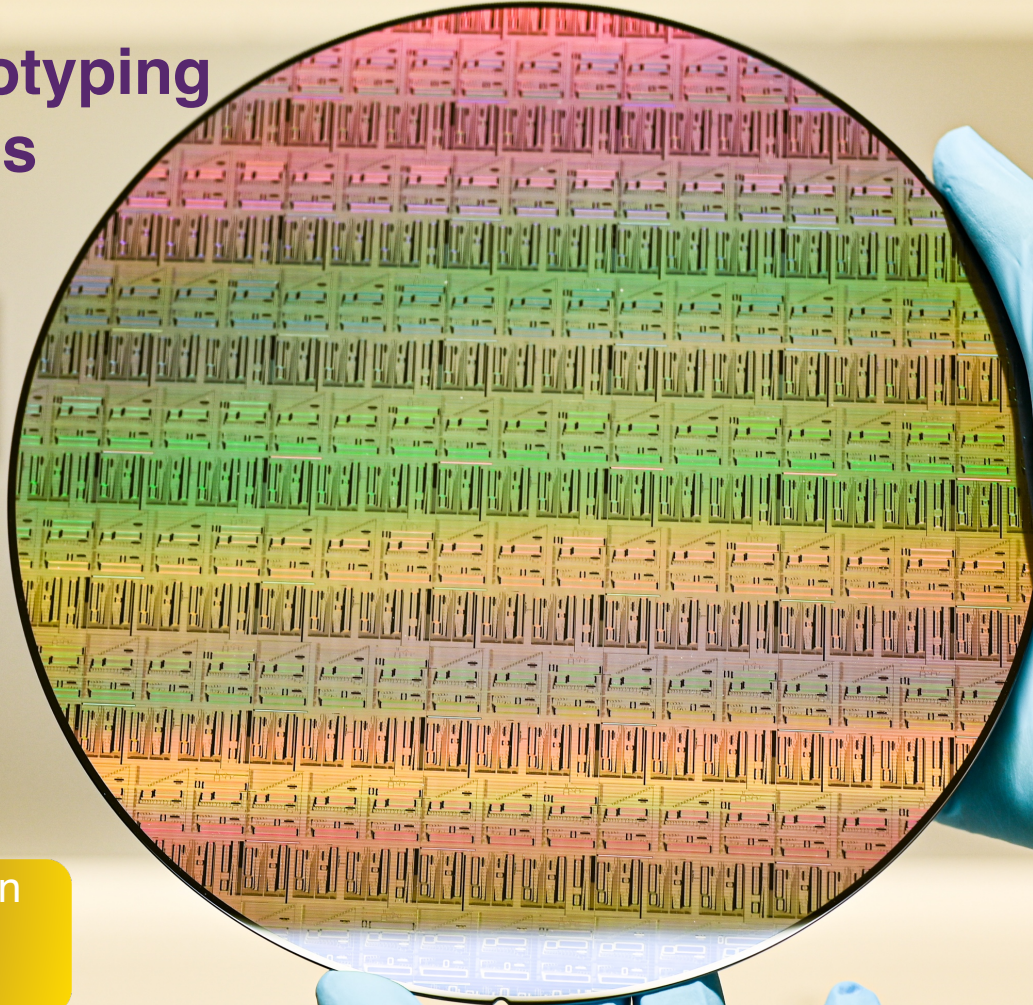


Low loss PICs: From fast prototyping to high volumes



Dr. Michael Geiselmann

mwg@ligentec.com

LIGENTEC

Leader in low loss Silicon Nitride Integrated Photonics



EPFL



LIGENTEC

European PIC Company

European origin

Europe based



Global Reach



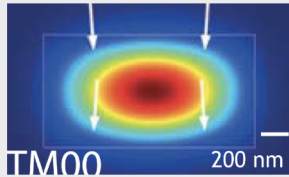
Headquarters in Lausanne (CH)

Originating from EPFL (Kippenberg Lab)

LIGENTEC Snapshot



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)

