



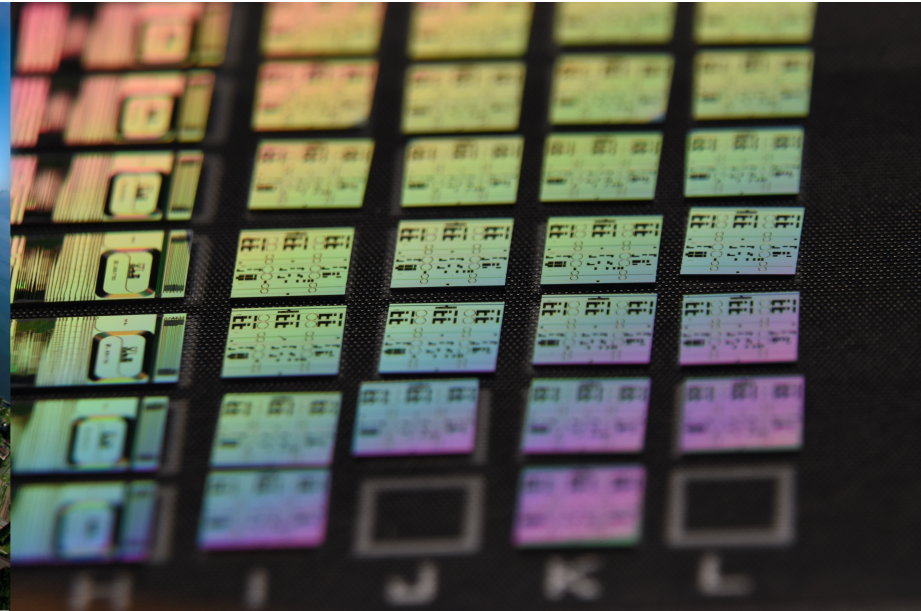
Photonic Integrated Circuits for Quantum Computing

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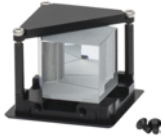
Low loss SiN PICs



