Advanced fiber-to-the-chip solutions

“Low-loss Optical Coupling of PIC with Ultra-compact Fiber-array-units”

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Univ-Eiffel, ESYCOM-CNRS

About us

Technological independent SME created in **2018**

Offices and Clean Room facilities in France, Paris region

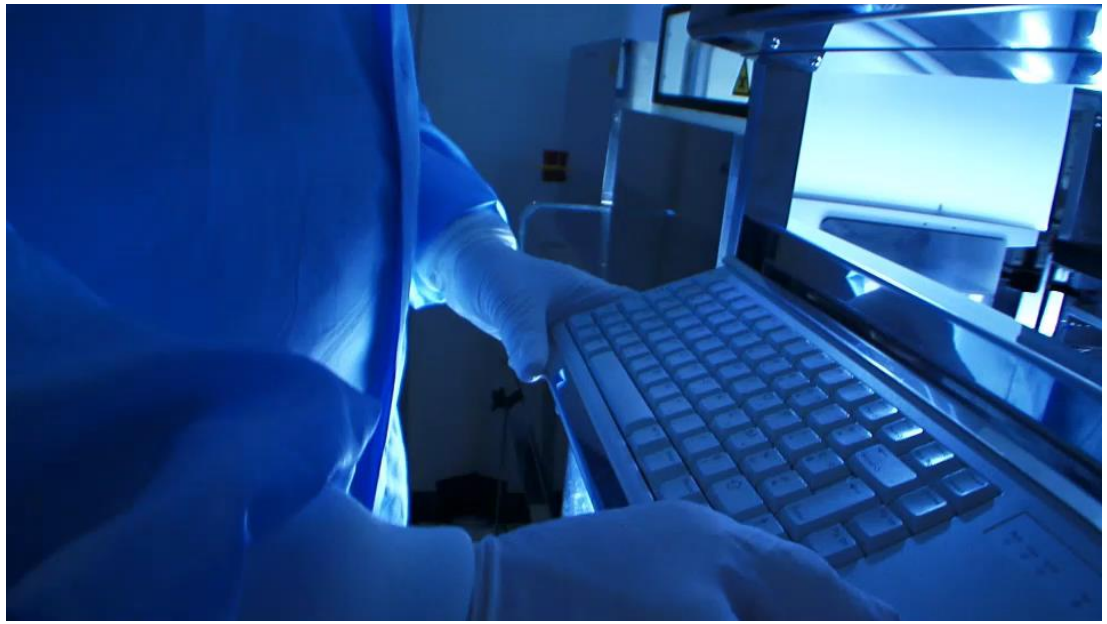
Spinoff of CNRS research center

- **10+ years of R&D** in microfabrication and photonics integrated packaging
- 650m² cleanrooms **production-line** (Class 100) platform
- **Licensing agreement** worldwide with **exclusivity** including 6 patents

8 Headcounts - **Strong R&D** > 50% PhD in Photonics

Develop & commercialize **fiber-to-the-chip connectivity solutions** enabling the next generation of **optical and quantum applications**

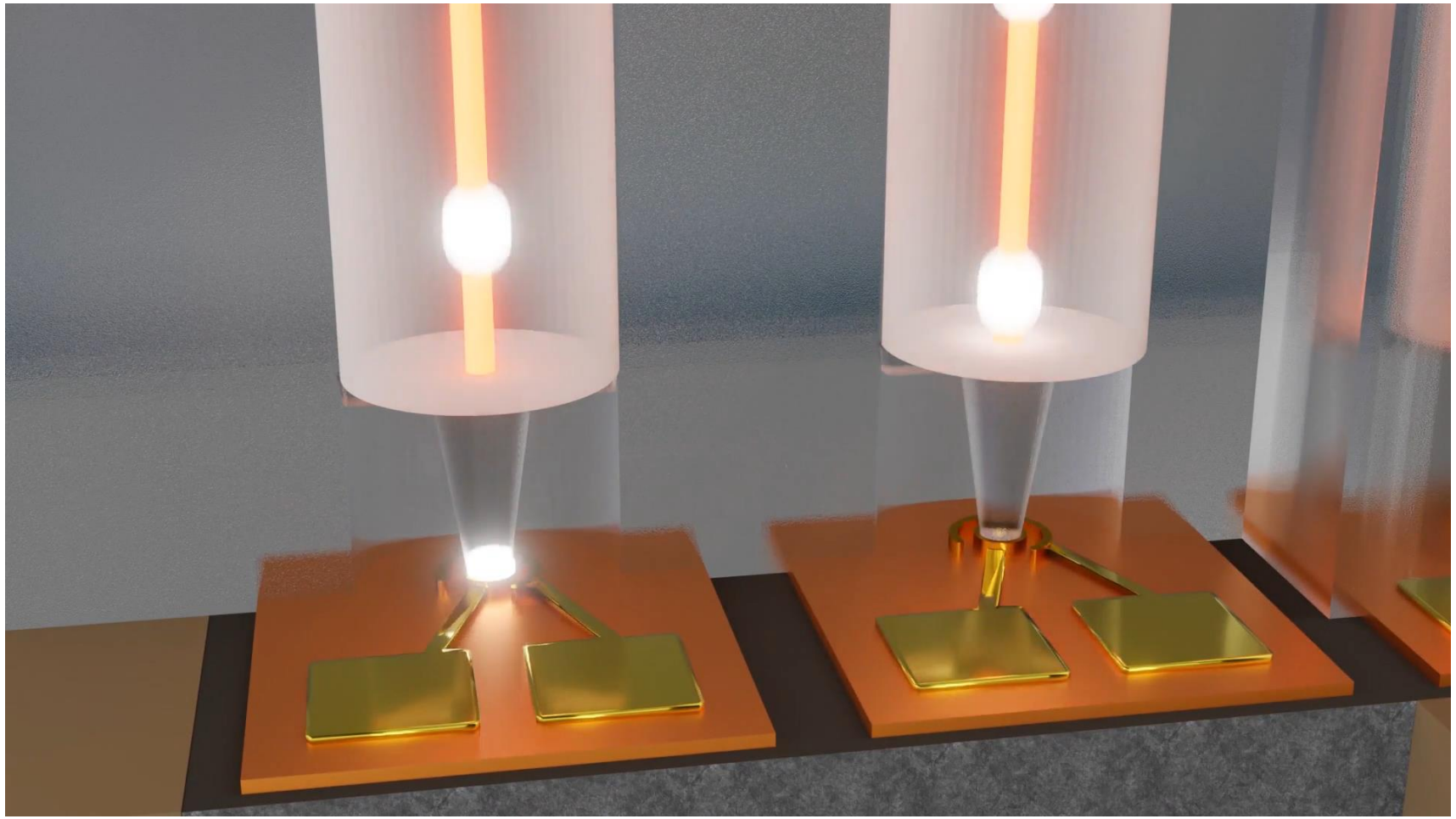
Optical coupling with high-volume production



- Wafer-level Si and Polymer Optical coupling structures
- Wafer level UV lithography
- Wafer bonding
- Through Wafer DRIE

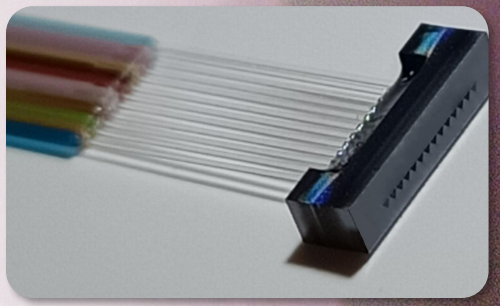
from NRE to low cost per module in volume … to get high performance

