Photonic integration for quantum technology

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The bill for an actual (!) quantum technology

Quantum computing needs >1M qubits...

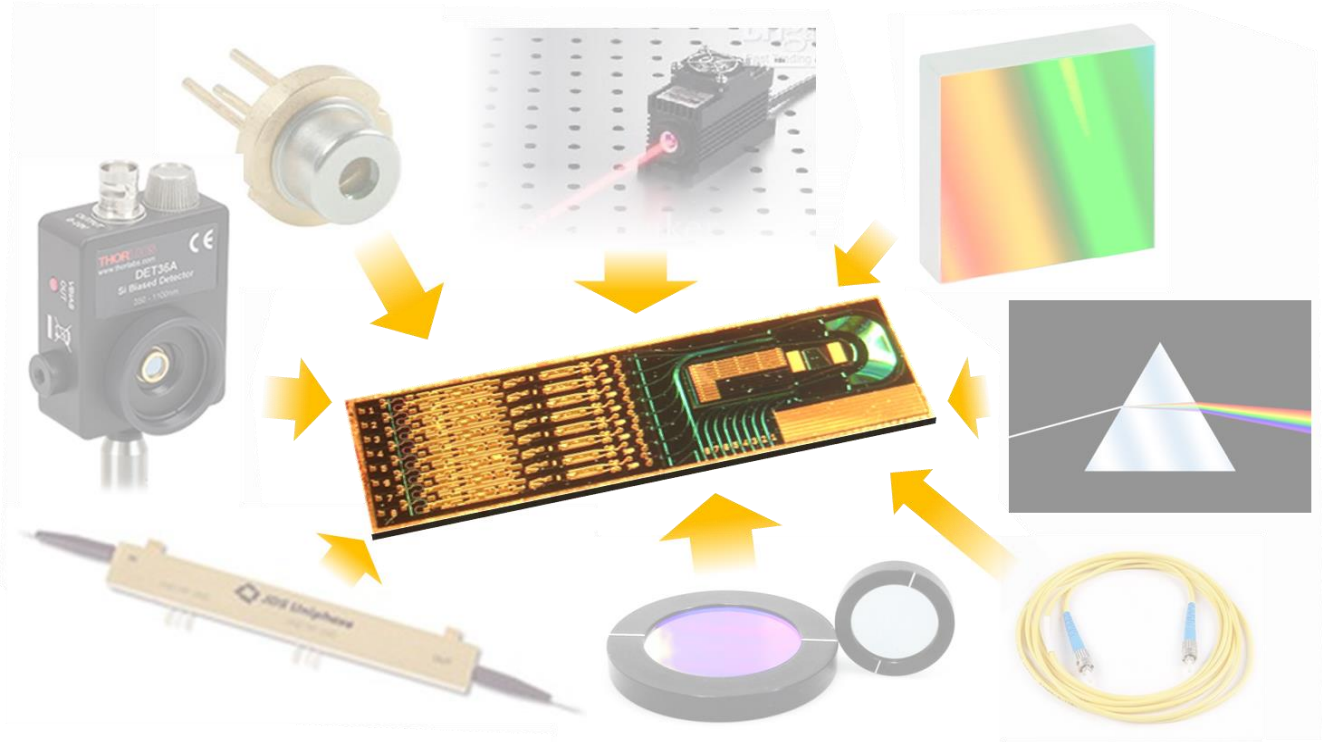
Quantum communication, sensors, QRNG hold promise for ubiquitous implementation

+

Total: millions to billions of components

And many of these are photonic and optical...

The/one solution: photonic integration – optical chips



Advantages of photonic integration

increased performance

in terms of stability, speed and sensitivity, improves electronics performance;

decreased size, weight and power (SWaP)

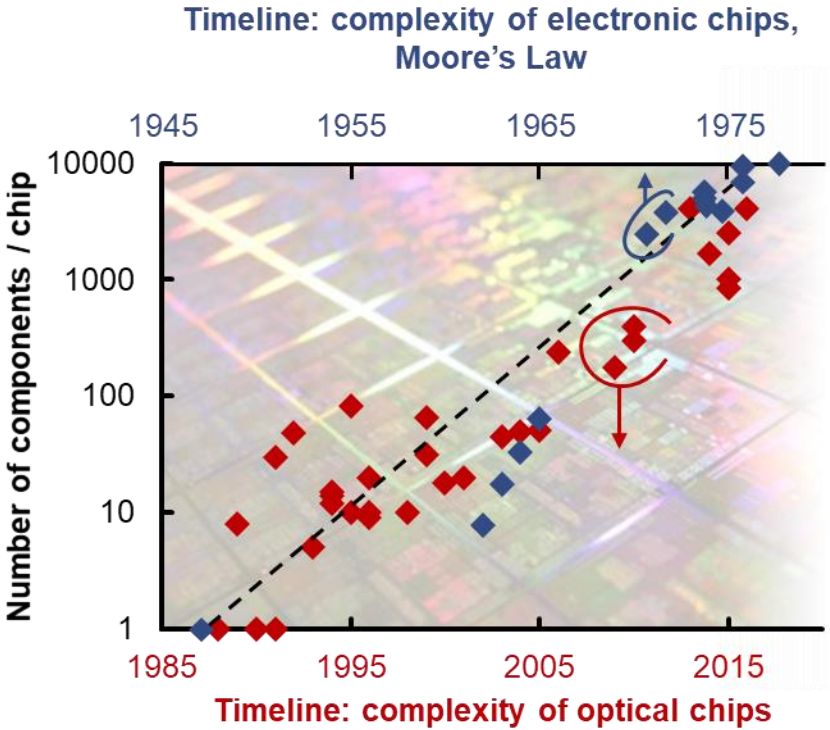
for use in, e.g., drones, space and aircraft, handheld and wearable devices;

