GlobalFoundries™

Establishing a Packaging Ecosystem for GlobalFoundries Leadership Silicon Photonics Wafers – 2022 view

Daniel Berger, Sr. Director

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18TH INTERNATIONAL CONFERENCE & EXHIBITION ON DEVICE PACKAGING
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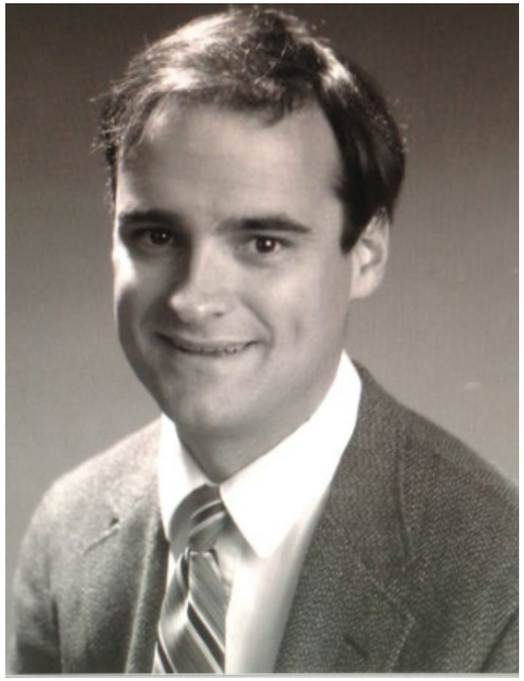
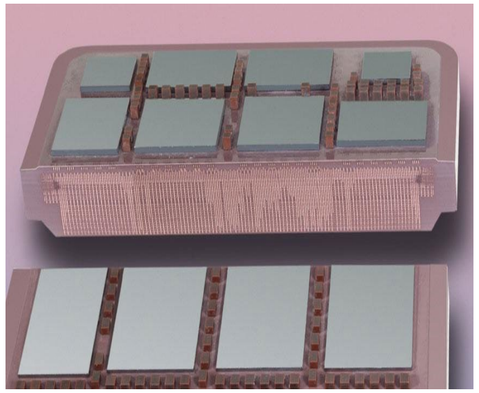
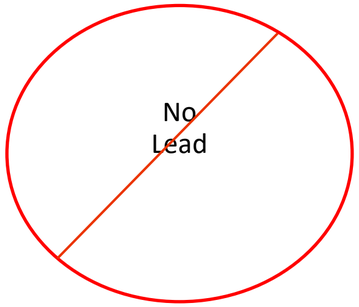
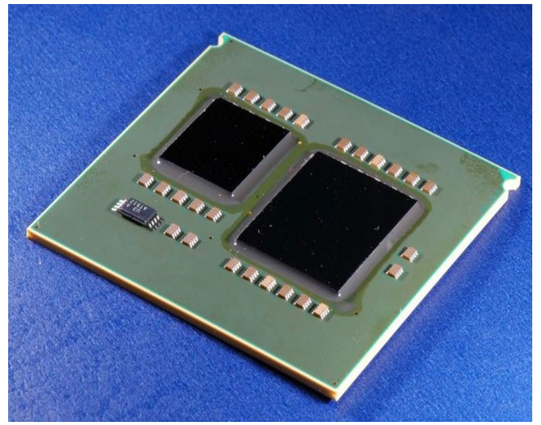
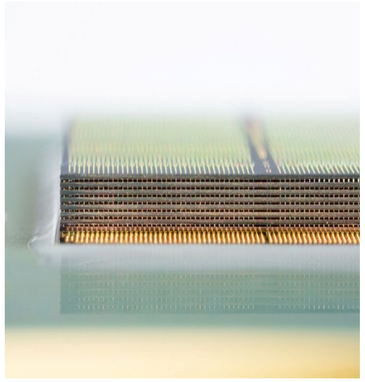
Dan Berger (Old Packaging guy short story- Focus: Smaller, Cheaper, Faster)

