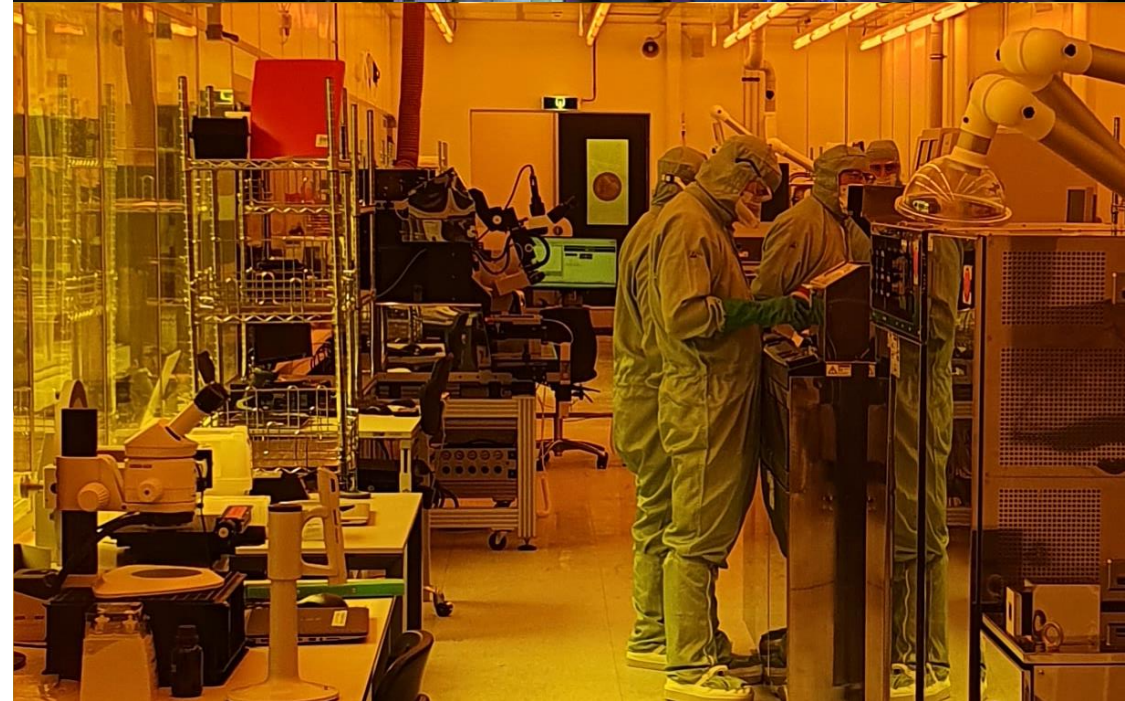

MONOLITHIC INP INTEGRATION IN SMART PHOTONICS

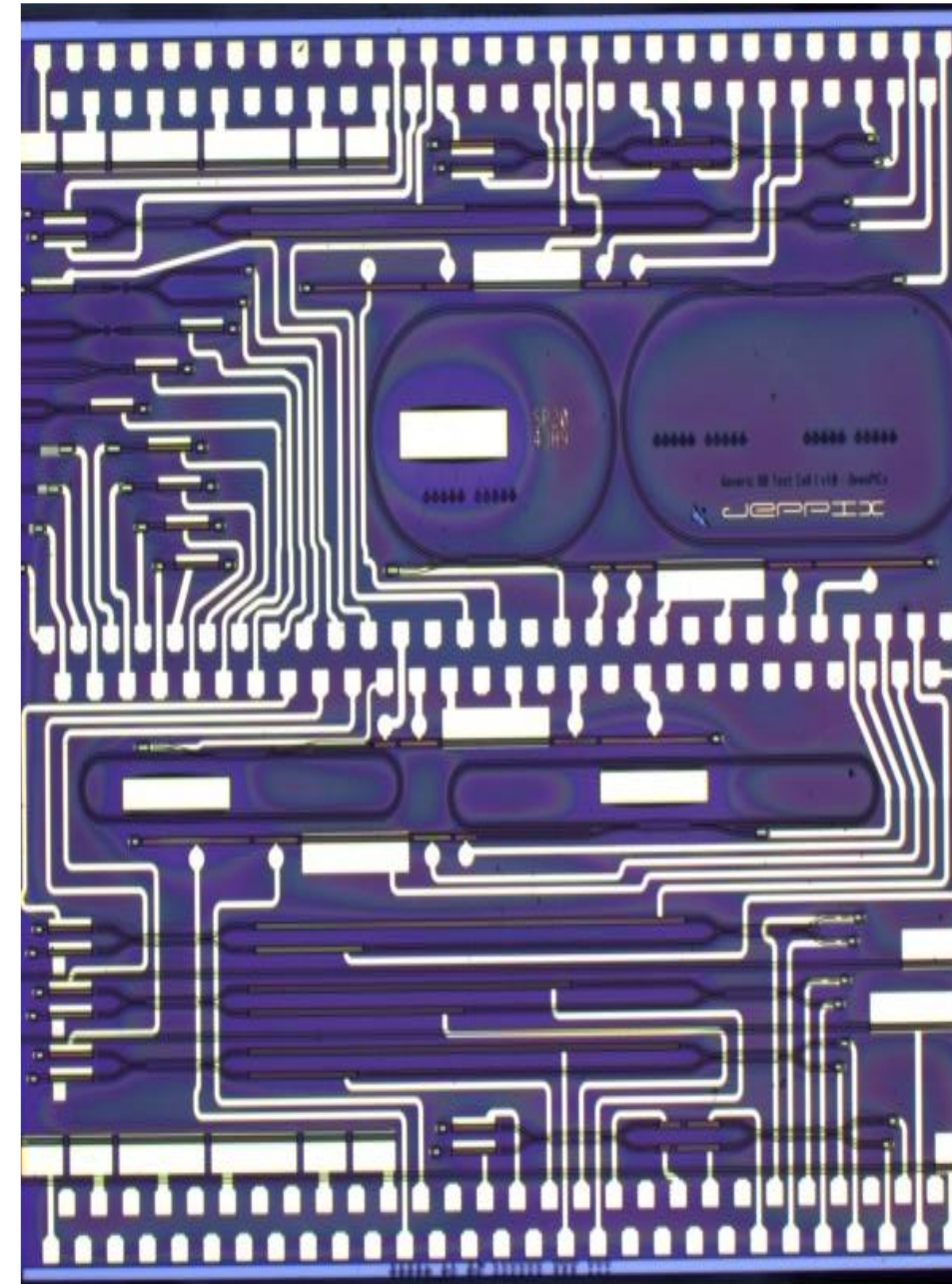
Stefano Aina
Commercial Director
SMART Photonics

22 April, 2021



AGENDA

- Photonic Integrated Circuits (PICs)
- Monolithic Indium-Phosphide (InP) Manufacturing
- Capabilities and Business Models
- Applications for sensors and communications
- Foundry Ecosystem and cooperation across the value chain



INTEGRATED PHOTONICS WILL HELP SOLVE MAJOR SOCIETAL ISSUES

- Photonics = using Integrated Circuits that operate on the basis of light instead of electronics
- Allows strongly improved and completely novel functionalities:
 - Smaller, faster, better performance and lower power
 - Photonic IC's (PIC's) enable major societal advancement



Faster data rates and reduced power consumption



Monitoring of "health" of materials and structures in civil, aerospace ..