Versatile PIC Platform

3+ thicknesses

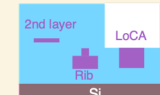
800 nm

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

synopsys

silicon to software

luceda

photonics

ansys

lumerical

Simulations

• Component and circuit simulation

• Technology files

• Cross section

Commercial Offering

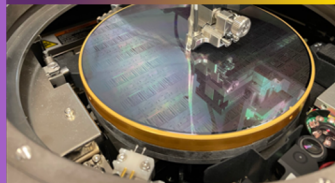
R&D and Prototyping

Open access, low barrier



Custom PIC Developments

High flexibility & competence

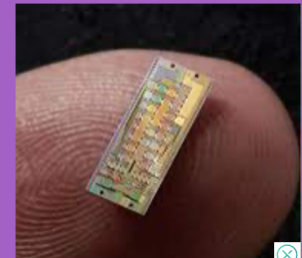


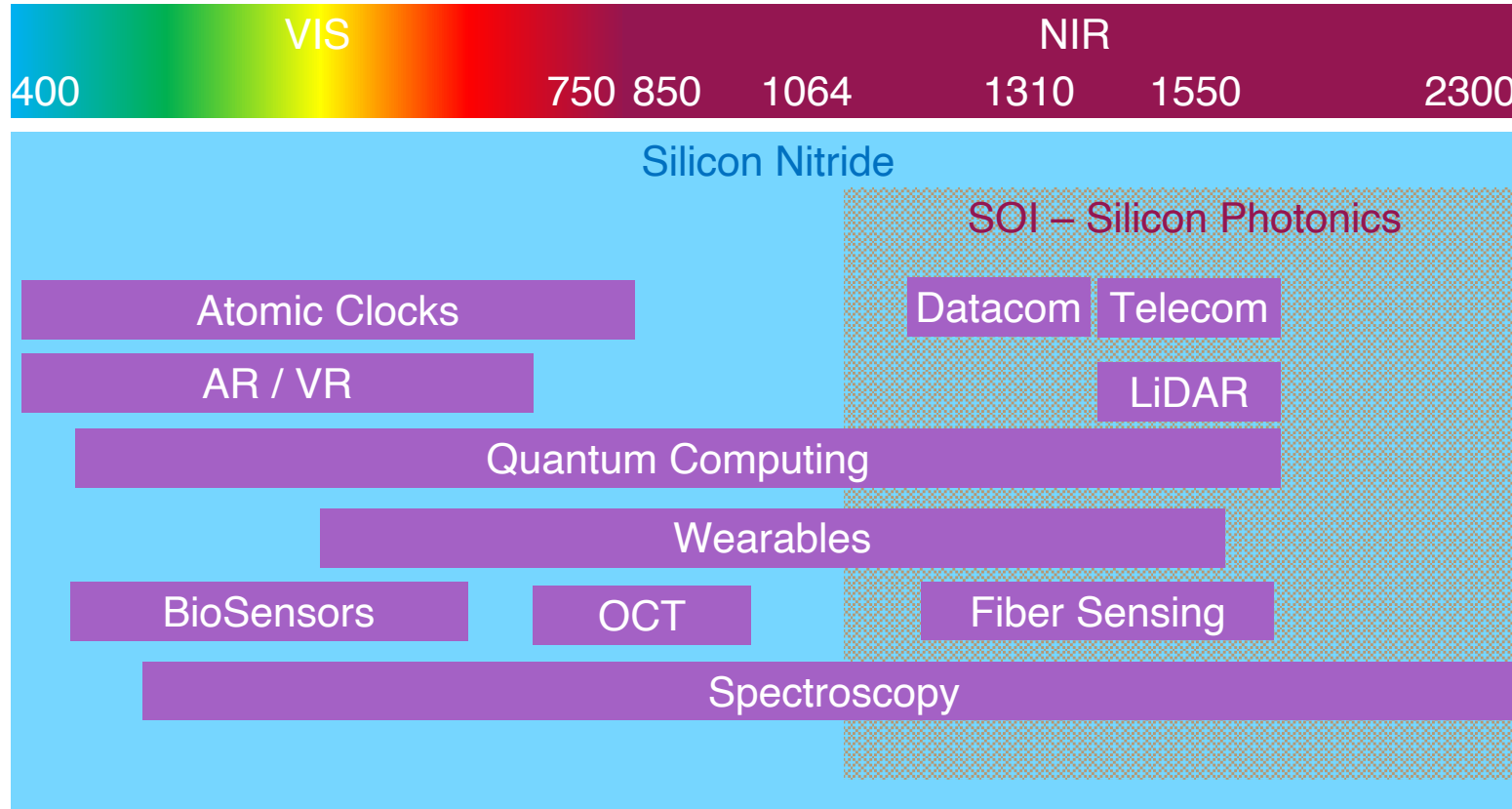
Manufacturing

Niche to high volumes



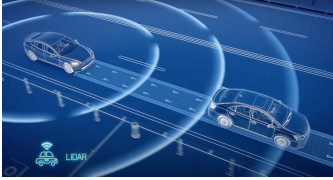
We deliver PICs





Photonic Integration: Motivation for low loss PICs

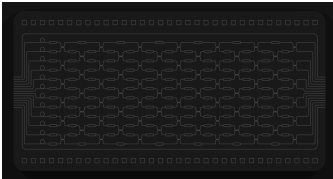
Why are losses important?



- Long delay lines require of 10s of cm
- Detection of photons coming back
- Phase noise is related to losses

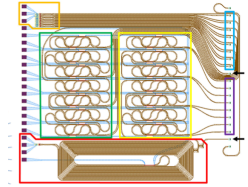


- Phase noise of AWGs is related to losses
- Tunable narrow linewidth lasers
- Narrow linewidth Filter

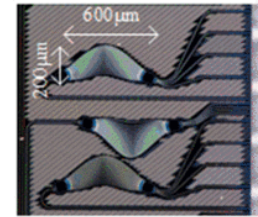


- Assymmetric MZI interferometers
- High Q ring resonators
- Every photon counts

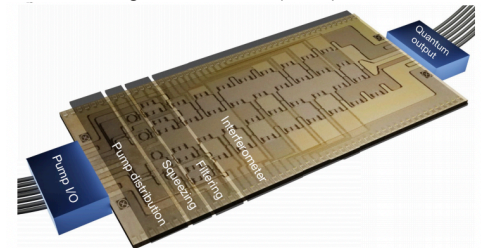
LIGENTEC



Martin et al., JLT **36** (2018)



Cheung et al., JLT **38** (2020)



Arrazola et al., Nature **54** March 2021

A base to build on

Versatile Platform



3+ thicknesses

10 process modules

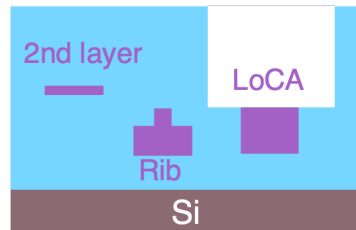
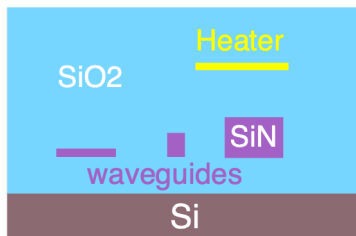
Extensive PDK