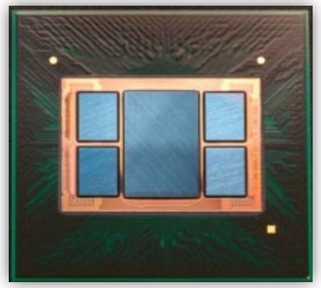


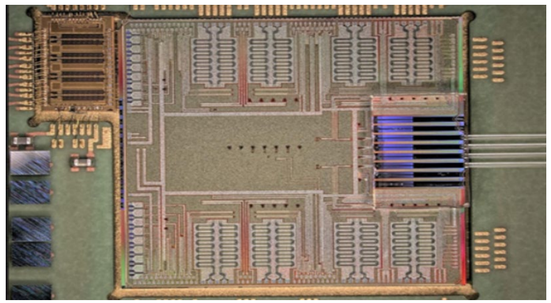










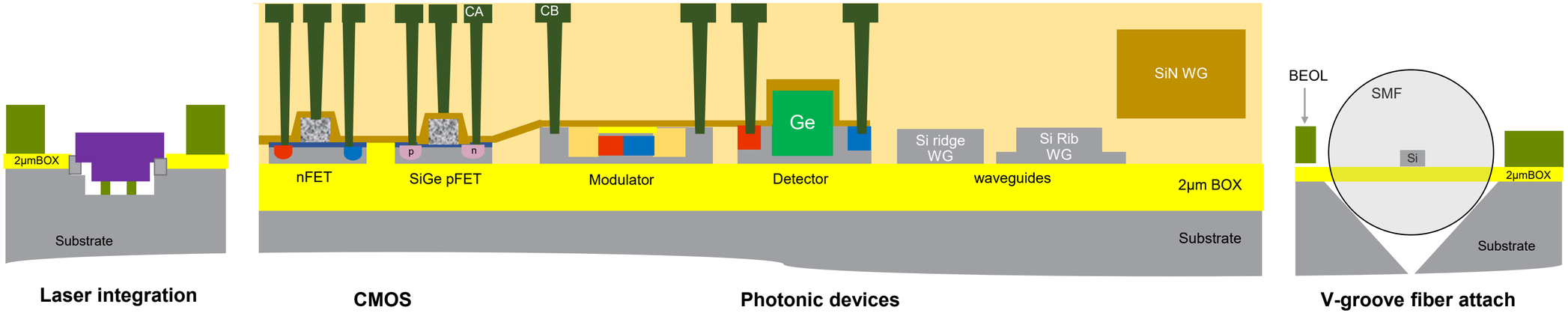


Outline

1. GF 45SPCLO SiPh Overview
2. Technology Packaging Features
3. The Need for a Packaging Ecosystem
4. 1Q 2022 Status
5. Conclusion

GF 45SPCLO SiPh Foundry Offering
Technology Overview

- High performance photonic passive and actives device library
- Monolithic integration of high performance 45nm RF SOI CMOS
- Dual SOI thickness: 160nm photonics, 88nm CMOS; 2µm BOX, SOI and SiN waveguides
- State-of art 300mm Fab8 Malta Fab, leveraging advanced immersion lithography
- Freeform design enabled with curve-linear GDS with advanced OPC
- Passive v-groove fiber array / attach, 250µm, 127µm pitch
- State-of-Art PDK enablement with EO co-design environment, standard cell digital library
- Automated electrical / optical wafer level test



