Low Loss Silicon Nitride – an integrated photonics platform for solid state LiDAR

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Potential of Photonic Integration

- **MAX-PLANCK-INSTITUTE OF QUANTUM OPTICS Garching**
- **MenloSystems**
- **CORES**

**SWaP**
- Size
- Weight
- Power
- Robustness
- Cost

**Dimensions**
- 1998: 4 m³
- 2008: 1 m³
- 2019: 1 cm³
Silicon Photonics Applications

- Space (QKD, comm)
- Aeronautics (in-flight entertainment)
- Medical
- Telecom (Metro)
- High-performance computing
- Data centres (In row/Inter/Intra)

Silicon Photonics Challenges
- High propagation losses
- Low optical power handling
- Narrow transparency window
- Expensive I/O coupling
Silicon Photonics 2.0
Our game Changer: Thick Film Silicon Nitride

90% light confined in SiN waveguide:
- Low loss (< 0.1 dB/cm)
- Small chip size
- High Yield
- VIS to IR
- High optical power handling (Watts)

All Nitride Core Technology: combining the benefits of
- Silicon Nitride (VIS-IR, low loss, high power) with
- Silicon Photonics (small chip size)
LIGENTEC

- R&D support in Design & Packaging
- Known Good Die Delivery from Prototype to Volume
- Circuit IP stays with customer
Fabrication Services

Multi Project Wafer Runs
- AN800 (IR), AN150 (VIS)
- Preset process modules
- 7 chips (5mm x 10mm)
- Fast (10 weeks)
- 4x per year, fixed dates

Custom Runs
- Can start any time
- Fast track options
- Full choice of process modules
- Custom thickness
- Custom quantities

www.ligentec.com/Ligentec-foundry/
### Modular Process Portfolio

<table>
<thead>
<tr>
<th>Base Process</th>
<th>Selected Advanced Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AN150</strong></td>
<td>WAVEGUIDE</td>
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<tr>
<td></td>
<td>X2. Multi level photonic circuits</td>
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<tr>
<td><strong>AN800</strong></td>
<td>HEATER</td>
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<tr>
<td></td>
<td>SiN</td>
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<td></td>
<td>M1. High efficiency heaters for thermo-optic tuning</td>
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<tr>
<td><strong>ANcustom</strong></td>
<td>LoCA. Local cladding open for sensing and bonding</td>
</tr>
</tbody>
</table>

- **Base Process**
  - **AN150**: visible wavelength
  - **AN800**: 1280-1650nm wavelength
  - **ANcustom**: Other wavelength, high level of customization

- **Selected Advanced Modules**
  - WAVEGUIDE
  - HEATER
  - SiN
  - M1. High efficiency heaters for thermo-optic tuning
  - LoCA. Local cladding open for sensing and bonding

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**EPIC Meeting on LIDAR Technologies for Automotive Oct. 2019**

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Components to realize e.g. a FMCW coherent LiDAR

LiDAR Requirements
- Range
- Resolution
- Cost
- Size
- Power

PIC Building Blocks
- MMIs
- Delay lines
- MZIs
- Phase Modulators
- Optical I/Os

BB requirements
- Low loss
- Low phase errors
- High laser power
Couplers / MMIs

**TE-TE**

SR\(\text{@}1550\text{nm} \):  
- Cross → 0.708  
- Bar → 0.292

**TM-TM**

SR\(\text{@}1550\text{nm} \):  
- Cross → 0.693  
- Bar → 0.307

First time right possible
Delay Lines & Delay Line Interferometers (DLIs)

- Short bend radii
- Low loss 5 dB/m
  => Long delay lines

- Small waveguide roughness
- High mode confinement
  => Low loss & low phase noise

Delay lines up to 1 m on 5x5 mm²

Long and low phase noise delay lines enable high resolution FMCW LiDAR
Phase Shifting - Thermal circuit tunability with no additional losses.

- Speed 25kHz
- 100mW for pi shift
- Up to 4nm tuning, several FSR / pi-shifts

Narrow gap & high mode confinement results in efficient tuning
Optical I/Os

- Vertical grating couplers
- Edge coupling with spot size converter

Spot Size Converter
- 0.5 μm position tolerance
- < 1dB coupling loss

Relaxed tolerances reduces packaging cost

- Heterogeneous integration to other material platforms with mode conversion or bonding
Optical Phase Array (OPA)

- Low loss & high power light propagation
- Low loss phase shifter
- Vertical grating couplers

=> Enabling for OPAs

1) Wikipedia
2) Reza Fatemi et al., IEEE Journal of Solid-State Circuits 02/2019
Low Loss SiN - Platform Overview

The Basics
- High Mode Confinement
- Low Loss
- Small Footprint
- High Power

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

WE ARE HIRING
How can we help you? How can you help us?

**We for you:**

**Partner** for low loss PICs
- Low entry barrier MPW runs
- Building Block Development
- Custom PICs
- Prototype to Volume

Established & sound partner network for
- Design
- Free Space Optics

**You for us:**

Challenge us with specific LiDAR requirements

Complement the PIC supply chain:
- Wafer Level Testing
- Packaging