Latest developments in glass-based photonic circuits and assemblies

Adrien BILLAT – Business and Product Developer

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teem PHOTONICS | A little piece of glass can change everything

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Teem Photonics – Corporate background

Established in 1998

- Spin-off from Schneider Electric
- Enters the telecommunication market for FTTH application
- Strong R&D team, several patents

1998 – Pioneer in erbium-doped waveguide amplifiers

2000 – Introduction of glass-based components and sub-systems for telrcommunications

2005 – Acquisition of the Q–switch microchip laser portfolio from Lumentum

2012 – 10,000 lasers shipped worldwide

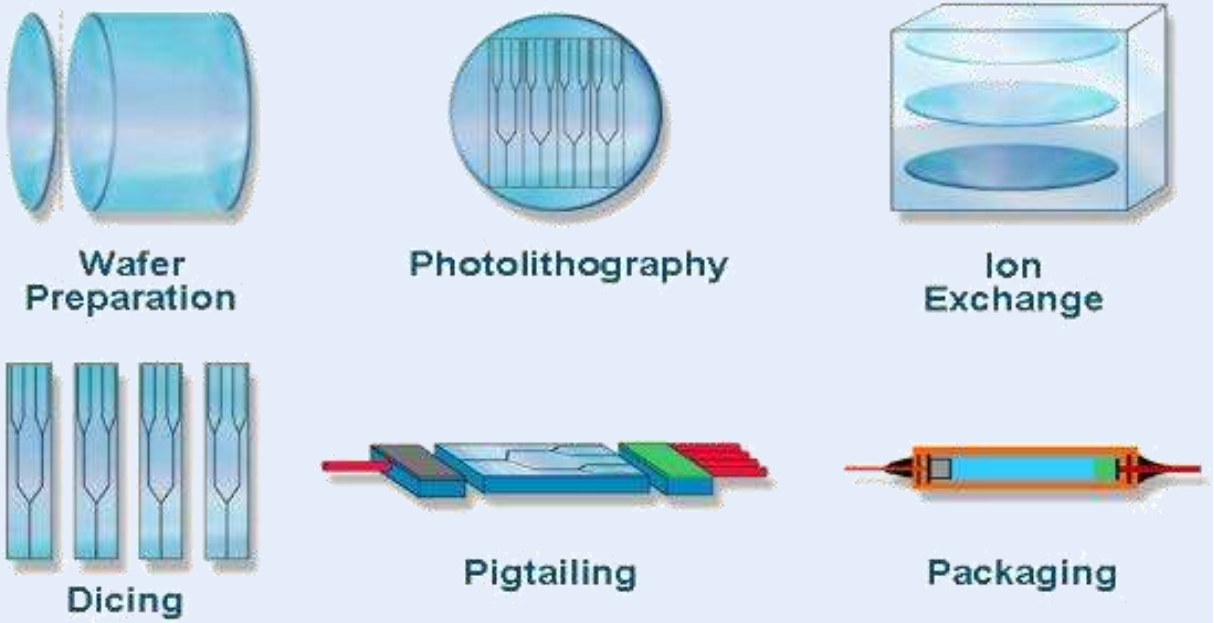
2016 – Introduction of WAFT – interposers for SiPh coupling

