

Inaugeratie Fotonica Pilootlijnen

InP Photonic Integration Process Line at TU/e

Frank Dirne, 23 Nov 2022

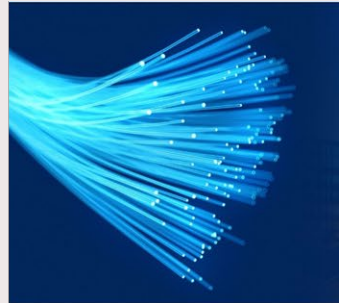


Cleanroom



- 800 m² ISO 5/6 – class 100/1000
- >25 M€ installed equipment base
- Appr. 65 process and analysis tools
- Micro and nano-device fabrication
- 3” wafer size
(options for piece parts and 4” in progress)
- Open access user facility
- 260 users, 32.000 user hrs per year
- External use: 30%
- Internal use TU/e: 70%
- 14 FTE staff (process engineers and technicians)

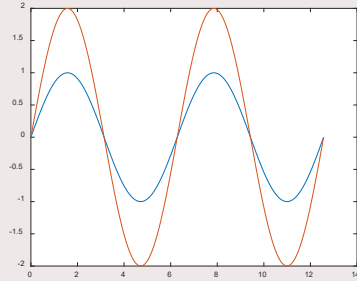
Photonics: science & technology



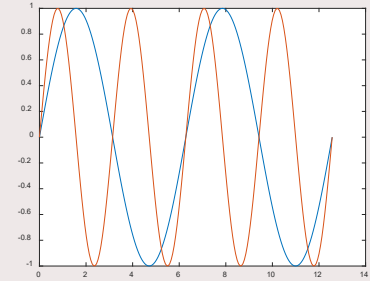
- Photonics is everywhere
- Generation, propagation, modification and detection of light

Controlling properties of light

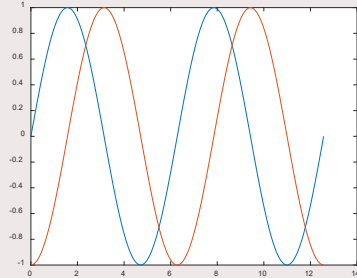
Intensity



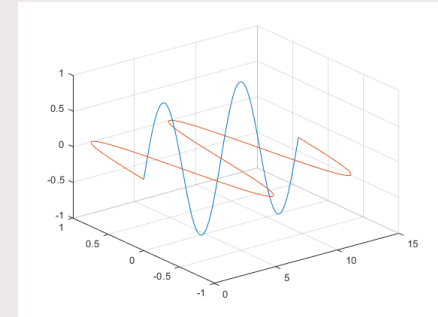
Wavelength



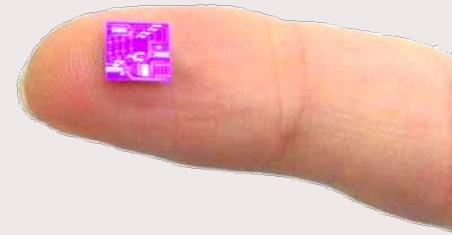
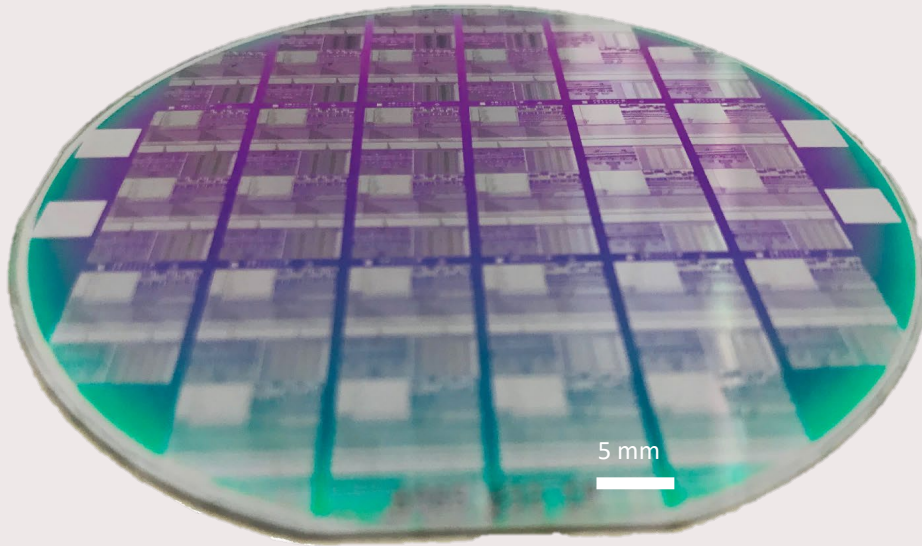
Phase



