



Optical PCBs

Embedded Waveguides solving Photonic
Chip Assembly Bottlenecks

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Who we are – vario-optics

- SME based in Heiden, Switzerland
- Spin-off from Varioprint AG (PCB manufacturer)
- Designer & Manufacturer of optical PCBs
- Applications & Markets:
 - Photonic Sensing (Medical, Industrial, Environmental)
 - High-speed on-board communication (Telecom, Aerospace)
 - Photonic chip packaging (Telecom, Sensing,...)

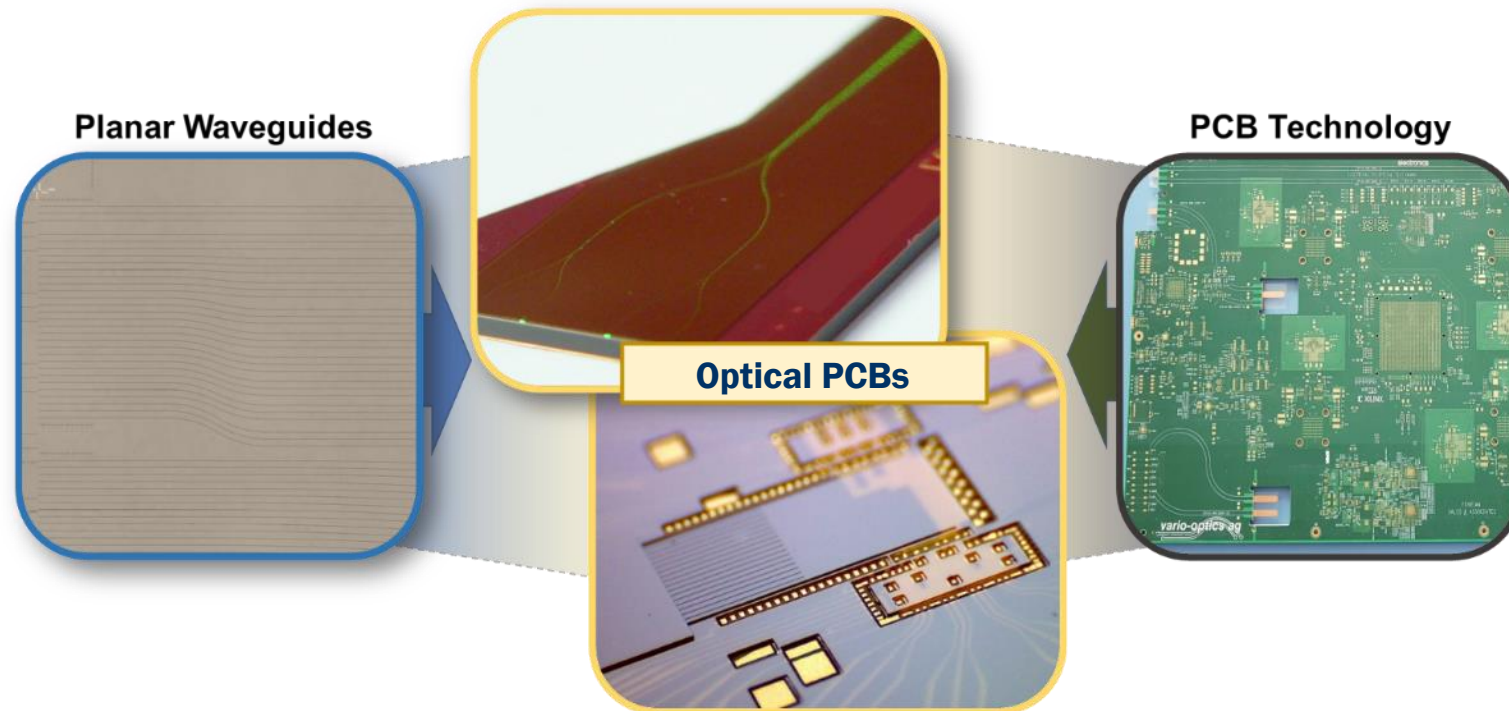


Agenda

- What is „Board Level Photonics“?
- Use-cases:
 - photonic interposer for PIC integration
 - Strategies for passive & high assembly tolerance using optical PCBs

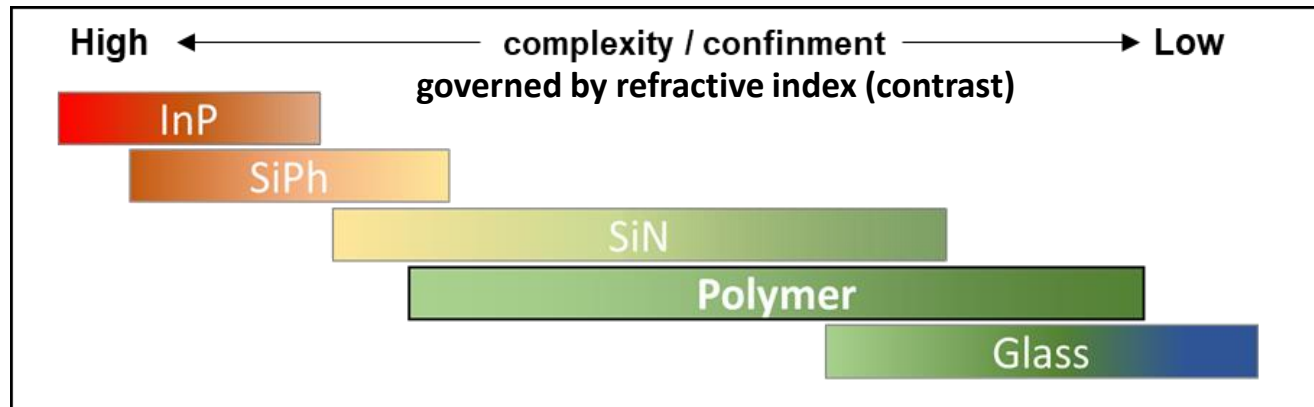
Optical PCBs in a nutshell

adding photonics functionality on the board level (optical PCBs)



merging **photonics** (waveguides) & **electronics** (PCB)

Planar Waveguide Technologies / PICs

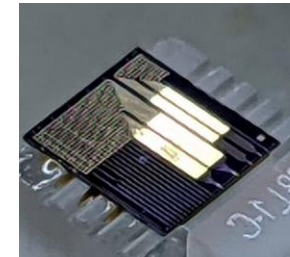
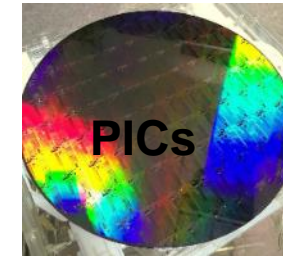


PICs / Transceivers

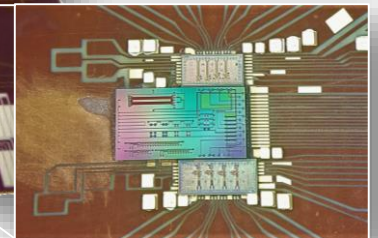
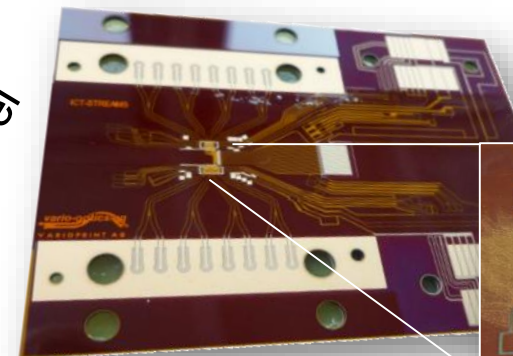
Sensing

