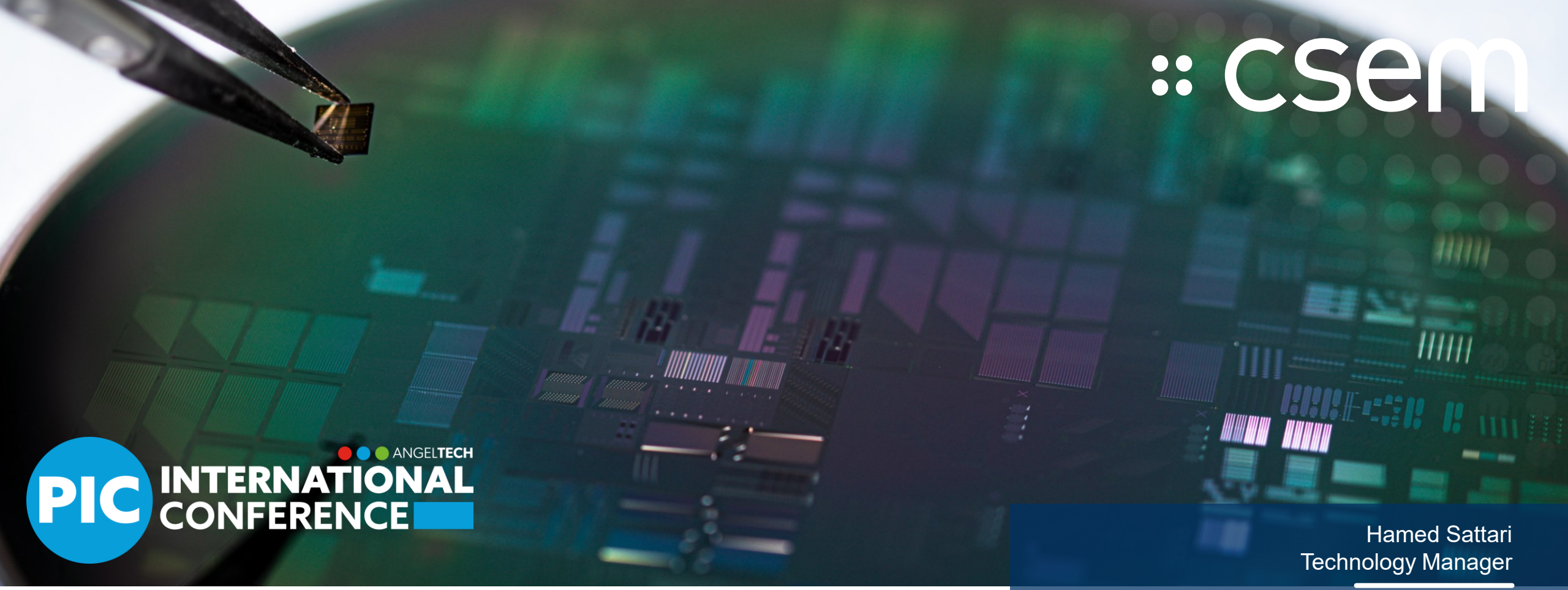

PIC INTERNATIONAL CONFERENCE
ANGELTECH

Hamed Sattari
Technology Manager

16.04.2024

TFLN PIC PLATFORM

UNLEASHING MONOLITHIC POWER TO ENHANCE HYBRID/HETEROGENEOUS PICS

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CSEM AT A GLANCE

We are a public-private, non-profit, Swiss technology innovation center

We enable competitiveness through innovation by developing and transferring world-class technologies to industry

230
INDUSTRIAL CLIENTS / YEAR

203
PATENT FAMILIES

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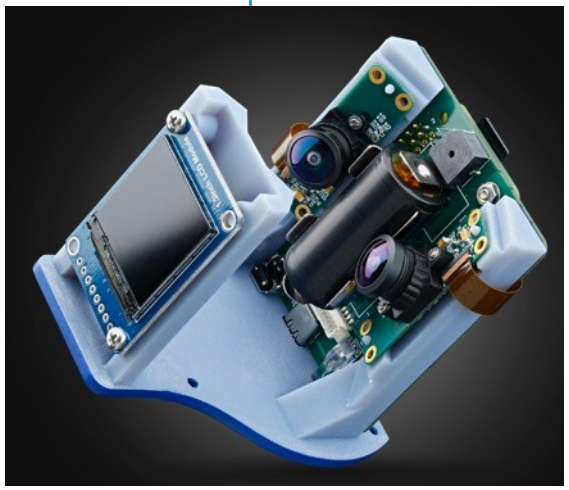
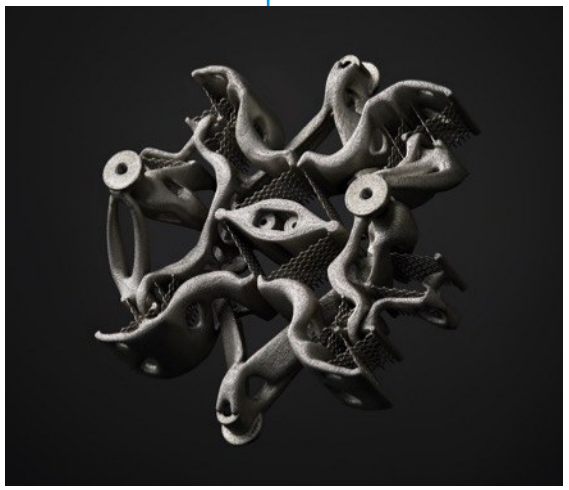
OUR DNA COMES FROM OUR WATCHMAKING ROOTS

