



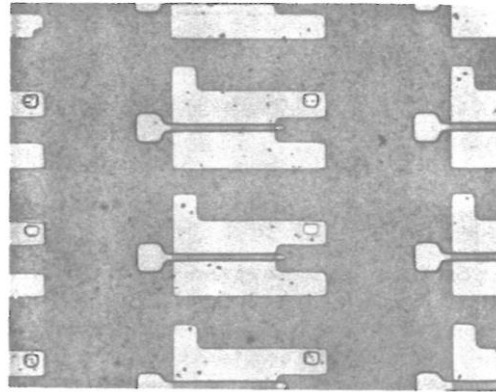
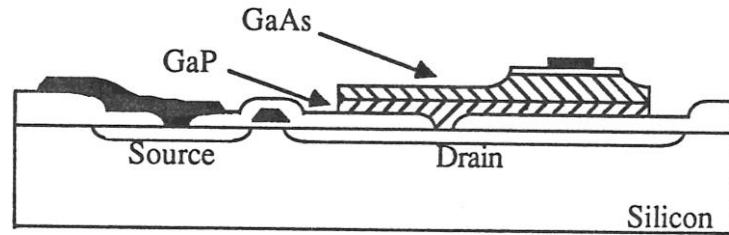
mec

LOW-COST PATHWAYS TO VOLUME PRODUCTION FOR
CMOS ASICS AND PHOTONIC ICs

PHILLIP CHRISTIE

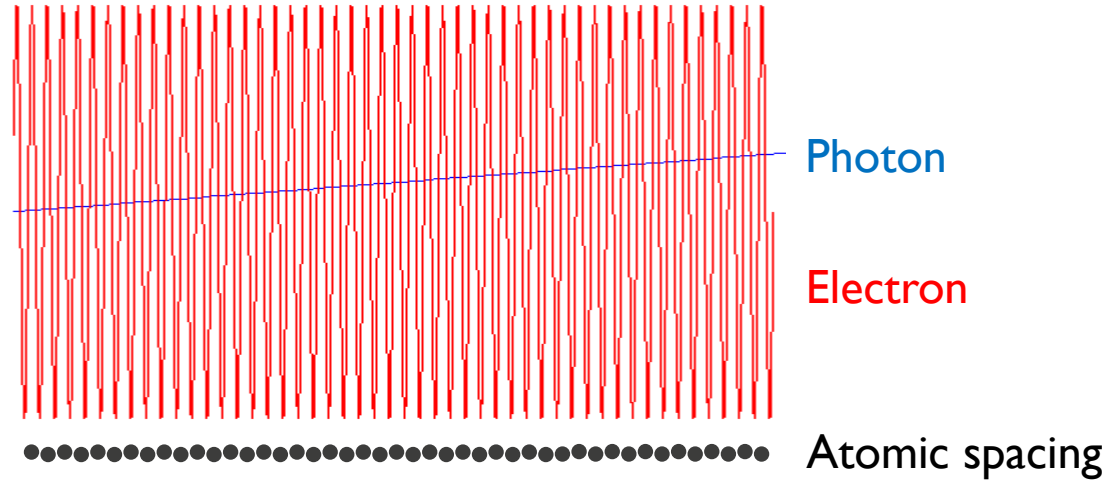
PHOTONS AND ELECTRONS

CO-DESIGN

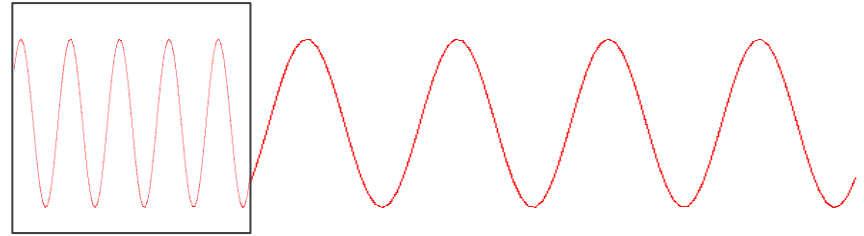
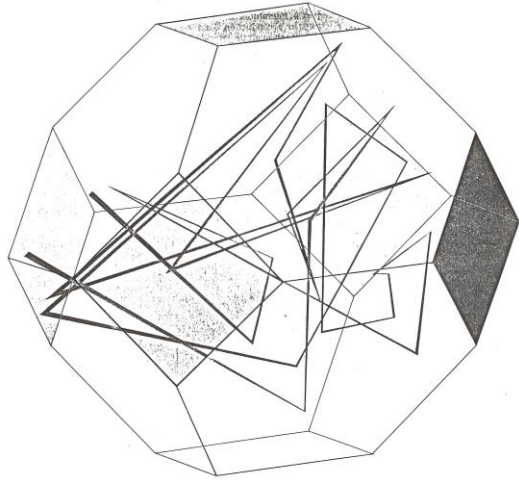