Polarization



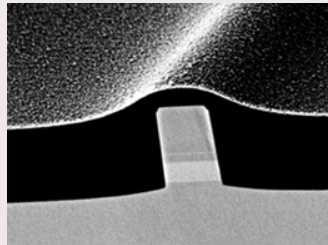
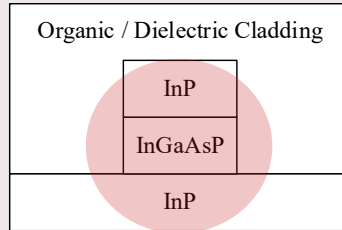
Photonic integrated circuits (PICs)



- Can be manufactured on wafers similar to micro-electronics
- Controlling of light at a micron or even nanometer scale

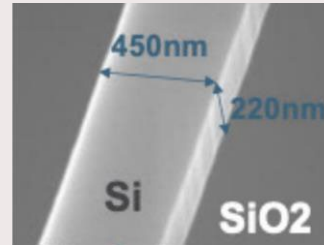
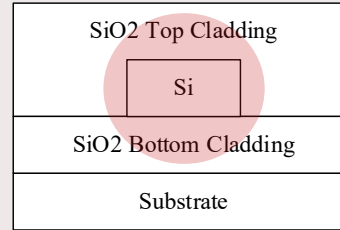
Guiding light on a chip

Indium Phosphide



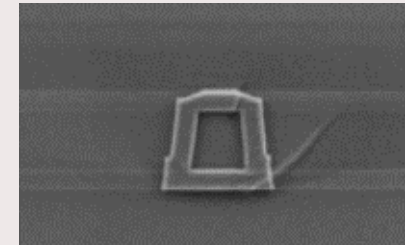
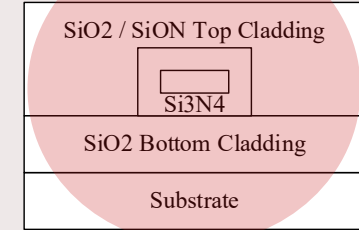
L. M. Augustin *et al.*, "InP-Based Generic Foundry Platform for Photonic Integrated Circuits," *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 24, no. 1, pp. 1–10, Jan. 2018.

Silicon



P. P. Absil *et al.*, "Imec iSiPP25G silicon photonics: a robust CMOS-based photonics technology platform," in *Silicon Photonics X*, Feb. 2015, vol. 9367, p. 93670V.

Silicon Nitride



C. G. H. Roeloffzen *et al.*, "Low-Loss Si₃N₄ TriPleX Optical Waveguides: Technology and Applications Overview," *IEEE Journal of Selected Topics in Quantum Electronics*, vol. 24, no. 4, pp. 1–21, Jul. 2018.

