Nexus Photonics

Transforming Photonics:
Fully Integrated Engines for AI, Quantum, and Beyond

Tin Komljenovic, CEO
komljenovic@nexusphotonics.com

LIGHTING THE WAY TO INNOVATION

Nexus Photonics

Problem

Advanced systems in:

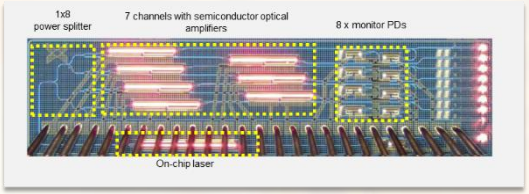
- **Communication**
- **Consumer**
- **Quantum**
- **Defense**

Need more capable, lower cost Lasers and Photonic Integrated Circuits ("PICs") to drive the next wave of innovation




The Solution

Nexus delivers the most advanced and scalable laser integration supporting wafer scale fabrication, screening and singulation

Funded and Partnered with:

Multiple customers FORTUNE 500 · DARPA · DIU · IARPA · DoD · Air Force · Navy · NASA · HARVARD UNIVERSITY · Caltech · UCSB · UCLA · UNIVERSITY of VIRGINIA

PROBLEM AND MARKET OPPORTUNITY

Artificial Intelligence

XR/Consumer

Mobility & Robotics

Quantum

Defense

NEXUS HETEROGENEOUS PLATFORM

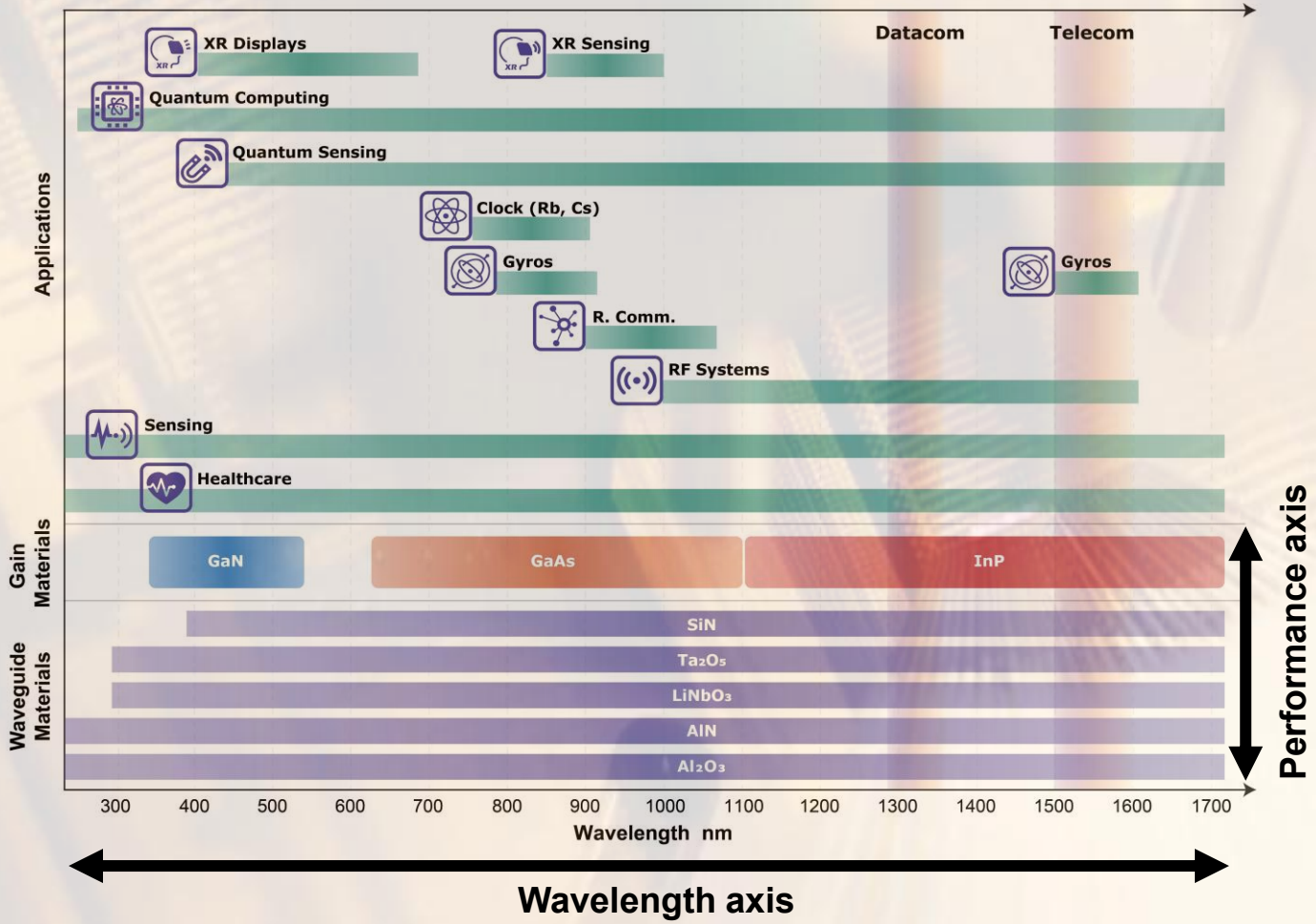
MEGATRENDS are defining the future

INCREASED LEVELS of **INTEGRATION** are required

NEXUS brings **PHOTONIC INTEGRATION BEYOND SILICON**
to have a **PIC** in **EVERY DEVICE**