PHOTONS AND ELECTRONS

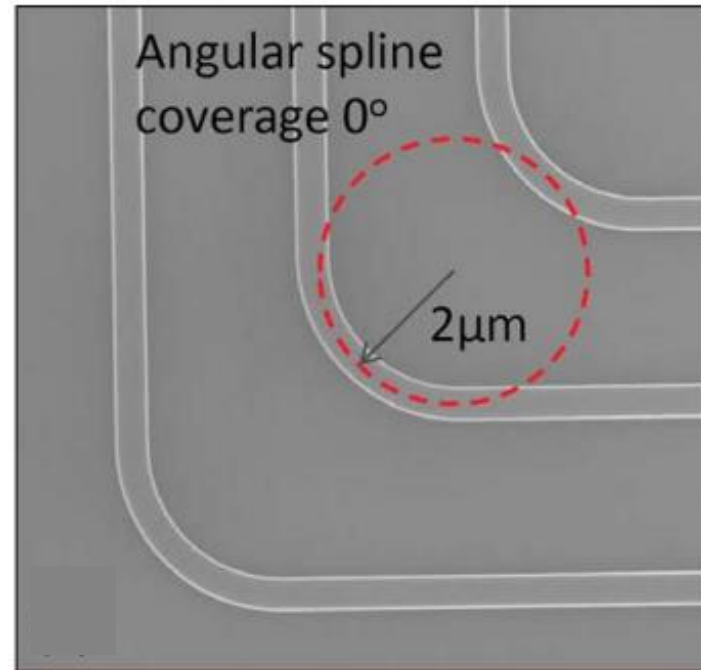
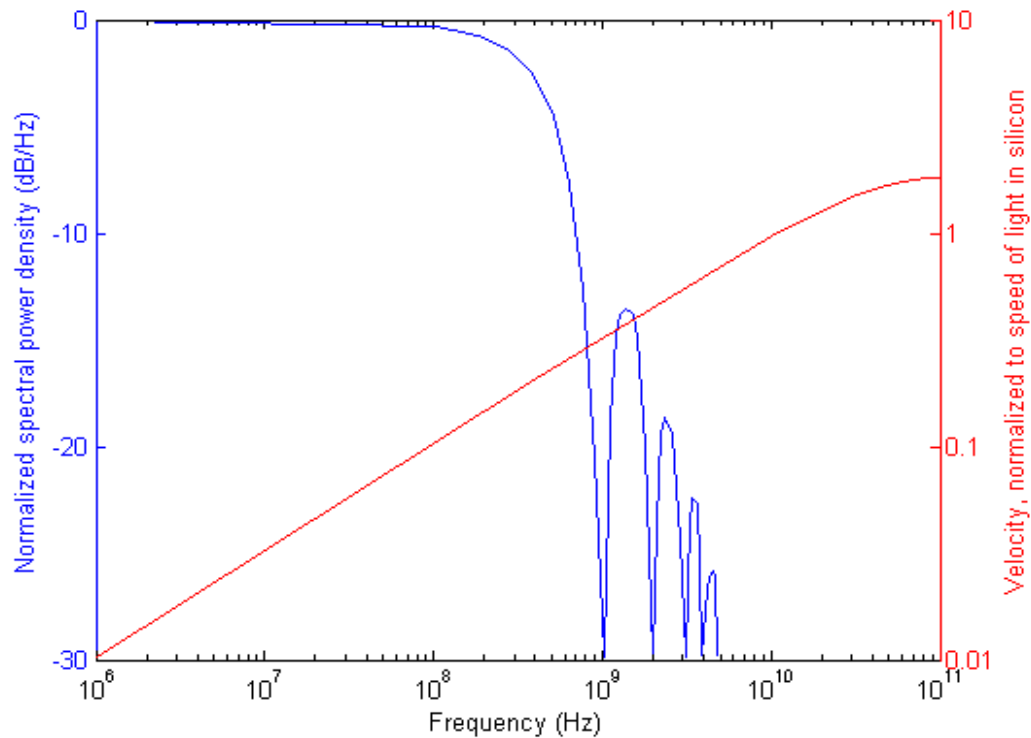
FREE SPACE



PHOTONS AND ELECTRONS IN MATERIALS

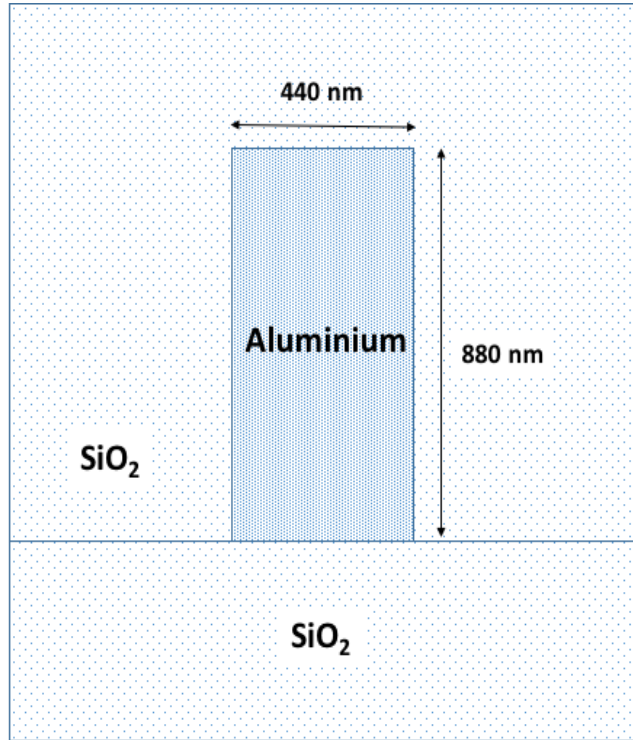


PHOTONS AND ELECTRONS IN WIRES

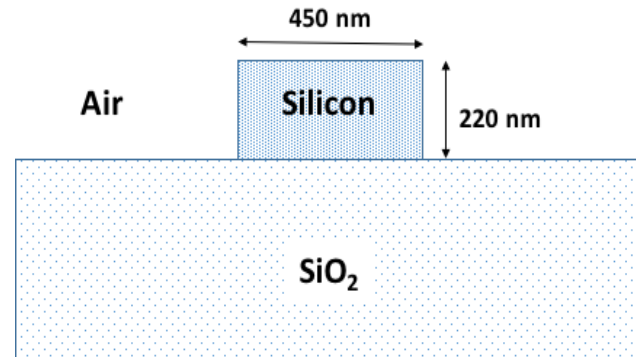


PHOTONICS AND ELECTRONS

PROCESSING COSTS



180nm ASIC



PIC

PHOTONS AND ELECTRONS

APPLICATIONS



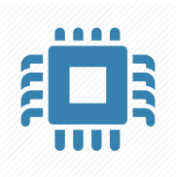
Photon's THz coherent bandwidth and high propagation speed at successively shorter distances



Narrow spectral bandwidth of photons lead to applications in molecular spectroscopy, remote sensing, medical applications



Resonant (ring) structures can be sensitized to a wide variety of compounds and biological molecules



Control and processing of photonic data input is ideally suited to low-cost digital ASICs

- ADC/DAC
- Heater control
- Error correction

FOUNDRY ACCESS

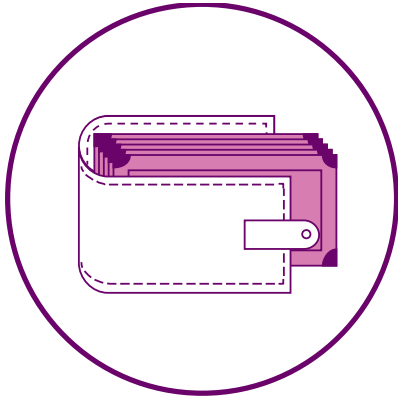
SMALL VOLUME PRODUCTION AND PROTO-TYPING