2018 – ioNext product line

2020 – First PDK release

ioNext: a unique process on glass

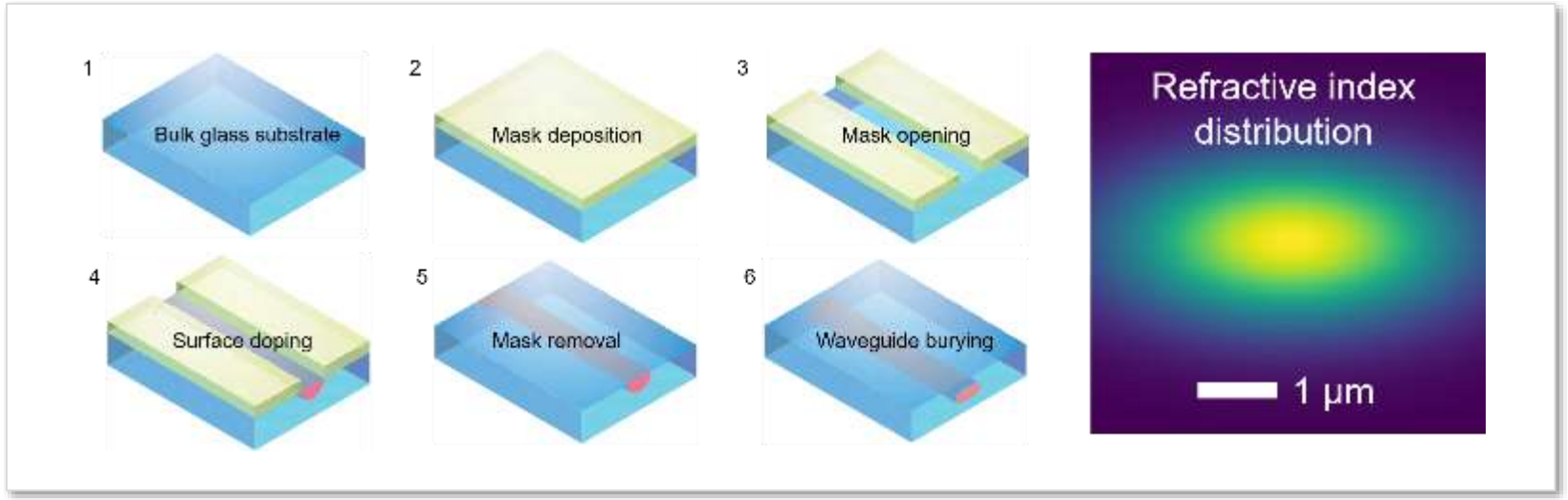
ioNext Process flow



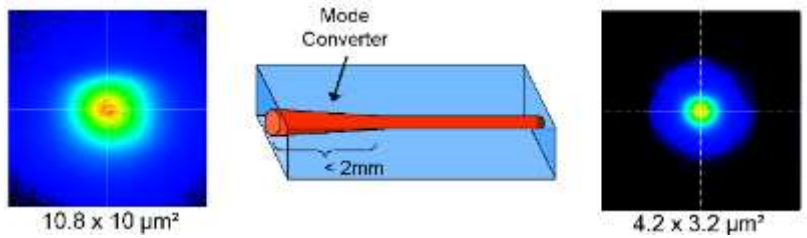
Value proposal

- Glass technology
  - Large transparency band: 400 – 2000 nm
  - Low propagation loss: 0.15 dB/cm
  - Polarization maintaining
  - Low PDL, low birefringence
  - Low temperature dependence: 10^{-5} $\Delta n_{eff}/K$
- ioNext specific
  - Low fiber coupling loss : < 0.2dB
  - Compactness : radius of curvature 800µm
  - **Short turnaround time: down to 4 weeks**

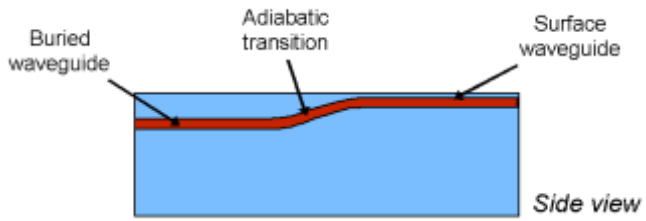
ioNext: the physics behind



Spot size converter



Depth modulation



Extended optical library

- Spot size converter
- Surface interaction

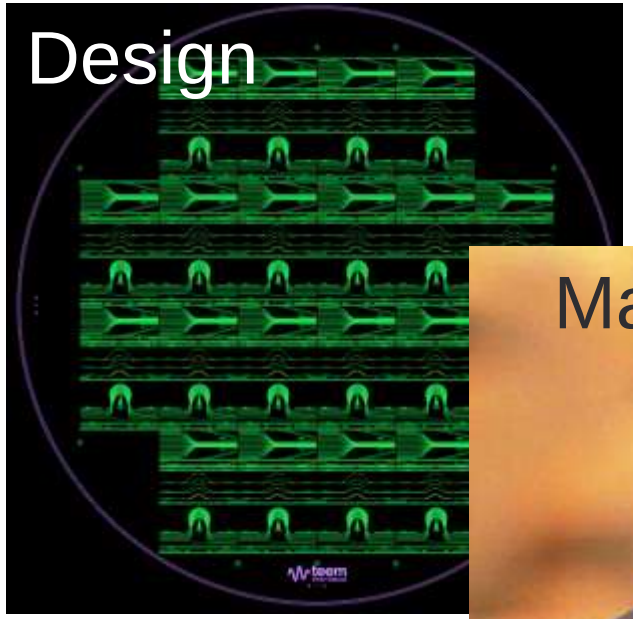
ioNext: a complete photonic platform

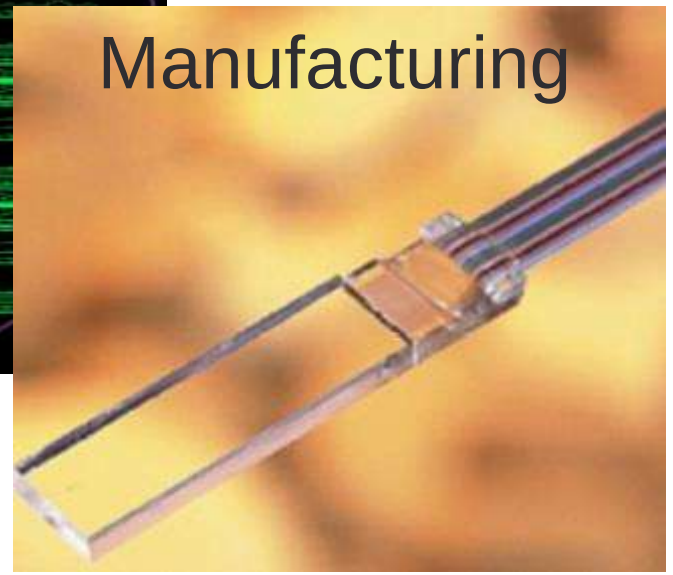
- Splitters and couplers
- Spot size converters
- MUX (duplexers and AWGs)
- Interferometers
- Waveguide crossings
- Waveguide Bragg gratings
- Thermo-optic phase shifter
- Polarization filters

Coming soon

PDK available !