Optical Interconnects

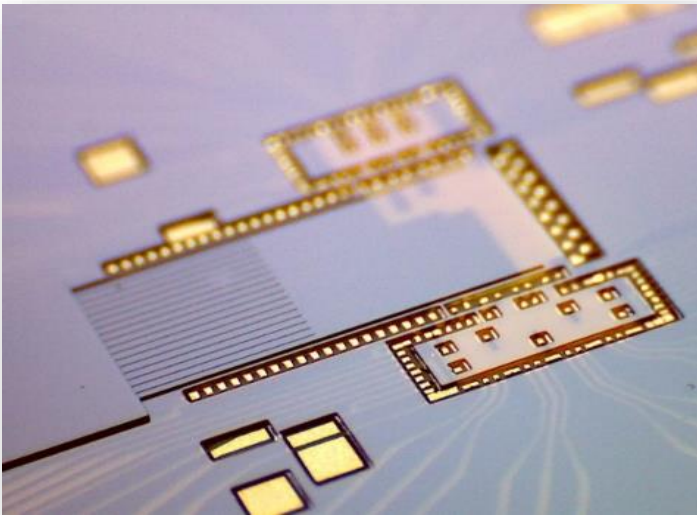
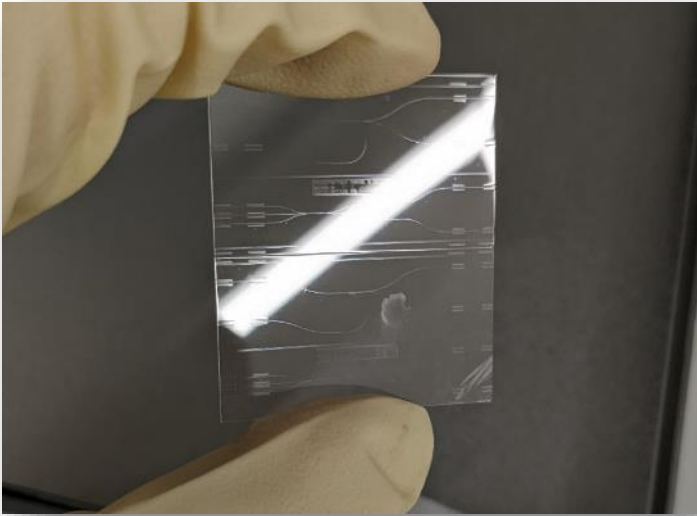
Chip level



Board level



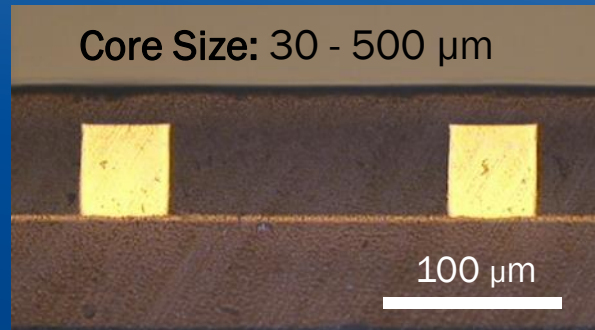
Core Technology: Planar Waveguides



Planar Waveguides

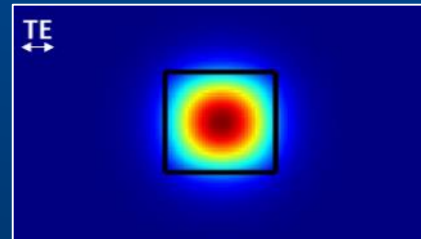
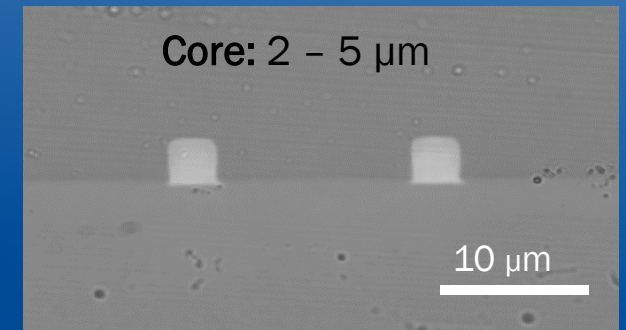
Multimode