Laser integration **CMOS** **Photonic devices** **V-groove fiber attach**

45SPCLO feature set

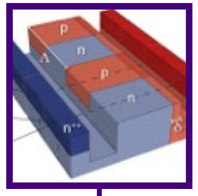
Focus on data com & co-packaged optics

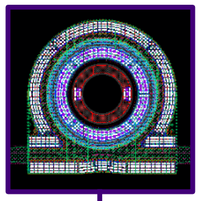
Legend:
CMOS
Optical

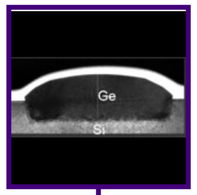
Ring modulators

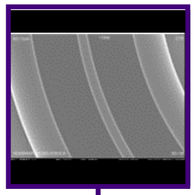
Ge EPI PD

MZI modulators



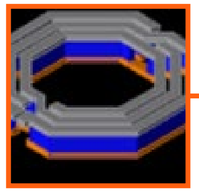






Ridge, Rib WGs, Bends, Tapers, Directional Couplers, WIC, Gratings, Absorbers

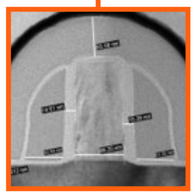
BEOL passives, inductors, VNcap

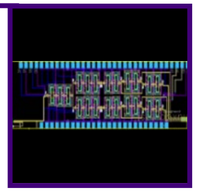


CMOS/Photonics IC

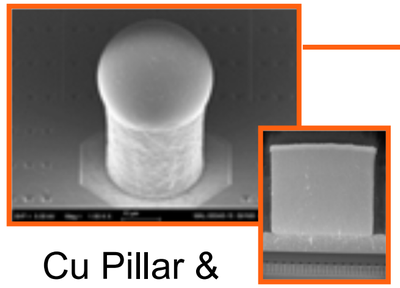
Thermal phase shifters standard & undercut

RF CMOS, standard cell, GPIO, ESD, eFuse, TIA, driver, precision resistor,

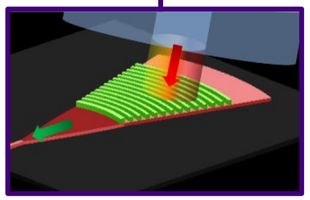




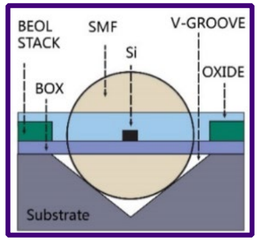
4x MUX/DeMUX tunable



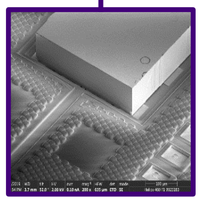
Cu Pillar & Cu Rcv Pads



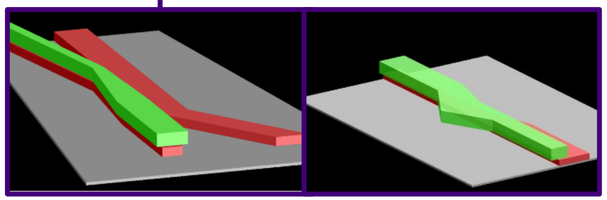
Top grating couplers



Edge fiber couple, passive or active align



Direct laser attach



Polarization splitter & polarization rotator

Understanding the Packaging Requirement Transition

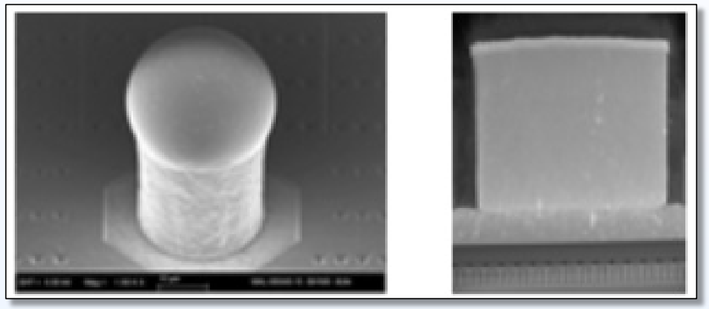
- These transitions are planned for packaging of GF PIC technology
- Customers are starting understand the importance of a Monolithic Vs Hybrid PIC value proposition
- Monolithic makes the packaging transition faster / cheaper

Packaging Element	Historical Industry solution	Support with GF Gen1 SiPh	Support for GF Gen2 SiPh for pluggable	Support for GF Gen2 SiPh for CPO
1st level electrical connection	Wirebond	Wirebond	Wirebond → **Flip Chip**	Flip Chip
2nd level electrical connection	Pluggable	Pluggable	Pluggable → **Small BGA package**	**Large BGA or LGA package**
Fiber Attach / count	Active alignment 1-4 SMF - Lens	**Passive: <12 SMF** **Active: 1-4 SMF**	Passive: <12 SMF **Passive: <4 PMF**	**Passive: 16 – 32+ SMF/PIC & up to 8 PMF**
Package type – Subassembly / Module	Hermetically sealed “Gold Box”	Hermetically sealed “Gold Box” → **Organic pkg for Subassembly**	Organic pkg for Subassembly **and Co- package Module**	**Organic pkg for Photonic Engine Subassembly/test and large Co-pkg Module**
Laser	Separate	Separate	Separate or **Integrated**	Separate or Integrated
Reliability	Telcordia “Optical” Specs	Telcordia “Optical” Specs	**JEDEC “Micro-electronic” Specs**	JEDEC “Micro-electronic” Specs

