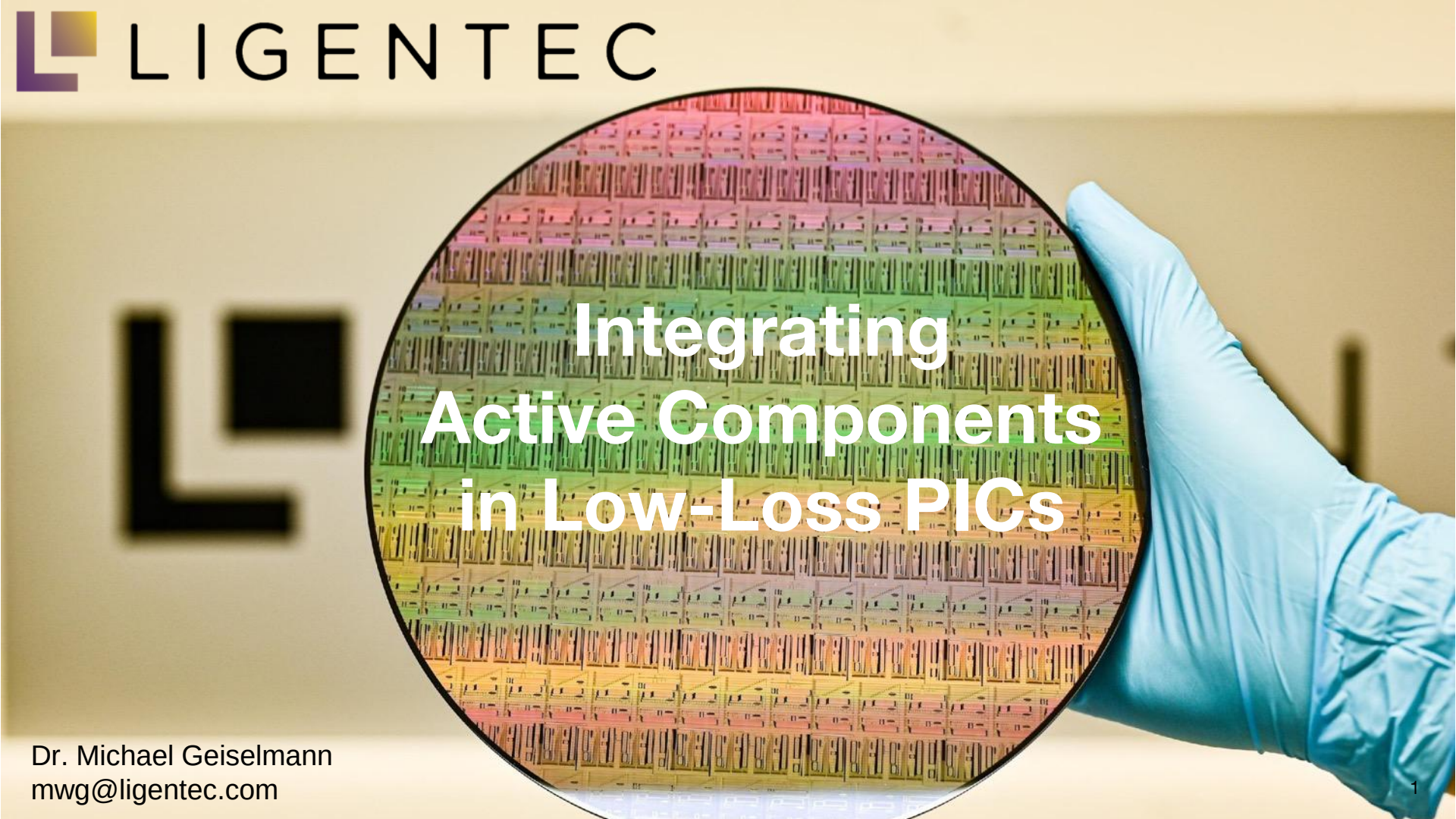
LIGENTEC



Integrating Active Components in Low-Loss PICs

Dr. Michael Geiselmann
mwg@ligentec.com

European PIC company with global reach

LIGENTEC

Ghent, Belgium

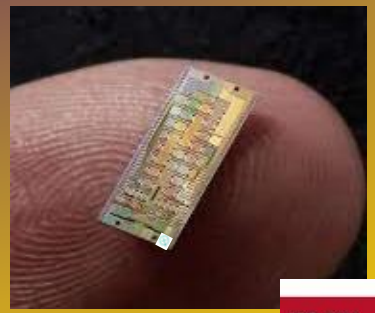
Lausanne, Switzerland

> 75 photonic enthusiasts

Corbeil, France

Best-in-class integrated passive SIN

- **Low Loss SiN**
  (< 5 dB/m SM to < 1 dB/m MM)
- **3 Technologies**
  (AN150, AN350, AN800)
- **Extensive PDK**

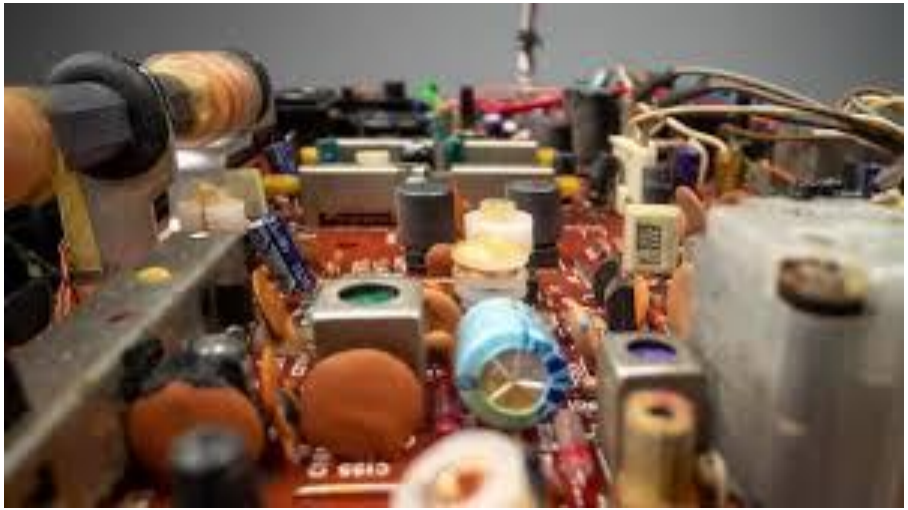


ISO 9001
BUREAU VERITAS
Certification

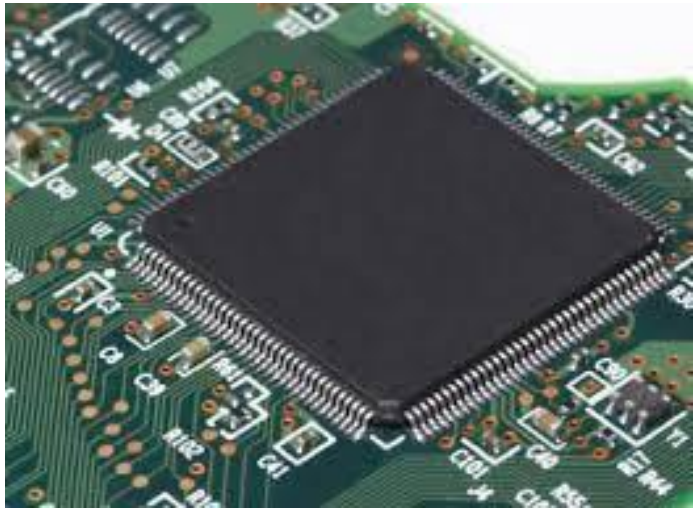
Photonic Integration?

The electronic integration story

LIGENTEC



1960’

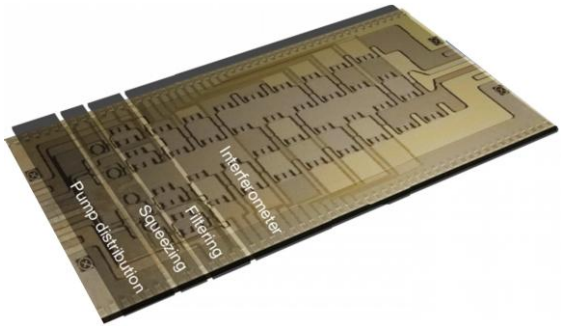


Many $$$ and 10’s of years later

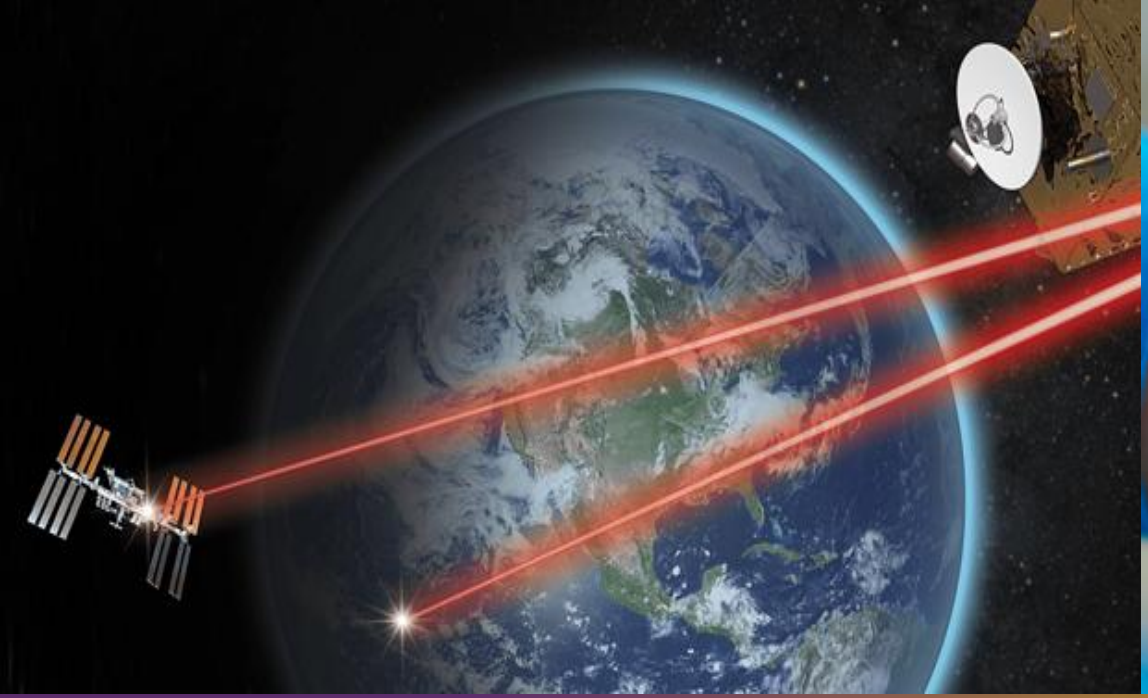
Photonic Integration?