SWaP

- ✓ Size
- ✓ Weight
- ✓ Power
- ✓ Robustness
- ✓ Cost

Beam splitter



~ cm



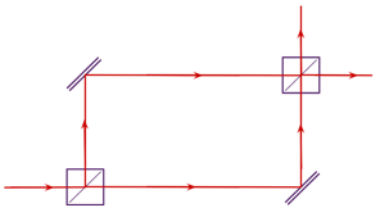
~ cm

Ratio tolerance ~ 5%



~100um (or smaller)
Ratio tolerance < 2%

Mach Zehnder Interferometer



~ cm



~ cm

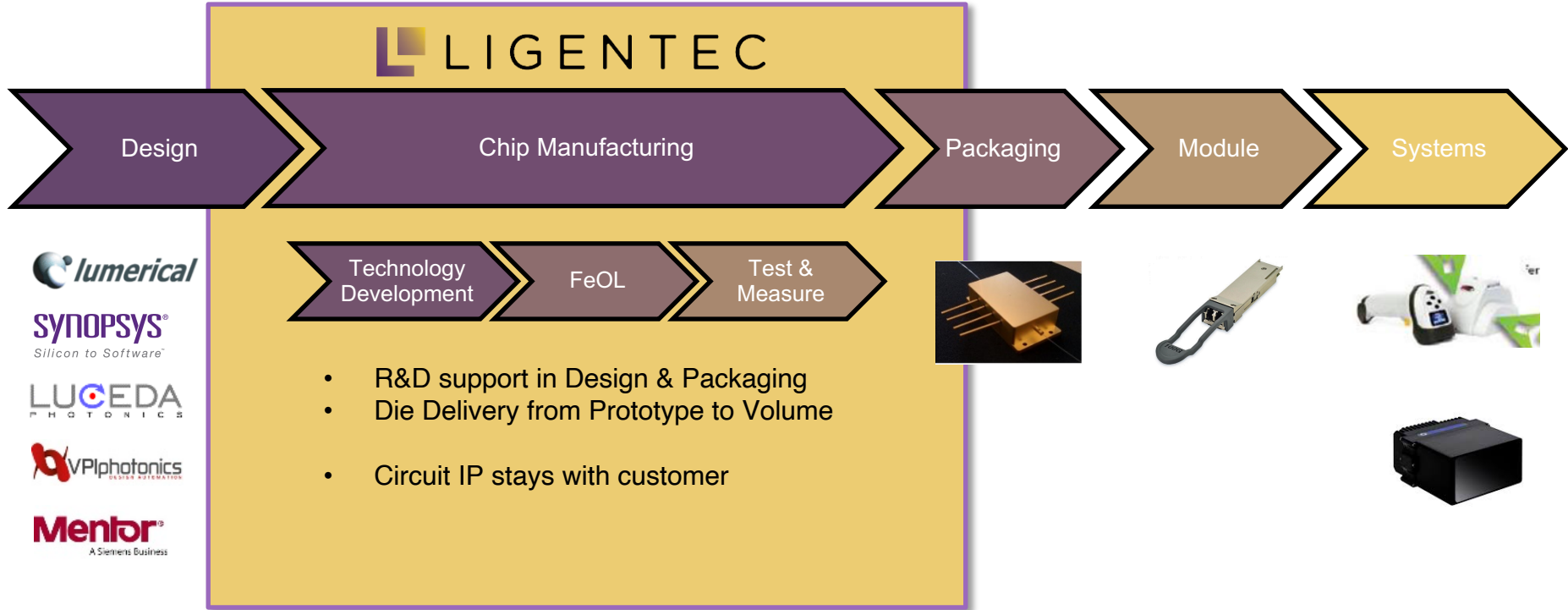


Small

Precise phase control

Imbalanced MZI with ~ 1m path difference on 5x5 mm chip
+ Modulators → Optical Switching

LIGEN TEC Offering Value chain



LIGEN TEC Offering Process Design Kit (PDK)

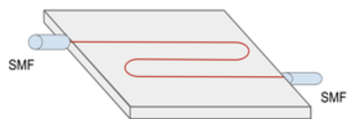


Design

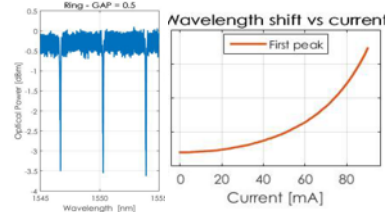
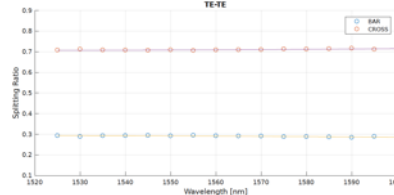
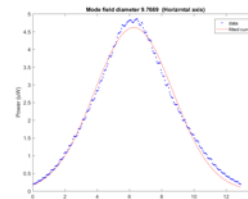
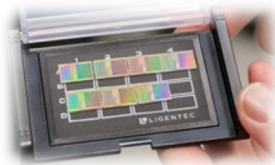
Fabrication

Measurement

Functionality



50% transmission



10um spot size converter for SMF fiber packaging

Low loss passive building blocks

Thermal tuning of resonances and phase



TE-TE

SR@1550nm:

Cross → 0.708

Bar → 0.292

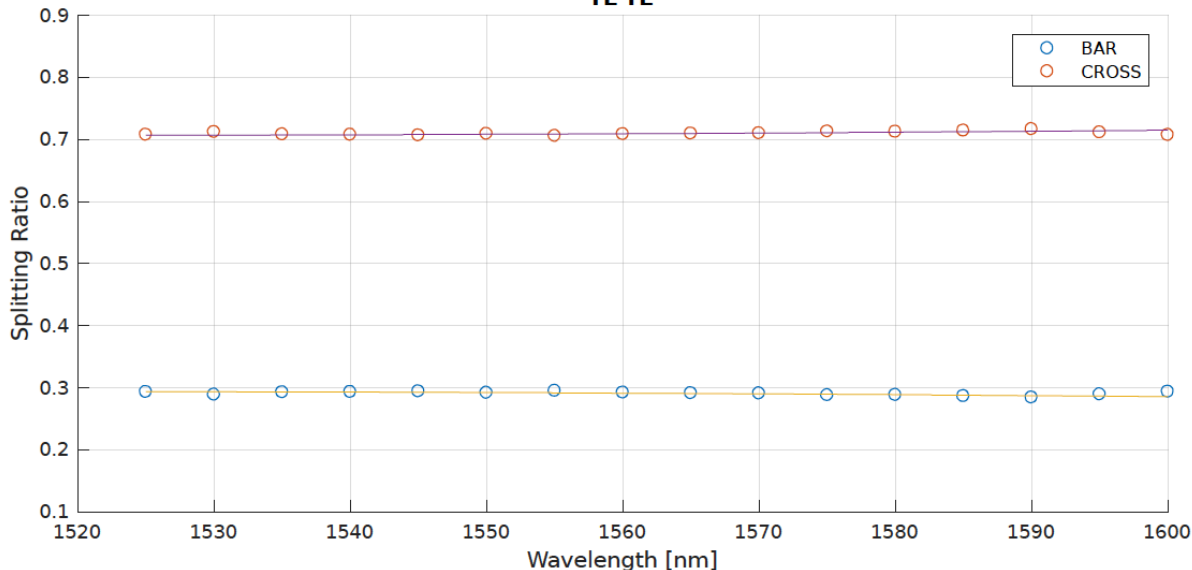
SR@1550nm:

Cross → 0.693

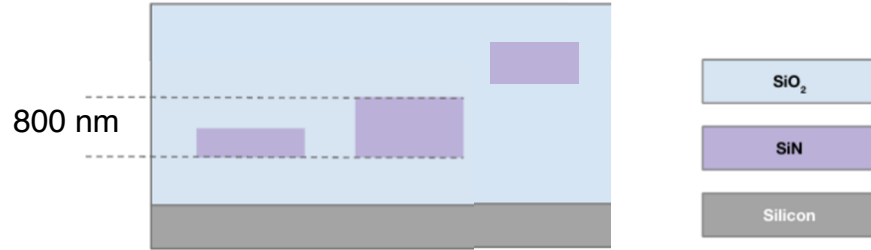
Bar → 0.307

TM-TM

**MMI Cascade
72 / 28
TE-TE**



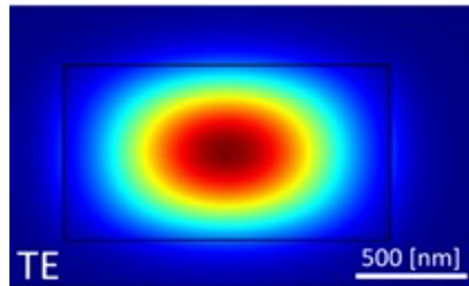
Basic Process: SiN waveguides



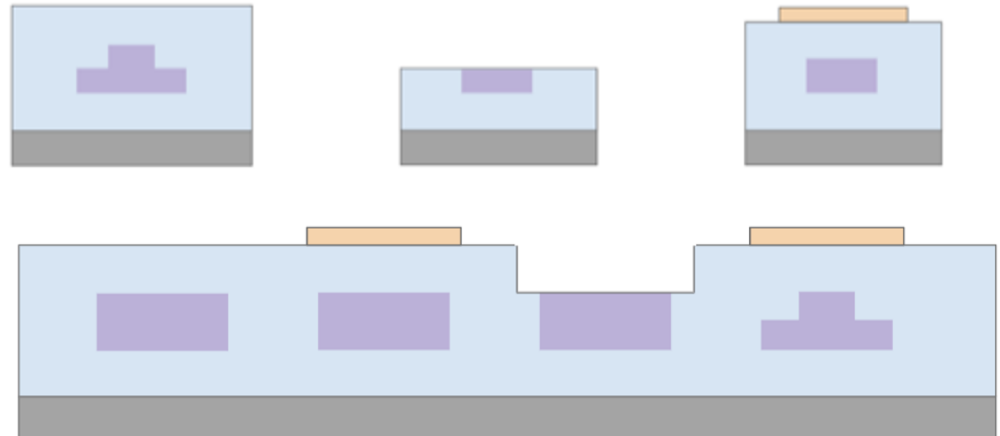
Low-loss (<0.1dB/cm)

