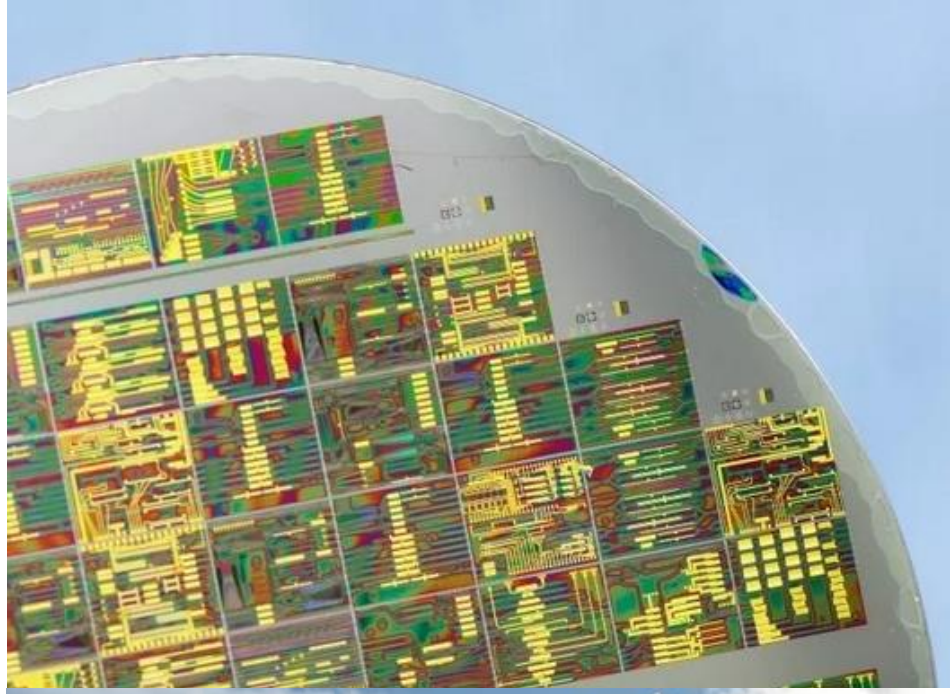
PhotonDelta

Gateway to Integrated Photonics



PhotonDelta integrated photonics ecosystem & integrated modules in space

Ewit Roos

Chief Executive Officer

PhotonDelta

Integrated Photonics: Highly promising key enabling technology…

PHOTONICS

- Technology for light generation, manipulation and detection functions
- Used in sensors, actuators and communication transceivers
- Deployed to-date mostly via discrete dedicated single-function components (e.g. lasers) and bulk optics

INTEGRATED PHOTONICS

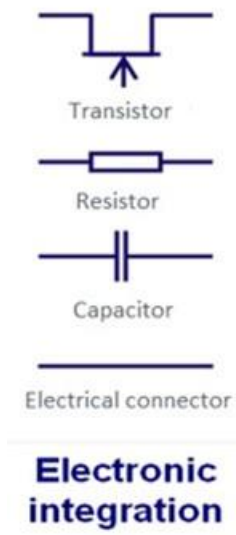
- Integration of multiple photonics functions on single Photonic Integrated Circuits (PIC) fabricated using automated wafer-scale generic integration technology over silicon, silica or InP substrates

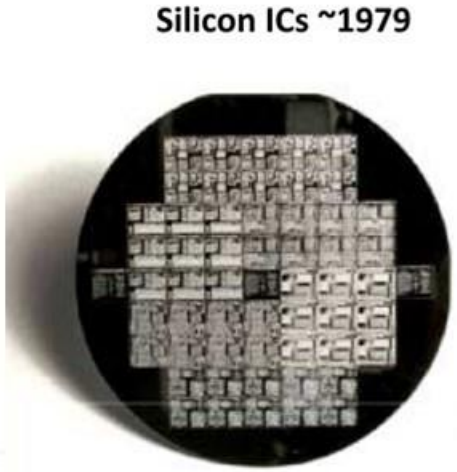
IMPACT

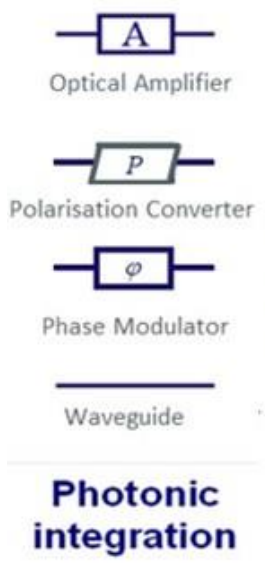
- Comparable to the impact semiconductors made on electronics

