

15 November 2022

Next Generation Microchips, Powered By Light

An introduction to the PhotonDelta ecosystem

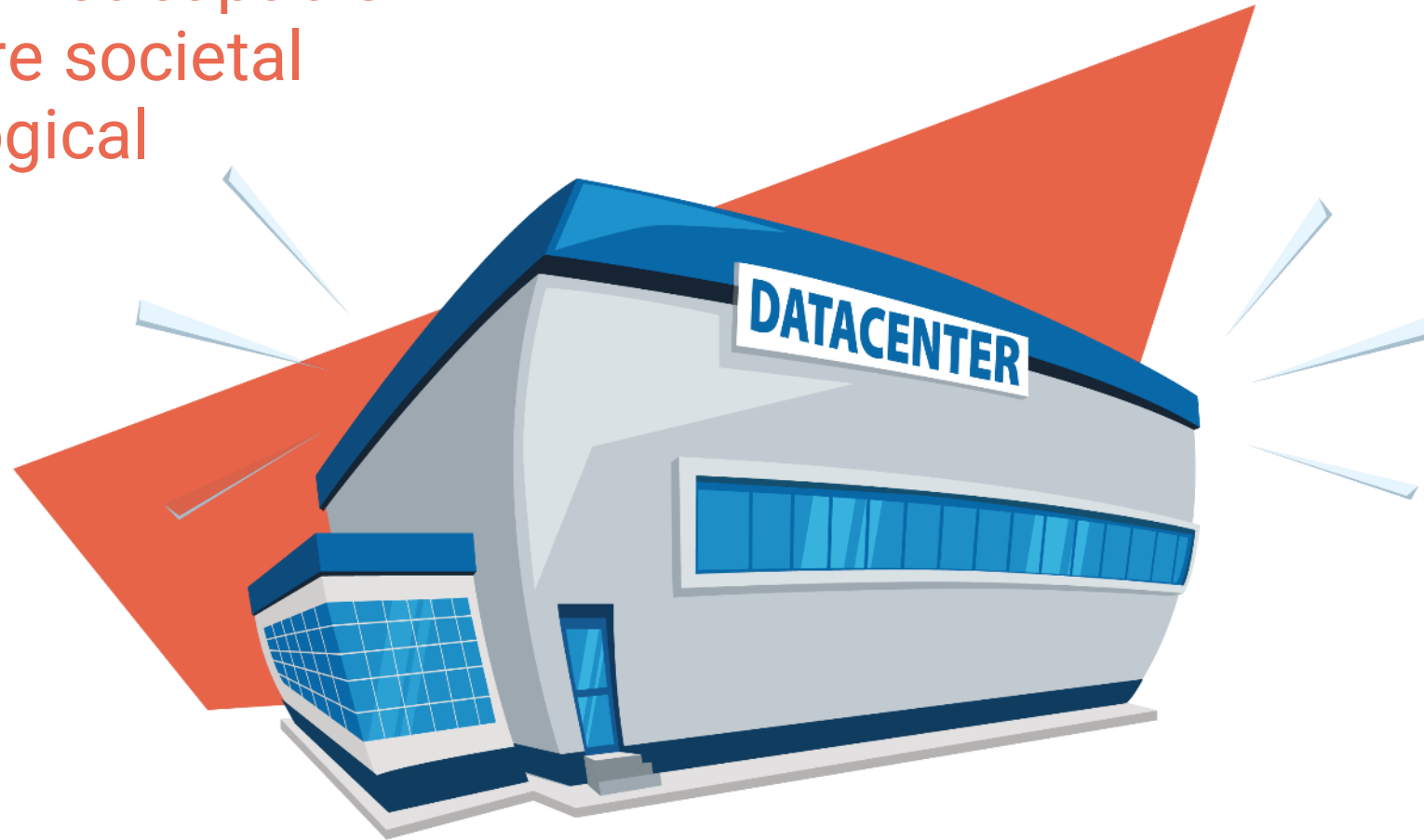
René Penning de Vries
Chairman of the Supervisory Board