decreased cost

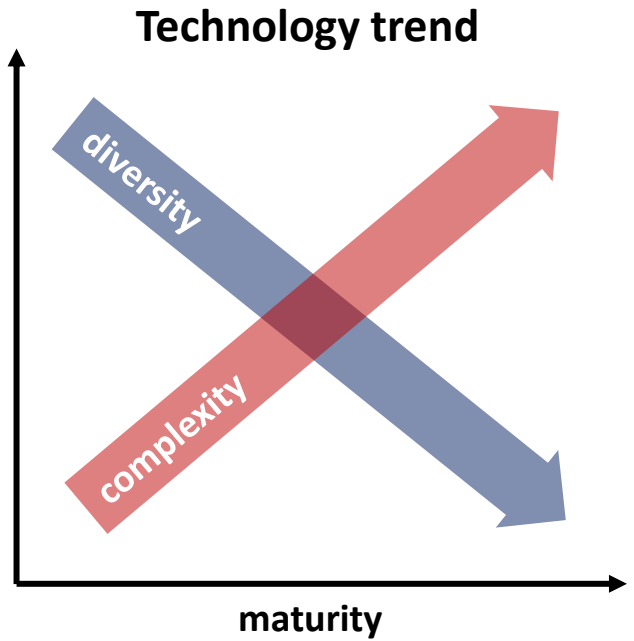
at high volumes due to wafer-scale manufacturing.