800 nm

400 nm

150 nm

custom



Design rules

Design Rule Checks

Layout files

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IP Cores

Components

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

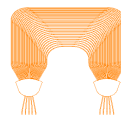
Optical I/O

- Grating couplers
- Inverted tapers
- Spot size converters

Design flows



Component simulations



A base to build on

Versatile Platform



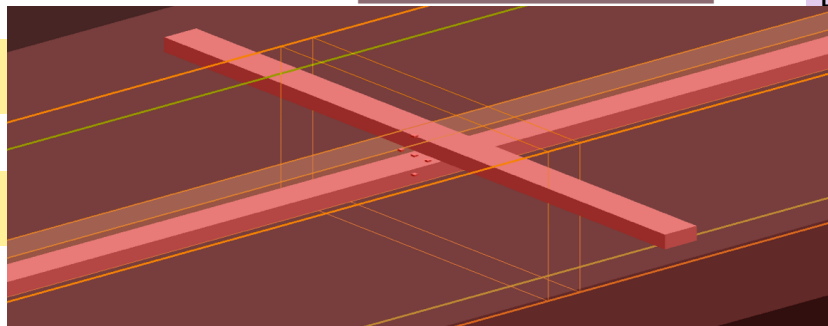
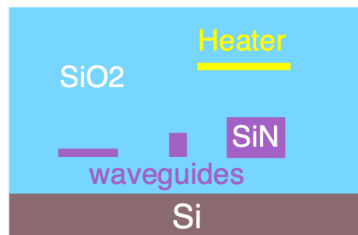
3+ thicknesses

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800 nm

400 nm



Design rules

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- Waveguides, delay lines
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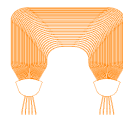
Optical I/O

- Grating couplers
- Inverted tapers
- Spot size converters

Design flows



Component simulations



One base – many options:

SiN – The platform for monolithic & heterogeneous integration



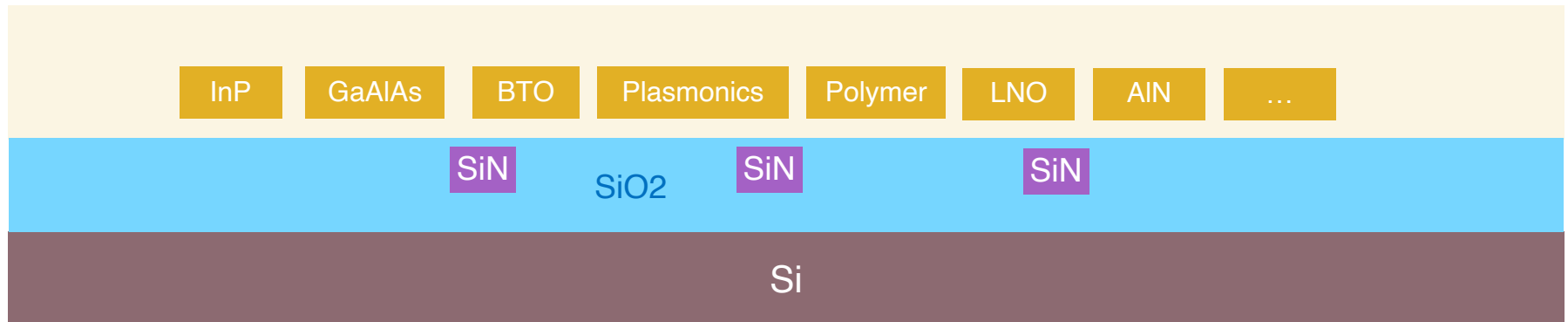
Use SiN as base platform for general circuitry

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

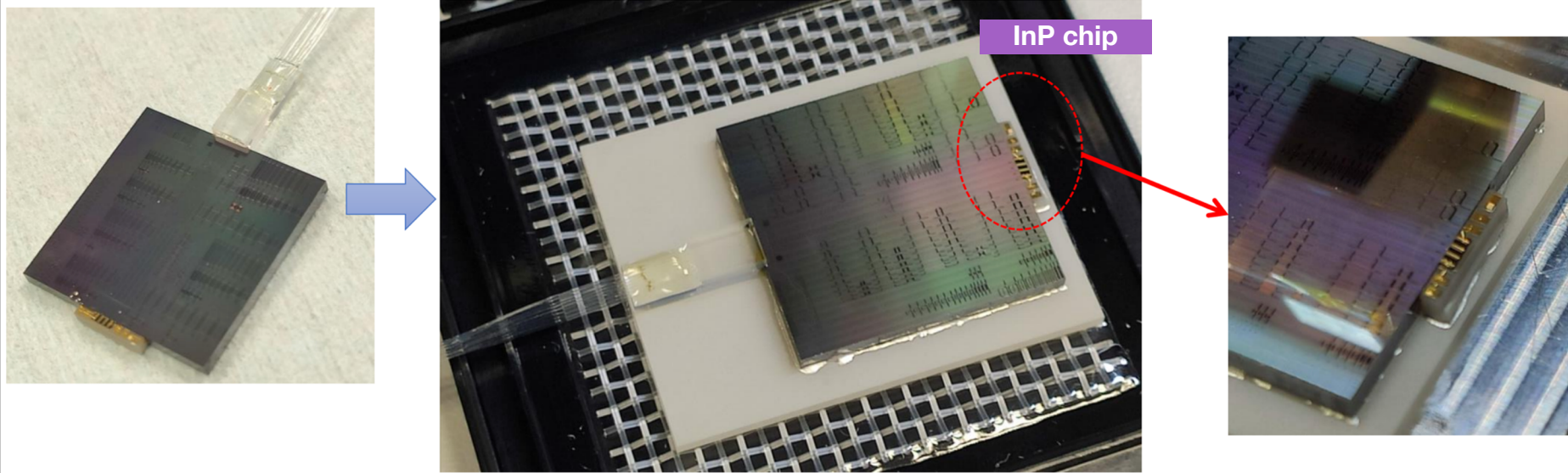
Add materials as required by application