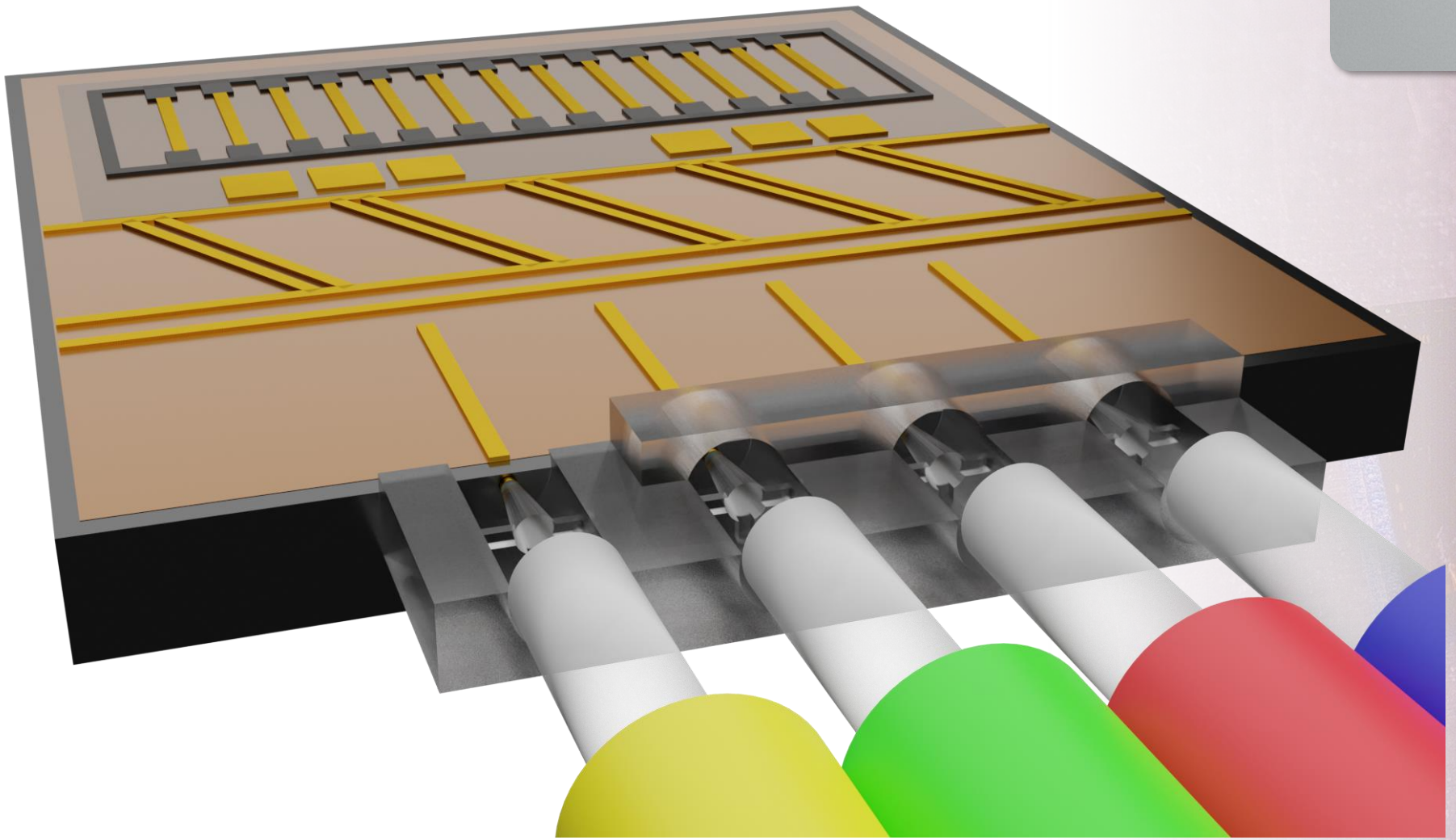
ICON Photonics Technology



Guide each photon / Shape the beam / Compensate for misalignments

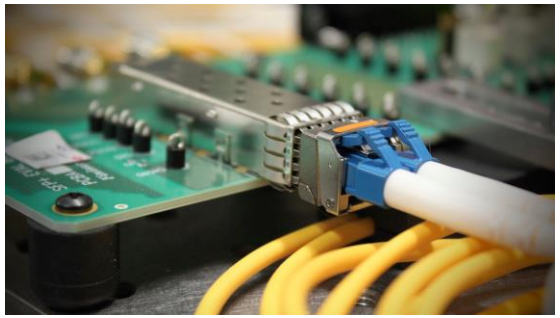
Focus on PIC to fiber coupling



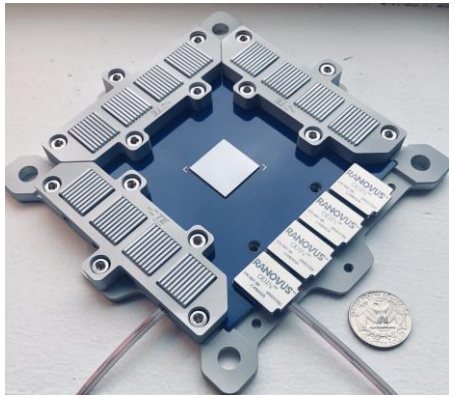


Market drivers

Pluggable Optics

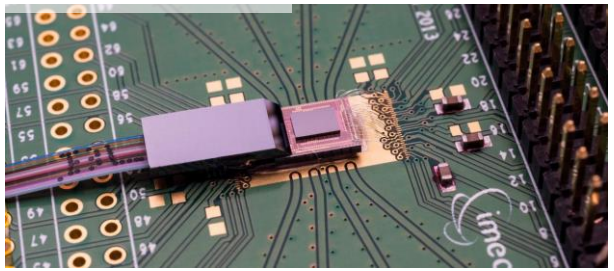


Co-Packaged Optics (CPO)



Ranovus 2021, nx100Gbps PAM4

CPO to 3D-chiplet



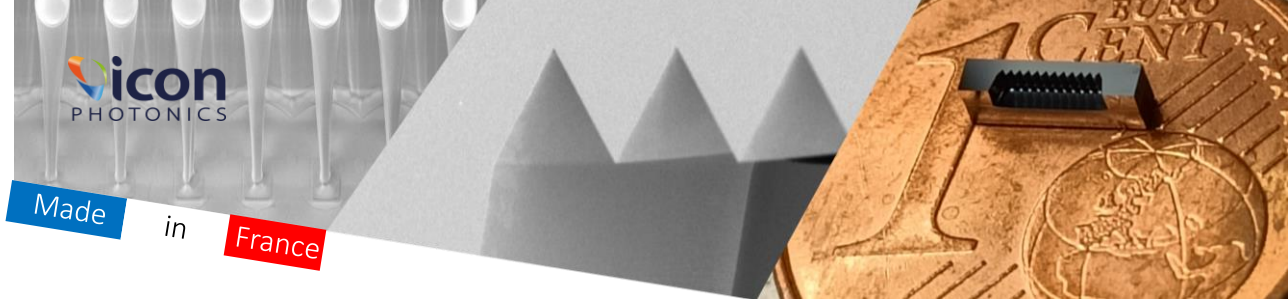
IMEC Si-PIC platform

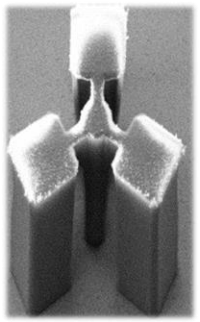
- **Integration:** key to lower cost and higher density
- **Speed:** get smaller to get higher data rates
  - + Scalable and Cost-efficient model: <100$ per 100Gbit/s
- **Robustness and attachability**
- **Efficiency:** save energy and save photons
  - + Going above the 98% efficiency
- Getting light In and Out of the chip **with standards at wafer-level**