Small & precise

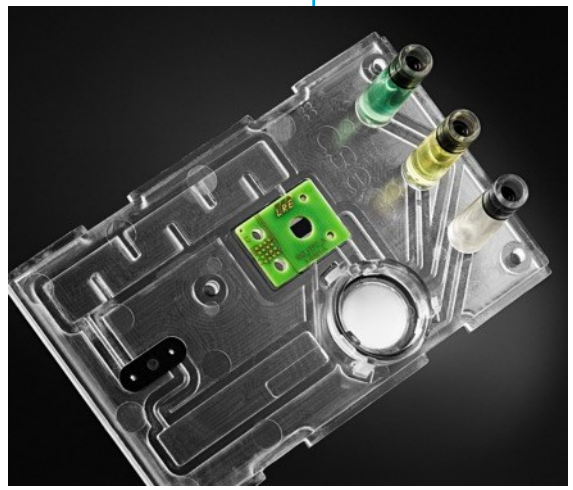


Complex



Ultra-low-power

Multidisciplinary



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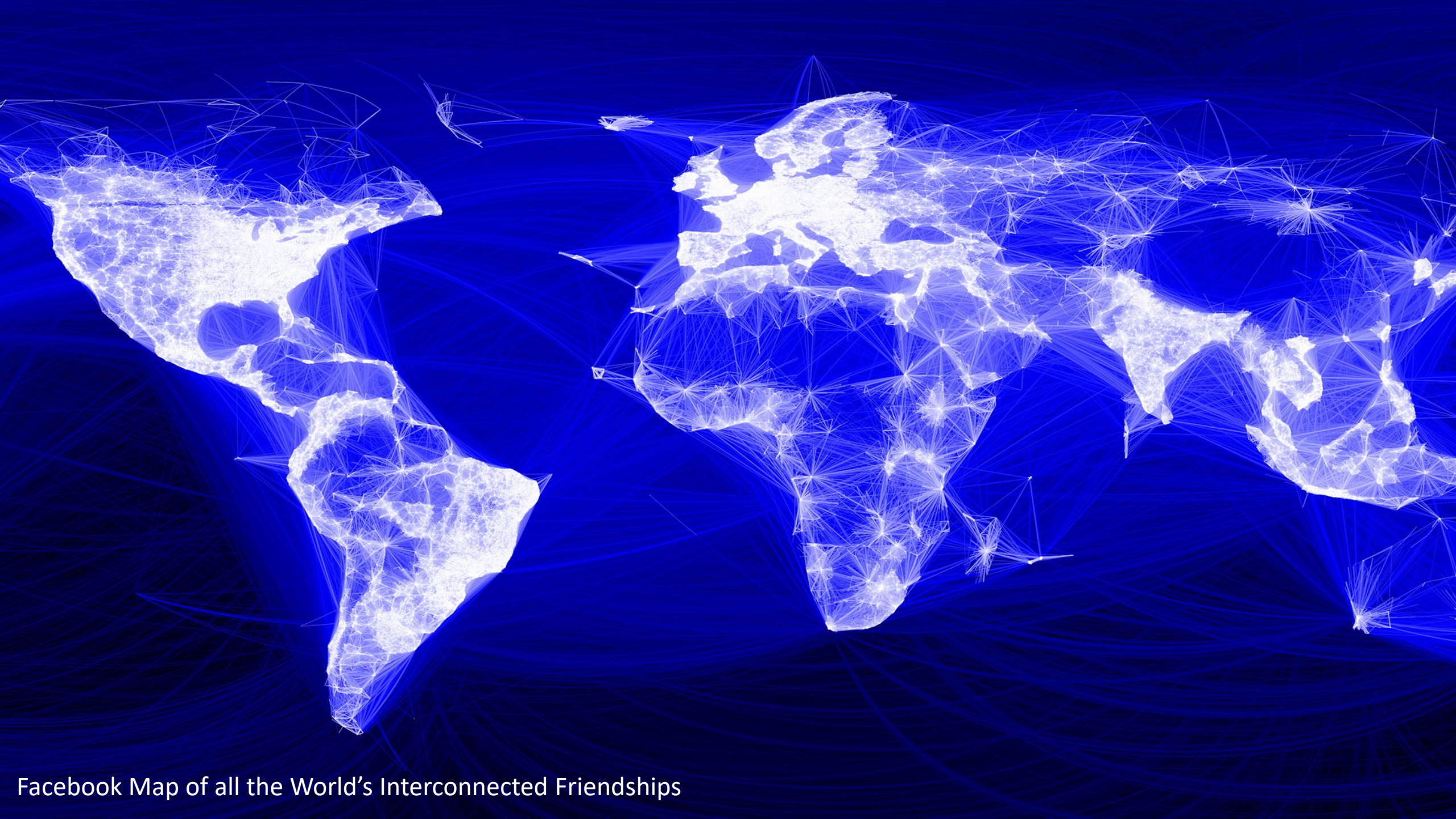
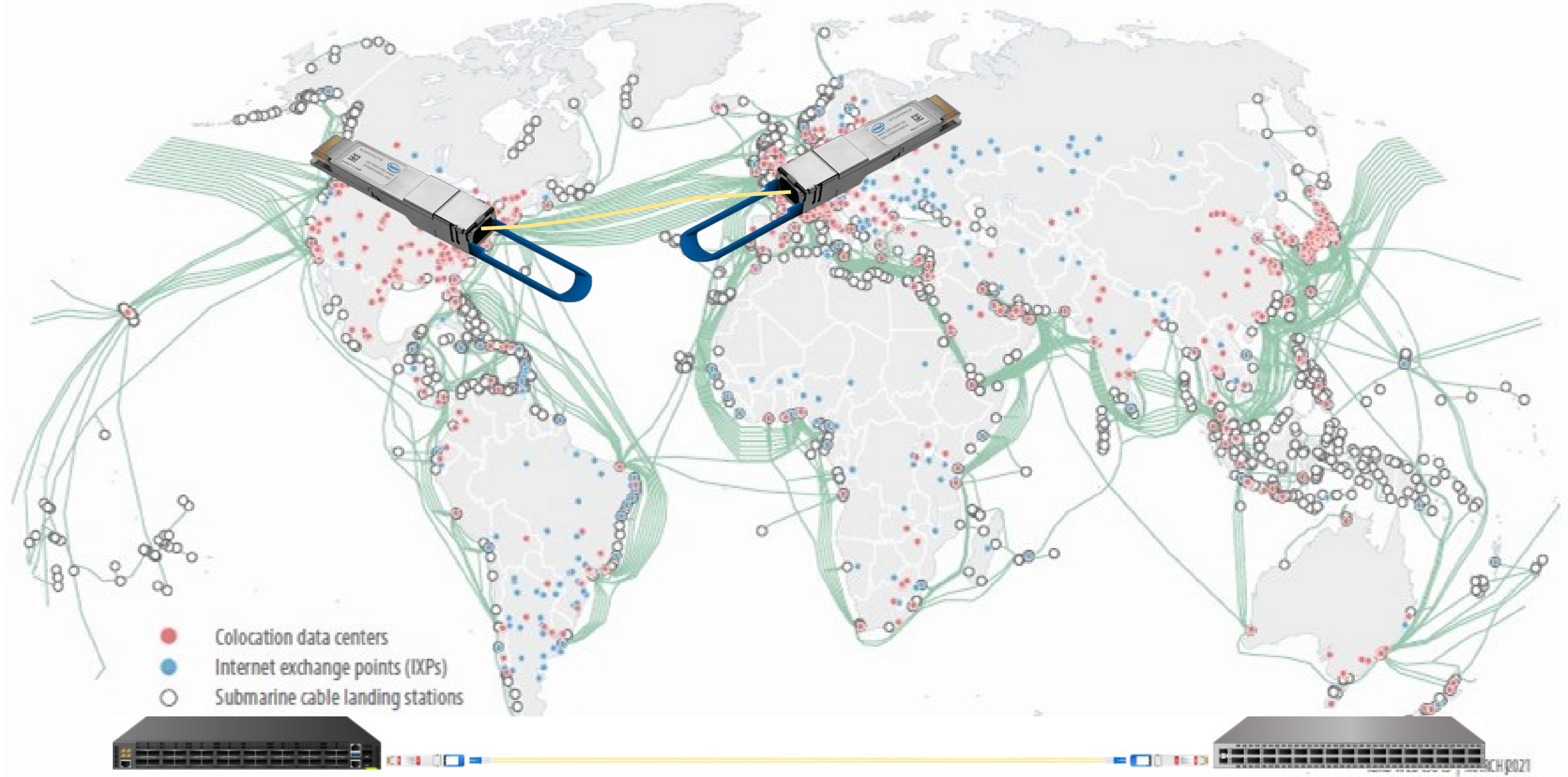
THREADS

Why PICs? Why TFLN PICs?

TFLN PICs Portfolio at CSEM



Facebook Map of all the World’s Interconnected Friendships



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8 DATA CENTER FACTS YOU MIGHT NOT KNOW

CIRKLA
THE DATA CENTER MARKETPLACE

1 There are over **8,000** Data Centers Worldwide

2 Over **33%** of the world's Data Centers are based in the **USA**

3 On average, one Data Center **consumes** as much energy as **25,000 homes**

4 Data Centers generate **1,670 new jobs** and **$77.7M in earnings** a year on average

5 Data Center **equipment** is **renewed** every **3** to **5** years

6 In a typical Data Center, only **40%** of **energy consumption** goes towards **computing**. The **rest** is used mostly for **cooling down** the **servers**

7 The worlds **largest** Data Center, owned by **China Telecom**, is over **10M** square feet in area

8 The **Uspenski Orthodox Cathedral** in Helsinki, Finland, is now the location of **a Data Center**, while historically being a bomb shelter during World War II

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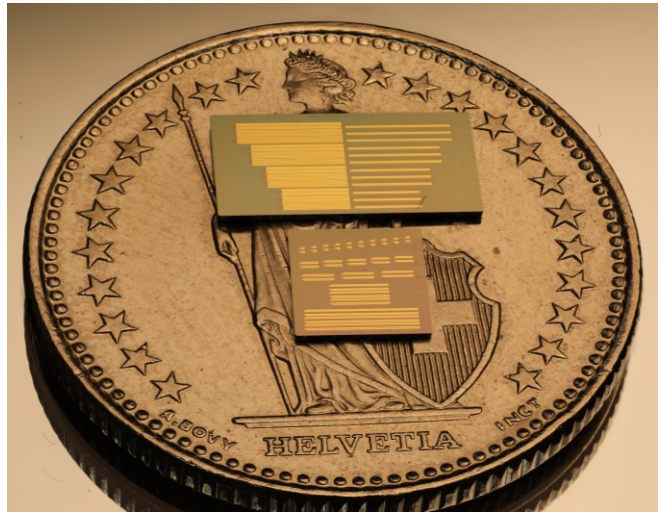
Photonic Integrated Circuit

- ✓ Complex systems
- ✓ Enhanced performance
- ✓ Novel functionalities
- ✓ **Low power**
- ✓ **Low cost**
- ✓ **Scalable**



