Connecting Integrated Optical Systems
Novel Connectors for Future Applications

Dr. Markus Michler

Workshop on „Connectors for Advanced Fiber Systems“
of Swissphotonics and Diamond SA

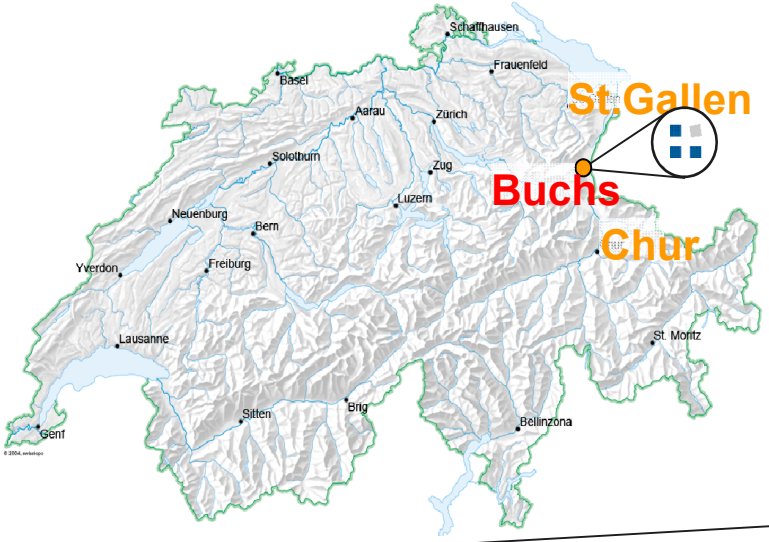
Losone 26.06.2014

NTB

Interstaatliche Hochschule
für Technik Buchs

FHO Fachhochschule Ostschweiz

Who we are ...



NTB Buchs

Institute for Micro- and Nanotechnology

Photonics group

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What we do ...

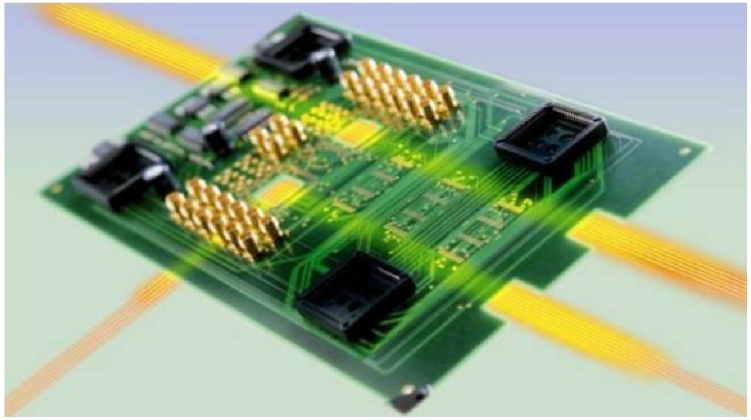
... where microtechnology meets optics

- Fiber Optics
- **Integrated Optics**
- **MOEMS**
- Thin Film Optics
- **Simulation** (**ray tracing** / physical optics / thin films)

vario-optics ag

EOCB technology

The EOCB concept ...



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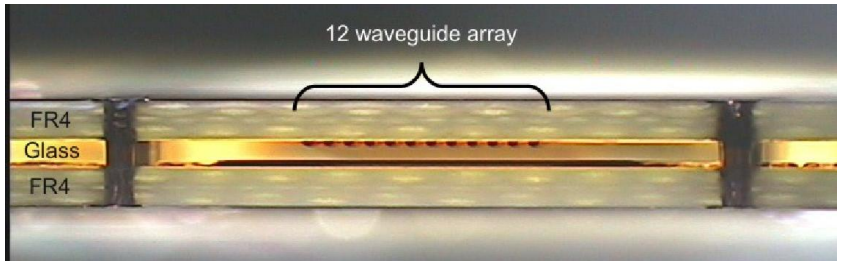
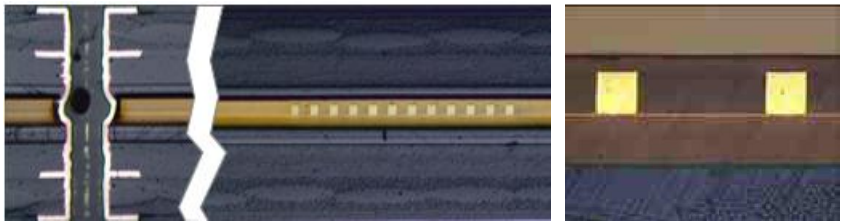
EOCB = electro-optical circuit board

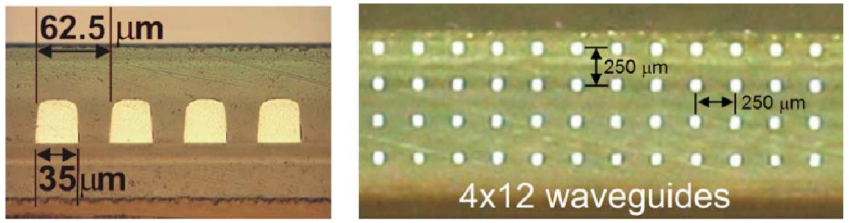
- Multimode waveguide technology
- Thin glass or **polymer waveguides**
- WGs in inner layers (laminated)
- Multilayer boards optical/electrical
- Different WG pitch possible (62,5µm / 125µm / **250µm**)