Put discrete components on a chip

LIGENTEC



Repeat the succes of the electronic chip revolution!



Our Mission: Unleashing the potential of PICs!

Let’s PIC it!

Commercial Offering

Seamless journey from Idea to Volumes

LIGENTEC

Entry: R&D & Prototyping

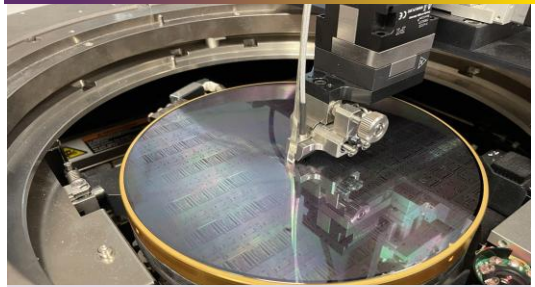
Open access, low barrier

Fast prototyping

- Established technology
- Fixed layer stack
- Extensive PDK
- **Regular MPW runs**
- Custom runs
- Design / layout support
- Characterization
- Packaging support

Optimize: Development

High flexibility & competence



Custom PIC Developments

- Engineering studies
- Layer stack adaptation
- Custom integrations

Ligentec Labs

- Early technology access

Manufacturing: Supply

Quality and guarantee

Pilot Fabrication

- Pilot and niche quantities

Volume Fabrication

- High-capacity wafer fab
- Fully automated testing
- Automotive quality system

ISO 9001
BUREAU VERITAS
Certification

Combining the best of two worlds

Two fabs with a different focus

LIGENTEC

100 mm line: R&D & Non-Standard

Flexibility and Speed

Non-standard SiN offering

- Prototyping to mid-volume

R&D

- New concepts & technologies

Heterogeneous Integration

- New materials & methods

200 mm line: Standard & Volume

Capacity and Stability

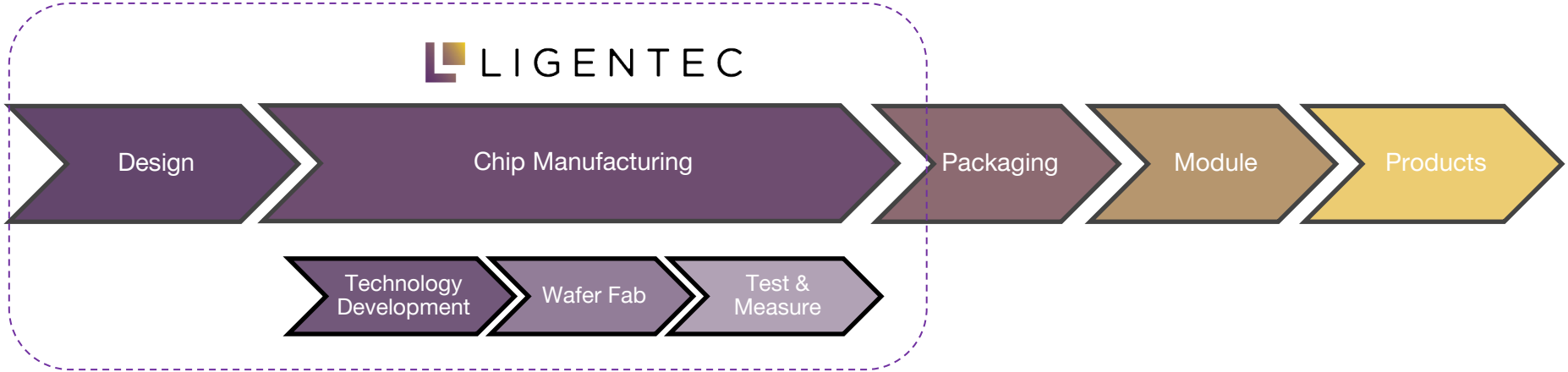
Standard SiN offering

- Standard SiN stacks
- MPW runs, Pilot & niche quantities
- High volume production

Automation & Quality

- Highly automated process flow
- Fully automated testing
- IATF 16949 certified / ISO 13485 compliant

Position within Ecosystem

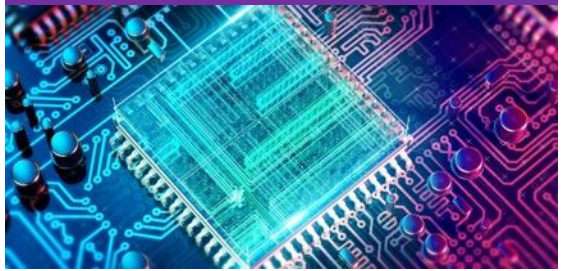


Our SiN technology in an enabler for…

LIGENTEC

Advanced Computing

Quantum Computing
Neuromorphic Computing
Optical I/O (AI)
…



Communication

QKD
Telecom
Data Transmission
Sattelite Communication
…

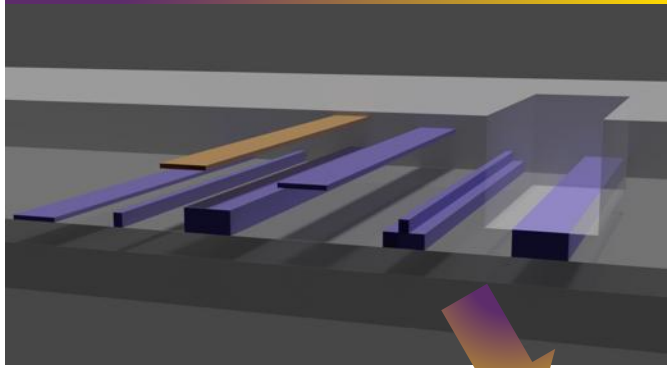
Sensing

OCT / LiDAR
Atomic Clocks / GPS-less navigation
Biosensing
Fiber sensing
Metrology
…

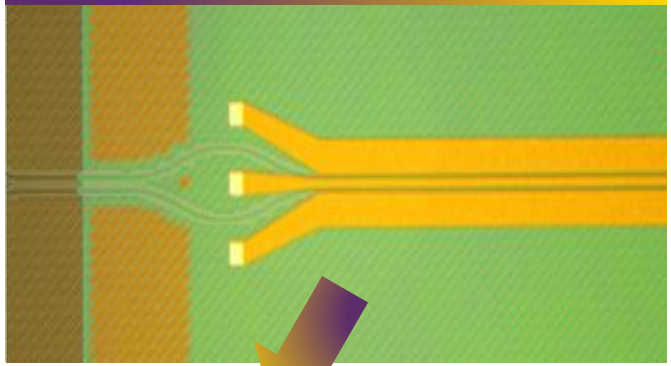
Unleash the potential of PICs!

LIGENTEC

Provide **lowest loss** Passive PICs **at scale**

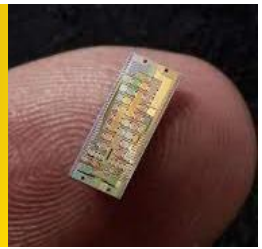


Integrate **light modulation and detection** on the PIC



Unleash the potential of PICs

‘Let’s PIC it’



Unleash the potential of PICs!

LIGENTEC

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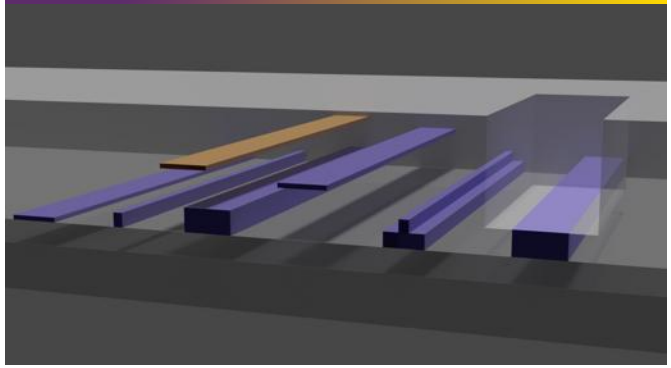

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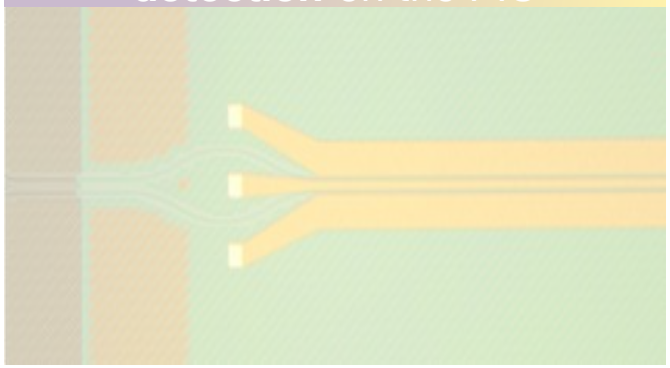
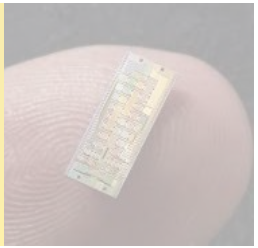


Unleash the potential of PICs

‘Let’s PIC it’