Nazca design
photonic IC design framework





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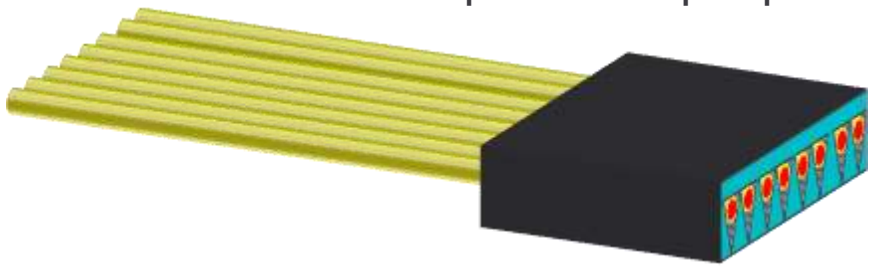
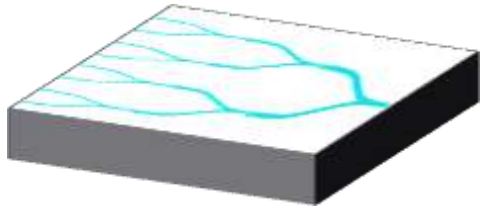
Fiber to chip assembly services

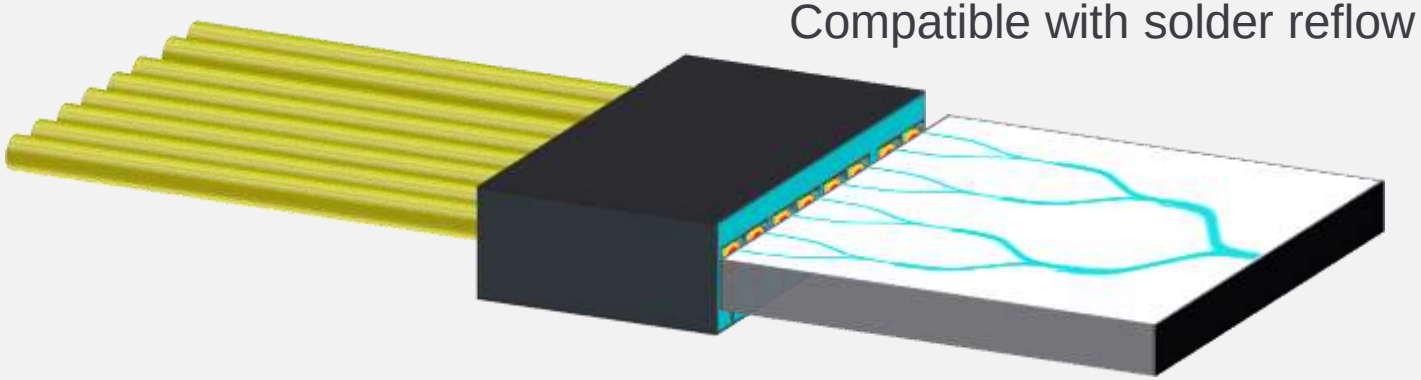
Fiber Array (FA)
SMF or PM fiber
250µm or 127µm pitch



ioNext chip
Polarization maintaining waveguides
250µm or 127µm pitch

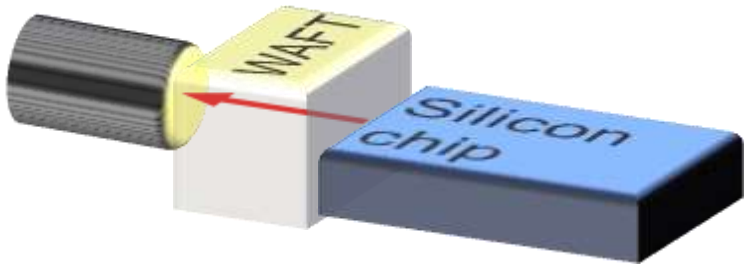


Fiber to chip assembly
Up to 64 fibers per FA
Insertion loss uniformity <0.2dB
Compatible with solder reflow