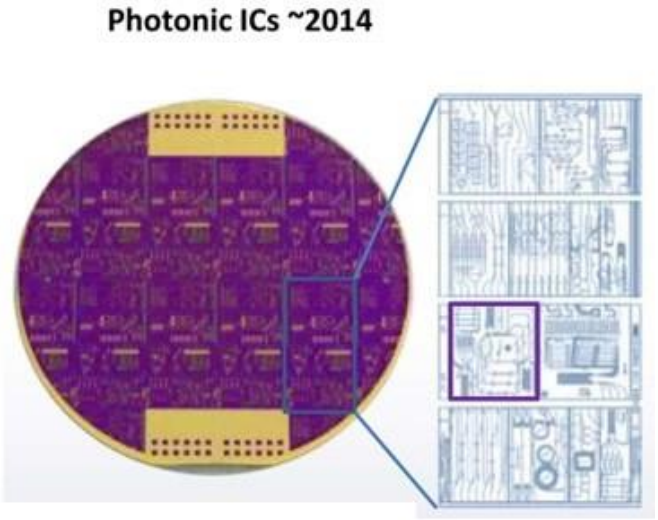
- Dramatic reduction of
  - size and weight
  - Power consumption
  - Manufacturing and Product cost
- Improved
  - thermal/vibration stability
  - reliability
- Intrinsic immunity to Electro-Magnetic Interference and Radio Frequency Interference

Enormous potential for innovative disruptive applications and solutions in many markets

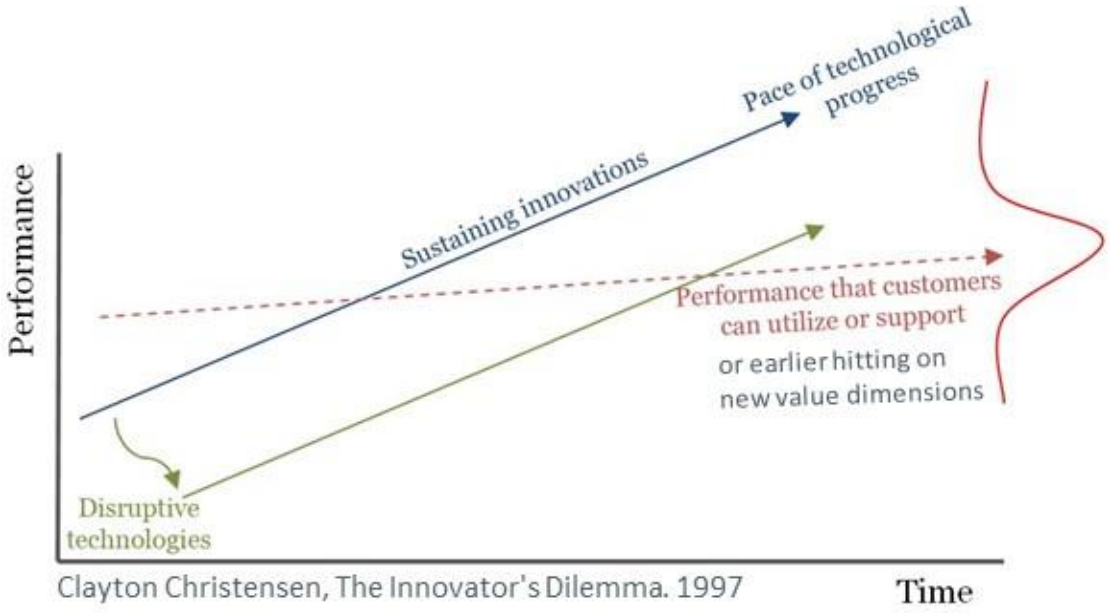








…enabling disruptive solutions in multiple markets



Clayton Christensen, The Innovator's Dilemma. 1997

Disruptive Solutions Paradigm Shift

	From	To
Sensors/ Communication Devices	▶ Expensive ▶ Large ▶ Complex	▶ Affordable ▶ Small ▶ Simple
Use	▶ Expert	▶ Trained personnel ▶ Consumers
Setting	▶ Centralized, dedicated facilities	▶ In the field ▶ At home/on-the-move
Volumes	▶ Small	▶ Large


Communication


Medical devices and Life Sciences


Infrastructure and Transportation


Food and Agriculture

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Monolithic InP-based and hybrid-SiN-based photonics integration

Strong technology platforms built up within PhotonDelta thanks to continued research, design, development and manufacturing activities over the last 25 years

InP excels at **light generation, amplification, modulation and detection** in the **NIR** wavelength range (1310, 1550nm) in basically any performance metric e.g. power handling, electro-optics efficiency, modulation speeds, detection efficiency, thermal efficiency as such enabling effective monolithically integrated PICs in this range.

