Optical PCBs

Bridging the gap between fibers & PIC

EPIC Tech Watch @ ECOC2023 Glasgow

Date: 04.10.2023

Who we are

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

What we do: Photonic Boards / Optical PCBs

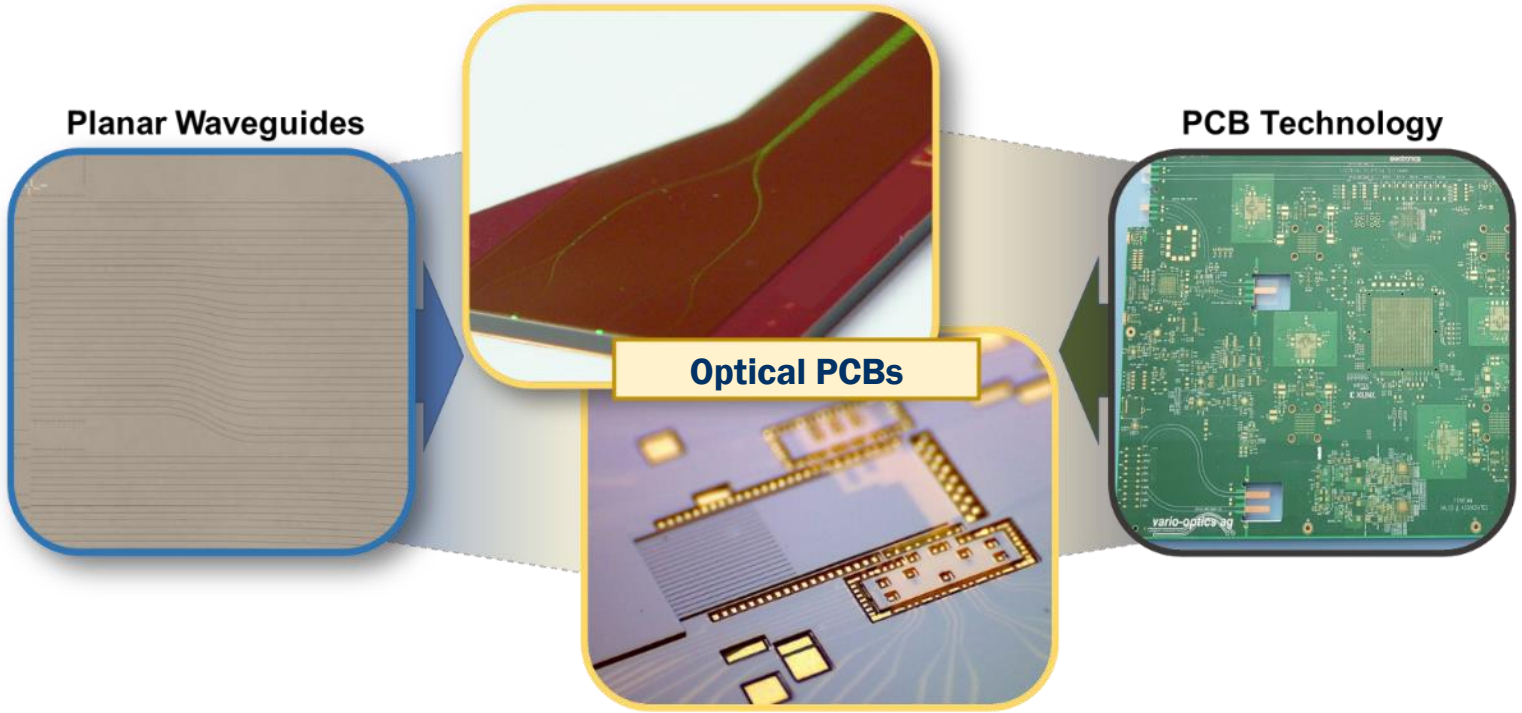
vario-optics manufactures optical printed circuit boards (oPCBs)

Design & Development
- Feasibility Studies, Engineering
- Electro-optical Co-Design

Focus

Manufacturing
- Prototyping / Evalution Boards
- Custom Runs
- Pilot Production / Volume

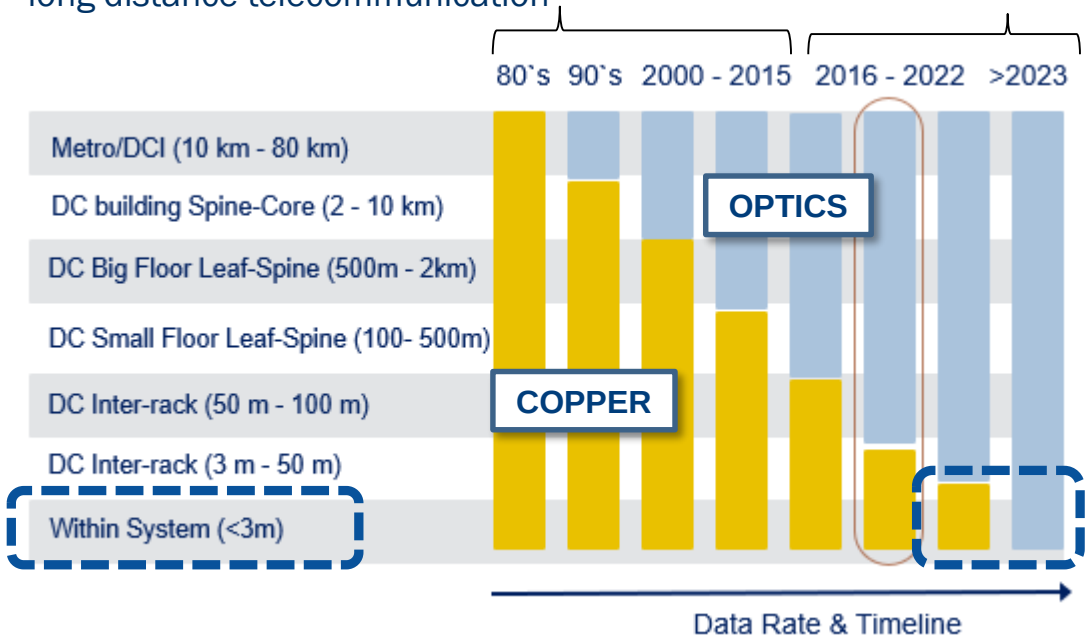
Assembly & Integration
- Providing Interfaces
- Support for packaging & assembly



The Poblem: Electrical Interconnects Reach Their Bandwidth Limit - NOW!