A base to build on

Versatile Platform

LIGENTEC

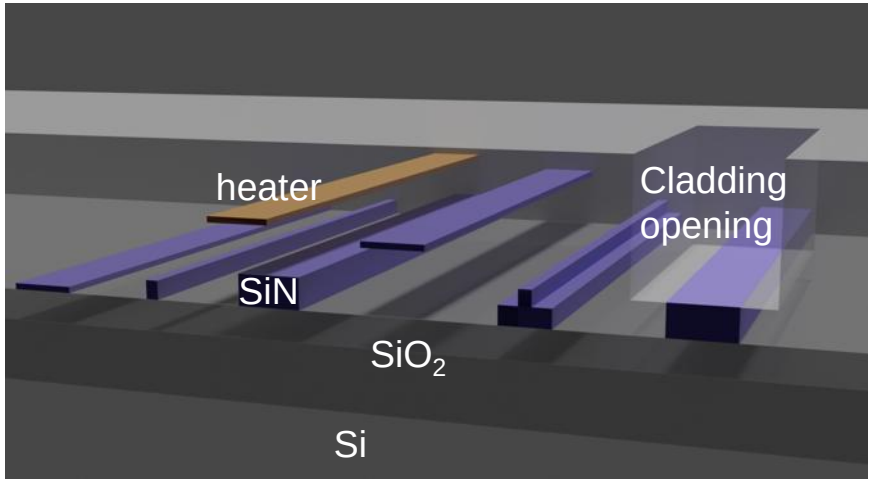
3+ thicknesses	10+ process modules	Extensive PDK

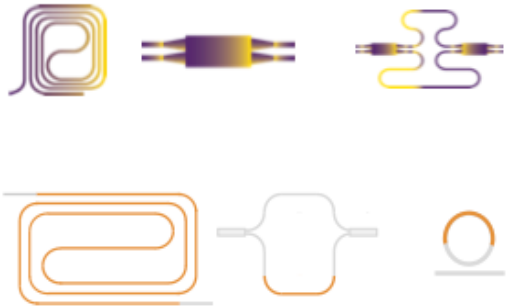
800 nm

350 nm

150 nm

custom





Mentor A Siemens Business

VPIphotonics DESIGN AUTOMATION

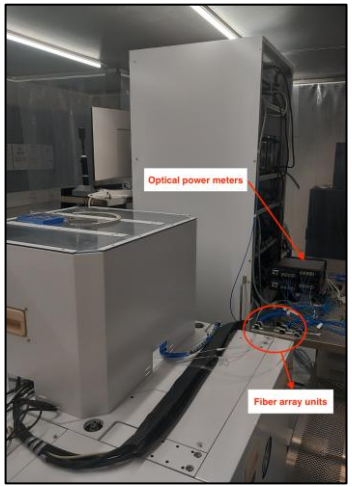
SYNOPSYS® Silicon to Software™

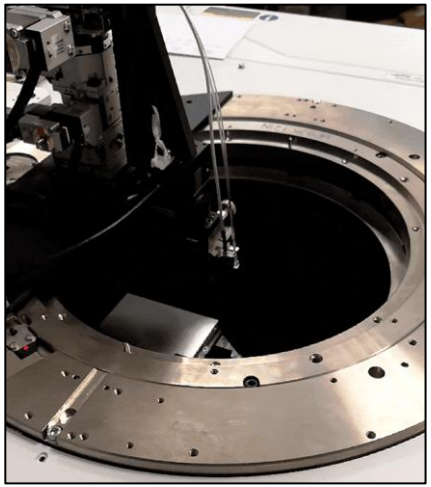
Ansys / LUMERICAL

LUCEDA PHOTONICS

Testing capabilities at Ligentec-FR: Wafer level tester

- ❑ Vertical coupling
- ❑ Fully automated (cassette loading)
- ❑ 16 channels measured simultaneously (~100nm WL span) O-band & C-band



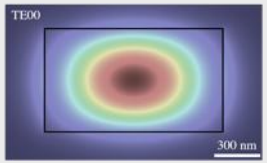


Available through MPW and at volume

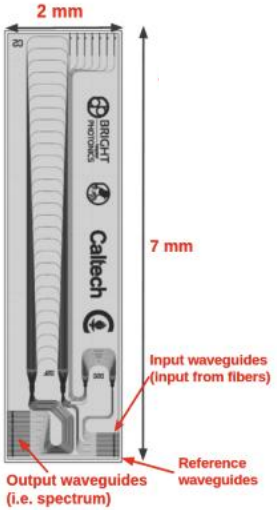
SiN thicknesses serving different applications

LIGENTEC

AN800 (800 nm SiN)



- High mode confinement (90%)
- <15 dB/m single mode loss @1550 nm
- Smallest bend radius
- Dispersion engineering
- (O-band) ,C-band, L-band
- <1 dB / facet edge couplers
- Extensive component library C-band



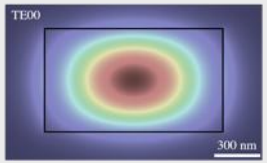
Gatkine et al., Proc. SPIE 11819 (2021)

Available through MPW and at volume

SiN thicknesses serving different applications

LIGENTEC

AN800 (800 nm SiN)



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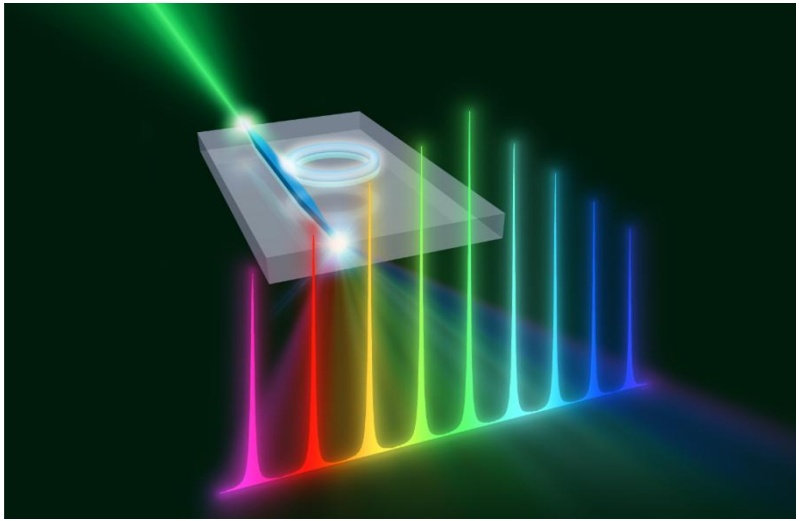

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SiN thicknesses serving different applications

LIGENTEC

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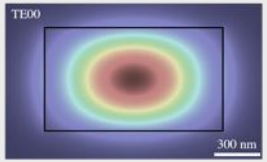

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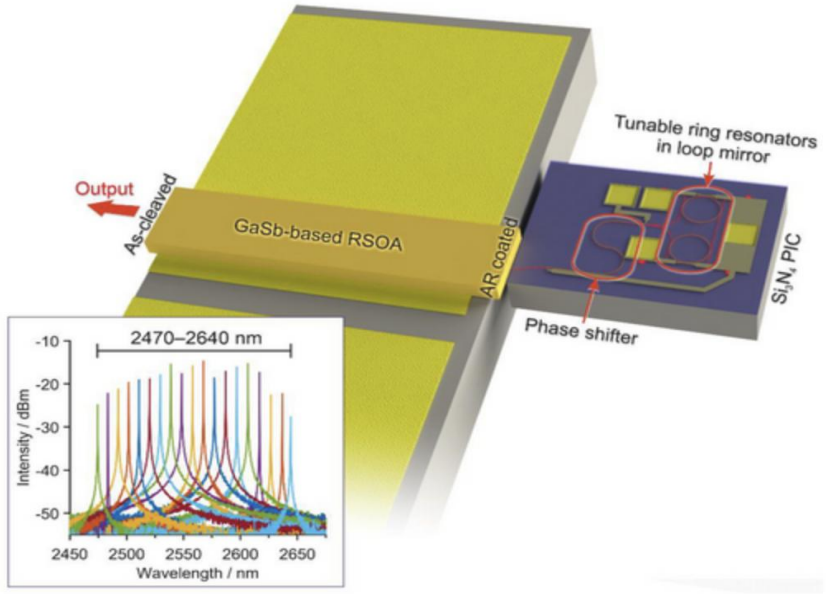


Ojanen et al., Laser&Photonics Review (2023)

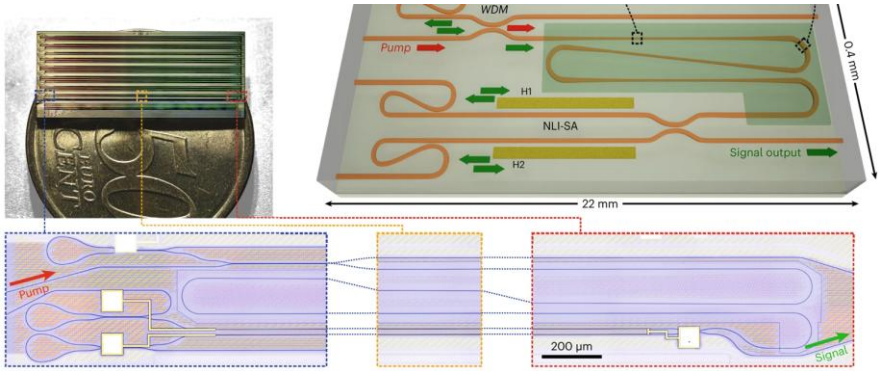
Available through MPW and at volume

SiN thicknesses serving different applications

LIGENTEC

AN350

- <5 dB/m single mode waveguide @1550 nm
- 1 dB/m multimode waveguide @1550 nm
- (NIR), O-band and C-band
- <1 dB/facet edge couplers
- C and O-band basic component library



Singh et al., Nature Photonics (2024)