NEXUS AND MEGATRENDS

Nexus Photonics
The only company that integrates III-V directly on lithium niobate and silicon nitride



Megatrends require

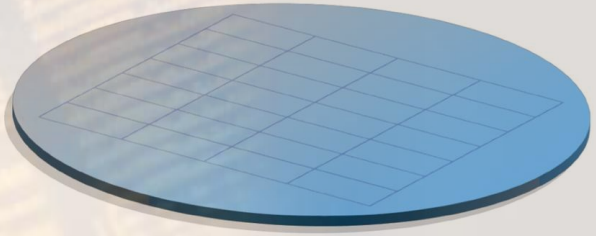
- **Better performance:** Nexus uses advanced materials (e.g., SiN for low loss/comb generation, LN for modulation) to enhance performance while enabling full integration of lasers, modulators, amplifiers and photodetectors
- **More wavelengths:** Nexus adds all wavelengths, becoming the only PIC platform with on-chip sources to support operation below 1.2 µm
- **Higher level of integration:** Nexus enables complete photonic system-on-a-chip to enable volume scaling

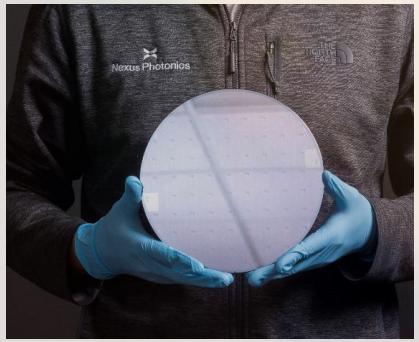
C. Zhang et al., "Integrated photonics beyond communications", Appl. Phys. Lett. 123, 230501 (2023)

NEXUS ADVANTAGE

Step 1
"Passive" process (up to 300 mm)

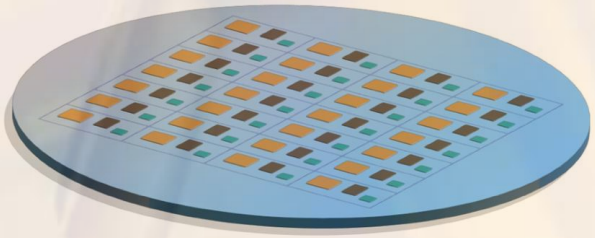
- Passive waveguides in SiN, TFLN, TaO,…
- Premium quality optical waveguide and passive components with advanced lithography tools
- Lithographic alignment marks defined for all subsequent III-V processing steps

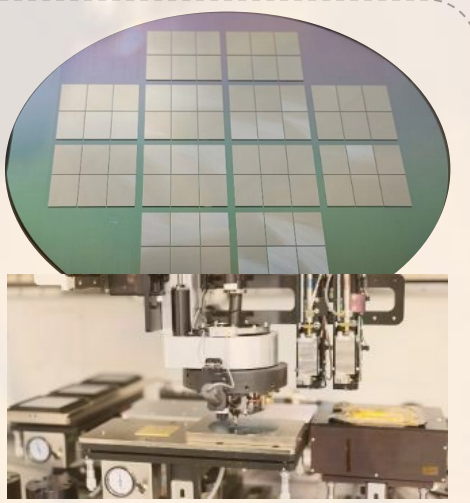




Step 2
Bonding (up to 300 mm)

- Blank III-V thin films transferred with no pre-process and *no fine-alignment required (>5 um)*
- Customized III-V materials and bonding map for versatile PIC designs, supporting different active functionalities and wavelengths

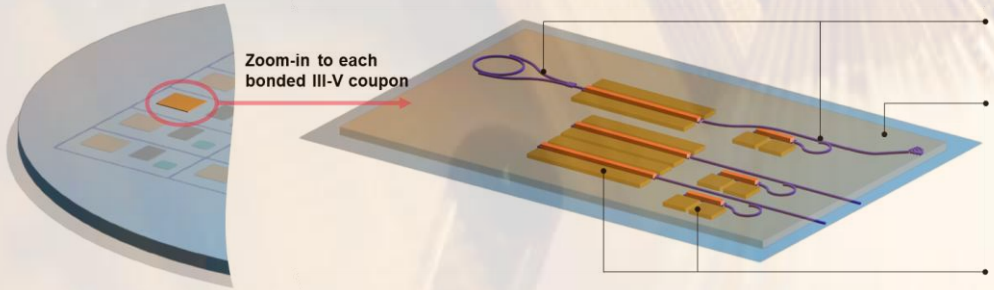


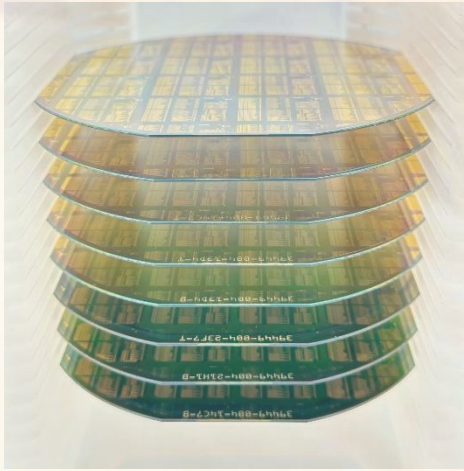


Step 3
III-V process (up to 300 mm)

- III-V process post thin-film transfer
- III-V to "passive" coupling ensured by advanced photo lithography and global alignment marks defined in step 1
- Metallization/passivation/via/contacts