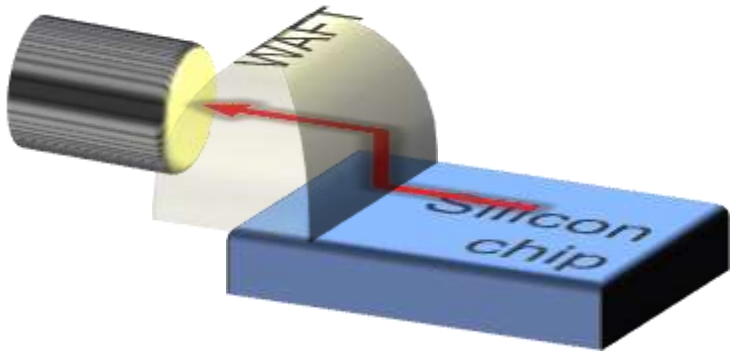
WAFT: PIC coupling solutions

Edge coupling



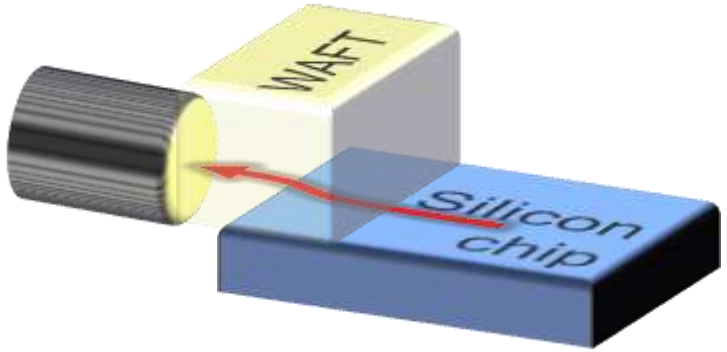
- Low loss
  WDM compatible
  TE and TM compatible
- Wafer-level incompatible
  Tight alignment accuracy

Top coupling



- Alignment tolerant
  Wafer level compatible
- Grating coupler loss
  WDM-limited
  TM limited

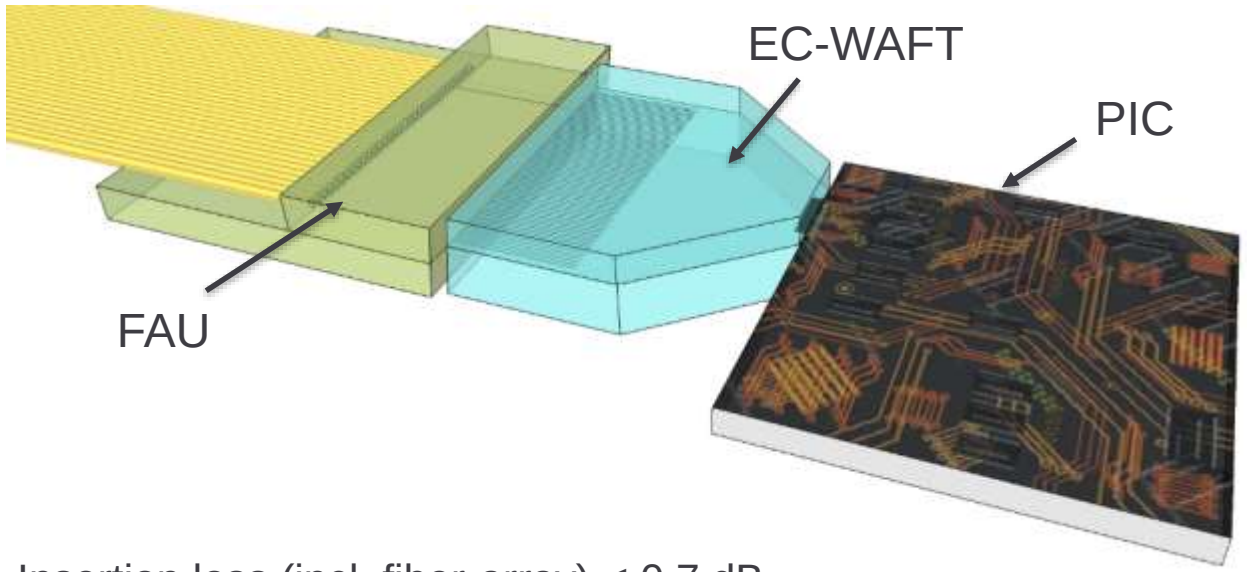
Evanescent coupling



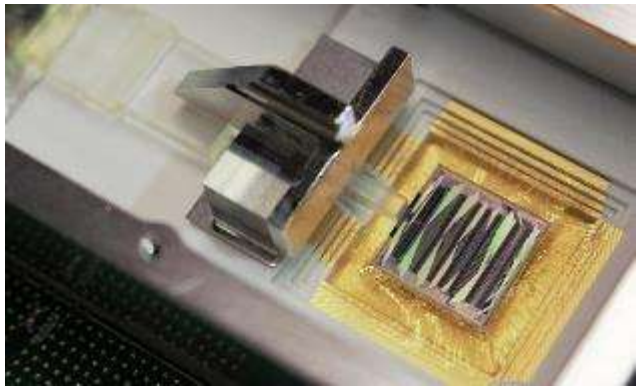
- Low loss
  WDM compatible
  TE and TM compatible
  Alignment tolerant
- BEOL constraint