✓ Miniaturization

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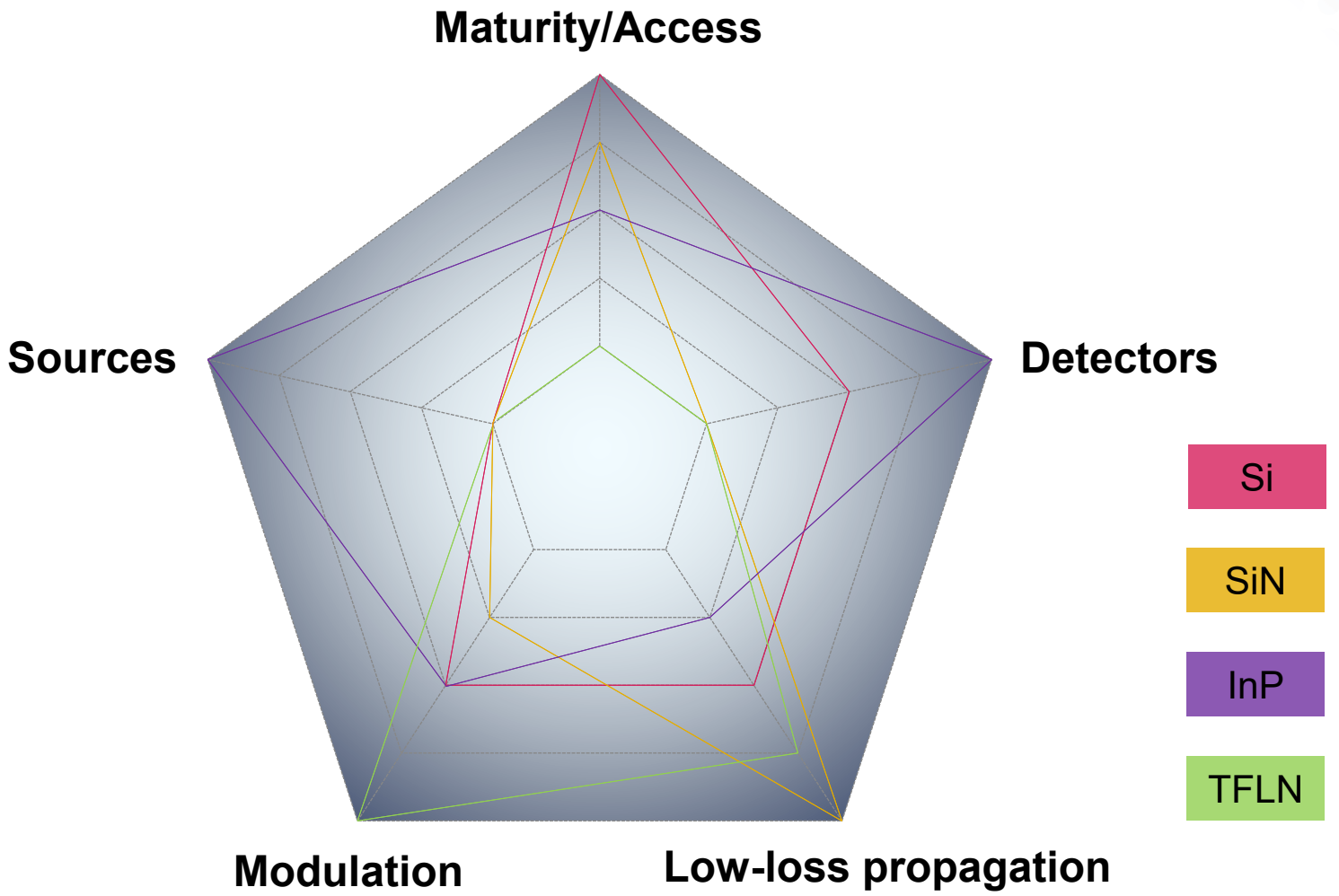
ARE PICS READY TO ADDRESS THE NEEDS?!

Need for Components to Generate, Manipulate, Transport, and Detect light

No single material can do everything!

PIC Systems

- Optical interfacing
- CMOS integration
- Power consumption
- Form factor



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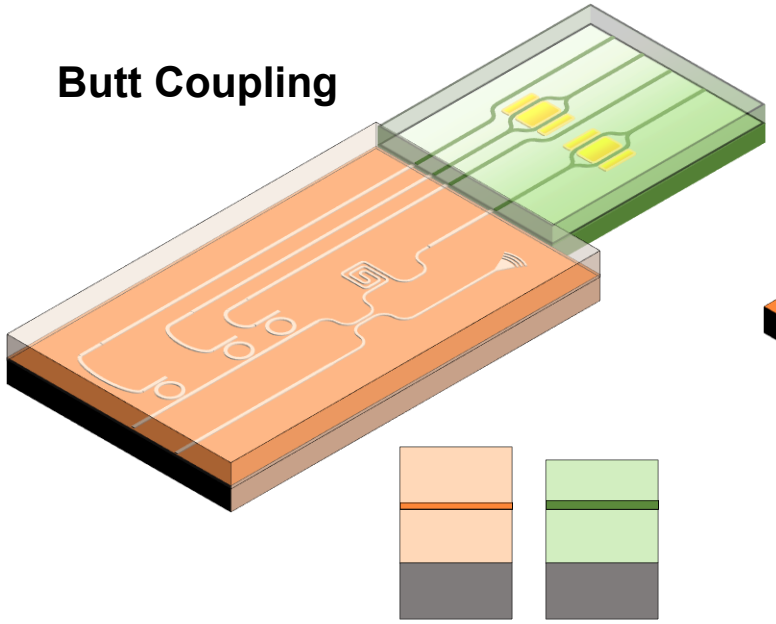
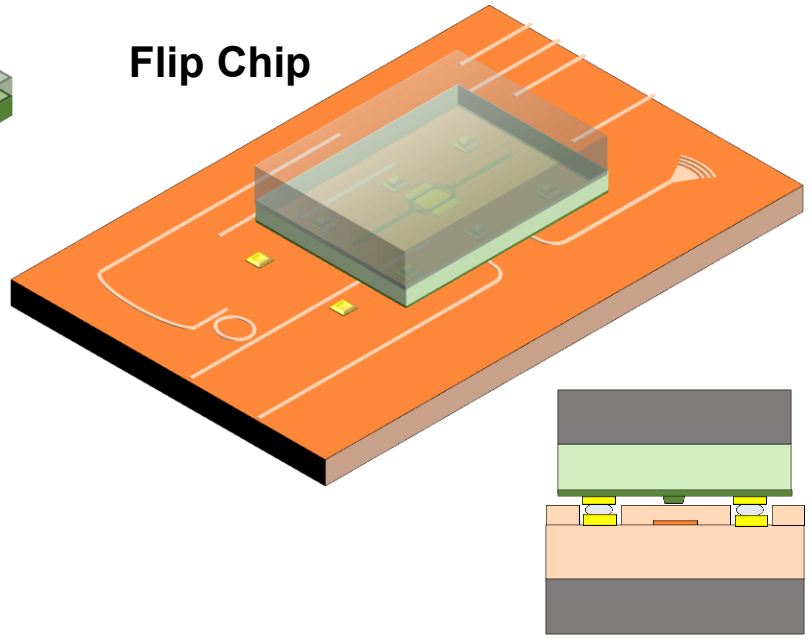
ADVANCED PICS OFFERINGS: HETEROGENEOUS/HYBRID INTEGRATION

