FLEXCOMPUTE | TIDY3D

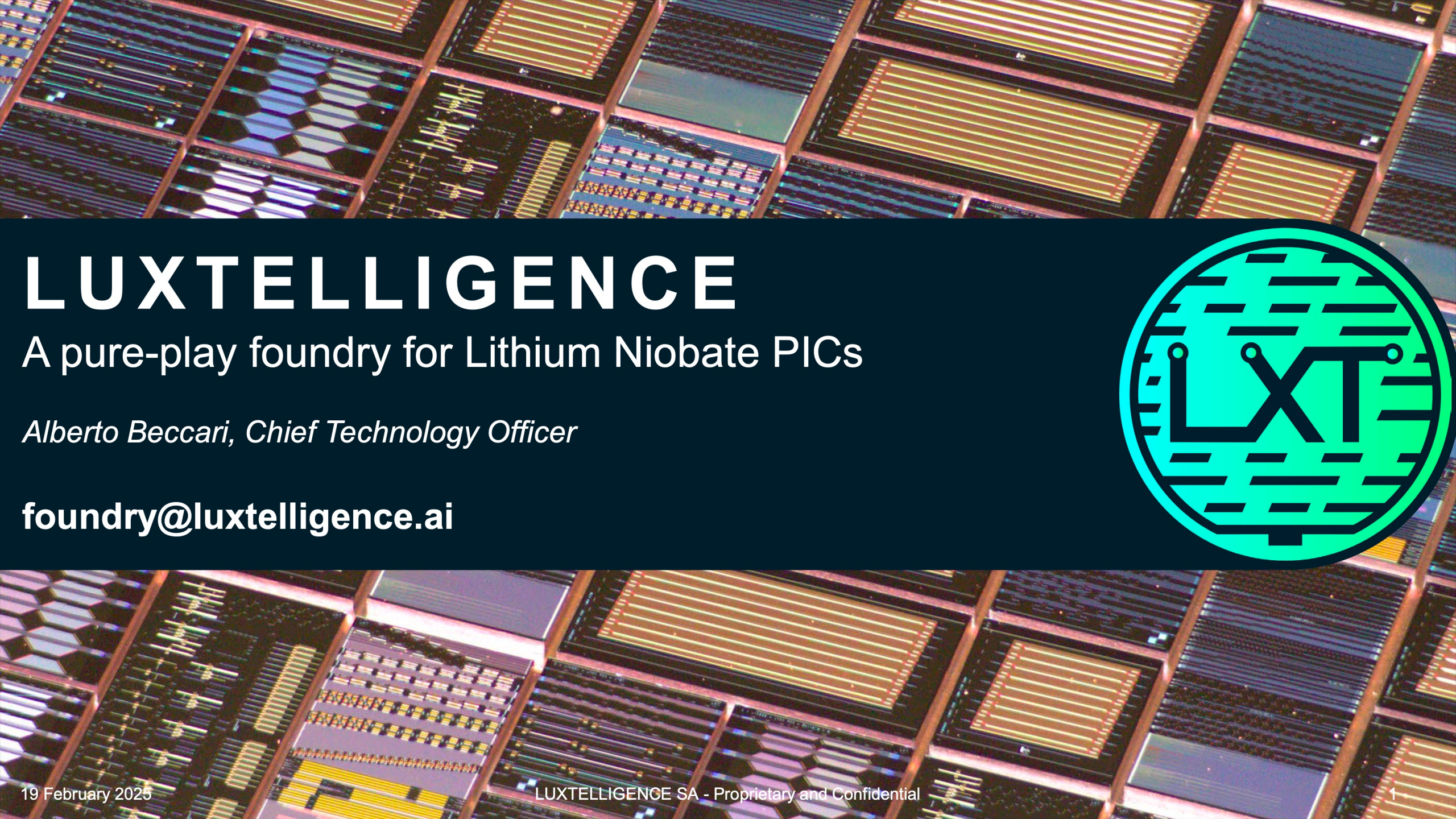
Advanced Photonics Seminar

Fabrication-Aware PIC Design With PDK Support

Prashanta Kharel

Technology Strategist, Flexcompute

Ph.D. Physics, Yale University



LUXTELLIGENCE

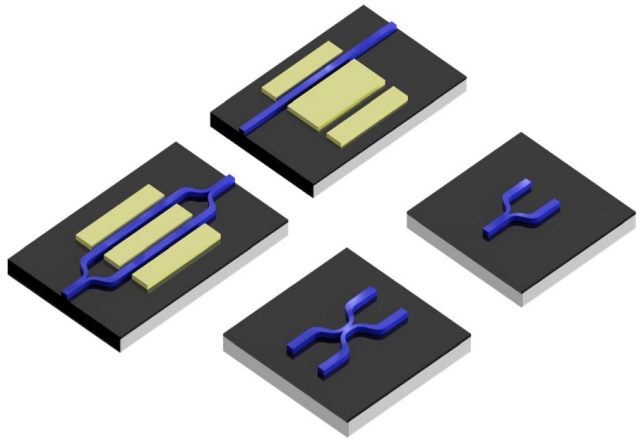
A pure-play foundry for Lithium Niobate PICs

Alberto Beccari, Chief Technology Officer

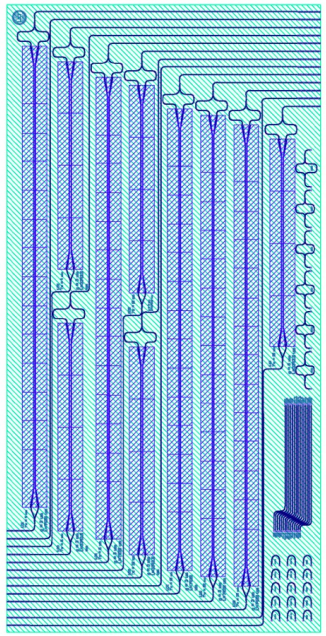
foundry@luxtelligence.ai

Thin film lithium niobate foundry operations

