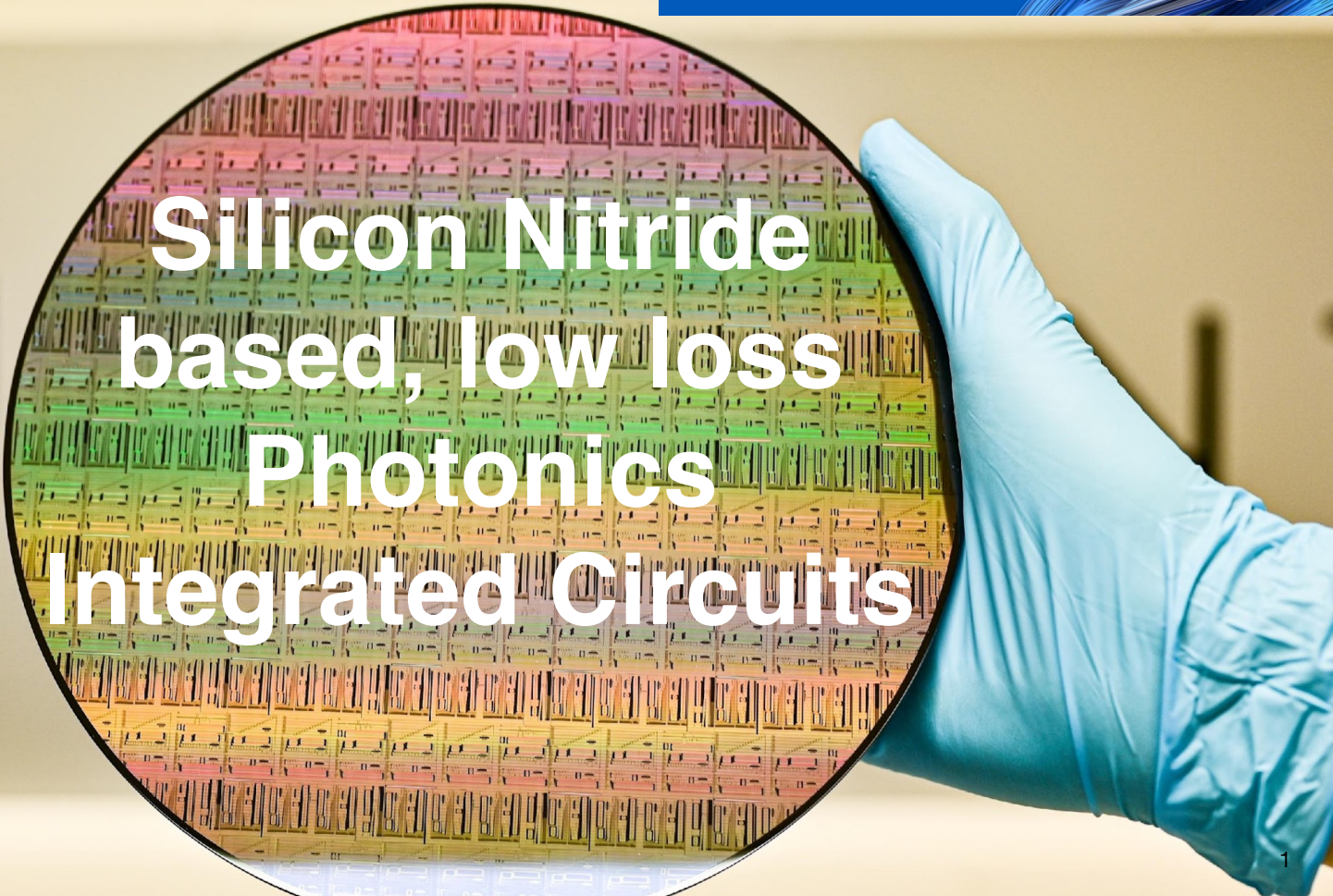




Silicon Nitride based, low loss Photonics Integrated Circuits

LIGENTEC

Leader in low loss Silicon Nitride Integrated Photonics



EPFL



LIGENTEC

European PIC Company

European origin



Europe based



Global Reach



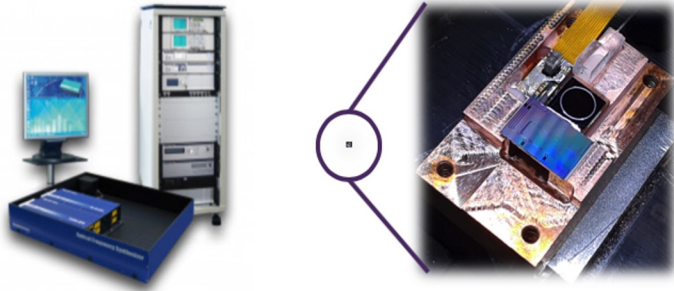
Headquarters in Lausanne (CH)