SiN excels at passive **light processing** in the **visible, NIR and IR range** thanks to its **very low channel attenuation** (<0.1dB/cm)

Scalable hybrid integration of SiN with active waveguides such as **InP**, GaNi, GaAs respectively allows for system-in-package photonics solutions in the NIR (1550, 1310nm) and IR (1050nm, 850nm) range

InP photonic circuits using generic integration [Invited]

K. A. Williams,* E. A. J. M. Bente, D. Heiss, Y. Jiao, K. Ławniczuk, X. J. M. Leijtens, J. J. G. M. van der Tol, and M. K. Smit

COBRA Research Institute, Eindhoven University of Technology, P.O. Box 513, Eindhoven 5600MB, The Netherlands

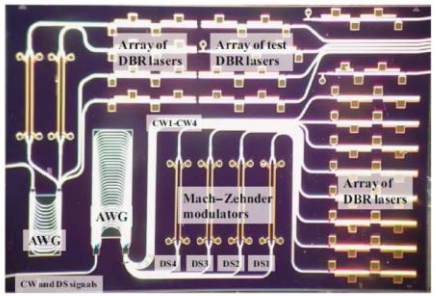

Fig. 1. Multiwavelength transmitter created from Bragg reflectors, optical amplifiers, phase modulators, and interferometers [12].

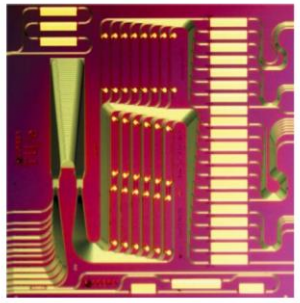

Fig. 2. Pulse compressor using on-chip gain and phase control to manipulate individual Fourier lines in the optical pulse spectrum [13].

TriPleX™ platform technology for photonic integration: applications from UV through NIR to IR

A. Leinse#, R.G. Heideman#, E.J. Klein*, R. Dekker*, C.G.H. Roeloffzen^, D.A.I. Marpaung^
LioniX bv, P.O. Box 456, 7500 AH, Enschede, The Netherlands; * XiO Photonics, PO Box 1254, 7500 BG Enschede, The Netherlands; ^ University of Twente, Faculty of Electrical Engineering, Mathematics and Computer Science, Telecommunication Engineering Group, P.O. Box 217, 7500 AE Enschede, The Netherlands

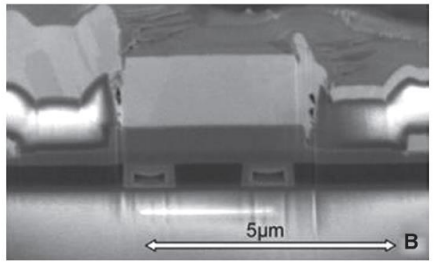

Figure 7: Concept of TriPleX integration with SOI and III/V: schematic view (A) and SEM micrograph of integration cross section (B) [57].

Flip-Chip Integration of InP and SiN

M. Theurer, M. Moehrle, A. Sigmund, K.-O. Velthaus, R.M. Oldenbeuving, L. Wevers, F.M. Postma, R. Mateman, F. Schreuder, D. Geskus, K. Wörhoff, R. Dekker, R.G. Heideman and M. Schell

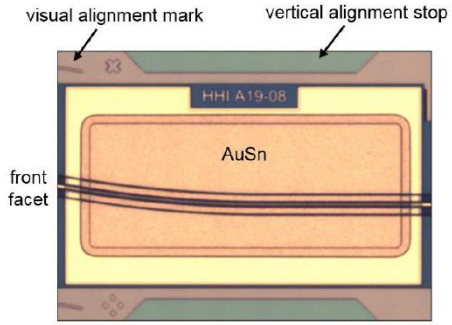

Fig. 1. Microscopic top view of the processed flip-chip DFB laser.

TriPleX™ patented proprietary Si^3N^4 platform

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PhotonDelta: gateway to integrated photonics

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Gateway to Integrated Photonics

integrated ecosystem for the **design**, **development**, **manufacturing** of **customized PICs** and PICs-based **modules/subsystems**
in the **MIR** (1550nm, 1310nm) and **IR** (850, 1050nm) ranges
leveraging **InP** or **hybrid SiN-based** proprietary **technology platforms**
(ie process technology, building blocks, assembly/packaging)

- InP
- Hybrid SiN-based

Research
TU/e · University of Twente. · SAXION

Small-volume foundries
NanoLab@TU/e · nanoPHAB The NanoPhotonics Foundry · MESA+ NANOLAB

PIC large-volume Foundries
SMART PHOTONICS · KAIST KANC Korea Advanced Nano Fab Center

PIC and/or PIC-based modules ODMers
PRODRIVE TECHNOLOGIES · VTEC LASERS & SENSORS · LIONIX INTERNATIONAL

PIC-based modules/ subsystems vendors
Technobis · tft-fos · EFFECT PHOTONICS

Technology Institutes
Packaging: CITC
Applications: TNO
Equipment Manufacturing: FRAUNHOFER PROJECT CENTER

Design/Engineering Houses
BRIGHT Ideas PHOTONICS · Photonic Integration Technology Centre

Assembly/Packaging Large volume Foundries
phix · Tipps BACK-END Foundry

Strong acting together…

As a verticalized ecosystem enabling **leading equipment manufacturers** and **high-potential scale-ups** to **effectively** and **timely** bring to market **innovative scalable solutions** powered by our disruptive customized **Photonics Integrated Circuits and Modules**

…while nurturing individual strenghts

Each ecosystem company offering own **services** and **products** under an **open-access pure-play** model

PhotonDelta ecosystem full framework

Co-operation with relevant initiatives and players around our ecosystem
Support from relevant national business development organizations

PhotonDelta Mission

Create an ecosystem of application-, design-, supply chain and knowledge institutes

Application driven companies with innovate products based on Integrated Photonics

Production Foundries with leading technology focused on both front-end and back-end

Design houses that serve customers of the ecosystem with design of applications and all elements therein (PIC, packaging etc.)