We are living in a technological revolution
with continuous generation of data

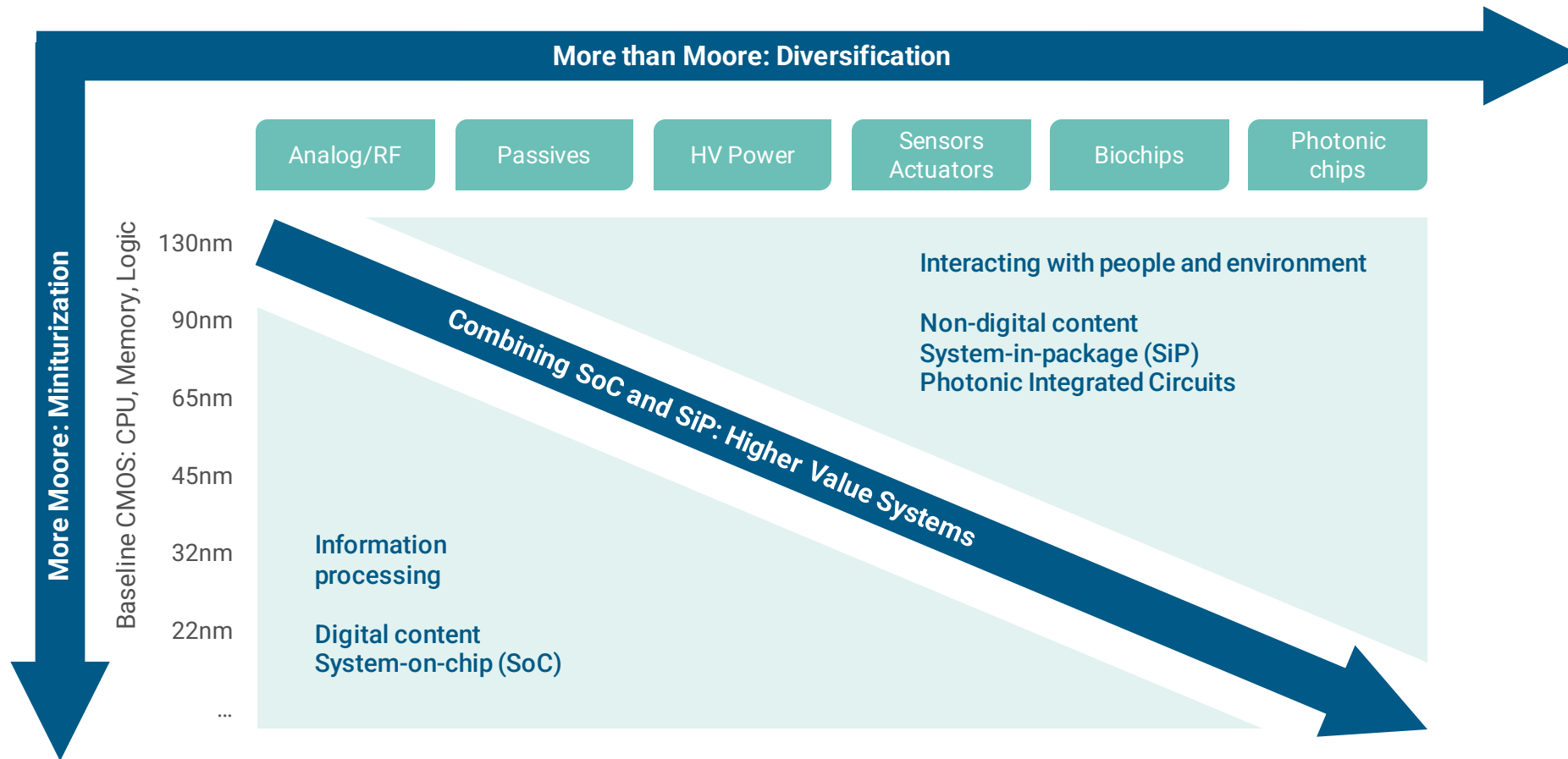


Traditional electronic
solutions are not capable
to meet future societal
and technological
challenges





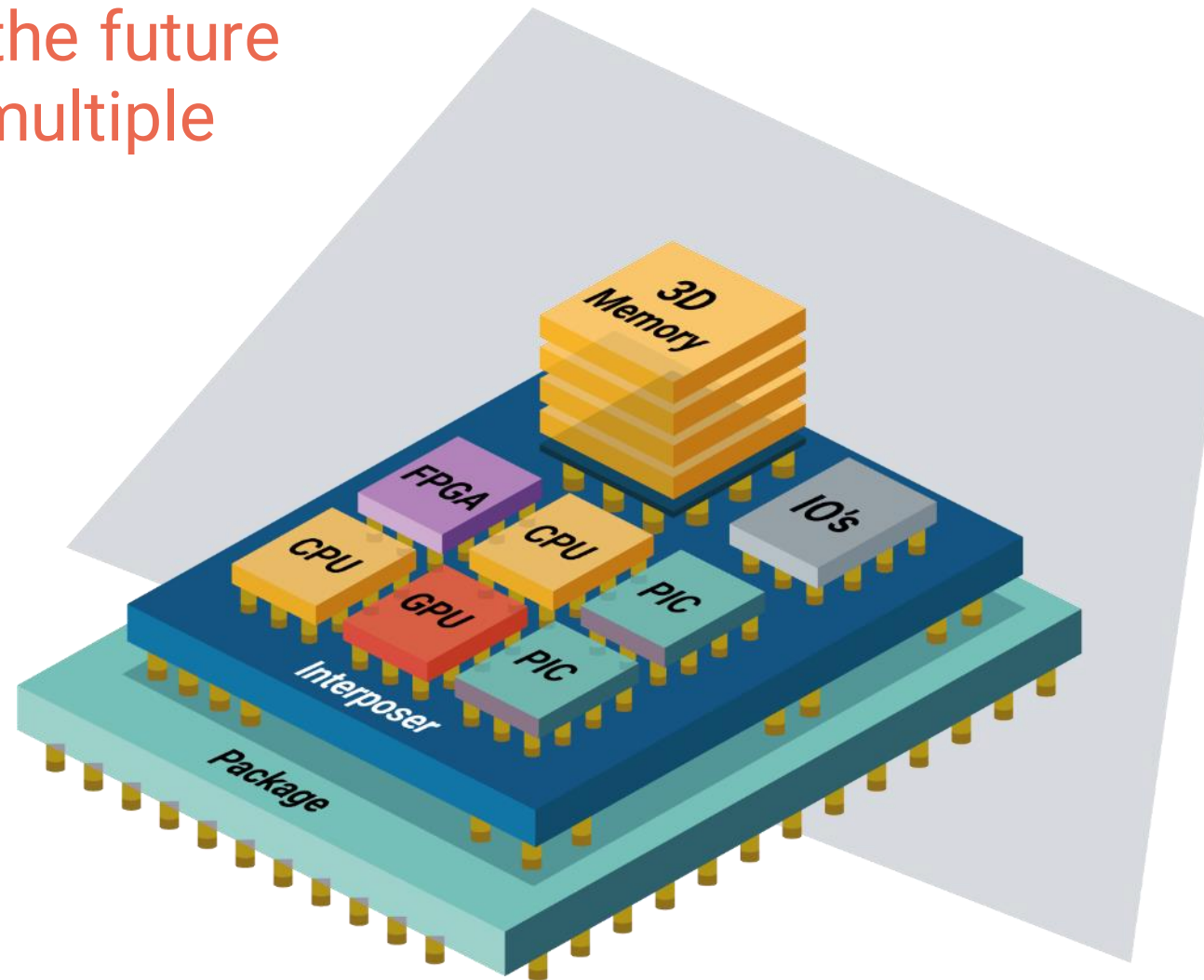
Next-generation chip technology goes beyond CMOS