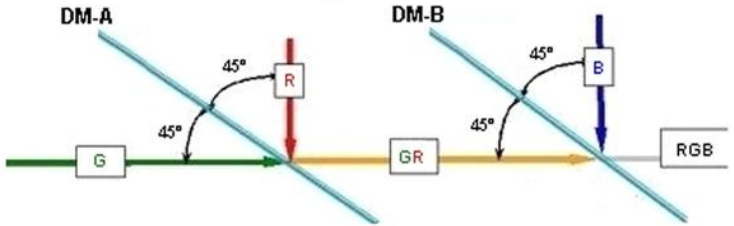
Available through MPW and at volume

SiN thicknesses serving different applications

LIGENTEC

AN150 SiN

- Visible & NIR applications
- Cladding openings for sensing
- Low confinement for IR wavelength



Available through MPW and at volume

SiN thicknesses serving different applications

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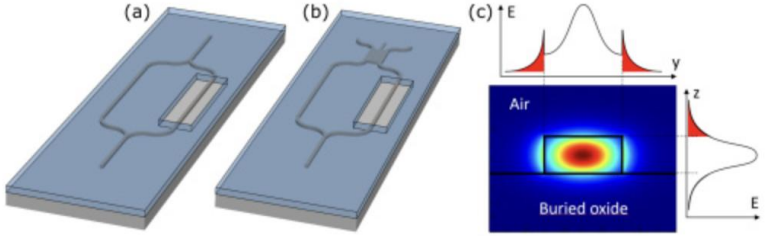
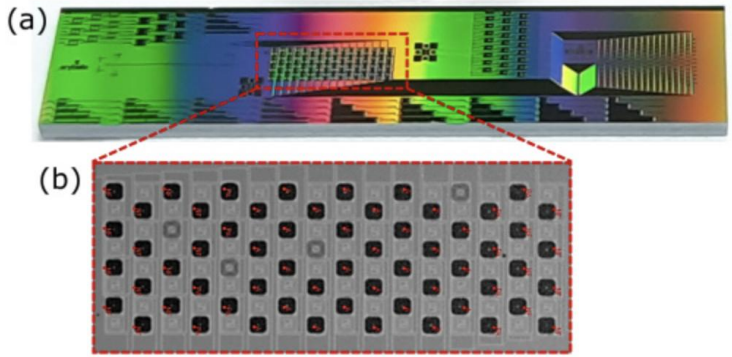
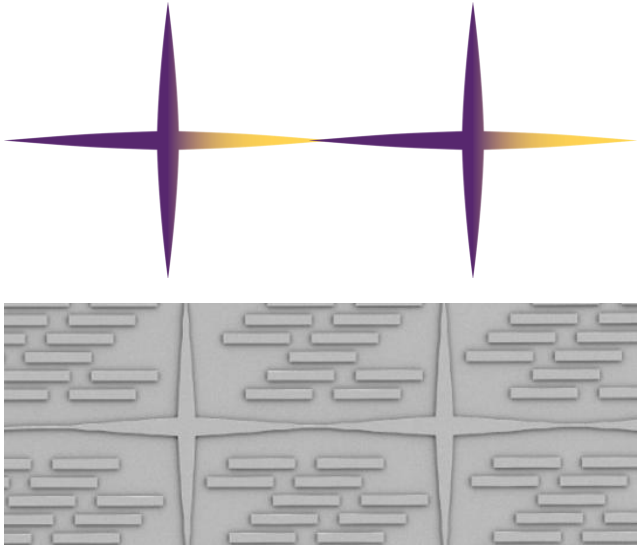


photonixFAB

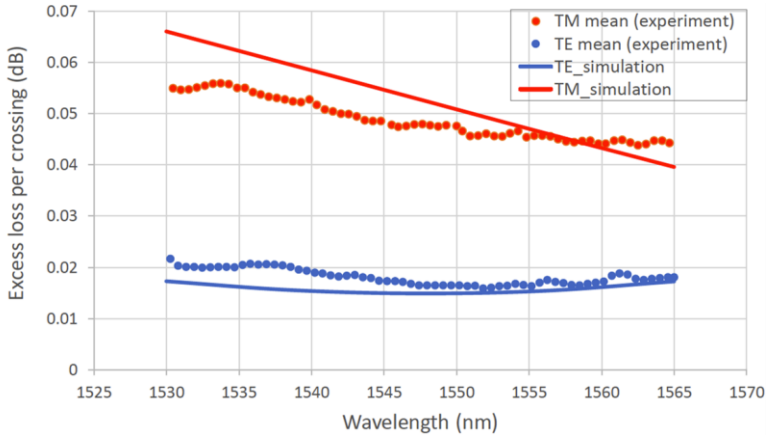


Compact Low loss Crossings: first time right possible

LIGENTEC

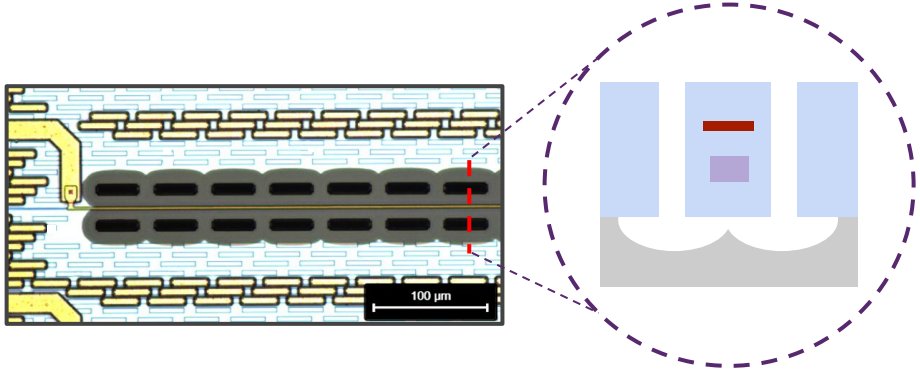


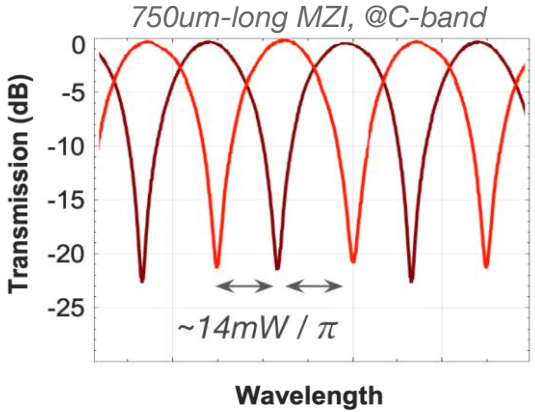
	Simulated	Measured
Excess loss (dB)	0.016	0.017
Crosstalk (dB)	- 65.48	< - 60



LIGENTEC
Ansys

Monolithic integration of modulators (kHz)





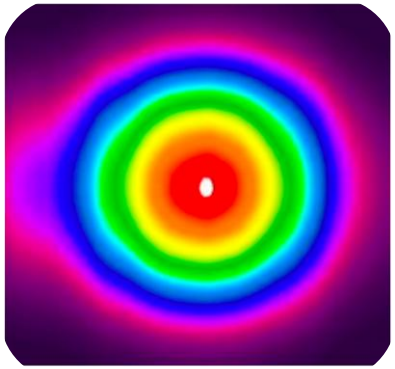
Monolithic undercut heater on top of SiN

π phase shift power : 15mW
Speed: ~kHz

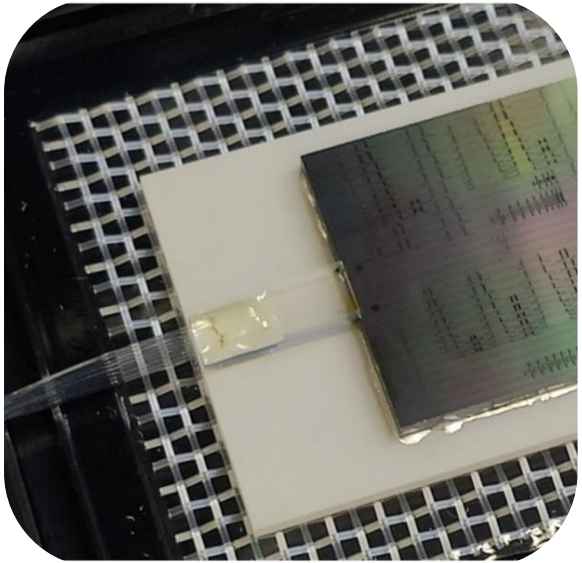
High performance optical I/O (ExSpot)

LIGENTEC

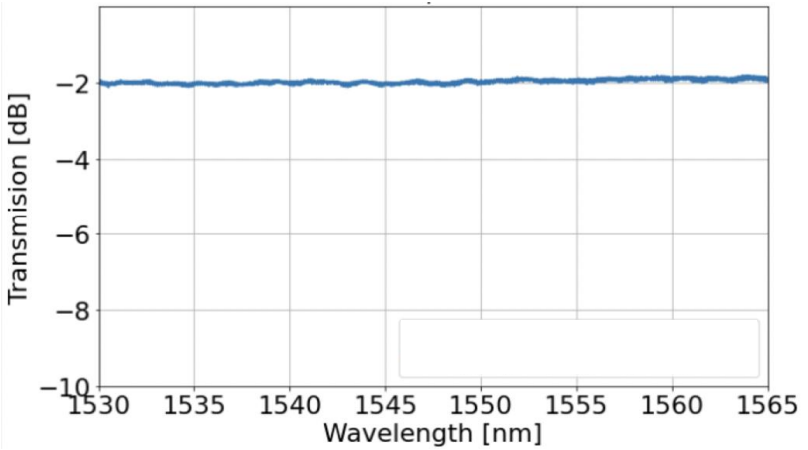
Proven track-record in development of efficient optical I/O interfaces