Unlike *transfer-printing* or other approaches, our process utilizes advanced lithography to form III-V active devices on the silicon substrate, resulting in **robust coupling between III-V to passives,** and **superior yield and scalability.**





NEXUS: BUILDING THE NEW QUANTUM PARADIGM

Nexus Photonics Transforms quantum by:

- **Better performance (lower noise)**
- **Scalability / Density (number of lasers, size of photonics subsystems)**

Quantum Computing

- Enable densities/scaling and loss/noise metrics

Quantum Networking

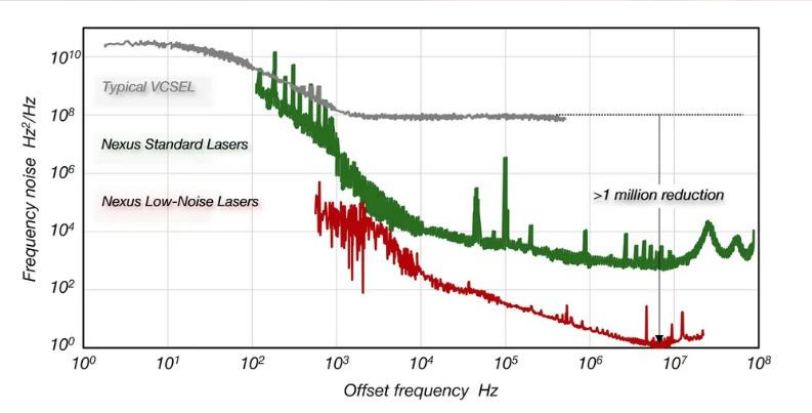
- Switching, entanglement using III-V or other materials on SiN, manufacturability

Quantum Sensors

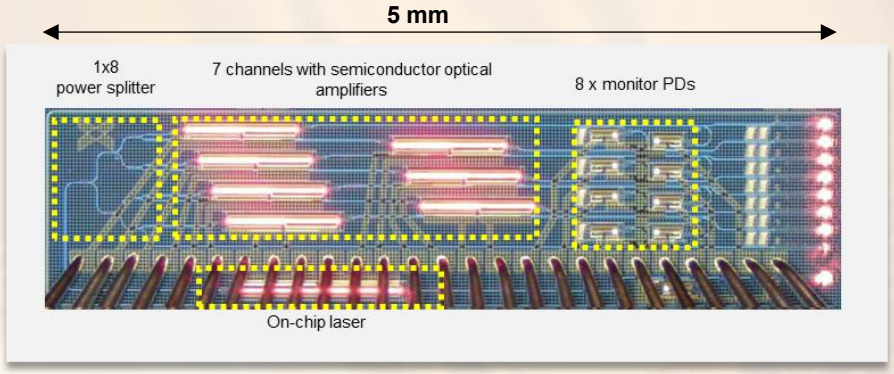
- Manufacturability, performance and SWaP-C improvement

Quantum Timing

- Manufacturability, performance, and SWaP-C improvementS



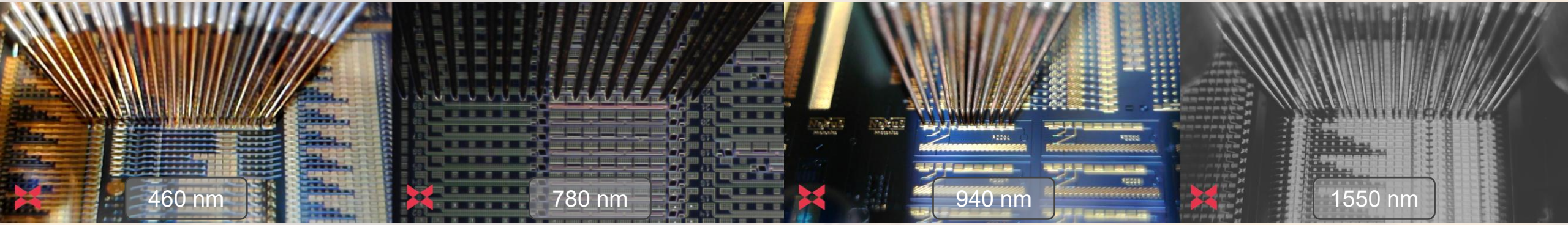
~1,000,000x performance improvement in noise



>40,000 (active) devices per 200 mm wafer

Nexus transforms quantum industries by providing >1M TIMES IMPROVEMENT IN NOISE, and UNPRECEDENTED DENSITIES (>40,000 active devices per 200 mm wafer)

NEXUS: BUILDING THE NEW QUANTUM PARADIGM

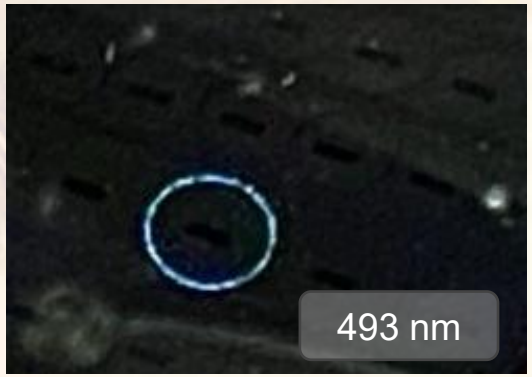


Automated wafer-scale testing of photonic integrated circuits with on-chip sources at various colors/wavelengths