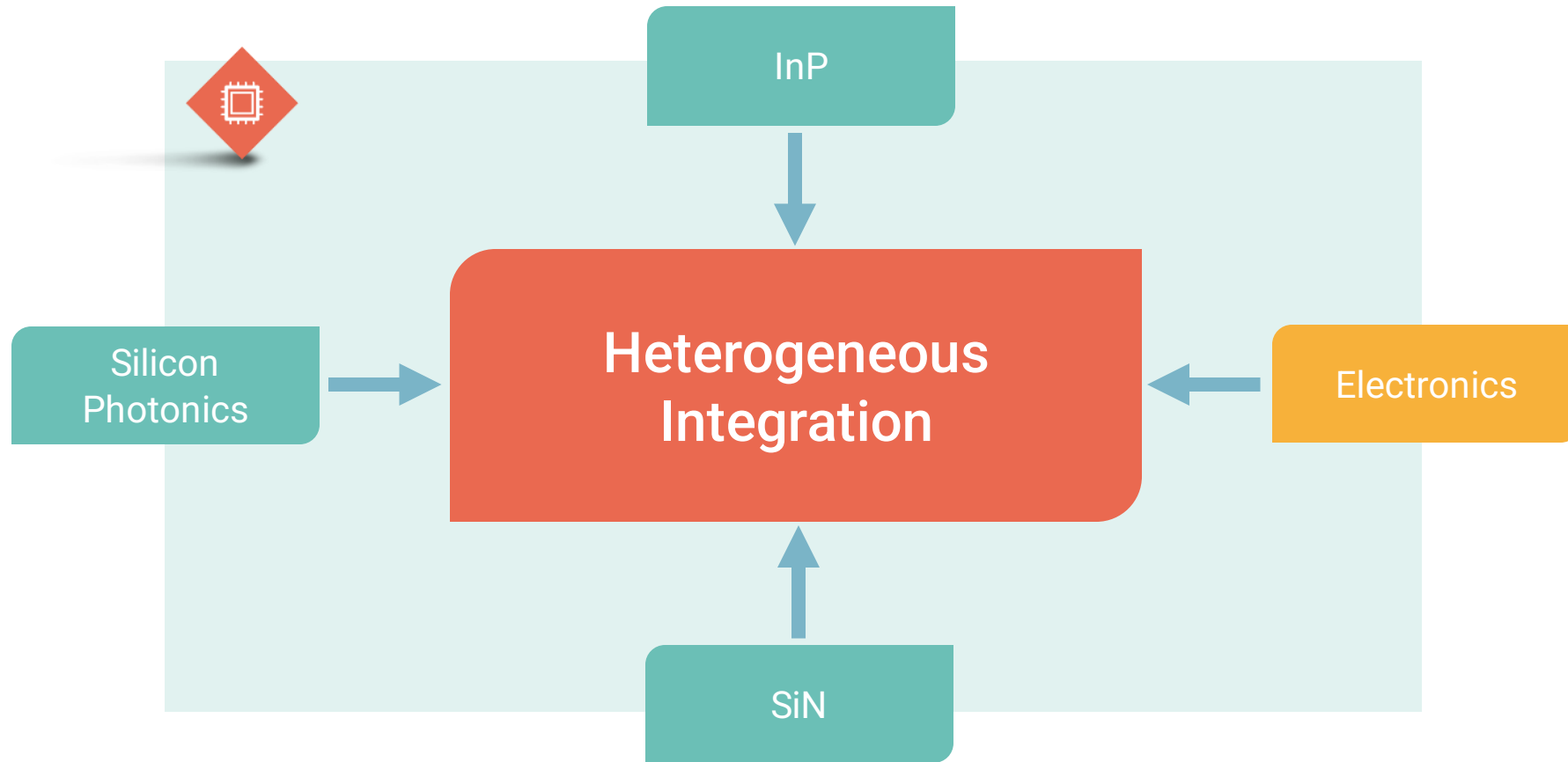


A new era of semicon tech
is on the horizon

The system of the future
will consist of multiple
technologies



Combining platforms: a stronger solution

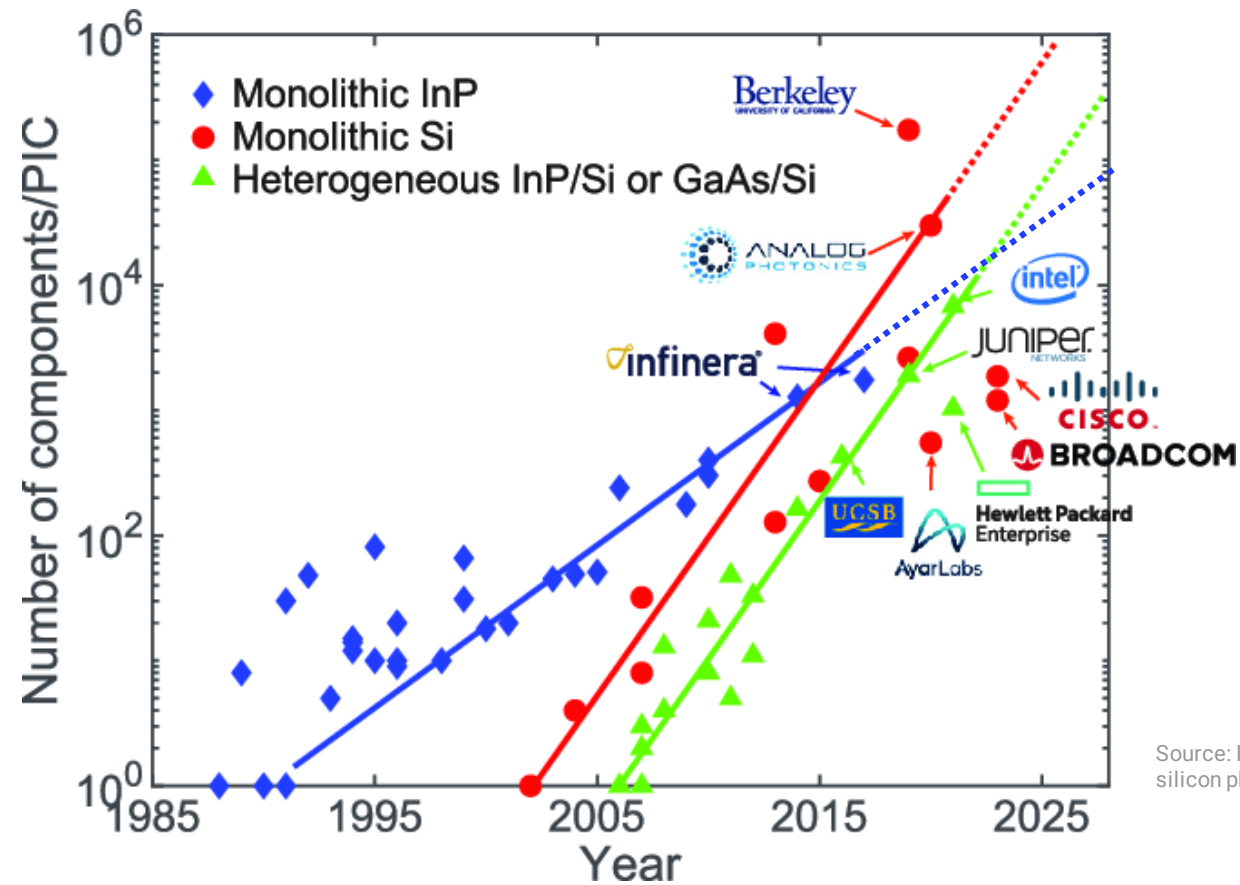


Mass production using wafer-scale method



Copyright EFFECT Photonics

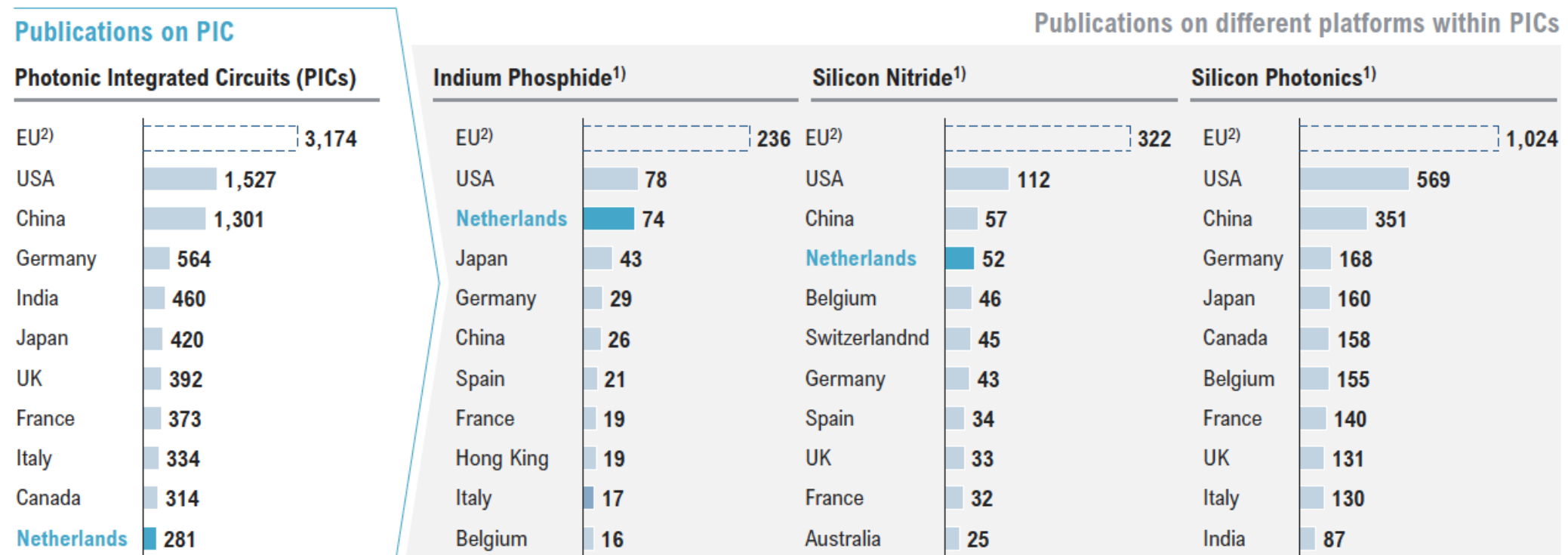
The emerging world of PICs is bound to make a difference



Source: Perspective on the future of silicon photonics and electronics, 2021