Originating from EPFL (Kippenberg Lab)

Problem - Barriers for Breakthrough Photonic Integrated Circuits (PICs) ...



PICs have a huge potential



Disruptive PICs:

Size: 100x smaller
Weight: 100x lighter
Power: 1/10th of energy
Cost: 1/100th of cost

Scalable with semi-conductor technologies

... and have become technology of choice in



Data Center



Telecom

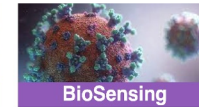
but there is more potential out there



AR / VR



Wearables



BioSensing



LiDAR



Space



Quantum Computing



Atomic Clocks



Astronomy



Neurom. Computing



5G



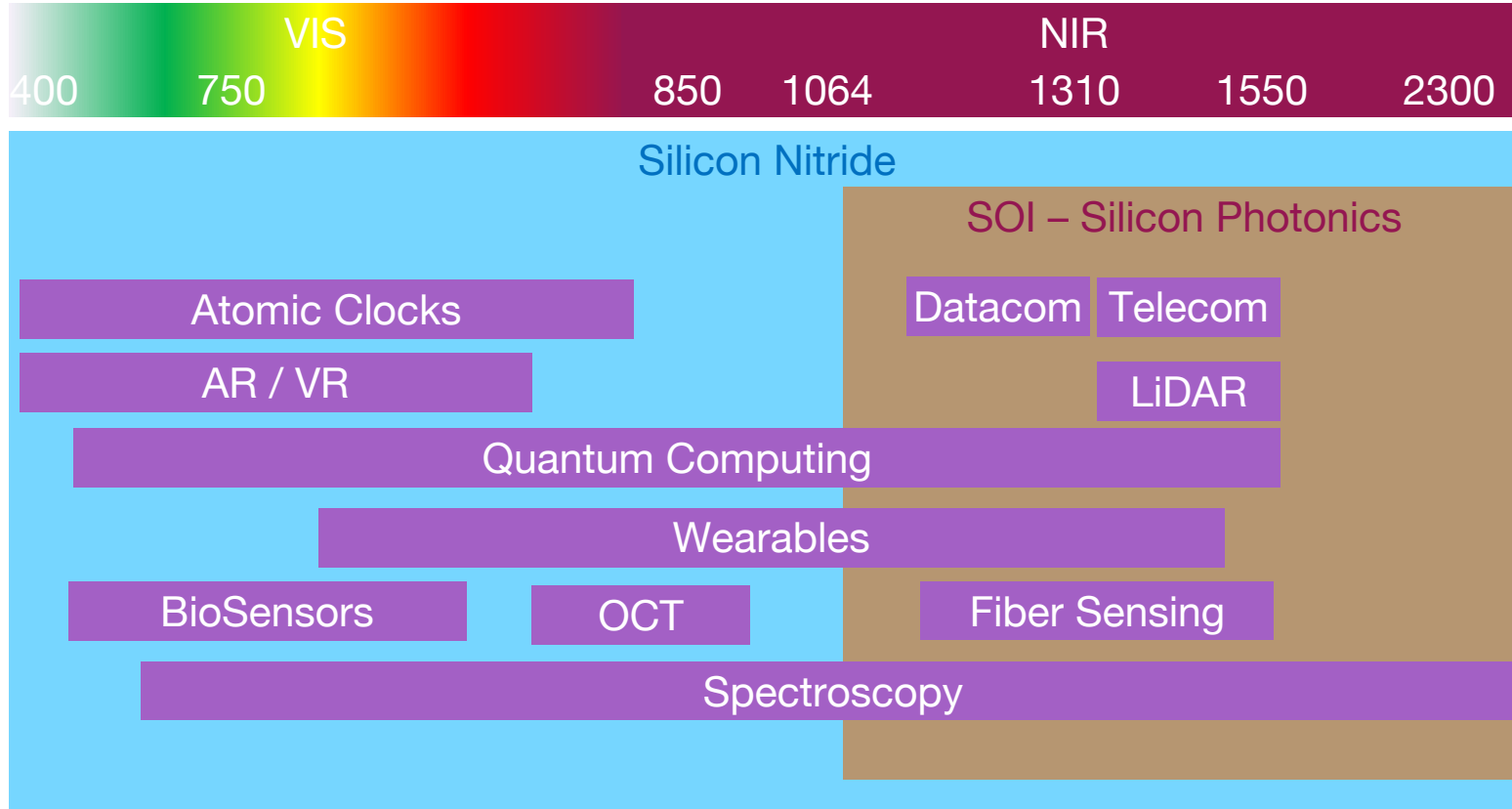
Quantum Crypto



Next big thing

with application specific requirements

- ☐ Operating wavelength below 1000 nm
- ☐ Low propagation losses



Photonic Integration: Motivation for low loss PICs

Why are losses important?



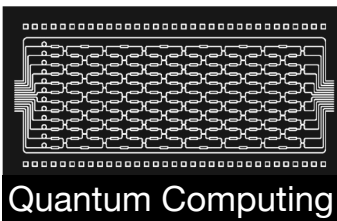