Low phase errors

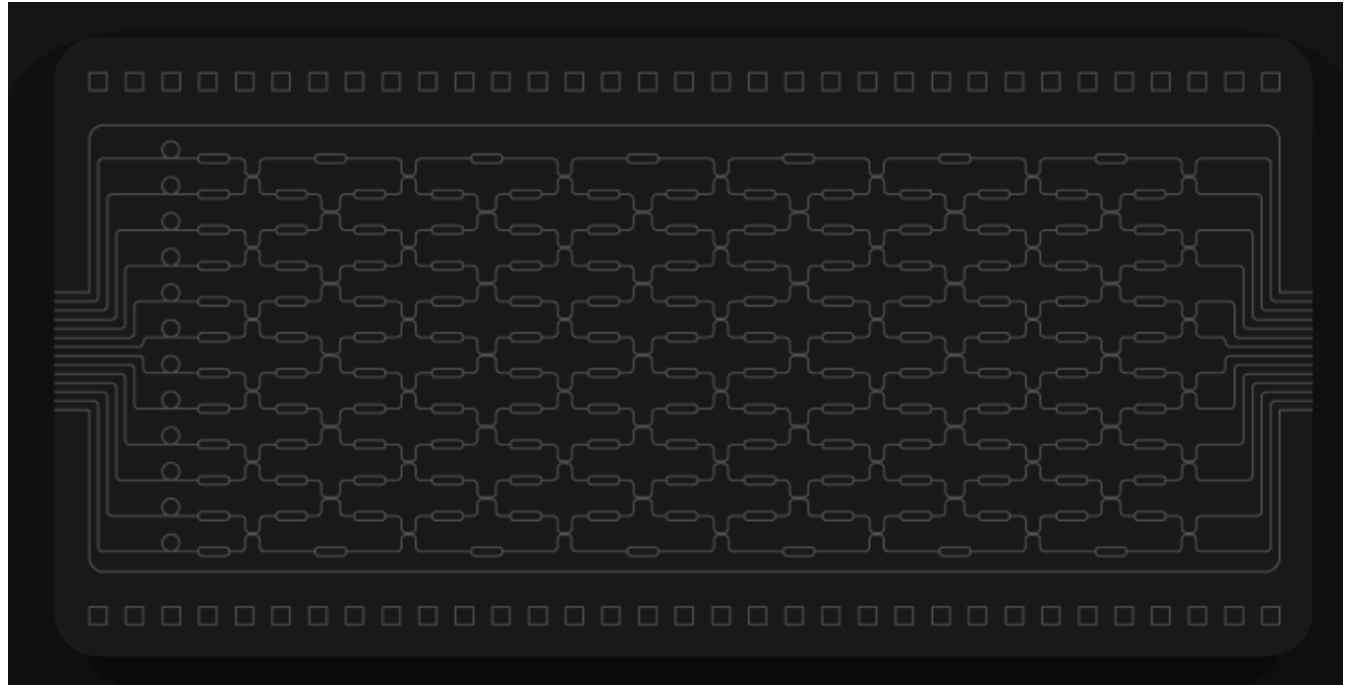
Small footprint



Modules:



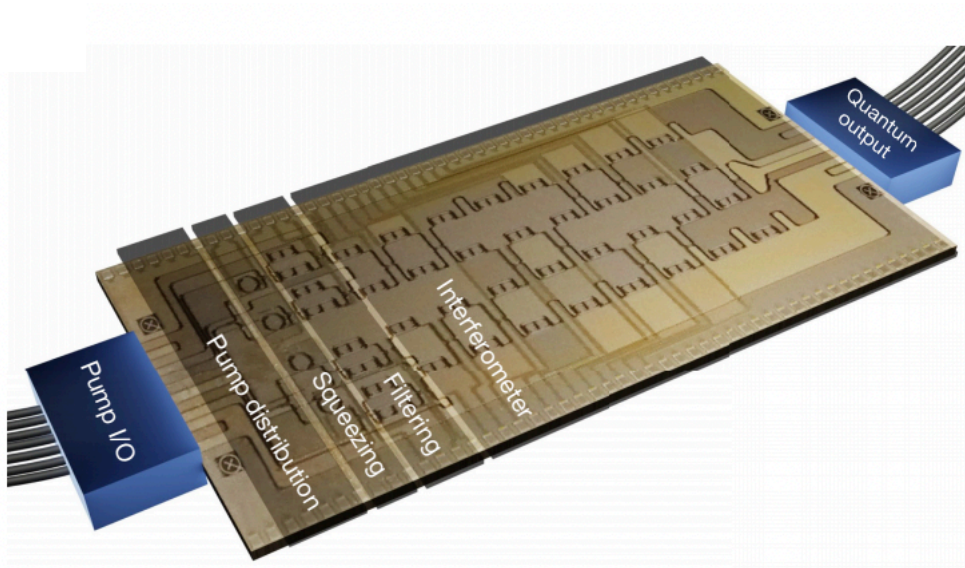
Quantum



- **No moveable parts**
 - **Phase stability**
- **Small size components**
 - **Everything is integrated on a chip**
- **Scaling to volume**
 - **Same chip 1 Million times with wafer processing**