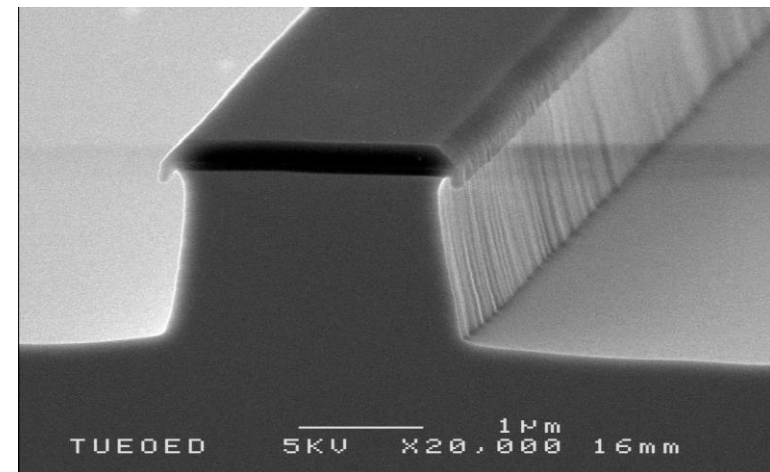
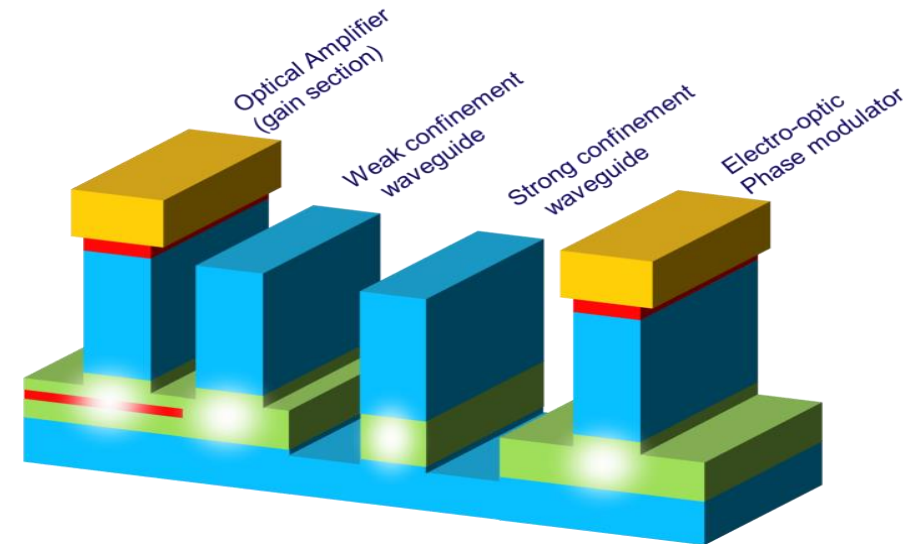
Medical diagnostics: portable and close to patient



Mobility: Autonomous driving
Eye safe LIDAR systems

INDIUM PHOSPHIDE INTEGRATION PLATFORM

- Photonic integration needs actives (lasers, amplifiers) and passive components
 - Light sources and amplification can only be realized in Indium Phosphide (InP)
 - InP Allows Monolithic (on a single IC) integration of all functionalities!
- Integration requires extreme control of multi-steps complex processes



WAFER MANUFACTURING JOURNEY

Layerstack growth

- Multiple layers are deposited on the wafer in a reactor

Definition & etching of waveguides

- Lithography is used to etch circuits on the wafer

Isolation & Passivation

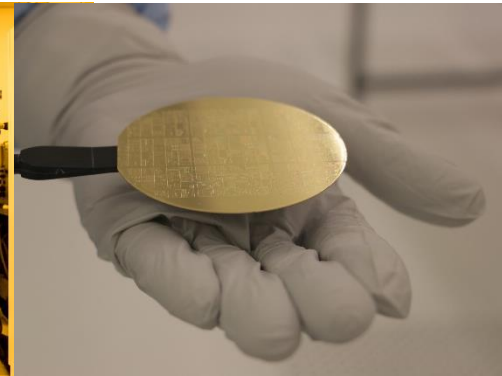
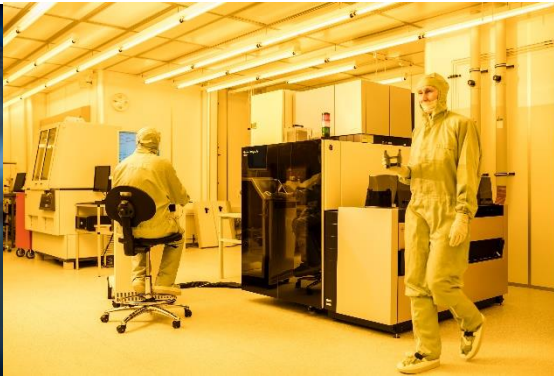
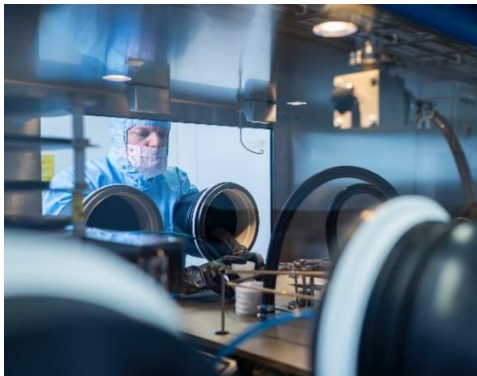
- Additional layers are deposited and etched