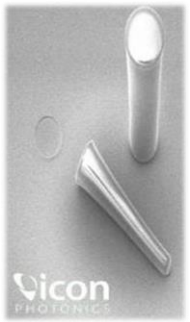
WAFER PRODUCTION

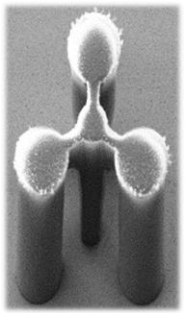
Some illustrations

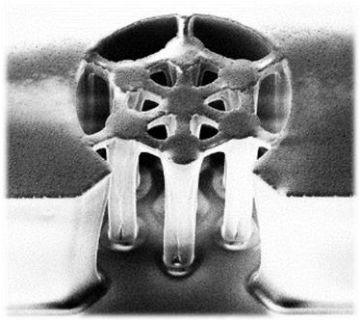
Flexibility of shapes

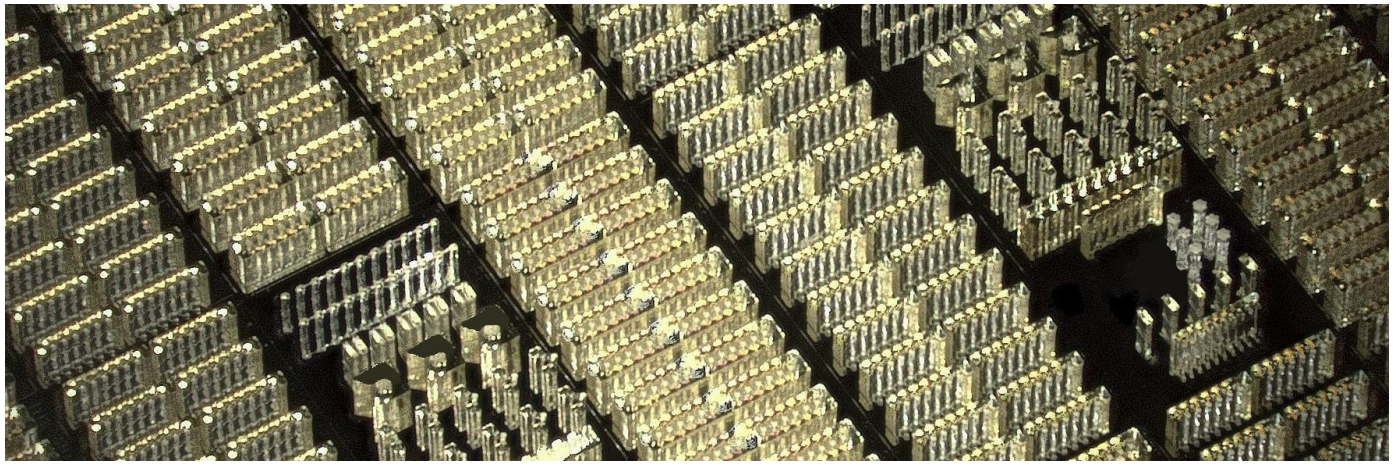




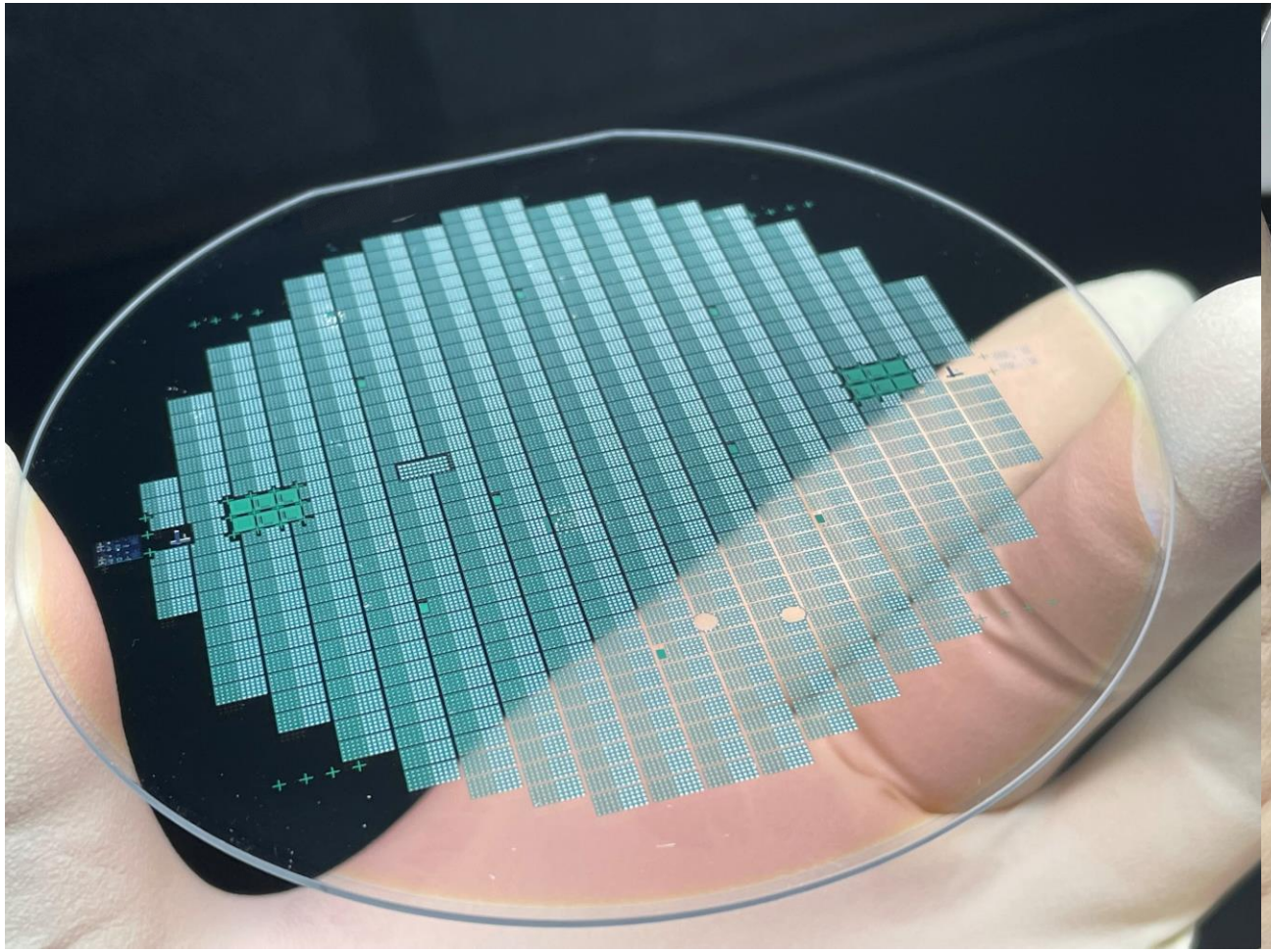


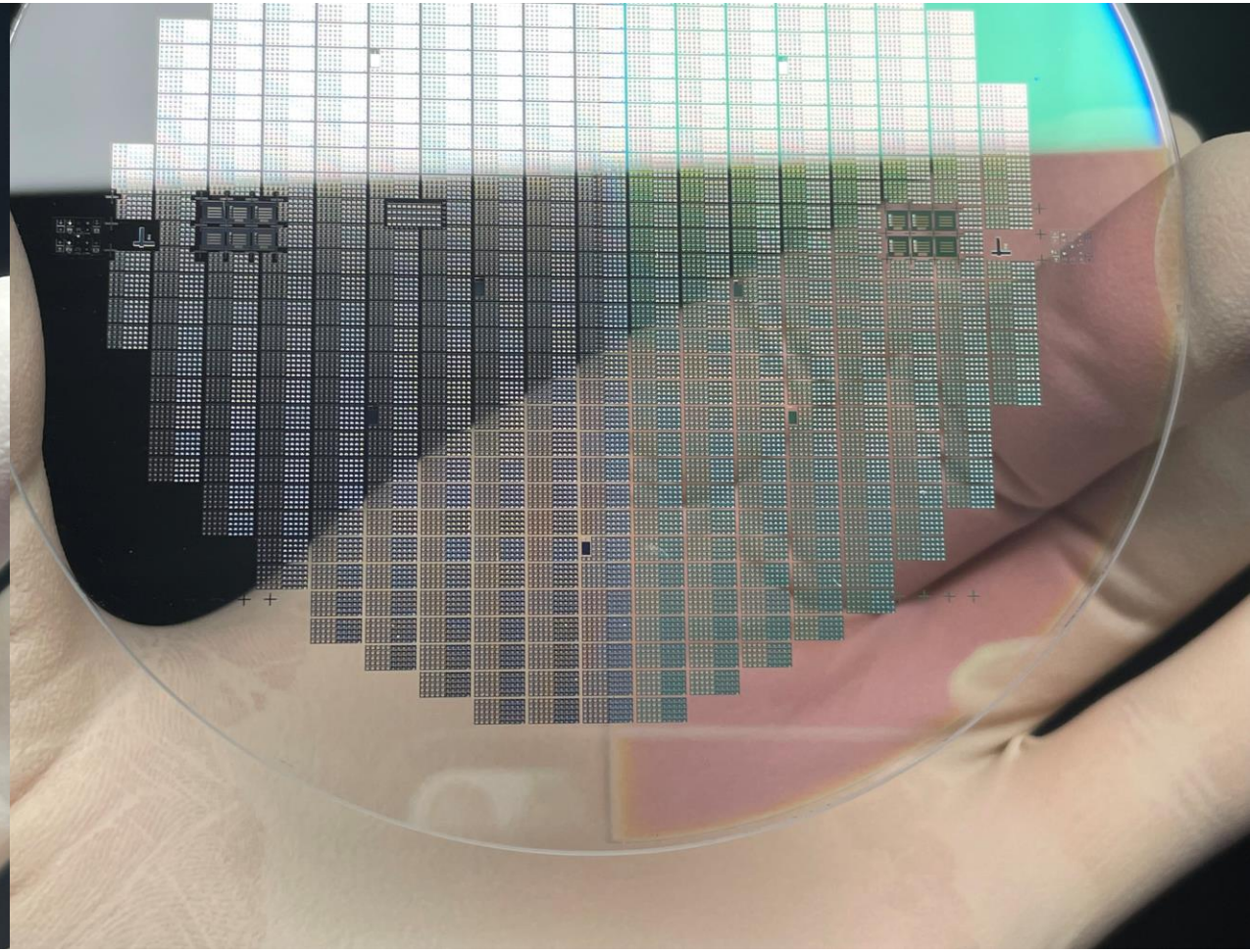






Thousands of SSC per wafer with ARC