Core Size: 30 - 500 μm



Singlemode

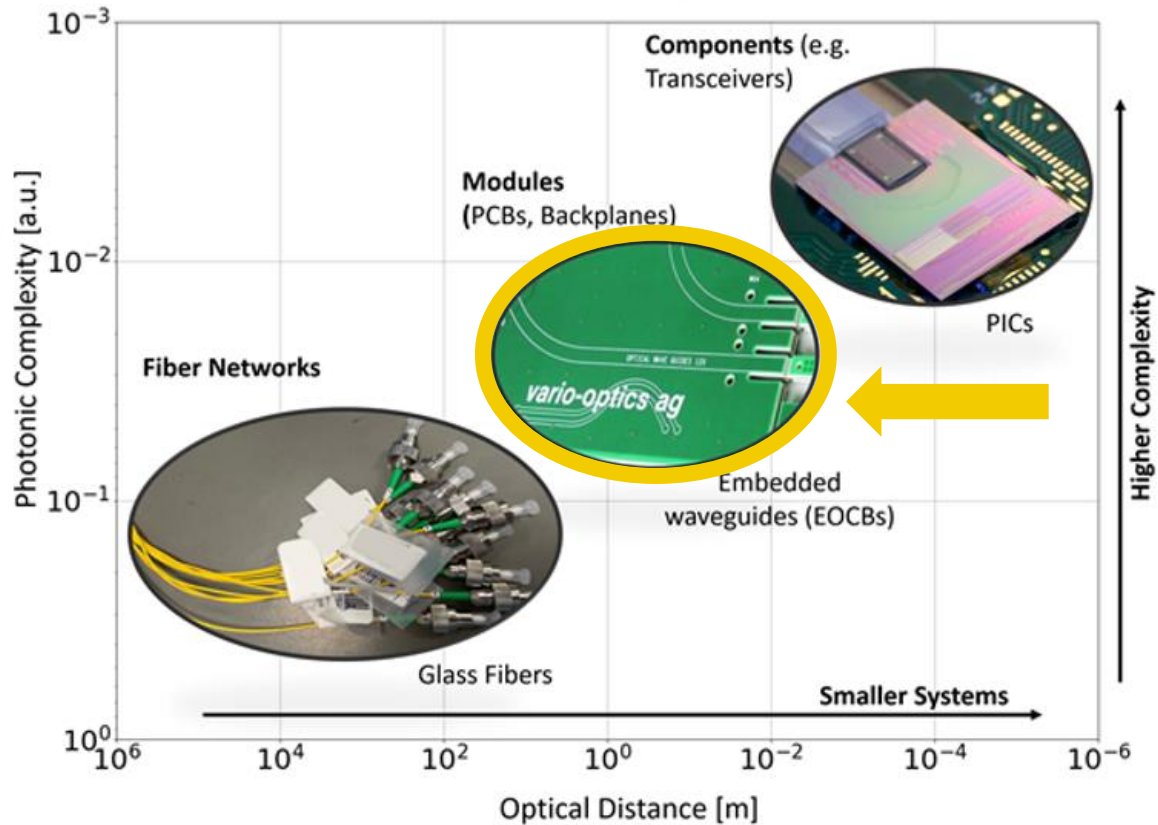
Core: 2 - 5 μm



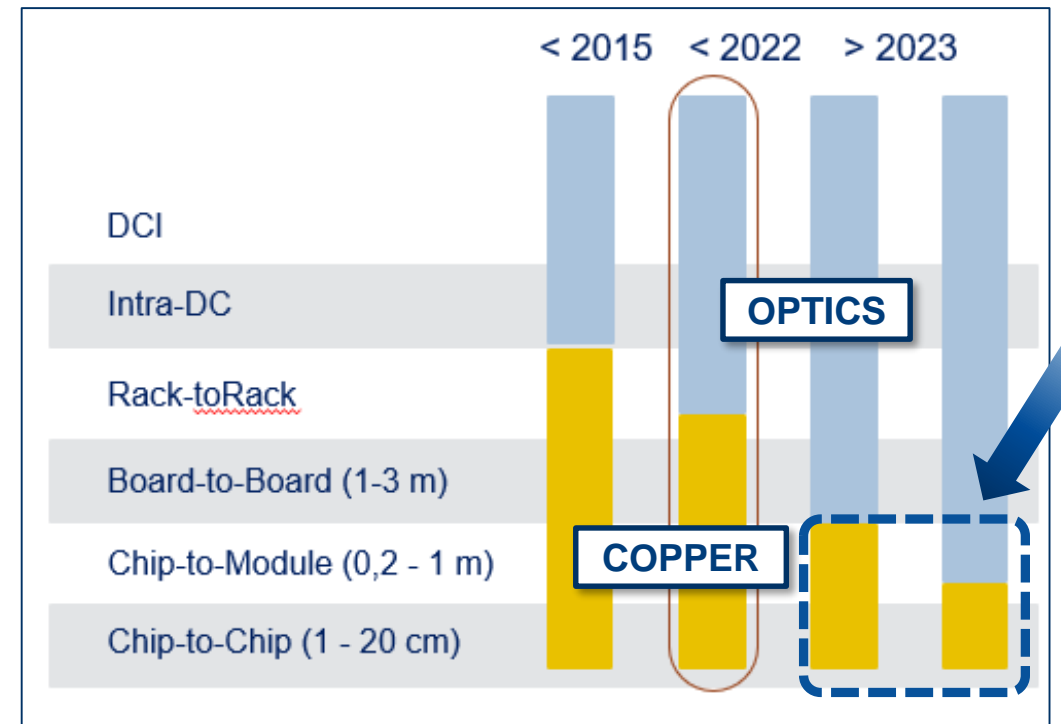
- Adjustable MFD (4 - 10 μm)
- On-chip mode conversion
- TE / TM Polarization supported
- Polarization maintaining!

Photonics on the board-level

Photonic Technologies in ICT



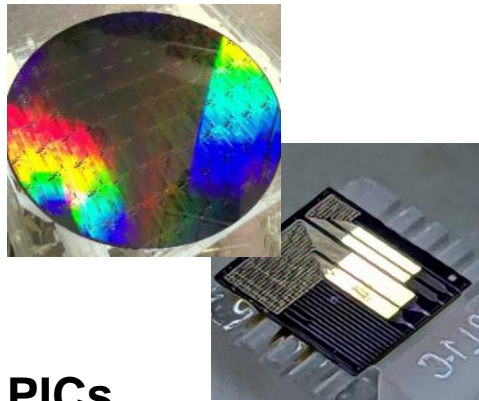
within the system



Source: Yole 2022 report on Optical Transceiver for Data- & Telecom Market, Graphic adapted

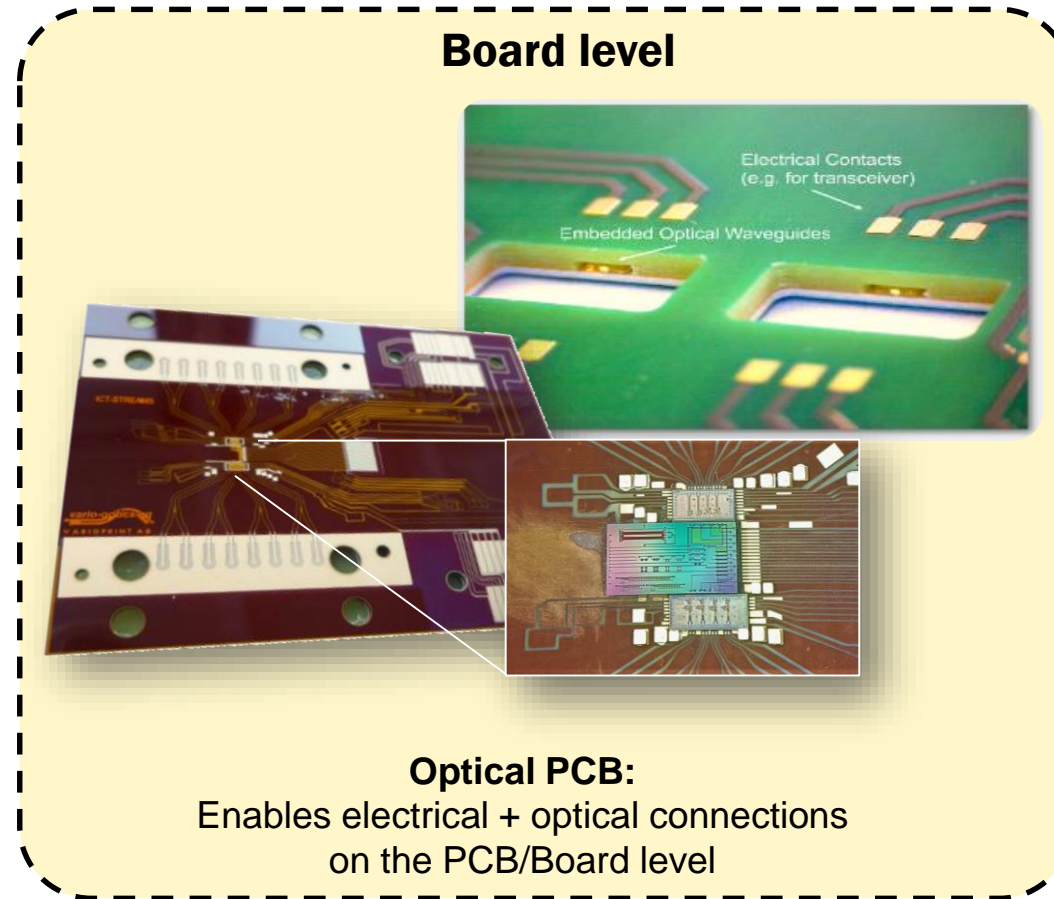
What we do: board-level photonics

Chip level

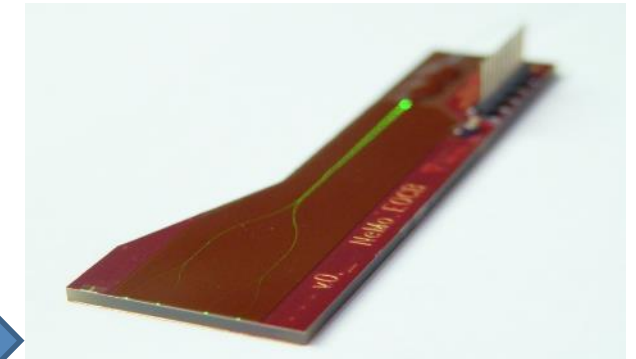


PICs
Components (LD, PD,...)

