

FOUNDRIES OVERVIEW

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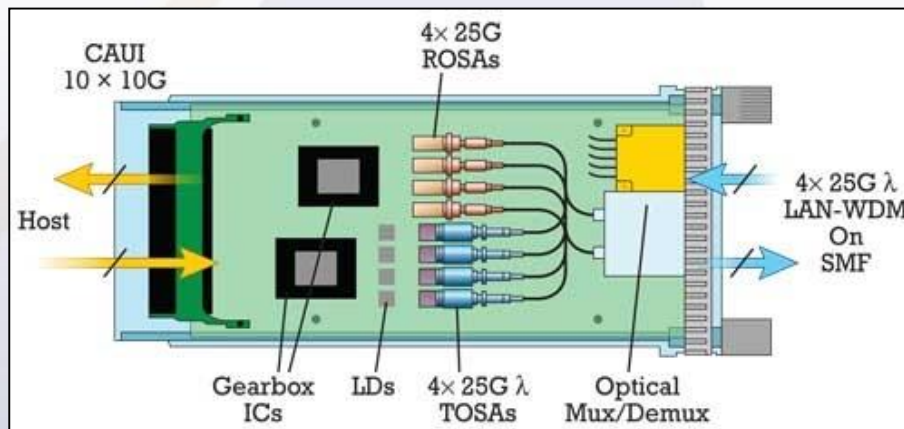


Stories

- WAN, MAN, LAN, HAN, BAN/NFC..IAN (40G-400G-)



- Bioensors/ Medical



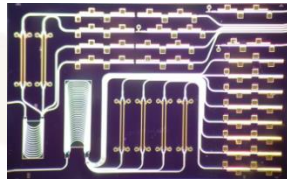
Source: Jon Anderson (Opnext) ,
Nov.1, 2011 Lightwave

- Structural health monitoring, LIDAR, military etc.

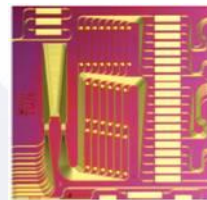
If You Need a PIC, Where Do You Go?

- You need an application specific PIC

Fiber to the Home
Wireless



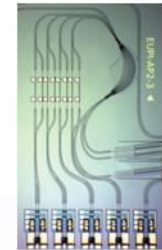
Medical
Bio-imaging



Datacom
Switching



Sensor
Readouts



- Please note that electronic ICs have paved the road for 50 years
- You need to decide on material and foundry
 - Options: InP, Silicon, or TriPleX (excluding PLC and LiNbO₃)
- Also need to decide on MPW vs. a custom run
 - MPW reduces costs, but custom runs may be needed in the end anyway (for volume and/or for unique performance)

Decide on a Material: InP, Si, TriPlex

Active materials (lasers...)
only possible in InP



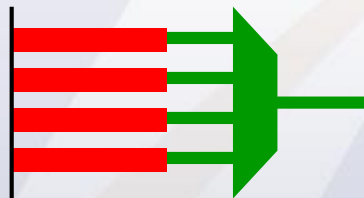
SOA



Fabry-Perot lasers



Tunable DBR lasers



Multiwavelength lasers



Picosecond pulse laser

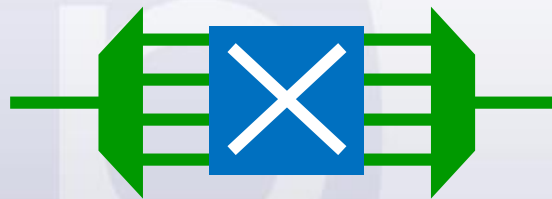
Switches & modulators
possible in InP & Silicon