MFD [µm]	9.7
M^2	1.06

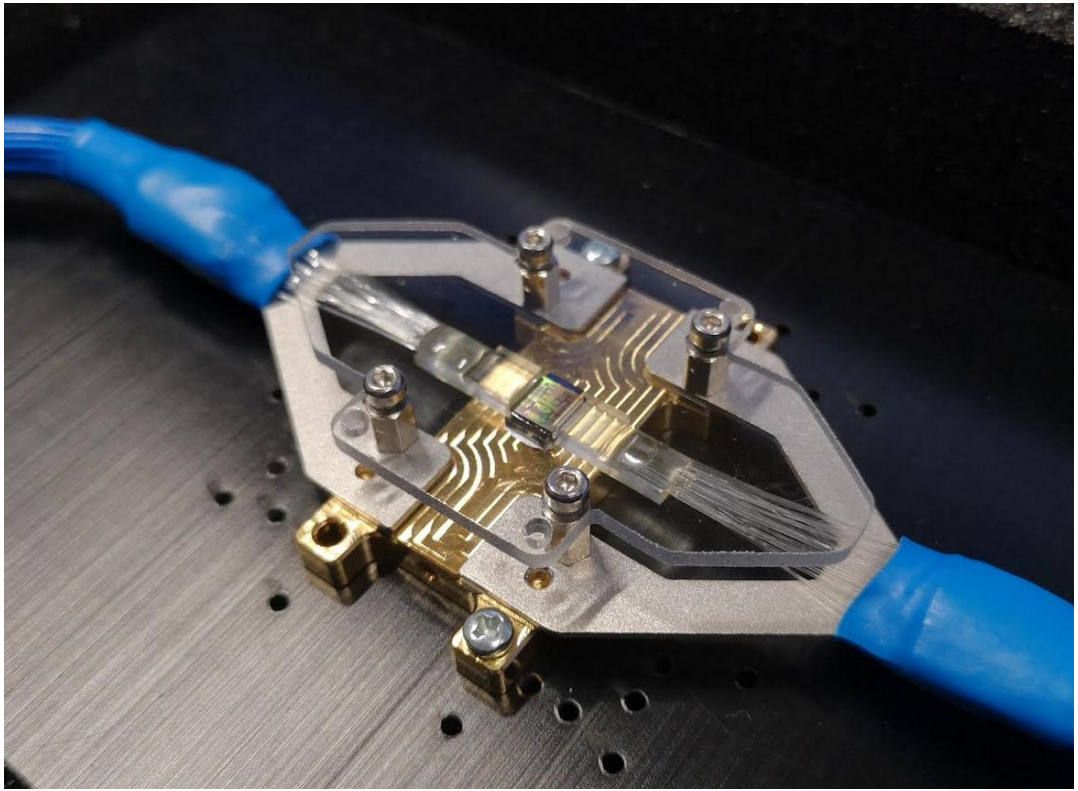


Packaged device: fiber to fiber loss



Lowering the entry barrier: MPW packaging

LIGENTEC



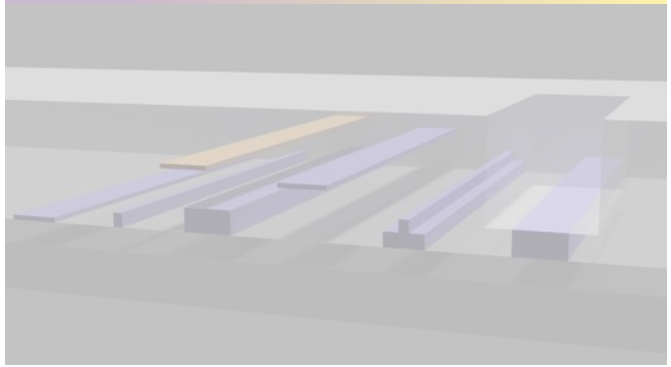
simple cost effective demonstrator

chip verification without the need of an optical bench

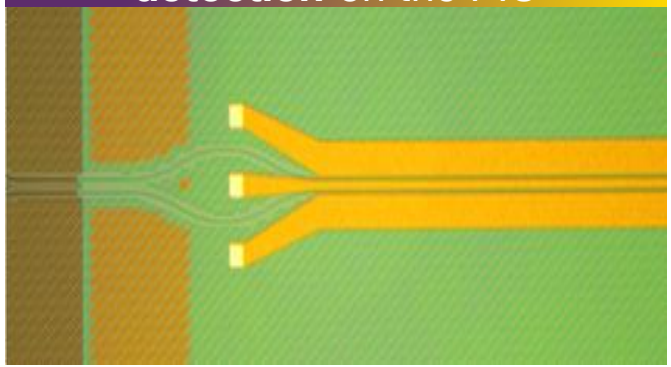
Unleash the potential of PICs!

LIGENTEC

Provide **lowest loss** Passive PICs **at scale**

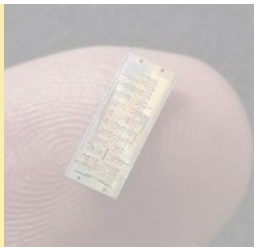


Integrate **light modulation and detection** on the PIC



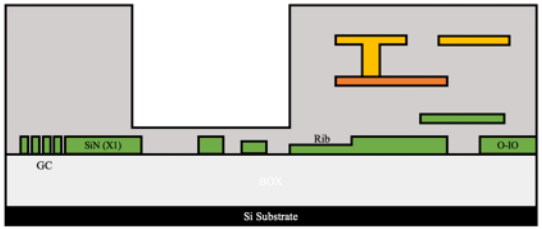
Unleash the potential of PICs

‘Let’s PIC it’

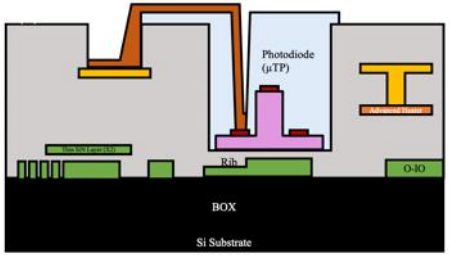


Maximally leverage the mature SiN

Keep the post processing as simple as possible and in the back-end of line



A 200 mm SiN wafer



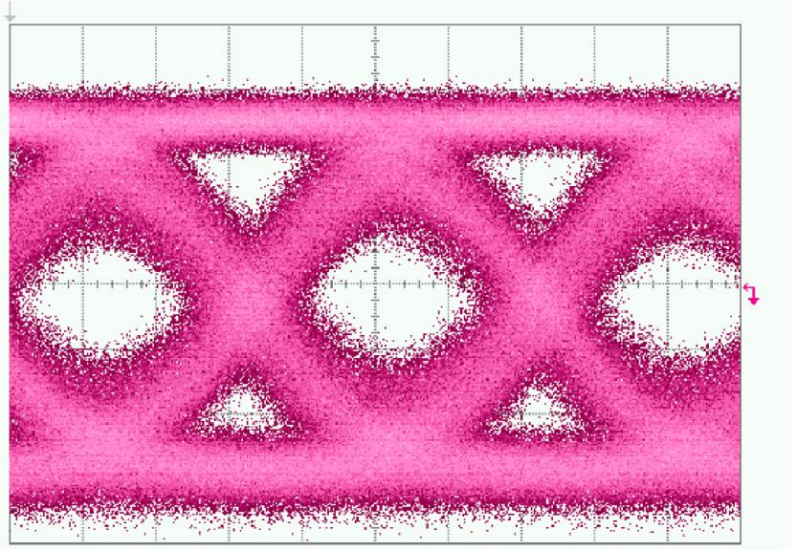
Integration in post-processing

Modulators, Photodiodes, Lasers

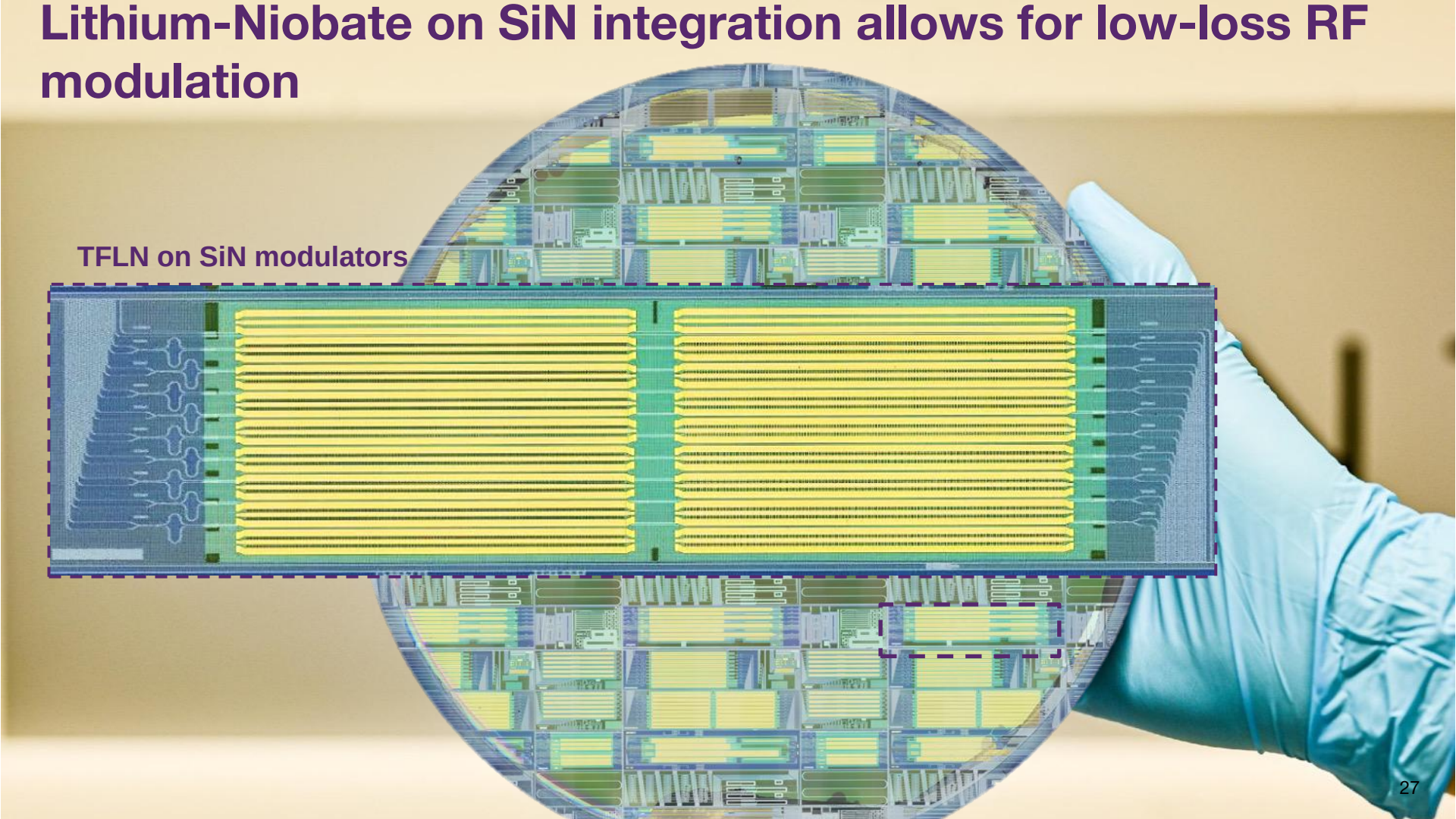
Component Transfer (printing) for complex active devices, collaborate with established suppliers (e.g. 3-5 lasers, photodiodes)

