3.4 Dutch Strengths:
Integrated Photonics

Netherlands

UNIQUE ELEMENTS OF THE NETHERLANDS

The hotspot for Integrated Photonics

1. Vibrant, deep and rich **ecosystem**, offering a complete value chain for the main PIC technology platforms (InP, SiN, SiP). PhotonDelta* actively supports companies to become part of this ecosystem.

2. Proven track record with decades of **semicon industrialization** experience which resulted in a strong supply chain and expertise for High Tech Systems and Materials (HTMS).

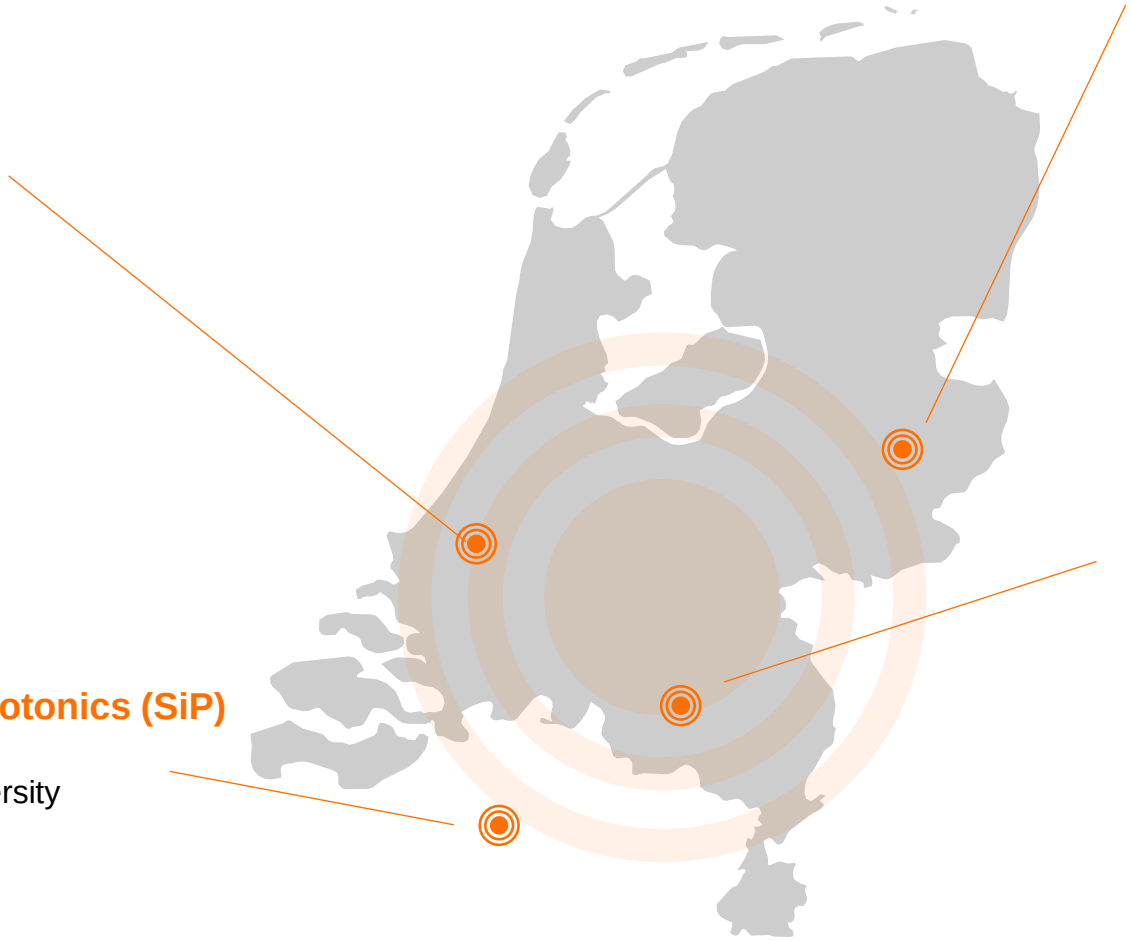
3. Widely embedded **optical knowledge** in business (ASML, Philips, Signify, Thermofisher) and academics (Technical Universities Delft, Twente, Eindhoven) build on
   - Photonics
   - Devices/Machines
   - Integrated Photonics

Sources: BUCK 2023

*PhotonDelta as organization runs national programs to further build and solidify the Dutch ecosystem for integrated photonics:

CLOSELY COLLABORATING CLUSTERS WITHIN 2 HOURS DISTANCE

Main Integrated Photonics platforms are present



Delft

- Technical university
- Optica cluster
- Dutch Optics Centre
- TNO research

Belgium | Silicon Photonics (SiP)