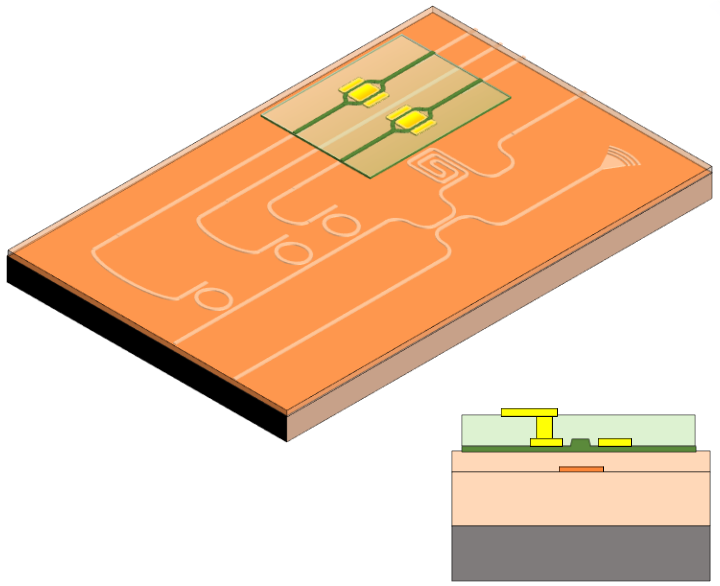
Butt Coupling



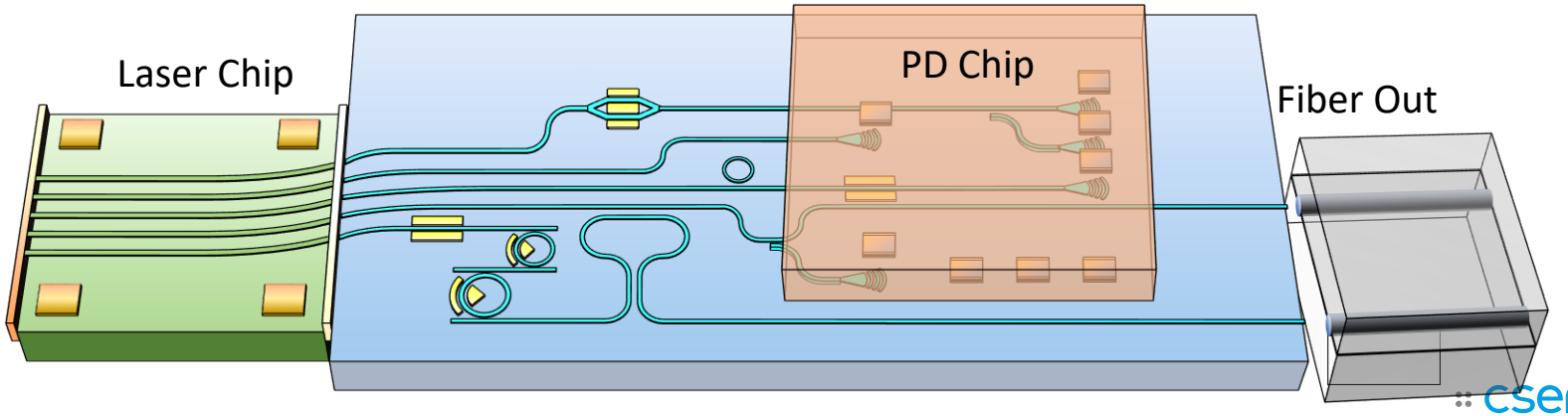
Flip Chip



Micro-Transfer Printing



- Alignment
- In/Out coupling efficiency
- Scalibility/Process compatibility
- Electronics integration



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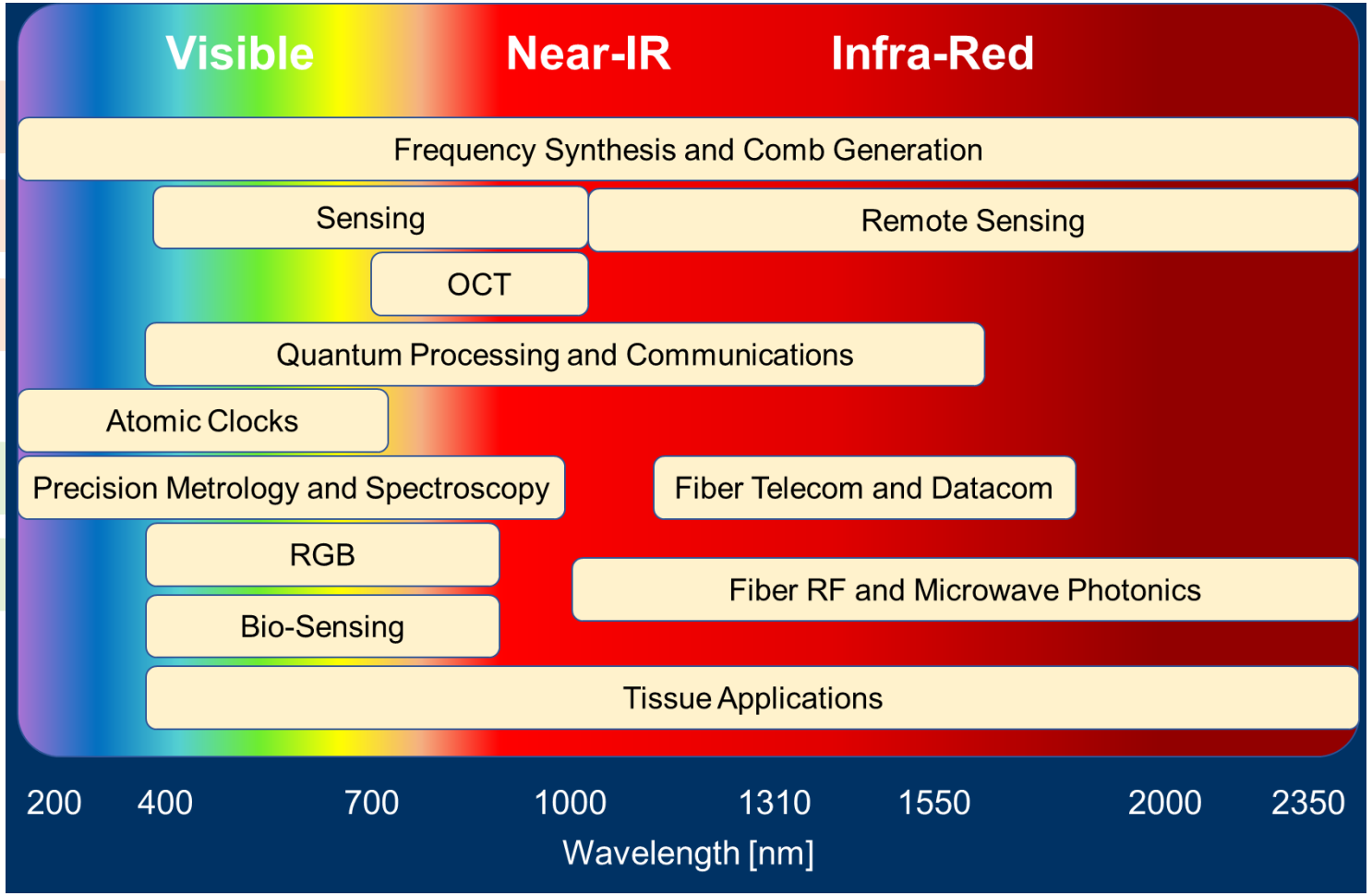
AN ENABLING TECHNOLOGY

Thin-film lithium niobate (TFLN) on insulator

- Intrinsic nonlinearity
- Wide Transparency Window
- High Optical Power Handling
- Fast EO Modulation
- Frequency Conversion