EU has built a strong knowledge position in PICs with the Netherlands in top 3 in terms of publications for InP and SiN

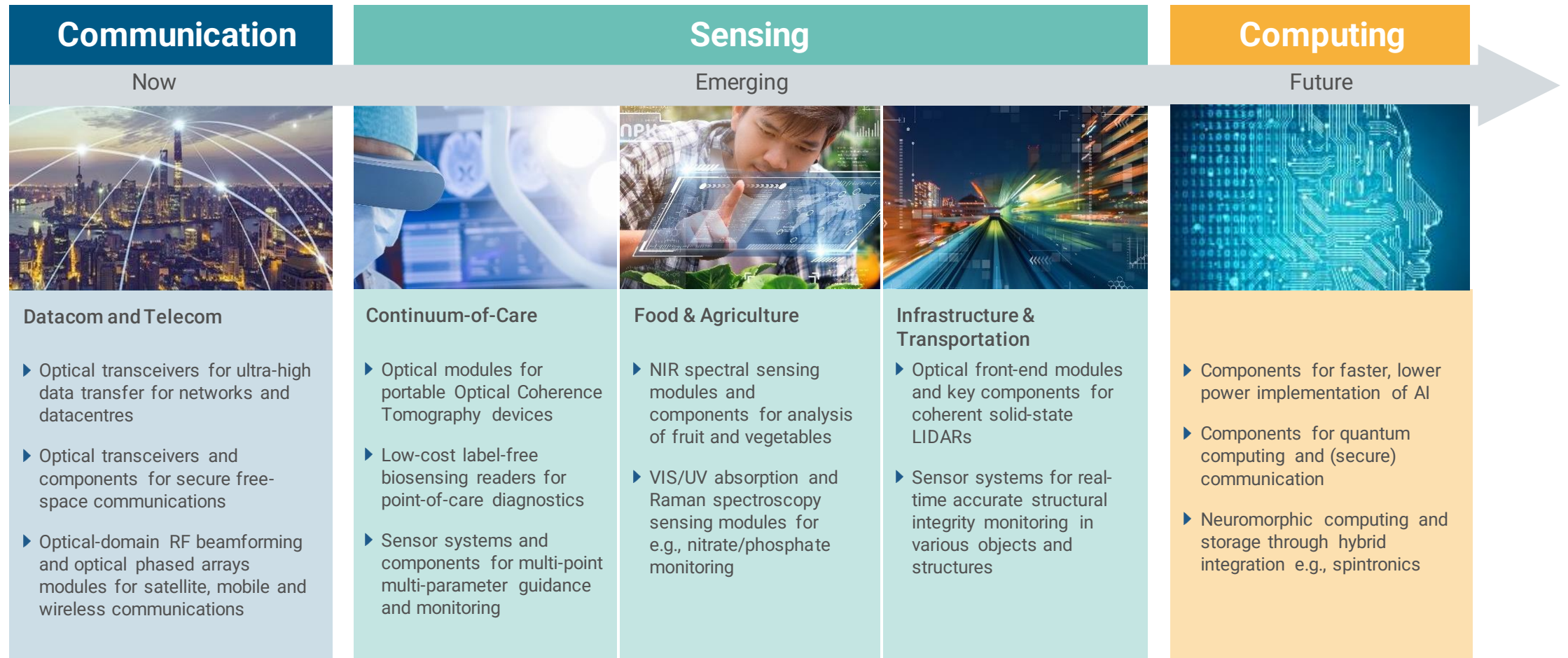
Research position of EU and the Netherlands, 2017 - 2021



1) As keyword within 'photonic integrated circuit' (PICs); 2) Includes countries within European union

Source: Scopus, Roland Berger

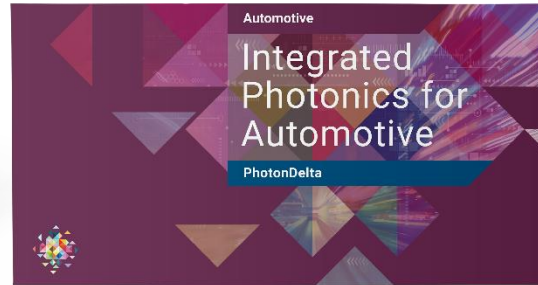
Opening the door to new applications and markets



Curious to discover the possibilities PICs can offer your industry?