Layer Transfer (bonding) when the device fabrication is simple and can be done post front-end at wafer-level (e.g. hybrid mode TFLN-SiN modulators)

Modulation



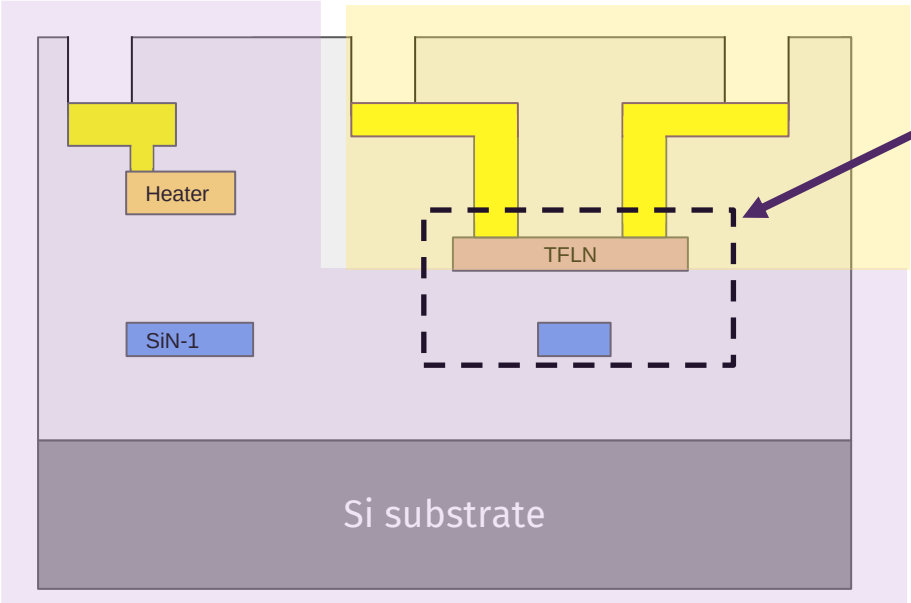
Lithium-Niobate on SiN integration allows for low-loss RF modulation



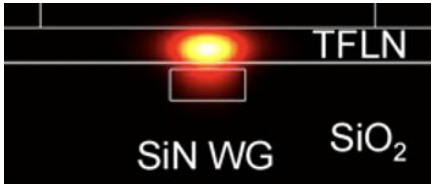
SiN – LN mode combines the best of both platforms

Ligentec's advanced **SiN technology** platform with full PDK availability

Integration of **thin-film lithium-niobate layer** for modulation

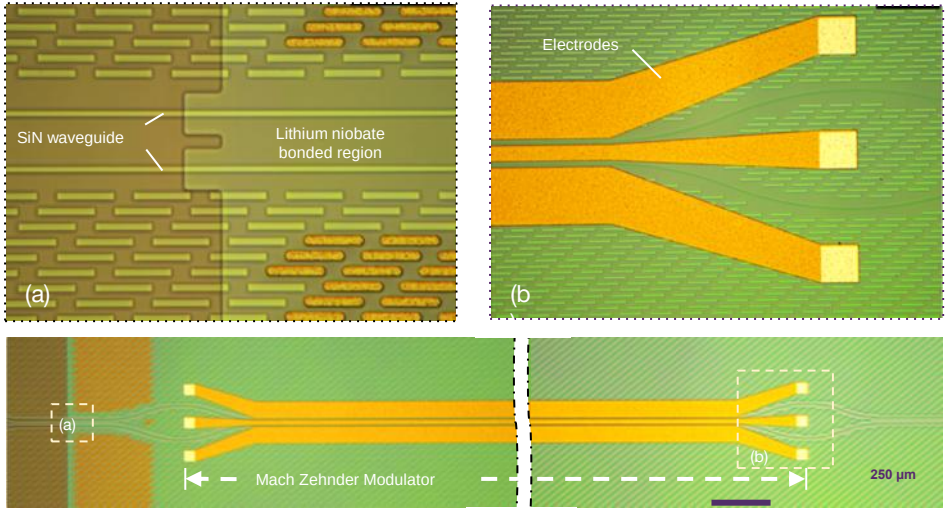


Hybrid mode at the heart



- Patterning on the SiN iso TFLN layer
- Only essential components in TFLN, all others remain in SiN

Modulator for low insertion loss modulation



Key specs of current technology

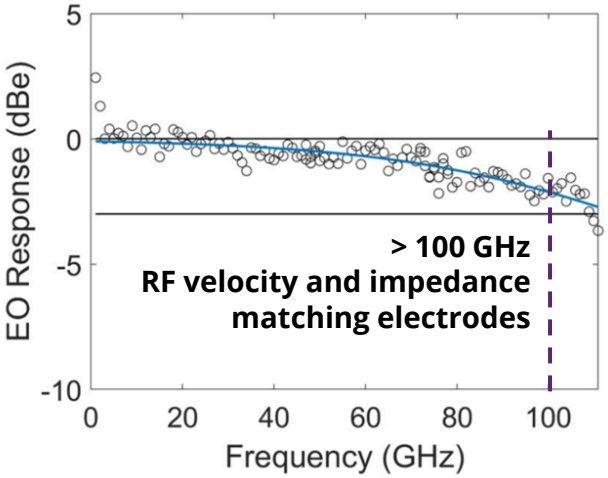
- > 10 GHz 3-dB bandwidth
- VπL < 4 V.cm (push-pull, C-band)
- VπL < 3 V.cm (push-pull, O-band)
- < 4 dB end-end insertion loss

AN800 PDK compatible

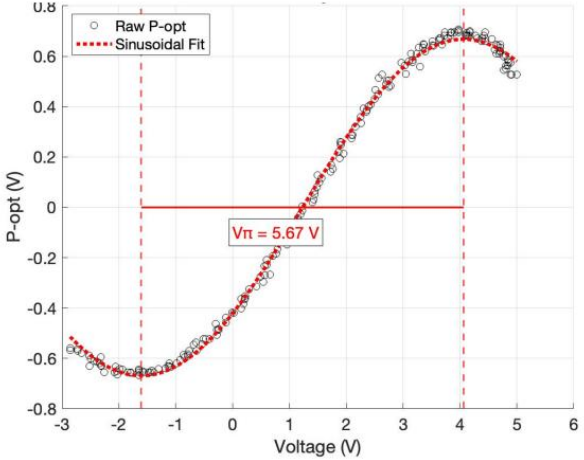
- High Q ring resonators
- 1 - 1.5 dB edge coupler loss
- All standard building blocks available

This is only the start, stay tuned!

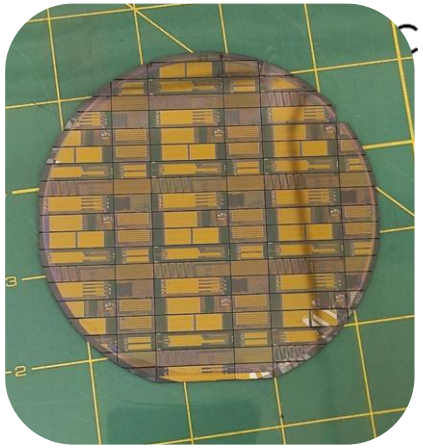
Wafer-scale, high-bandwidth modulators on LIGENTEC's platform



Electro-optic response normalized to 3 GHz
Bandwidth up to **110 GHz** measured
Device length: 0.6 cm

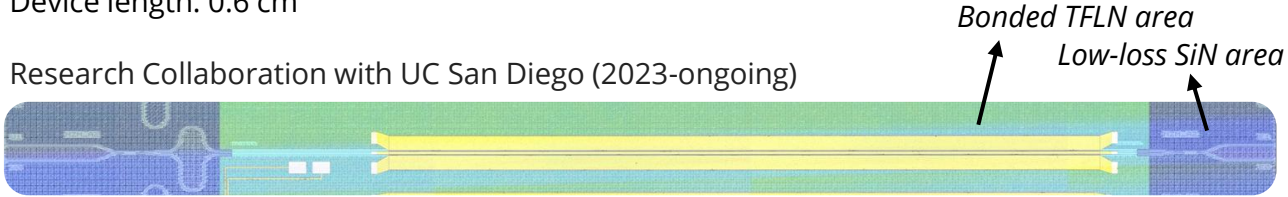


MZM insertion loss < 5 dB
VπL = 3.4 V.cm



LIGENTEC 100 mm wafer with high-bandwidth SiN / TFLN modulators

Research Collaboration with UC San Diego (2023-ongoing)