Equipment manufactures with state-of-the-art equipment for both front- & back-end production and testing

Knowledge Institutes who develop new generations building blocks, elements and production processes and train future photonics talent

Impact / Ambition

>25 companies in integrated photonics with a total annual revenue of **EUR 1 mld**

Direct employment of **~4k FTE** within integrated photonics and a multitude of connected indirect employment

Dutch focused business growth resulting from our photonics applications with an incremental effect on the entire value chain

Output serves the public interest, such as energy saving, limiting healthcare costs and improving the competitive position of the Netherlands

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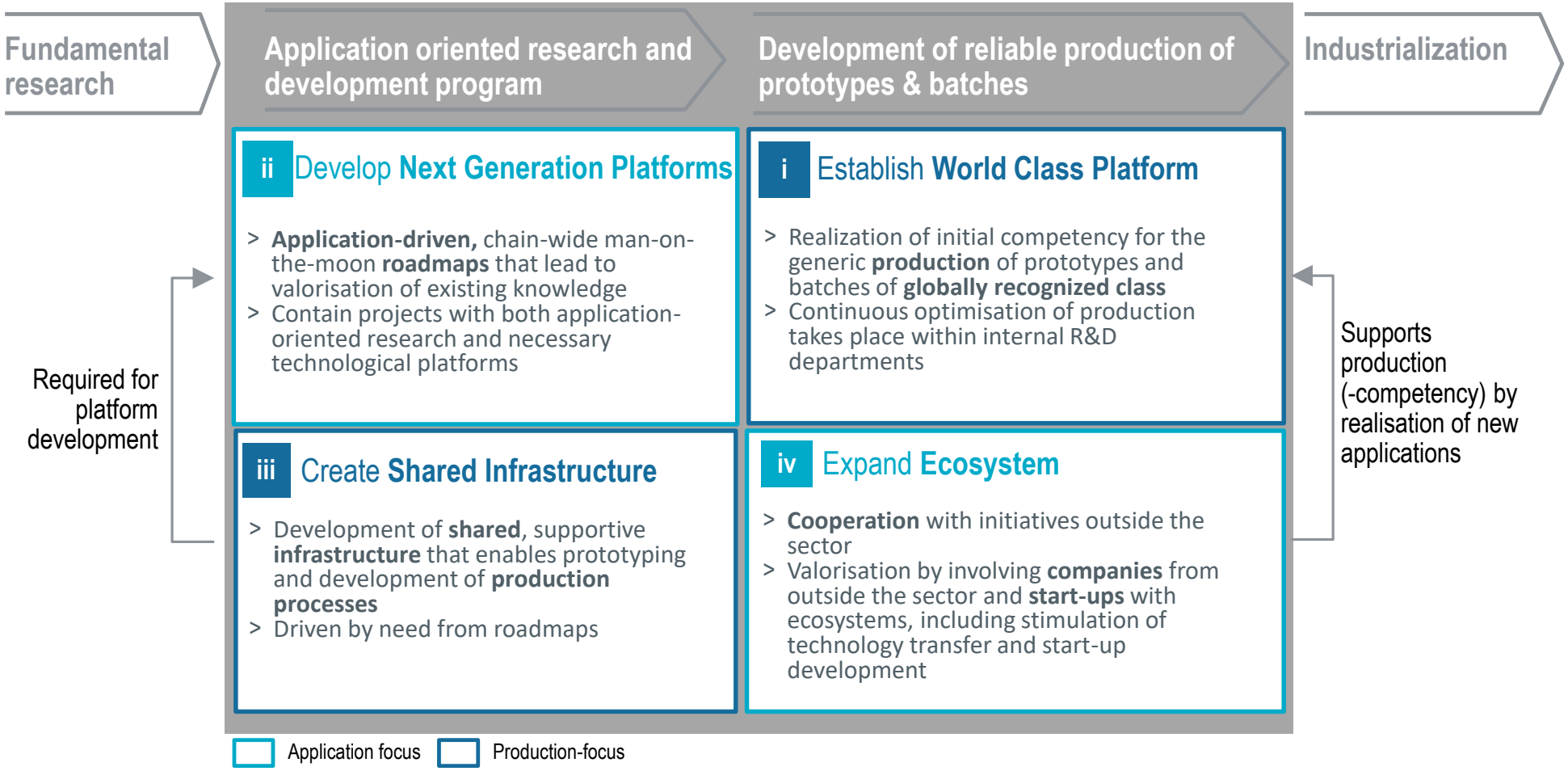
PhotonDelta long-term strategy