- Leuven Technical University
- IMEC research

East Netherlands | Silicon Nitride (SiN)

- University of Twente,
  Radboud University
  University of Wageningen
- Research institutions & facilities
  MESA+ Nanolab, Frauenhofer Oneplanet Research
- High Tech infrastructure
  Kennispark, Noviotech
- Semicon cluster
  eg NXP & Ampleon

Noord Brabant | Indium Phosphide (InP)

- Eindhoven University of Technology (TU/e)
- Research institutions & facilities
  EHCI, Cobra, JEPPIX, Nanolab
- High Tech infrastructure
  High Tech Campus, Brainport Industry Campus, Automotive Campus Helmond
- Semicon cluster
  eg ASML, Philips, NXP

Source: BUCK (2023)

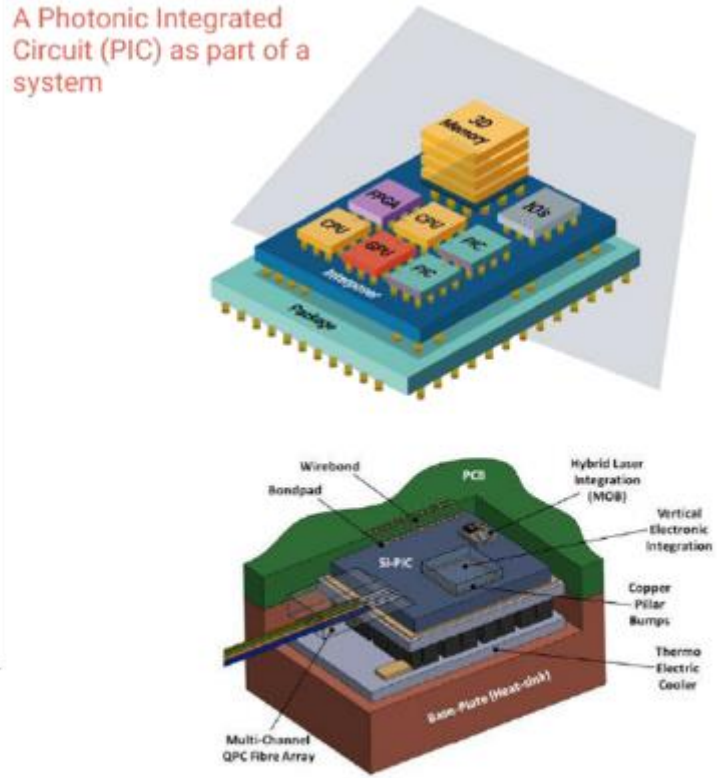
KEY TECHNOLOGIES FOR NEXT GENERATION INTEGRATED CIRCUITS

Integrated photonics ecosystem

1. Complete value chain from design to packaging and application

2. Ecosystem closely collaborating on new innovations on
    1. Pakaging
    2. Design
    3. Interface electronics design
    4. Volume increase/scaling

3. Solving industrialization challenges on heterogeneous integration
    1. Miniaturization of components
    2. Heterogeneous integration of chips and substrates
    3. New manufacturing and assembly techniques
    4. Metrology