Optical glass fiber technology has enabled long distance telecommunication

NOW: On-Board Optics enables all-optical transceivers with 100x higher speed



Source: Yole 2022 market report on Optical Transceiver for Datacom & Telecom Market, Graphic adapted

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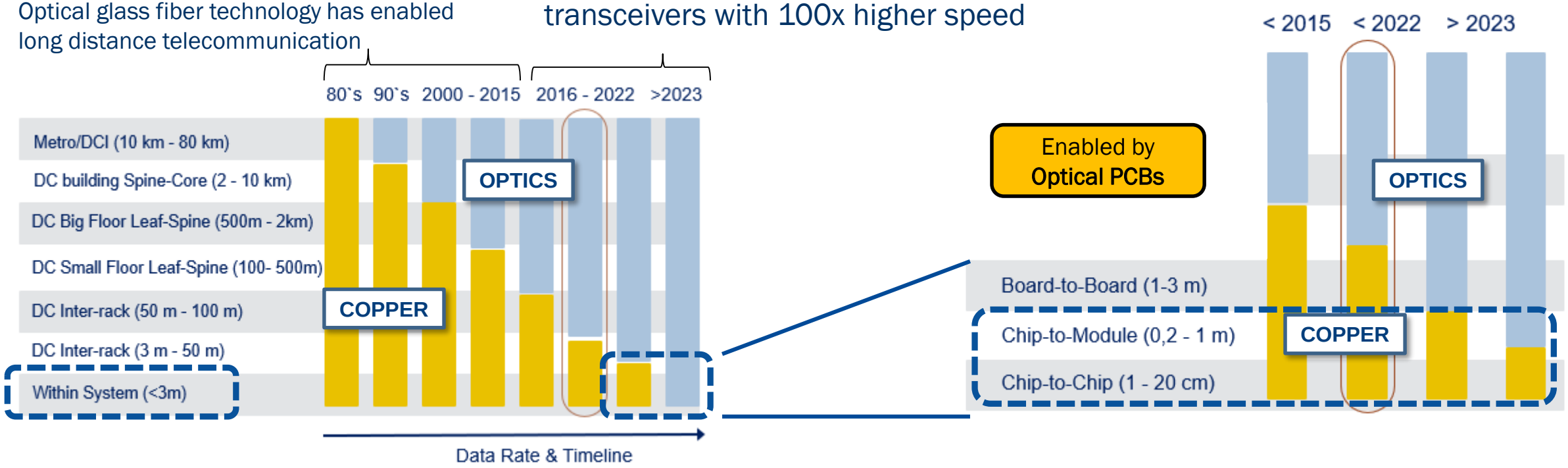

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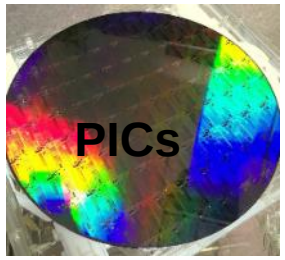
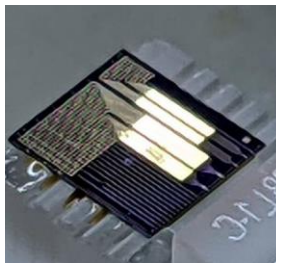
The PIC packaging bottleneck

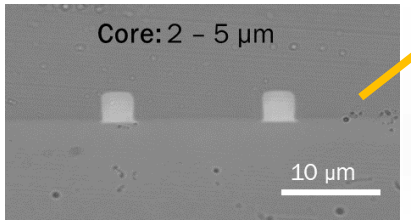
Chip level (PICs)