Use Case: Laser for FMCW LiDAR

- Laser chirp control with long delay lines
- Narrow linewidth extended cavity lasers
- Phase noise is related to losses



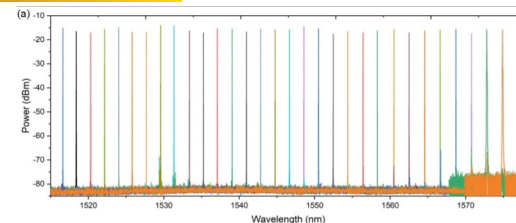
Use Case: MUX/DeMUX & Filters

- AWGs phase noise is related to losses
- Ring resonator narrow linewidth filter
- Tunable narrow linewidth lasers (<5 kHz)

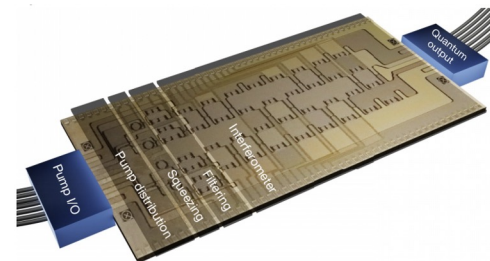
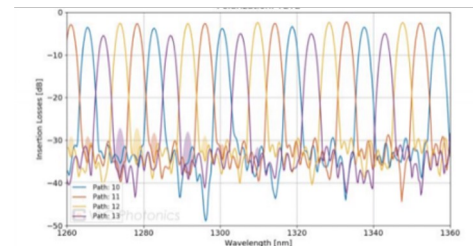


Use Case: photon pair generation & processing

- High Q ring resonators, non-linear optics
- Asymmetric MZI interferometers, Qubit loss / every photon counts



Y.Guo et al., IEEE Photonics Journal (2021)

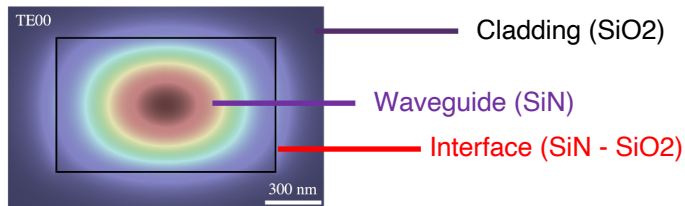


Arrazola et al., Nature 54 March 2021

Low loss is a requirement for many applications and a performance enabler

Low loss waveguides

Simplified loss mode



Loss origin:

Absorption

Approach to reduce losses:

Choose the best material (SiN & SiO₂)
Improve the material quality

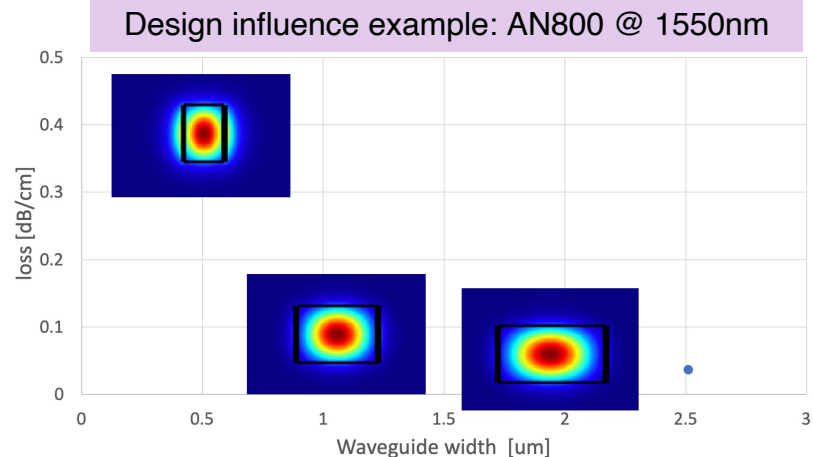
Sidewall scattering

Reduce sidewall roughness
Reduce interaction:

- **High confinement** or
- Ultra low confinement (large chips)

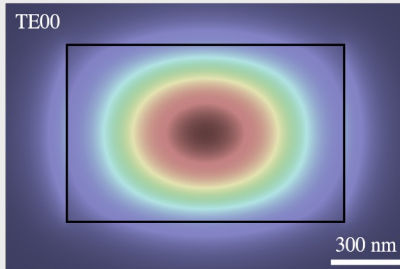
Radiation at bends

- Large bends (large chips)
- **High confinement**, strong guidance, compact size, low bend loss



Propagation loss < 0.05 dB/cm achievable
for high confinement waveguides

Thick SiN – the game changer



90% of the light is confined

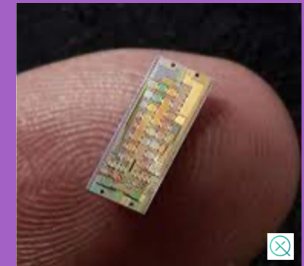
- Low propagation loss
- Small chip size
- Non-linear optics
- High Power, VIS to IR

All Nitride Core Technology: combining the benefits of

- **Silicon Nitride** (VIS-IR, low loss, high power) with
- **Silicon Photonics** (small chip size, scalability)

Loss down to 0.05 dB/cm for high confinement waveguides

We deliver PICs



A base to build on

Versatile Platform



3+ thicknesses

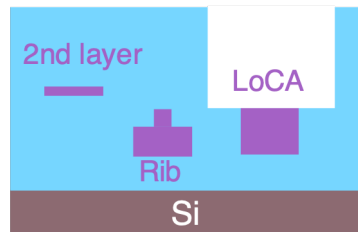
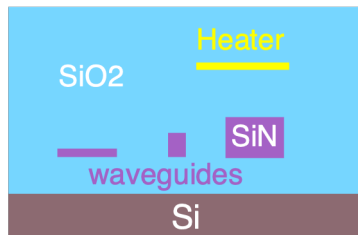
800 nm

400 nm

150 nm

custom

10 process modules



- Modular
- CMOS compatible
- Scalable

Extensive PDK

Design rules

Design Rule Checks

Layout files

Primitives

Building Blocks

IP Cores

Components

- Waveguides, delay lines
- Couplers / MMIs
- Crossings
- Filters (RRs, AWGs)
- Switches
- Polarization mgt

Optical I/O

- Grating couplers
- Inverted tapers
- Spot size converters

Design flows

VLC
PHOTONICS

Mentor
A Siemens Business

SYNOPSYS

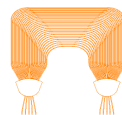
Silicon to Software™
LUCEDA
PHOTONICS

VPIphotonics
DESIGN AUTOMATION

Anslys / LUMERICAL

Simulations

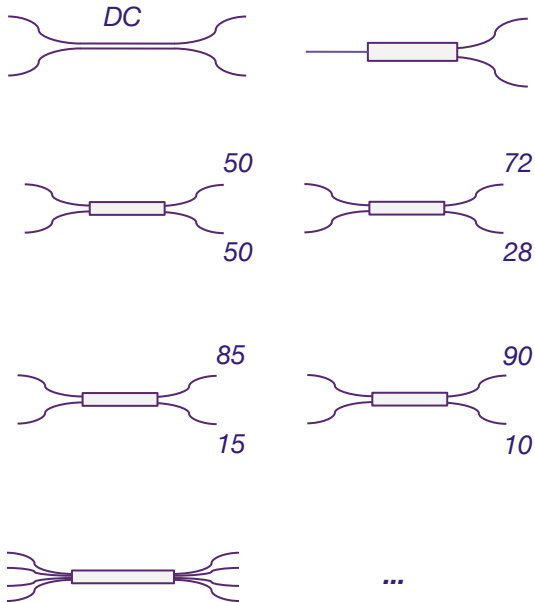
- Component and circuit simulation
- Technology files
- Cross section