Applications - Quantum

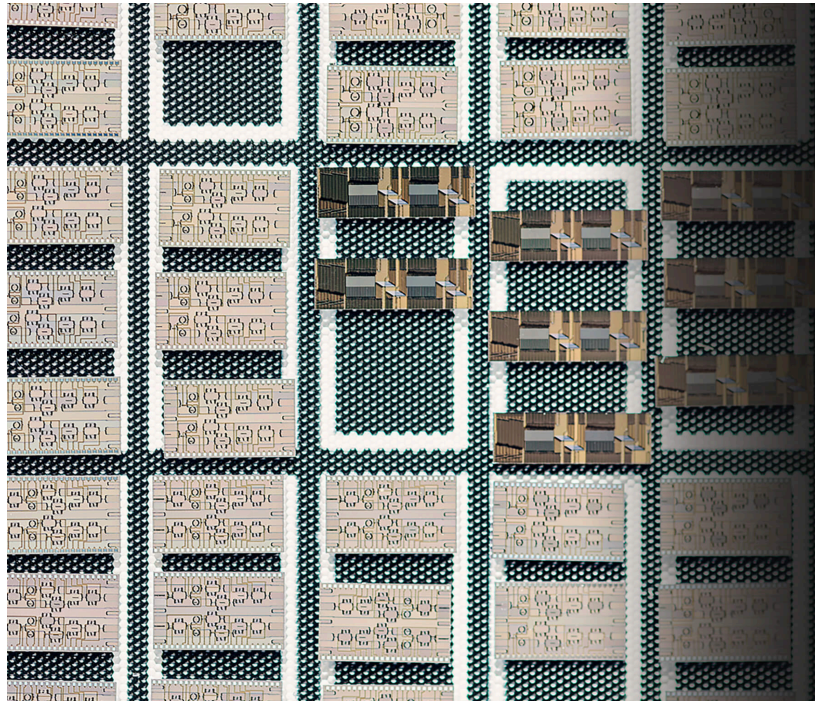
Towards an optical quantum computer



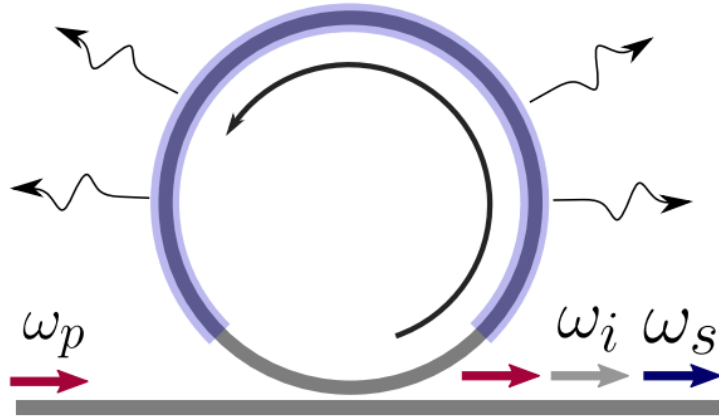
Applications - Quantum

Towards an optical quantum computer

Spontaneous four wave mixing allows photon pair generation.



Spontaneous four wave mixing allows photon pair generation.



$$R \sim (\gamma P)^2 Q^3 L^{-2}$$

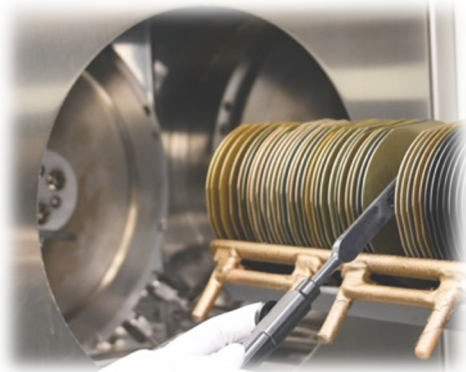
expected photon pair
generation rate R
for a given pump power P



***Small-size, High-Q
microring
resonator is a key***

Custom Runs

- Can start any time
- Fast track options (6 weeks)
- Full choice of process modules
- Pilot runs to high volumes



**“We are impressed with
the device performance.”**

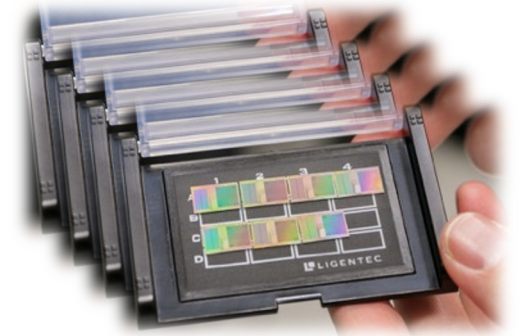
USA customer

**“We even got the chips before
estimated shipping date.”**

Canadian customer

Multi Project Wafer Runs

- AN800 (IR), AN150 (VIS)
- Preset process modules
- Fast (10 weeks)
- 4x per year, fixed dates
- Next run: March 2021
www.ligentec.com/Ligentec-foundry/