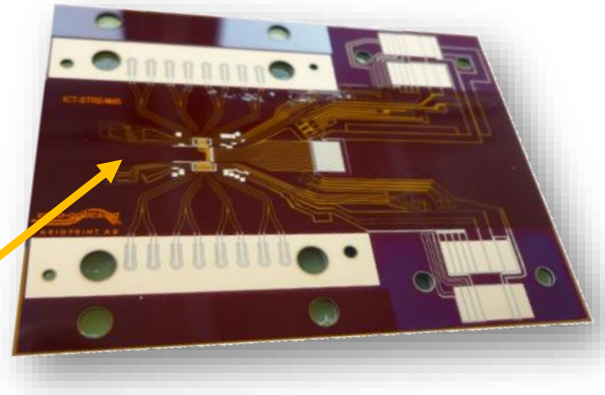


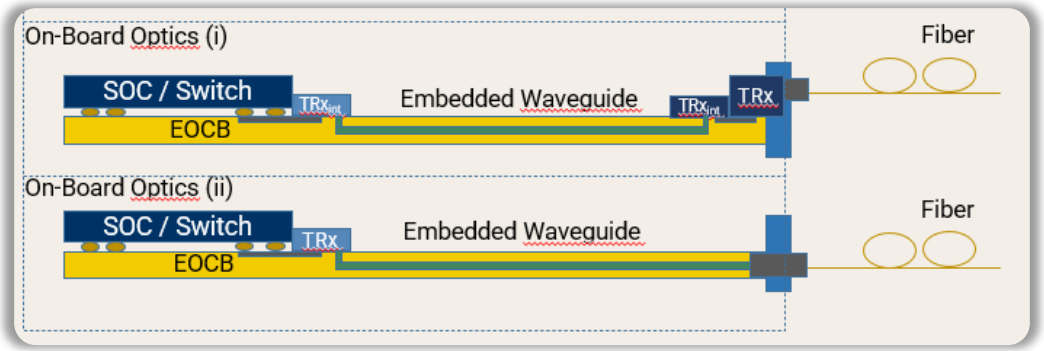


Optical PCBs:
Enables electrical + optical connections on the PCB/Board level

Board level





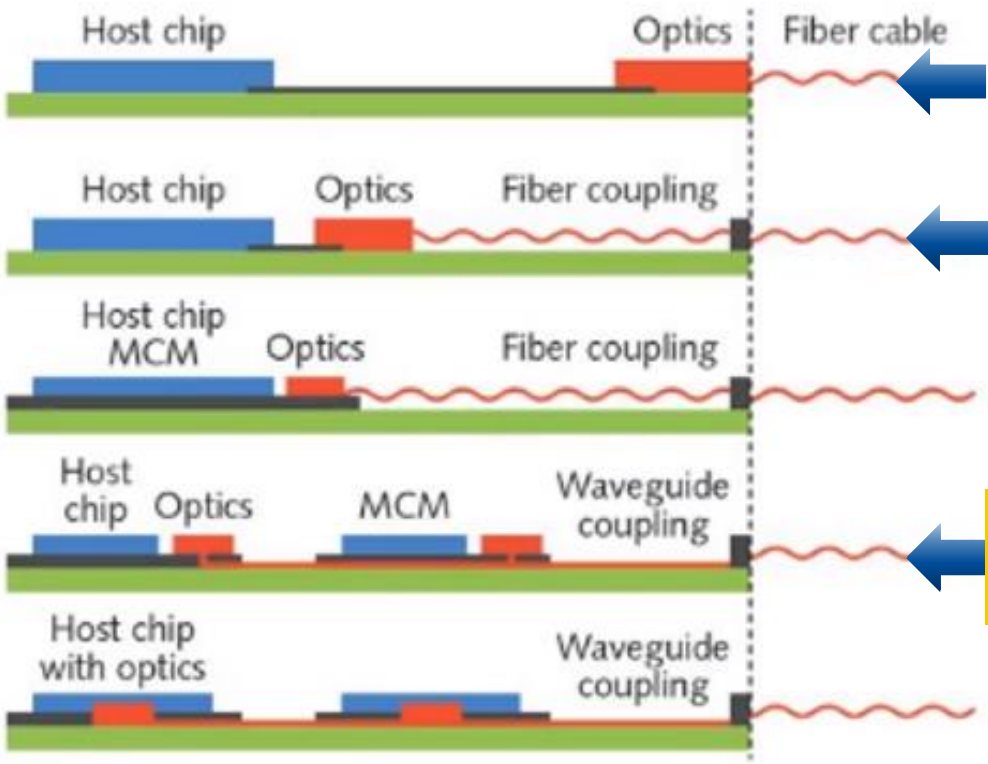


Systems & Applications

1) On-Board Photonics

100G demonstrator-board within COBO to be shown at OFC24

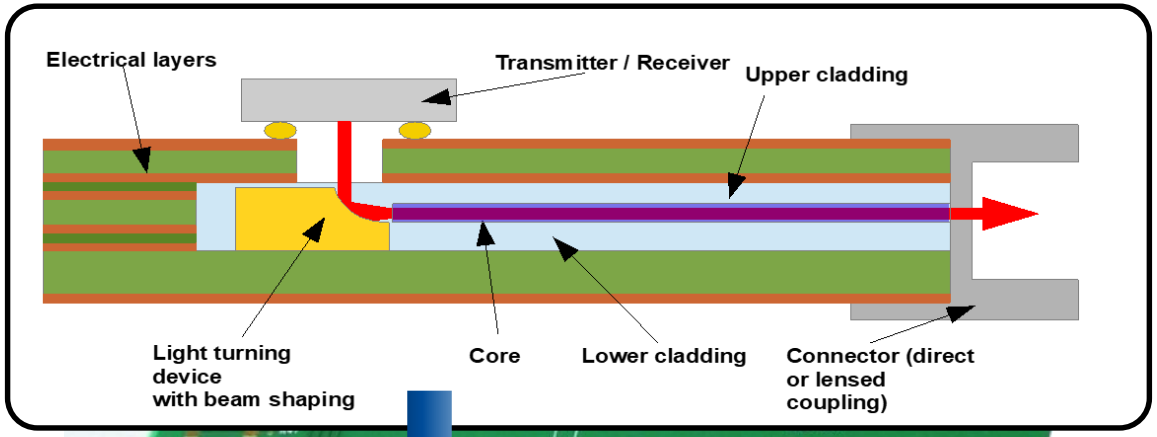
cobo

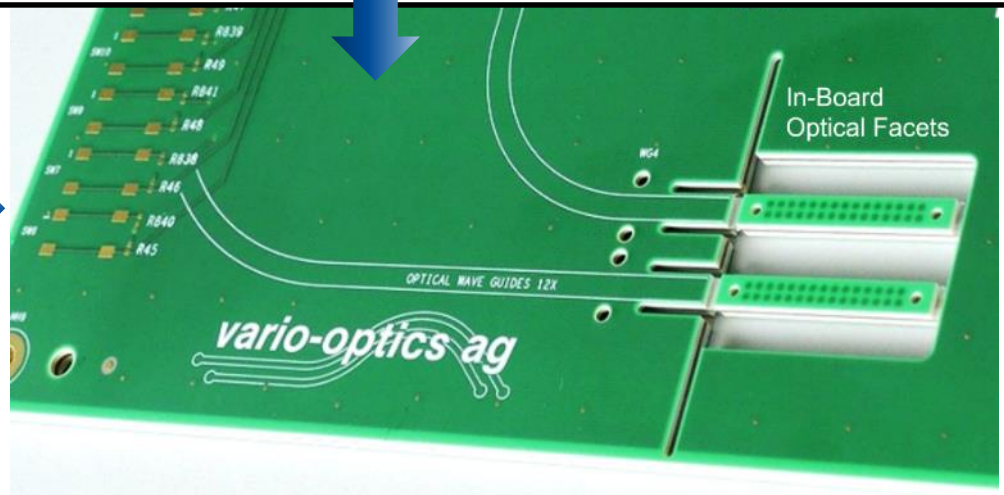


standard approach

Fiber-bundles

On-board photonics



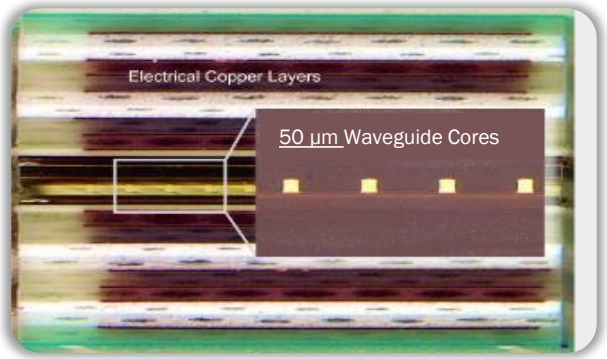


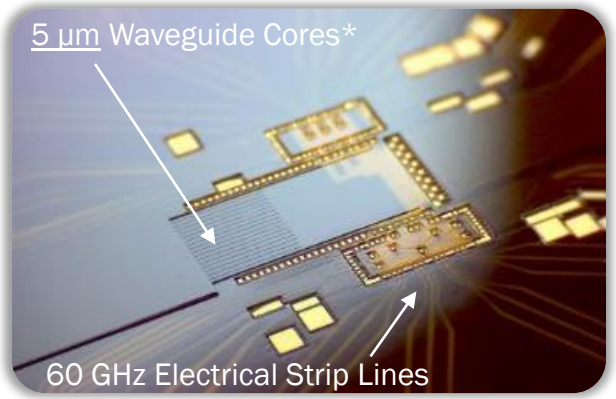
1) On-Board Photonics

Planar waveguides are integrated into conventional electrical printed circuit boards

- No optical fibers
- Replacing electrical connections for high-speed signals

Planar **optical waveguides** & structures, optimized for a **broad wavelength spectrum**

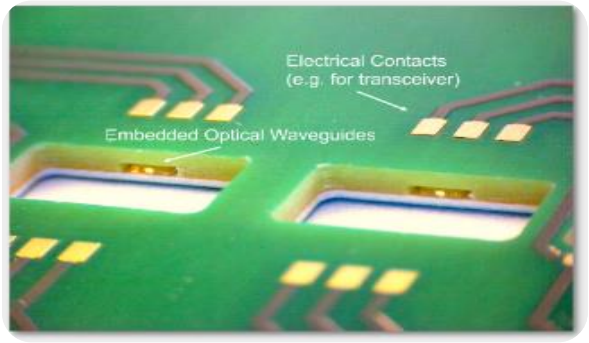


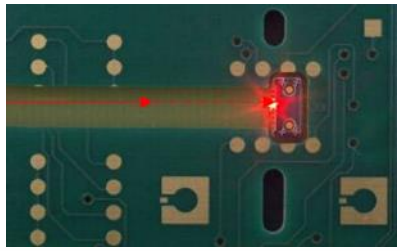


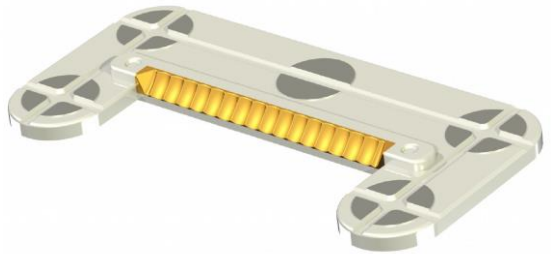
* 16x smaller than a hair (80 – 100 µm)