- imec.IC-link is an accredited TSMC Value Chain aggregator
- 500 tape-outs per year
- 175+ PIC designs since 2011
- From 24 countries
- MPW PICs, active and passive runs

LOW COST

MULTI-PROJECT WAFER (MPW) RUNS



- 180nm
- 45 samples
- 25mm²
- €16k
- ISiPP50G
- 20 samples
- 25mm²
- €40k

IP PROTECTION

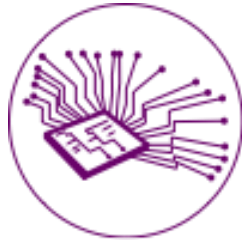
ASICS ARE HARD TO COPY



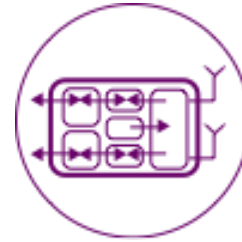
- Patents provide protection only if you can enforce them
- PCBs are easy to reverse engineer
- Extremely difficult and expensive to reverse engineer an ASIC



FOUNDRY ACCESS

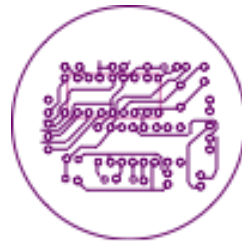


TEST



DESIGN & IP

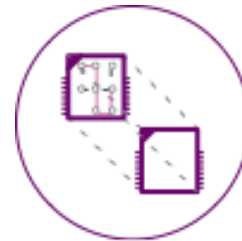
imec **IC link**



PCB/PBA



IMEC RESEARCH



ASSEMBLY

90NM DEDICATED MASK EXAMPLE

13 MM² WIRELESS CAMERA

Dedicated mask NRE costs

Mask cost	\$480,000
Engineering lot (6 wafers)	\$20,000
Total dedicated mask NRE costs	\$500,000

Dedicated mask wafer processing costs

Processing cost	\$3,000
Wafer area (cm ²)	730
Dies per wafer	5600
Processing cost per die	\$0.5



All numbers are approximate and do not represent market prices

90NM MPW EXAMPLE

13 MM² WIRELESS CAMERA

MPW NRE costs

Minimum production cost (inc 1 wafer)	\$50,000
Dies per wafer	100
Minimum die area (mm ²)	16
Actual die area (mm ²)	13
Actual MPW cost	\$50,000
Processing cost per die (first wafer)	\$500

MPW wafer processing costs

Additional wafer cost	\$6,000
Processing cost per additional die	\$60

All numbers are approximate and do not represent market prices



180 NM EXAMPLE

11 MM² SENSOR NETWORK CHIP

MPW NRE costs

Minimum production cost (inc 1 wafer)	\$25,000.00
Dies per wafer	40
Minimum die area (mm ²)	25
Actual die area (mm ²)	11
Actual MPW cost	\$25,000.00
Processing cost per die (first wafer)	\$625.00

MPW wafer processing costs

Additional wafer cost	\$2,000.00
Processing cost per additional die	\$50.00

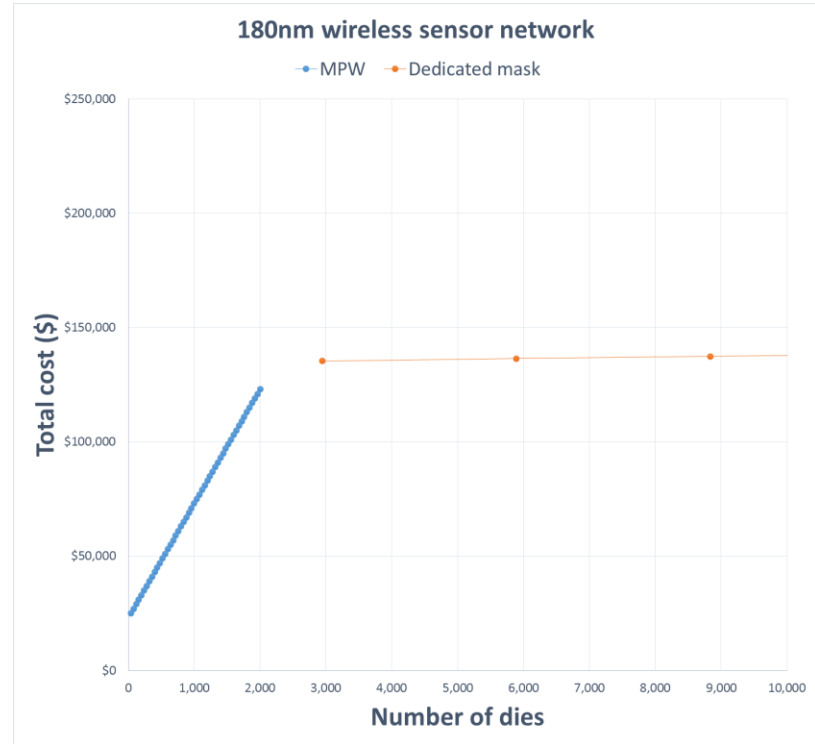
Dedicated mask NRE costs

Mask cost	\$120,000.00
Engineering lot (12 wafers)	\$14,400.00
Total dedicate dmask NRE costs	\$134,400.00