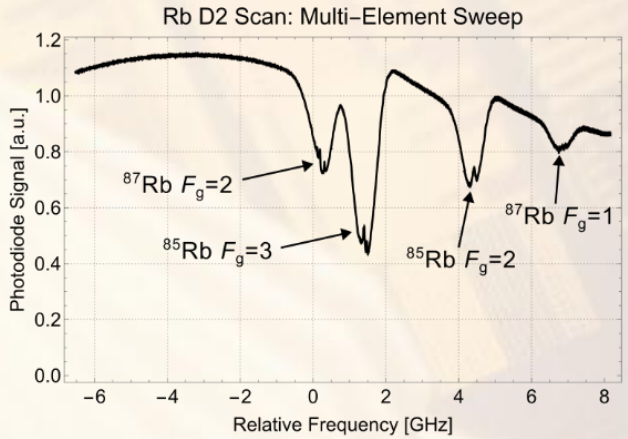
Broadband Photonic Integration supporting **FULL WAVELENGTH RANGE** for **QUANTUM SYSTEMS**.

Gain medium:

- GaN: 400-530 nm
- $\chi^{(2)}$: 530–630 nm
- GaAs: 630-1100 nm
- InP: 1100-1700+ nm



$\chi^{(2)}$ converted signal



Scanning of fine resonances with Nexus tunable laser

NEXUS: SCALING FOR THE MAINSTREAM (PHONE/LAPTOPS/XR/ROBOTS)

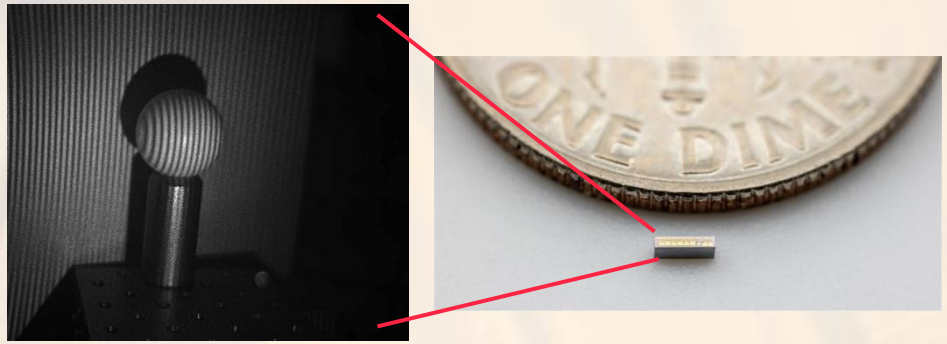
The only PIC technology with on-chip sources operating around 940 nm – wavelength of choice for depth perception

> 1 billion phones sold in 2023, almost 2 billion expected to be sold in 2030
> 200 million XR headsets expected to be sold in 2030