High integration density for any number of optical channels

Combination with PCBs: integration of **optical and electrical connections**

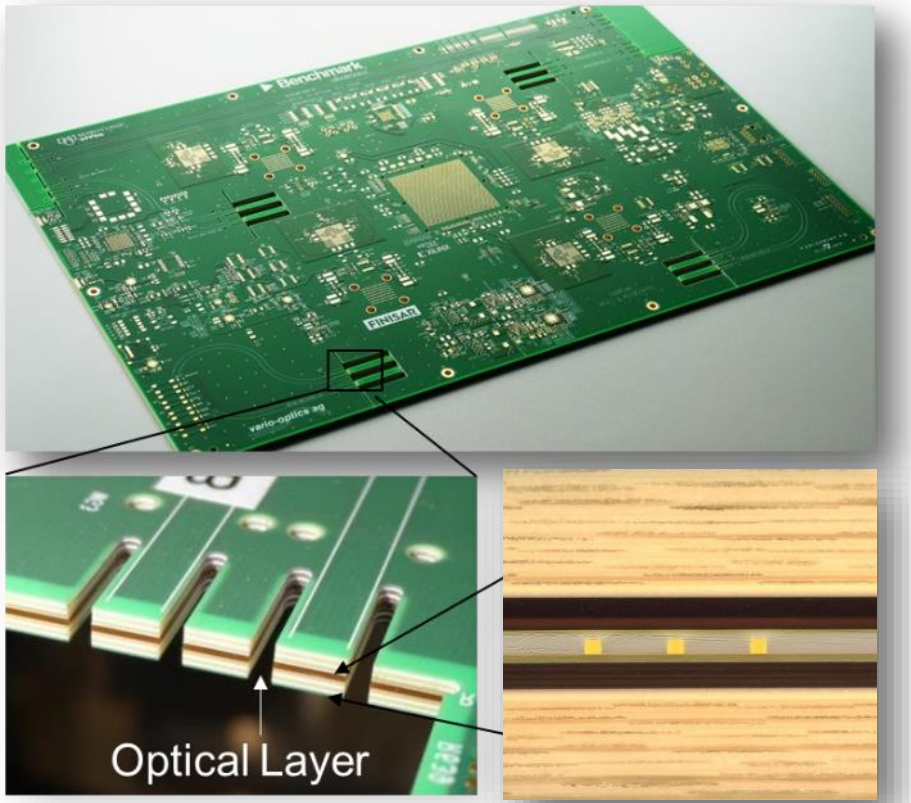




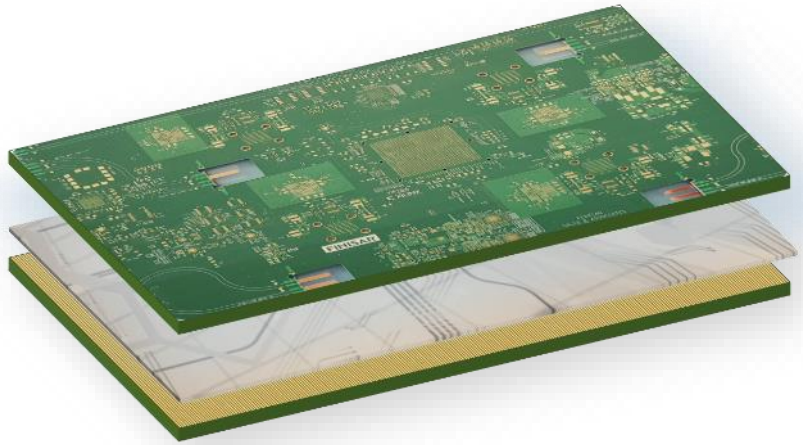


Access to photonic functionalities via **standardized electro-optic interfaces**

1) On-Board Photonics: Reliability



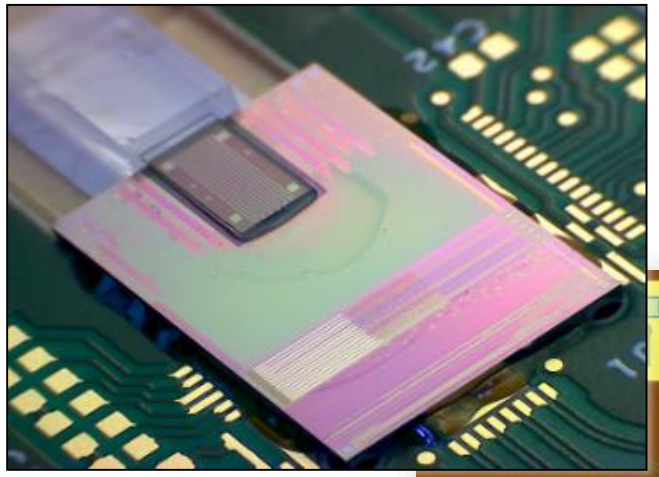
- Max Panel Size (MM): up to 305 – 460 mm^2
- **Reflow soldering** compatible (260 °C, 0.5 min)
- Recently successfully passed **ESA technology validation**

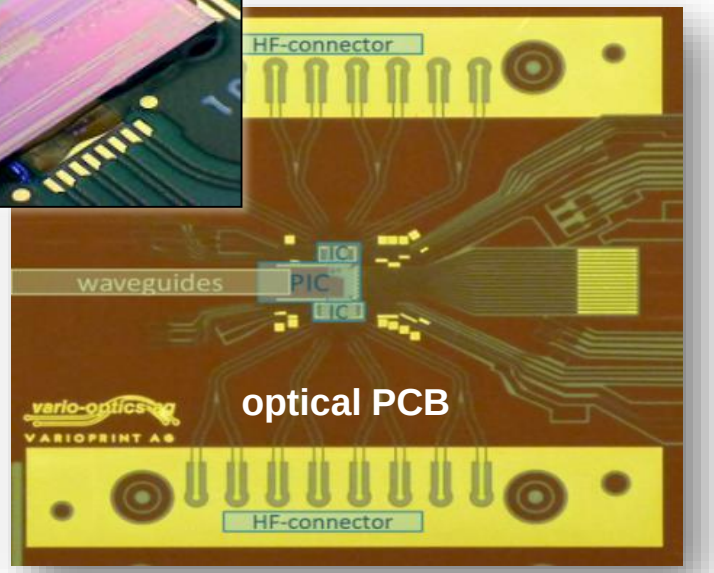


Environmental Stability:	
Operating Temperature	120 °C
Environmental Test	85% rel.h / 85 °C for 2000h (Telcordia)
Temperature Cycling	- 50 °C to + 100 °C