EC-WAFT : Pitch and mode adpatation

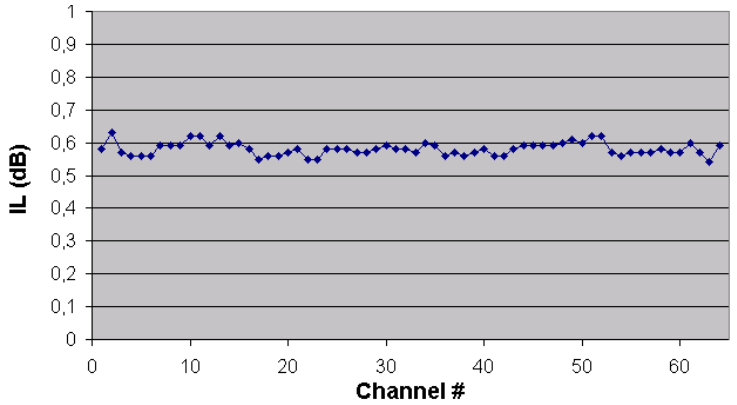
MFD matching to PIC edge couplers



Insertion loss (incl. fiber-array) < 0.7 dB
PIC side MFD 4x3 µm (1/e²)
PIC-side pitch >20 µm
SM and PM fiber-compatible