100 Gbps transmitter
R. Nagarajan, Infinera, 2006

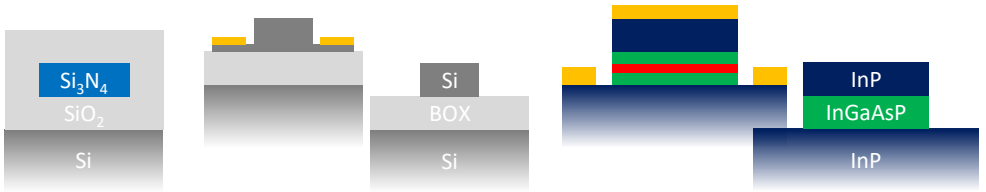
“Moore’s Law” of Photonics



Semiconductors: the engineering vs. physics trade-off

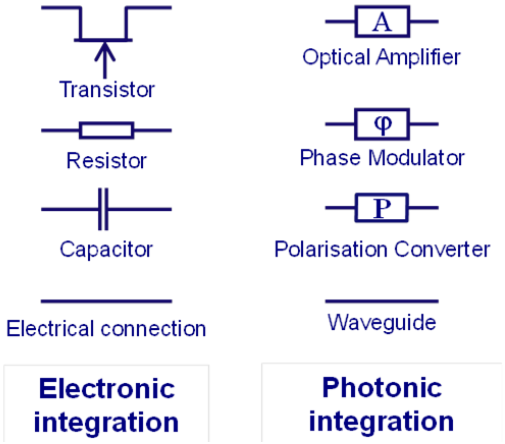


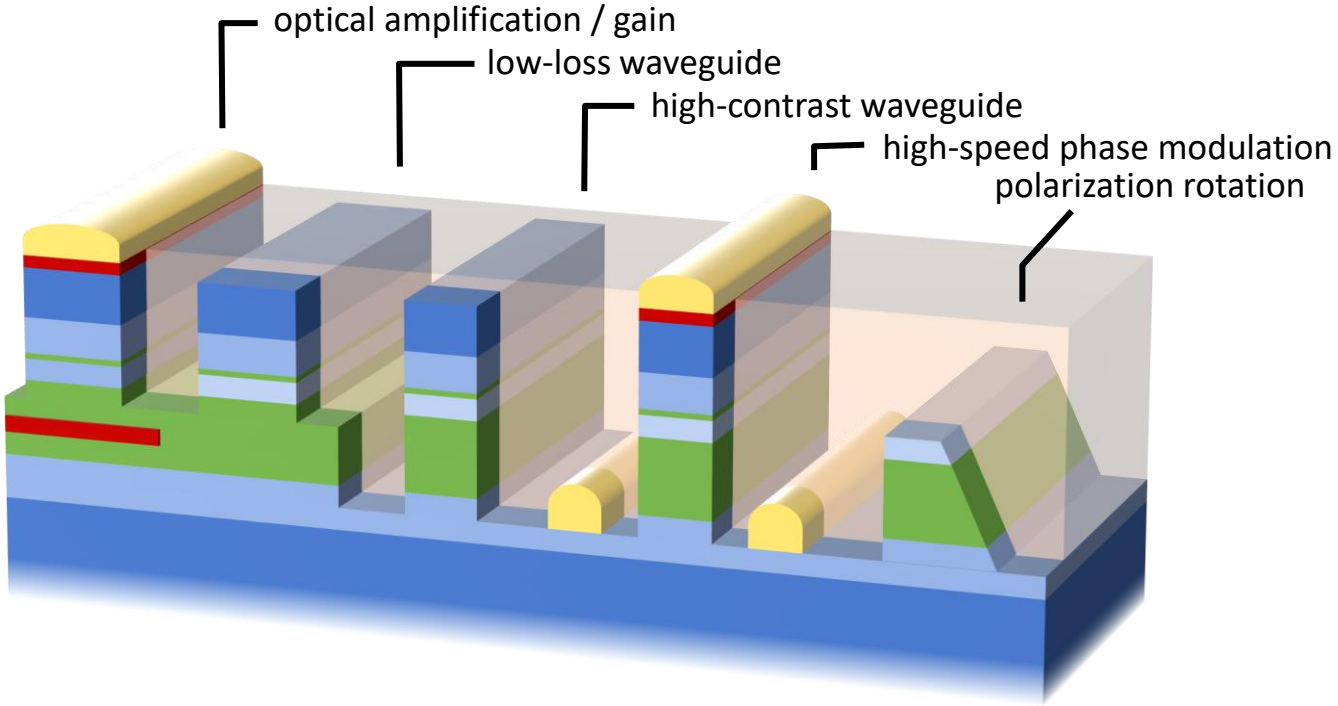
Converge on three major integration platforms



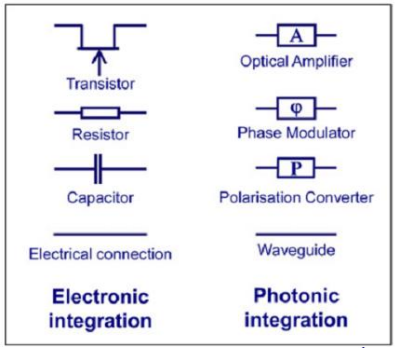
	silica / silicon nitride	silicon-on-insulator	indium phosphide
wavelength range	0.3 µm – 3 µm	1.1 µm – 4.5 µm	1.3 µm – 1.6 µm
lasers, amplifers	NA	NA	+++
photodetectors	NA	++	+++
modulators	NA	+	++
passive devices	+++	++	+
wafer level packaging	+++	+++	NA
electronic SoC and SiP integration	+++	+++	NA