Miniaturization



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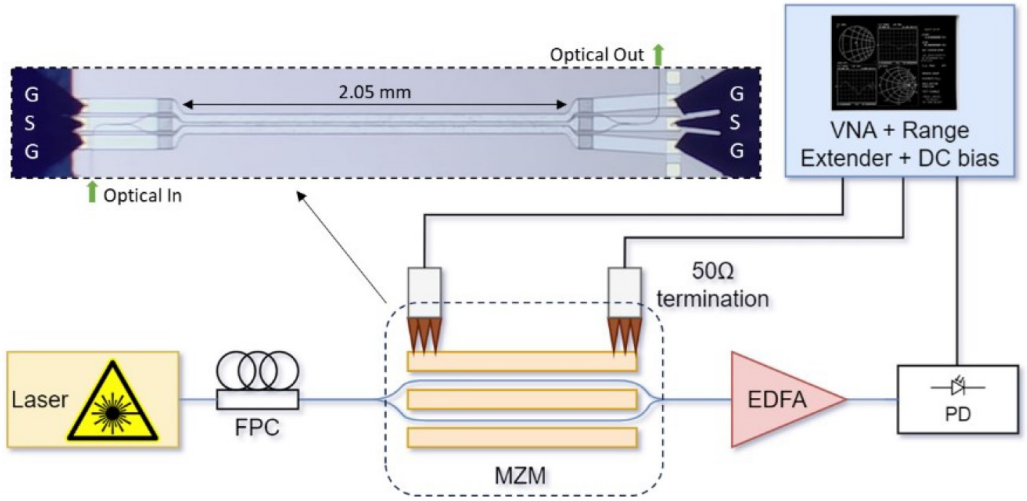
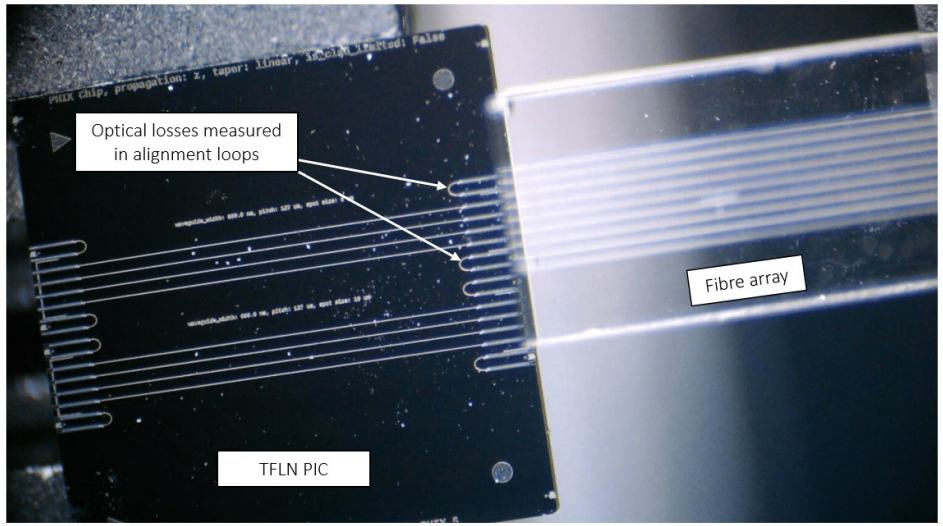
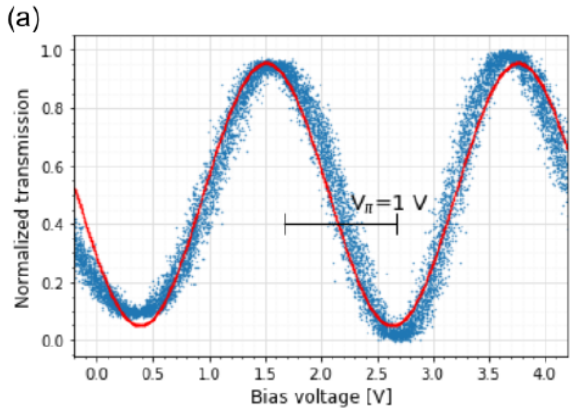
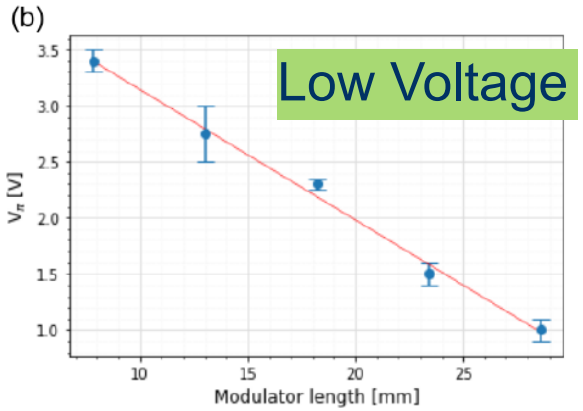
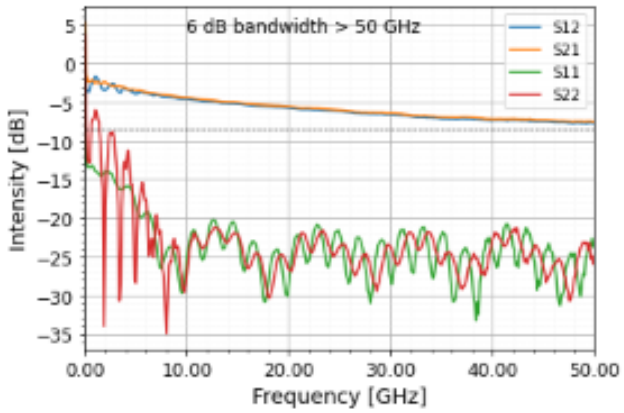
CSEM TFLN PIC PLATFORM TECHNOLOGY: HIGHLIGHTS

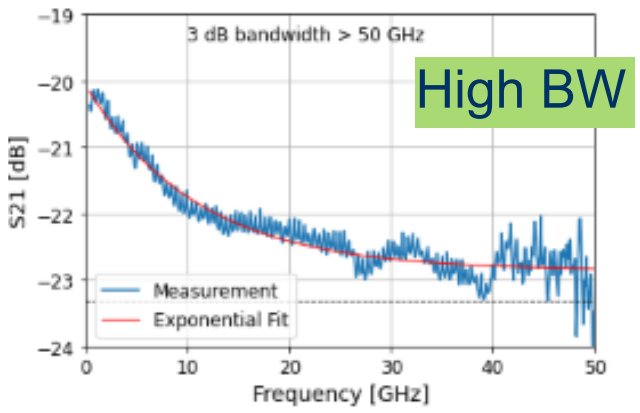












Fiber-to-chip optical coupling losses of less than 2.0 dB per facet, demonstrated by PHIX

https://pattern-project.eu/key-milestone-achieved-for-facet-fiber-chip-coupling/

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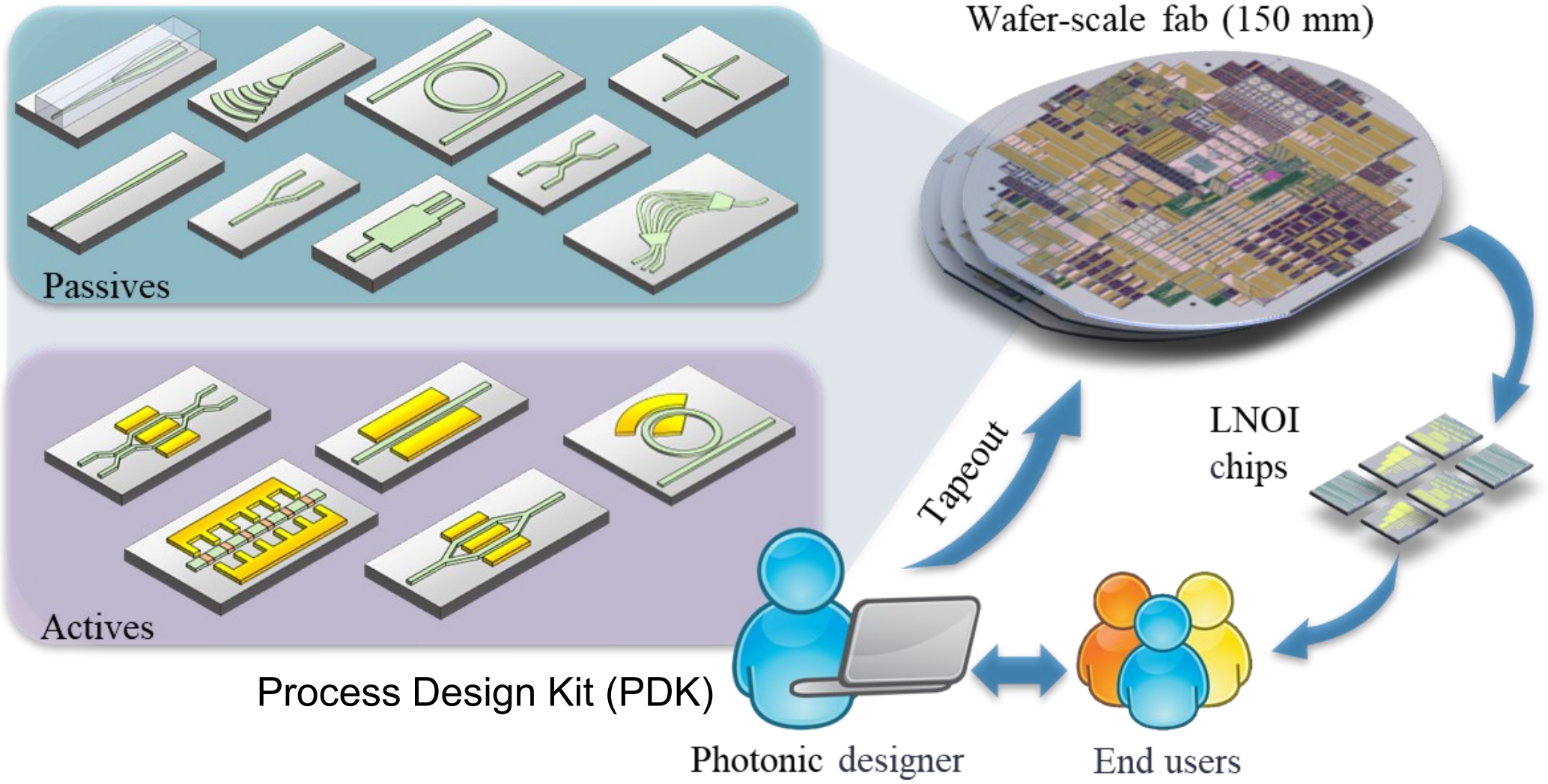
CSEM TFLN PIC PLATFORM: OPEN-ACCESS



