

Integrated biosensing from the visible to the IR using low loss silicon nitride

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Anton Vasiliev, PhD
anv@ligentec.com

LIGENEC - Largest SiN open access foundry in the EU

Leader in low loss Silicon Nitride Integrated Photonics



LIGENEC



LIGENEC HQ, Switzerland

LIGENEC France

European PIC Company

European origin

Europe based



Global Reach

Headquarters in Lausanne (CH)

Originating from EPFL (Kippenberg Lab)

Challenges of Photonic Integrated Circuits (PICs)



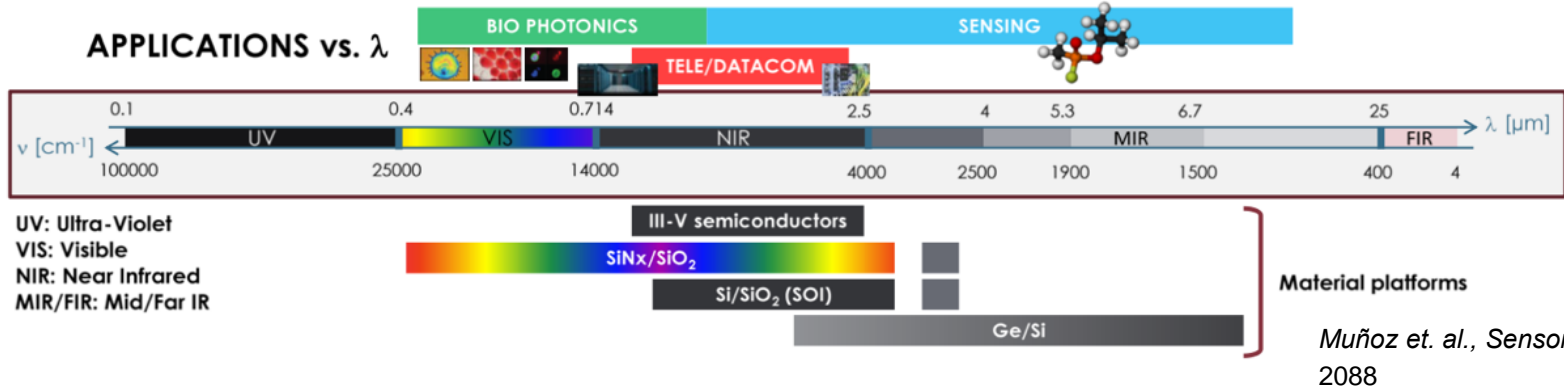
ADVANTAGES

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

CHALLENGES

- propagation losses
- coupling losses
- long & expensive R&D cycles
- no one fits all solution

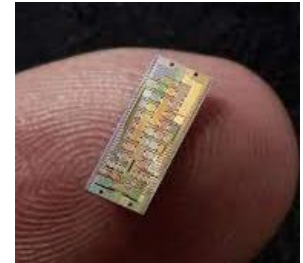
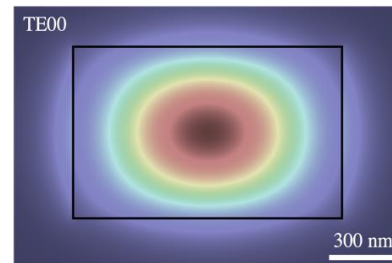
Benefits of Silicon Nitride for (Bio)Sensing



Low propagation loss: **0.01 to 0.05 dB/cm**
Reference Silicon: 2.5 to 1 dB/cm

Large transparency window: **400 – 4'000 nm**
Reference Silicon: 1'100 – 4'000 nm