Phase modulator



Amplitude modulator

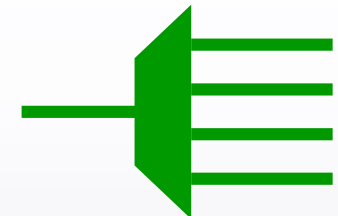


WDM crossconnect
WDM add-drop

Passives possible in InP,
Silicon, and TriPlex



MMI-couplers
MMI reflectors



AWG-demux



Ring filters



Thermo optic
phase modulator

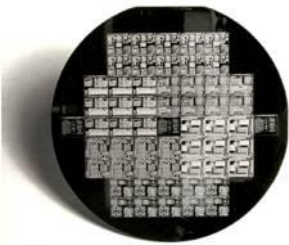
Comparing MPW offers in InP, Si, TriPleX

Broker	Process	Lasers	SOAs	TDBR	Modulators / Phase shifters				Detectors			Prop loss
					L (mm)	Vp - Pp	Loss (dB)	B (GHz)	R(A/W)	B (GHz)	I _{dark} (nA)	dB/cm
JePPIX	Oclaro TxRx 10G	YES	YES	YES	1	3.5	< 2	> 10	0.8	10		2-3
JePPIX	HHI TxRx 25G	YES	YES	YES	0.5	(25 mW)	< 2	(kHz)	0.8	40	< 10	1-2
JePPIX	SMART TxRx 10G	YES	YES		2	7	< 2	10	0.8	10	< 20	3-4
JePPIX	TriPleX (DS-500-170)				1-2	(500 mW)	< 0.1	(kHz)				< 0.5
VTT	VTT 3 μm SOI				1		< 0.1	(kHz)				0.1-0.15
Europractice	Imec ISIPP25G+				1.5	7	6	20	0.7	> 50	< 50	1.5-2.5
Europractice / LETI	CEA-LETI Si310-PHMP2M				1 - 4	< 7.5	< 2.5	< 25	0.7	30	< 10	< 2.5
Europractice	SG25_PIC				2,3,4	7.5	5	15	0.8	60	50	1.5-2.5

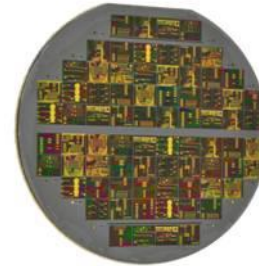
- TriPleX & VTT 3 μm SOI lowest losses. TriPleX suitable for visible light
- For active components with gain, only InP can be used
- E.g. for modulators & detectors, InP and Silicon have comparable performance
- Silicon is key for high integration density, reproducibility, and volume scalability

Deciding on MPW vs. Custom Runs...

- Multi Project Wafer (MPW) shares cost between users



MOSIS started MPW in Electronics ICs in 1981



Photonics MPW now by JePPIX, EURO PRACTICE, LioniX, and MOSIS

- Lower cost is ideal for prototyping
- MPW broker provides complete ecosystem
- MPW uses a generic platform
- Custom runs may be beneficial in volume
 - Can run more frequently
 - Can optimize process for better yield or unique performance

MPW vs. Custom: Generic Processes

- MPW users all share the same generic process
 - Imposes limits, but comes with a library of building blocks
 - “Lego” building blocks allow for virtually all chips
 - >350 PICs developed in generic fabs via MPW runs



- There are several key MPW brokers:
 - Europractice-IC for Silicon photonics
 - LioniX for TriPleX material ($\text{Si}_3\text{N}_4/\text{SiO}_2$)
 - JePPIX for InP: Smart Photonics , Oclaro, and HHI
 - AIM Photonics won the IP-IMI award in US
 - Each MPW broker brings its own solution ecosystem

List of Brokers for MPW foundries

Technology	Broker	Runs/Year
Silicon Photonics		
Imec PSV	Europpractice/MOSIS	2
Imec ISIPP25G+	Europpractice/MOSIS	3
CEA-LETI Si310-PH	Europpractice	2
CEA-LETI Full Platform SI310-PHMP2M	CEA-LETI	1 (available 2016)
IHP PIC	Europpractice	1
VTT	VTT	1
IME Full platform	IME	3
Indium Phosphide		
SMART Photonics	JePPIX	3..4
Oclaro	JePPIX	1
Fraunhofer HHI	JePPIX	2
Silicon Nitride		
LioniX	LioniX / JePPIX	3..4