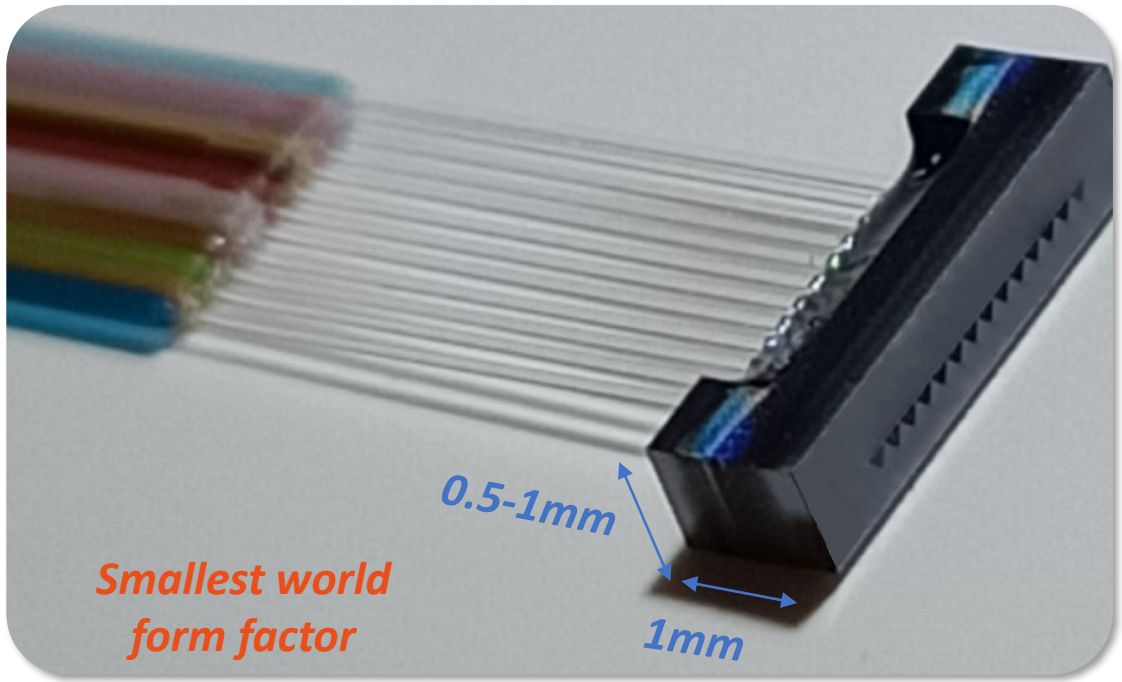
KEY BLOCKS FOR THE OPTICAL COUPLING

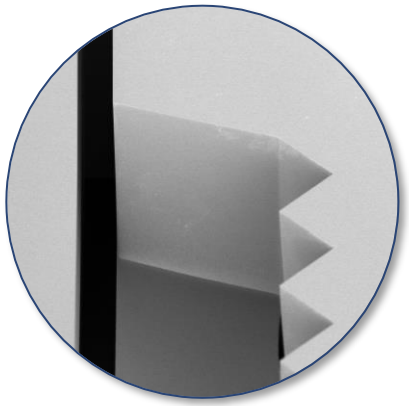
❶ Fiber maintaining and fixing to the PIC

Fiber maintaining

- *from standard V-grooves*

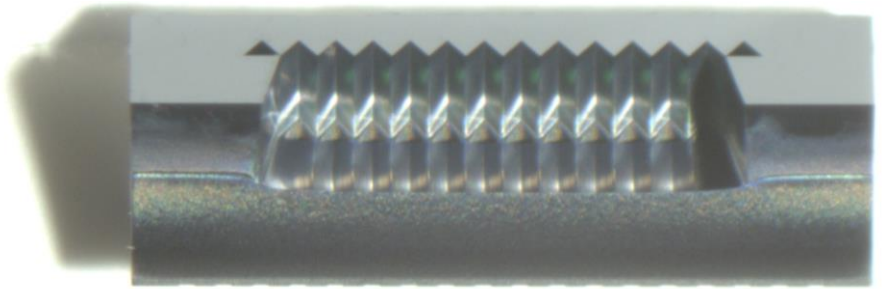
to advanced V-groove





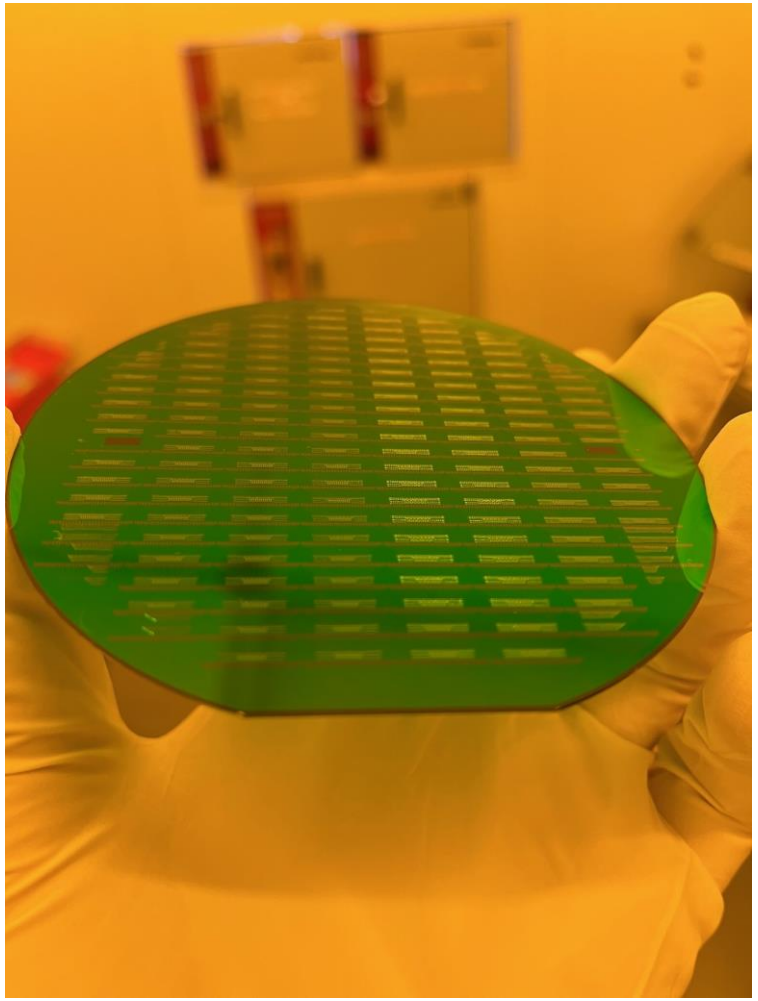
fiber centering <0.5µm
from channel 1 to … 128