RGB laser displays
Eye tracking
Gesture recognition

3D depth perception

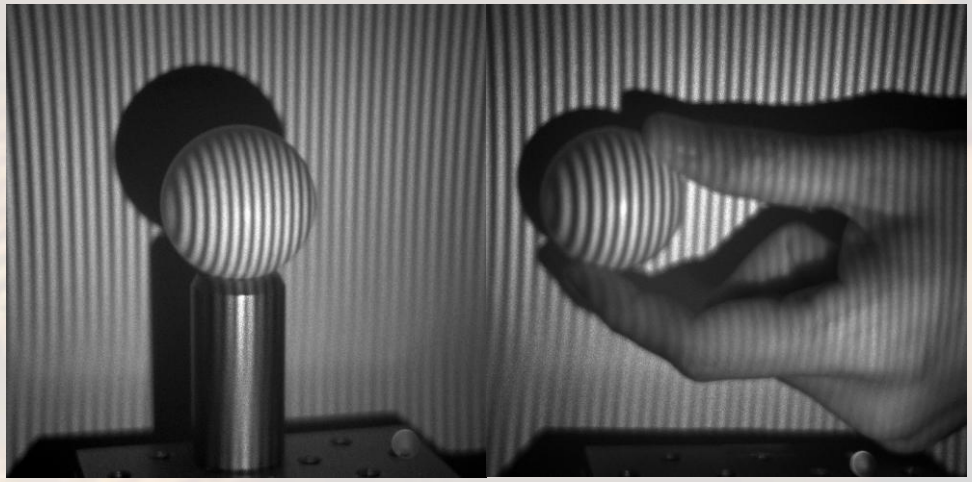
Nexus Prototypes

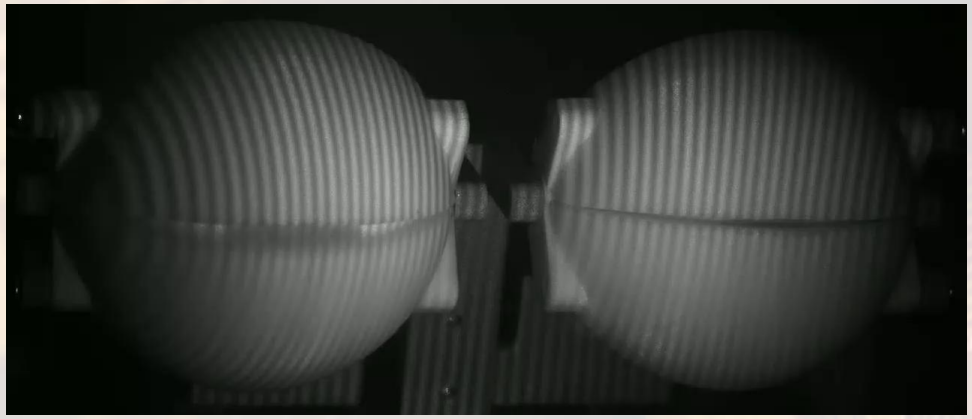


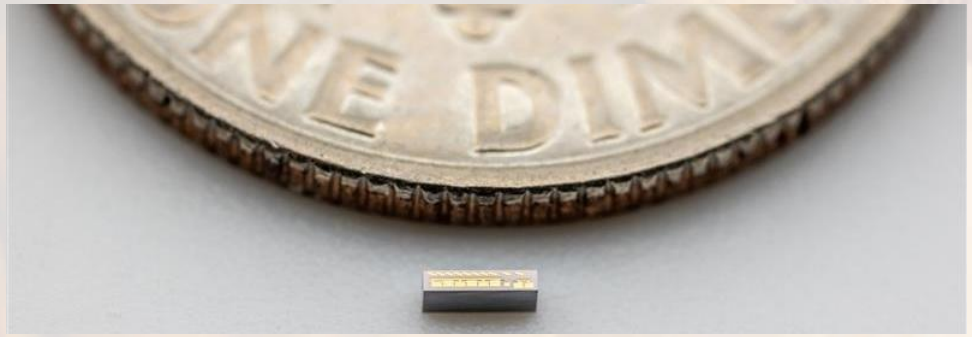
Nexus transforms AR/VR industries by providing **SMALLEST FORM FACTOR PIC**s with embedded advanced functionality including optical sources.

(Example: Advanced illuminator PIC has size of only 0.5 mm^2)

"There is no reason that GaAs (native) will support level of integration that Infinera built with InP (due to regrowth challenges) — QED-C PICs-QA Workshop







Nexus Photonics

Illuminators for **Depth Perception**

A single chip with:

No external optics needed

Customizable field of view (> 180°)

Customizable wavelengths (650 nm – 1700 nm)

Various fringe densities (0.1° - 30°)

Steerable fringes as option

Flood illumination as option

Adaptive light power management

Form factor:

Single chip, typically < 1 mm^2

Scalability:

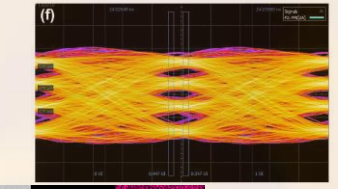
Wafer-scale Fabrication and Encapsulation

Wafer-scale Screening and Singulation

Basic non-hermetic packaging

komljenovic@nexusphotonics.com www.nexusphotonics.com | 6500 Hollister Ave, Ste. 150, Goleta, CA, 93117

ADDRESSING THE COMMUNICATION BOTTLENECK



TODAY'S LIMITATIONS

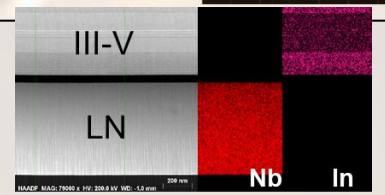
Modulator bandwidth

Channel count

Power handling, latency and wavelength range

BEYOND Si MODULATOR

III/V and TFLN

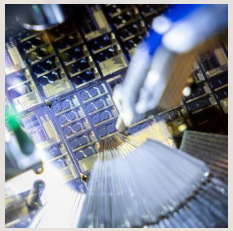


III-V on TFLN integration for on-chip lasers, amplifiers and detectors

BEYOND DFB/VSCEL

Tunable lasers and Comb sources

Automated wafer-scale testing

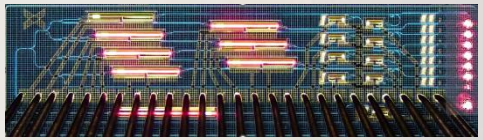


5 mm, $5

Self-calibrated widely-tunable laser

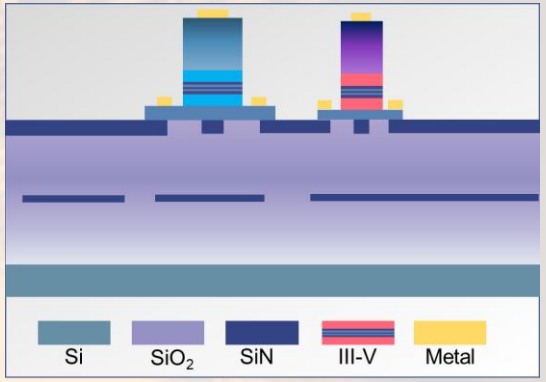
BEYOND Si WAVEGUIDES

SiN waveguides and InP/GaAs gain (+ hollow core fiber)