Focus on wafer level integration e.g.:

- Monolithic integration
- Wafer bonding
- Micro Transfer Printing



Hybrid Integration example InP Chip to passive SiN PIC



- SiN chip with FAU and SOA attached to it
- Assembly is glued on a ceramic carrier
- **Requires flat and smooth chip facets**

Hybrid integrated lasers

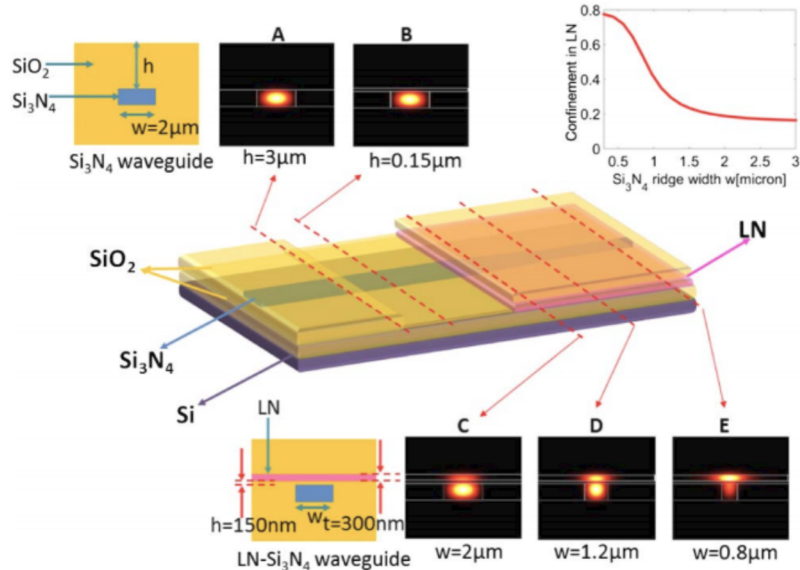
- Calo et al., OFC 2022
- Guo et al., IEEE Xplore (2021)

LIGENTEC platform

Heterogeneous Integration examples

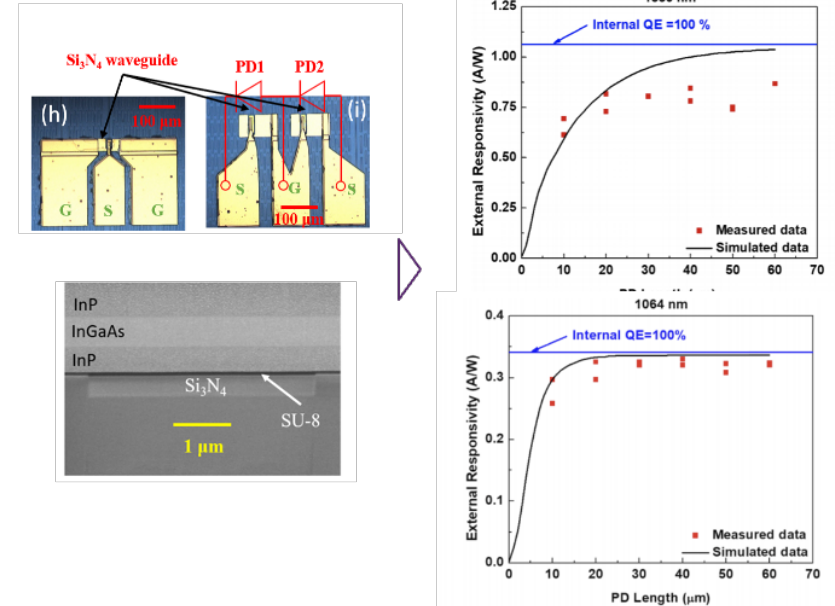


LiNbO3



Heterogeneous integration of lithium niobate,
Chang et al., Optics Letters (2017)

InGaAs Photodiodes



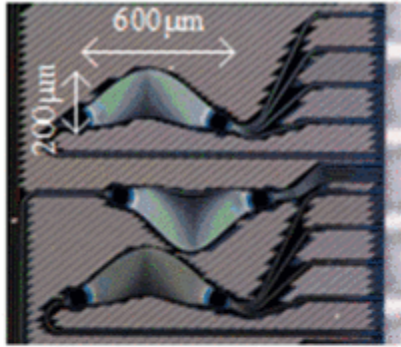
Heterogeneous photodiodes on SiN,
Yu, Optics Express 28 (2020)

Communications

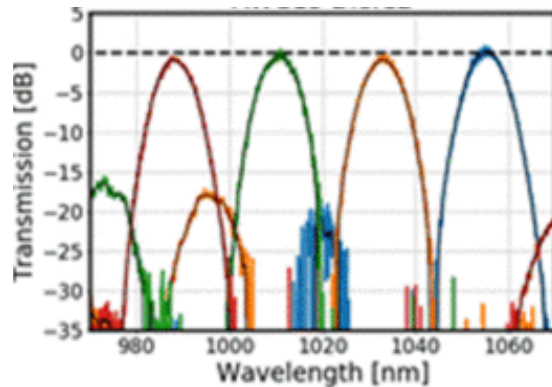


Applications – Communications

Arrayed Waveguide Gratings (AWG)