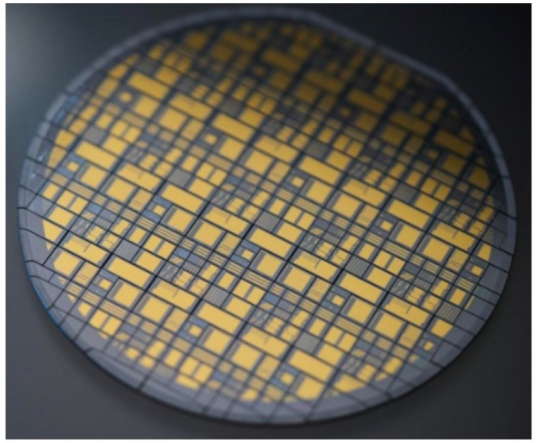
1. Verified component library (PDK)



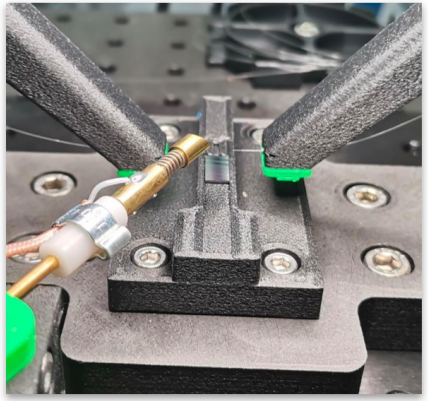
2. Design support and DRC



3. Custom or multi-project fabrication

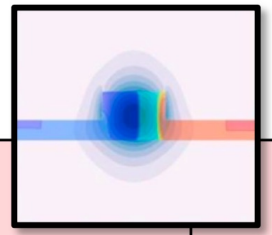


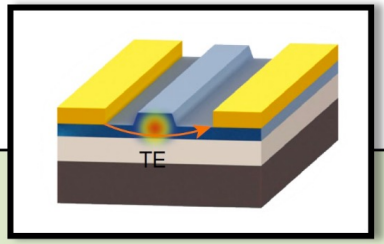
4. PIC testing services




Germany
Belgium
English Channel
Guernsey
Jersey
Luxembourg
France
Lausanne, CH
Croatia
Bosnia and Herzegovina
San Marino
Monaco
Italy
Andorra
Adriatic Sea
Biscay