Thin Glas WG for Optical Printed Circuit Boards
© Frauenhofer IZM



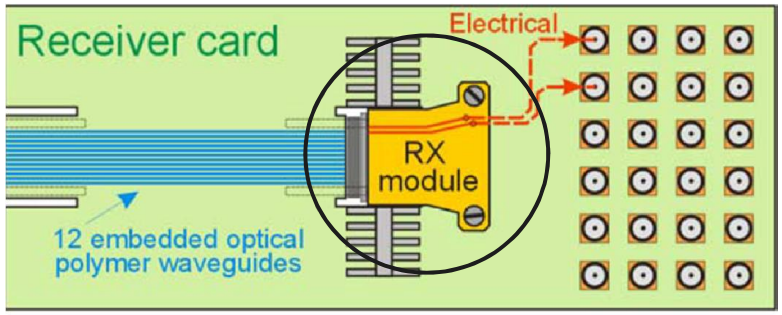
Polymer Waveguides 50x50µm embedded in PCB
© vario-optics ag

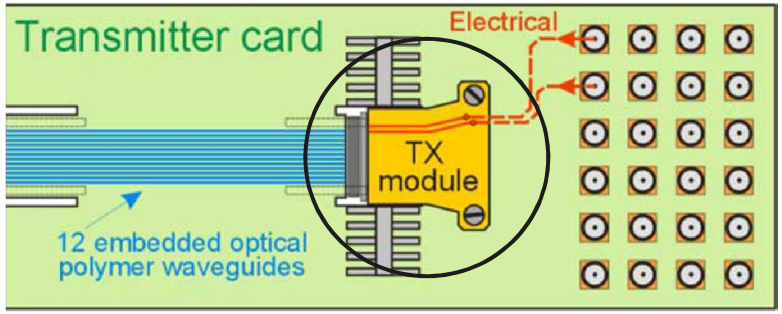


© DANGEL et al.: Polymer Waveguide based board level optical interconnect technology for datacom applications (2008)

... and where connector solutions are needed (I)

Transceiver (TX) / Receiver (RX) coupling

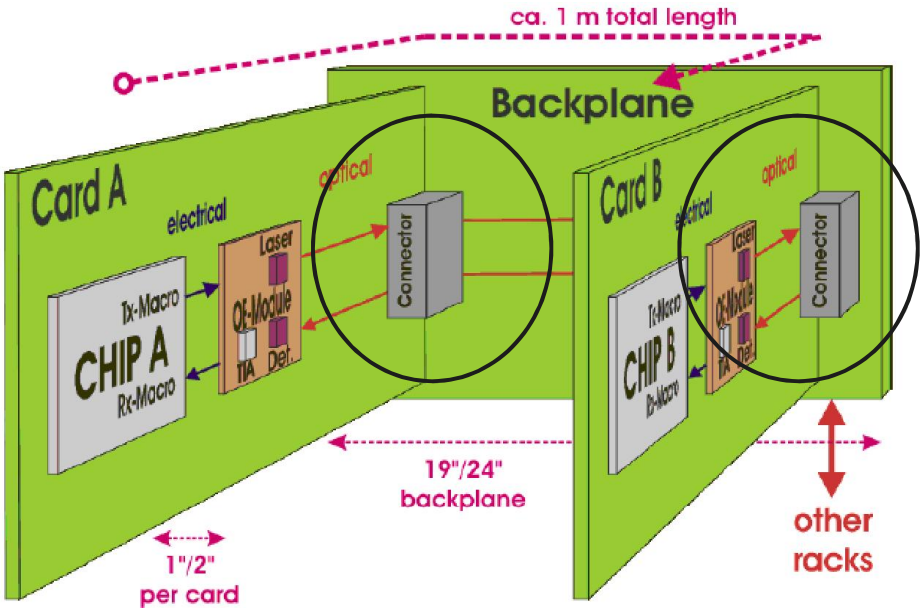




- Fixed / reworkable connection
- Small optical tolerances (~µm)
- Active / machine vision alignment possible

... and where connector solutions are needed (II)

Board to board coupling: (e.g. daughter card to backplane)

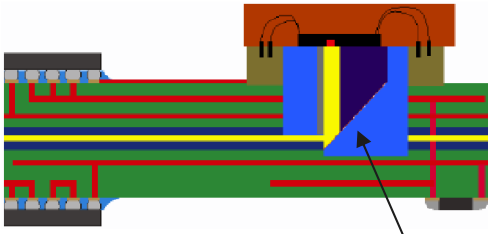


- Optical AND electrical connectors
- detachable connection
- big mechanical tolerances (~mm)

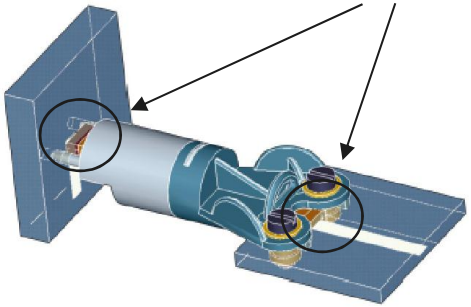
© IBM – Optical Interconnects – Intra system data transfer with light (2005)