Biosensing



Automotive



Global



Agrifood



Data/telecom

On a 6" wafer platform, the market demand for InP PIC wafers in mid-terms grows to about 70-100k wafers in 2030

InP PIC global demand from specialized foundry, 2022-2040 [# of InP kwafers/annum¹⁾]

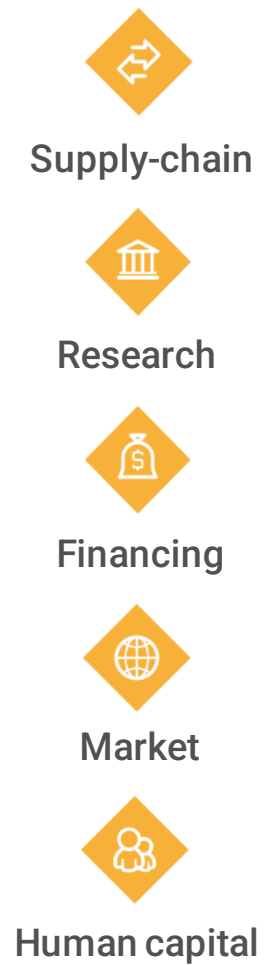


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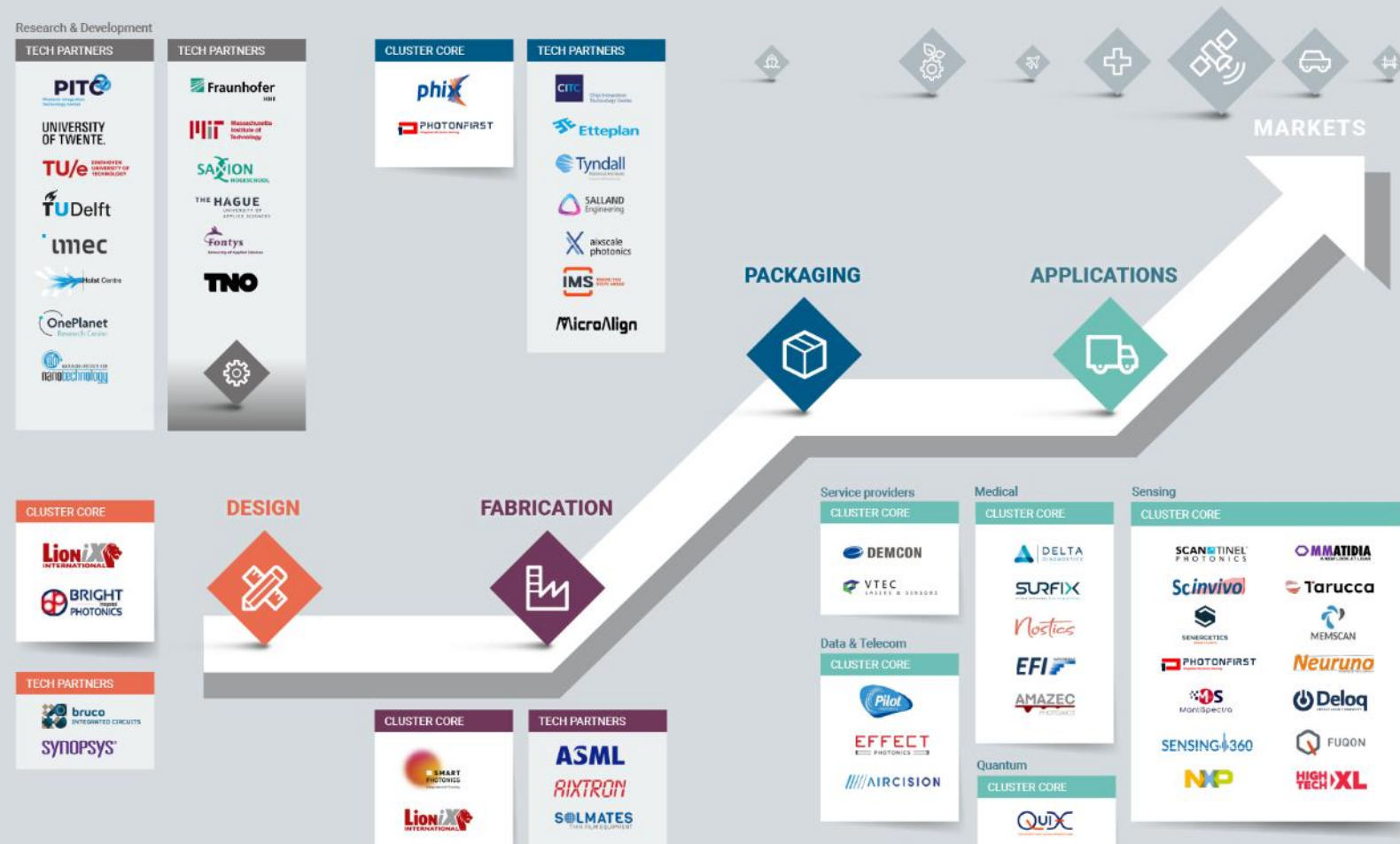
- ▶ The total market demand for InP PIC wafers is estimated in the previous sections in different scenarios of growth and integration
- ▶ It is assumed that InP will develop further on 6 inch wafer platform
- ▶ The estimated size of InP PIC is 10 sq. mm based on expert interviews

1) 4" wafer with a yield of 800 chips and 6" wafer with a yield of 1600 chips. On average a complex PIC has a yield of 200 chips per 4" and a simple PIC has a yield of 1400 chips per wafer. Hence an average of 800 chips per 4" wafer is assumed.

PhotonDelta is an ecosystem for integrated photonics



We design, develop and manufacture innovative solutions with PIC technology



The strategy is built upon three core pillars



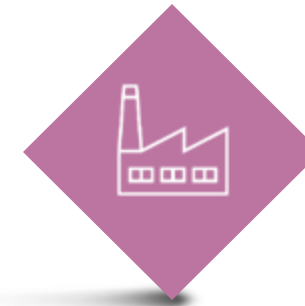
Ecosystem development

- a. Talent programme
- b. Startup support
- c. Shared innovation facilities
- d. Internationalisation
- e. Programme management