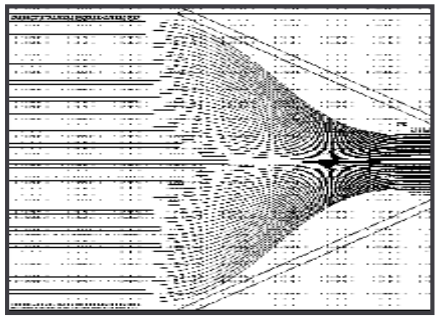
High channel count uniformity



Large pitch adaptation

64 channels

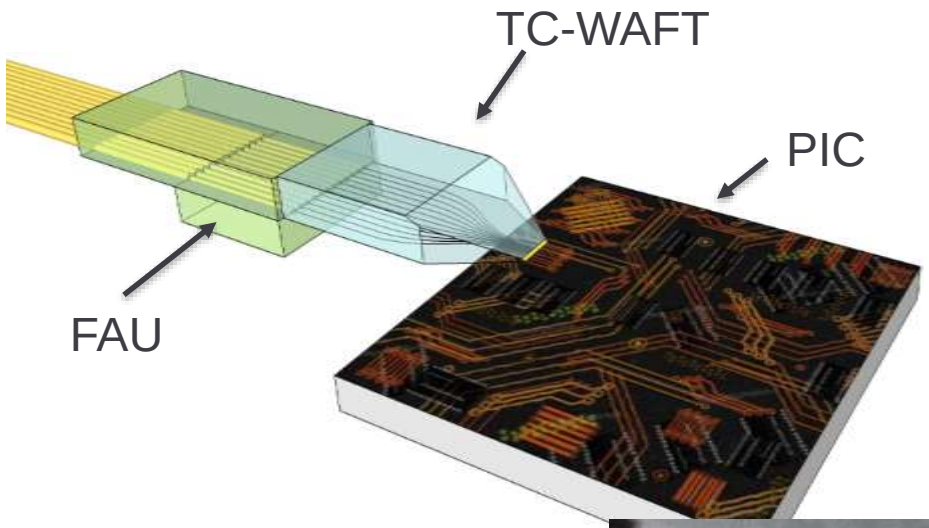
127 µm

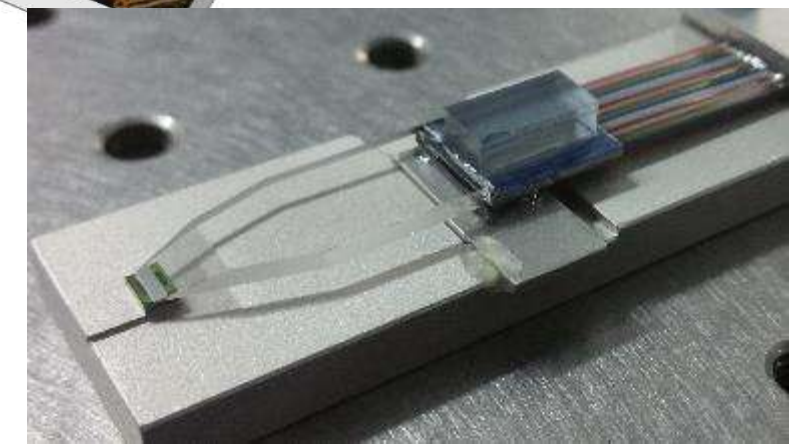


20 µm

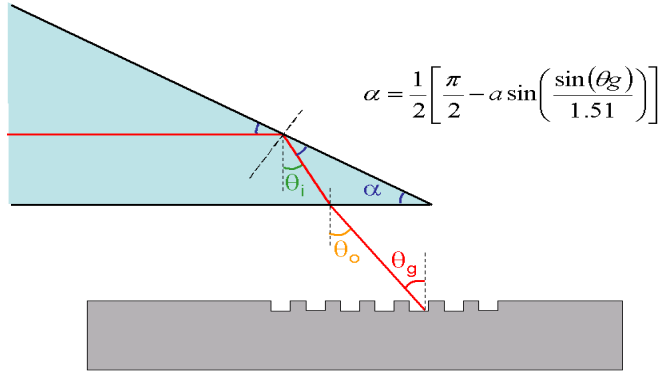
TC-WAFT series for SiP top coupling

Low profile solution for grating couplers

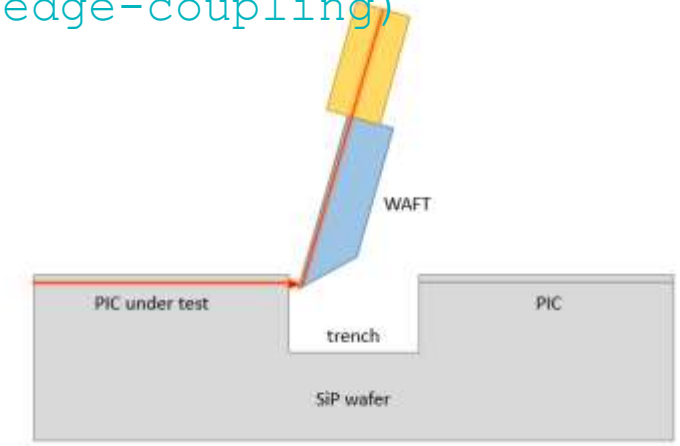




- Packaging



- Wafer-level PIC testing (edge-coupling)



EV-WAFT series for evanescent coupling

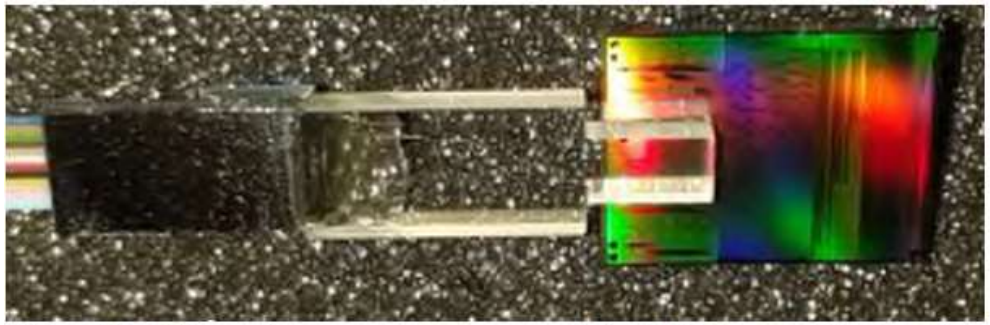
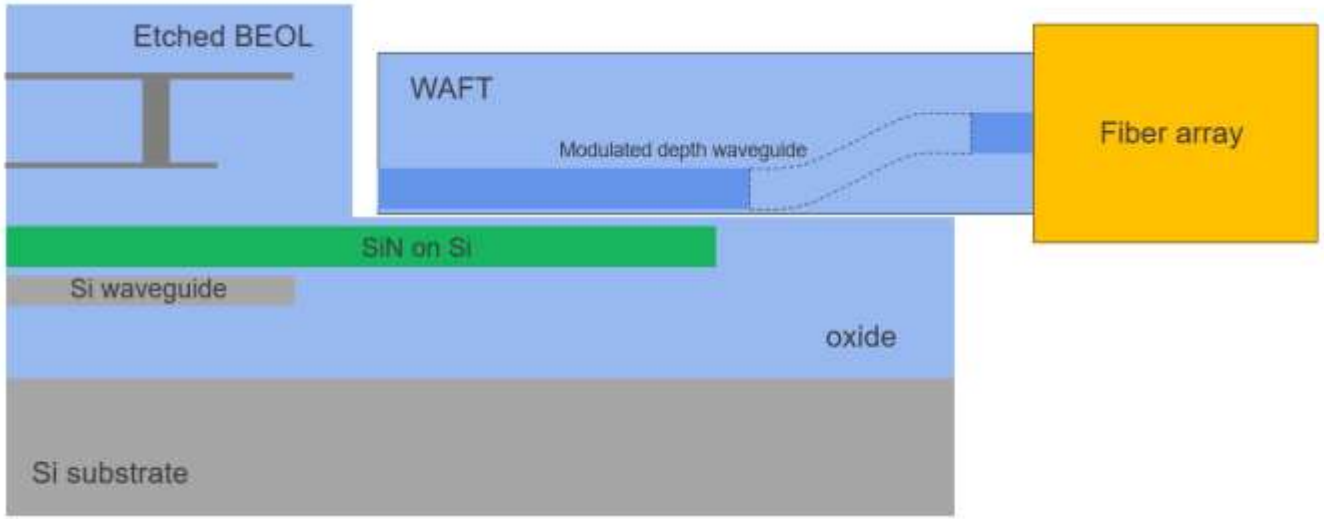