Dedicated mask wafer processing costs

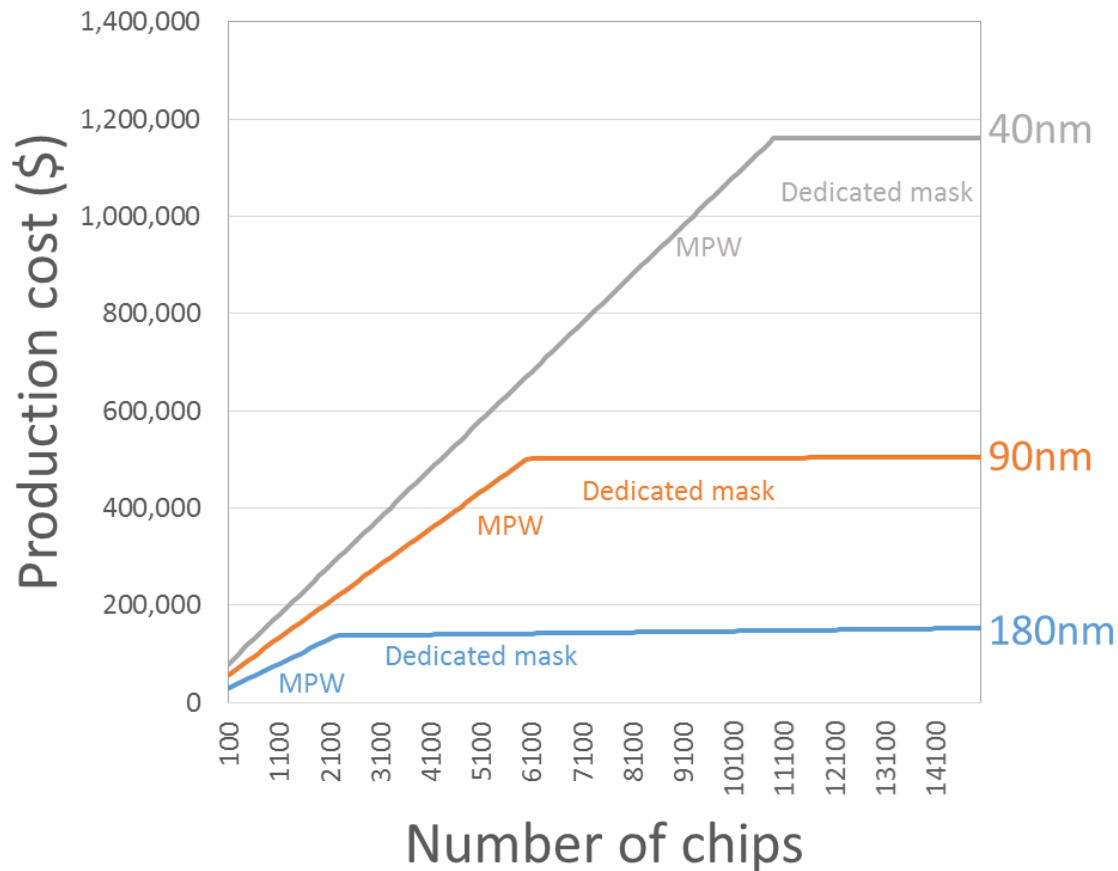
Processing cost	\$1,000.00
Wafer area (cm ²)	324
Dies per wafer	2945
Processing cost per die	\$0.34