High performance PDK Splitters, combiners, mixers

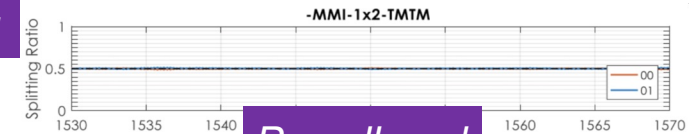
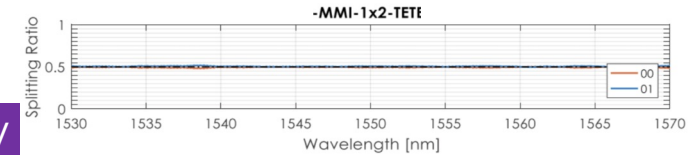


Component Design => Fabrication => Wafer level testing

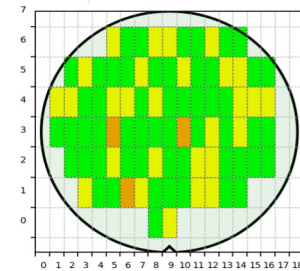


TE /
TM

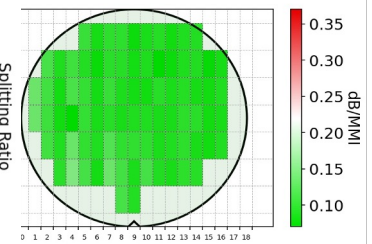
High quality PDK Components



Broadband



Reproducible



Low-loss

Simplify the access to PIC technology

Seamless journey from Idea to Volumes



Entry: R&D & Prototyping

Open access, low barrier

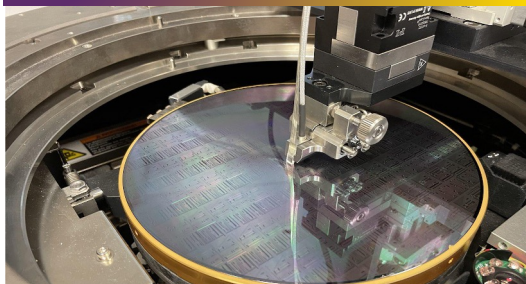


Fast prototyping

- 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

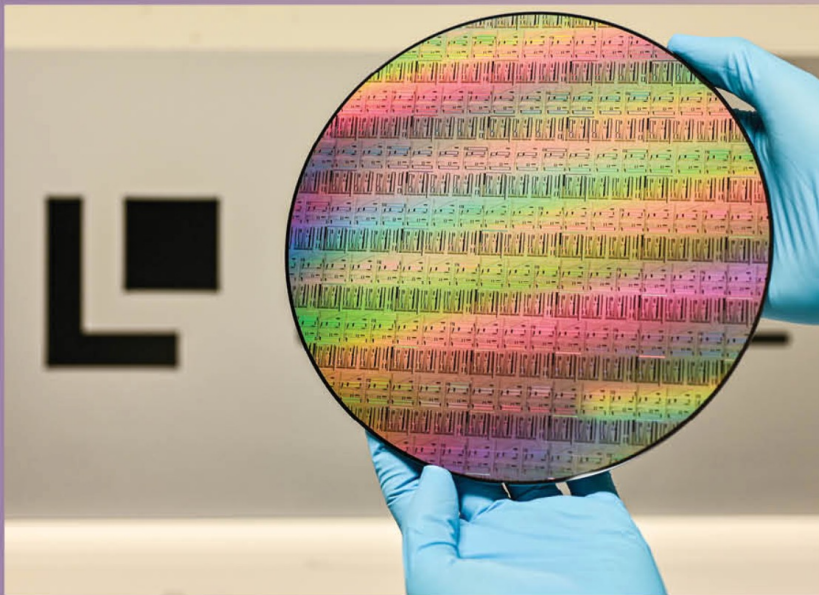


Pilot Fabrication

- Pilot and niche quantities

Volume Fabrication

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



New PIC Partnership!