A Packaging Ecosystem is needed to support these increasing packaging requirement

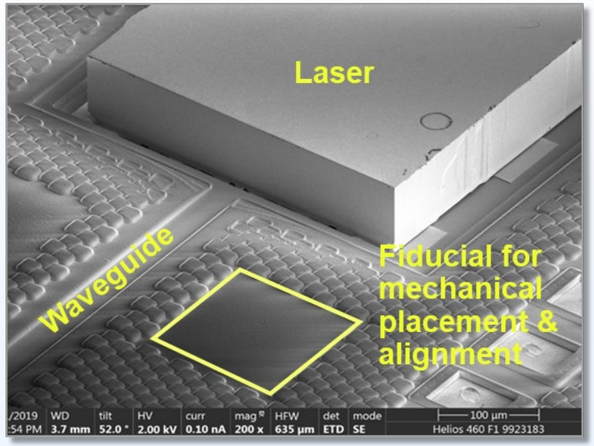
Co-packaged Optics Features – Packaging Technology (today)

Copper Pillars & Copper Receive Pads



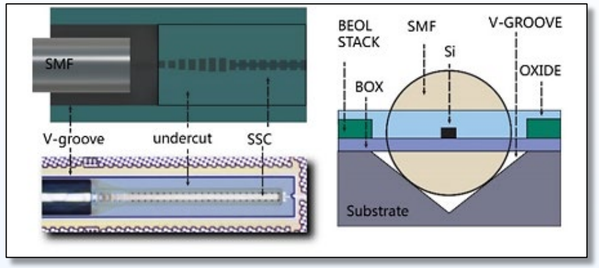
Cu pillars provide 2.5D interconnect for chip stacking and chip-to-chip optical interconnect

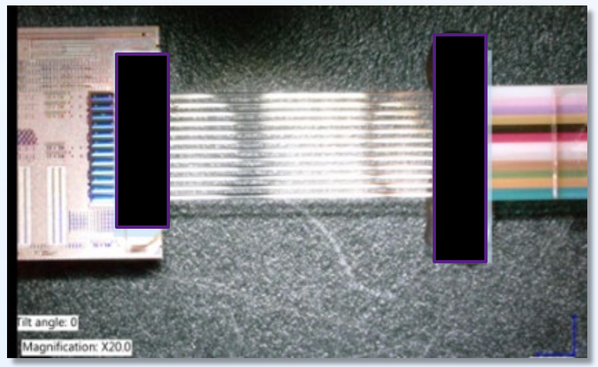
On-die Laser Attach



Laser placement on SiPh chip has potential to significantly reduce packaging costs for Datacom, LiDAR & photonic computing applications