Within each pillar the entire ecosystem in scope



(Aero)Space industry
Drivers and Trends

Drivers	Needs
▶ Increasing concerns for spectrum congestion due to increasing amount of (real-time) data exchange between spaceborn/airborne vehicles/platforms	▶ Higher spectrally efficient, higher capacity, lower latency communication networks/links
▶ Increased concerns over data integrity and security (e.g. protection from cyber-attacks/hi-jacking)	▶ Higher fidelity, intrinsically resilient and secure (low risk of interception/anti-jamming) communication links
▶ Increased concern for sustainability	▶ Smaller and lighter vehicles ▶ Higher power-efficient communication links
▶ Increasing commercial value exploitation /approach	▶ Designed to costs space infrastructures ▶ Lower vehicles manufacturing and MRO (maintenance, repair, operations) costs ▶ Reduced pilot/crew presence

Drivers on-board (communication) devices

SMALLER IN SIZE

REDUCED POWER CONSUMPTION

LOWER WEIGHT

Integrated Photonics is one of the key enablers

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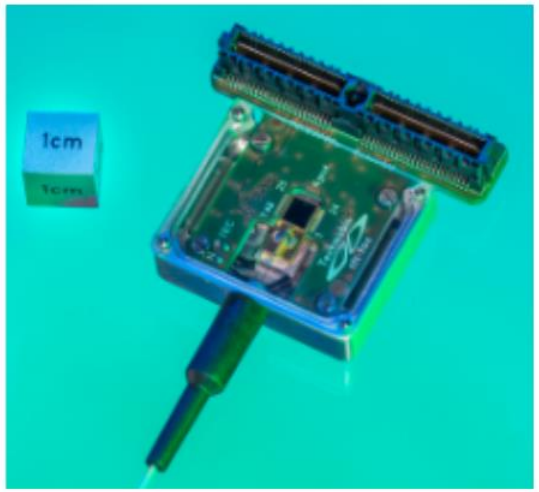
Airplane continuous health monitoring

Mini-interrogator for Fiber Optics Sensing

State of the art highly accurate PICs-powered **interrogator** modules/subsystems for simultaneous **high-frequency** measurement of **force, pressure, temperature** and **relative spatial position** of distributed **sensors** over (multiple) FBG optic fibres

Platform Owner: Technobis



One of the key advantages of fiber sensing compared to electronics sensors is the ability to integrate multiple measurement points down a single fiber line.

Weight less, smaller in size and lower energy consumption

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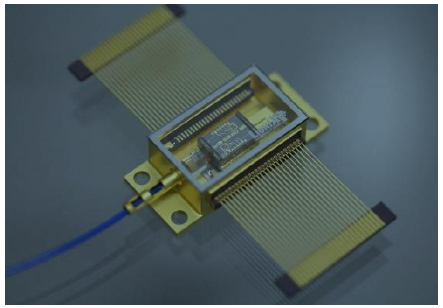
Some of our relevant module platforms for communication

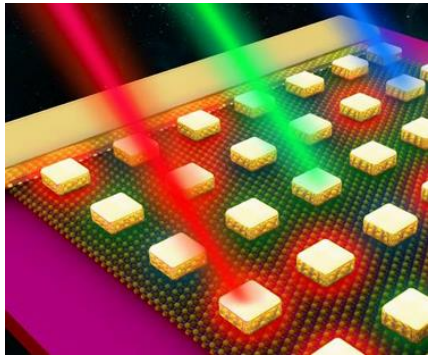
Broadband Ultra-narrow linewidth Tunable Lasers

Scalable, compact, low-cost highly-integrated fast **dynamically** tunable lasers sub-systems with stable **high-resolution** and **narrow linewidth** for various frequency bands (VIS, IR C-band, NIR and MIR), for coherent telecom networks and sensing systems



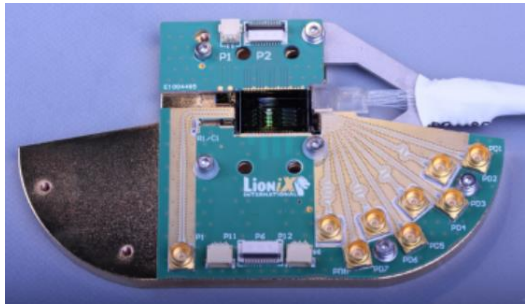
High sensitivity photodetectors

Scalable, **low cost**, **high sensitive** photo detector for **compact** and **lightweight light collection** for application in e.g. free-space optical communications