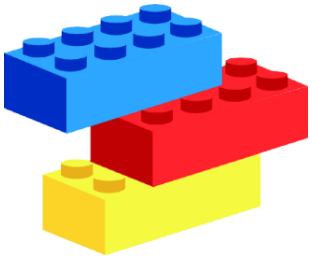
Monolithic InP PICs

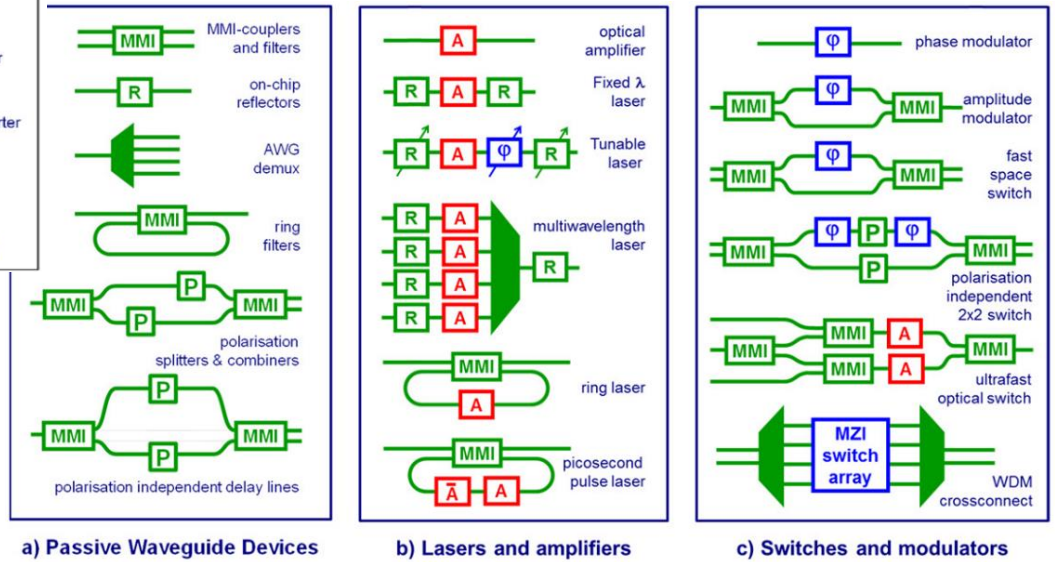




Building blocks to make a circuit

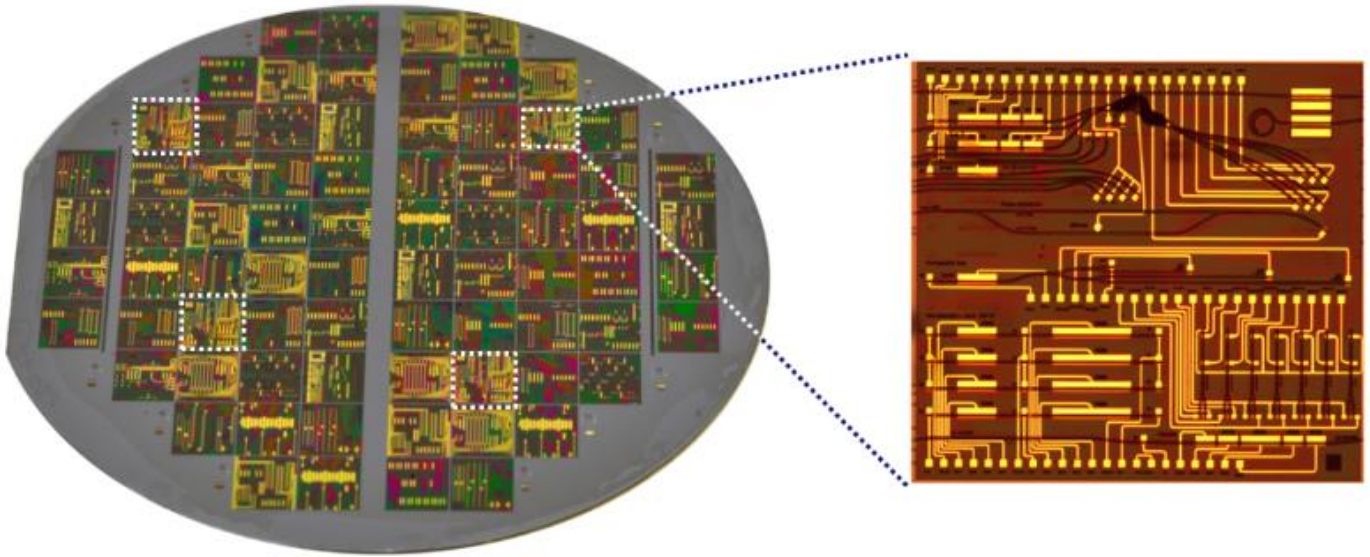






Smit et al., Semiconductor Science and Technology 29, 8 (2014)

MPWs – Wafers with many circuits



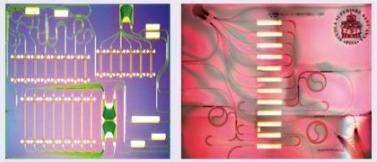
The ecosystem

JePPIX Knowledge JePPIX MPW Services JePPIX Pilot Line

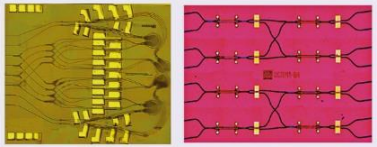
Over 500 PIC designs realised in JePPIX foundries