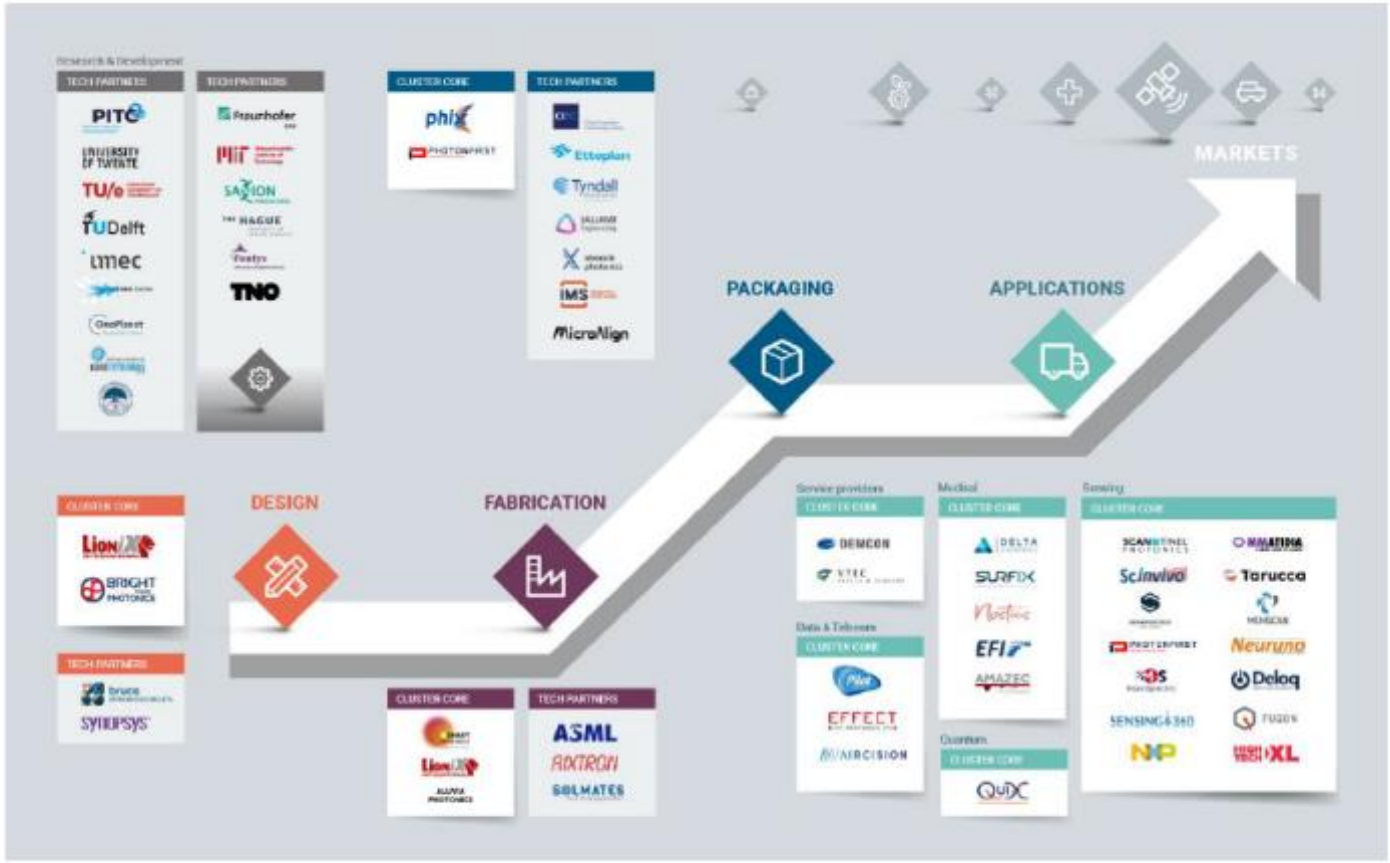
High Tech NL

ECOSYSTEMS FOR KEY TECHNOLOGIES

A complete value chain for integrated photonics.

The Netherlands offer:

- ✓ Complete eco-system
- ✓ InP pure-play foundry
- ✓ SiN prototyping & small series
- ✓ Strong partnership with IMEC for CMOS & SiPh
- ✓ Finished product companies, proven technology & customers
- ✓ Range of technologies: integrated photonics, optics, sensors, spectroscopy & quantum optics



Source: PhotonDelta

3.5 Dutch Strengths:
Quantum

Netherlands

UNIQUE ASPECTS OF THE DUTCH QUANTUM ECOSYSTEM

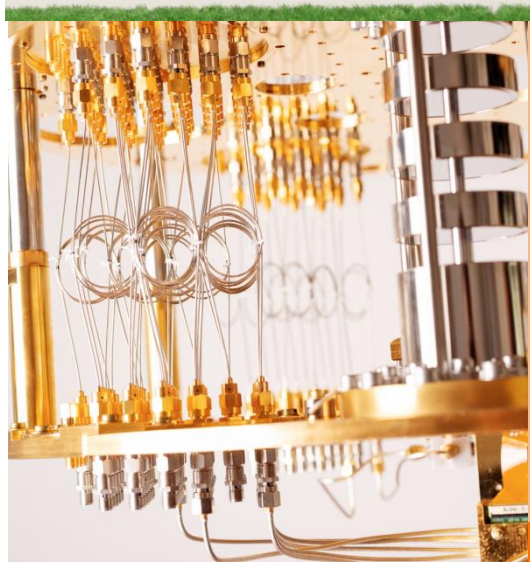
Growing Quantum ecosystem, from fundamental research to industrialization

1. National program (**Quantum Delta NL**) with substantial funding to further build and solidify the Dutch Quantum ecosystem in coming years, including a wide range of open test facilities and testbeds.

2. Within 2 hours drive, **5 strong regional quantum hubs** within the Dutch borders. Each with their own but complementary focus areas.