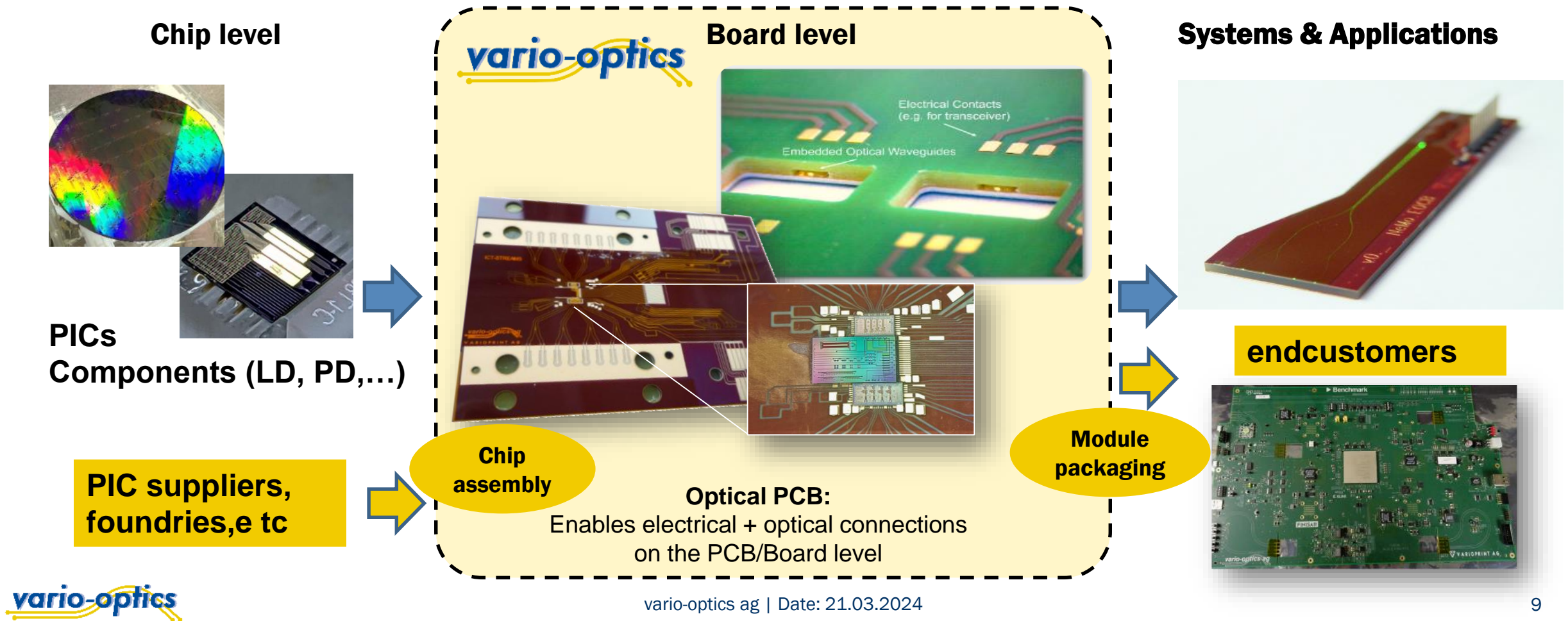
Board level



Systems & Applications



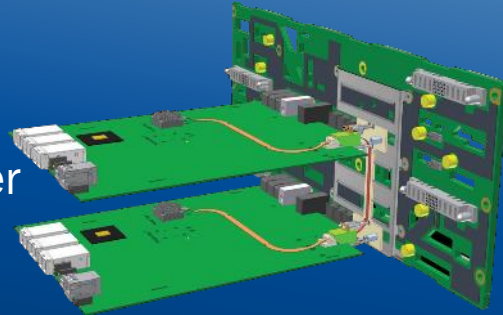
What we do: board-level photonics



Applications & Markets

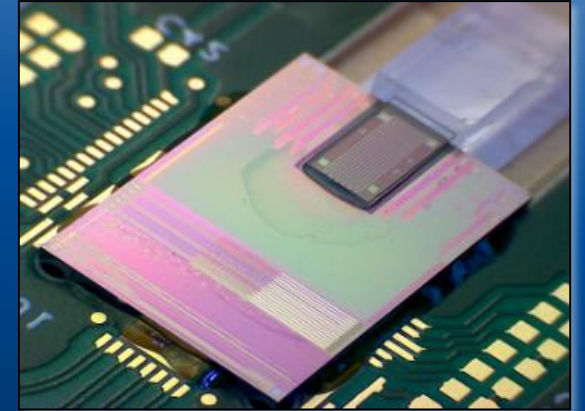
On-Board Photonics

Optical data-transfer (high data-rates, low power consumption) in datacenter racks, flight computer etc (optical backplane)



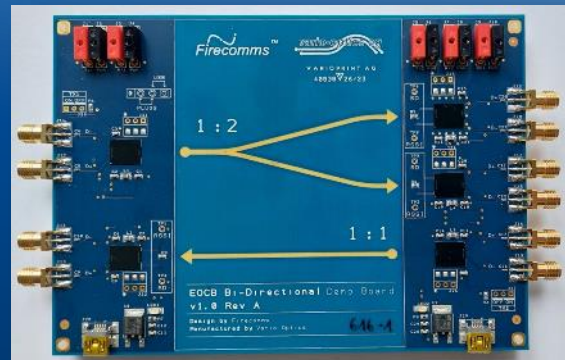
Integration Platform for photonic chips

Efficient & scalable packaging/access to PICs & PIC/IC chiplets (e.g. silicon photonics)



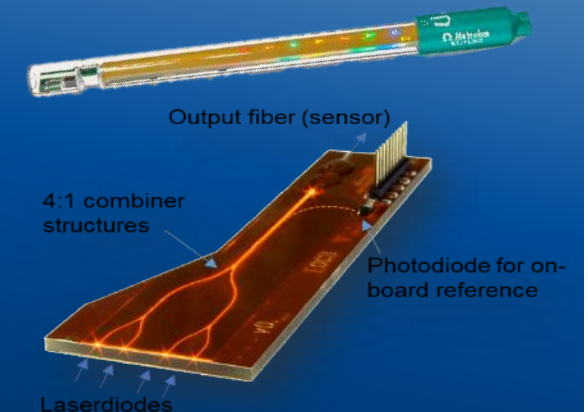
Harsh-environment optical communication

Embedded, galvanic isolated optical communication; e.g. control circuits for high-voltage, etc



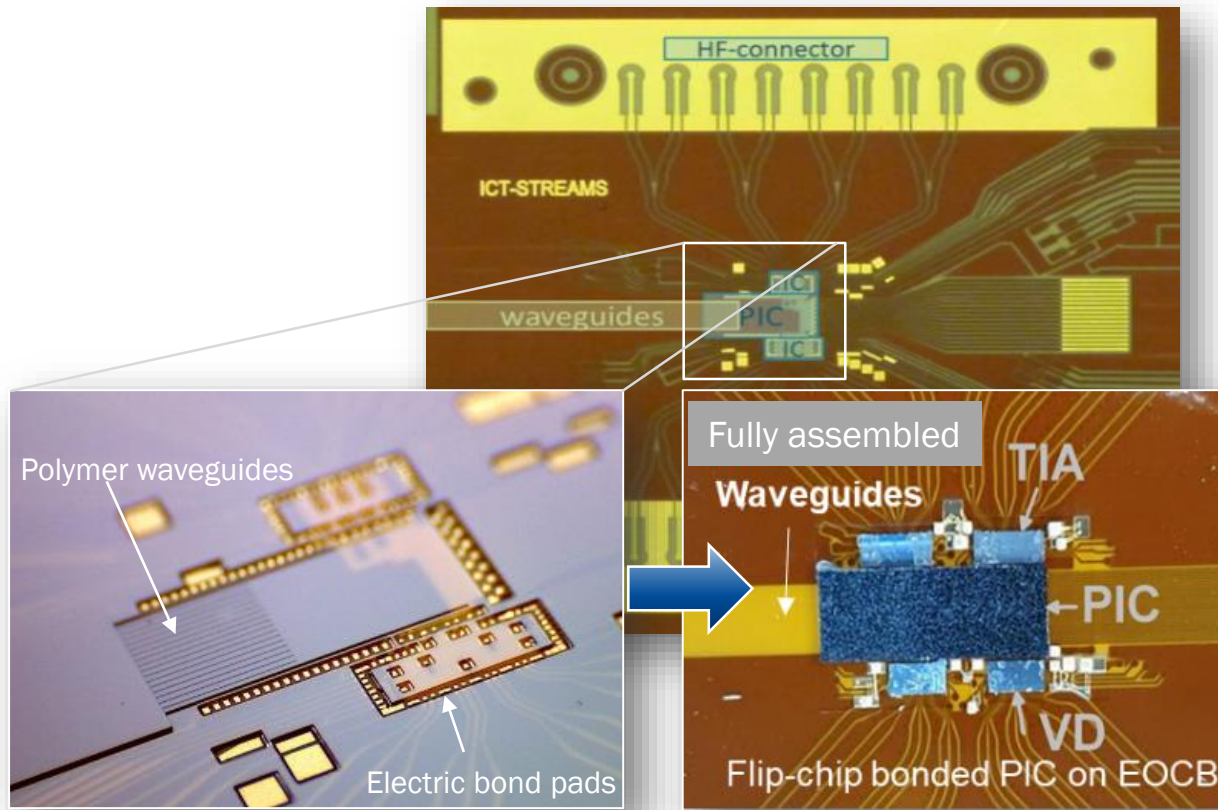
Optical Sensing

Small footprint, miniaturized, highly-integrated electro-optical subsystems



PIC packaging on an optical PCB

PCB with integrated evanescent coupling interface



Planar Waveguides

- High I/O number optical Fan-outs
- On-chip mode conversion (e.g. SiPh to Fiber)
- Polarization maintaining Waveguides