Platform Strengths

TU/e



Building Block	Performance		
	InP	SiP	SiN
Passive components	●●	●●	●●●
Polarisation components	●●	●●	●●●
Lasers	●●●	H	H
Phase modulators	●●●	●●	●
Electro-absorption modulators	●●●	●●	●
Switches	●●	●●	●
Optical amplifiers	●●●	H	H
Detectors	●●●	●●	H

Performance	
●●●	Very good
●●	Good
●	Modest

Fabrication Technology	
H	Hybrid/Heterogeneous

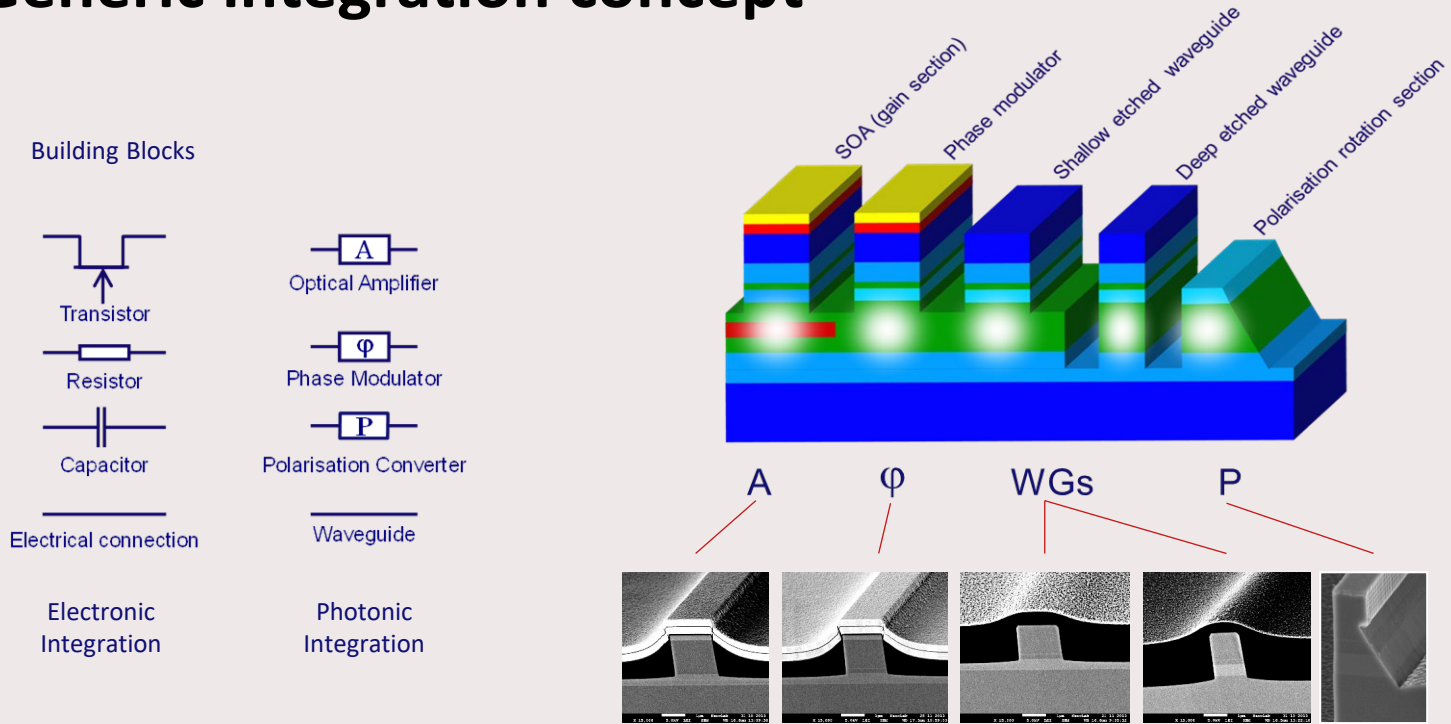
[1]

- Light generation and amplification can only monolithically be done on InP
- Recent fundamental work at TU/e on generating light from silicon [2]