3. Long track record of high tech industrialization with a rich, deep ecosystem allowing companies to focus on their core activities whilst benefiting from expertise available through horizontally integration.

4. Attractive business climate with academic and industry talent, **gateway to Europe** and access to international venture capital through the **Infinfity** program.



QUANTUM EXPERTISE

Hubs have their own focus areas and expertise

AMSTERDAM | Qusoft, UvA, CWI*
- Quantum Software
- Quantum Algorithms
- Quantum Sensors
- Quantum Cryptography
- Quantum application lab

LEIDEN | aQa, UL *
- Applied quantum algorithms.
- Quantum sensors (force, magnetic or electronic microscopy)

DELFT | QuTech, TuD, TNO *
- Qubit technology:
  - Super conducting
  - Spin
  - NV center
- Quantum electronics control
- QKD systems
- Quantum network development (technology)
- Quantum algorithms
- Quantum sensors

TWENTE | qUan, UT *
- Photonic quantum computers Quantum sensing
- Quantum authentication

Supportive ecosystem
- *Integrated photonics*

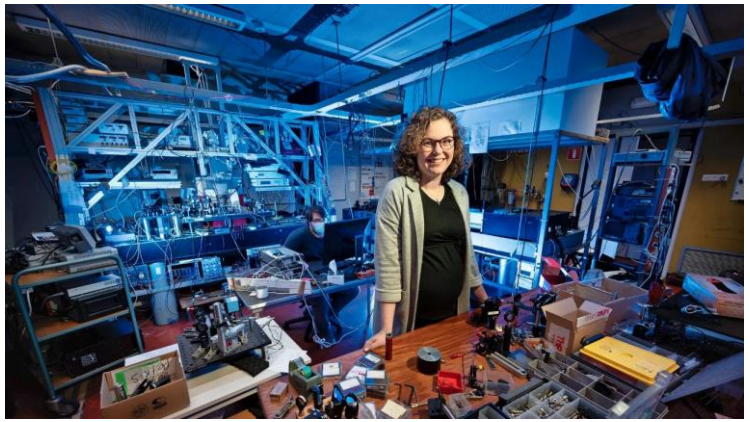
EINDHOVEN | QT/e, TU/e
- Post quantum cryptography (*Prof Dr. Tanja Lange*)
- Quantum network open test bed
- Quantum industrialisation
- Hybrid quantum computing
- Cold atom quantum computing
- Ion trap technology

Supportive ecosystem
- *High tech system industrialization*
- *Integrated photonics*

Source: Introduction to QuTech (2022)

QUANTUM RESEARCH INITIATIVES

Regional initiatives and groups for quantum research



AMSTERDAM
- Qusoft
- Theory of quantum computing (QIQC)
- Quantum clocks (QMLA)
- Quantum Computing (Rydberg atoms)

LEIDEN
- Quantum microscopy Fieldlab
- Ultra Microscopy Hall
- Quantum and Society
- Quantum artificial intelligence Lab
- Leiden institute of physics

DELFT
- Qutech (collaboration with TNO)
- Quantum Inspire
- House of Quantum (cryo labs)
- Quantum for business
- Kavli Nanolab
- Quantum network Explorer (QNE)
- Technology Test facility (QITT)

TWENTE
- MESA+
- Institute for Theoretical Physics (ITP)
- TechMed centre

EINDHOVEN
- Qutech (collaboration with TNO for quantum information processing)
- Eindhoven Hendrik Casimir Institute (EHCI) – fundamental research
- Institute for Photonic Integration (IPI) – applied research
- Center for quantum materials & technology Eindhoven(QT/e)
- Dutch Institute for Fundamental Energy Research (DIFFER)

Source: Introduction to QuTech (2022)

4. Research and Education

Netherlands

ACCESS TO TALENT

The rich ecosystem and universities are an excellent talent base

Top Technical Universities

TU/e Technische Universiteit Eindhoven University of Technology

UNIVERSITY OF TWENTE.

TU Delft

Technical Students in the Netherlands

85.600

Technical Workforce in the Netherlands

1.762.000

Universities of applied sciences.

SAXION UNIVERSITY OF APPLIED SCIENCES

Fontys UNIVERSITY OF APPLIED SCIENCES

(nano technology/semicon programs)

Semiconductor, Photonics, Quantum and Nanotech Research Institutes

UNIVERSITY OF TWENTE. | MESA+ INSTITUTE

EHCI EINDHOVEN HENDRIK CASIMIR INSTITUTE

TU/e

Source: Universities of the Netherlands, 2021, TechniekPact, 2022

協力
=
Cooperation