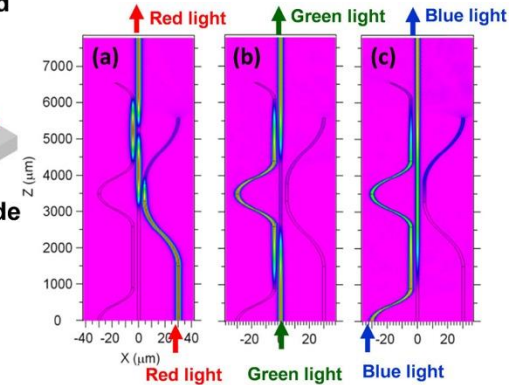
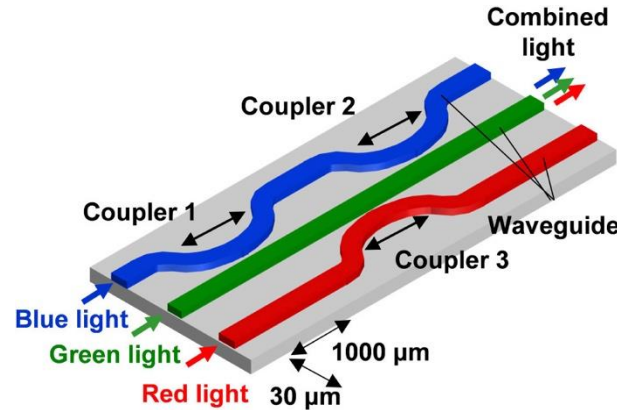
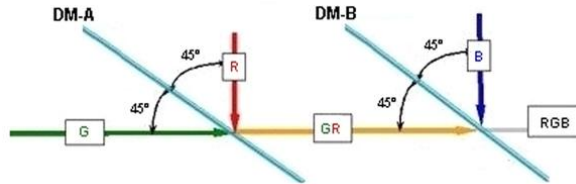
High optical power: **> 5 W per waveguide (10^9 W/cm²)**



Application - simple example of a PIC

Beam combiner in the Visible

Replacement of bulky free space optics with integrated solution

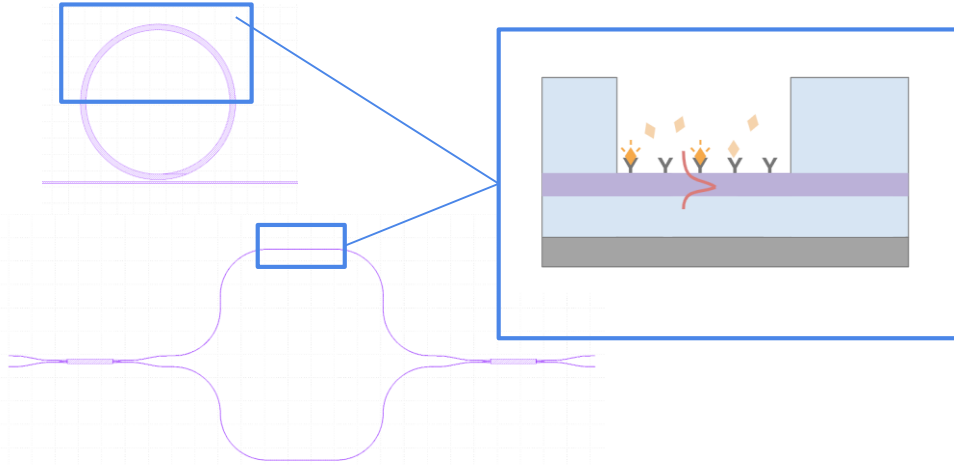


Katsuyama et al. 2014 <https://doi.org/10.1117/12.2072420>

Key system parameters: propagation loss, IO coupling loss, Extinction Ratio

Applications - BioSensing *chip*

Evanescent field sensing on exposed SiN waveguides

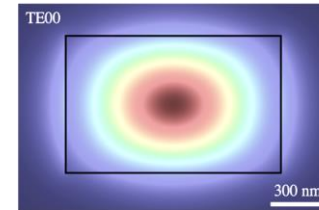
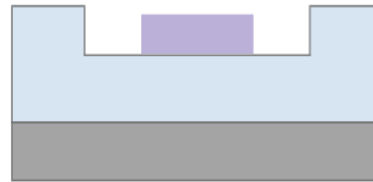
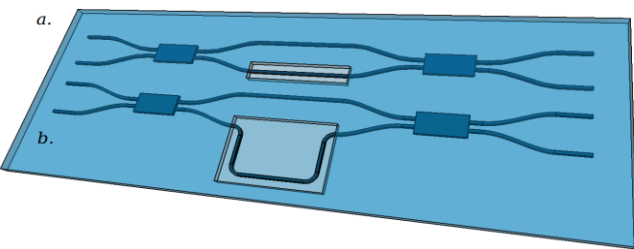