V-groove based Fiber Attach

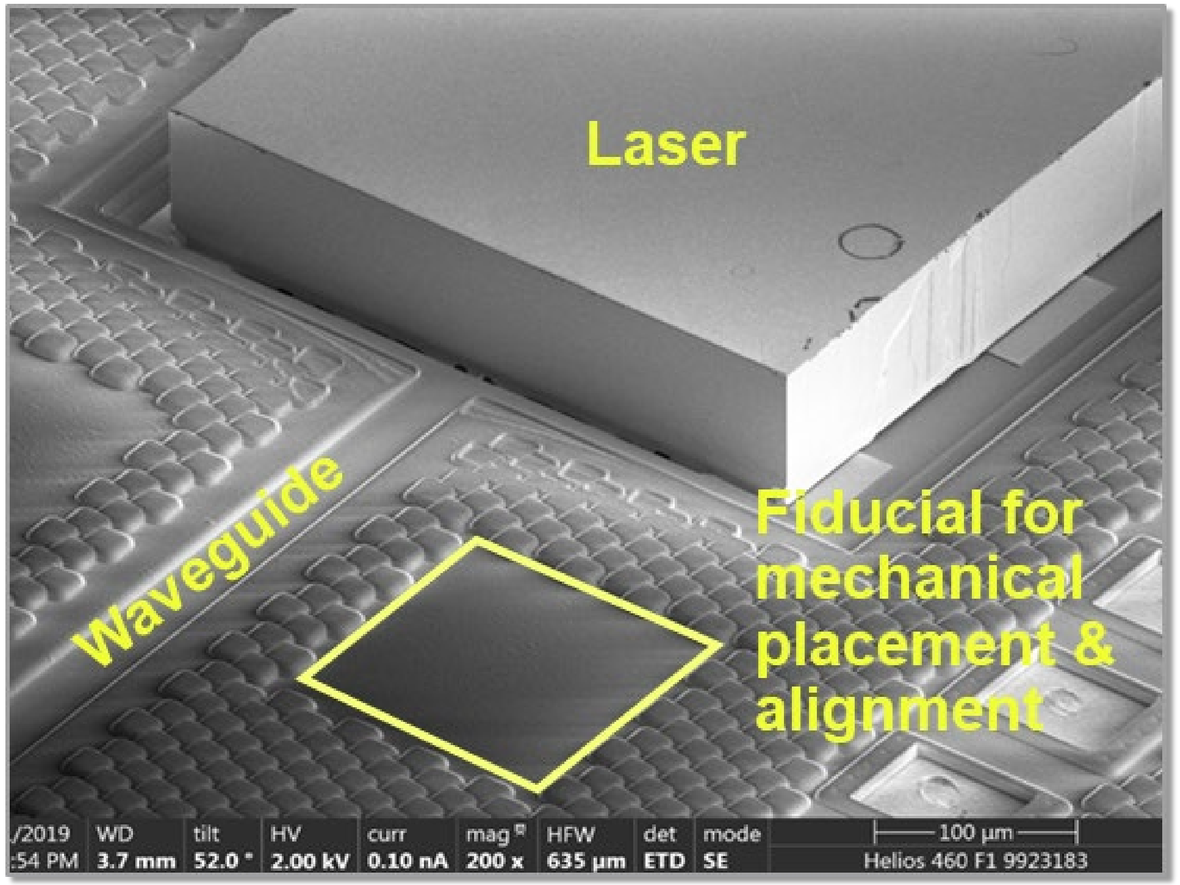




Significant value add for high-count fiber arrays where active alignment of fibers is not possible
Reflow compatible process