Deflection coupling – NeGIT- pin

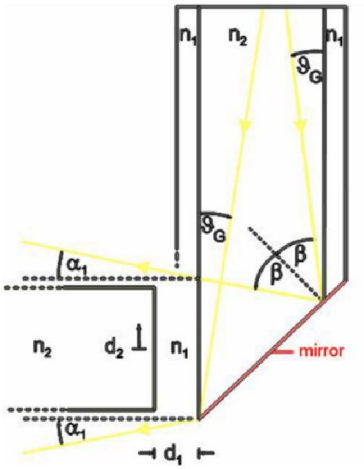
Tx / Rx Modul

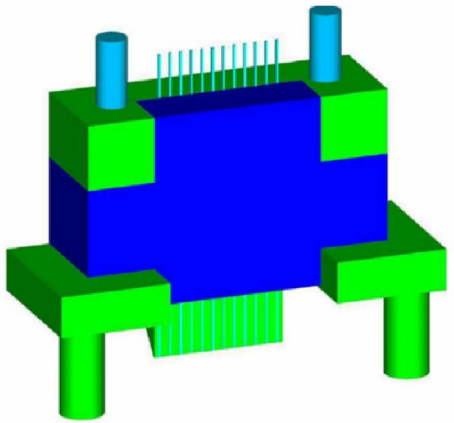


NeGIT- pin



board to board coupling

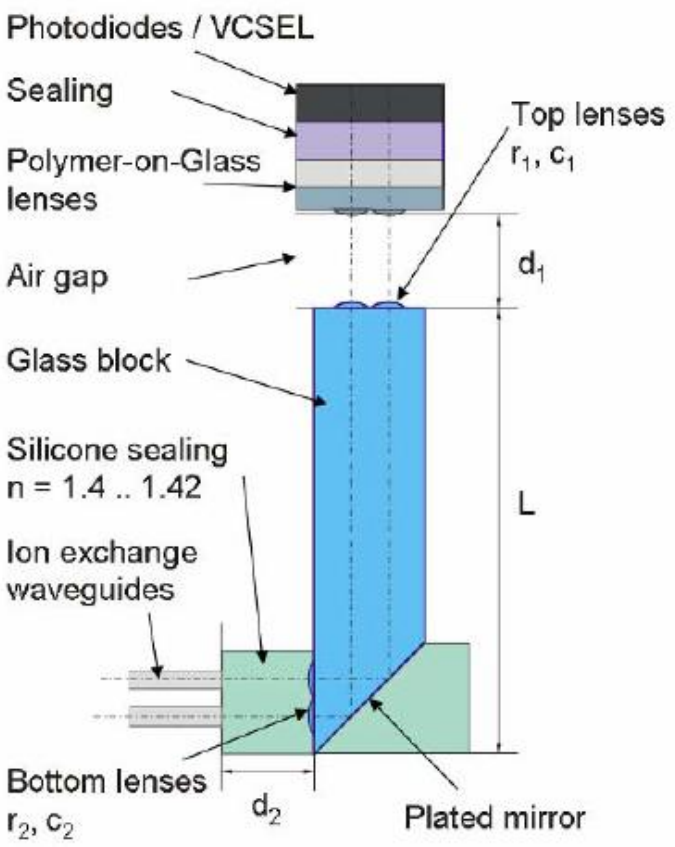


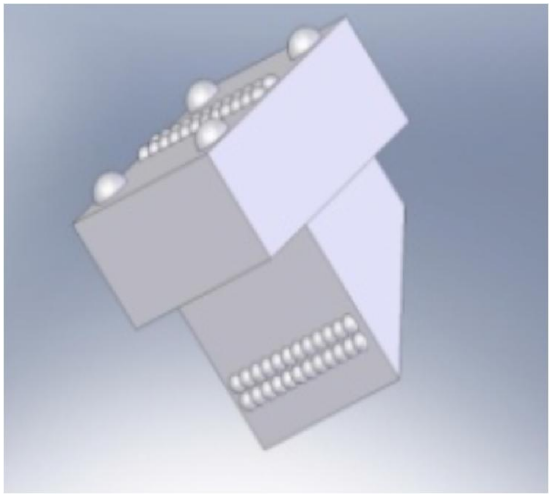


- 90° mirror reflection (kind of butt coupling)
- MM waveguides → ray-tracing simulation
- ca. 1.5dB losses @ ~5µm tolerances
- Rx/Tx coupling & board to board coupling

Erni / Frauenhofer IZM, et al. in Proc. of SPIE Vol. 6124 612407 (2006)