https://www.csem.ch/en/tailored-services/tfln-foundry-services/

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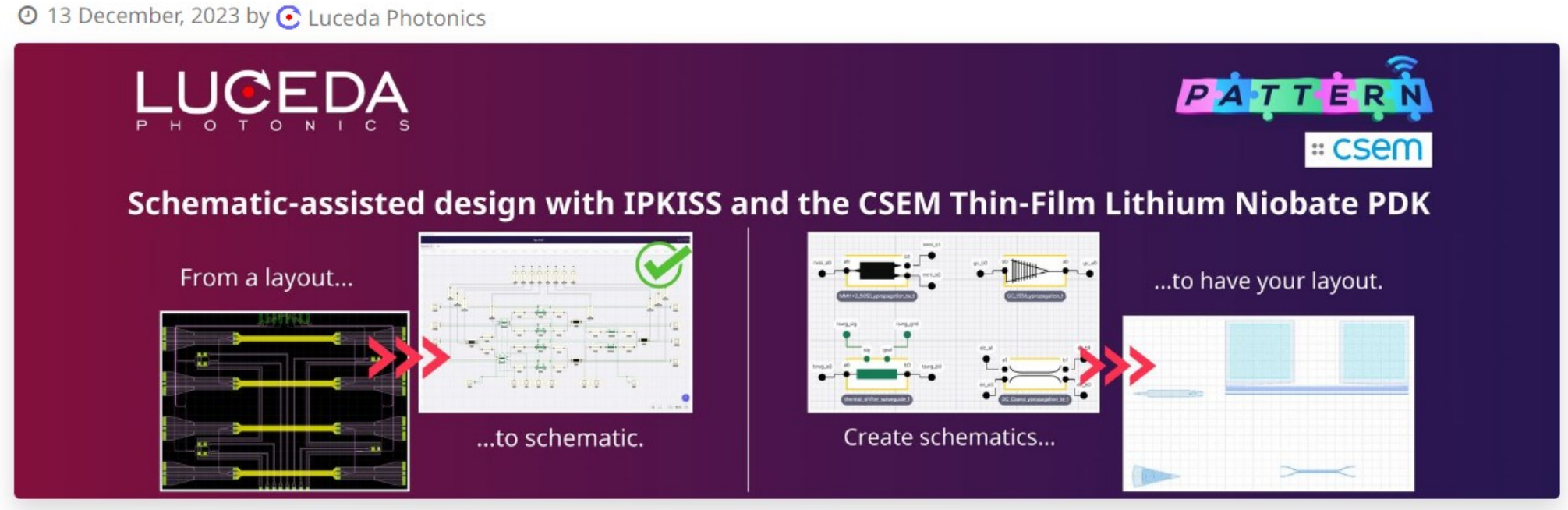
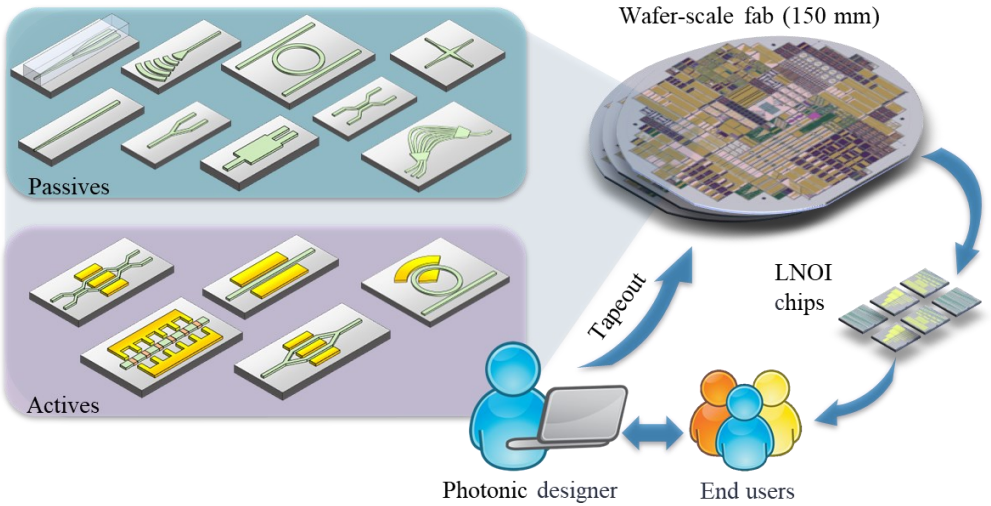
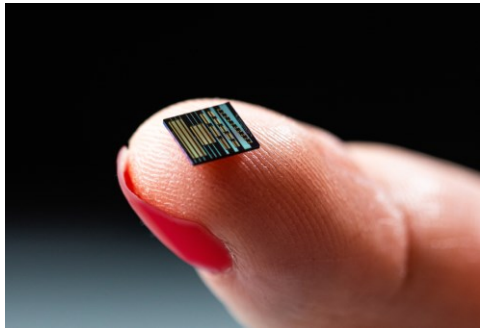
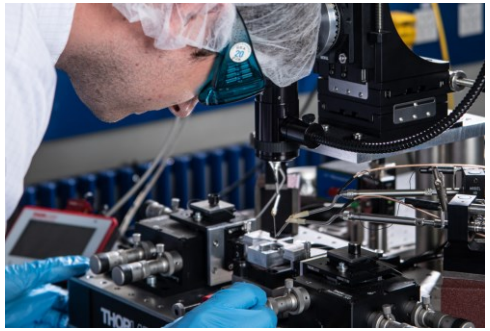
CSEM TFLN PIC PLATFORM: OPEN-ACCESS



https://www.lucedaphotonics.com/blog/news-6/pattern-schematic-assisted-design-with-luceda-ipkiss-and-the-csem-thin-film-lithium-niobate-tfln-pdk-74







https://www.csem.ch/en/tailored-services/tfln-foundry-services/

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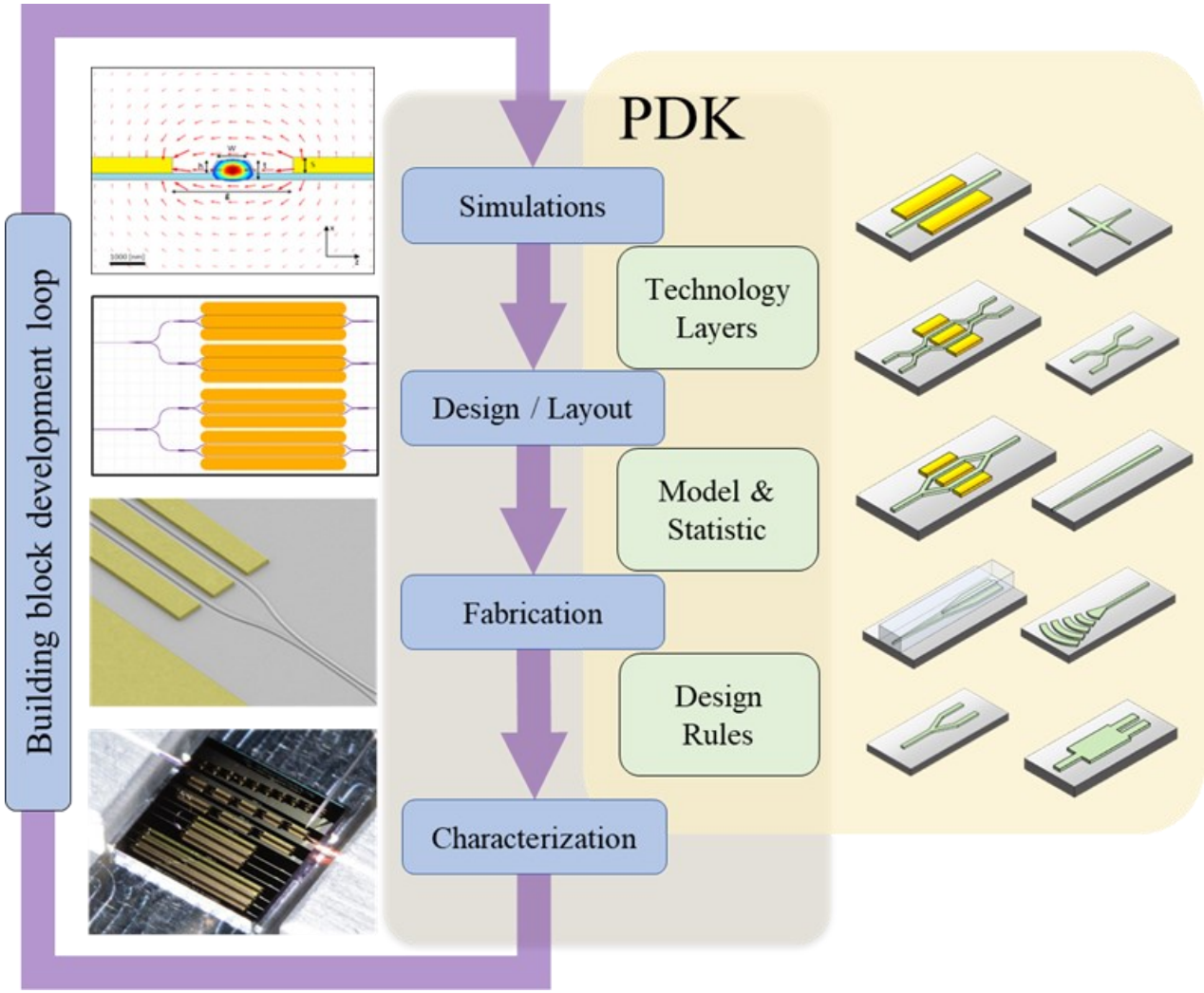
TOWARDS STANDARDIZATION