Fig 15 Glass interposer assembled Silicon Photonics Device with Cavity Etched BEOL

Evanescent coupling to SiN-on-Si waveguide layer:

- **Broadband and single-mode** in O-band and C-band
- **Low loss** (< 1.5 dB from fiber to SiN)
- **Low PDL** (< 0.2 dB)
- **Alignment tolerant**



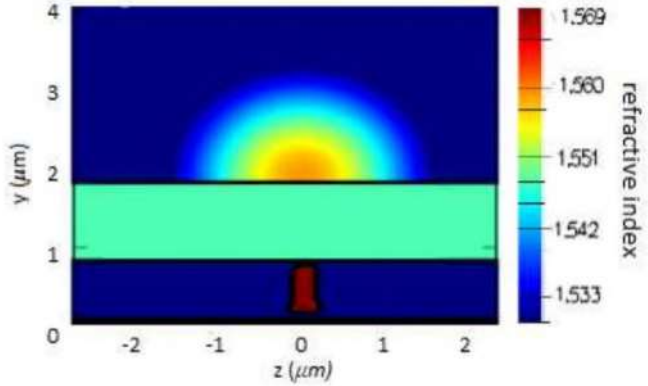
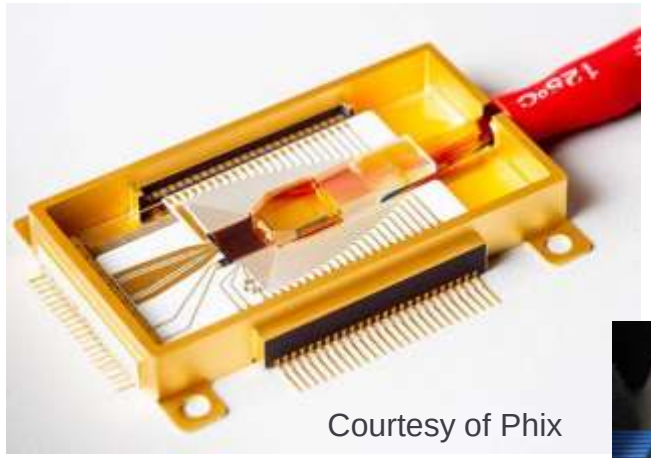


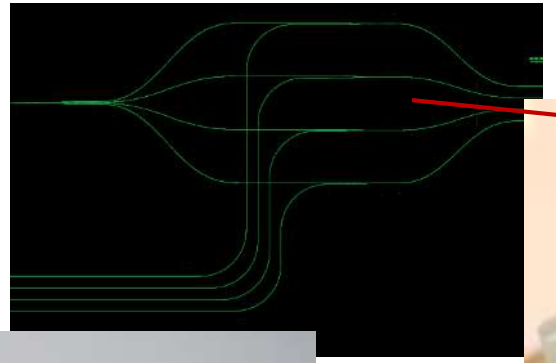
Fig. 11 Refractive index profile of the transversal cross-section of an Ion-Exhange interposer with mask width 1.7μm, on top of the glue layer (light green) and the SiN waveguide (red)

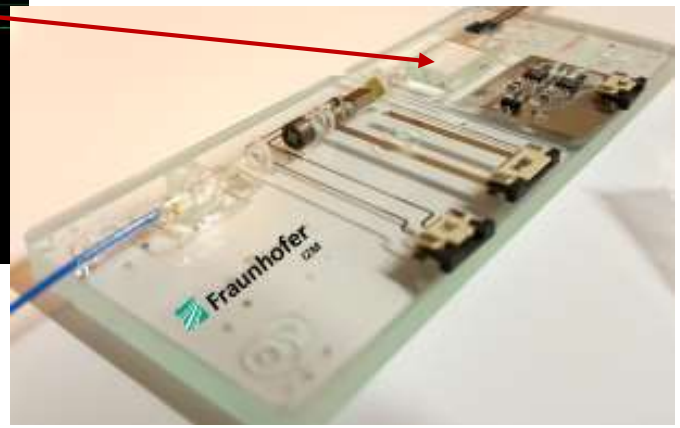
From Binda et al, EMPC 2019

Hybrid photonics concepts

- AWGs can be combined with SiP (or LNOI) modulation through WAFT interposers
  - Temperature-robust
  - Fabrication tolerant
- Power per I/O can be reduced thanks to splitting WAFTs in LIDAR or photonic computing hardware
  - No undesired non-linear effect (free carrier absorption, spectral broadening…)
  - Higher damage threshold
- Glass hybridizes well with bulk LiNbO for complex modulation schemes