Deflection coupling – lens / mirror combinations

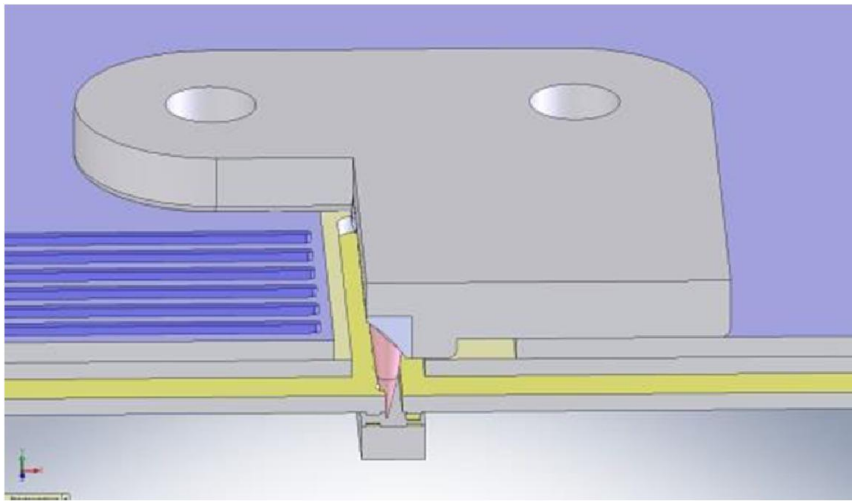


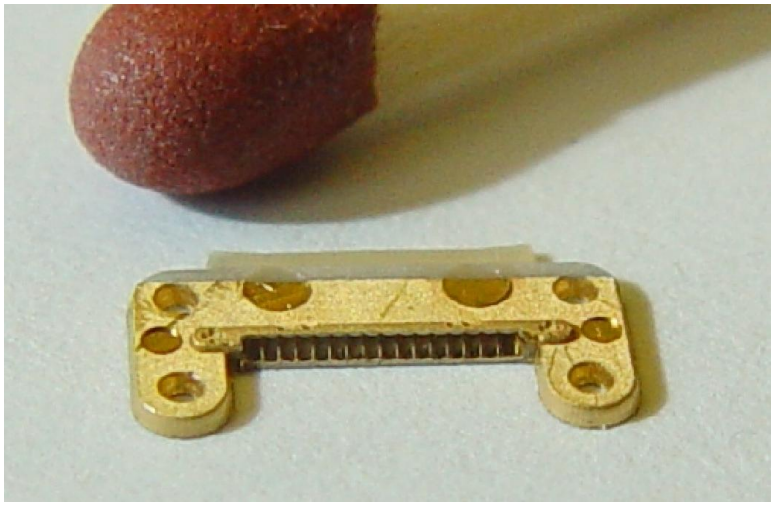


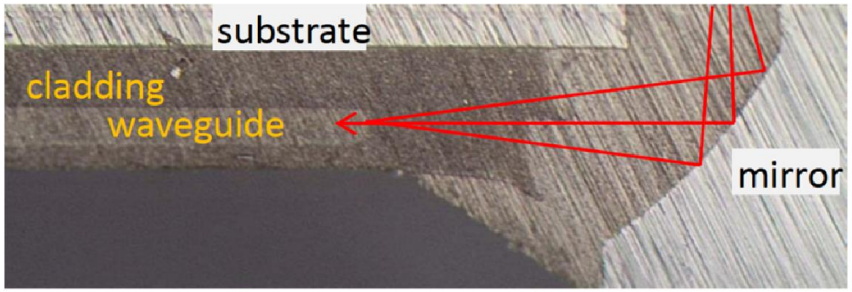
- Passive element using TIR and lenses
- high refractive index glass with n > 1.8
- Parallel beam optics inside
- multilayer waveguides can be connected

Erni / Frauenhofer IZM, et al. in Electronic Comp. and Techn. Conf. / IEEE 2008

Deflection coupling – integrated mirror device

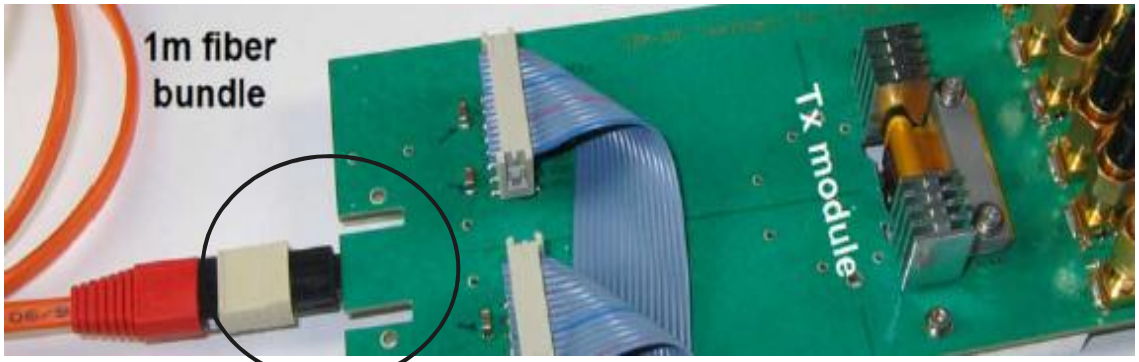




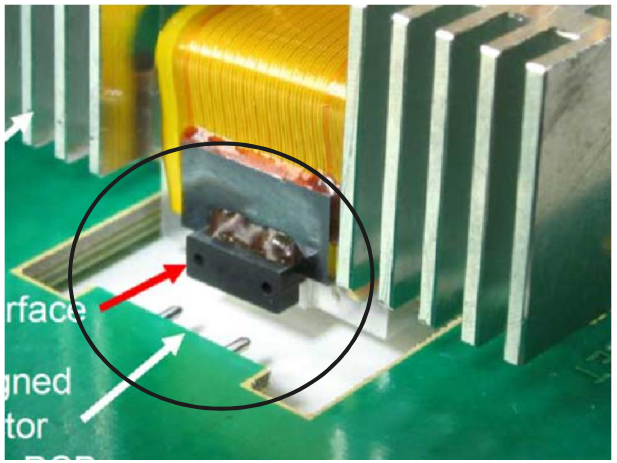


- Mirror device with beam-shaping
- Metallized injection moulded parts
- Integrated in waveguide layer
- Integrated in EOCB production flow