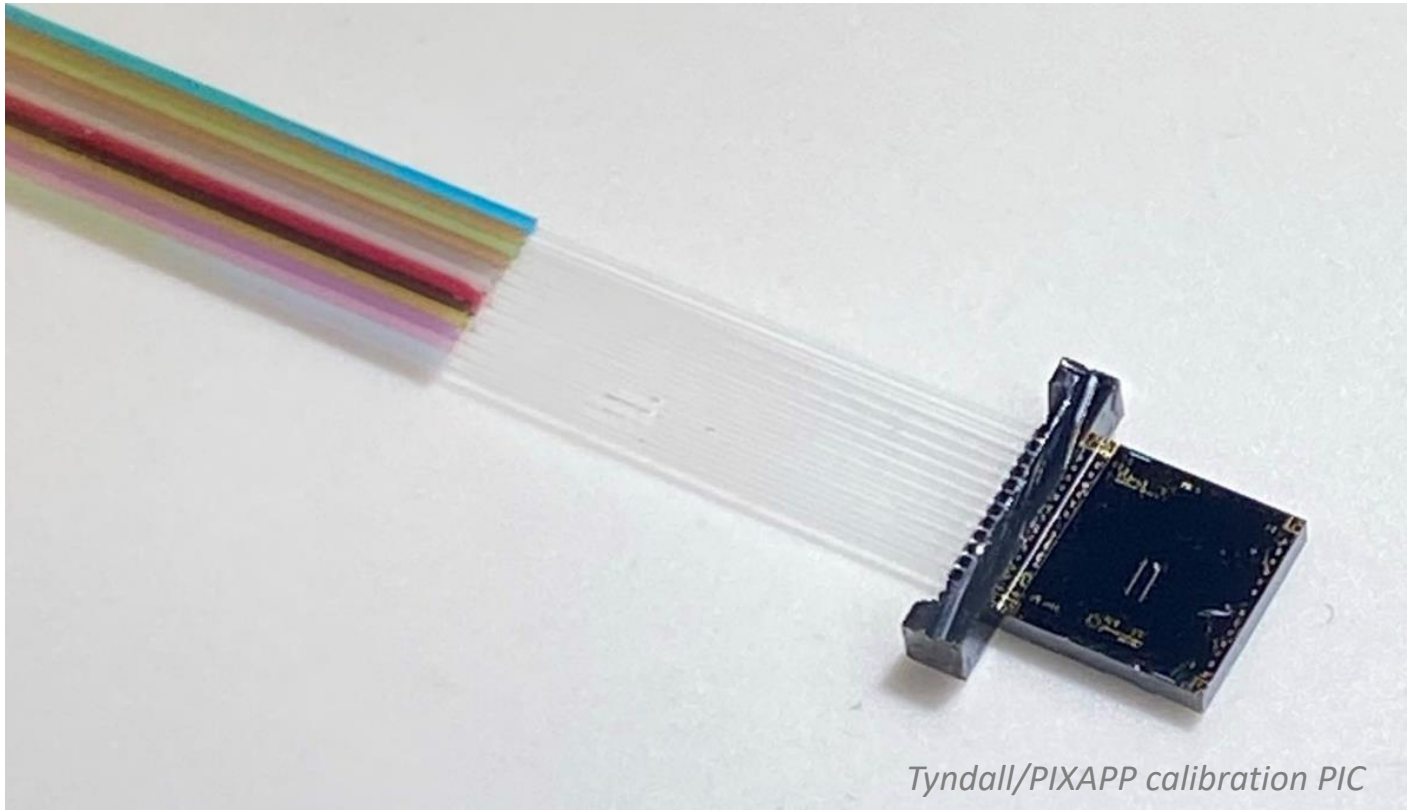
Patent pending



- Ultra compact V-grooves with integrated lid
- Pitch from 50 to 500µm (82µm – 127µm – 250µm)
- Arrays or matrices, regular or irregular shapes