1. JePPIX, "JePPIX Roadmap 2018," *JePPIX*, 2018. <https://www.jeppix.eu> (accessed Nov. 03, 2020).

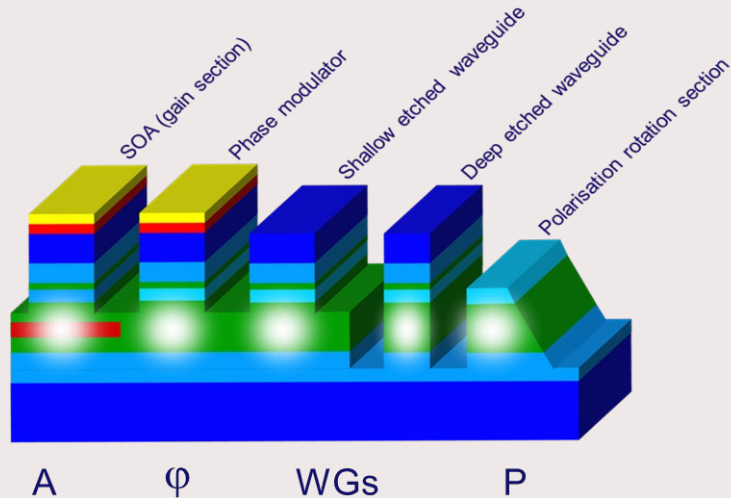
2. E. M. T. Fadaly *et al.*, "Direct-bandgap emission from hexagonal Ge and SiGe alloys," *Nature*, vol. 580, no. 7802, Art. no. 7802, Apr. 2020.

InP Generic integration concept



M. Smit et al., "An introduction to InP-based generic integration technology," Semiconductor Science and Technology, vol. 29, no. 8, p. 083001, Jun. 2014

Key Enabling Technologies



Lithography

Reactive Ion etching

PE-CVD (dielectrics)

MO-VPE (InP based (Ga,As,Al) epitaxial films)

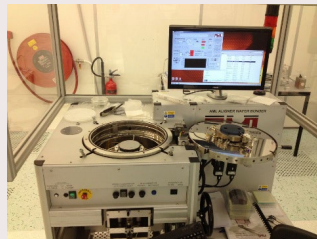
Technology domains : Current scope



Process equipment
OIP4NWE; OIP pilotlijnen



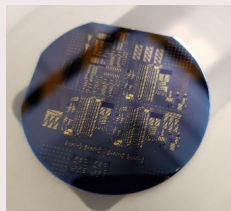
Precision lithography
Precision PICs



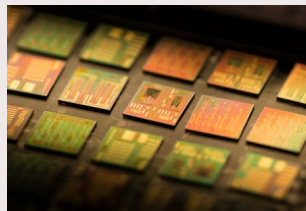
Wafer bonding
Zwaartekracht



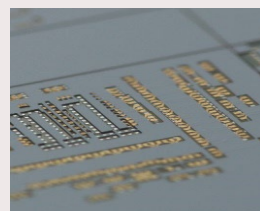
Test automation
Pixapp



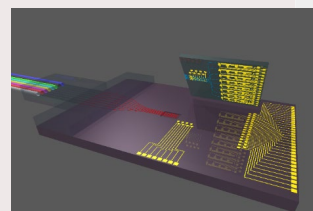
Nanophotonics
IMOS4all;



Foundry model
JePPIX; InPulse



Electronic integration
WIPE



Assembly
Flexfix



25

OIP4NWE and OIP Pilotlijnen – bridging the TRL gap

Infrastructure Nanotechnology



1	2	3	4	5	6	7	8	9
Basic Principle Observed	Techn Concept Formulated	Exp Proof of Concept	Techn Validation in lab	Techn Validation Relevant Environment	Demo in Relevant Env	Demo in Operational Env	System Complete and Qualified	Successful Mission Operations