Application technology

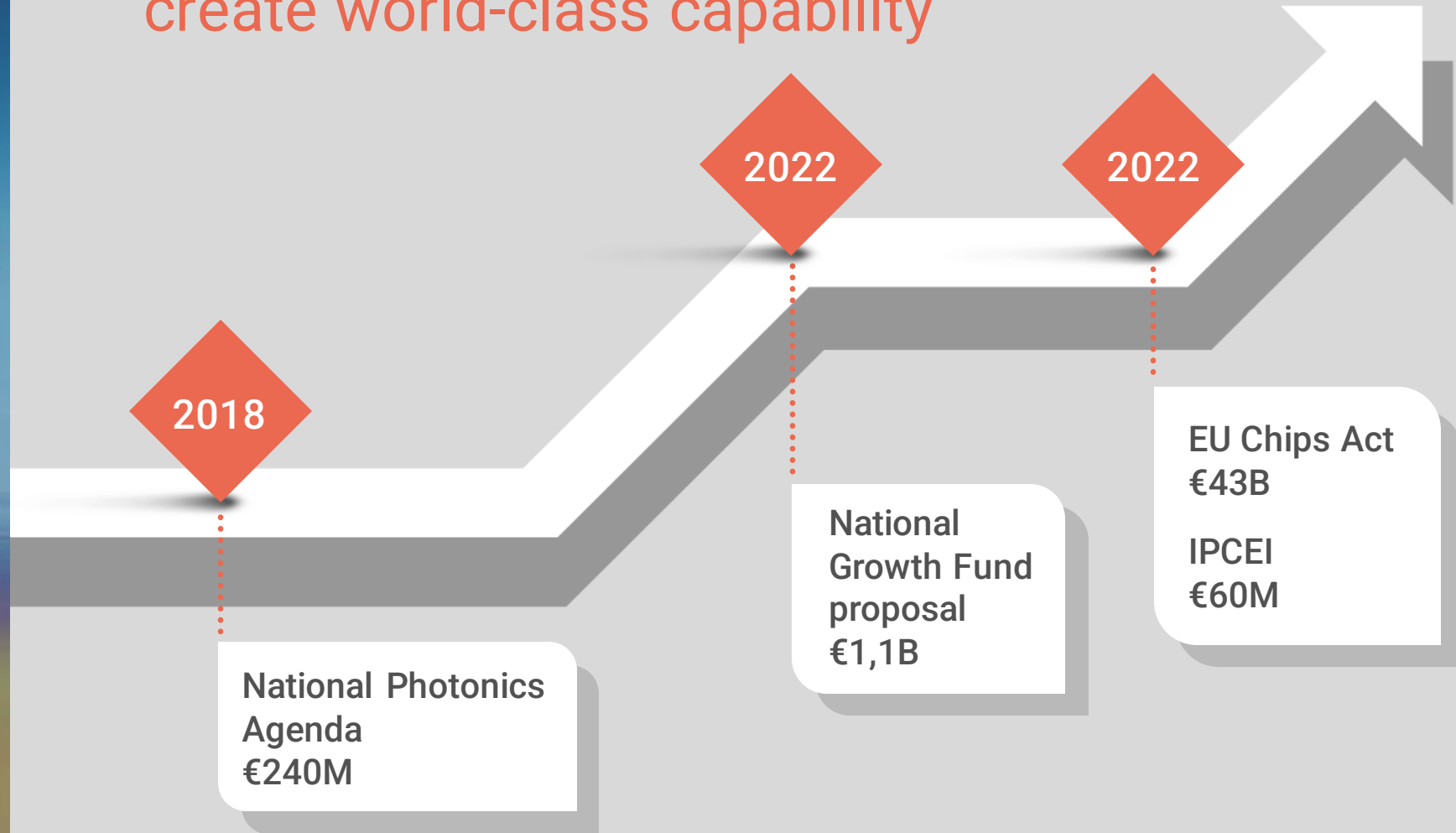
- a. Design library
- b. Functional optimisation & combination



Industrialisation & scaling

- a. Hybrid integration
- b. Process optimisation
- c. Scalability

Strong Dutch & European support to create world-class capability



1. Research & development

The background features a dark blue gradient with horizontal light streaks in shades of cyan and green. On the right side, there is a complex geometric pattern composed of various triangles and diamonds in shades of blue, green, and purple, creating a crystalline or molecular structure.

1. Research & development

Our partners include knowledge institutes and universities whose pioneering research fuels our entire ecosystem and keeps us at the forefront of integrated photonics.

This pipeline of innovation is essential for the competitive strength of our ecosystem by continuously developing



SiN chip fabrication @ MESA+ Universiteit Twente



InP chip fabrication @ Nanolab TUE



Chip integration @ TNO Eindhoven/Nijmegen

Partners in R&D

TNO

MIT Massachusetts Institute of Technology

TU Delft

Fraunhofer
HHI

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

UNIVERSITY OF TWENTE.

imec

Holst Centre
Financed by IMEC & TNO

OnePlanet
Research Center

WATERLOO INSTITUTE FOR nanotechnology

Fontys
University of Applied Sciences

SAXION
HOGESCHOOL

THE HAGUE
UNIVERSITY OF APPLIED SCIENCES

PITC
Photonic Integration Technology Center

PhotonDelta Gateway to Integrated Photonics

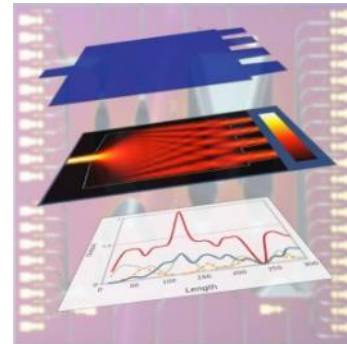
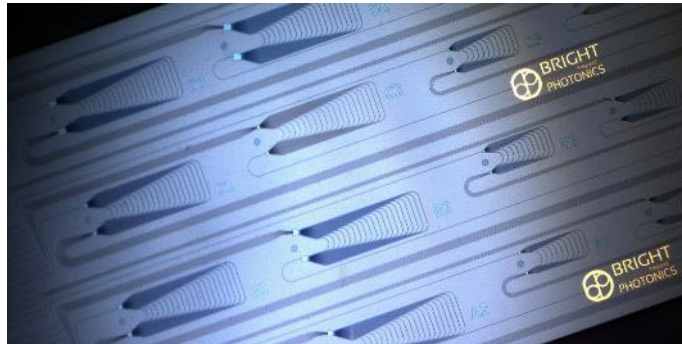
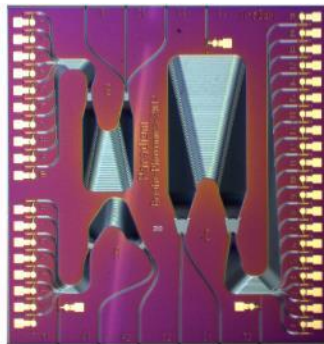
2. Chip design & testing