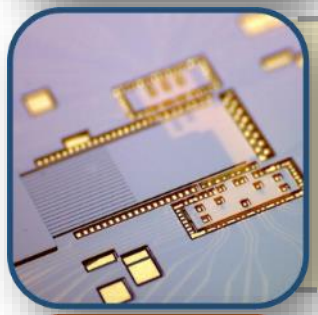
2) chip-to-chip optical interconnects

PIC Packaging Platform





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

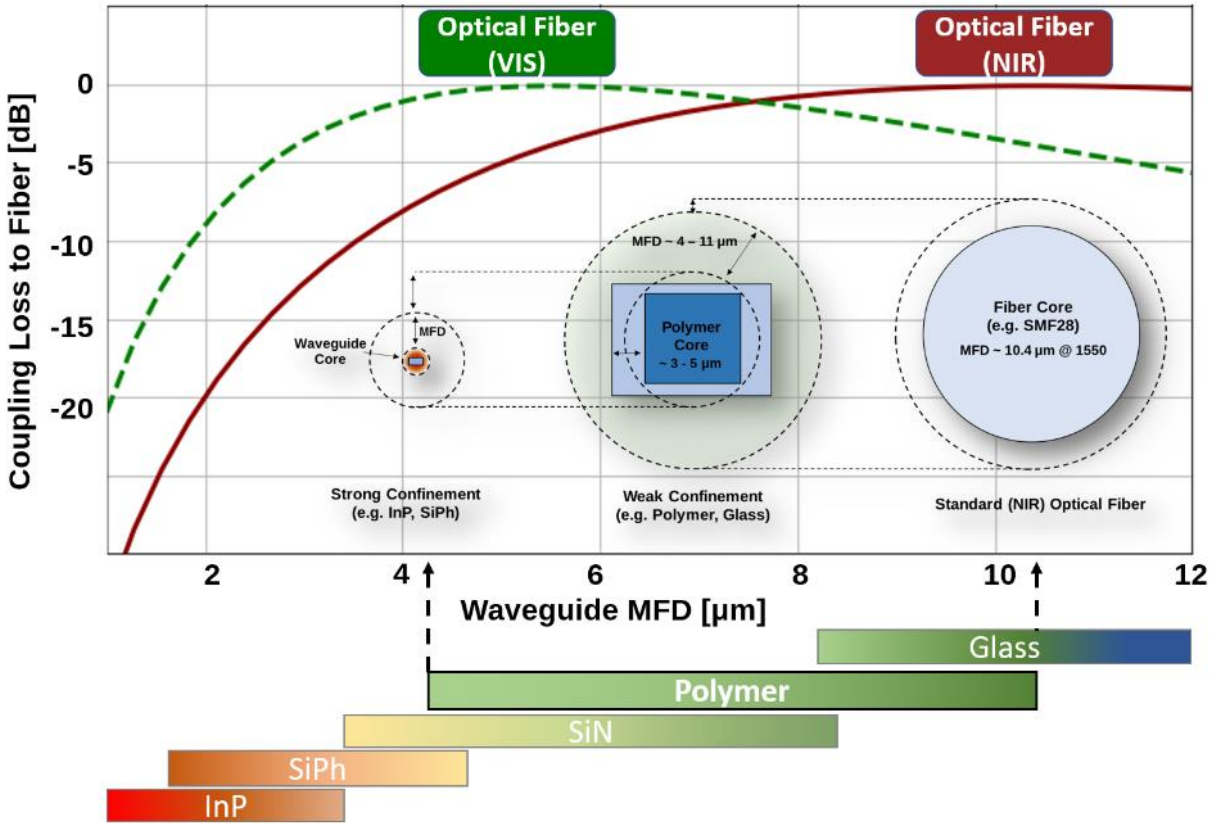


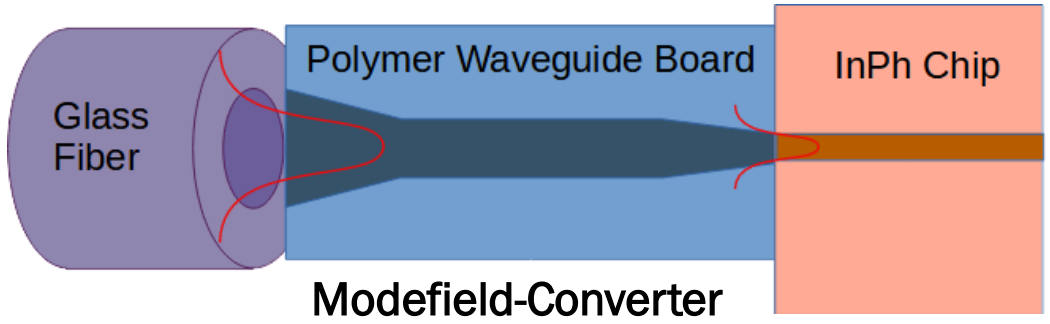
Optical Interfaces
Efficient PIC-Waveguide Coupling
(Adiabatic or Butt-Coupling)
Fiber-Interface & Connectors

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

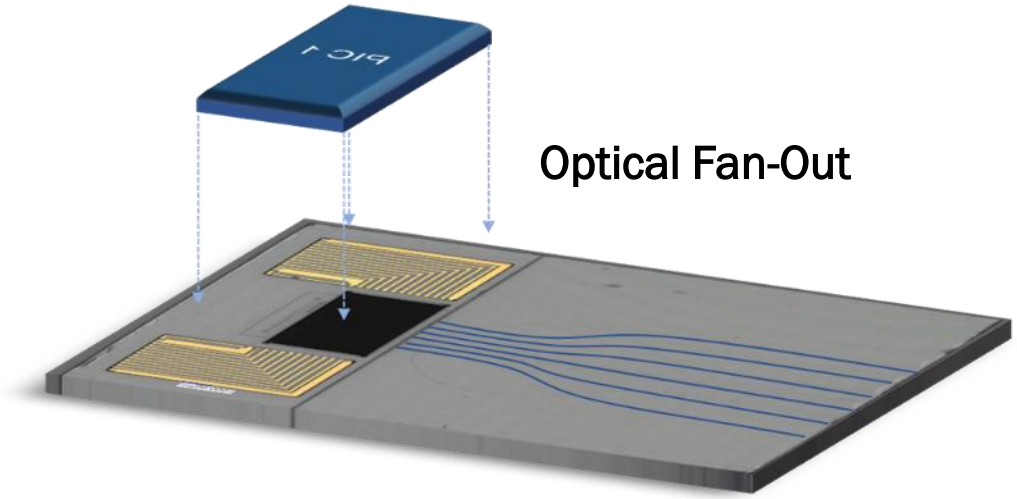
2) Polymer Photonics for advanced PIC Packaging