On-die Laser Attach

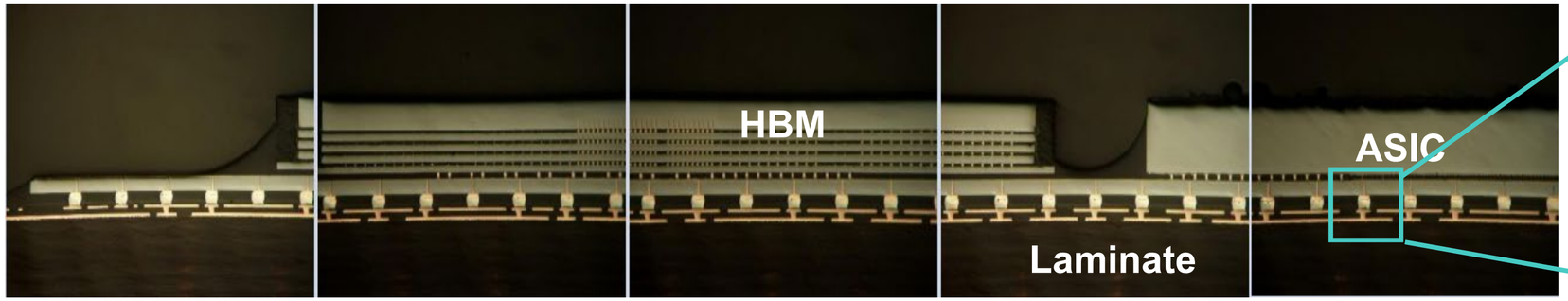
Packaging solutions

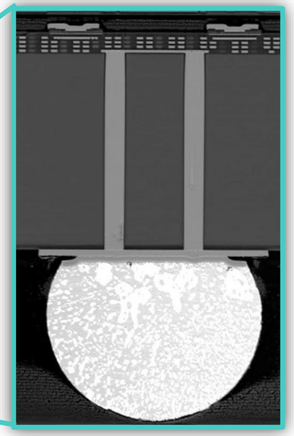


- Silicon does not intrinsically lase
- III-V based material needed for laser
  - Monolithic growth III-V on Si and laser forming still at research phase
- GF approach:
  - Passively place InP laser in laser trench using fiducial marks
  - Laser placement on SiPh chip has potential to significantly reduce packaging costs for Datacom, LiDAR & photonic computing applications
- GF reported:
  - 11dBm optical power coupled to Si waveguide
  - Passed Reliability performance: (humidity/thermal cycle)