LIGEN TEC Offering
From prototype to production



**Idea and design
phase**

Technical specs
Feasibility study
Module definition
Fabrication tolerances

**Development &
Prototyping**

MPW / dedicated runs
with design
Parametrisation

**Pilot
production**

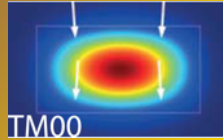
Optimisation of
cost and yield

Production

Volume fabrication

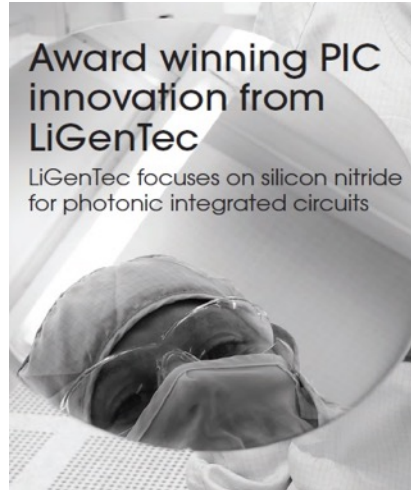
The Basics

- ✓ High Mode Confinement
- ✓ Low Loss
- ✓ Small Footprint
- ✓ High Power



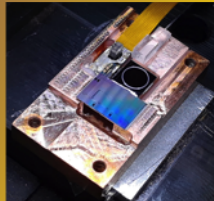
Award winning PIC innovation from LiGenTec

LiGenTec focuses on silicon nitride for photonic integrated circuits



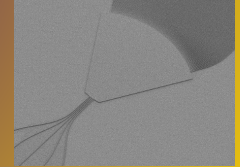
Actives

- ✓ Electrical Tuning
- ✓ Modulators
- ✓ Lasers
- ✓ Detectors



Full Creativity

- ✓ Couplers
 - ✓ Mux / DeMux
 - ✓ MZIs / DLIs
 - ✓ Resonators
- many more



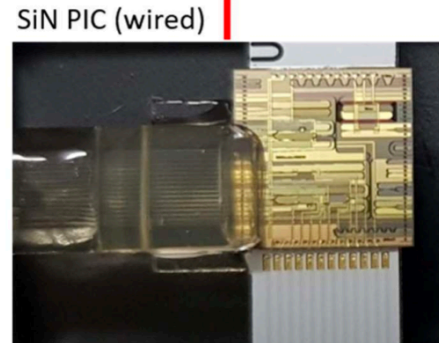
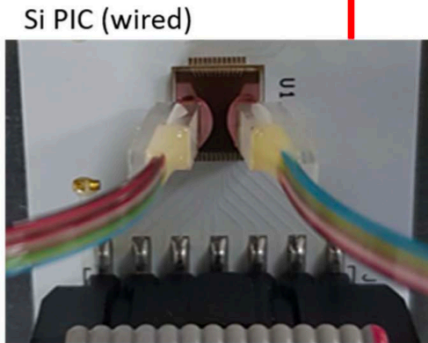
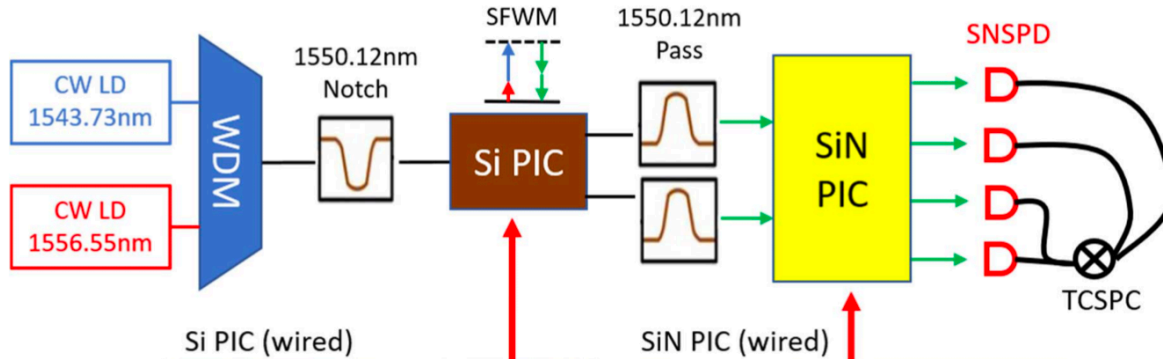
World Connections

- ✓ Edge Coupling / U Grooves
- ✓ Spot Size Converter
- ✓ Grating Couplers
- ✓ Arbitrary Die Shape
- ✓ Bond pads



Applications - Quantum

SiN photonic controlled-NOT gate



Lee et al., ECOC paper 2020