TFLN complements Silicon Photonics





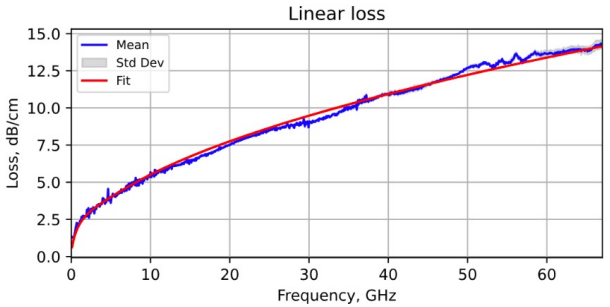
	Silicon (Si)	Indium Phosphide (InP)	Thin-film Lithium Niobate (TFLN)
Bandwidth	< 80 GHz	< 80 GHz	**> 100 GHz**
Driving voltage	~1.5 V	~1.5 V	**~ 2.5 V**
Insertion Loss	2 dB	3 dB	**< 1 dB**
Transparency band	1000-3500 nm	1000-2000 nm	**400-5000 nm**
Pure phase modulation	No	No	**Yes**

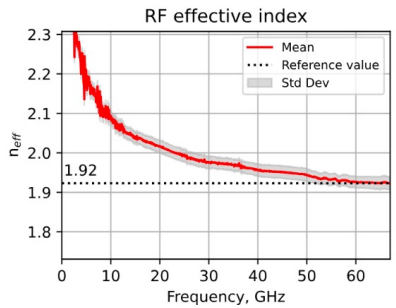
TFLN combines the low loss, wide transparency of Si_3N_4 with strong electro-optic modulation

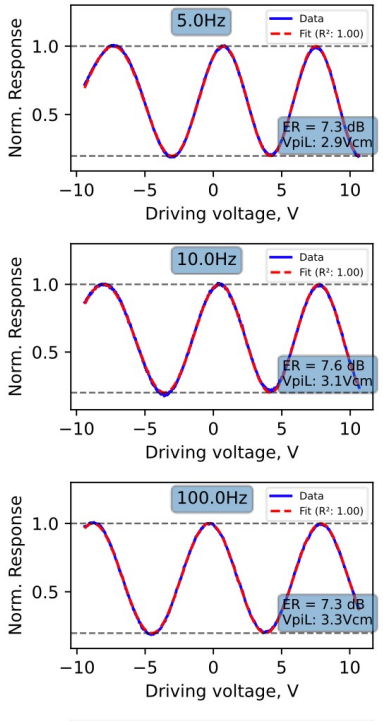
Image credit: Zhang et al., Optica (2021)

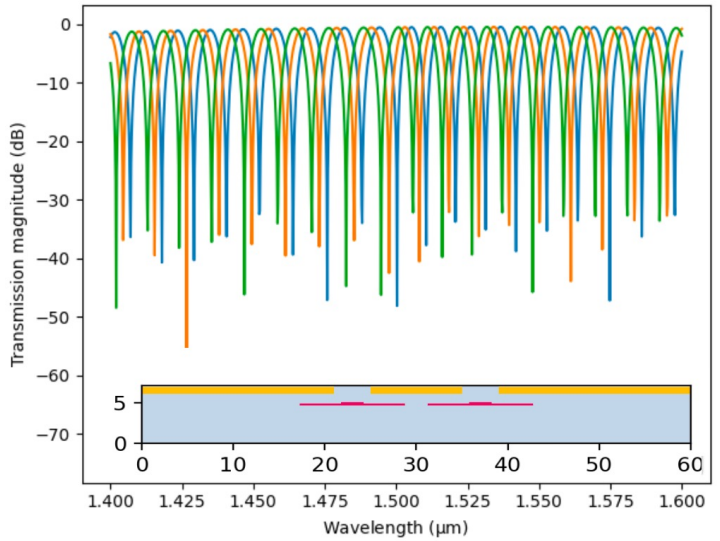
Open-access Process Design Kit (PDK)