Planarization & Metallization

- Contacts are made to connect the circuits

Wafer finishing and dicing

- Wafers are polished, coated and diced into chips



OUR HERITAGE: MADE IN EINDHOVEN



PHILIPS

Early
1980s: start
of activities

First
commercialization
of components

1991

1994

TU/e

Eindhoven University
starts R&D on monolithic
integration

 **JDS Uniphase**

Acquisition by
Uniphase for
€1.2B

1998

2002

NanoLab

Established first
shared facility for
integrated Photonics
prototyping

**SMART
PHOTONICS**

2012: Spin-off as
independent pure-play
foundry

2013

First Multi
Project
Wafer
produced

2017

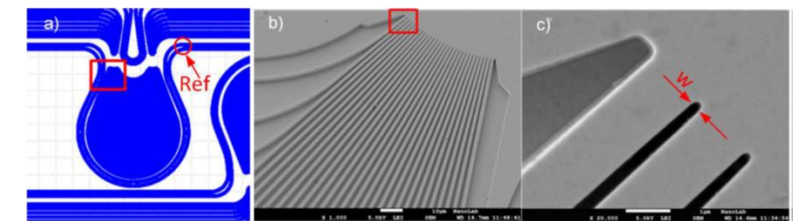
Move to own
cleanroom at
High Tech
Campus

2020

New
Investment
for capacity
ramp up

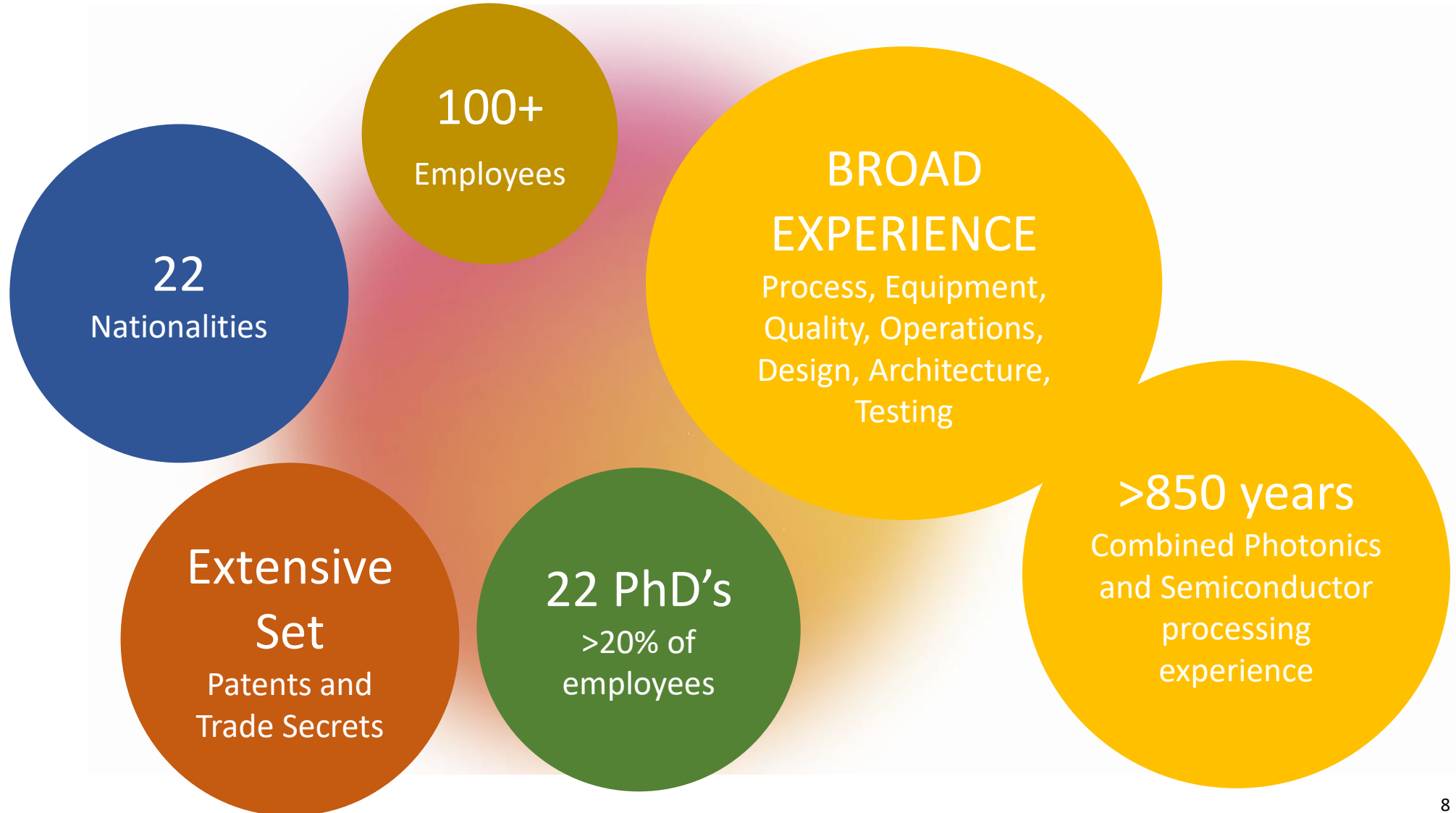
STATE OF THE ART MANUFACTURING FACILITIES