**“LIGENTEC and X-FAB
collaboration creates Europe’s
largest capacity foundry service
for integrated photonic circuits”**

**CLICK TO READ THE
PRESS RELEASE**

Challenge application diversity

Combine the best

Application Challenges	Wavelength		Non-linear effects		Phase noise		Integration Density		Bandwidth	
	Propagation Loss		Power	T Stability		Radiation hardness		Optical Uniformity		
	Linearity	Size	Voltage	Cost	Opt. I/O	Back reflection		Scalability	Crosstalk	

	InP	Silicon	SiN	Silica
Wavelength	NIR upwards	NIR to MIR	VIS to MIR	VIS to MIR
Passives	Moderate loss, TPA, T sensitive	Moderate loss, TPA, T sensitive	Very low loss, high power	Very low loss
Lasers	Monolithic	Heterogeneous	Heterogeneous integration	External / hybrid
Modulators	Monolithic	Monolithic	Heterogeneous integration	NA
Photodetectors	Monolithic	Monolithic	Monolithic	External / hybrid
Compactness / index contrast	low	high	moderate	high
Cost	high	low	moderate	high
Maturity	high	high	emerging	high

There is **no** one fits all technology

High application diversity, no one fits all solution,
Optimizing for a single application only possible high-volume applications

Approach:

Best and scalable base platform for circuitry with standard I/Os and PDK



Application specific choices of integration

⇒ Combine the best to lower adoption barriers

Combine the best with the best

SiN – the platform for monolithic & heterogeneous integration



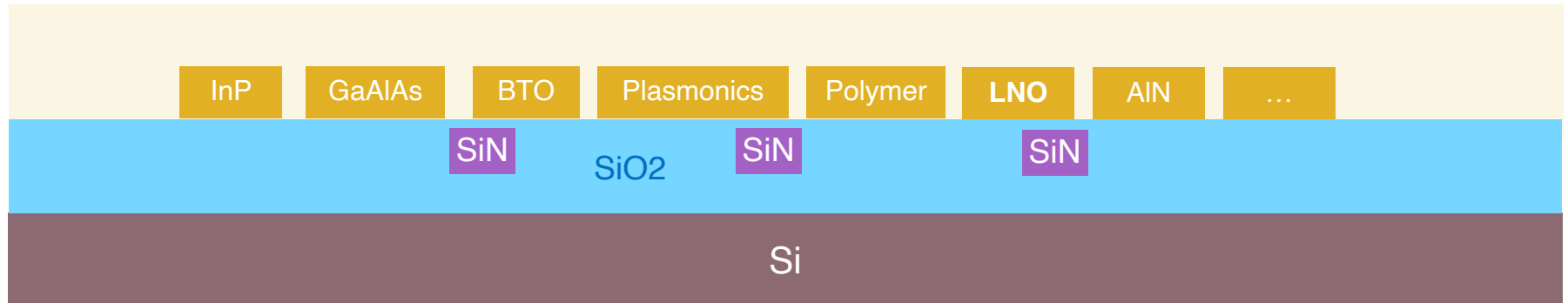
Use SiN as base platform for general circuitry

- Comprehensive PDK
- Standard I/Os
- Scalable to volume

Add materials as required by application

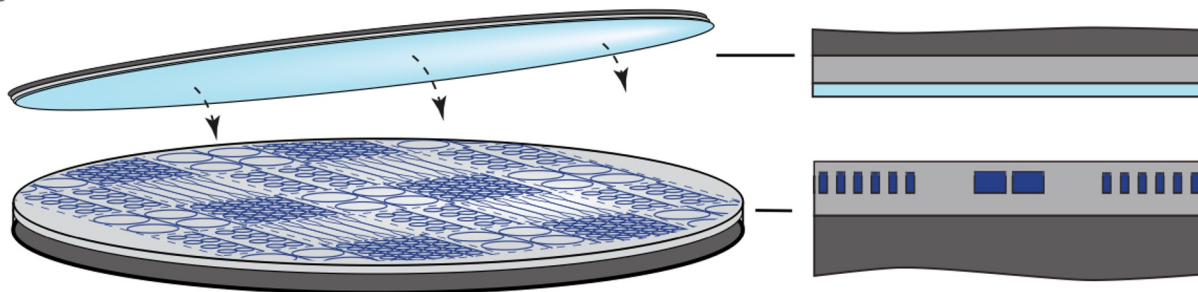
Integration technologies applied:

- Monolithic integration
- Wafer bonding
- Micro Transfer Printing
- Hybrid integration



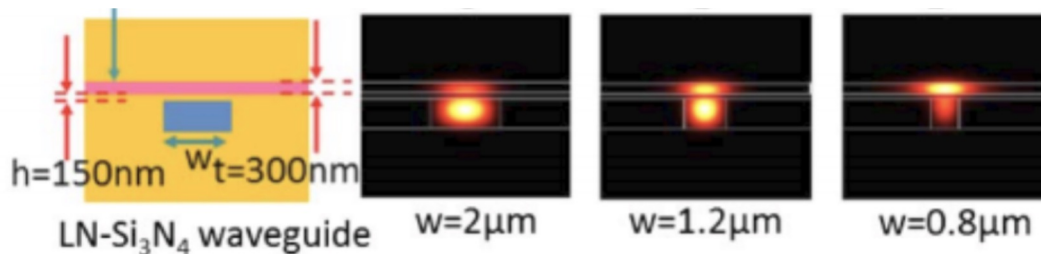
Heterogeneous Integration example
LNOI / SiN wafer level bonding

LiNbO₃



SiN

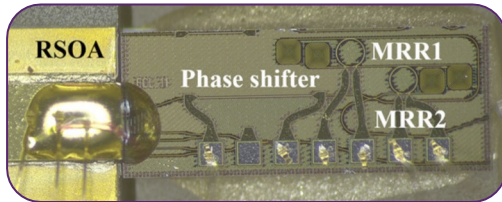
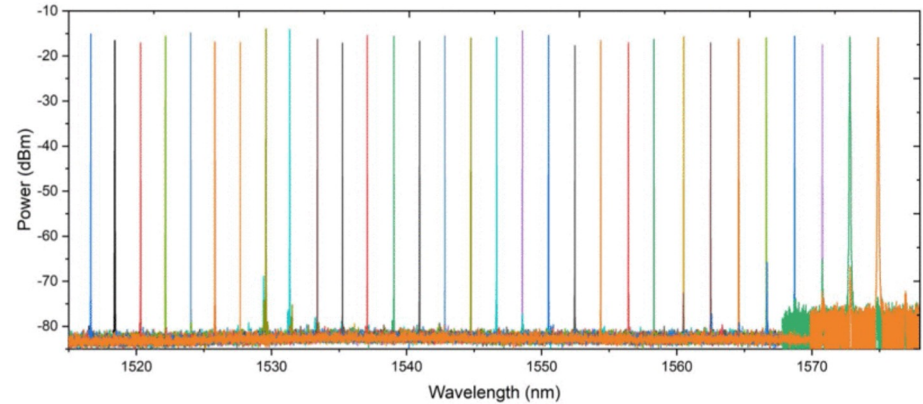
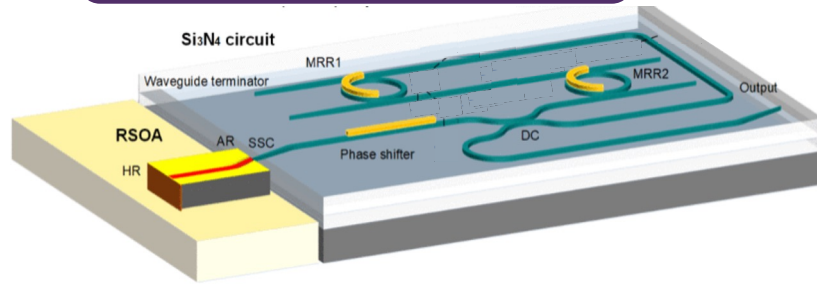
Enables early-stage engagement
with our R&D team
to access advanced technologies