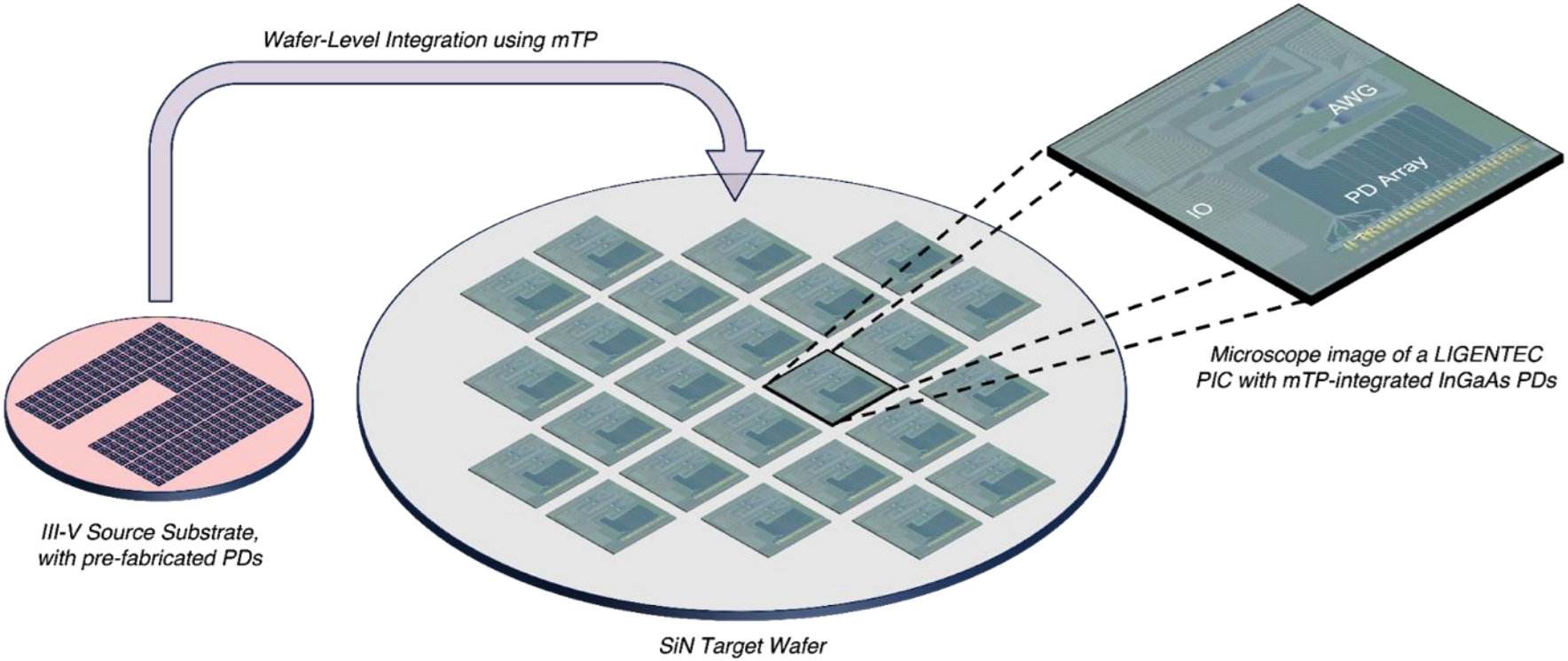


"High-performance Hybrid Lithium Niobate Electro-optic Modulators Integrated with Low-loss Silicon Nitride Waveguides on a Wafer-scale Photonics Platform" (Preprint, 2025)

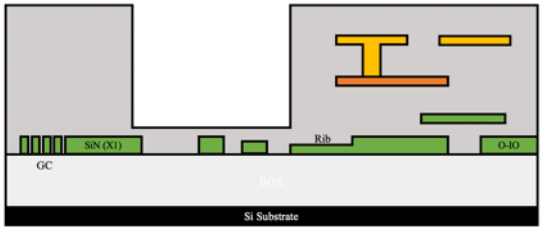
LIGENTEC PROPRIETARY AND CONFIDENTIAL

Detection

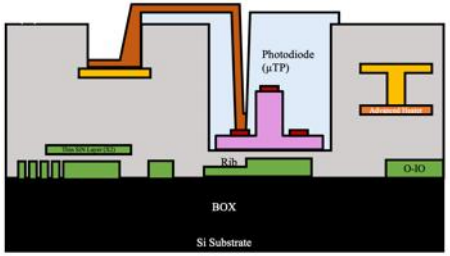
Transfer printing for flexible PD integration



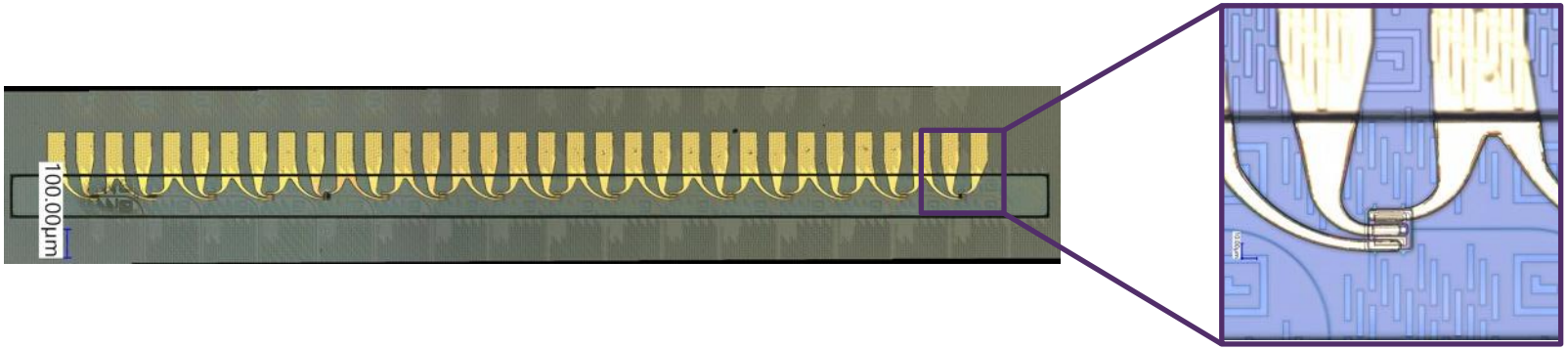
Transfer printing for flexible PD integration



A 200 mm SiN wafer



Integration in post-processing



Detection

Transfer printing for flexible PD integration

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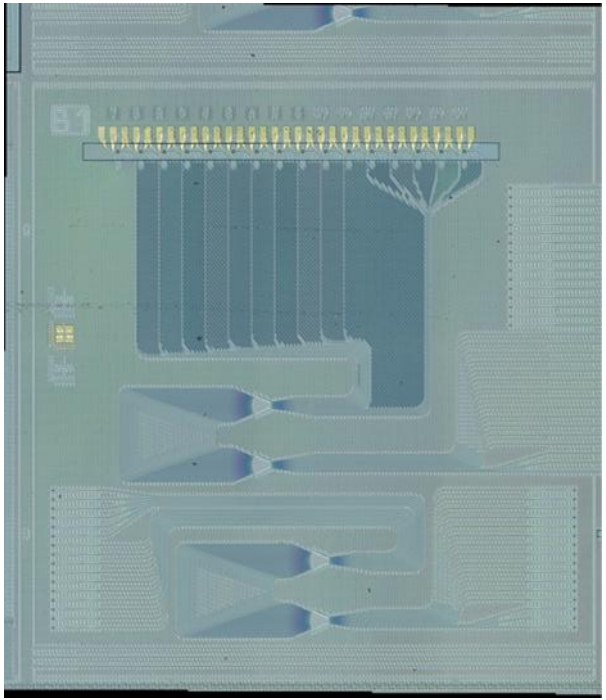
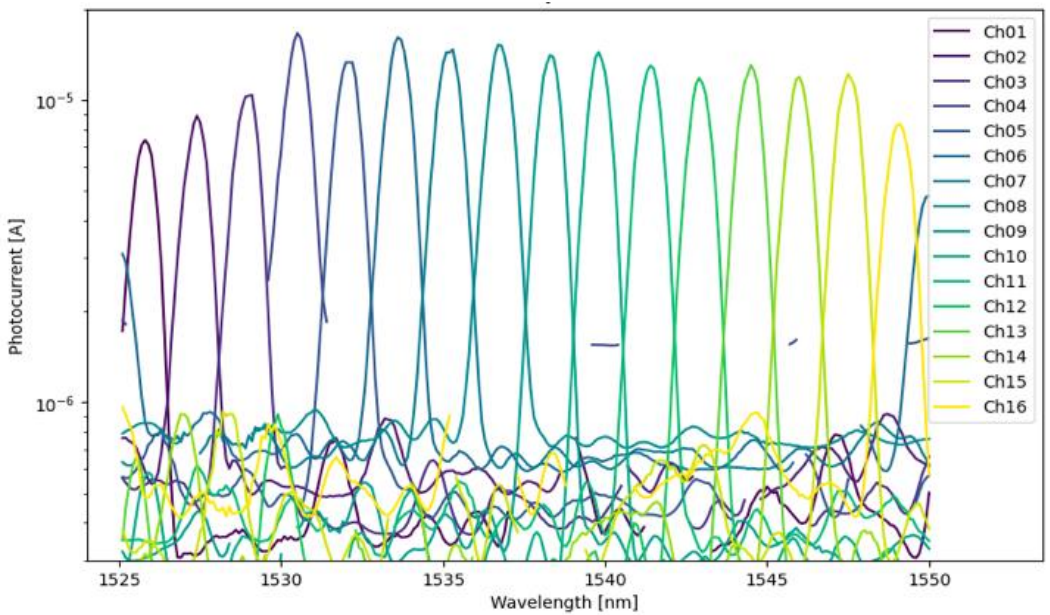
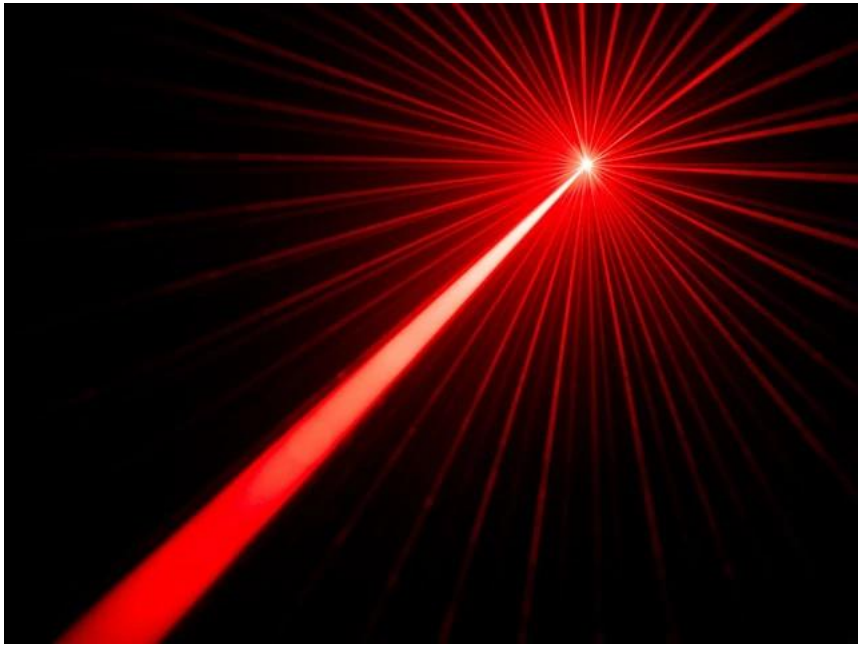