(bio)marker receptors → **Selectivity**

Low propagation loss interferometer → **Sensitivity**

Low I/O coupling loss → **SNR**

Wavelength “fingerprint” not used, **no complex tuning**

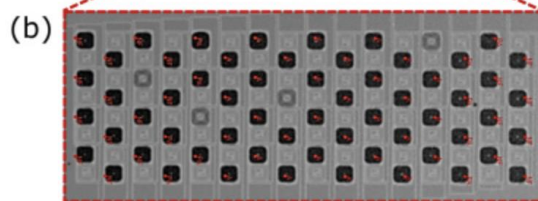
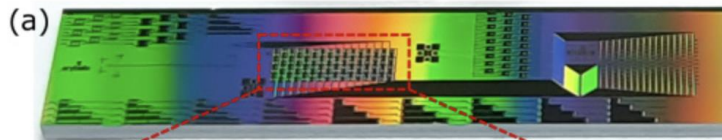
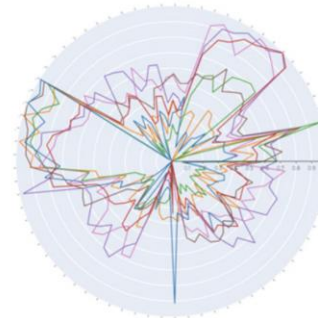
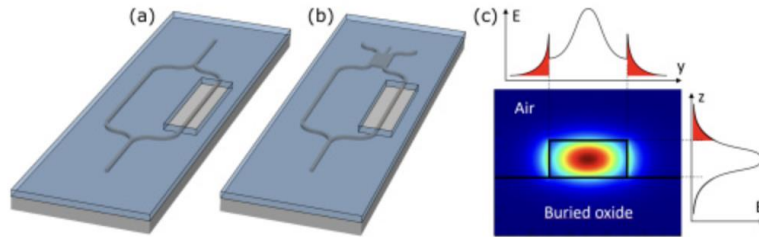


Applications - BioSensing device

Evanescient field sensing on exposed SiN waveguides



e-nose for odor analytics



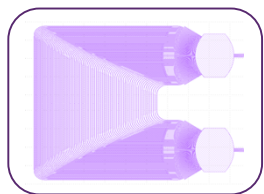
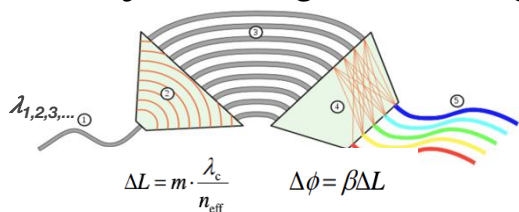
- Rancid
- Fruity
- Solvent - Sharp
- Fat
- Vinegar
- Solvent - Sweet
- Sweet



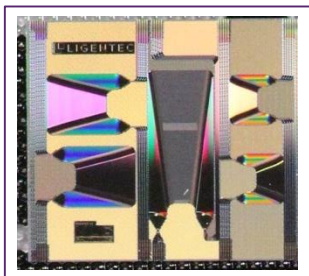
L. Laplatine et al., *Optics Express* 30 (19) (2022)
<https://www.photonixfab.eu/>
<https://aryballe.com/>

Dispersive on-chip spectrometer from VIS-NIR

Arrayed Waveguide Grating (AWG)

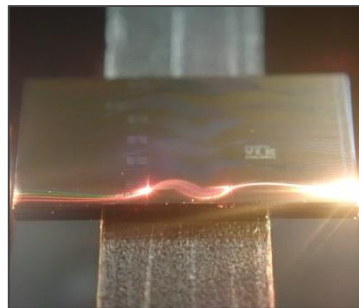


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Visible



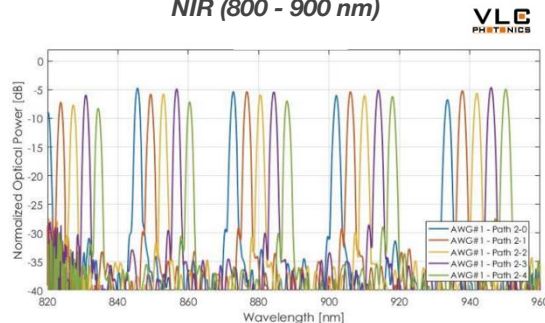
broadband source + AWG → **Selectivity**