All numbers are approximate and do not represent market prices



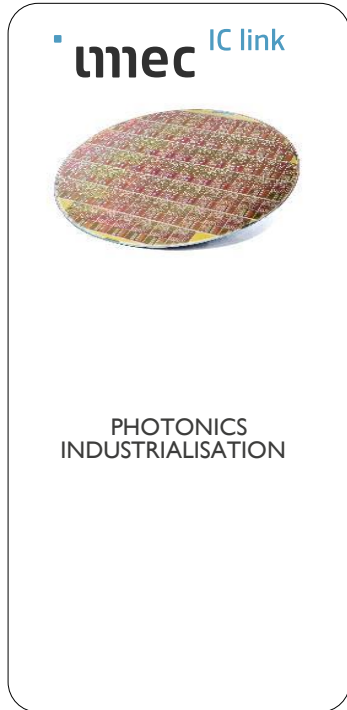
PRODUCTION AND NRE COST

OVERVIEW



All numbers are approximate and do not represent market prices

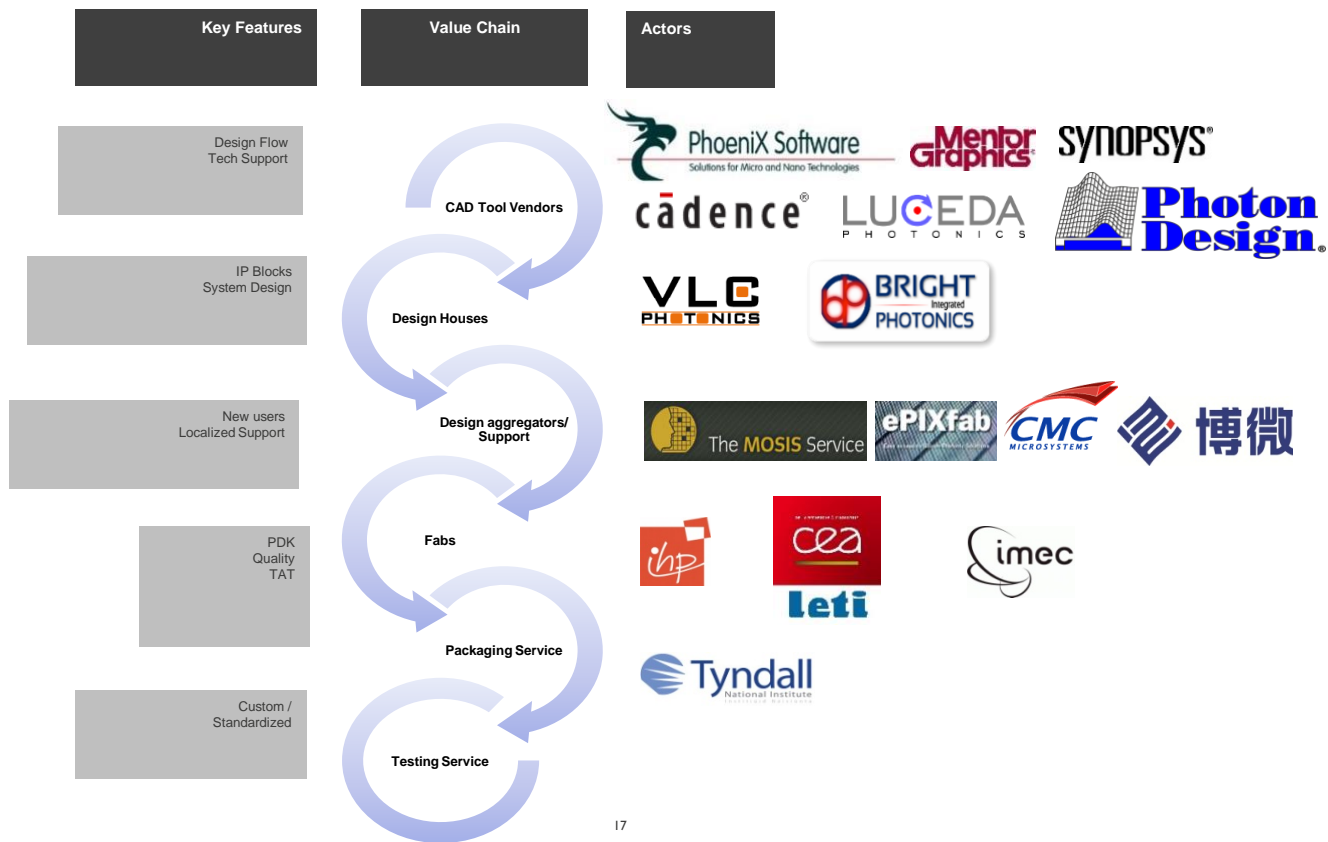
IMEC SILICON PHOTONICS



- MPW service and Low Volume Production
 - 2 passive and 2 active MPW runs per year
 - Dedicated runs and production on request
- More than 175 photonics ICs taped-out since 2011

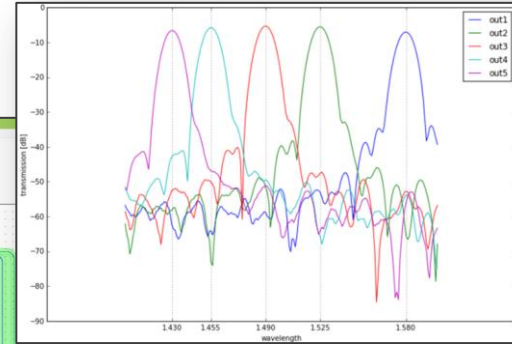
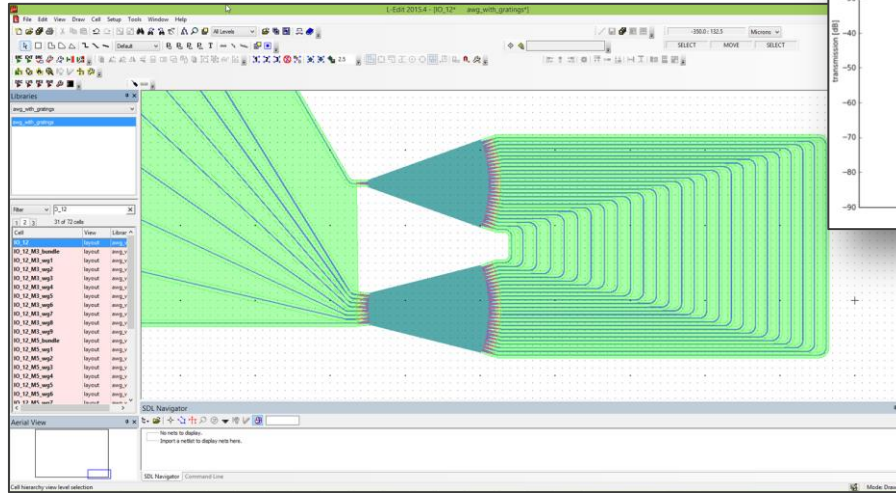
IMEC SILICON PHOTONICS

GROWING ECOSYSTEM FOR SERVICES



PHOTONIC EDA AND DESIGN

LAYOUT IS KEY TO OPTIMIZE YIELD



PIC EXAMPLE

5x5mm²

MPW NRE costs

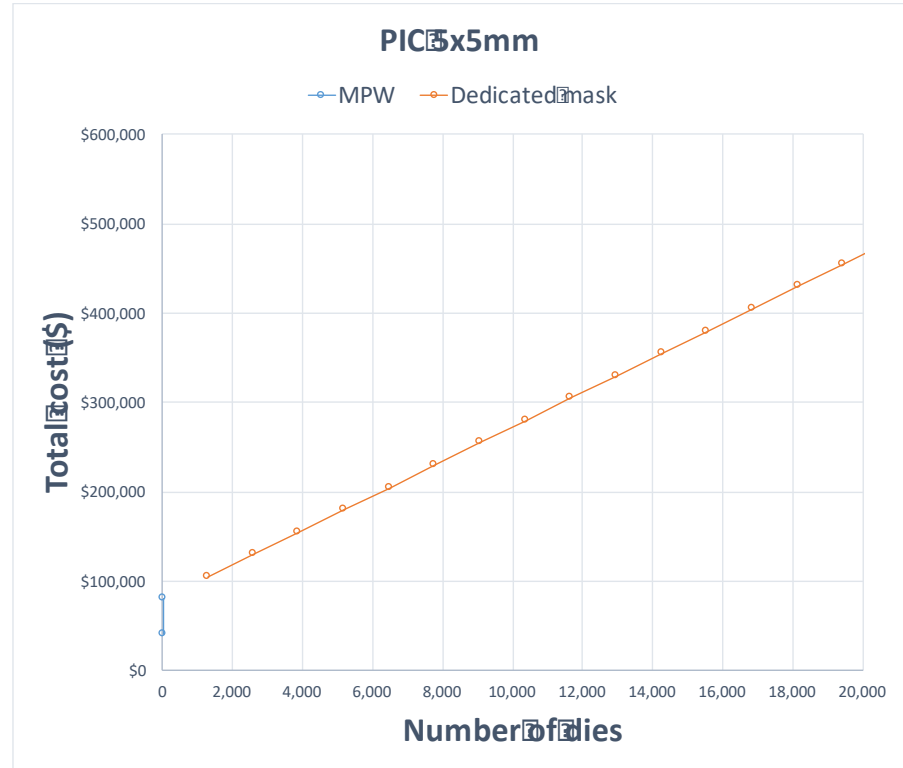
Minimum production cost	\$40,000
Dies per wafer	20
Processing cost per additional die	\$2,000