C-Band Building Blocks (version 2023)

Building Block	Performance
Waveguide	Propagation loss: 1 dB/cm single mode, < 0.2 dB/cm multimode
MMI (1x2, 2x2)	Insertion loss < 0.2 dB, 3dB BW > 60nm
Directional Coupler	Insertion loss < 0.2 dB, 3dB BW > 30nm
Waveguide Crossing	Insertion loss < 0.1 dB, Crosstalk < 30 dB
Grating Couplers	Coupling loss: 8 dB, 3dB BW > 30 nm
Edge couplers	Coupling loss: 3 dB, 3dB BW > 70 nm
EO modulaors	V_{π},L < 3 V.cm, BW > 45 GHz

✓ Pcell for customized components

In the pipeline in 2024:

- Thermal phase shifters
- Polarization controllers
- PPLN for SHG
- 780 nm PDK

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FROM PLATFORM STANDARDIZATION TO THE APPLICATION

Standardization

- Monolithic TFLN - PDK
- Hybrid and Heterogeneous
- CMOS integration
- Packaging - ADK

Application oriented

- LIDAR
- Telecom
- Quantum
- Sensing

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STANDARDIZATION; TFLN PICS VALUE CHAIN

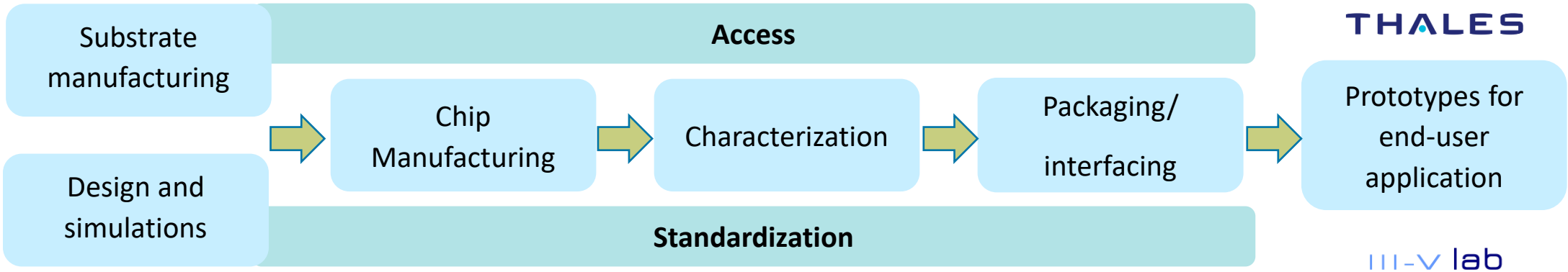
ELENA
Lithium Niobate PICs for Europe

- LNOI PIC Foundry, PDK
- Supply chain for TFLN PICs

PATTERN

- Hybrid/Heterogeneous integration
- ADK
- Supply chain for hybrid PICs

soitec leti ceatech Fraunhofer HHI Microwave Photonics imec Ghent University cnrs THALES



VPIphotonics Design Automation csem THALES vanguard Automation III-V lab

ETH zürich UCL phix Rosenberger

LUCEDA PHOTONICS

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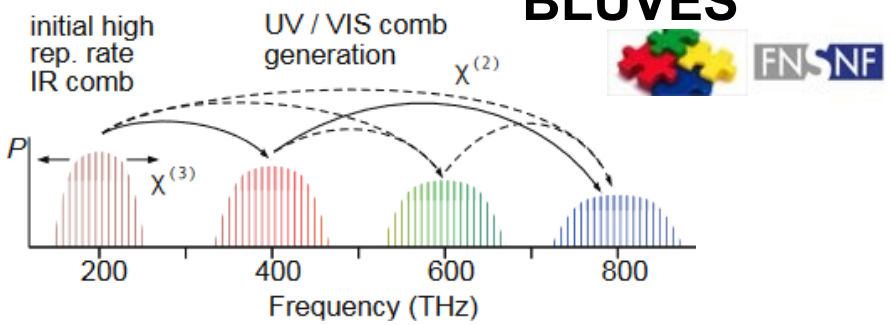
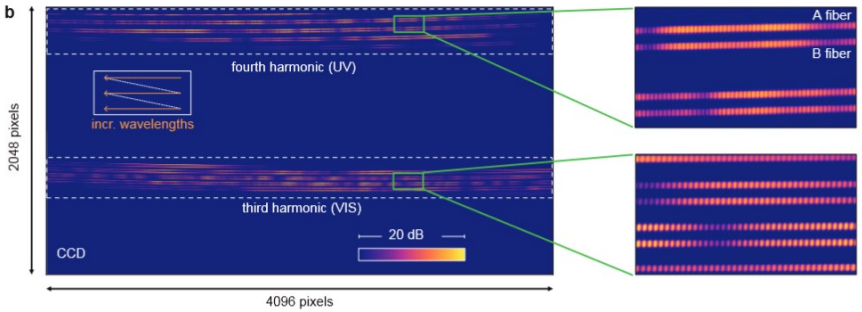
FROM PLATFORM STANDARDIZATION TO THE APPLICATION

Astronomical calibration

Electro-optic comb frequency conversion to the Vis/UV

BLUVES



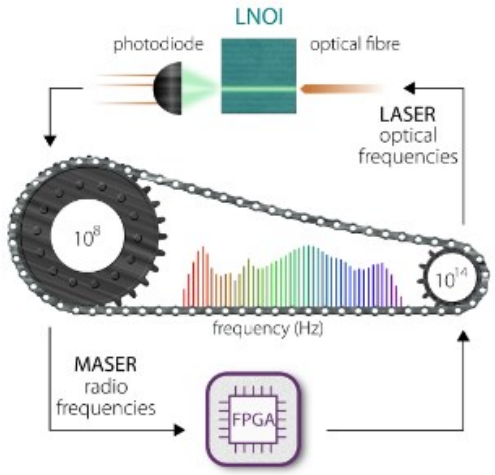


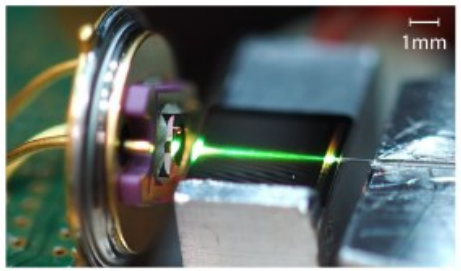
Ludwig, M. *et al.*arXiv:2306.13609 (2023)