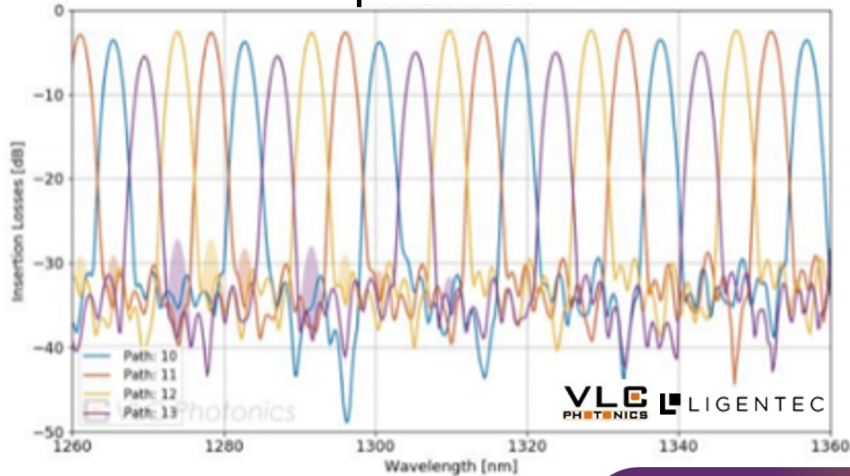
- ✓ low temperature dependence
- ✓ good process tolerance
- ✓ scalable
- ✓ Low phase errors
- ✓ small footprint



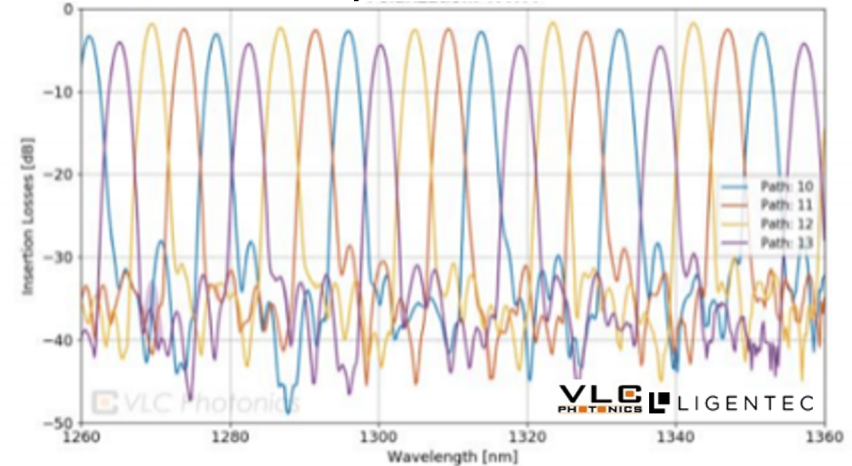
Gaussian AWG

- < -35 dB crosstalk
- < 0.5 dB insertion loss
- STD around 0.5nm

TE polarisation

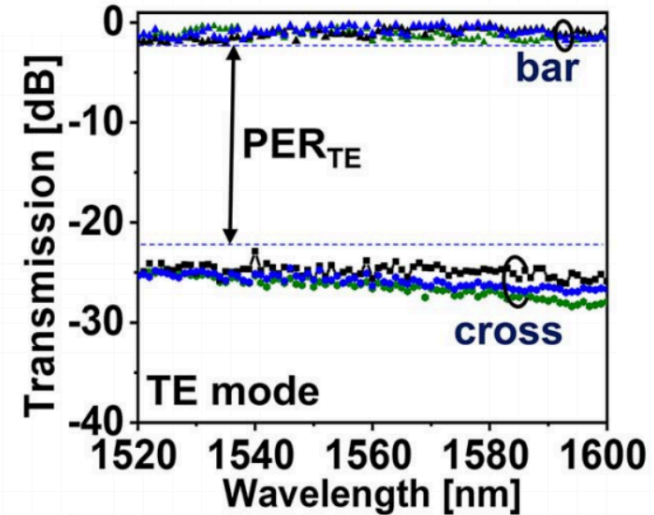
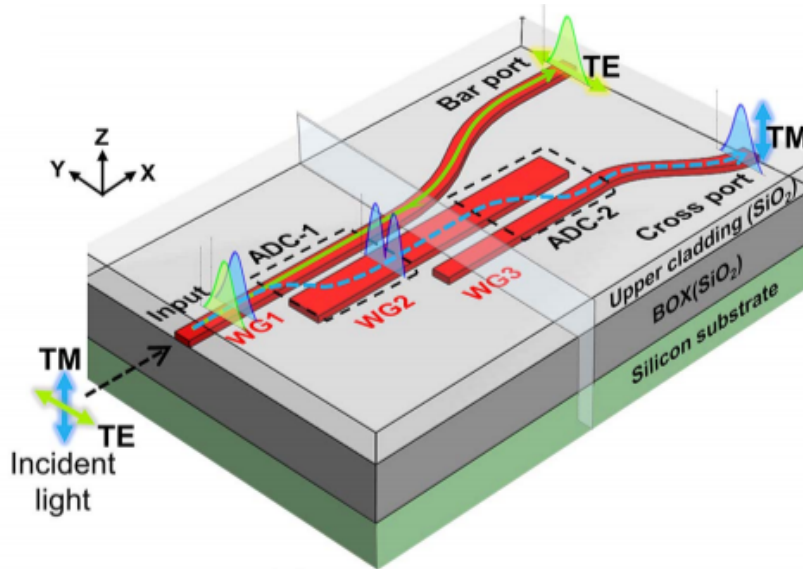