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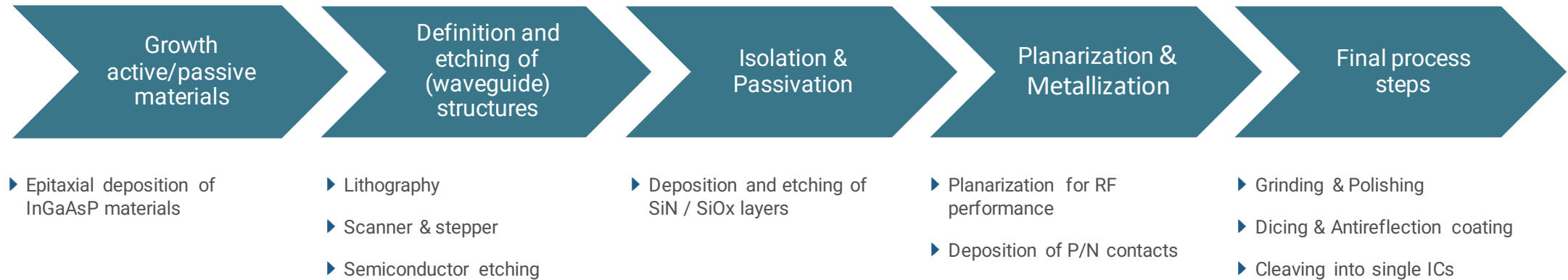
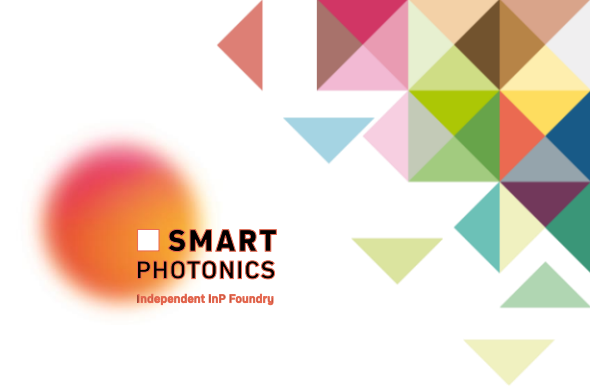
Designing PICs means balancing between customer specifications and production protocols of the foundry.

The PhotonDelta ecosystem works together to develop a world-class design library with predefined and tested building blocks to reduce design costs and speed up the process.

Partners in design



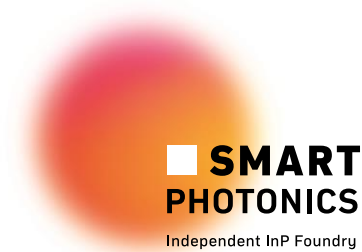
Generic process and PDK



Proprietary & Confidential

3. Manufacturing & prototyping

3. Manufacturing & prototyping



Indium Phosphide (InP)

- ▶ Pure-play foundry
- ▶ Discrete components
 - Single high-end components
 - Connected to passive photonic devices
- ▶ Discrete + components
 - Combines several discrete components onto one chip
 - Facilitates Si Photonics integration
- ▶ Indium Phosphide PICs
- ▶ Multi Project Wafer runs (MPW)

Silicon Nitride (SiN)

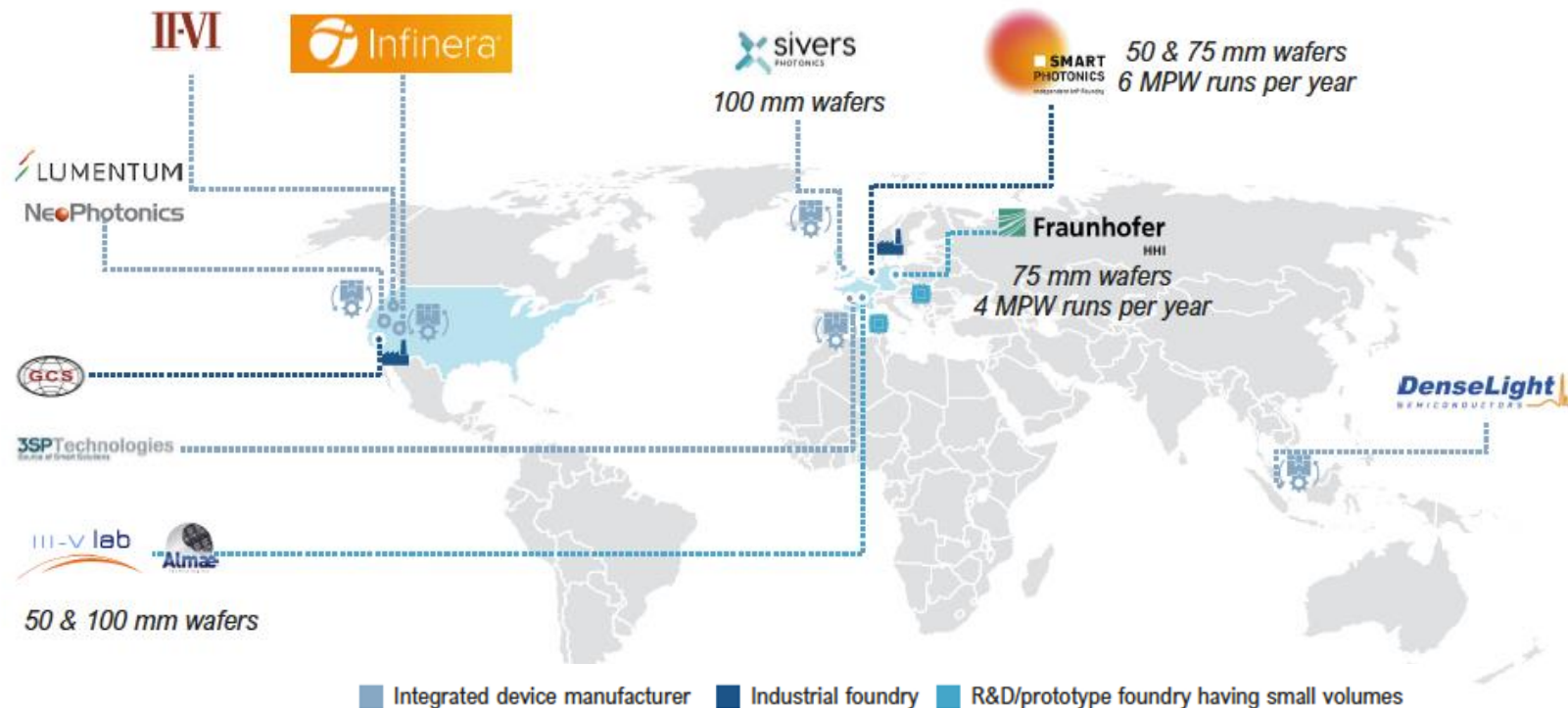
- ▶ Integrated photonics
 - Low loss TriPleX™ waveguide (silicon nitride)
 - Operates from 405nm to 2350nm
 - Waveguide tapering for mode optimization
 - Hybrid assembly with semiconductor material
 - Assembly & packaging into PIC module
- ▶ Customized MEMs
- ▶ (Opto) Fluidics

Silicon Photonics (SiPh)

- ▶ Pilot Line
- ▶ Integrated photonics
 - 1310nm/1550nm Wavelengths
 - Low-loss Passive Silicon Waveguide Devices and Fiber Coupling Structures
 - 56Gb/s+ (Ge)Si Modulators and Ge(Si) Photodetectors
- ▶ Silicon compatible (PECVD)
- ▶ Low loss platform (< 0.1dB/cm)

There are a few InP open access foundries like Smart Photonics – Majority of production is through integrated device manufacturers