BLUVES

Laser Metrology

Laser stabilization

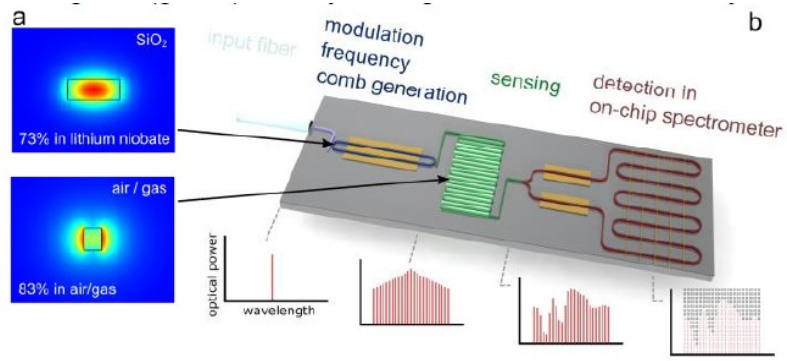


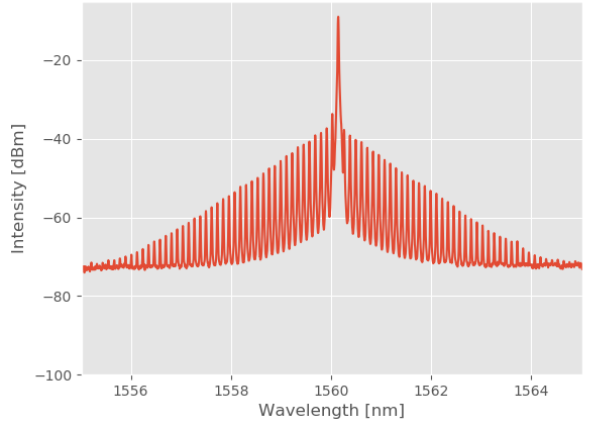


Obrzud, E. *et al. APL Photonics* **6**, 121303 (2021)

Gas spectroscopy

Electro-optic comb + spectrometer





LINIOS BRIDGE

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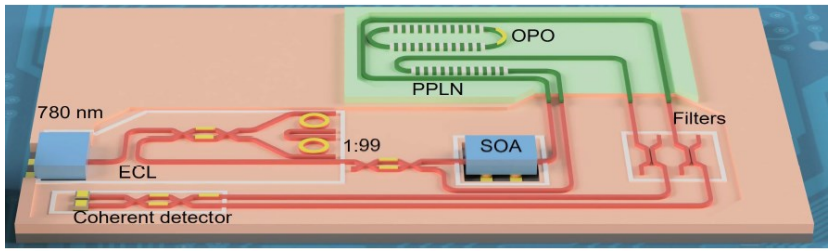
FROM PLATFORM STANDARDIZATION TO THE APPLICATION

Quantum

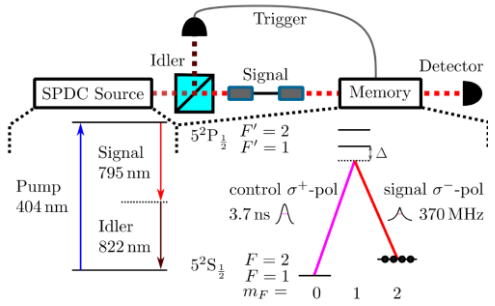
QKD transmitter
(Integration with SiN, Ge, GaAs)



Single photon
frequency conversion

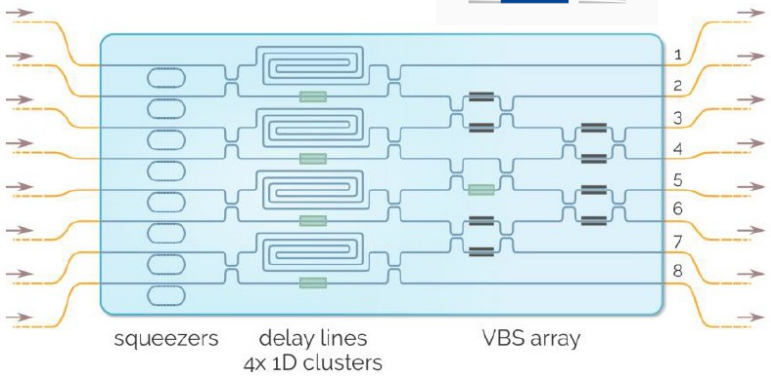
sQnet

FNSNF



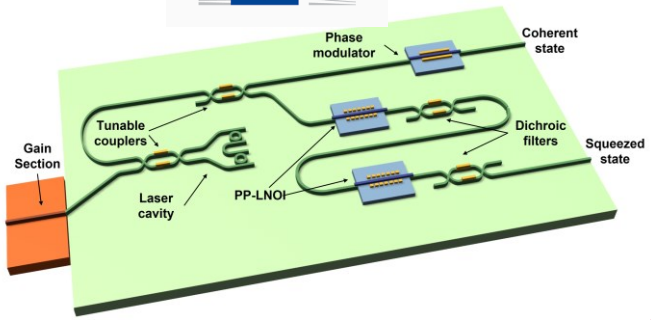
Photonic Quantum
Computing

CLUSTEC



Squeezed state laser
(Integration with SiN. GaAs)

QUANTIFY



LIDAR

On-chip FMCW LIDAR module
(Integration with SiN, InP, Ge)

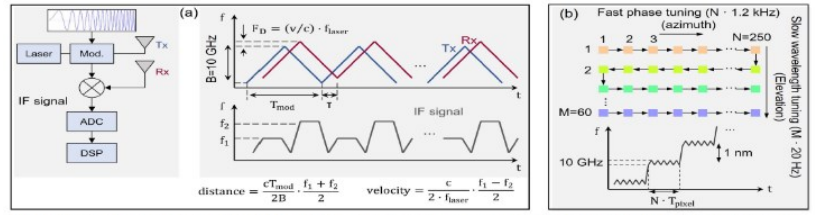
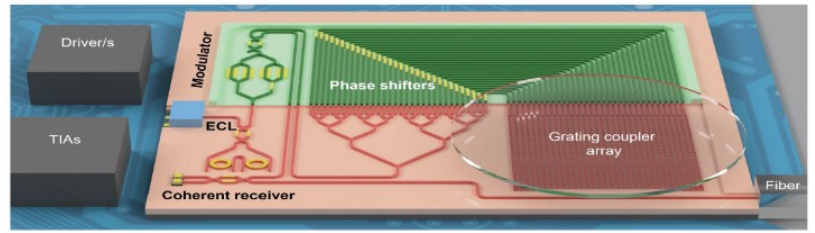


Figure 6: (a) Fundamentals of FMCW LIDAR operation. (b) Synchronization scheme for simultaneous 2D scanning and FMCW operation.



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TAKEAWAY MESSAGE

- Monolithic PIC platform development is essential for advanced hybrid/heterogeneous PICs
- Not every application requires hybrid-heterogeneous PICs
- TFLN brings huge added value to the PIC portfolio: monolithic and heterogeneous

Focus Area

- Chip manufacturing
- Packaging
- Hybrid/Heterogeneous Integration
- Enhancing the supply chain

Challenges

- Optical interfacing
- CMOS integration
- Power consumption
- Standardization

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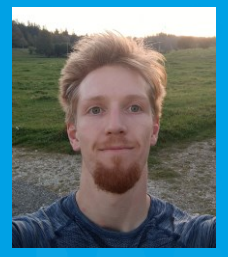
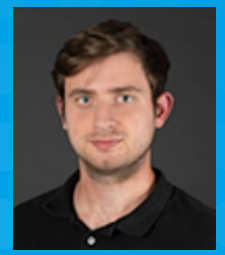
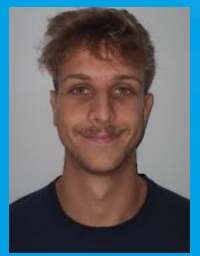
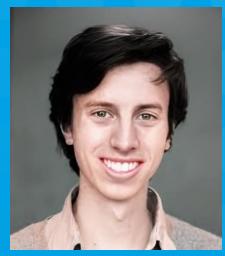
FACING A CHALLENGE? LET'S TACKLE IT TOGETHER!












A big Thanks to the TFLN PIC team at CSEM

FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

Innosuisse

BRIDGE

HORIZON 2020

Horizon Europe
THE NEXT EU RESEARCH & INNOVATION PROGRAMME (2021 - 2027)

European Commission

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FACING THE CHALLENGES OF OUR TIME