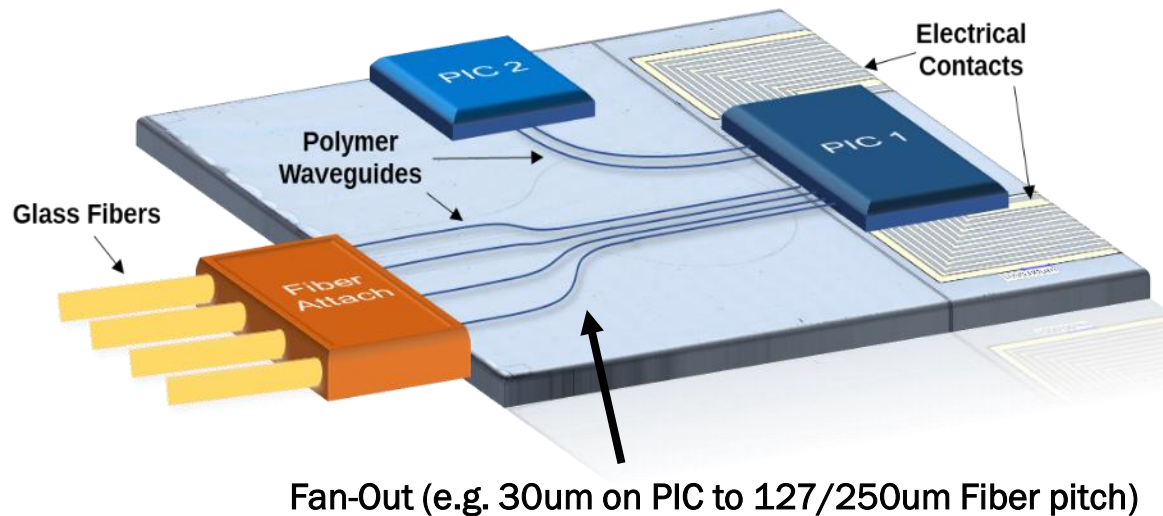
Optical Interfaces

- Efficient PIC-Waveguide Coupling (Adiabatic or Butt-Coupling)
- Fiber-Interface & Connectors

Electrical Interface

- Metallization & PCB Integration
- Fine-Pitch, Flip-Chip Bonding
- RF Interface

Challenges in PIC packaging



Each interface looks different

- MFD, PIC platform
- Channel #, pitch

In order for an actual module – packaging (not only assembly) is required

- Electrical
- Thermal, mechanical

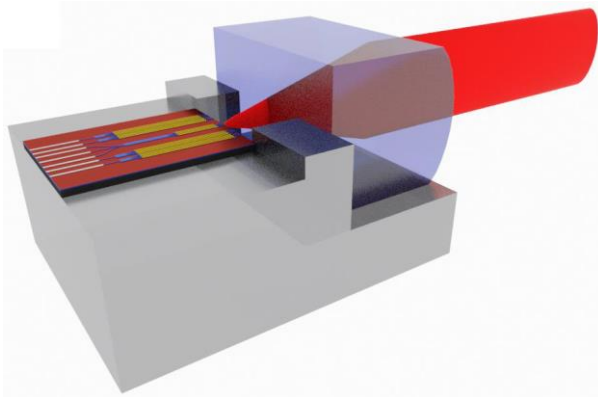
Singlemode assembly (precision) is just hard

- e.g. different materials
- Temperature stability
- Pluggable interfaces

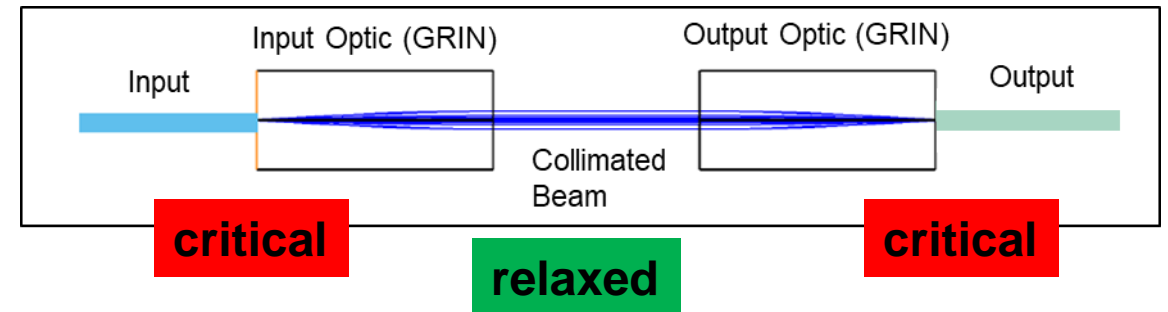
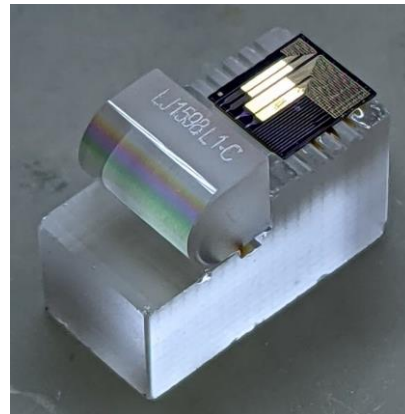
Challenges in PIC packaging

-> opportunities

e.g. expanded beam interfaces can relax tolerances:



Glass-microstructured substrate

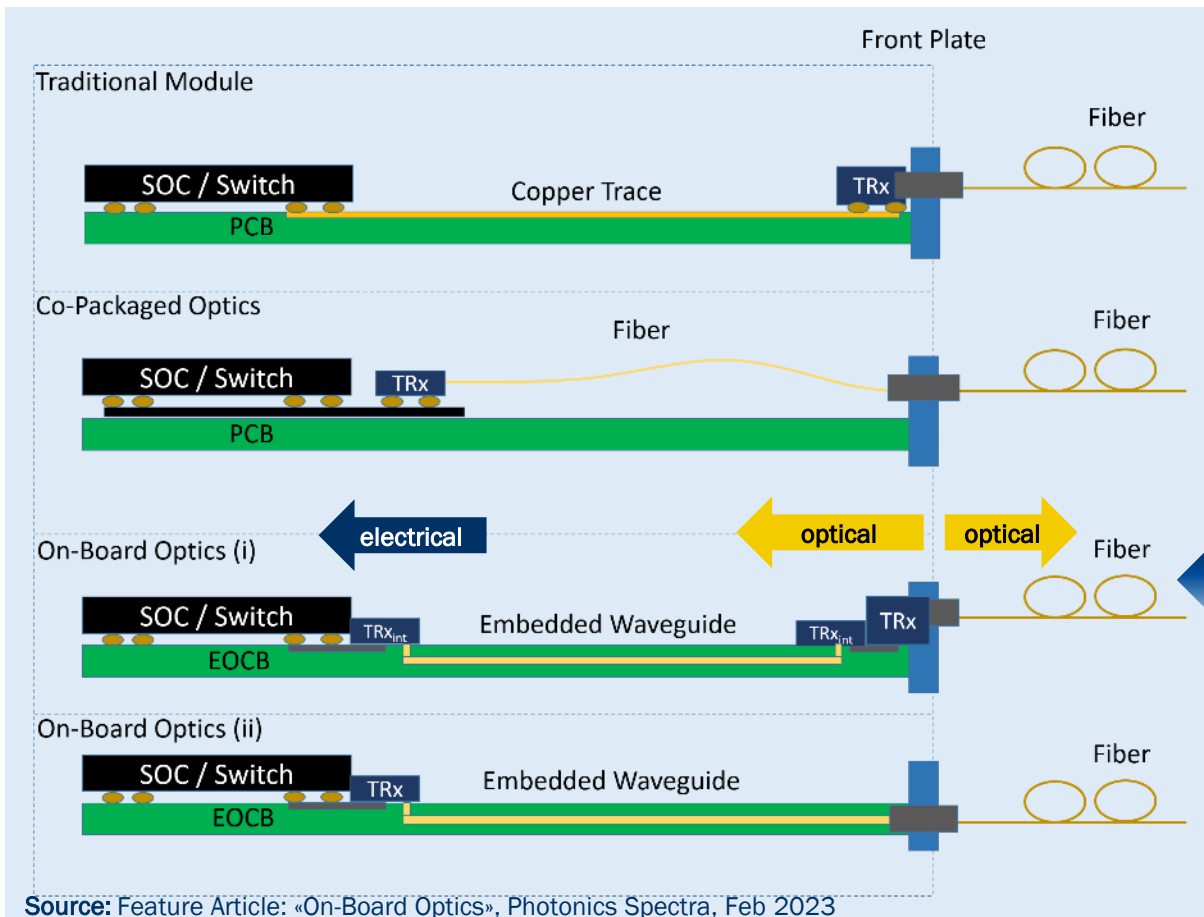


Concepts such as expanded beam create effort on the chip/component assembly side, but facilitate board/system-level integration

Close collaboration with packaging partners are essential.



Novel (optical) DC concepts are being developed with one central goal: Bringing in data closer to the main processing chip using light!



Traditional

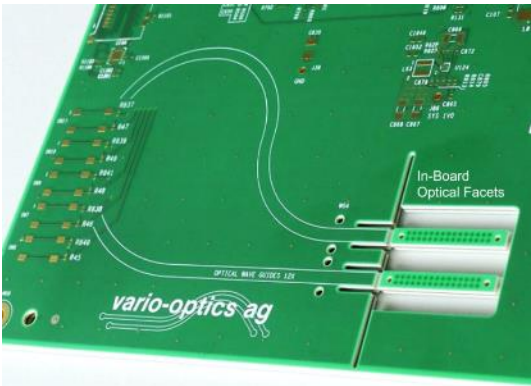
„Standard“ Co-packaged optics

Board-Level Photonics using embedded waveguides:

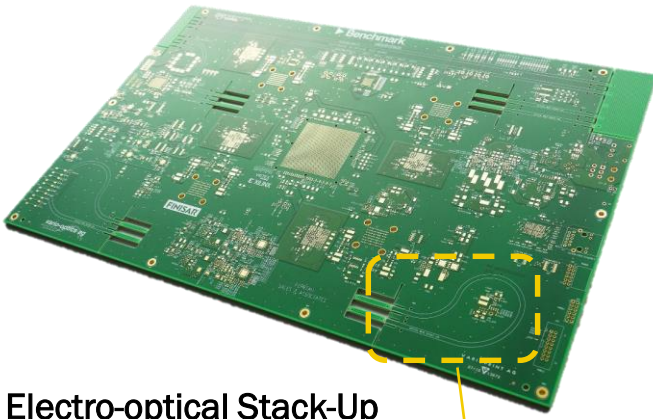
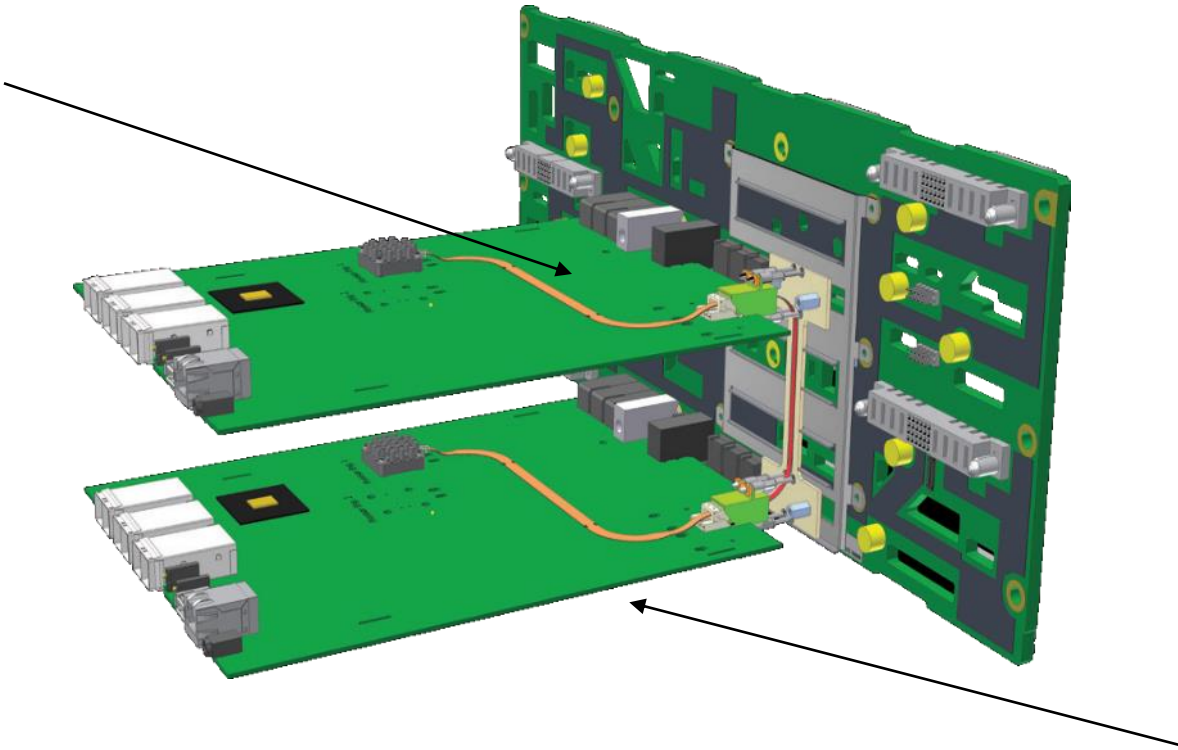
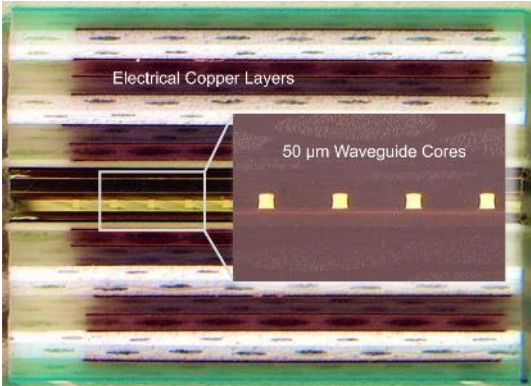
- + Embedded waveguides inside module (low loss)
- + No fiber handling issues
- + Pluggable interface at front plate