Dedicated mask NRE costs

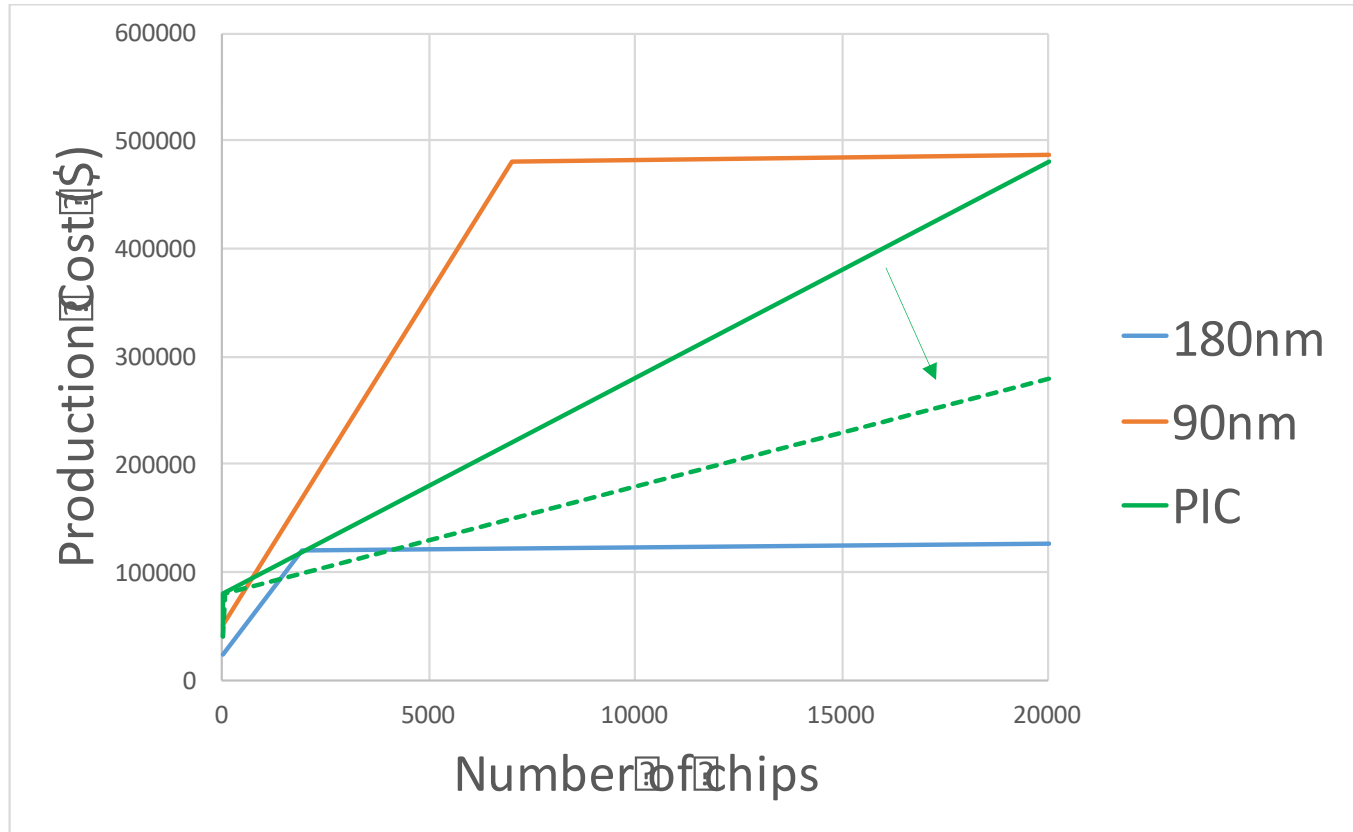
Mask cost	\$80,000.00
-----------	-------------

Dedicated mask wafer processing costs

Processing cost	\$25,000
Wafer area (cm ²)	324
Dies per wafer	1256
Processing cost per die	\$20

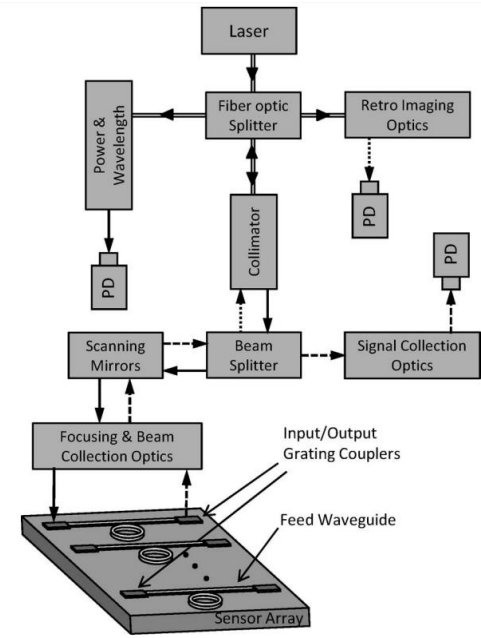
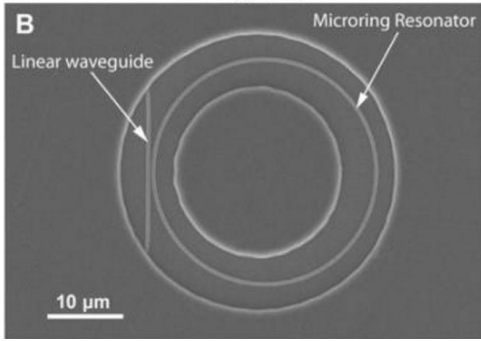
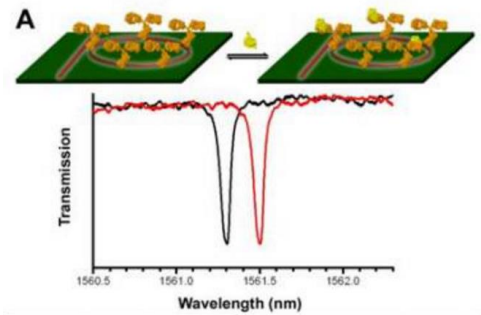
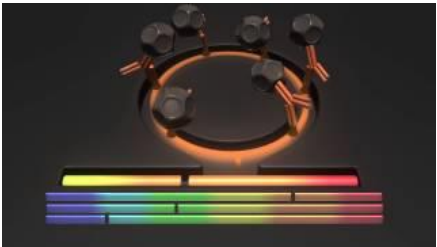