THz and RF circuits

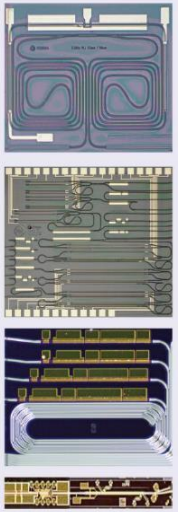
Optical data handling



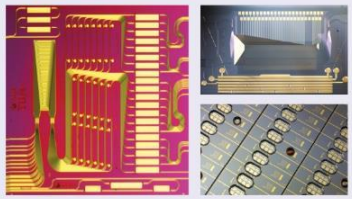
Optical switching



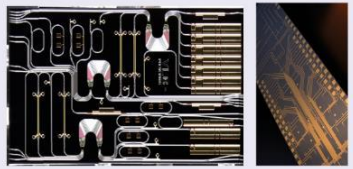
Variety of Lasers



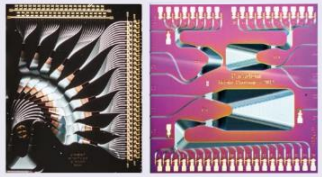
Medical and bio-imaging



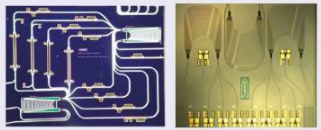
Microwave photonics beam-former



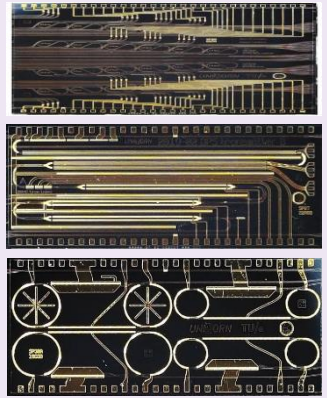
Sensor readout units



Fibre to the home



QKD transceivers



New **pilot line services** launched with manufacturing-grade PDKs and test automation

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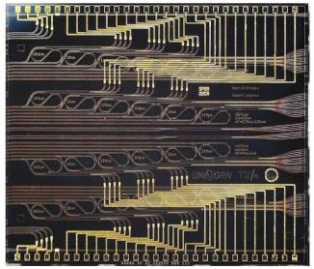
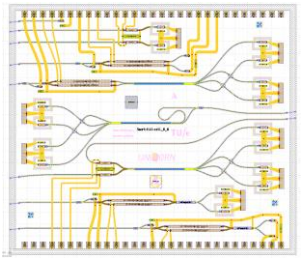
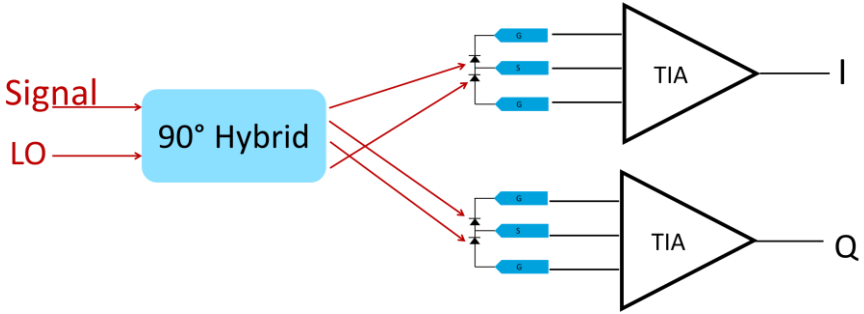
Quantum communication – InP platform – CV receiver