- Facilitate design for LNOI **MPW runs**
- Verified building blocks for **C-band** PICs
- Fast turnaround (**12 weeks**)







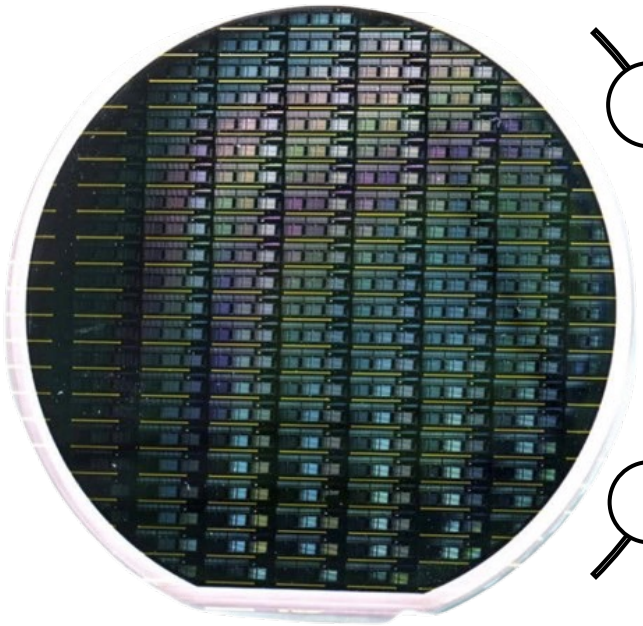


Wafer diameter	100 mm
Optical propagation loss (dB/cm)	0.1 – 0.2
Edge coupler loss (dB/facet, MFD 2.5 μm)	1.3 – 1.7
MZM $V_\pi L$ (V cm)	2.5 – 3.0
MZM bandwidth (GHz)	> 70
MMI imbalance	< 5%

TFLN PHOTONICS

Lithium niobate has gone from being the workhorse of telecom industry to now leading a revolution in integrated photonics