PIC AND ASIC PRODUCTION AND NRE COSTS COMPARISON



PASSIVE DEVICES : USE CASE

GENALYTE EXAMPLE - PASSIVE CIRCUITRY USED AS BIOSENSOR

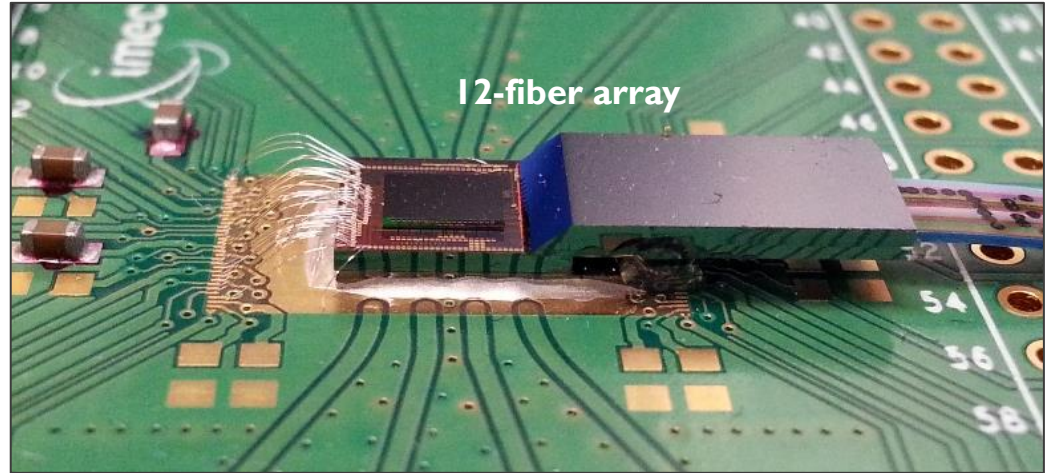
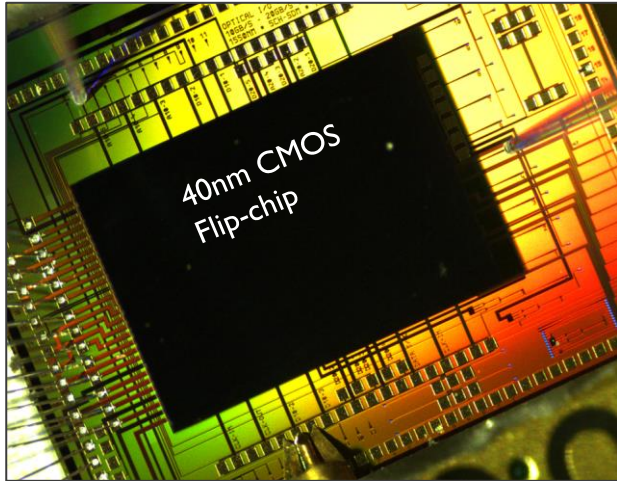


REFERENCES:

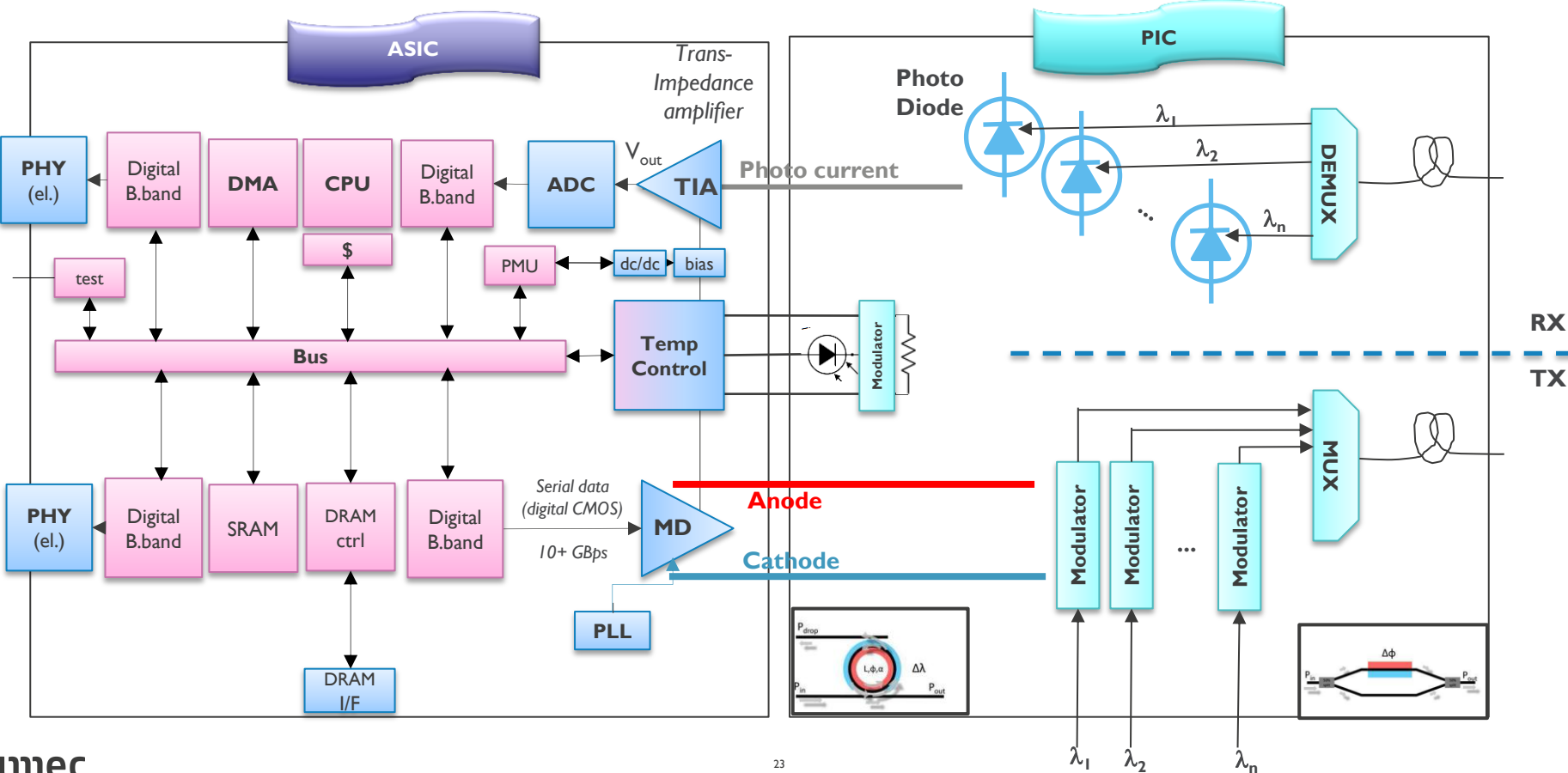
- Washburn, Adam L., L. Cary Gunn, and Ryan C. Bailey. "Label-free quantitation of a cancer biomarker in complex media using silicon photonic microring resonators." *Analytical chemistry* 81.22 (2009): 9499-9506.
- Iqbal, Muzammil, et al. "Label-free biosensor arrays based on silicon ring resonators and high-speed optical scanning instrumentation." *IEEE Journal of Selected Topics in Quantum Electronics* 16.3 (2010): 654-661.