Si Photonics MPW Foundries

Technology	IHP	Imec	LETI NEW!	VTT
SOI Type	SOI 220nm/2µm BOX	SOI 220nm/2µm BOX	SOI 310nm/800nm BOX	SOI 3µm/3µm BOX
Access	Europractice	Europractice/MOSIS	Europractice/LETI	VTT
Passive SOI etching steps	2	3+1poly	3	3
PDK Tools	IPKISS/TexEda/ (PhoeniX Software)	Mentor Graphics/ Synopsys/IPKISS/ PhoeniX Software	Cadence/ PhoeniX Software/ Mentor Graphics	PhoeniX Software
Min Critical Dimension on Mask	130nm	130nm	120nm*****	600nm
Minimum Cost Euro/mm ²	180**	278** / 1508*****	124** / 935***	120**/ 250***
Polarization Dependence	TE only	TE only	TE only	Low
Packaging	Tyndall Institute	Tyndall Institute	Tyndall Institute	VTT
Passives Building blocks	x	x	x	x
Active Building blocks	x	x	x	Thermo optical
Minimum number of Die	25	25	15*	1 large or 8 small
Low volume production	x	x	x	x

Notes: *) Mini block available for academic
 **) Cost for passive only
 ***) Cost for Heater technology
 ****) Cost for active
 *****) Compatible design rules with 300 mm industrial foundry

InP photonics platforms

Building Blocks InP	2015		
	Fraunhofer HHI	SMART Photonics	Oclaro
Passive waveguide	3 etch depths	2 etch depths	2 etch depths
SOA	✓	✓	✓
Photodetector	40 GHz	10 GHz	10 GHz
Electro-refractive phase modulator		10 GHz	10 GHz
Injection-type electro-refractive modulator		✓	1 GHz
Tuneable Bragg grating / reflector	✓	*2016	✓
DFB lasers	✓		
Spot-size converter	✓		✓
Polarisation rotation section	✓		
Access	JePPIX	JePPIX	JePPIX - Oclaro
PDK Tools	PhoeniX Software /ASPIC /PhotonDesign	PhoeniX Software	PhoeniX Software /ASPIC /PhotonDesign
Packaging templates	Linkra/Technobis	Linkra/Technobis	Linkra/Technobis
MPW price per mm ² design [€]	450	500	800
Typical IC sizes	2,4,6 x 6 mm ²	4 x 4.6 mm ²	2,4,6 x 6 mm ²
Number of chips from MPW	4-8	6	8

Comparison of Costs for MPW PICs

Broker	Process	MPW die size mm ²	Price EUR	MPW cost/mm ²	Chips per MPW run	Material
JePPIX	SMART TxRx 10	2 x 4.6	4500	500	8	InP
JePPIX	HHI TXRx 25	3 x 6	5500	300	8	InP
JePPIX	Oclaro TxRx 10	2 x 6	12000	1000	8	InP
JePPIX	TriPleX	16 x 16	16000, 8500*	63	4	Si ₃ N ₄ /SiO ₂
	VTT 3 μm SOI	5 x 10	8000	160	8	Si
Europractice	Imec PSV	6 x 3	5000	280	25	Si
Europractice	Imec ISIPP25G	2.5 x 2.5	10000	1600	10	Si
Europractice	LETI Si310-PH	1.7 x 3.7*	6610*	1050	15	Si
Europractice	IHP-Passive	Custom		180	25	Si

- InP MPWs: 2"- 3" wafers, 50 – 200 chips per wafer
- Silicon Photonics MPWs: 6"-8" wafers, 300 – 5000 chips per wafer
- Perception is that Silicon Photonics is more cost effective at high volume (e.g. datacom)
 - Table shows that InP is cost effective relative to Silicon Photonics
 - Question is what the high volume is and at which cost metrics changes

*) for universities/academia