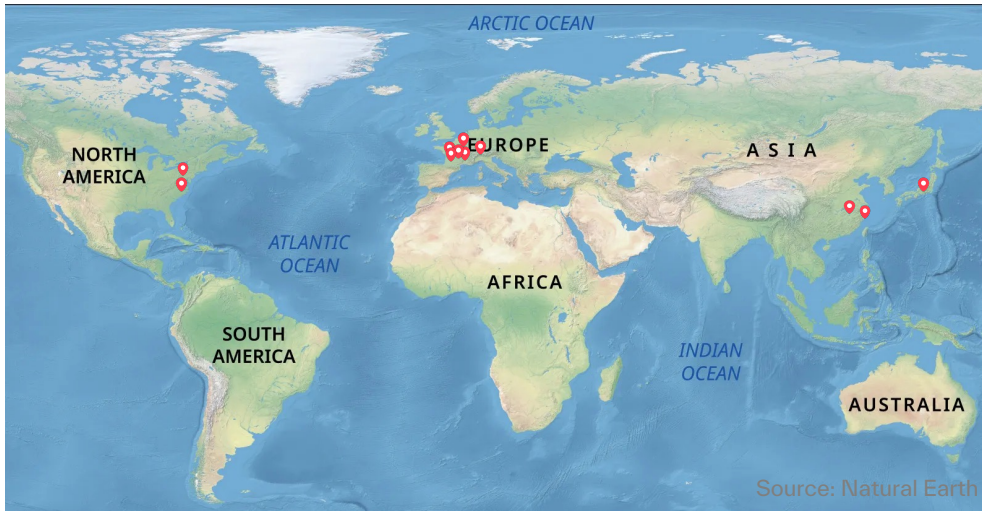
6-inch TFLN wafer



- Exceptional electro-, nonlinear-, and acousto-optic properties
- Wide-bandgap (0.35 – 5um)
- Low-losses
- Photonic integration (monolithic/heterogenous)

Luke, Kevin et al. *Optics Express* 28.17 (2020)

Growing ecosystem of foundries and companies



HYPERLIGHT · LUXTELLIGENCE · LIGHTIUM · QCi · FUJITSU · Fraunhofer HHI · csem · LIOBATE · OPTO CHIP · VERSICS HIGH-SPEED PHOTONIC SOLUTIONS · RAPID PHOTONICS

and more...

TFLN SIMULATION NEEDS & CHALLENGES

Multi-physics simulations, involving photons, RF, and thermal, are inherently challenging. Fabrication uncertainty further increases the project risk.