90° hybrid mixers

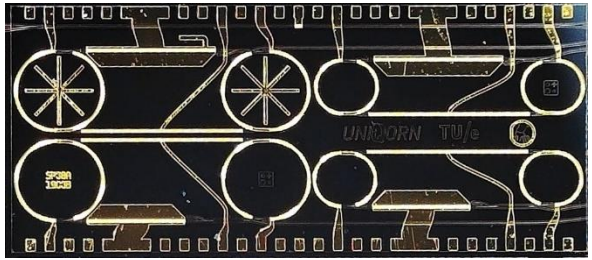


Balanced receiver

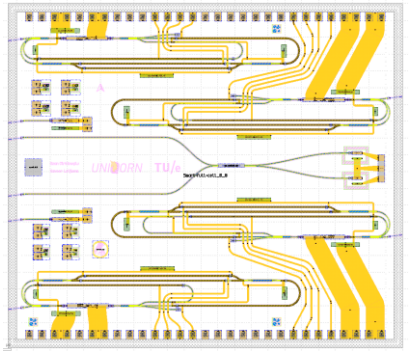




Tunable >30 nm, ~60-kHz linewidth lasers @1550



UNIQORN



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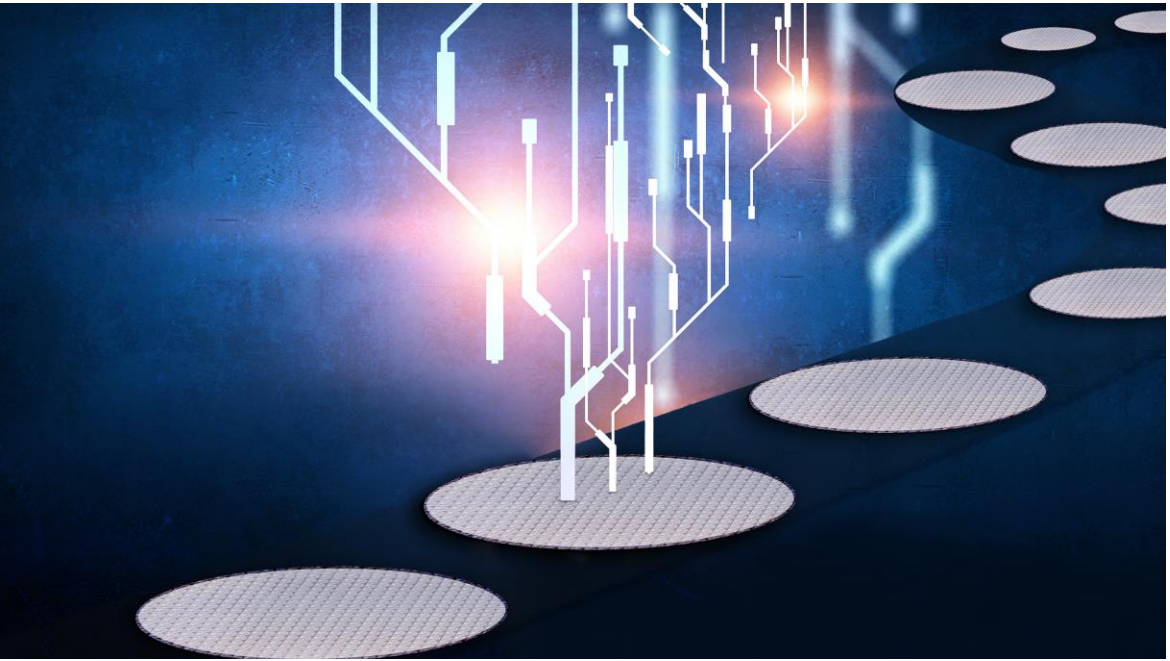
JePPIX Pilot Line



Photonic integrated circuit foundry **to your design** with 15-year track record

Trusted supply chain with foundry-calibrated design

Turn-key solutions for design, mass-manufacture, and automated test

Accelerated development programs with integrated design loops

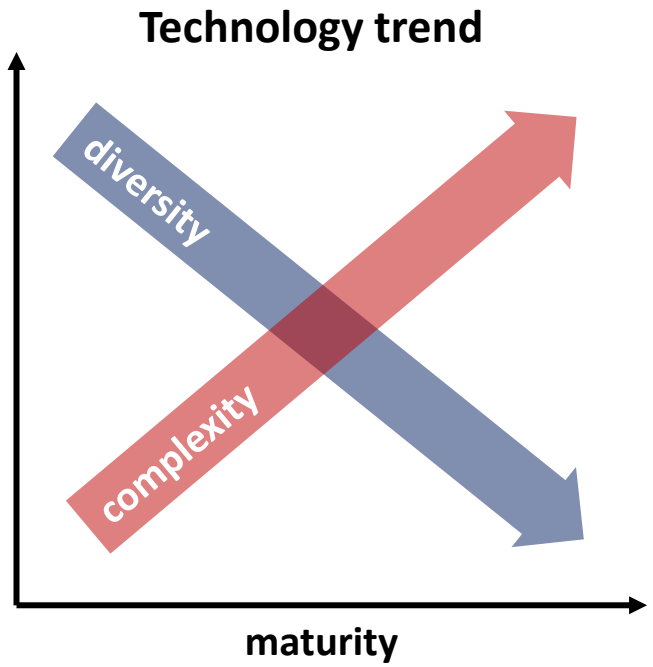
Comprehensive components including **lasers and amplifiers**

Seamlessly from idea to small series and mass production

jeppix.eu/pilotline pilotline@jeppix.eu

But is QT ready for this trade-off?

QT is different...
- diverse wavelengths
- performance, e.g., ultra-low loss
- single photons
- low(er) unit volumes



