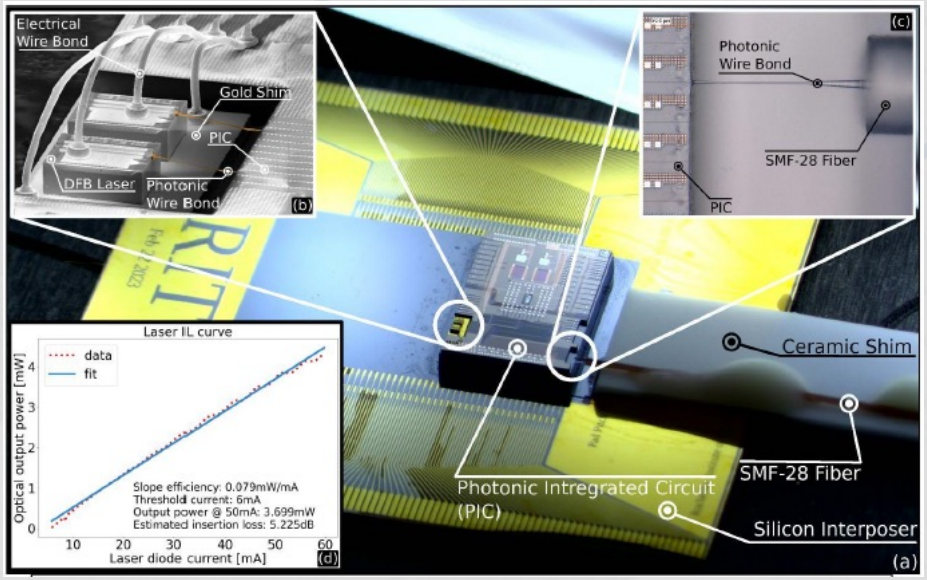
Photonic Wire Bonds: Passive to Active Components

No Active Alignment or Lenses for Mode Field Matching, Relaxed Placement Tolerances

Step 1: Lense / Active Alignment → Step 2: Lenses / Passive Alignment → **Step 3: PWBs / No Alignment**



Multi-Chip Hybrid Integration*

Fiber to Chip to III-V Laser in one fabrication process.

No Active Alignment nor Lenses for Mode Field Matching

Photonic Wire Bonding doesn't require an alignment process and PWB has mode-field-matching designed in.

Highly Relaxed Pick and Place Tolerances

PWB compensates pick and place tolerances of ± 30 µm easily.

RIT Rochester Institute of Technology

UBC

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***Packaged Tunable Single-Mode III-V Laser Integrated on a Silicon Photonic Integrated Chip Using Photonic Wire Bonding** (V. Deenadayalan et al., 2024 IEEE 74th Electronic Components*

Vanguard Automation's Photonics Packaging Platform

Machines

SONATA 1000

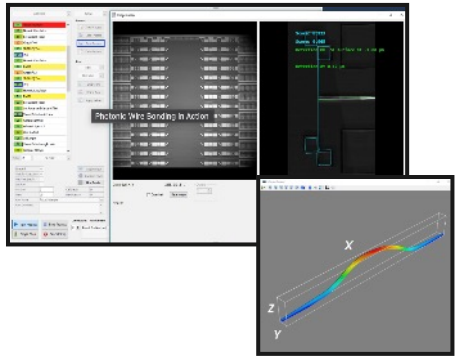
Automated 3D Lithography-based Nano Printing

REPRISE 1000

Automated Pre- and Post-Processing: Development and Encapsulation

Software

Composer and BrightWire3D



Software for Machine Control, Process Development and Management

Additional Products and Services

VanCore, VanClad, …

Materials for the Production of PWBs and Micro Optical Lenses

Professional Services

- Training
- Process Development
- Feasibility Studies
- Development Support
- Maintenance Services

The Full Suite: SYMPHONY 1000

"Photonic integration and packaging with Photonic Wire Bonding and facet-attached micro-optical elements", PIC Magazine, September 2023

"As PIC Production Ramps Up, Fabricator Eye Alignment Options", Photonics Spectra, June 2022

"Photonic Wire Bonding: Using Lasers to Integrate Lasers", Photonics Spectra, August 2022

"Integrated photonics for quantum applications", Laser Focus World, September 2022

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Commercial Accounts, Research, Eco-System Partners

UBC

KIT
Karlsruhe Institute of Technology

Nanjing University 1902
南京大學

中山大學 Sun Yat-sen University

SUMITOMO ELECTRIC
Connect with Innovation

VE RI TAS HARVARD

C2MI
Centre de Collaboration MiQro Innovation

DREAM PHOTONICS

RIT
Rochester Institute of Technology

University of Delaware

FREEDOM PHOTONICS
a Luminar company

POET Technologies

Tyndall National Institute
Institiúid Náisiúnta

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

UESTC 1956

Fraunhofer IZM

Keystone photonics

University of Stuttgart

mentech

UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

FormFactor™

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SONATA 1000

Automated 3D Lithography-based
Nano Printing

Don’t Miss the Demo

14:00 – 15:30
Lab-Tours at Fraunhofer IZM, including Demo by Vanguard Automation (Dr. Laura Horan).

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