- 1400m² Production facility
 - >1000m² 3" Production cleanroom (Class 1000)
 - Epitaxy growth and Etching
 - Back-end, testing
 - Additional 850m² fully integrated R&D facility at Nano Lab, in Eindhoven University Technology Science Park
- Operating on 3" wafers (equipment ready for 4")
- Unique lithography capabilities allowing extremely precise features definition (90nm)



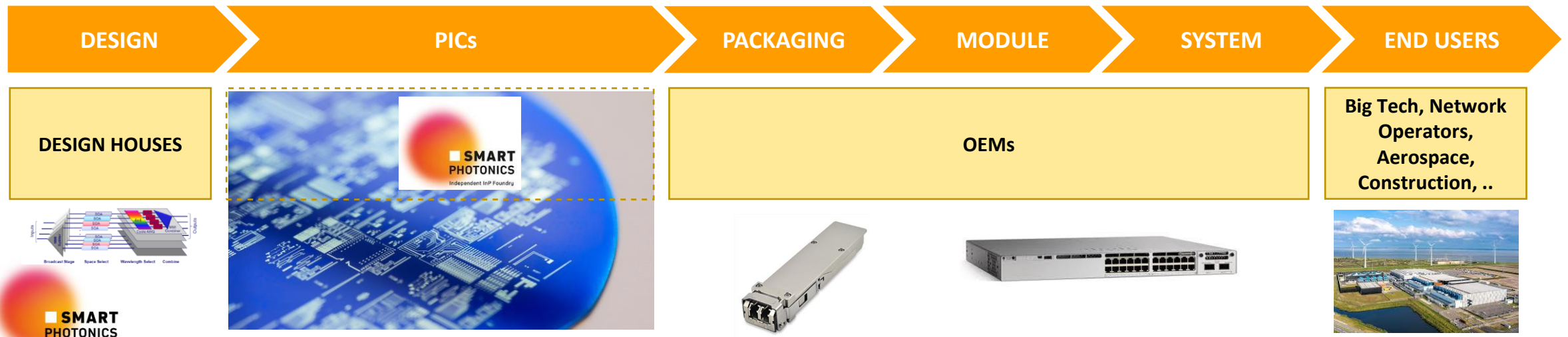
Arrayed Waveguide Grating and details of input arm $W = 300$ nm

SMART PHOTONICS' TEAM: DIVERSE AND HIGHLY EDUCATED



SMART PHOTONICS BUSINESS MODEL

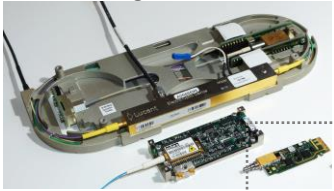
- Open foundry manufacturing services for Indium Phosphide (InP) PICs
- Standardized process based on validated Photonics Development Kit (PDK)
 - Enables customers to design reliably for a broad set of applications
- Support production volumes via dedicated wafers AND fast prototyping via Multi-Project Wafer (MPW) runs, where costs are shared between different users