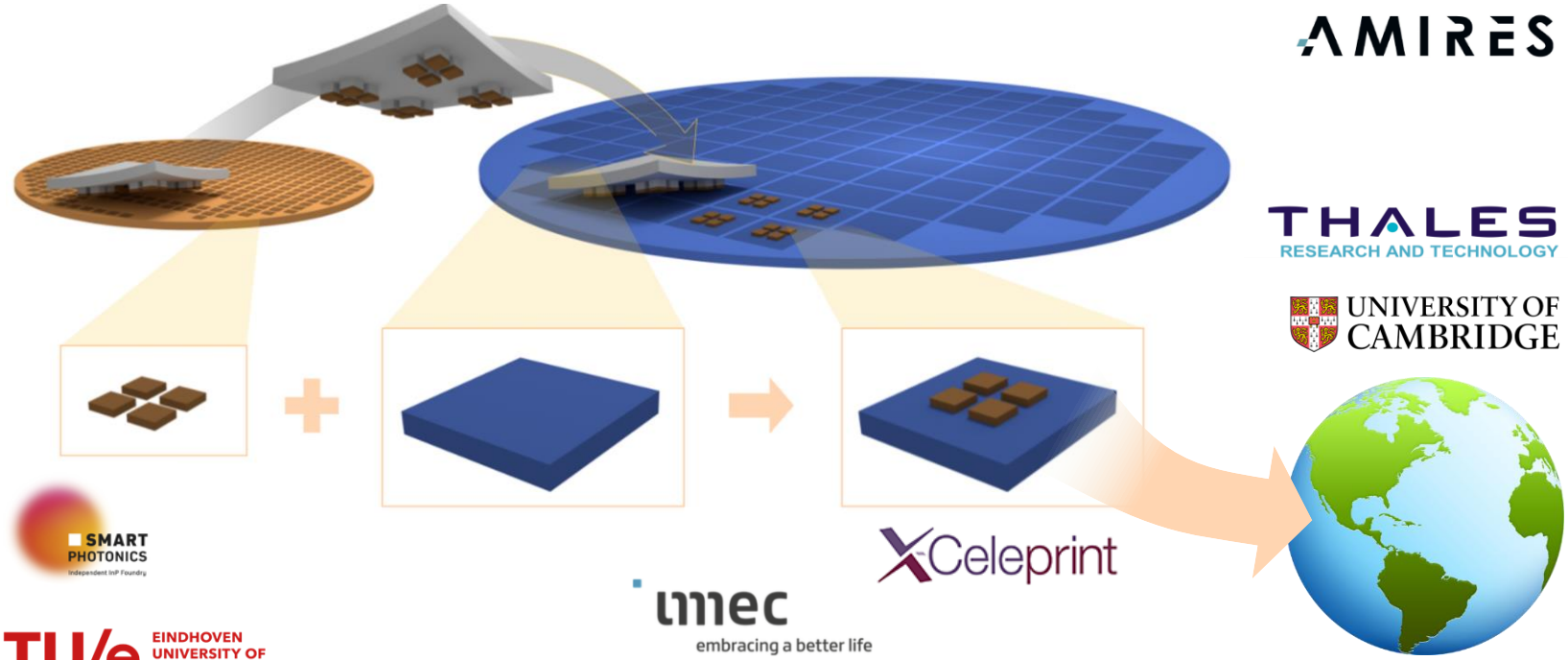
Will we have a QPIC platform? What should it be?

Serve many of the existing QT approaches, so:

- flexible in wavelengths, from visible to IR, and in their combination;
- performance, e.g., ultra-low loss and minimum tolerance margins;
- single photons: options for integrating single photon sources and detectors;
- possibly also addressing ion, cold-atom, superconductor, and diamond approaches;
- low(er) unit volumes are okay;

Our vision is that this calls for a **modular** platform. Our INSPIRE platform could be the basis.