Material challenges

Anisotropic material leads to rotation dependent performance

Large device footprint (index~2.2) means long simulation times

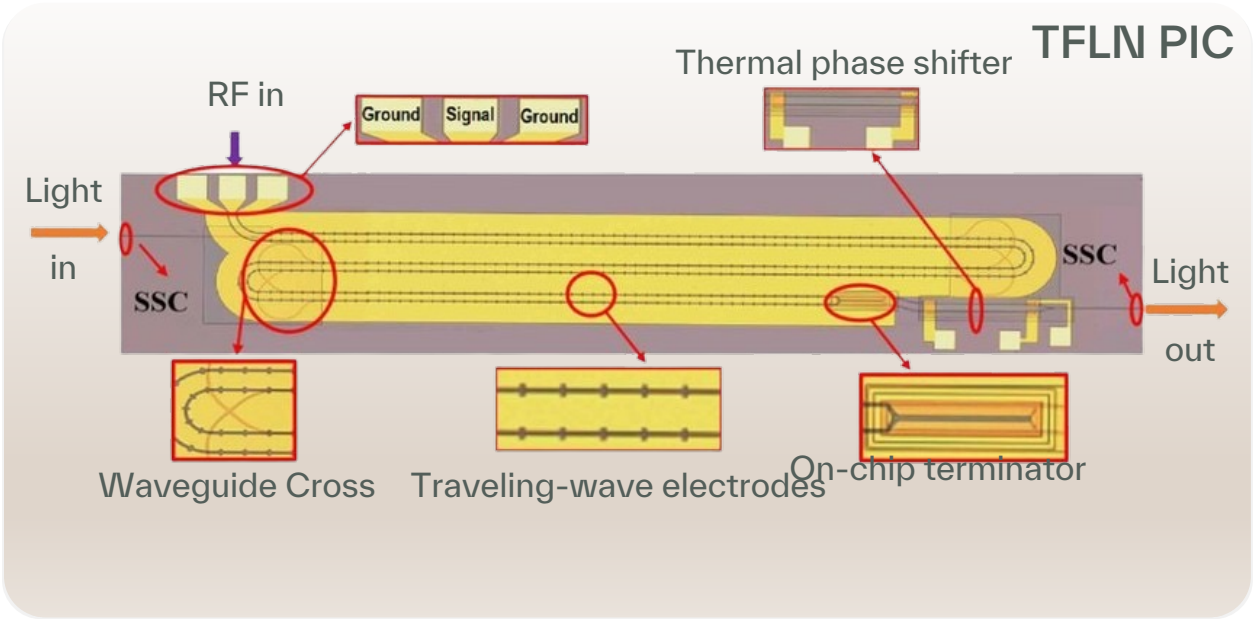
Tool challenges

Tedious to switch between tools for optical and RF simulations

System-level analysis

Non-trivial to go from component level simulations to system-level analysis

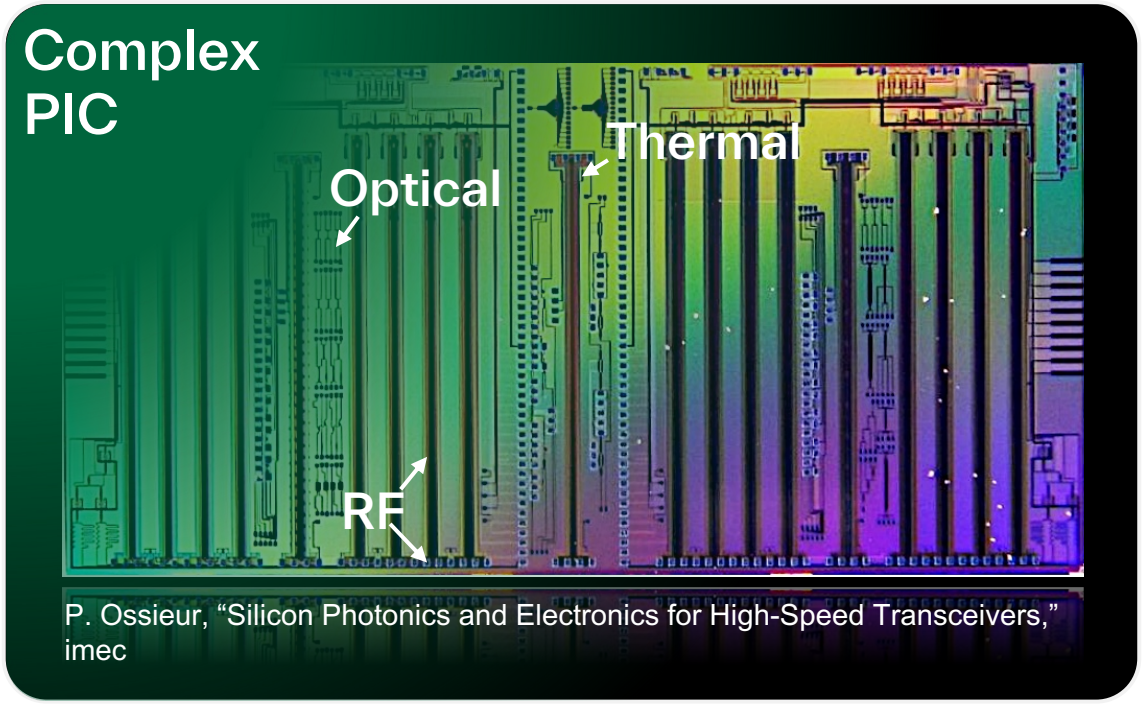
Multi-discipline simulation is an integral part of design



Li, Heng, et al. *Journal of Physics D: Applied Physics* 56.15 (2023)

OUR VISION

Unified platform for running multi-physics simulations and fabrication-aware photonic design to avoid costly tape-out errors, accelerate time-to-market, and reduce development costs of integrated photonics solutions.



Optical

- FDTD
- MODE
- EME
- Inverse Design

RF

- Transmission line
- Vias and interconnect
- Wirebond simulation
- Signal integrity