Courteously of Y. Bian, OFC 2021

2.5D Microelectronic only transitioning to Photonic

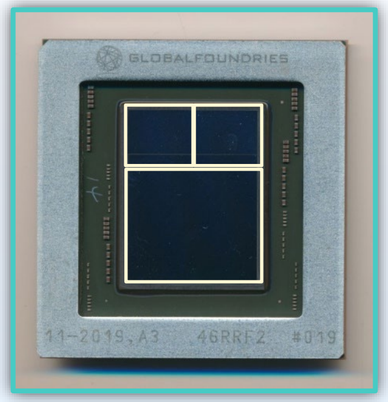




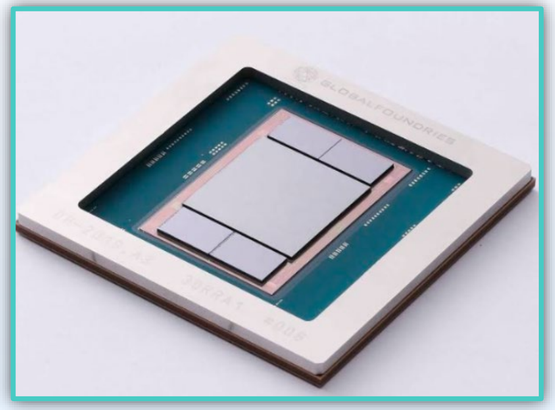
TSV

C4

Here Today

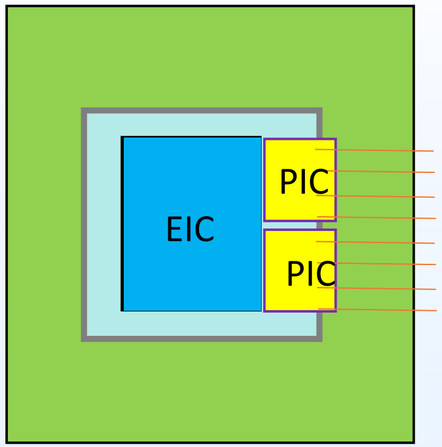


2 HBM + ASIC
55mm^2 laminate

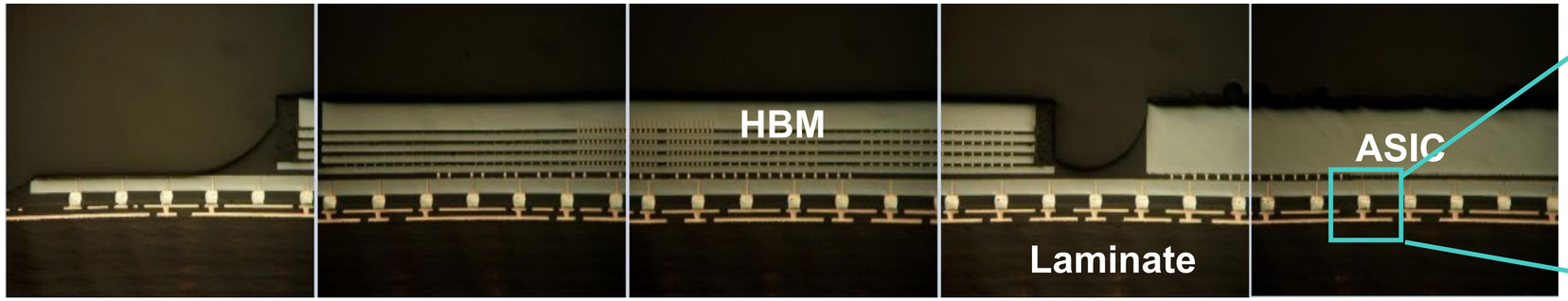


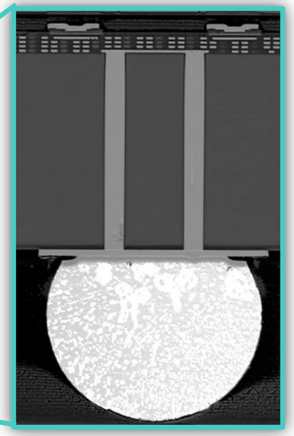
4 HBM + ASIC
70mm^2 laminate

(Coming soon !!)



2.5D Microelectronic only transitioning to Photonic

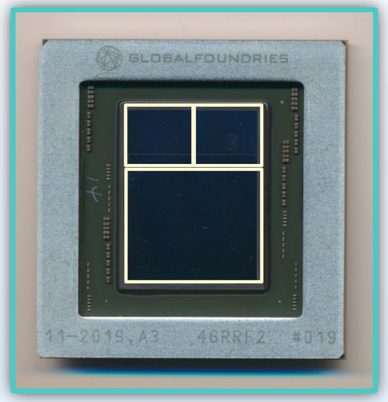




TSV

C4

Here Today



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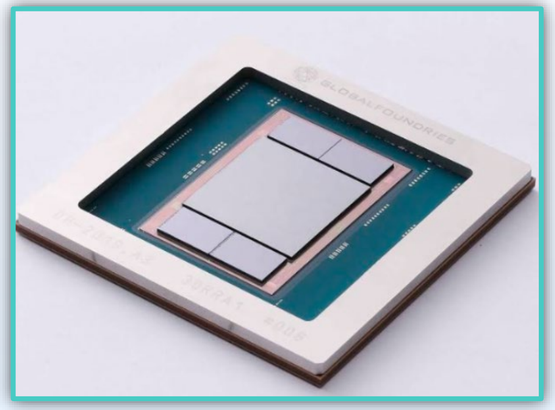

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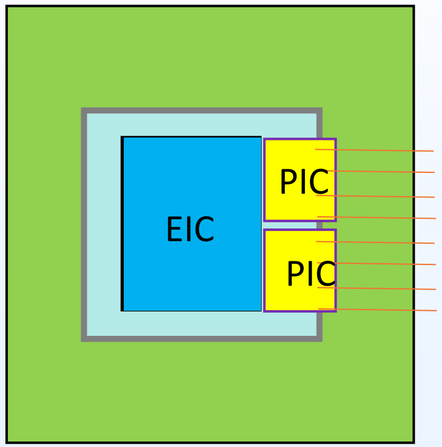