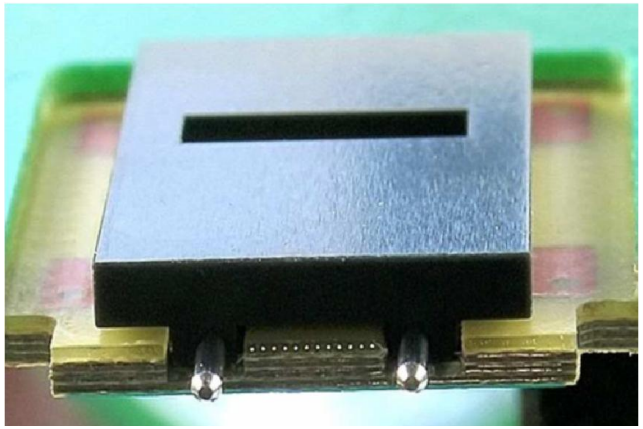
Butt coupling at the facet



Board to board



Tx / Rx to board

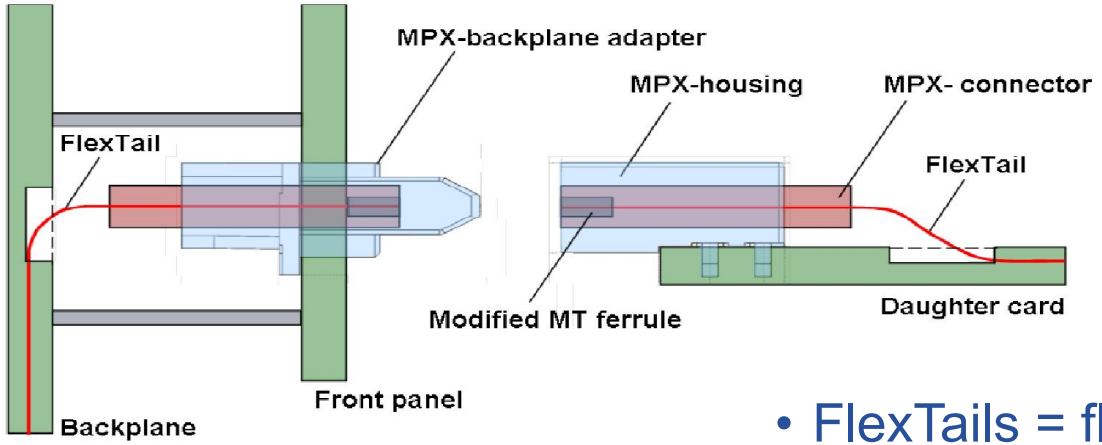


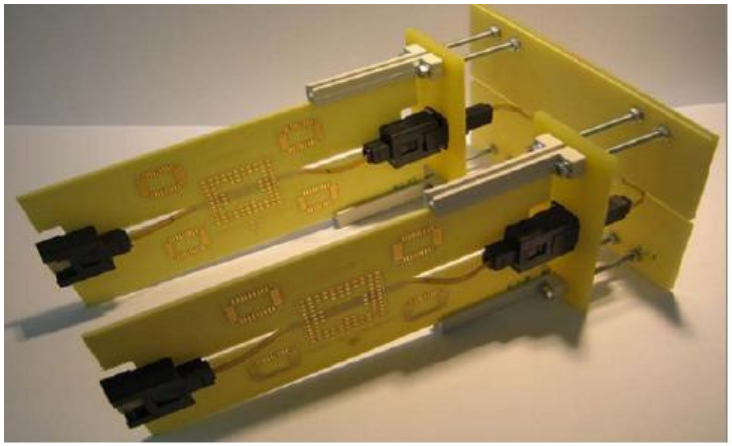
MT compatible pins

- Milling of PCB – butt coupling to WG facet
- Integrated passive alignment structures for MT pin adaptors
- Direct coupling of Rx / Tx modules
- Direct coupling to MT connector for board to board coupling

IBM / DANGEL et al.: *"Polymer Waveguide based board level optical interconnect technology for datacom applications"* (2008)

Flexible waveguide coupling - FlexTail



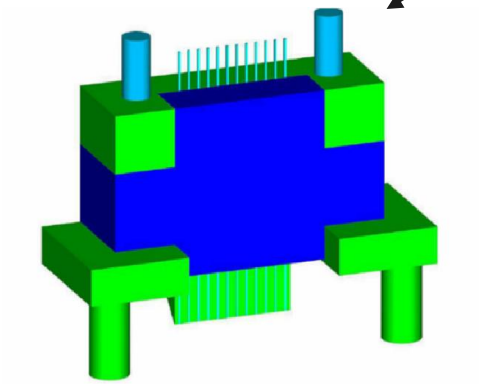


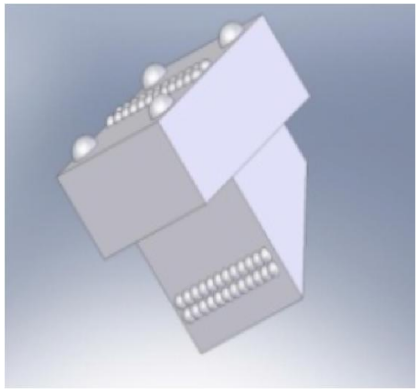
- FlexTails = flexible out-of-plane coupling bridges for the polymer WGs
- FlexTails terminated with modified MT based fiber ferrules
- pluggable coupling solution based on MPX^{TM} multi fiber connectors
- Tolerance staging (3mm→300µm→3µm)

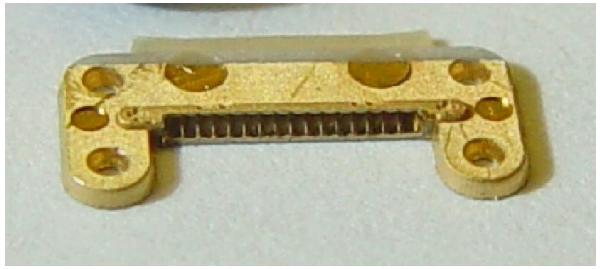
Tyco Electronics / vario-optics: „*All optical pluggable board-backplane interconnection system based on an MPX^{TM}-FlexTail connector solution*" (2010)