Thermal

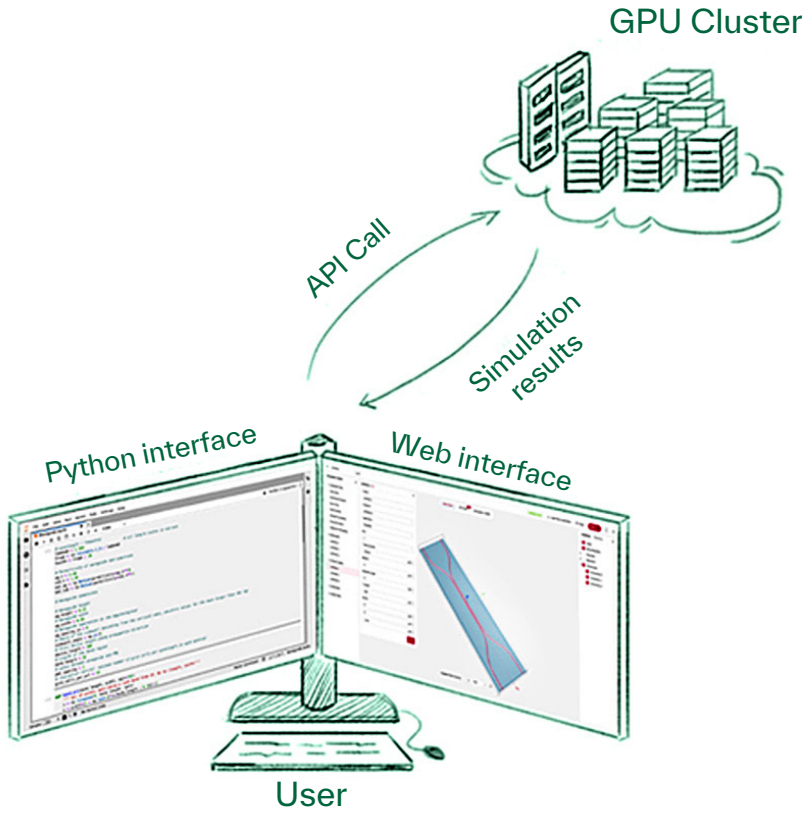
- Component level
- Module level

Active Device

- Electro-optic simulation
- Charge simulation

TIDY3D

A next-generation electromagnetic simulation technology leveraging advanced algorithms and fastest GPUs



Large-scale

100-1000x larger problem size than workstations

Ultra-fast

10-500x faster than workstations

High-throughput

Tens and hundreds of concurrent jobs without additional licenses or computers

Memory-efficient FDTD algorithms

Fine tuning for advanced GPU

Award-winning Python workflow

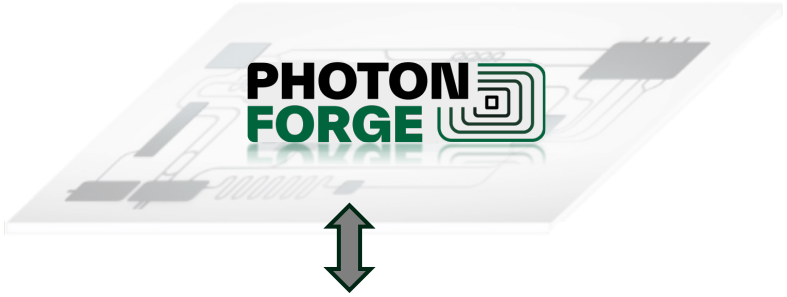
Proprietary HPC

Elastic Cloud

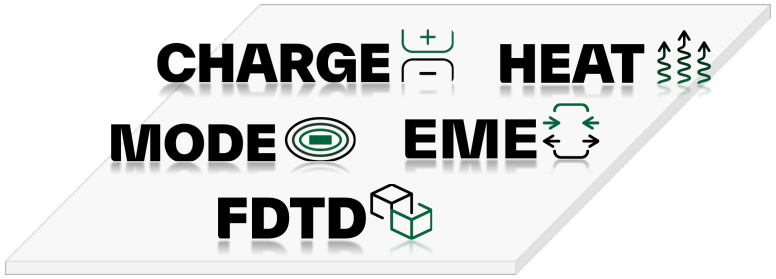
PHOTONFORGE

End-to-end photonic design automation platform which seamlessly integrates with our GPU-accelerated multi-physics solvers for fabrication-aware photonic design