Hybrid Integration example

Tunable Narrow Linewidth Lasers

LIGENTEC design, layout and fabrication



Narrow Linewidth External Cavity Lasers

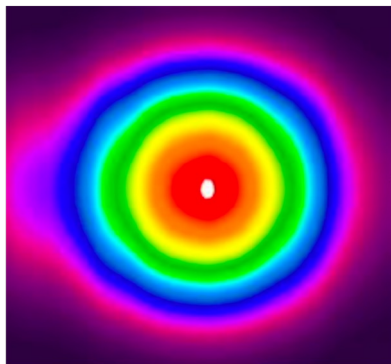
Linewidth: <3kHz

Max power: 34mW

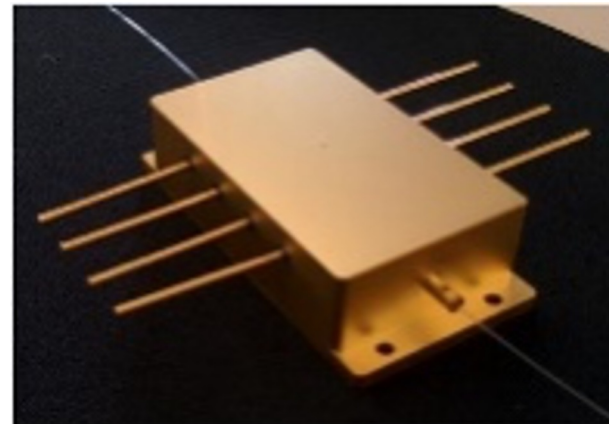
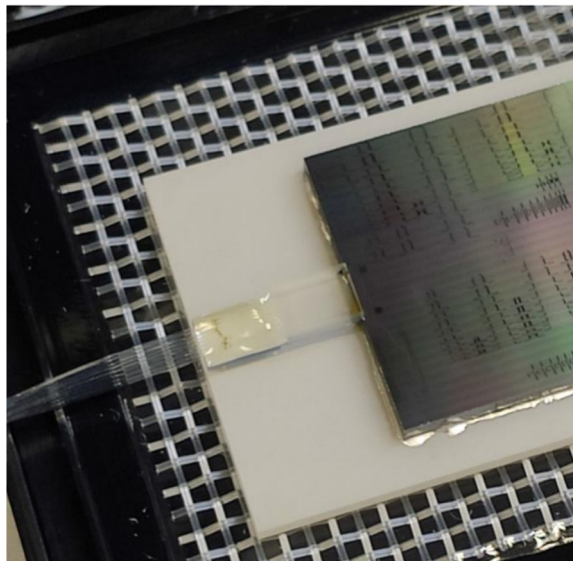
SMSR: -70dB

Tuning: 58.5nm

Hybrid Integration example
High performance optical I/O (ExSpot)



MFD [μm]	9.7
M^2	1.06

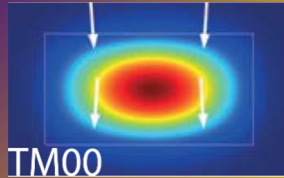


Summary

Low Loss SiN - Platform Overview



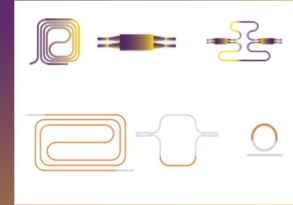
Low loss waveguides



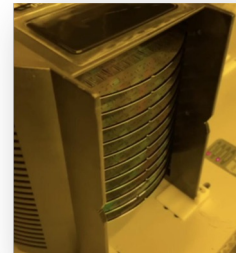
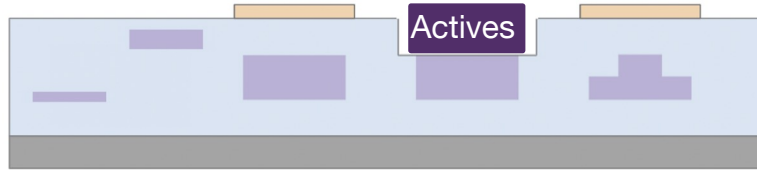
MPW / Dedicated runs
Short turn around

Flexible R&D line
Volume line

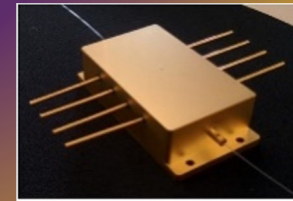
Extensive PDK



Actives Integration



Low loss optical I/O



Let's PIC it to make the world a better one!

Join our PIC journey!
ligentec.com/careers



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