InP PIC foundries worldwide



Comment

- ▶ Majority of the InP PIC production is currently through integrated device manufacturers (IDM) such as Lumentum and Infinera
- ▶ These IDM manufacture relatively simple PICs with 2 or 3 components
- ▶ Within Europe, HHI and III-V labs offers open access foundries for pilot/prototype production line

1) O-band refers to the wavelength range 1260-1360 nm, C-band refers to the wavelength range 1530-1565 nm and L-band refers to the wavelength 1575-1610 nm

Source: Company websites, Jeppix roadmap 2021-2025, Roland Berger

There is a need to
manufacture strategic
technologies in Europe



4. Packaging & assembly

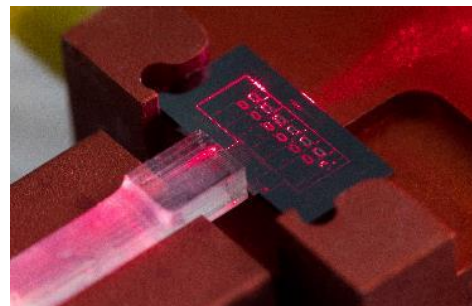
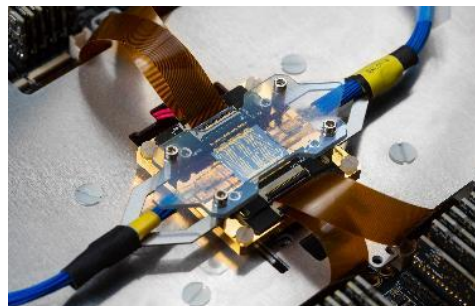
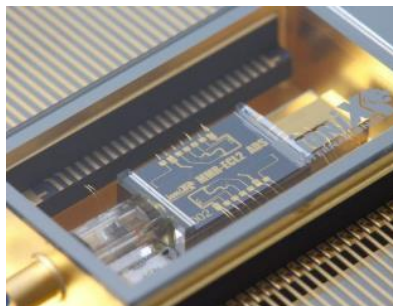
The background is a deep blue gradient. In the upper right corner, there is a cluster of overlapping triangles in various shades of blue, teal, and purple. Several bright, horizontal light streaks in shades of cyan and white cut across the lower half of the image, creating a sense of motion and depth.

4. Packaging & assembly

PICs are packaged for protection and mounting on a printed circuit board. Photonic chips and electronic chips can be combined in a hybrid module, leveraging the benefits of multiple production platforms.

Services include:

- ▶ Prototype packaging
- ▶ Volume packaging
- ▶ Contract manufacturing
- ▶ Fiber arrays
- ▶ Spot size converting fiber arrays
- ▶ Lensed fiber arrays



Partners in packaging



MicroAlign



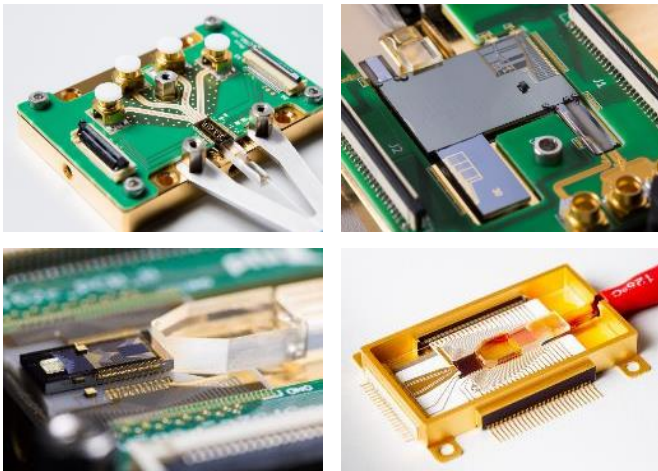
Chip Integration
Technology Center

PhotonDelta Gateway to
Integrated Photonics

Showcases

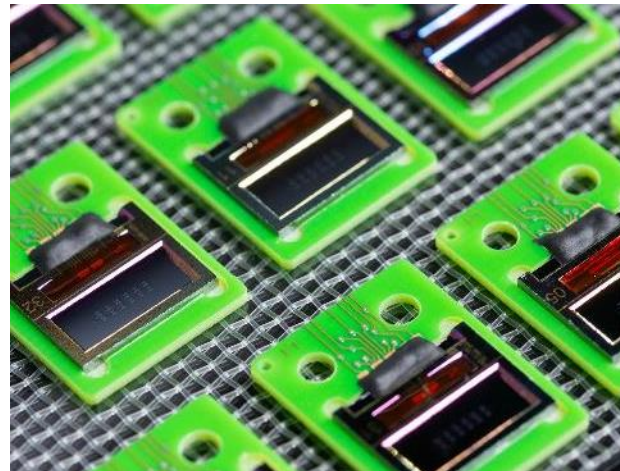
Examples of PIC modules

- ▶ Hybrid assembly of various PIC platforms (SiN, InP, and others)
- ▶ DC and high-speed RF electrical interfacing
- ▶ Mode field matching optical interfacing

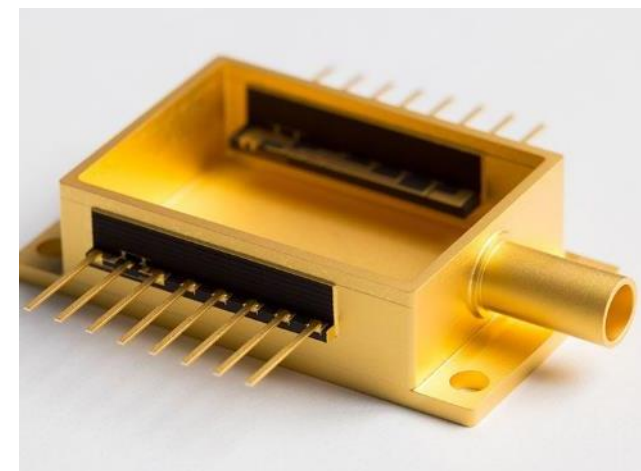


Biosensor application

- ▶ Label-free refractive index sensing
- ▶ Multiple MRR and/or MZI sensor arrays
- ▶ Flip chip assembly of VCSELs and detector arrays



Tunable laser application





To succeed, we need to collaborate

Europe has a strong position in PIC technology that can be leveraged

- ▶ The technology and supply-chain are both maturing
- ▶ Extra functionalities are an opportunity for traditional semiconductor technology
- ▶ Applications are in development with volume markets in sight
- ▶ Opportunity for strategic autonomy in Europe

Need to collaborate with mature semicon industry for scaling

- ▶ Building up the PDK library with world-class building blocks
- ▶ Facilitated access to PIC foundries, from prototyping to volume production
- ▶ Funding opportunities within the Dutch National Growth Fund (NGF)



Tomorrow starts today. Let's collaborate.

Meet us at stand # C1329