TM polarisation

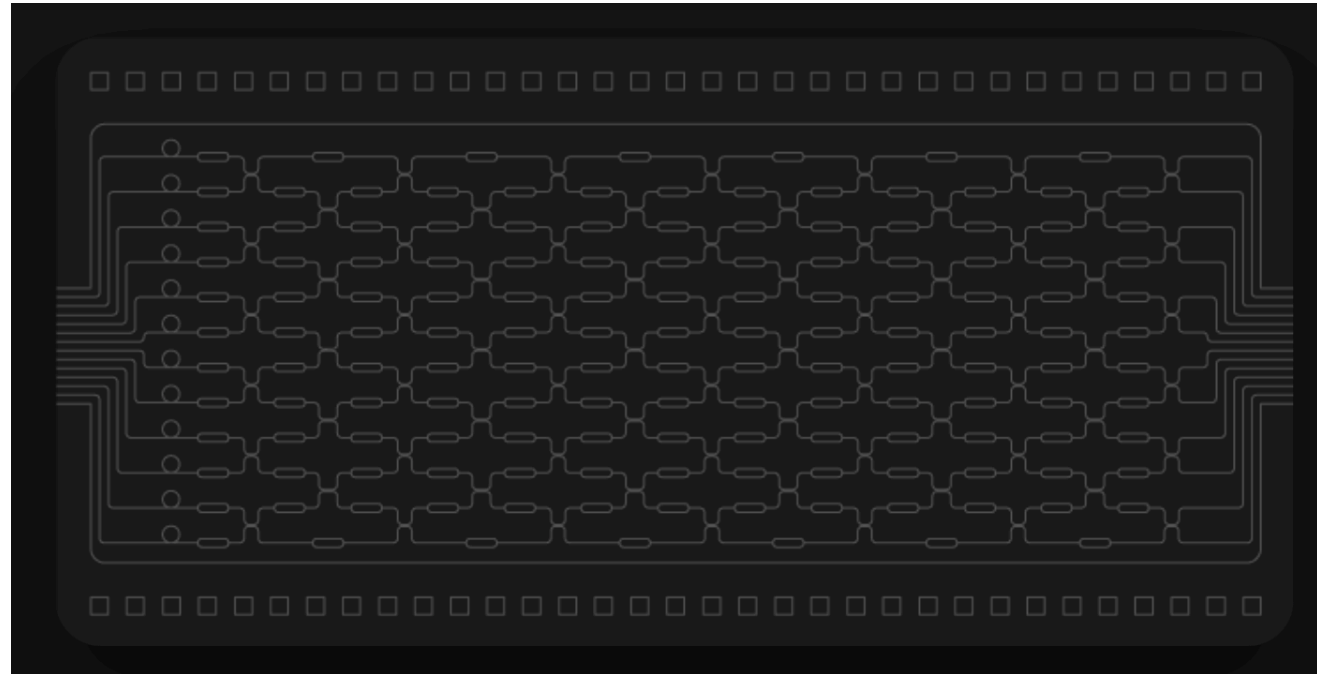


- ✓ low temperature dependence
- ✓ good process tolerance
- ✓ scalable
- ✓ Low phase errors
- ✓ small footprint

Efficient broadband polarisation splitter

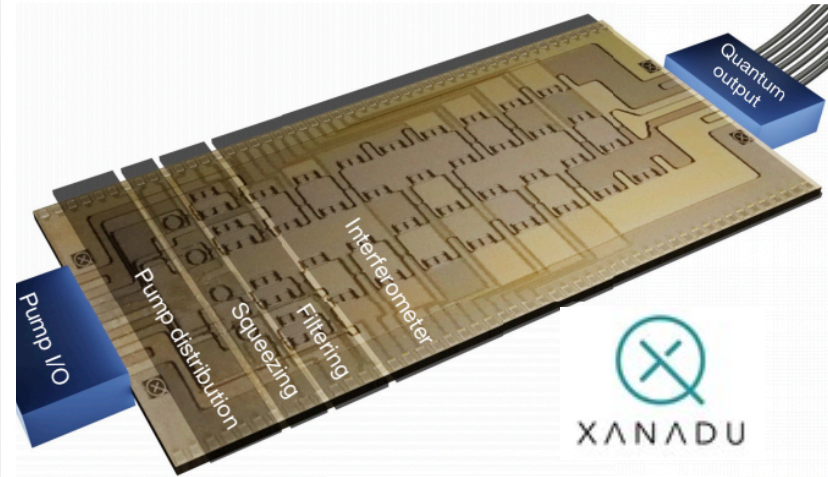
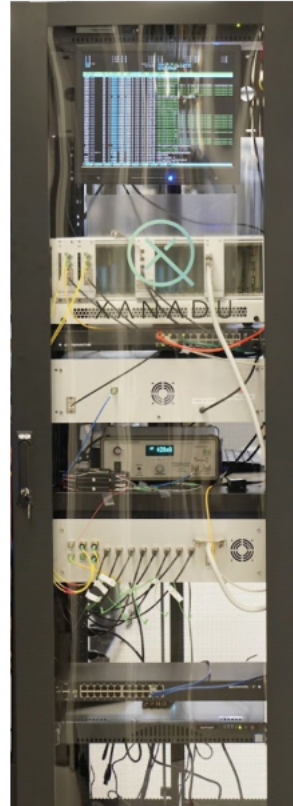


Quantum Computing



Key requirements include:

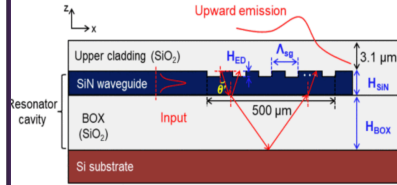
- Every Photon counts
=> low loss circuitry
- High phase stability
=> No moveable parts
- Small size components
=> integrated on a chip
- Scalable to high volumes
=> Wafer technology



Arrazola et al., *Nature* **54** March 2021

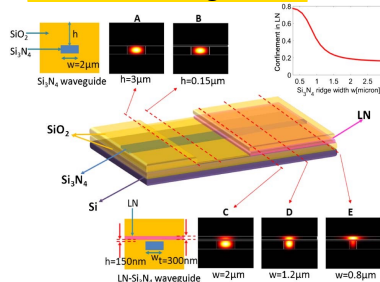
Used cases examples of LIGENTEC platform