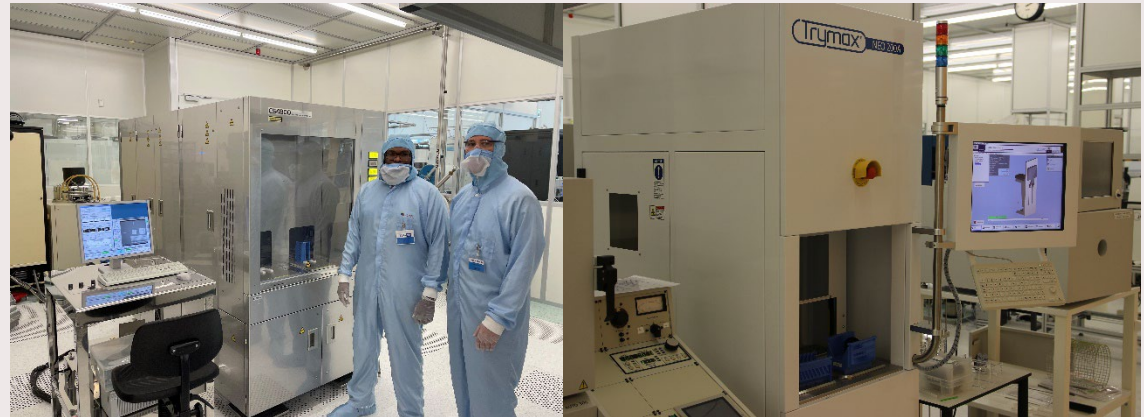
Open-Access Nanolab

Foundries
Production facilities
Industry

Key Process Technologies at highTRL

Lithography cluster (existing):

- ASML 192 nm scanner
- CD-SEM
- Trymax resist strip



SPTS cluster – RIE en PE-CVD

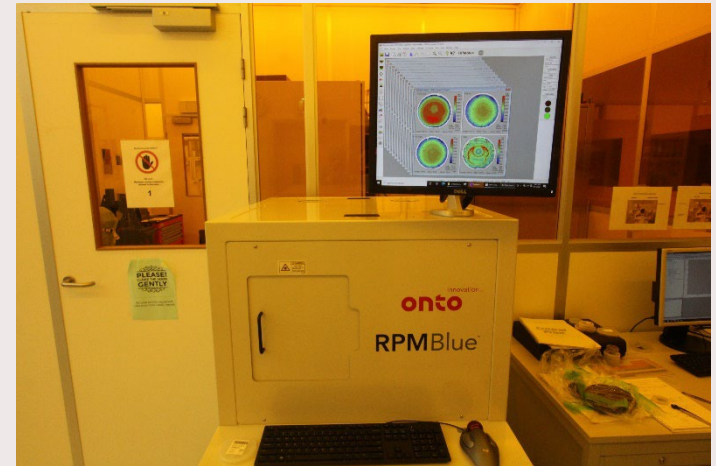
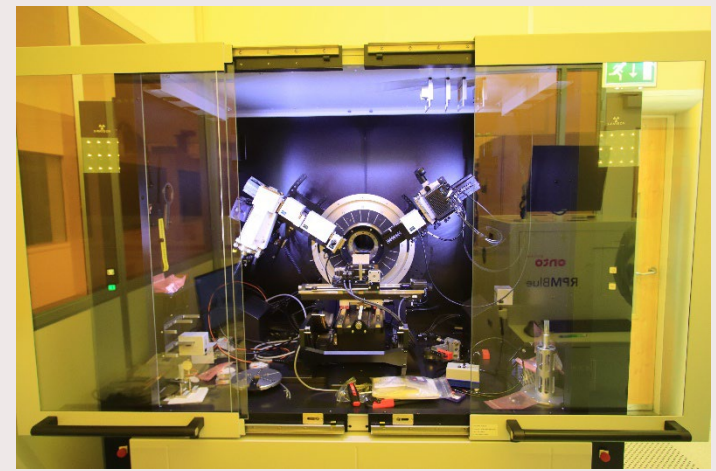
Aixtron Gen 5 MOVPE reactor



Analysis of epitaxial films

- Bruker XRD
- Onto Innovation PL Mapper

Epitaxial growth – upgrade of R-reactor



Thank you for your attention