Courtesy of Phix

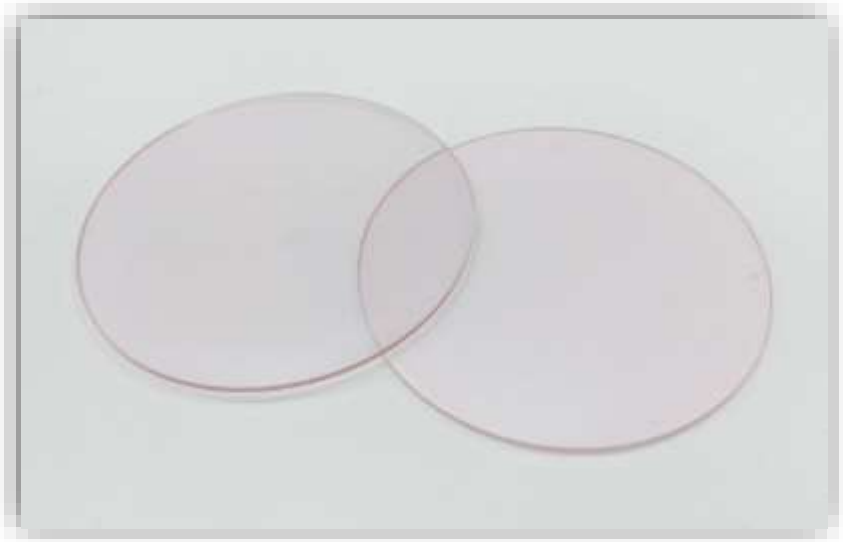




Er:ioNext overview

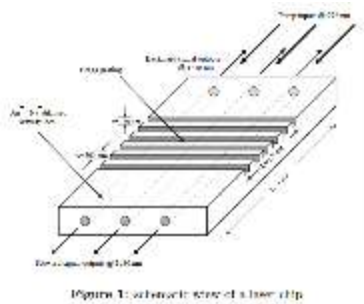
Based on a proprietary glass:

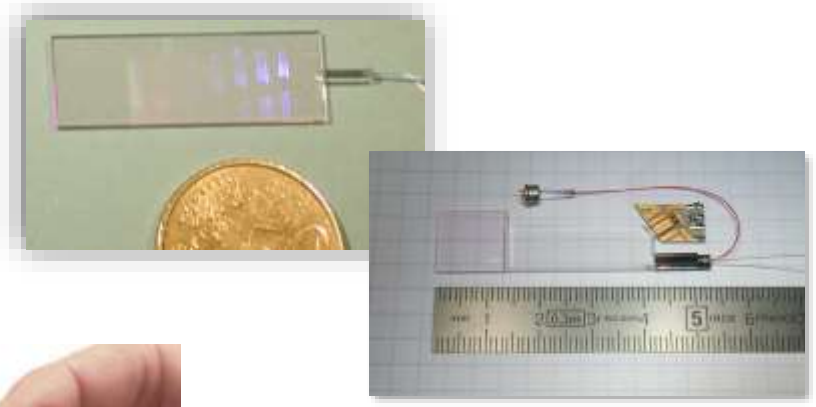
- Er- and Er/Yb-doped
- Tailored for ioNext waveguides:
  - ✓ Low loss @ 1550nm
  - ✓ High confinement, short bends
  - ✓ Long gain sections (up to 50cm)
- High absorption @ 980nm
- Other rare-earth dopants possible (Nd, Yb, Pr…)

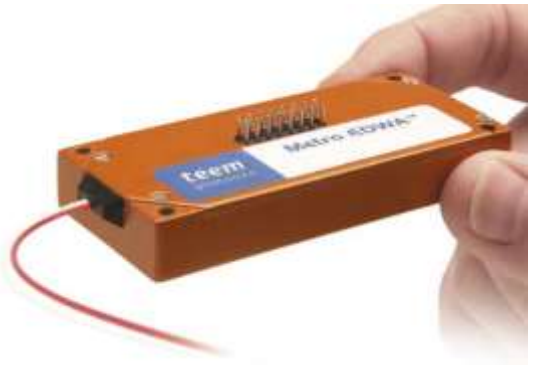


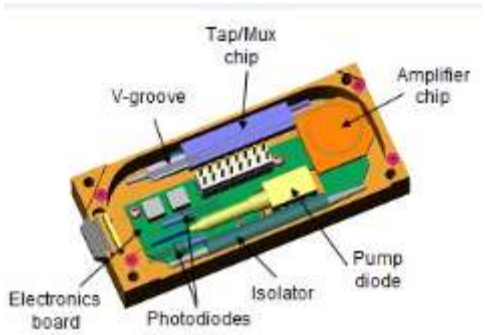
Applications:

- DFB laser arrays
- Amplifier arrays
- Amplifying WAFT/interposers for SiPh
- Customer-inspired ideas welcome!









Thank you for your attention

a.billat@teemphotonics.com

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