What we think is best for Rx/Tx coupling

Deflection coupling / 90° coupling

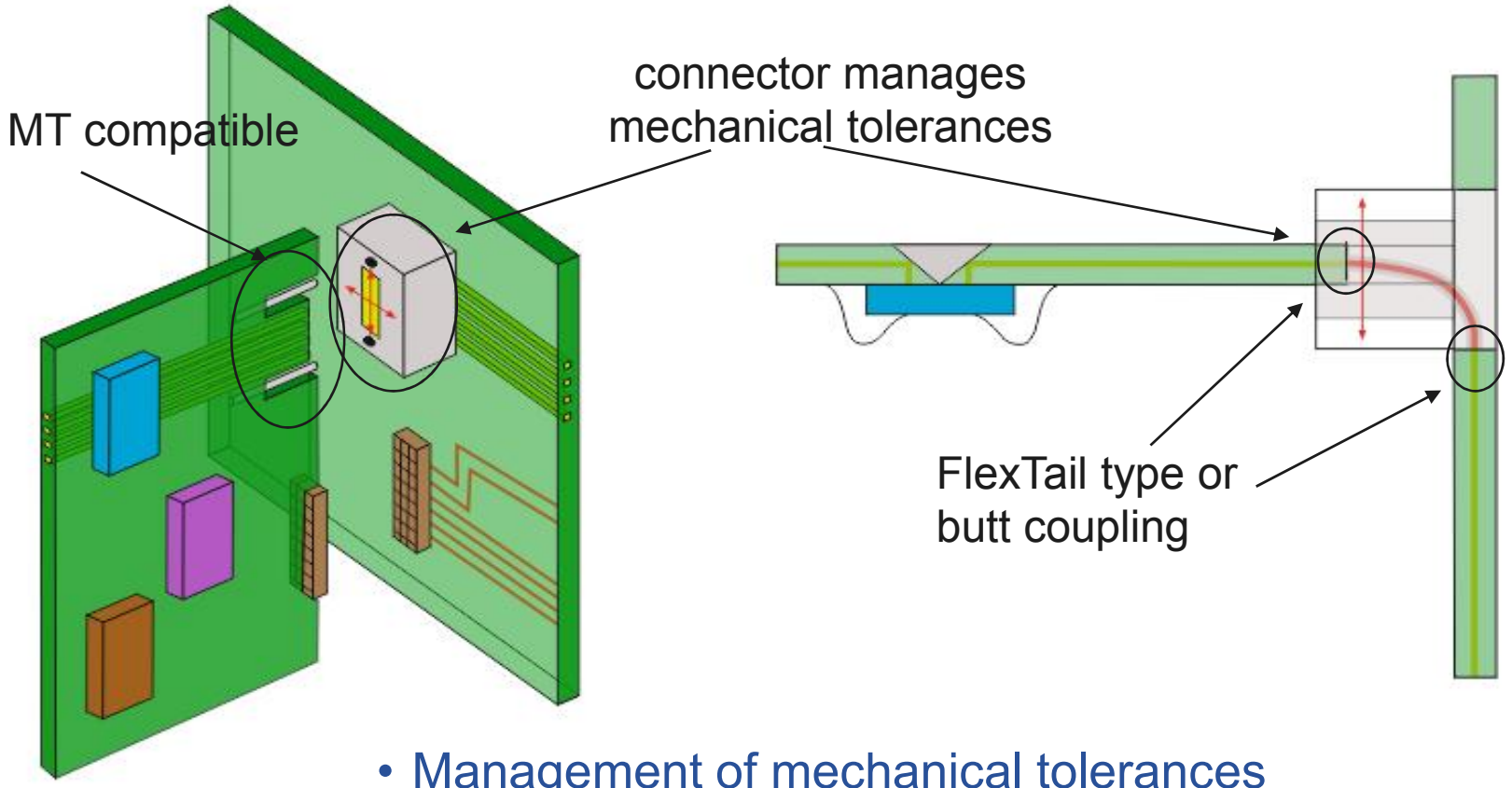






- Optical Pad: VCSEL-arrays (Tx) and diode arrays (Rx) mounted on EOCB top layer using a receptacle (not directly soldered or glued)
- Active alignment (not preferred) or vision based alignment possible
- Deflection element doesn‘t have to be reworkable

What we think is best for board to board coupling



- Management of mechanical tolerances
- FlexTail type / butt coupling concept to minimize losses
- Daughter card with MT compatible connector

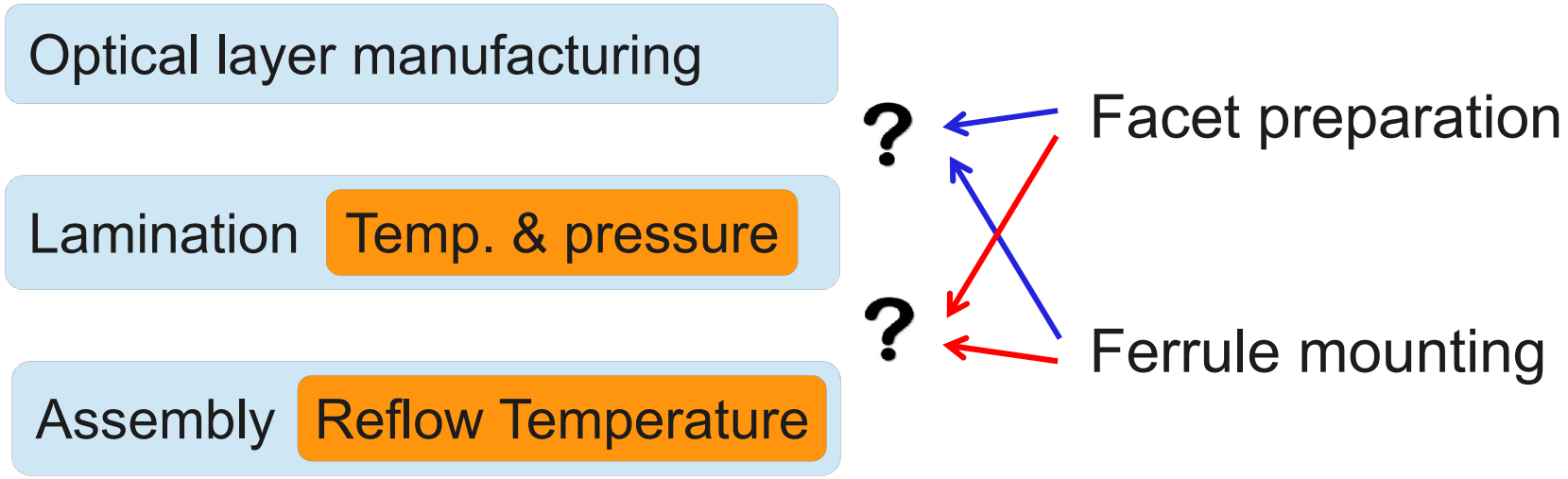
Requirements for board to board coupling