Phase Arrays



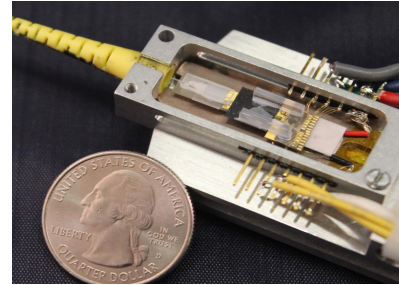
Optical phased array enabling efficient wavelength-tuned beam steering, *Im et al., IEEE Photonics Journal Vol 12 (10/2020)*

LiNbO3 Integration



Heterogeneous integration of lithium niobate, *Chang et al., Optics Letters (2017)*

Frequency Combs



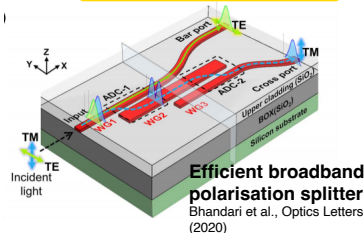
Frequency comb generation
B. Shen, et al. Nature 582 (2020)

Squeezing



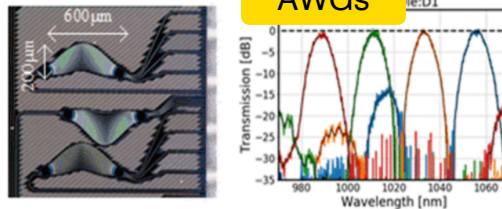
Squeezed light on a chip
Vaidya et al., Science Advances 6 (2020)

Polarization mgt



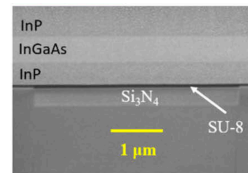
Efficient broadband polarisation splitter
Bhandari et al., Optics Letters (2020)

AWGs



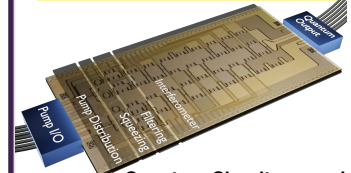
Ultra-low loss SiN (de-)muxes
Cheung et al., OFC 2020

PD Integration



Heterogeneous photodiodes on SiN,
Yu, Optics Express 28 (2020)

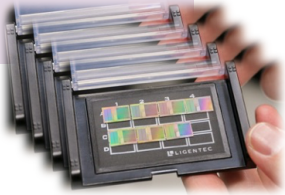
Quantum Computing



Quantum Circuits on a chip
Arrazola et al., Nature 591 (2021)

Fast prototyping

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



Custom Development

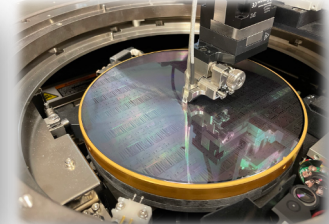
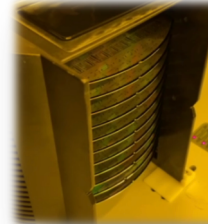
- Engineering studies
 - Layer stack adaptation
 - Custom integrations
- #### Ligentec Labs
- Early technology access

Pilot Fabrication

- Pilot and niche quantities

Volume Fabrication

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

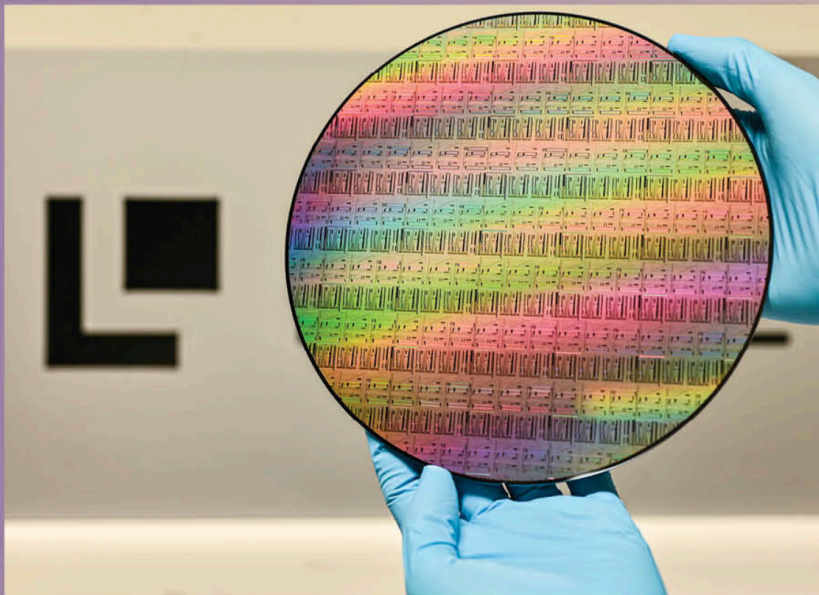


Pillars to assist ideas to the market

Open access, low entry barrier

High flexibility & competence

Quality and supply guarantee



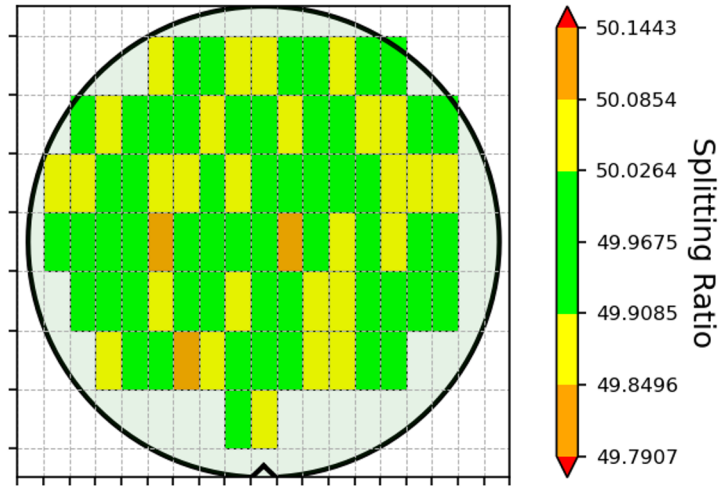
New PIC Partnership!