Photonic circuit design & automation

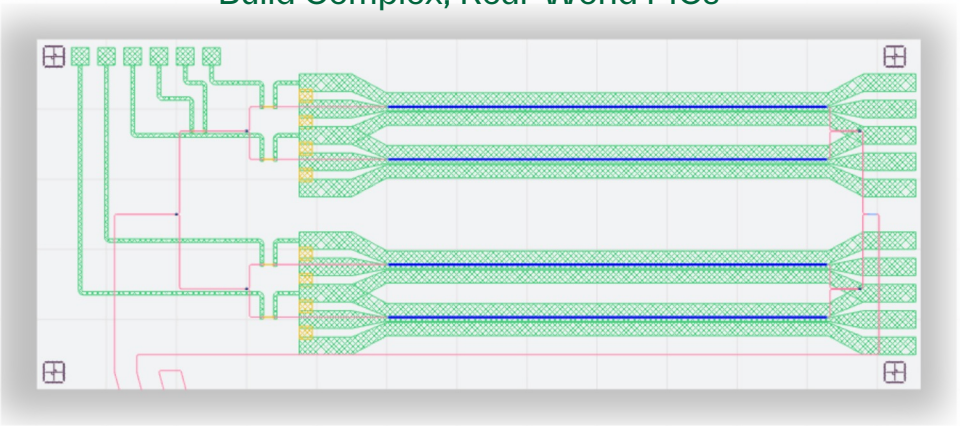


Component level simulation



- Seamless integration with GPU-accelerated solvers
- Access to foundry PDKs
- Circuit simulations, both frequency and time-domain
- Powerful layout editor

Build Complex, Real-World PICs



Growing Foundry PDK Support

Tower Semiconductor · imec · AIM PHOTONICS · Fraunhofer · LXT · LIGENTEC · SiEPIC

Material platforms: Si, SiN, IIIV, TFLN

TODAY'S TUTORIAL

In today's tutorial, we will demonstrate end-to-end active device design in TFLN using PhotonForge

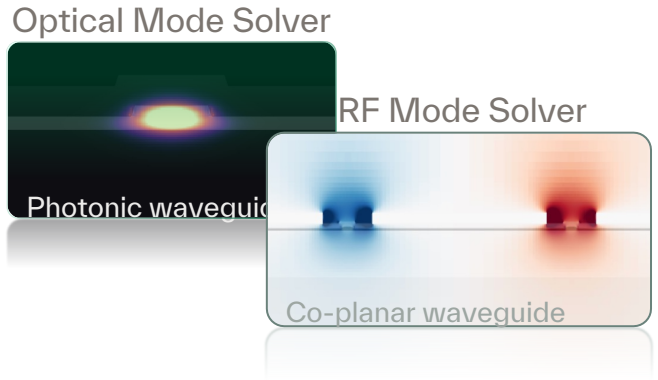
Part 1: Loading Luxtelligence PDK
Inspect cross-section, run optical and RF simulations

Part 2: Calculate Vpi.L
Electro-optic overlap and Vpi.L calculation at 1 GHz

Part 3: Design a RF taper to impedance match to 50 Ohms
Better impedance matching of CPW to source

Part 4: Design a y-splitter using Tidy3D
Design and simulate custom PDK component

Part 5: Layout of the entire chip
Utilize schematic-driven layout



Electro-optic modulator design



https://docs.flexcompute.com/projects/photonforge/en/latest/examples.html

Q&A + FREE-TRIAL

Please check out our website or reach out to us if you want to learn more

FREE-TRIAL OFFER: PhotonForge access + 200 FlexCredits

1. Existing Tidy3D User:
We will add 200 FlexCredits to your account using your registration email

2. New User:
Sign up a free **"Tidy 3D"** Account using the link: https://tinyurl.com/photonforge

https://tinyurl.com/photonforge

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prash@flexcompute.com

FLEXCOMPUTE