Integrated Optical Beamforming

World's first subsystem, powered by dedicated proprietary Photonic integrated Circuits (PIC) and hybrid PIC packaging, for **single/multiantenna optical-domain beamforming**



Plattform owner: Lionix International

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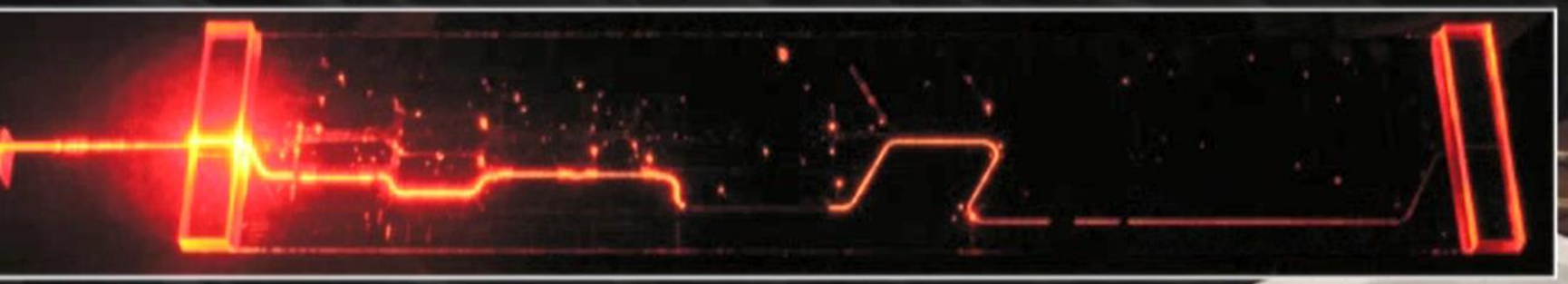
Anastasia 2009

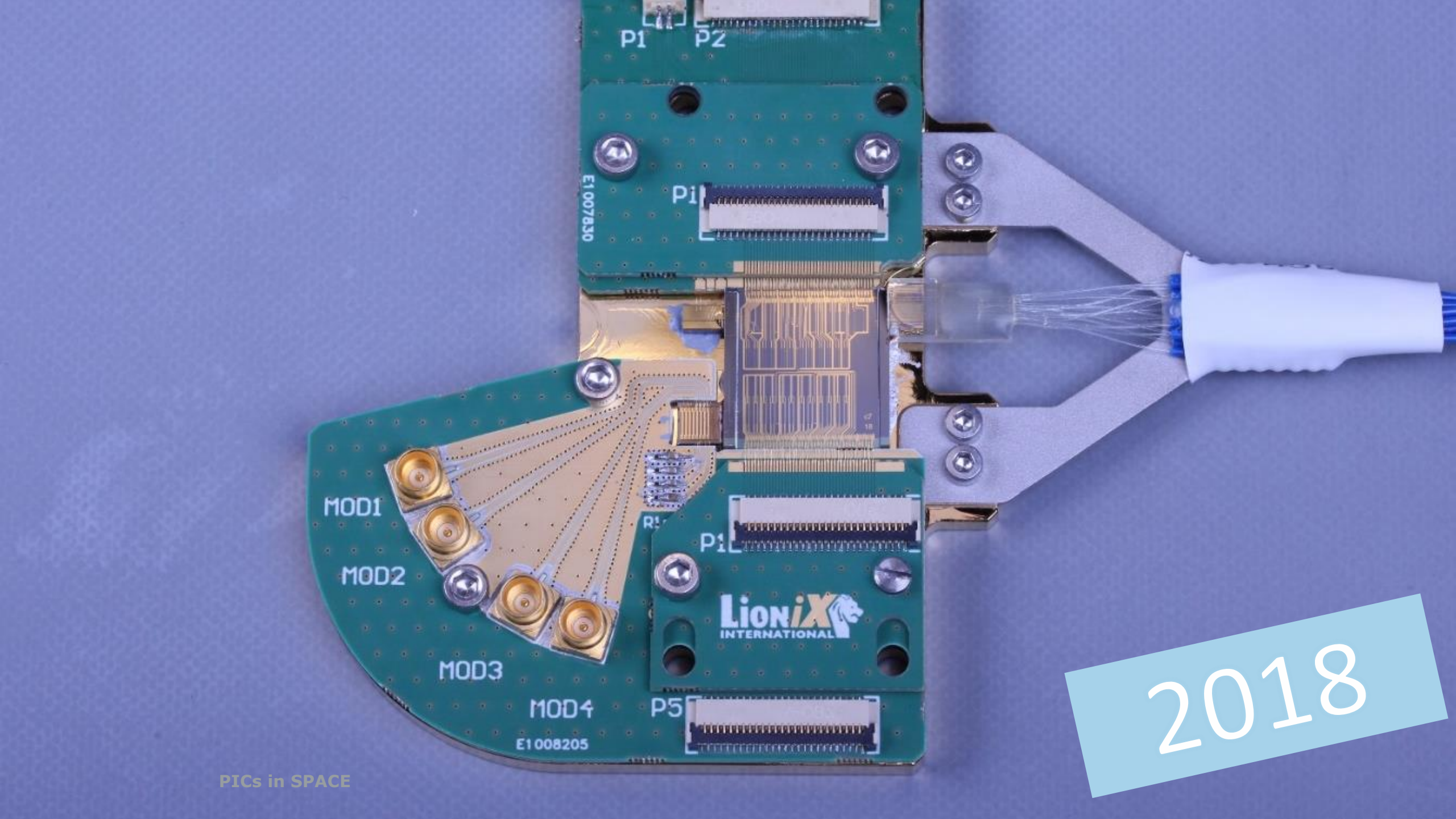
Phased Array Antenna with Optical Beamforming Network