MADE AT WAFER LEVEL



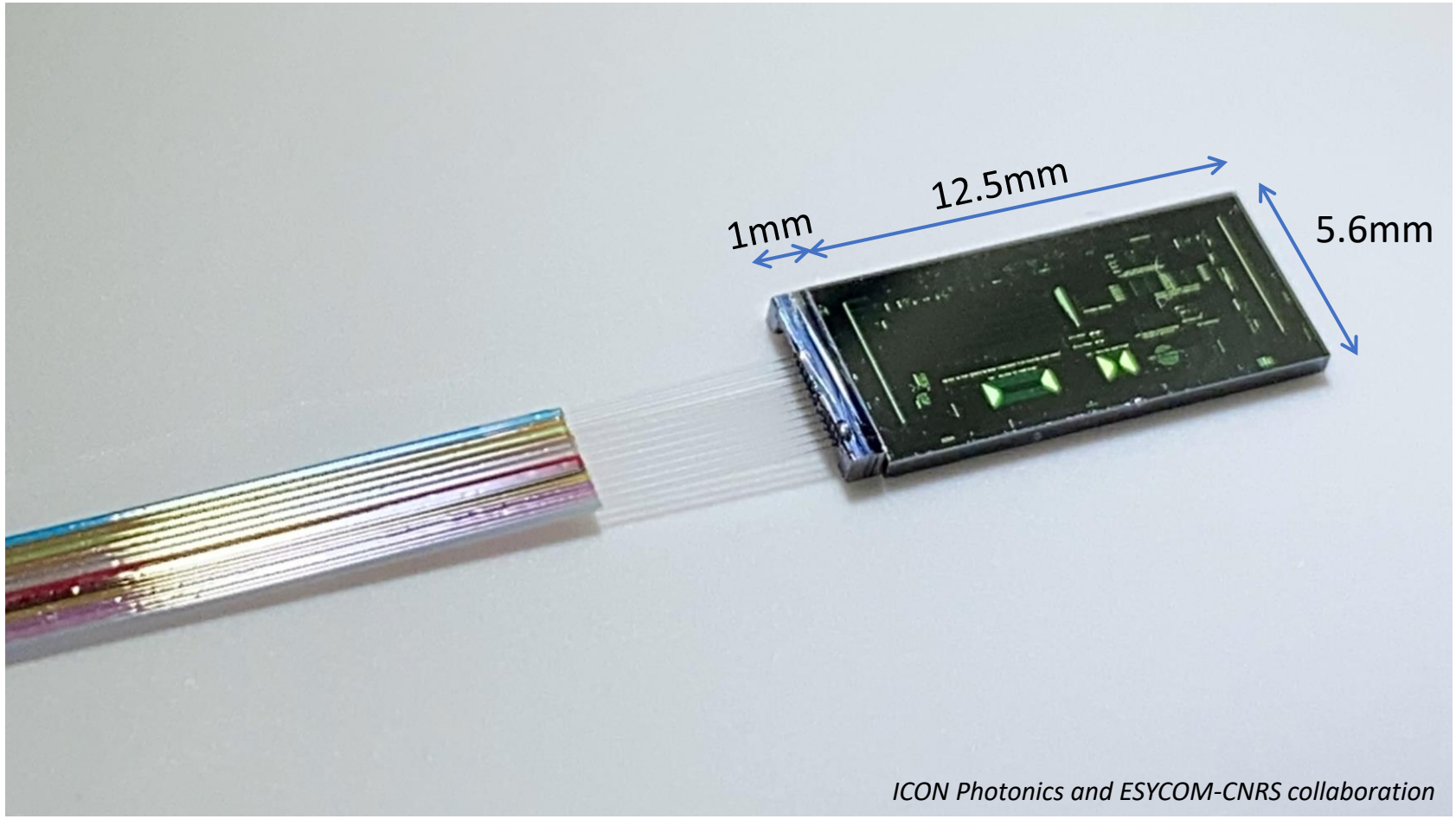


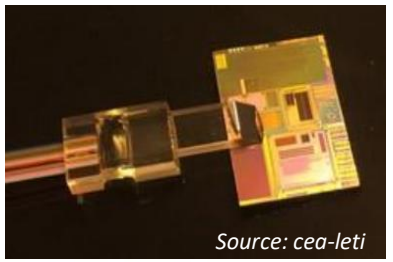
Tyndall/PIXAPP calibration PIC

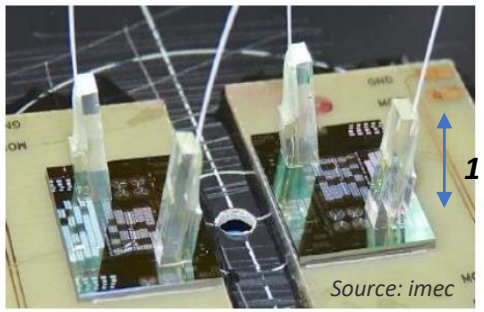
SMALLEST FORM FACTOR
Advanced V-GROOVE

How to showcase further?

Ultra-compact FAU to PIC butt-coupling



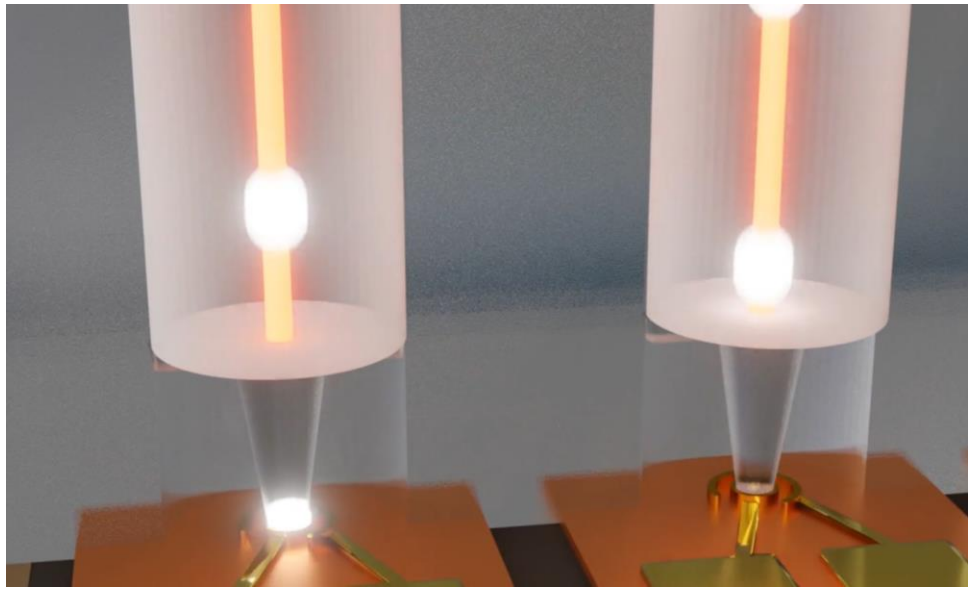


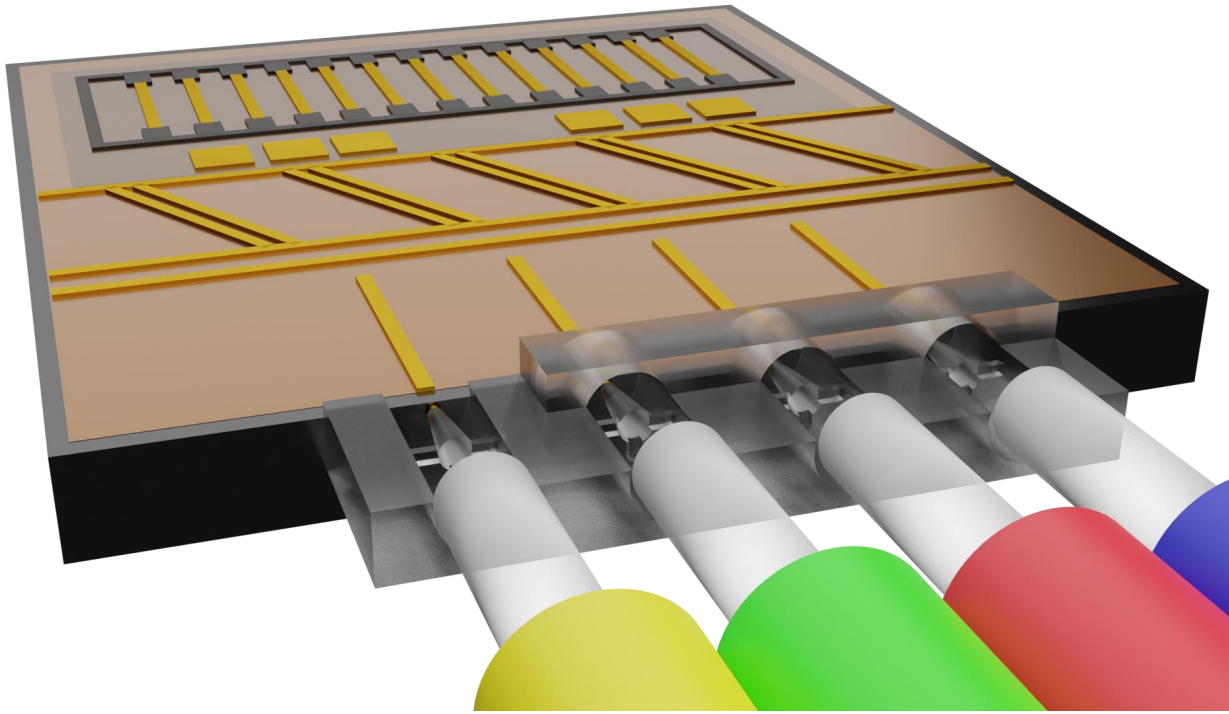


KEY BLOCKS FOR THE OPTICAL COUPLING

❷ Spot-Size-Converters (SSC)