Opto-mechanical interface	Channel spacing: pitch 125µm (250µm) Number of waveguides: 12 (per row) [48 / 96 multi row] Space requirements: total waveguide width +4mm
Thermal stability	Ferrule has to withstand reflow (4x) / lamination
Optical coupling losses	≤ 0.9 dB (waveguide to waveguide)
Tolerances: relative deviation between the two boards to be coupled	To be defined assumption: ±0.2mm in all three dimensions defined by the electrical connector
Compensation of mechanical tolerances	Integrated in the optical connector → passive alignment required
Mechanical dimensions	Minimum line-card spacing: 15mm Space requirement on line card: ca. 15mm (distance between line-card and backplane: ca.10mm)

Connectors and EOCB production flow

Connector concepts have to be realized close together with EOCB manufacturer and assembler due to the EOCB production flow

- Temperature load / pressure during lamination or reflow
- Machining (e.g. milling) of processed boards is critical



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Thanks a lot for your attention

I am ready for open questions

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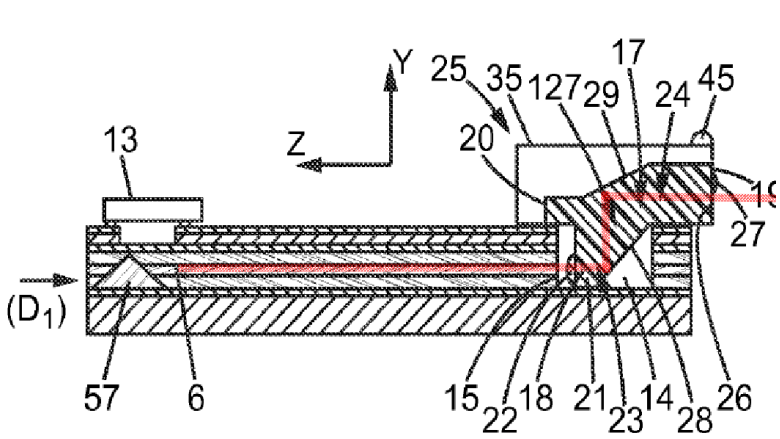
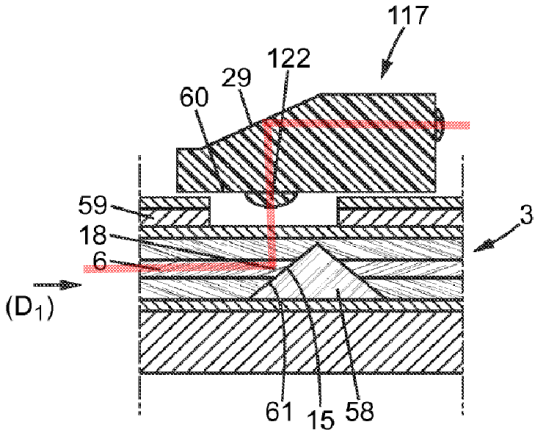
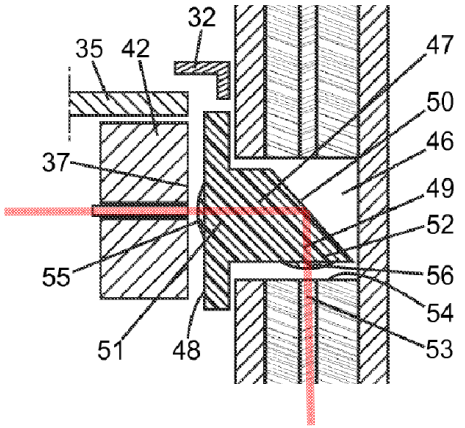
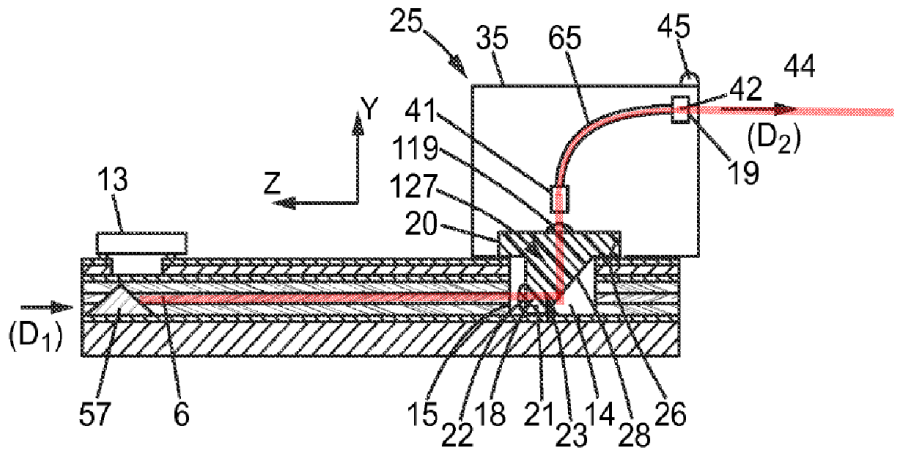
Deflection coupling – The FCI patent (lens & TIR)