2007-2009: Collaboration between
NLR Royal Netherlands Aerospace Centre & University Twente

OBFN - Optical Beam Forming Network




2007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Integrated Optical Beamforming

Functional Characteristics

Integrated microwave beamforming

- Overcoming limits of high speed electronics capabilities preventing future scale-up to higher frequencies/bandwidth
- Overcoming time-consuming, and power consuming high speed electronics required to bring radio signals into the optical domain via beamforming technologies, processing them and transforming them back into radio frequencies

Core technology

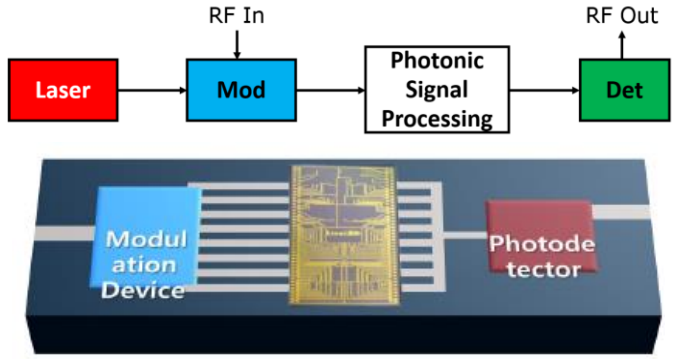
TriPleX™ based platform including tunable delays, phase shifters and filters powered by InP active integrated photonics circuits incorporating: lasers modulators and photodiodes

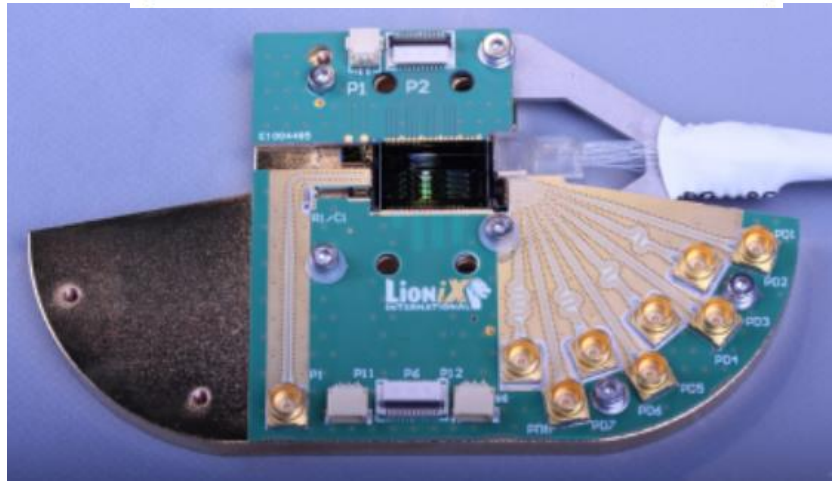
Differentiators

Microwave Photonics as frequency agnostic with large bandwidth
Low-Power actuation through (PZT) stress optic tuning on TriPleX™ processor
Multi-beaming capability
Future scalability to higher frequency, mmWave & THz applications