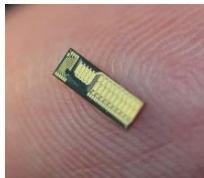
APPLICATIONS FOR SENSORS AND COMMUNICATIONS

Enable 5G

Previous generations:



New generation:



Sensing within Aerospace

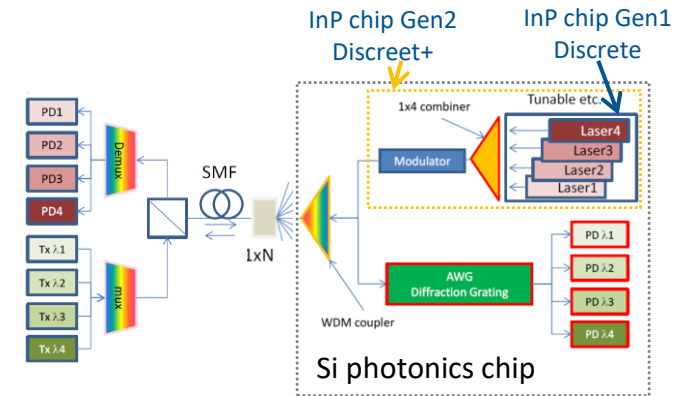
Original:



New:



Enable Fiber to the Home



SMART Solution
 PIC enables tunable laser at cost of discrete laser
 Much smaller with enhanced performance
 Full integration of light sources and modulators
 Route to low-cost high bandwidth >>100Gb/s

SMART Solution:
 Much smaller
 10,000 times more sensitive
 Lower power consumption
 Lower cost
 Full integration allows continuous safety monitoring

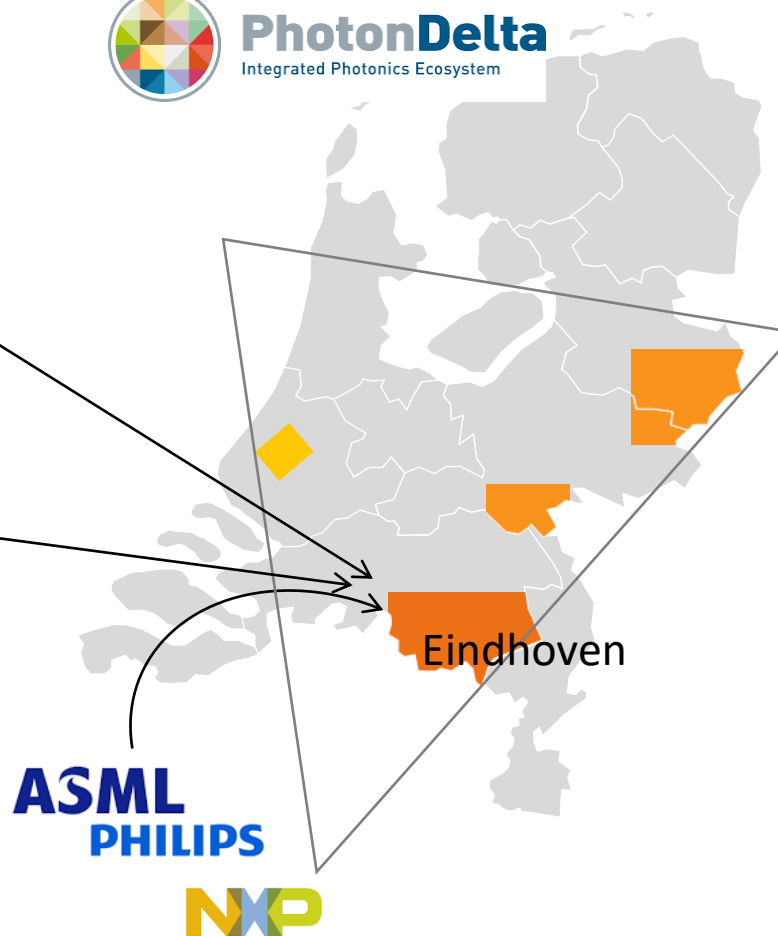
SMART Solution:
 Increased integration
 Reduced power loss