High contrast index tapers for SSC



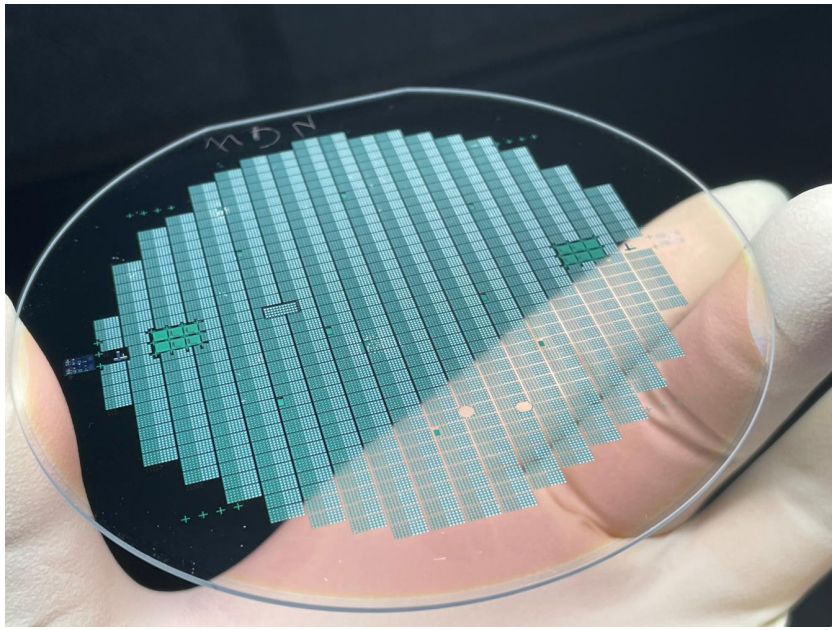


Collect all photons / Shape the beam / Compensate for misalignments with custom shapes and multi-layer design

SSC / Beamshapers

Match the MFD

Increase tolerances

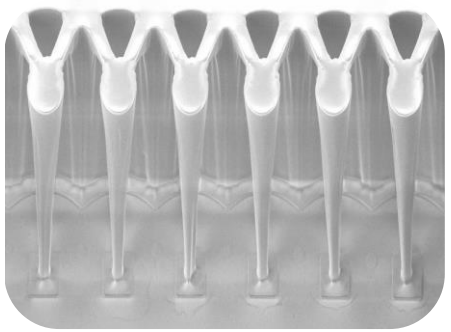


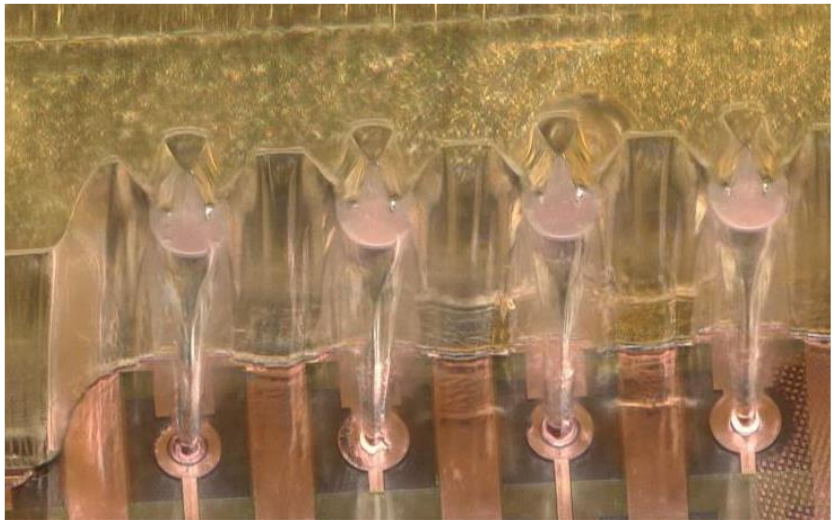
- from 9-10µm MFD fiber mode

  to rectangular mode-shape 1x3µm MFD

- Increase fiber alignment tolerance

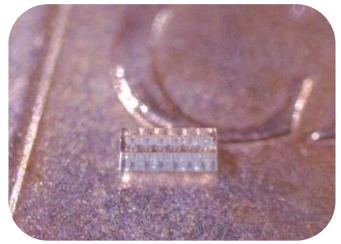
  from 0.5µm*/0.5dB* ***to 2µm and more*** */0.5dB (20µm MMF)*

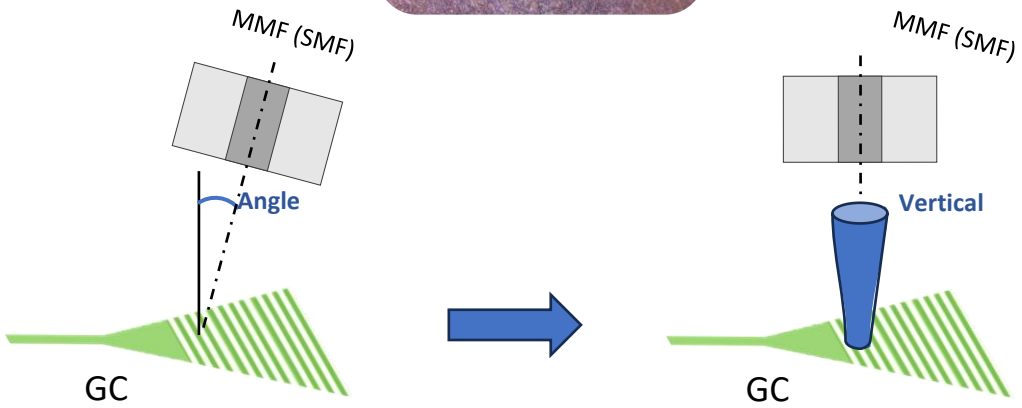


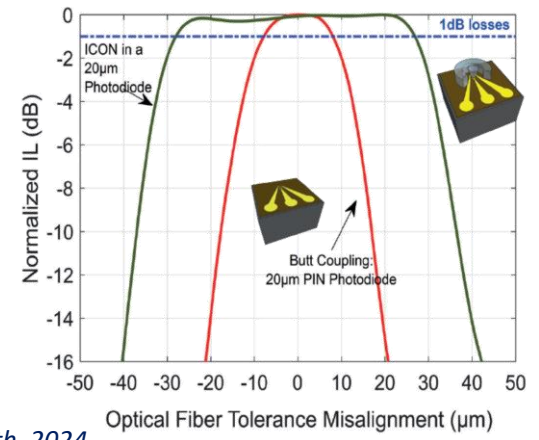


Functions of SSC / beamshapers

- Edge coupling of PIC & EEL
- Surface coupling with GC-PIC (MMF)
- Surface coupling of detectors / VCSELs