LIGENTEC
xfab
XCeleprint
World's first integrated value chain platform initiative for heterogeneous integration in photonics

Lasers

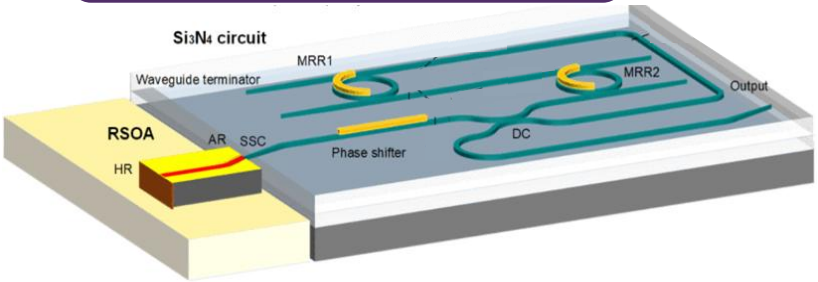


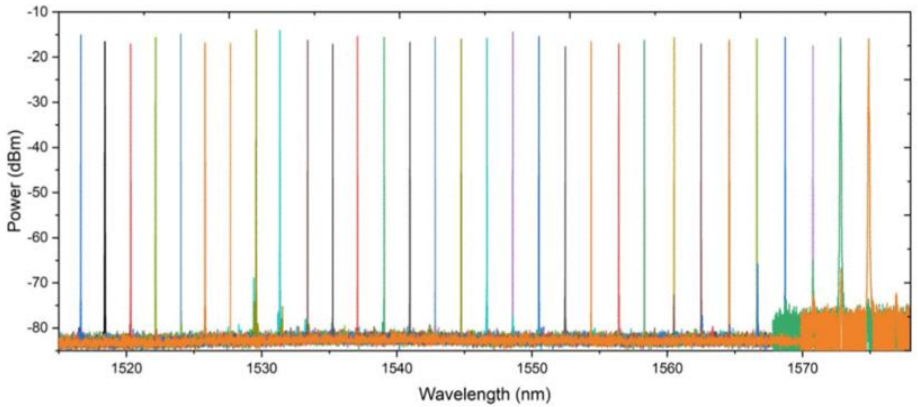
Hybrid Integration example

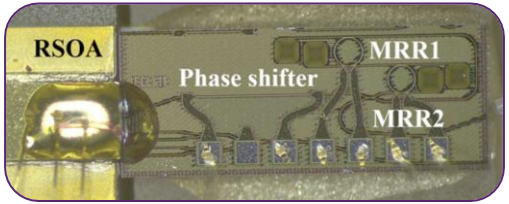
Tunable Narrow Linewidth Lasers

LIGENTEC

LIGENTEC's capability to design, layout and fabrication







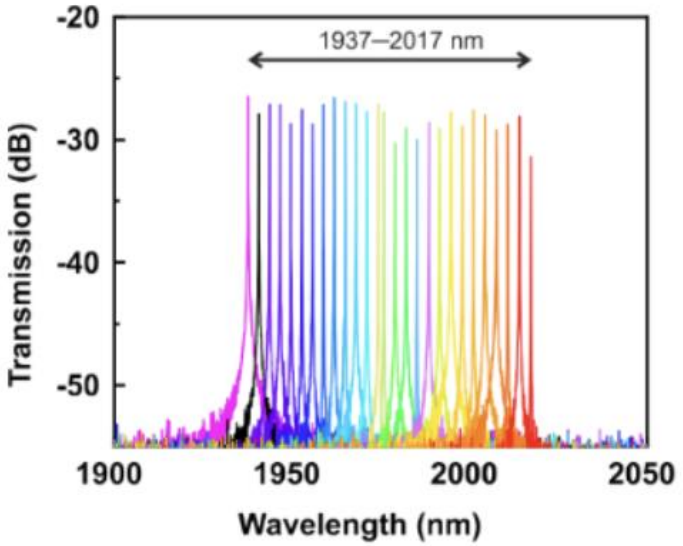
Narrow Linewidth External Cavity Lasers

Linewidth: <3kHz ***Max power: 34mW***
SMSR: -70dB ***Tuning: 58.5nm***

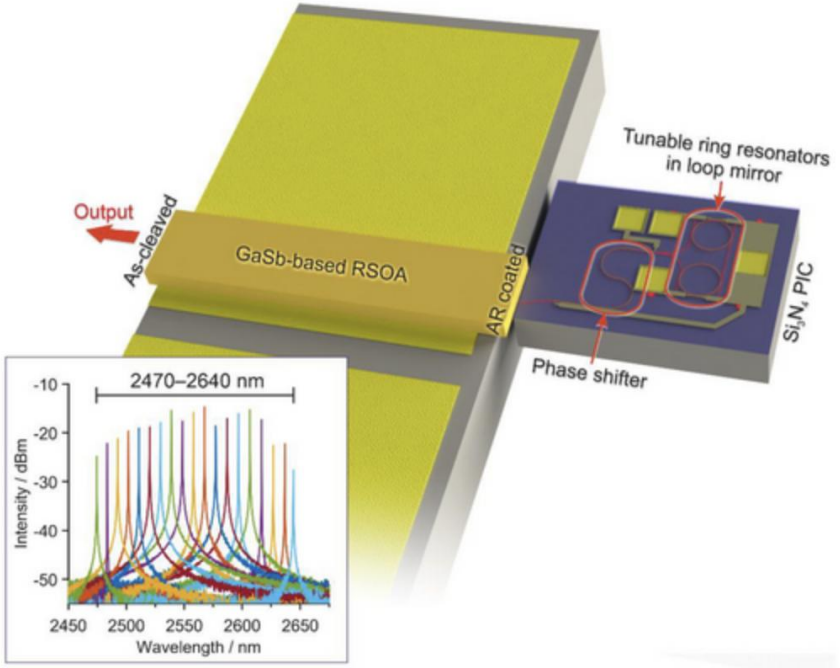
Y.Guo et al., IEEE Photonics Journal (2021)
C.Liu et al., JLT (2022)
Zia et al., arXiv 2211.02135 (2022)

Hybrid Integration example

GaSb/Si3N4 hybrid laser at 2 µm and 2.5 µm



Zia et al., arXiv 2211.02135 (2022)



Ojanen et al., Laser&Photonics Review (2023)

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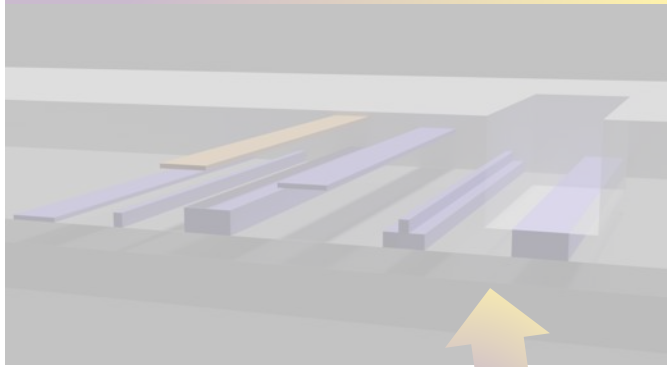
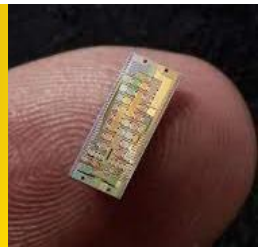
Provide **lowest loss** Passive PICs **at scale**



Integrate **light modulation and detection** on the PIC

Unleash the potential of PICs

‘Let’s PIC it’



LIGENTEC

Provide **lowest loss** Passive PICs **at scale**

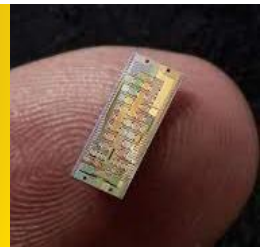
MPW runs every 2 months
Dedicated runs

www.ligentec.com/offering/

Integrate **light modulation and detection** on the PIC

Unleash the potential of PICs

‘Let’s PIC it’



LIGENTEC

Provide **lowest loss** Passive PICs **at scale**

MPW runs every 2 months
Dedicated runs any time

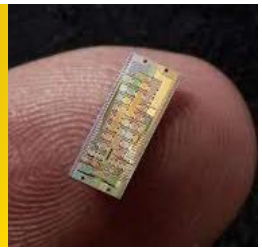
www.ligentec.com/offering/

Integrate **light modulation and detection** on the PIC

LABS

Unleash the potential of PICs

‘Let’s PIC it’



LIGENTEC Labs provides early-stage to access advanced technologies

- **From the Lab, for the Lab**
- **Early access to advanced technology in cost sharing mode**
- **Opportunity to steer technology developments from your application**

Upcoming LABS MPW's

June '25: TFLN on SiN hybrid-mode modulators

April '25: 3-5 Photodiodes on SiN

Let’s PIC it!