AT THE HEART OF THE DUTCH ECOSYSTEM

High Tech Campus



NanoLab



Eindhoven area



Overijssel / Gelderland area



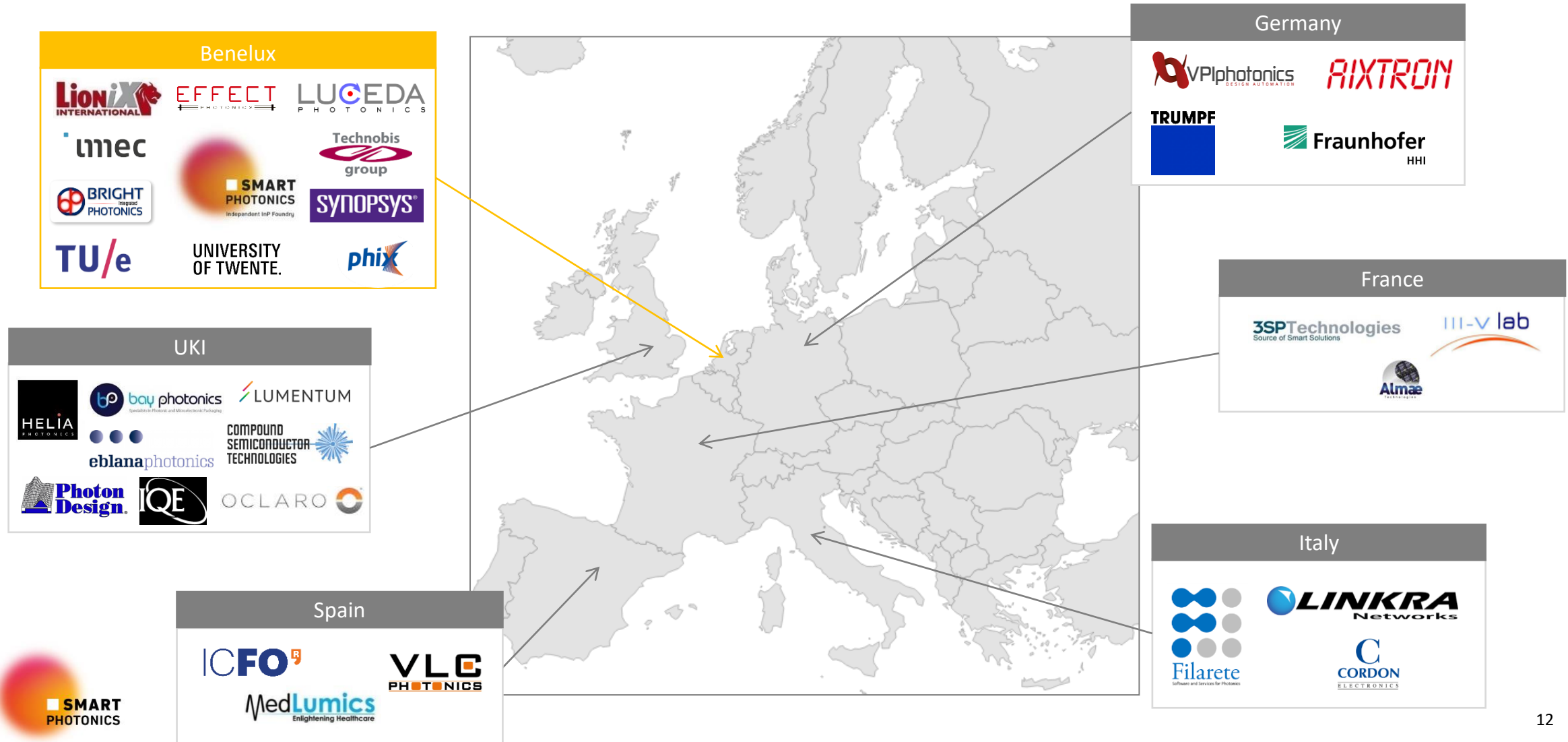
Delft area



Others



AT THE HEART OF PHOTONICS IN EU





**SMART
PHOTONICS**

Independent InP Foundry