ACTIVE DEVICES : USE CASE

ASIC CONTROL OF PIC

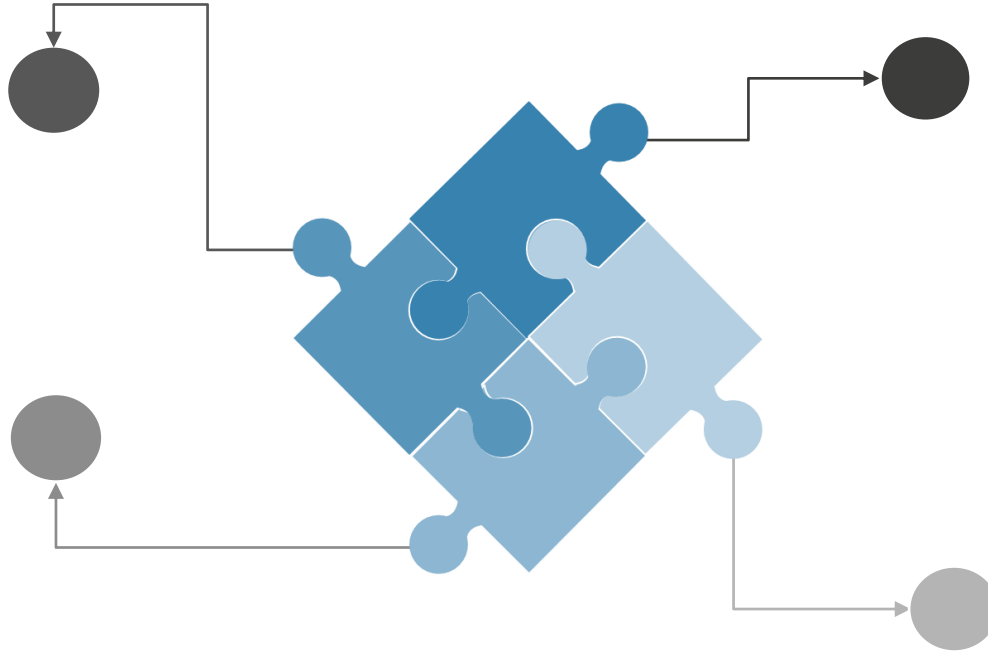


CO-DESIGN PIC/ASIC SYSTEM



imec
Offers low-cost industrialization pathways for both CMOS ASICs and PICs

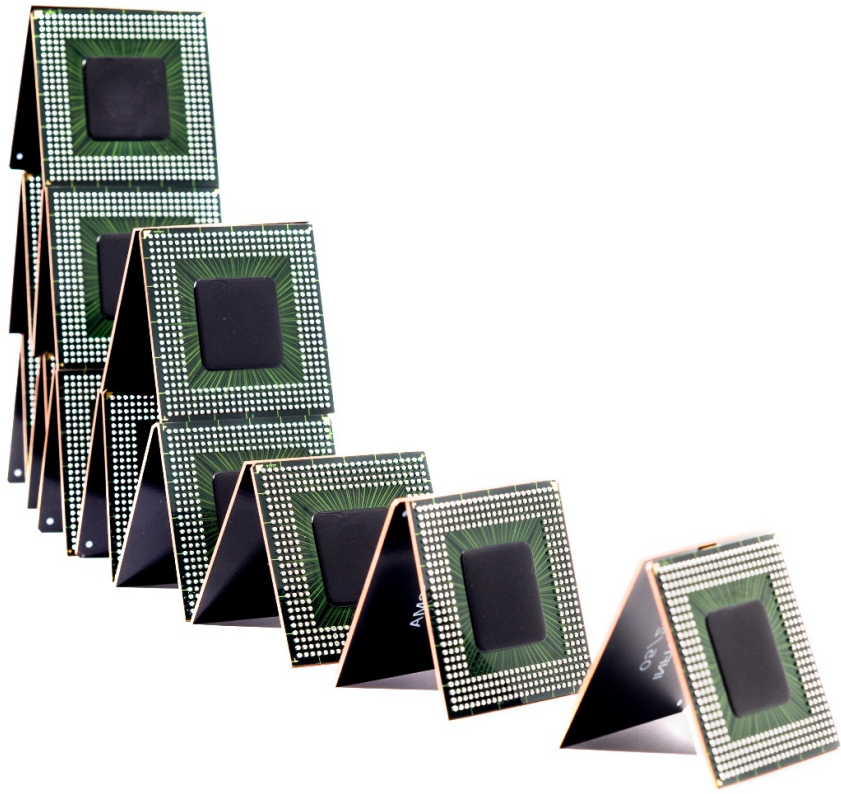
Substream Innovation Business Model
Enabling innovation in a fragmented market



Photonics
offers coherent sensitivity with applications in sensing, spectroscopy and long-haul data-com

Electronics
Low-cost ASICs provide accessible wireless and digital processing power

■ umec IC link



COMMITTED TO
MAKING GREAT
PRODUCTS HAPPEN