Edge-Coupling





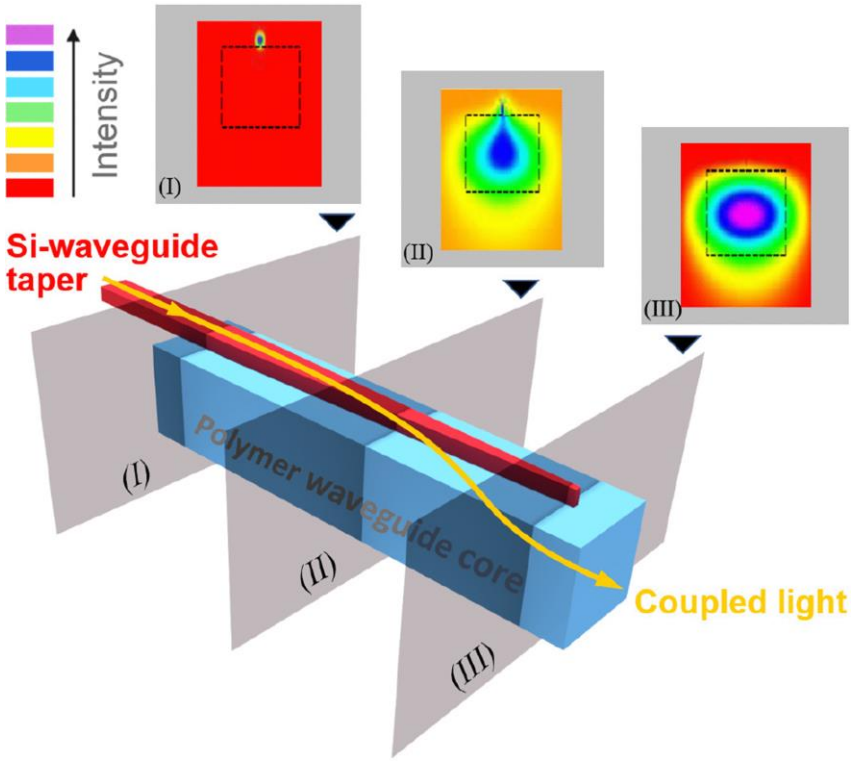
Modefield-Converter

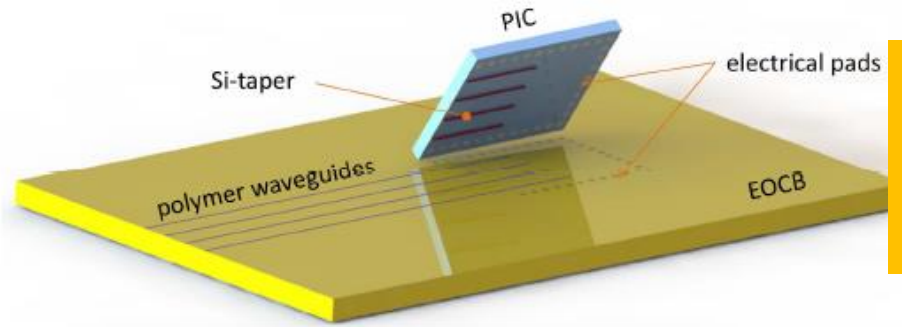


Optical Fan-Out

2) Polymer Photonics for advanced PIC Packaging

Adiabatic (Evanescent)-Coupling

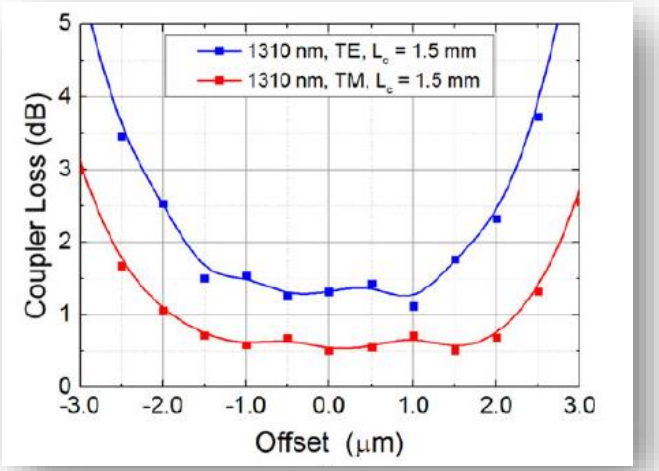


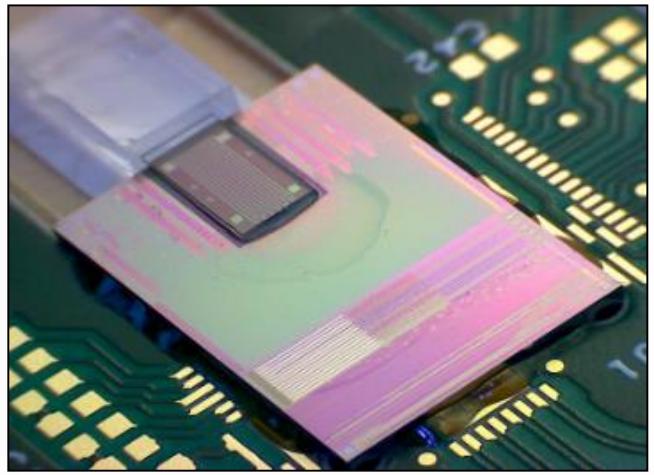


< 1dB loss

assembly tolerance ± 2µm

Broadband spectral operation

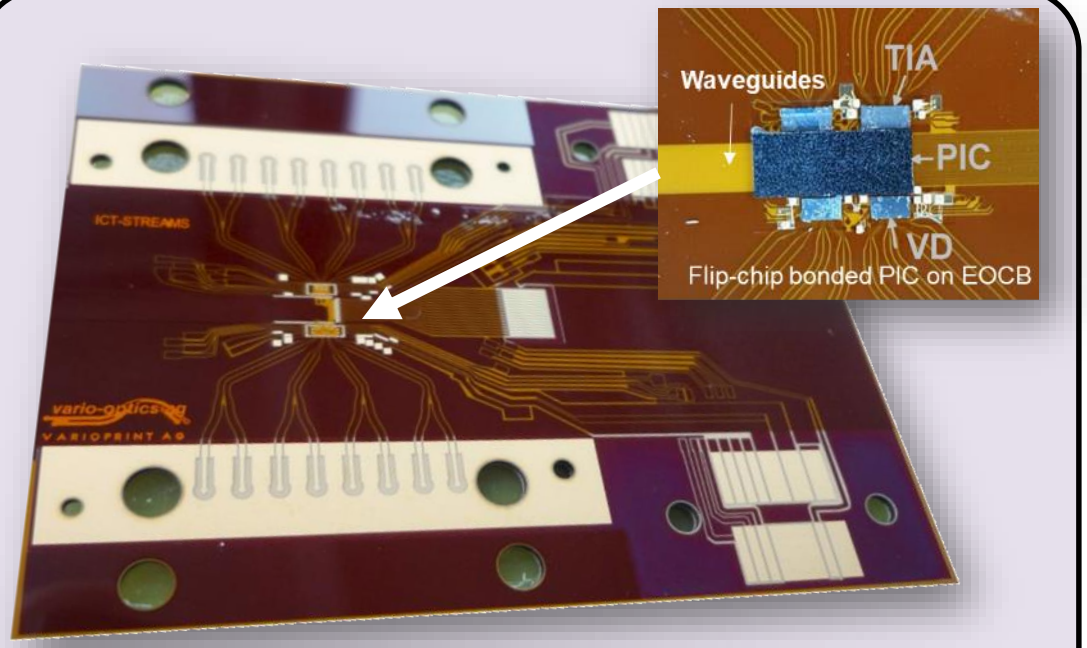




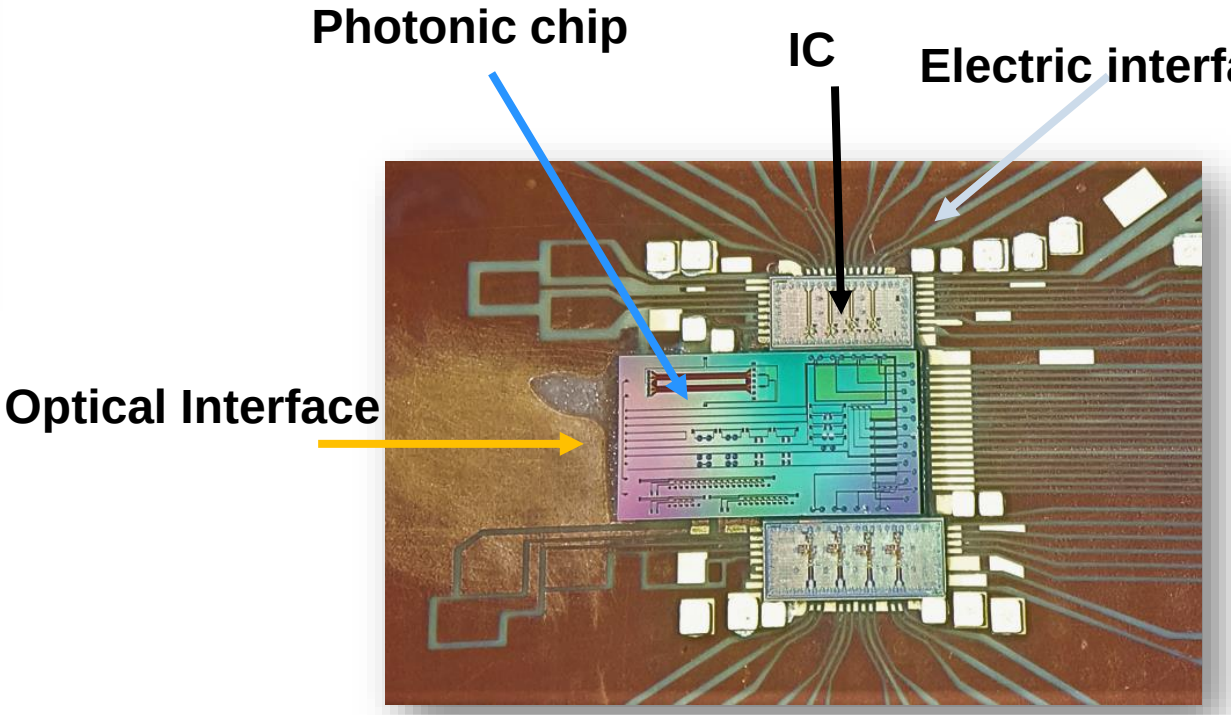
R. Dangel et al., "," in IEEE J Sel Top Quantum Electron vol. 24, no. 4, 2018.

PICs are not stand-alone systems

electro-optical-mechanical-thermal aspects