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

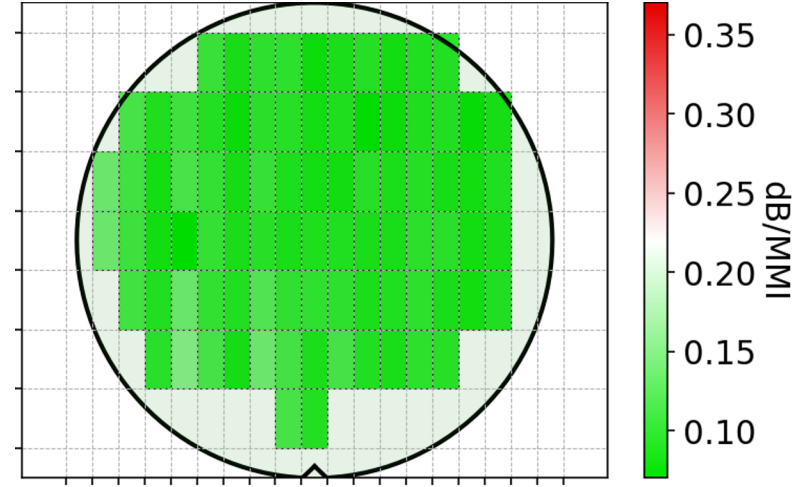
**CLICK TO READ THE
PRESS RELEASE**

8 inch process component performance

MMI splitting ratio



MMI insertion loss

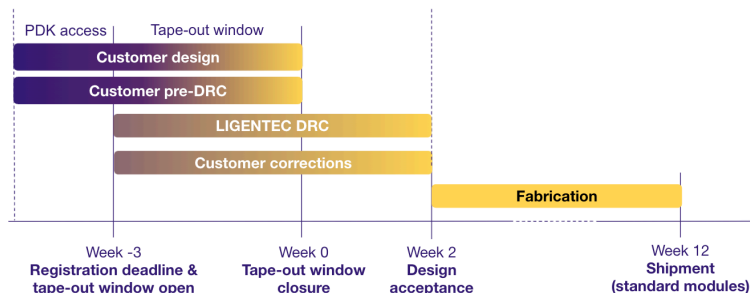


You are not left alone

MPW runs



MPW process flow and support services



- Access to LIGENTEC PDK
- Training session on LIGENTEC PDK
- Training webinar on MPW submission
- Application engineering support
- DRC (design rule check) for manufacturability
- Post fabrication review session

Frequent MPW runs

MPW number	SIN thickness	Registration deadline	Design submission window	Expected shipping date for base module
LGT-MPW-AN800-20	800nm	01/11/21	01/11/21-22/11/21	28/03/22
LGT-MPW-AN800-21	800nm	15/12/21	15/12/21-22/01/22	14/04/22
LGT-MPW-AN800-22	800nm	01/03/22	01/03/22-22/03/22	14/06/22
LGT-MPW-AN800-23	800nm	01/06/22	01/06/22-22/06/22	14/09/22
LGT-MPW-AN800-24	800nm	01/09/22	01/09/22-22/09/22	14/12/22
LGT-MPW-AN150-11	150nm	15/12/21	15/12/21-22/01/22	14/04/22
LGT-MPW-AN150-12	150nm	01/03/22	01/03/22-22/03/22	14/06/22
LGT-MPW-AN150-13	150nm	01/06/22	01/06/22-22/06/22	14/09/22
LGT-MPW-AN150-14	150nm	01/09/22	01/09/22-22/09/22	14/12/22
LGT-MPW-AN400-02	400nm	01/03/22	01/03/22-22/03/22	14/06/22

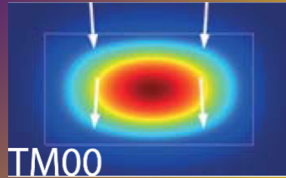
Typically 5 runs per year

Up to date schedule: ligentec.com/mpw

LIGENTEC PROPRIETARY

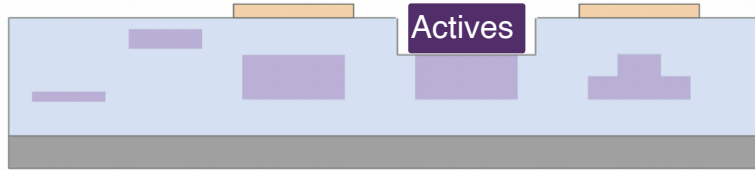
Low Loss SiN - Platform Overview

Low loss waveguides

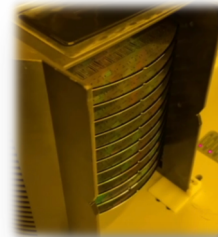


MPW / Dedicated runs
Short turn around

Flexible R&D line
Volume line

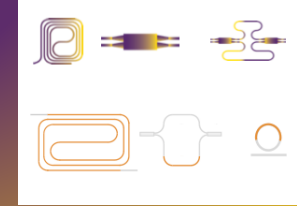


Actives Integration

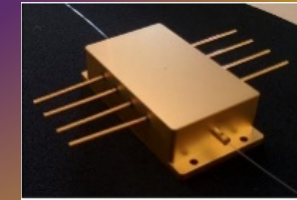


LIGENTEC

Extensive PDK



Low loss optical I/O



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

Join our team: open positions under
[www. www.ligentec.com/careers-ligentec/](http://www.ligentec.com/careers-ligentec/)