Low propagation loss → Low AWG XT

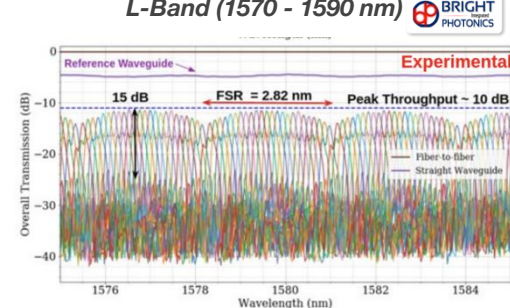
Low I/O coupling loss → **SNR**

Wavelength “fingerprint” probed

NIR (800 - 900 nm)



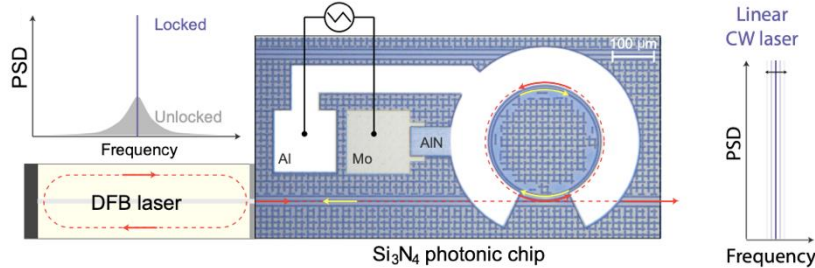
L-Band (1570 - 1590 nm)



Applications - Advanced frequency comb source

Octave spanning frequency combs

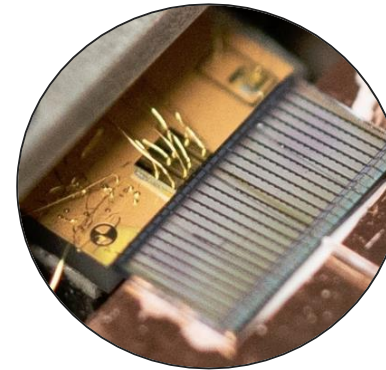
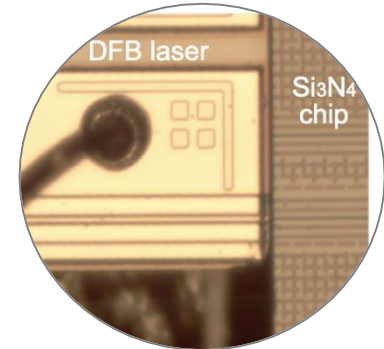
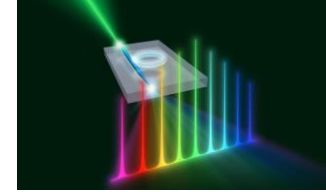
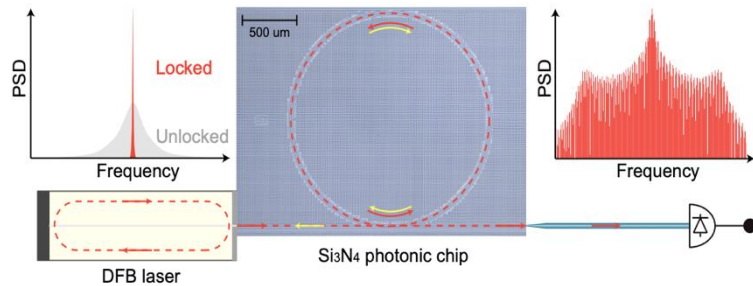
Low loss SiN enables advanced nonlinear devices