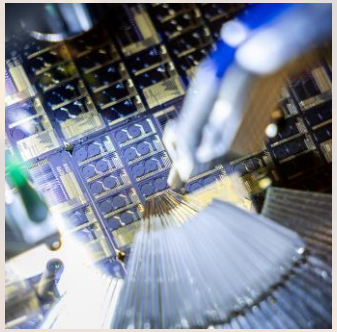


Includes 1 µm wavelength range

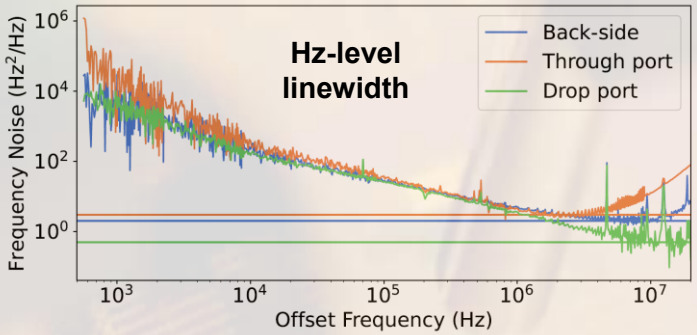
NEXUS: POWERING THE EXASCALE ERA



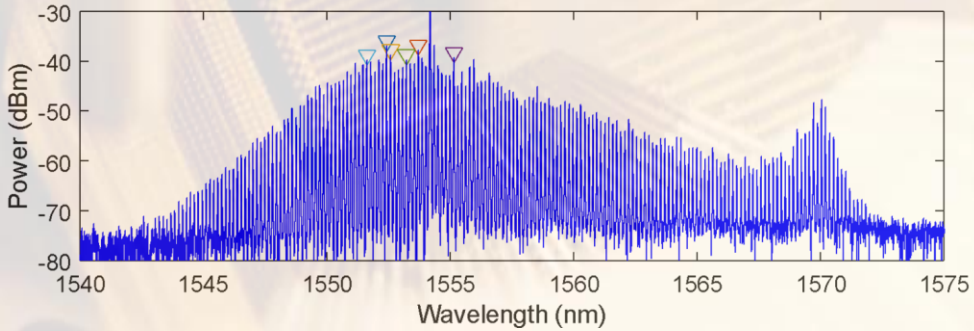
Multi-layered SiN platform with III-V



Automated wafer-scale testing



Noise performance of lasers using multi-layered SiN



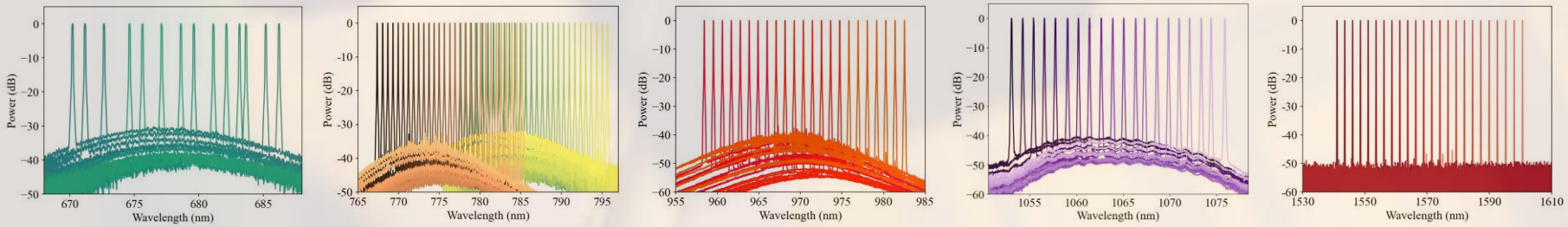
Comb optimized for sensing applications

- Full-wafer scale testing
- Multi-layered SiN for routing and low loss (propagation and coupling)
- Thick dielectrics for improved modulator bandwidth (reduced capacitance)
- Comb generation using optimized SiN layers including multiple resonator geometries

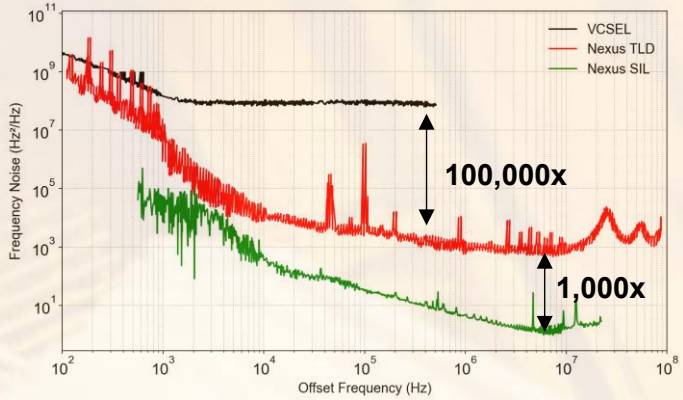
NEXUS ADVANTAGE

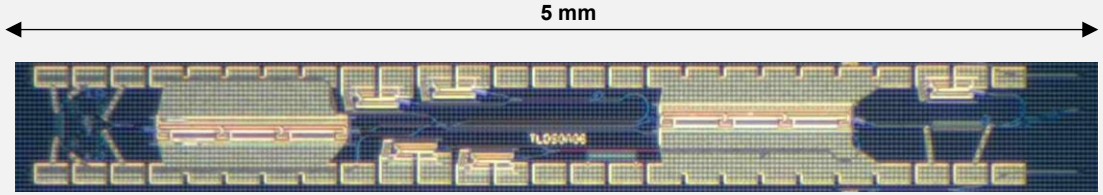
THE LASER

Tunable
(any wavelength, every time)
Low noise
(<kHz level)
Self-calibration
(guaranteed long-term stability)
Tiny
(~mm^2)
Mass manufacturable
(wafer scale integrated)
Economical
(low production cost)