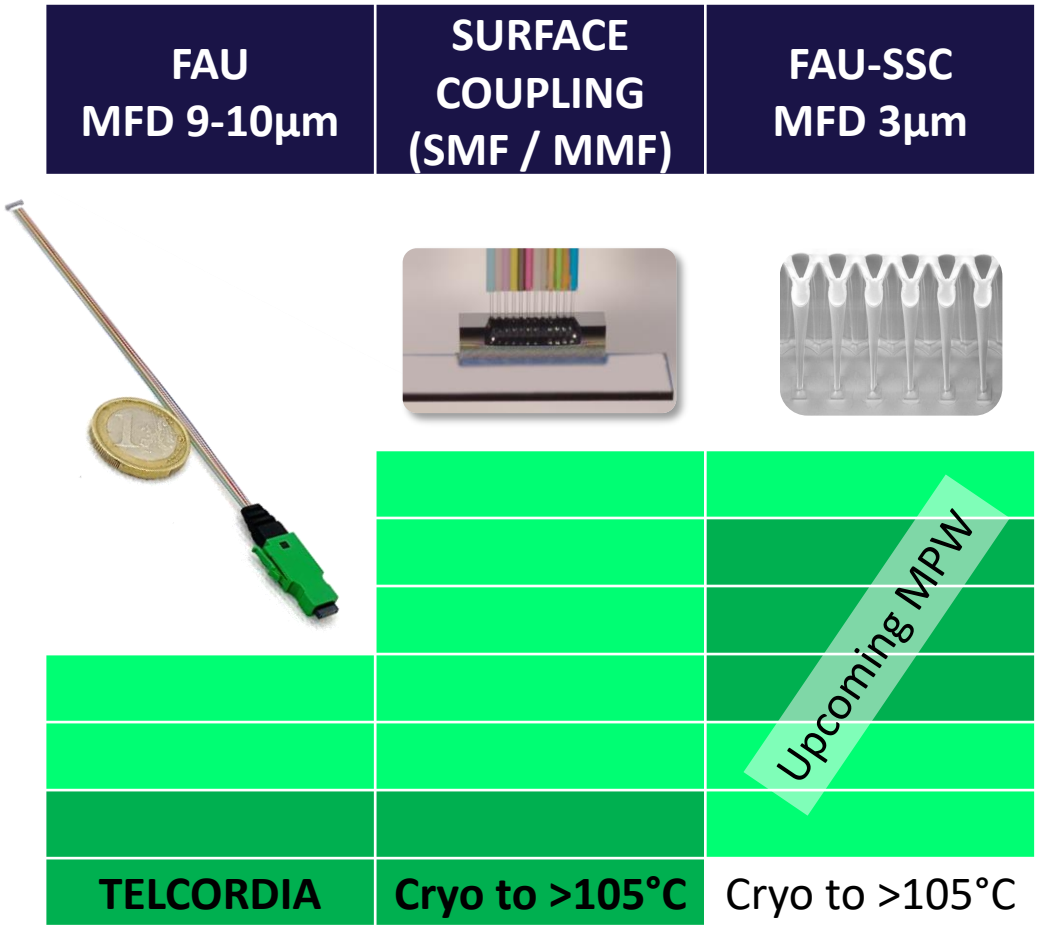


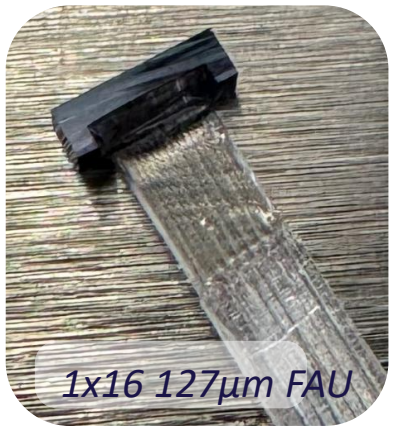
RESULTING COUPLING LOSSES

Coupling losses

from cryo to 105°C through TELCORDIA

T(%)	A(dB)	Gom(dB)	
1%	-20	-40	
10%	-10	-20	
50%	-3.0	-6	
63%	**-2**	**-4**	*Standard IL*
70%	**-1.5**	**-3**	
80%	**-1.0**	**-2**	
90%	**-0.5**	**-1**	*Ultra-low IL*
93%	-0.3	-0.6	
95%	-0.2	-0.4	
98%	-0.1	-0.2	
100%	**0**	**0**	



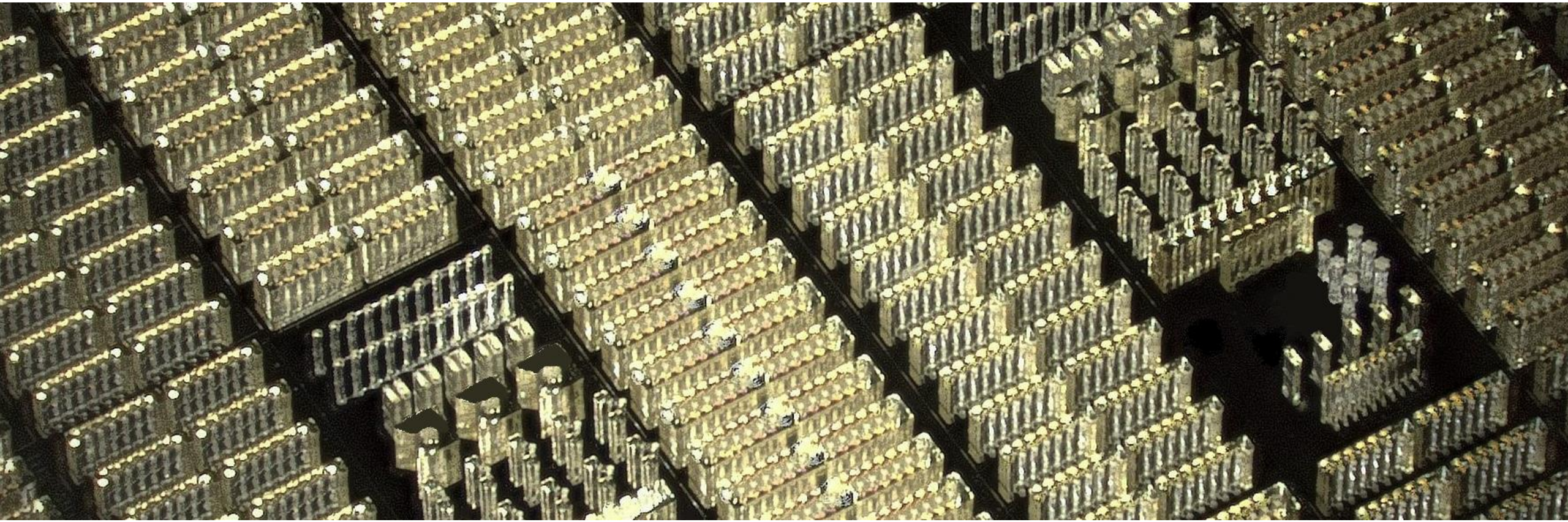


ARE WE USING GREYSCALE / NIL / 2PP ?

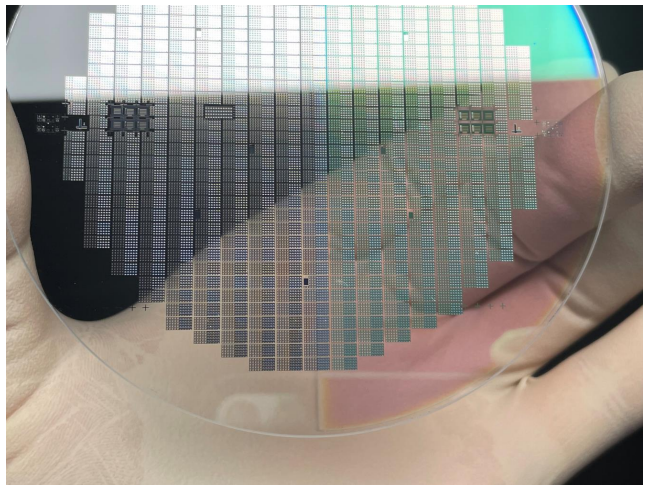
UV “standard” lithography

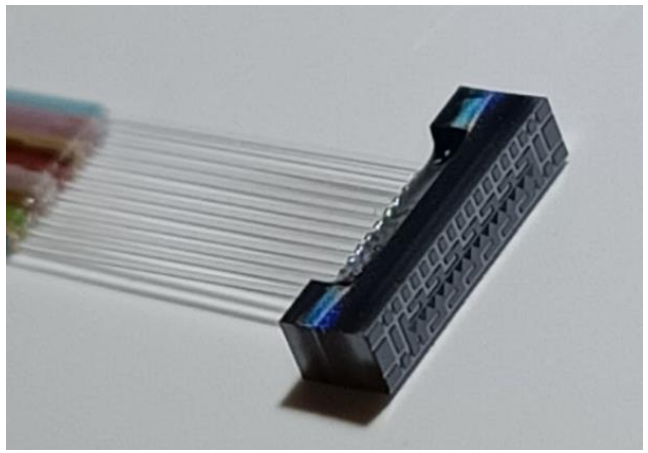
- Volume capabilities and low cost
- Not real 3D but 2.5D with layer stacking options
- Smooth surface due to wet chemistry
- Smart combination of wafer bonding / DRIE / photolitho
  … combining various scales from µm to mm with high precision

Density of SSC on wafer



Annoucement: Next MPW Run for FAU-SSC





Registration July 2024

Tape-out septembre 2024

Delivery December 2024

Custom geometry, pitch (50µm to 500µm), number of fiber (1 to 128), ARC (940nm, 1550nm), fiber type (λ from 0.5µm-5µm), Elliptical shapes, PIC bonding service included

Share specifications: taper slope

- ➥ MMF : MFD ~20µm to 15µm
- ➥ SMF : MFD ~5µm to 3µm

icon PHOTONICS

Thanks!

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