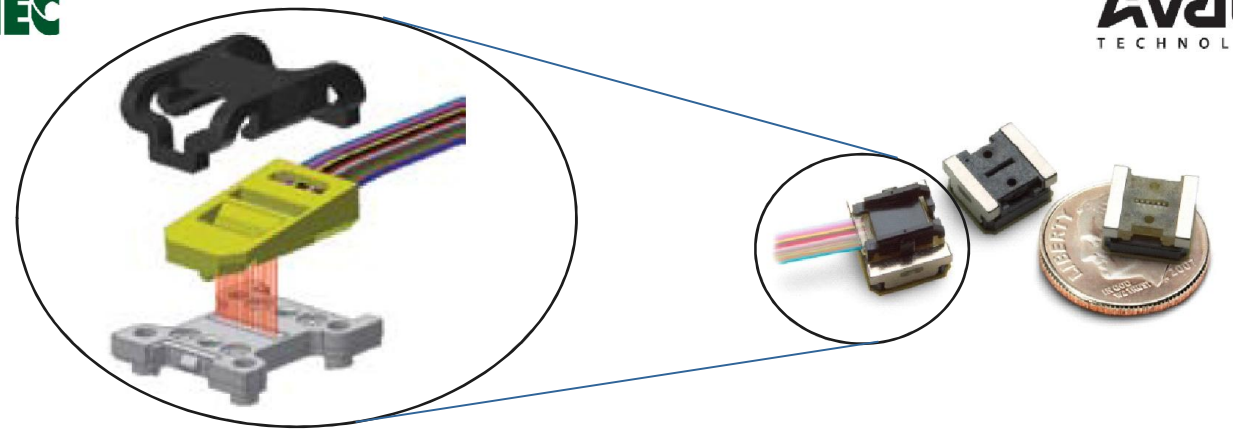




- Lens - TIR - lens combination
- Collimated beam optics inside
- Light guided parallel outside the board or deflected by 90°

FCI - Patent Application WO 2012/017318 A2

Deflection coupling – prizm connector

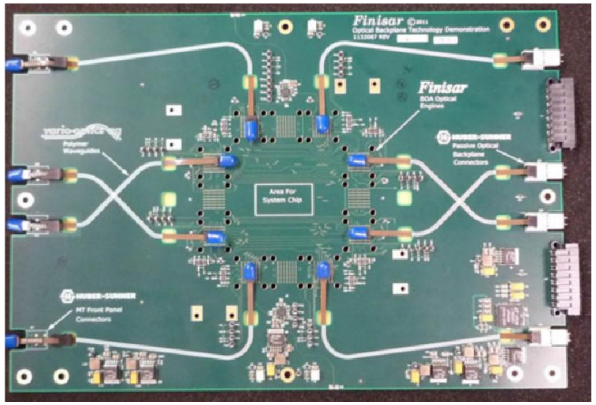


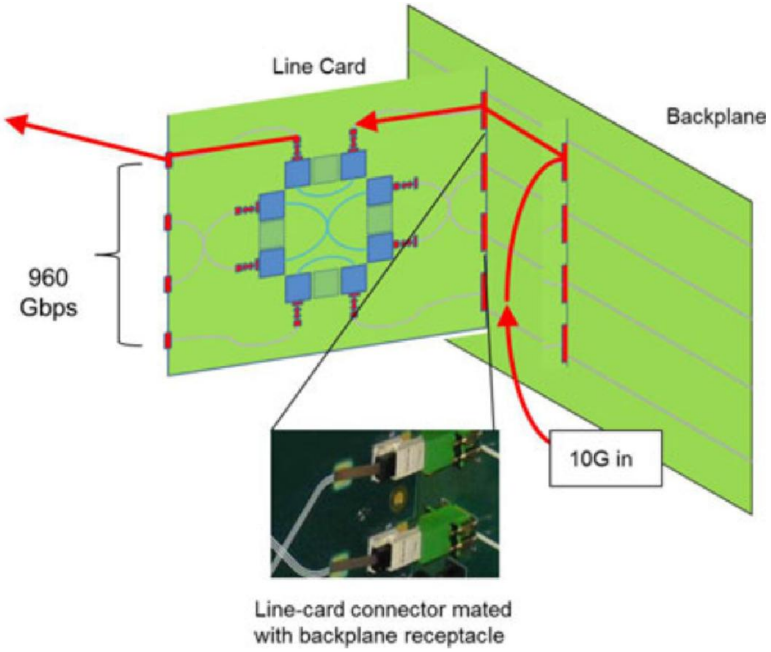
PRIZM® LightTurn® Connector

- TIR (total internal reflection) lens
- Integrated alignment pins
- Housing protects TIR lens array
- Collimated light at optical interface

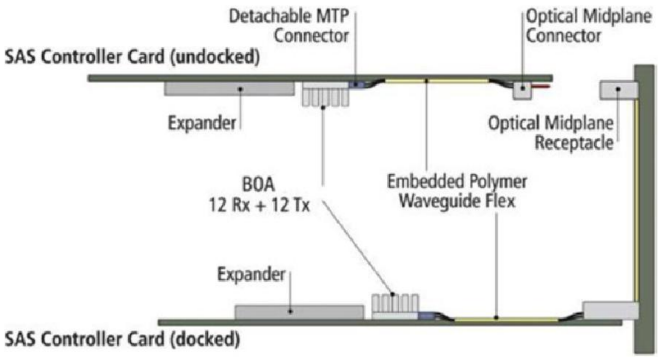
USCONEC / Avago Technologies

Flexible waveguide coupling - FiberGate





Line-card connector mated
with backplane receptacle



- System similar to FlexTrail
- FiberGate connectors instead of MPX™

Huber+Suhner / vario-optics: „*960 Gb/s Optical Backplane Ecosystem Using Embedded Polymer Waveguides and Demonstration in a 12G SAS Storage Array*" (2013)