Arrays of lasers

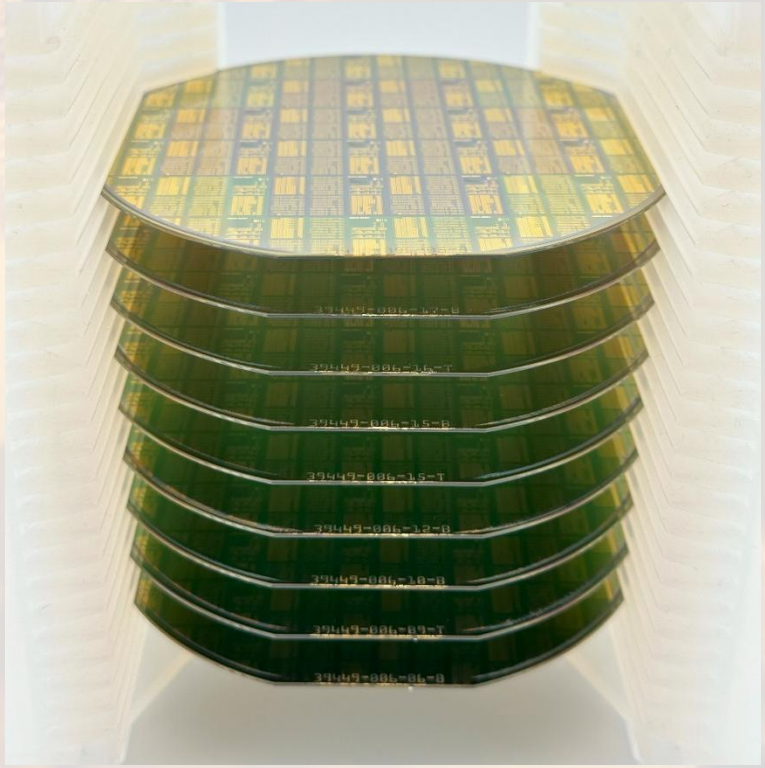


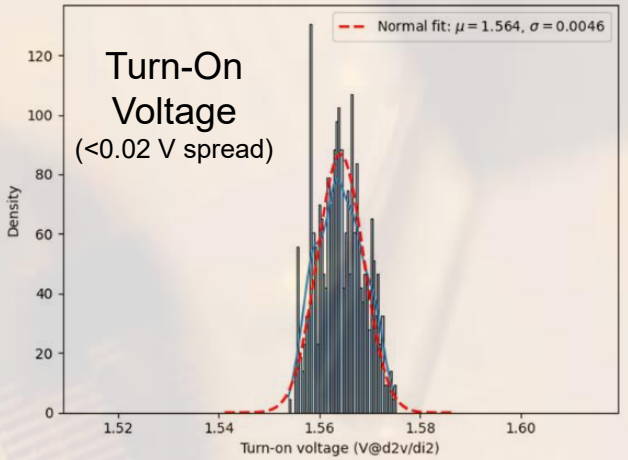


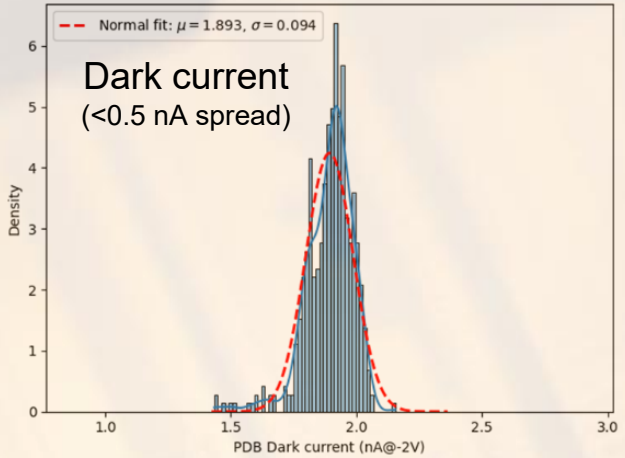
Self-calibrated widely-tunable laser

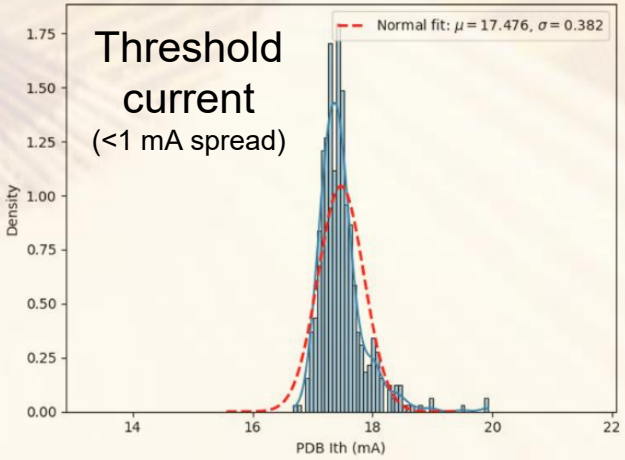
- >5,000 tunable lasers per 200 mm wafer
- Full-wafer scale testing
- On-chip calibration capability
- Precise power control with amplifier and on-chip monitors

GAIN INTEGRATION









NEXUS ADVANTAGE

Nexus' Approach Application Specific PIC / SOC Brings the Cost Down by >100x

Application Specific PIC/SOC

Nexus Photonics

Lasers
(FP, single frequency, tunable)