- **70 GHz photonic board for a transceiver**
- **400 Gb/s (8-channel)** data-transmission
- **5pJ/bit (50Gbit/s)**



- **PIC are not stand-alone systems**
  - (Fiber, Waveguides, ICs, RF, Thermal…)

Chip-packaging example: ICT STREAMS

Substrate for High-Speed optical Chip-Chip Communication, Silicon Photonics

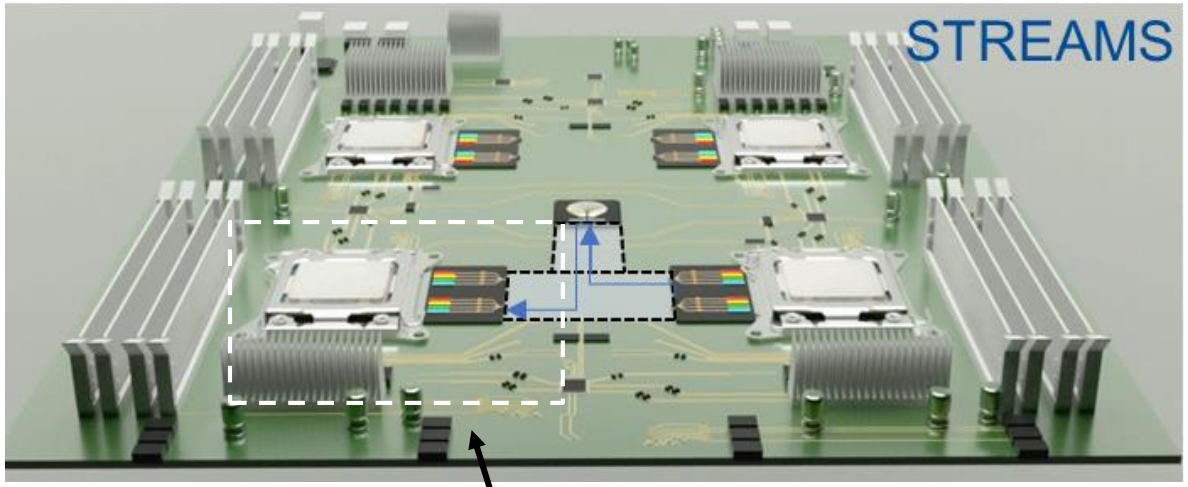
www.ict-streams.eu

In cooperaton with

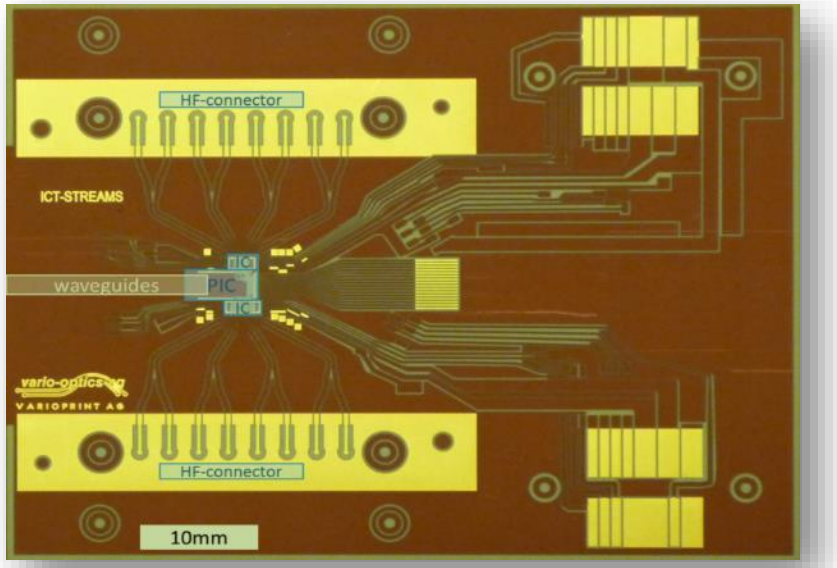
VARIOPRINT AG

- **EC-funded project ICT STREAMS:**

Efficient optical any-to-any communication for multi-socket boards (beyond 4 nodes, 25Tbit/s)