Board-Level Photonics Modules

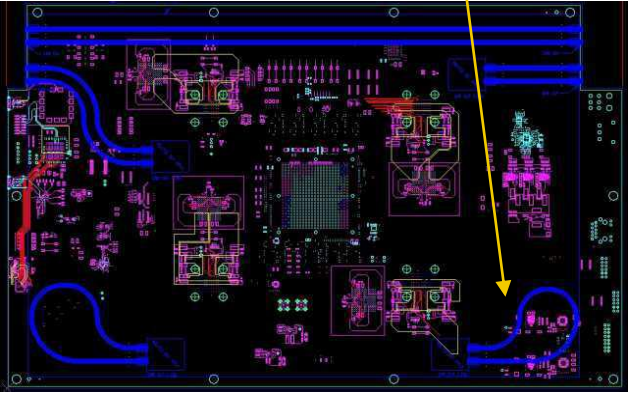
Datacenter architectures



Embedded optical Waveguides

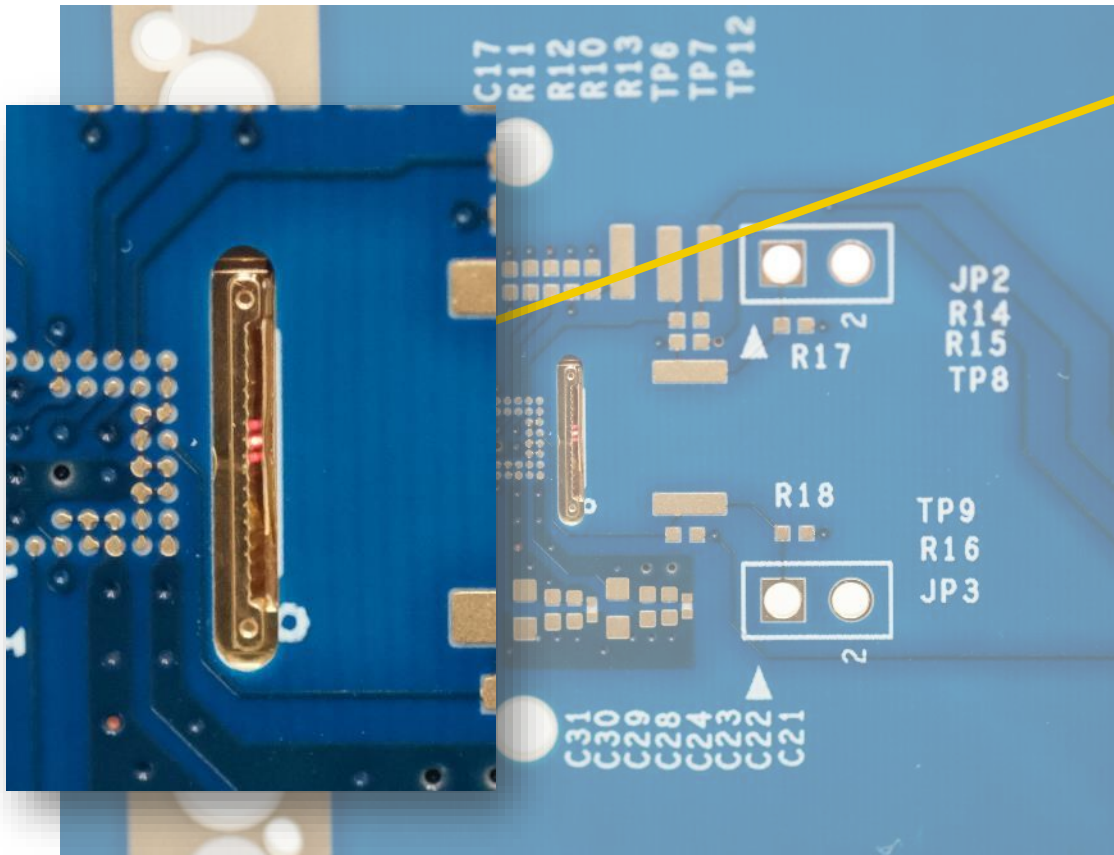


Electro-optical Stack-Up

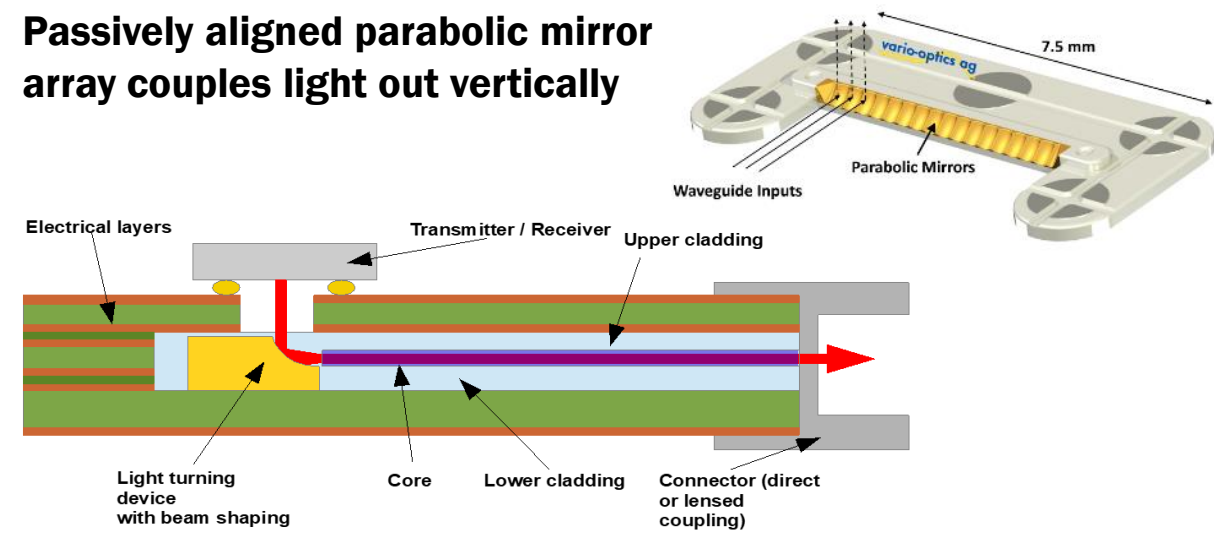


High-Speed on-board communication

vertical coupling

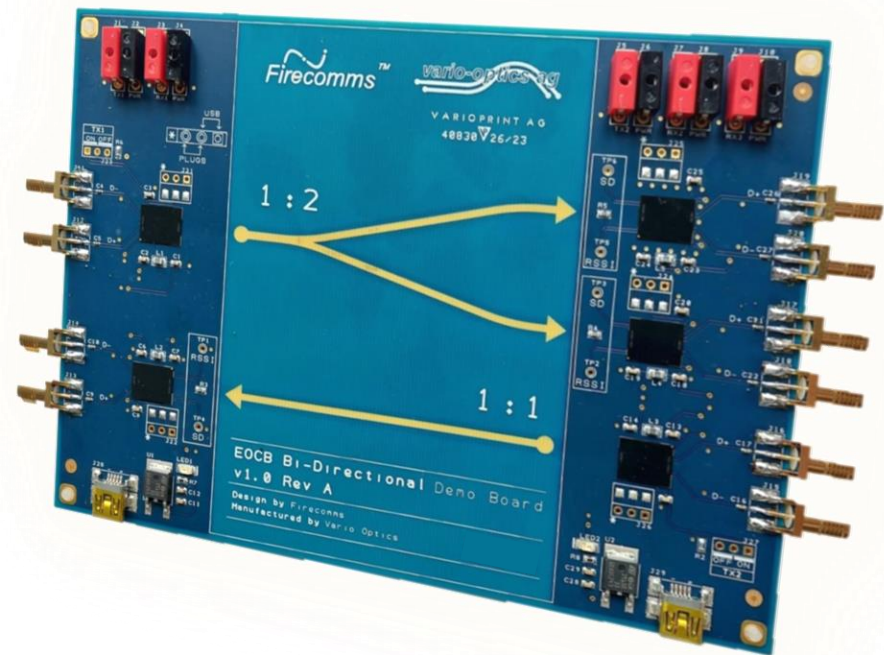


Passively aligned parabolic mirror array couples light out vertically



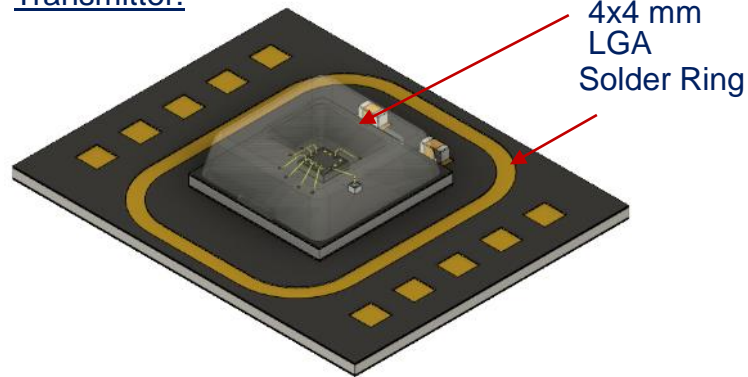
**Placement of optical engine with +/- 10 μm required
- possible with die-bonder**

Harsh environment optical communication galvanic isolation

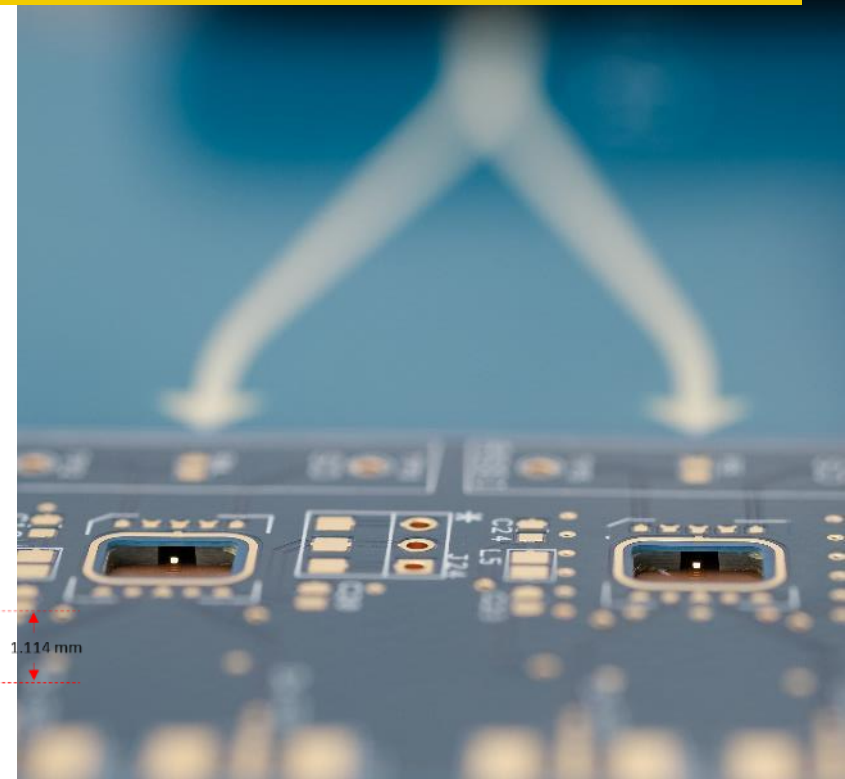
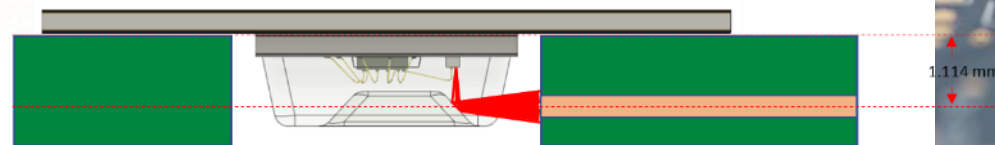