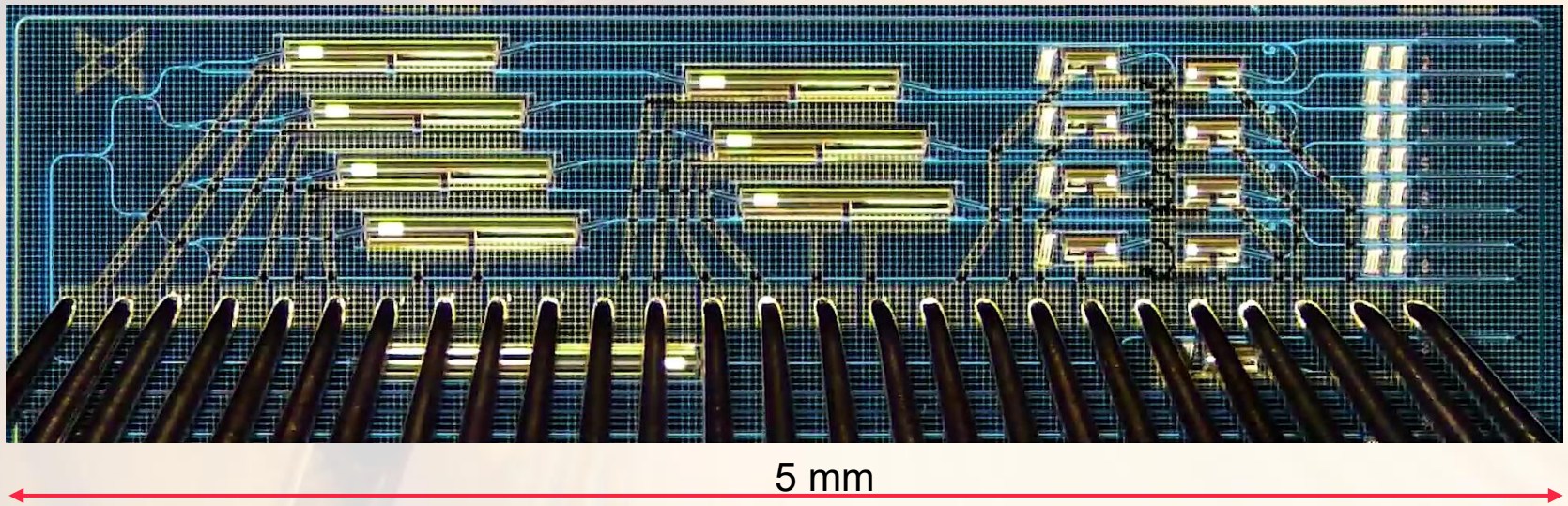
Amplifiers
(boost power, recover losses, gate output)

Detectors
(high speed, monitor, feedback control)

Modulators
(imprint data, generate sidebands, lock)

Passives
(route, split, combine, filter, comb generation)

Beam-shaping
(advanced I/O, collimated/divergent beams)



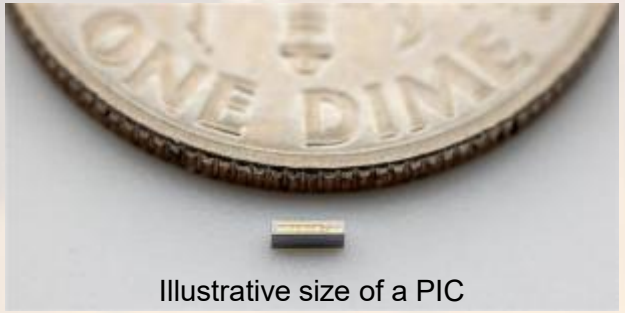
PIC – Photonic Integrated Circuit
SOC – System On a Chip
FP – Fabry Perot
I/O – Input/Output

BEYOND SILICON PERFORMANCE USING SILICON INFRASTRUCTURE

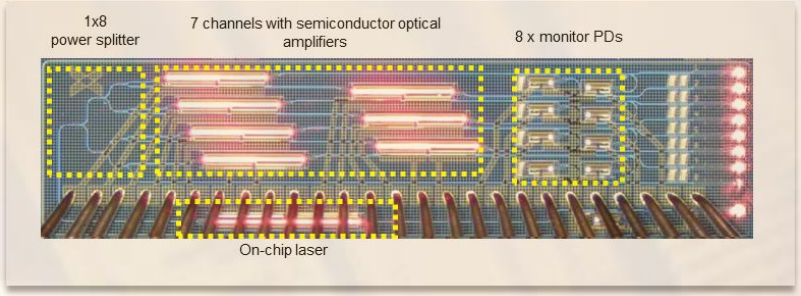
Smallest size
- Single-chip integration for minimum size and weight
- No optical alignment needed

Robust and reliable
- High coupling efficiency reduces requirements on laser
- On-chip amplifiers reduce requirements on laser
- Ability to include multiple lasers for redundancy

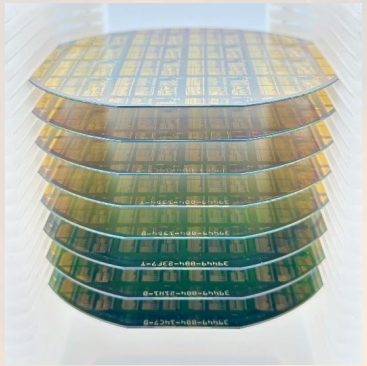
Scalable and low cost
- Wafer scale fabrication, testing/screening and singulation
- Using silicon photonics infrastructure for high uniformity and yield



Illustrative size of a PIC



Wafer-scale testing


Wafer-scale fabrication and testing

Wafer-scale singulation


Beyond state-of-the-art reliability

Nexus Photonics

Transforming Photonics:
Fully Integrated Engines for AI, Quantum, and Beyond

Tin Komljenovic, CEO
komljenovic@nexusphotonics.com