Photonic motherboard to host ICs, PICs
+ el. & optical on-board communication



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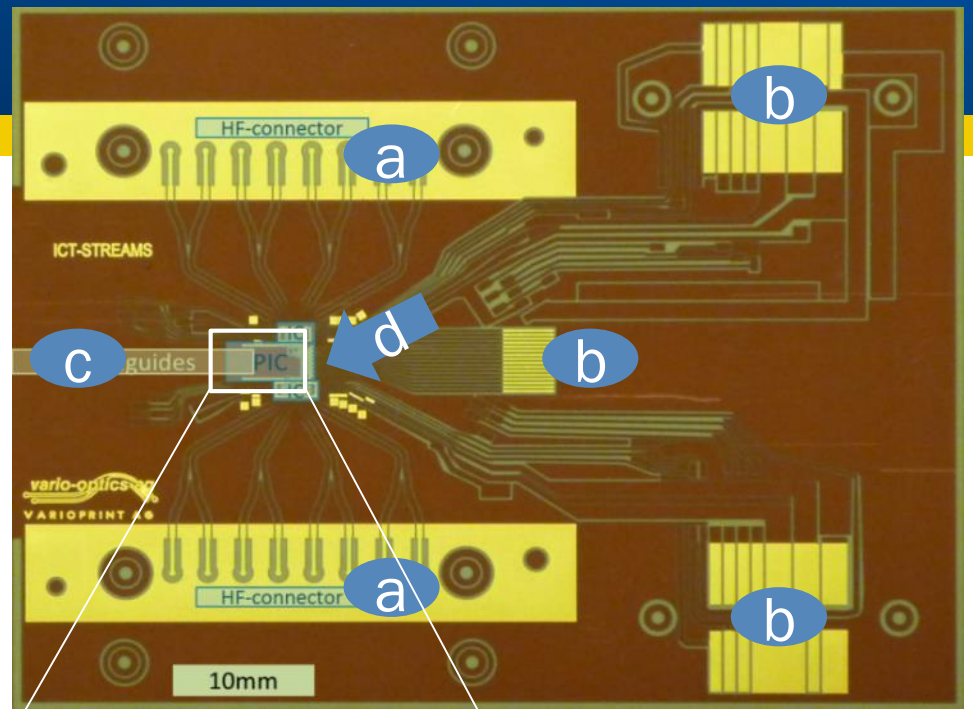
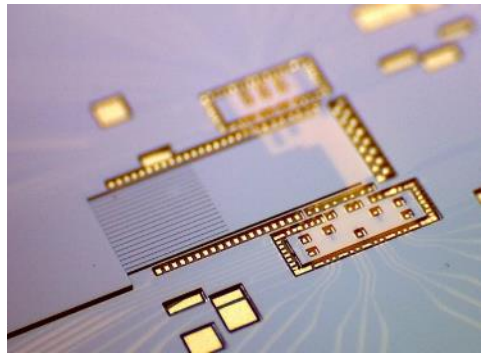
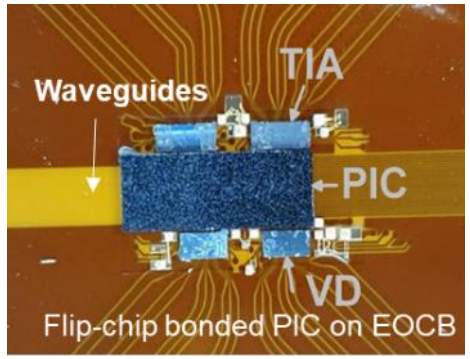






High-performance **Electro-optical circuit board** for high-data rate Silicon Photonic transceivers, with ultra-low power consumption

- a) & b) high-frequency RF electrical signal interface
- c) Polymer Singlemode waveguides (@1310 nm)
- d) adiabatic optical-coupling interface (< 1dB loss; assembly tolerance ± 2µm; Broadband spectral operation)

- **400 Gb/s (8-channel)** data-transmission
- 70% power reduction (compared to electrical communication)
- **5pJ/bit (50Gbit/s)** vs. 16pJ/bit (QPI)*

* T. Lamprecht et al., "EOCB-Platform for Integrated Photonic Chips Direct-on-Board Assembly within Tb/s Applications" , IEEE 68th Electronic Components and Technology Conference (ECTC), San Diego, USA, 2018, pp. 854-858

Summary: vario-optics Polymer Photonics Portfolio

> 15 years of Waveguide R&D Know-How

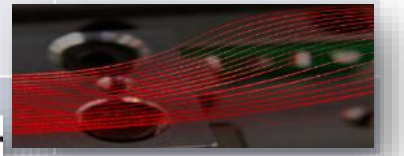
Process / Technology

Polymer

Multimode	30 – 500 µm
• 500 µm • 250 µm • 50 µm	

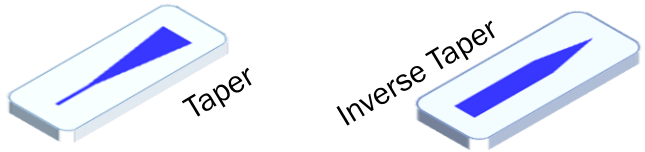
Singlemode	2 – 8 µm
• 3 µm • 5 µm	

Glass

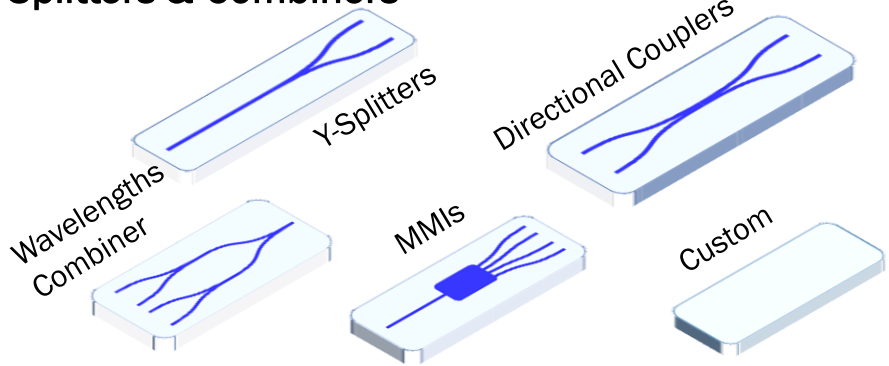
Singlemode	
~ 5 µm In collaboration with Fraunhofer IZM	

Functionality

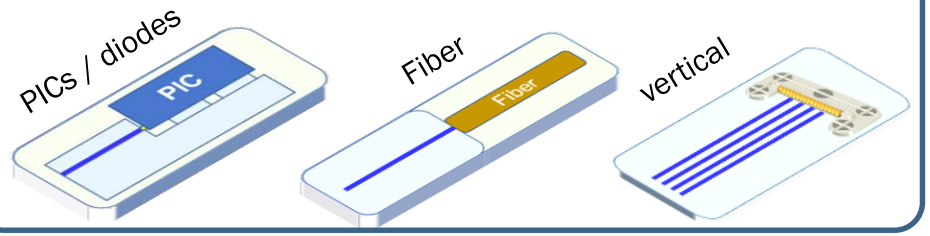
Modefield / NA Adjustment



Splitters & Combiners

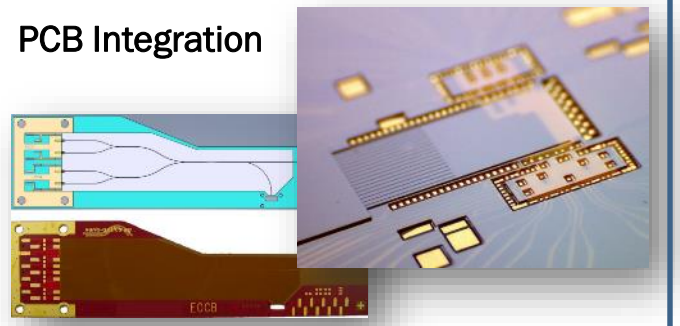


Connectivity

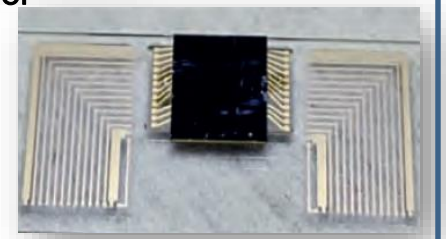


Integration & Assembly

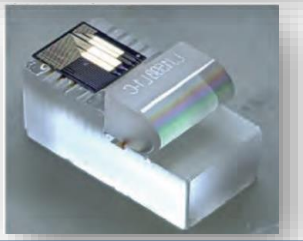
PCB Integration



Glass Interposer



Free-Space optics



Let´s keep up inspiring

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

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