**Fully passive SMT assembly (solder ring)
Standard pick&place tools**

Transmitter:

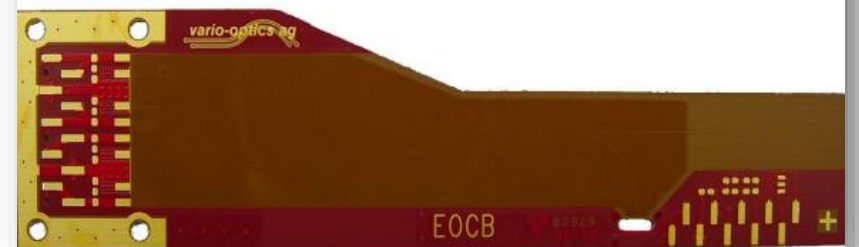
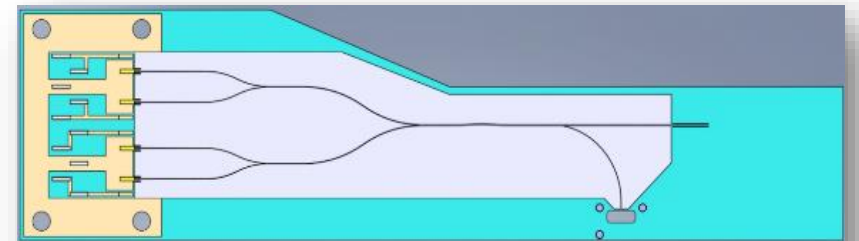
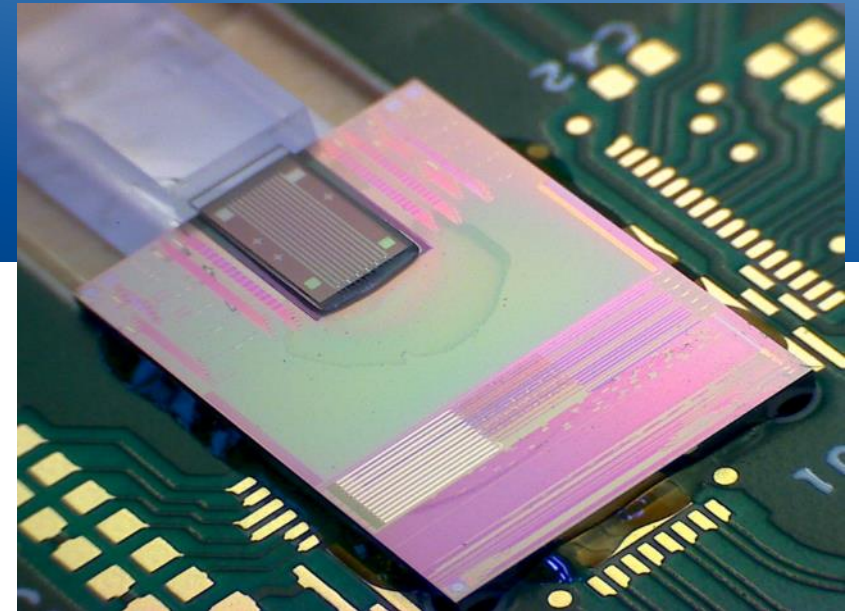


SMT Tx/Rx module
(VCSEL-based)



Summary

- High precision assembly is difficult
- Strategies/concepts exist to facilitate packaging (passive, expanded beam,...)
- Endcustomers care about cost/effort on system level
- Board-Level Photonics is a powerful integration platform for various components, PICs, and waferscale-packaged devices





Let's keep up inspiring

Globally leading, energy saving high-speed solution provider for optical communication and miniaturized sensors

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