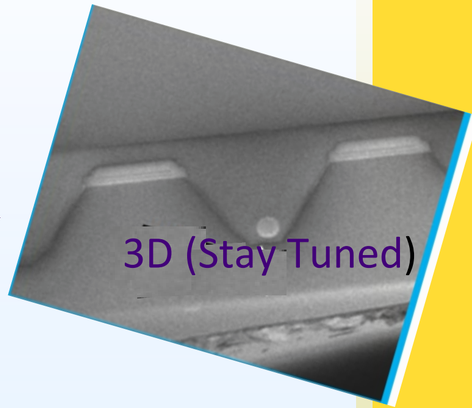

Die stacking without losing all the benefits of 2D Photonic packaging

Ecosystem Today …. Many solutions, but some common elements

CPO JDF*

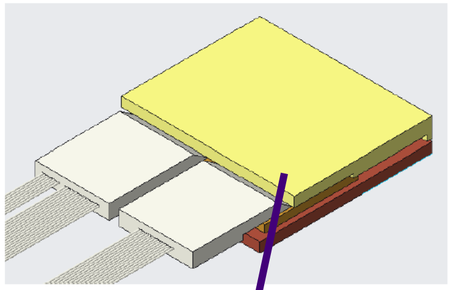

Figure 3: Example of an optical module for CPO applications

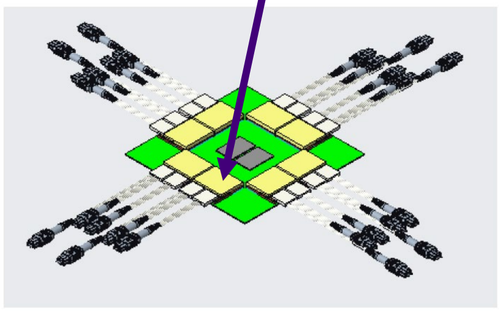

Figure 2: Example embodiment of a 51Tb/s CPO assembly

Company	A	B	C	D
Co-Packaging approach	2.5D - Si Interposer & cavity laminate	2.5D – organic Interposer	Fan-out package & cavity laminate	Complex dual side Organic packaging w/ cut-out
Laser source	Off module	On Module	Off Module	On Module
Fiber Attach	GF passive	GF Passive	GF Passive	GF Passive
Fiber count per PIC (SMF)	24	16	30	16
Other key PIC features supporting Co-package	Flip chip compatible, Cu u-pillars,	Laser cavity w/ multiple direct laser attach on PIC, Cu-P receive pads	Cu u-pillar receive pads, backside grind, Reflow compatible	Cu-P receive pads, Reflow compatible, 2-sided PIC FA
Packaging portable to Microelectronic OSATs?	Y	Y	Y	Y

* From Co-Packaged Optical Module Discussion Document - Facebook 9/2019 https://www.facebook.com/CoPackagedOpticsCollaboration/

Ecosystem Today …. Many solutions, but some common elements

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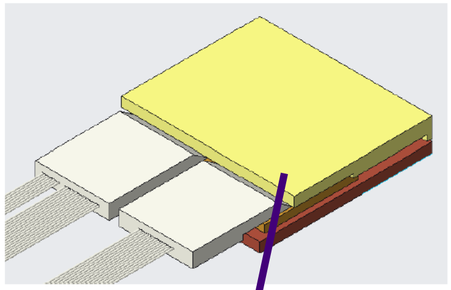

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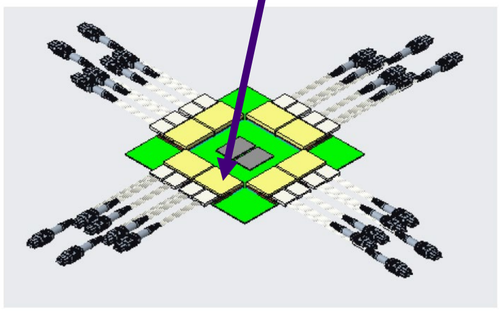

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Packaging portable to Microelectronic OSATs?	Y	Y	Y	Y

1) GF has fully qualified 1 OSAT for our 45CLO Platform (P6 qualification)
   - Passive Fiber Attach
   - Flip Chip Die to Die interconnect
   - Organic Laminate (non-hermetic ☺)

   (sorry, can't share the exact form factor just yet without an NDA)

* From Co-Packaged Optical Module Discussion Document https://www.facebook.com/CoPackagedOpticsCollaboratio

Conclusion

1) GF has a leadership monolithic 45SPCLO technology platform available to our customers
   - Utilizes 300mm state of the art tools and PDK enablement with EO co-design environment
   - The combined CMOS and optical devices bring unique performance advantages

2)“Winners and Losers” will evolve out of the standardization option down select process
   - Many different heterogeneous integration techniques are being tried
   - GF is supporting the “common” packaging features to enable next generation DC/CPO applications

1) GF has fully qualified one packaging OSAT with our 45CLO Platform (P6 qualification) targeting CPO
   - High fiber count Passive Fiber Attach
   - Flip Chip Die to Die interconnect
   - Organic non-hermetic laminate package

2) GF is working with customers and partners on additional qualifications to extend the ecosystem (more to be announced soon)

Thank You