INSPIRE project – micro-transfer printing



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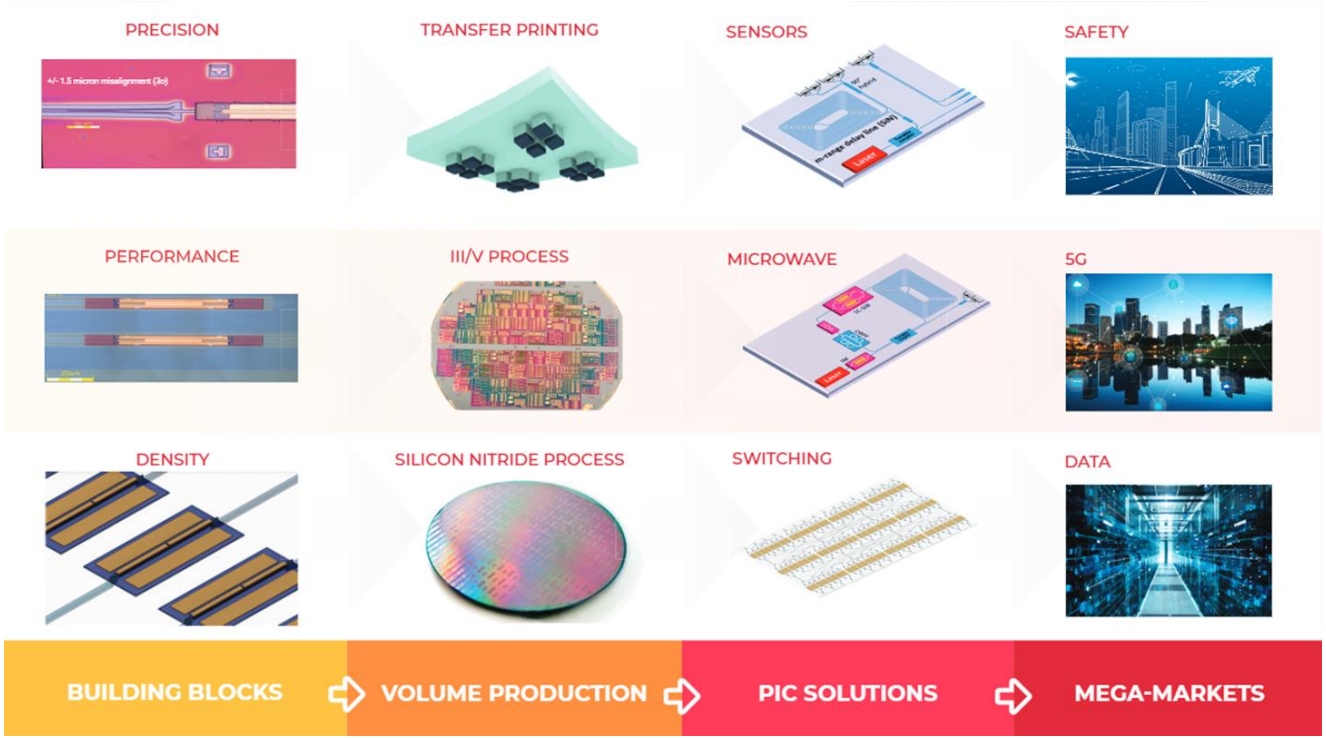
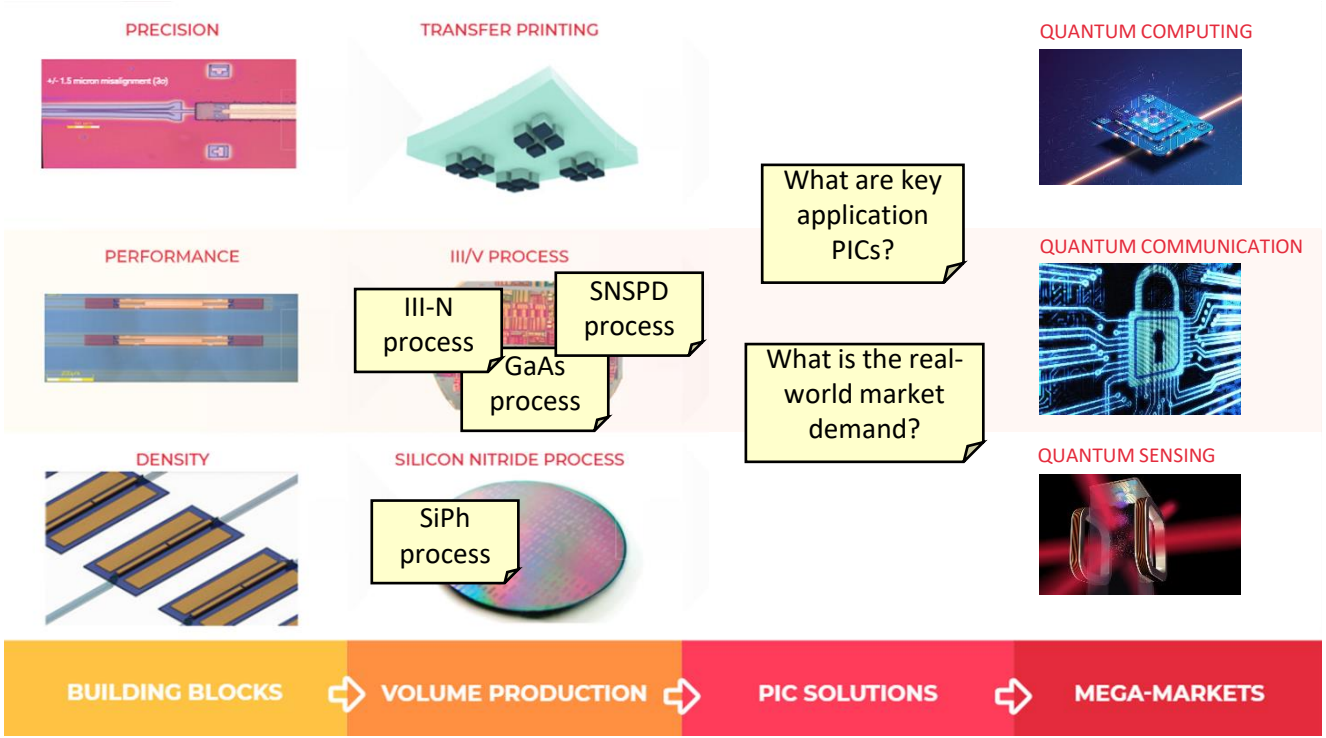
INSPIRE high-level overview



INSPIRE as QPIC platform?



Conclusion

- We already have “QPIC platforms”... for some QT applications
  → most credible route to real technology;
- Modular platforms required for most other QT applications
  → use should be (mostly) beyond QT;
- No consensus on technology roadmap (QPIC specs) yet → field is not ready for scaling;
- Available technology will drive QT, not the other way around... but this is an opinion :-)

Let’s engage and put the T in QT!

Eindhoven Hendrik Casimir Institute – EHCI

https://www.tue.nl/en/research/institutes/eindhoven-hendrik-casimir-institute/

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