Linewidth: <math><50\text{Hz}</math>
SMSR: -50dB

Max power: ~1.5mW
Locking range: 2GHz

or



Dual-comb Spectroscopy enabled by low loss SiN

Fast and precise probing of the full “fingerprint” spectrum

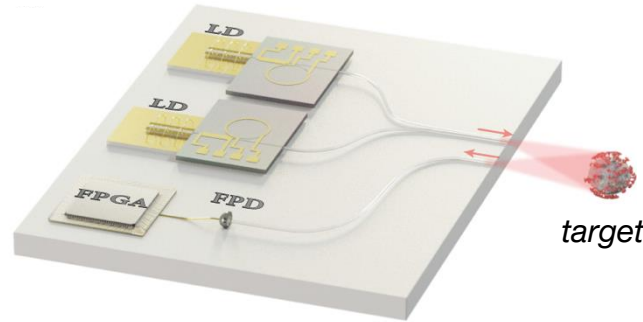
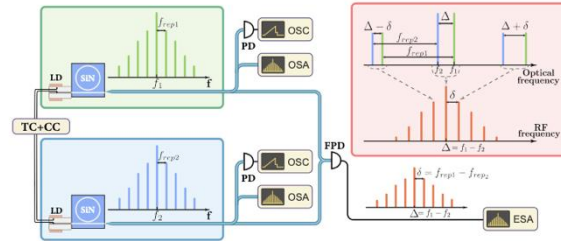
Dual-comb spectroscopy allows direct optical-to-electrical mapping and read-out

Shown implementation:

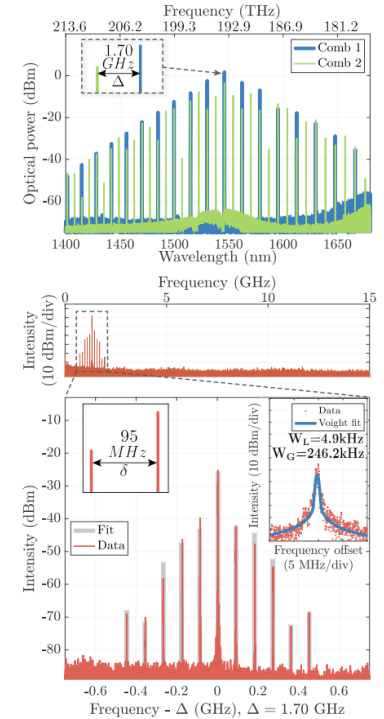
Laser Diode + SiN microresonators

OFC via Self injection-locking

Beatnote in RF domain



N.Dmitriev et al., arXiv (2021)



How can Ligentec help scale your biosensing business?

Seamless journey from Idea to Volumes

Entry: R&D & Prototyping

Open access, low barrier

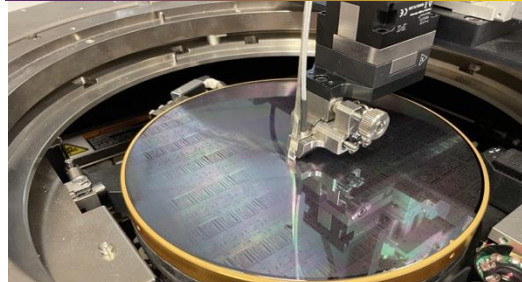


Fast prototyping

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

Optimize: Development

High flexibility & competence



Custom PIC Developments

- Engineering studies
- Layer stack adaptation

Custom Integrations

- **LNOI**
- **PD** integration
- Polymers, BTO, AlN, III-V,...

Manufacturing: Supply

Quality and guarantee



Pilot Fabrication

- Pilot and niche quantities

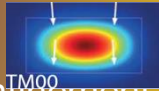
Volume Fabrication

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

Low Loss SiN - Platform Overview

The Basics

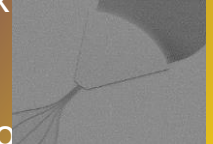
- ✓ High Mode Confinement
- ✓ Low Loss
- ✓ Small Footprint
- ✓ High Power



In what area (basic performance, design, active components, IO) lies your greatest challenge today?

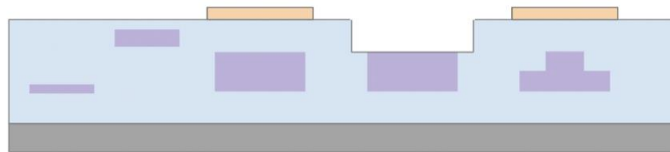
Full Creativity (PDK)

- ✓ Couplers
- ✓ Mux / DeMux
- ✓ MZIs / DLIs
- ✓ Resonators
- ✓ Polarization co...



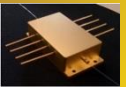
Actives

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



World Connections

- ✓ Edge / Grating Coupler
- ✓ Spot Size Converter
- ✓ Arbitrary Die Shape
- ✓ Bond pads
- ✓ Cladding opening for sensing



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