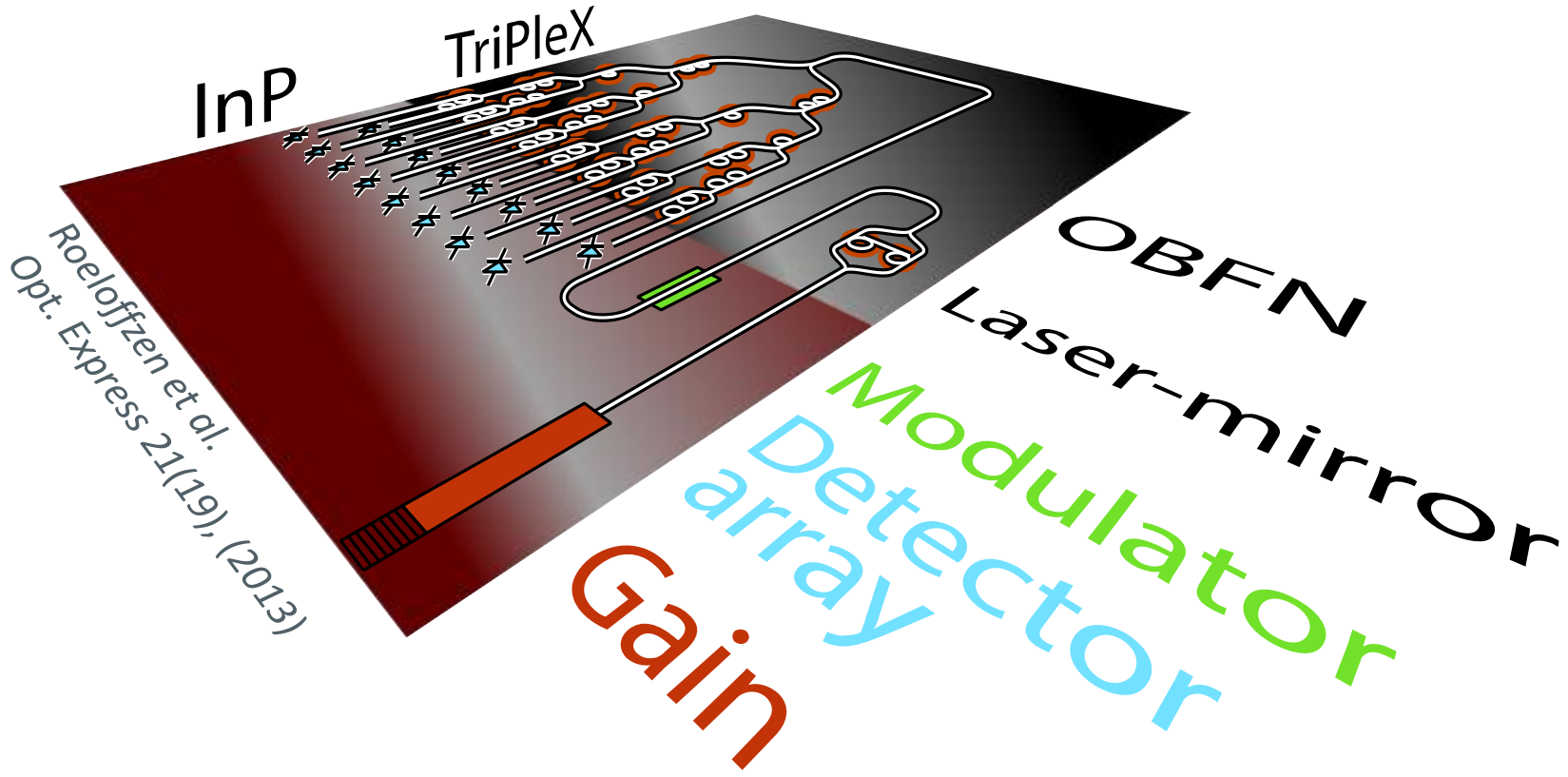
Application Examples

Datacom/Telecom: e.g. High capacity dynamic beamforming (i.e. spatial multiplexing) for radio-based mobile communications (i.e. base stations in 5G mobile networks, satellites) and wireless short-range connectivity (e.g. LiFi)
Medical Devices and Life Sciences: e.g. MRI scanners
AR/VR: e.g. Head-up displays





Active/Passive Integration



A fully integrated broadband optical beamforming module

Engagement models to accelerate joint growth !

JOINT ROADMAPPING

Long-term 1-to-1 partnership for the joint development of new products/solutions

- **Customers** defines requirements, develops, integrate, certifies and brings to market its solutions
- **PhotonDelta** develops, manufactures and delivers the customized PICs or PICs powered modules/subsystems matching Partners requirements

Business model: ODM/Contract R&D, possible financing of PhotonDelta ecosystem own NRE costs under specific conditions

APPLICATION LABS

Joint exploration for the **identification and early validation** of **options for new product/solutions**

- **Customers** brings in application domain knowledge, use-case requirements and, for early validation, testing capabilities/facilities
- **PhotonDelta** brings technology knowledge, concept definition, modeling and, for early validation, development of early stage prototypes/test platforms

Business model: Contract R&D, possible financing of PhotonDelta ecosystem own NRE costs under specific conditions

APPLICATION LABS BOOTCAMPS

3 full days challenge-driven bootcamp, low-threshold **closed-pockets** opportunity to leverage PhotonDelta ecosystem expertise and **bootstrap definition** of possible winning concepts to be further explored in joint projects/developments going forward

- **Customers** brings in use-case requirements
- **PhotonDelta** brings technology knowledge leading to initial definition of viable concepts

YOU WANT TO HAVE MORE INFORMATION?
PLEASE EMAIL OR CALL

EWIT@PHOTONDELTA.EU / +31 610914971

THANKS FOR YOUR ATTENTION

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This presentation was presented at EPIC Meeting on New Space 2019

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EU initiatives funded by
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