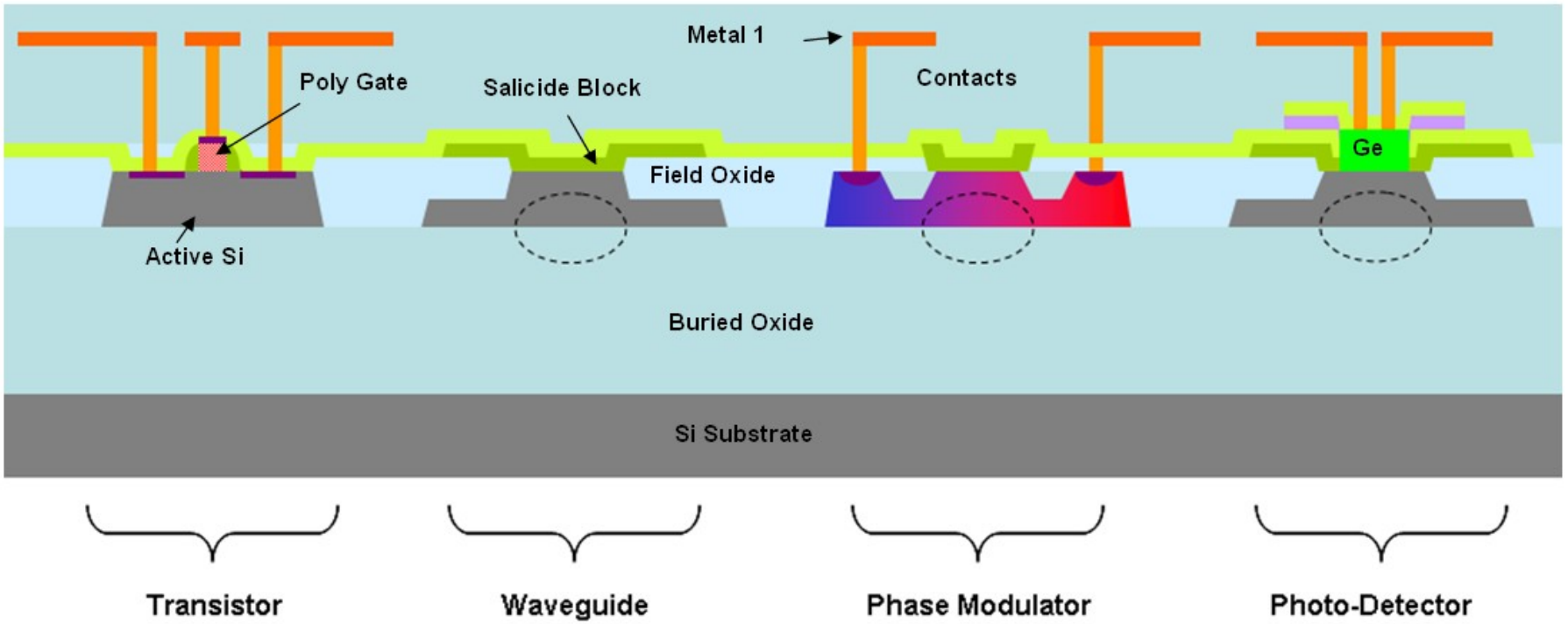
SPE
Silicon Photonics Experiment

- Costruzione e test di un dimostratore di un sistema di trasmissione ad alta banda passante (~10 Gbps) basato su Silicon Photonics
- Durata del progetto: 2 anni
- Interesse del CERN (progetto congiunto CERN-INTEL)

Si-Photonics, a paradigm changing technology?

- Si
  - is an excellent optical material with high refractive index
  - Is widely available in high quality grade
  - Can be processed with extreme precision using deep submicron CMOS processing techniques
- So, why not build a photonic circuit in a CMOS Si-wafer?



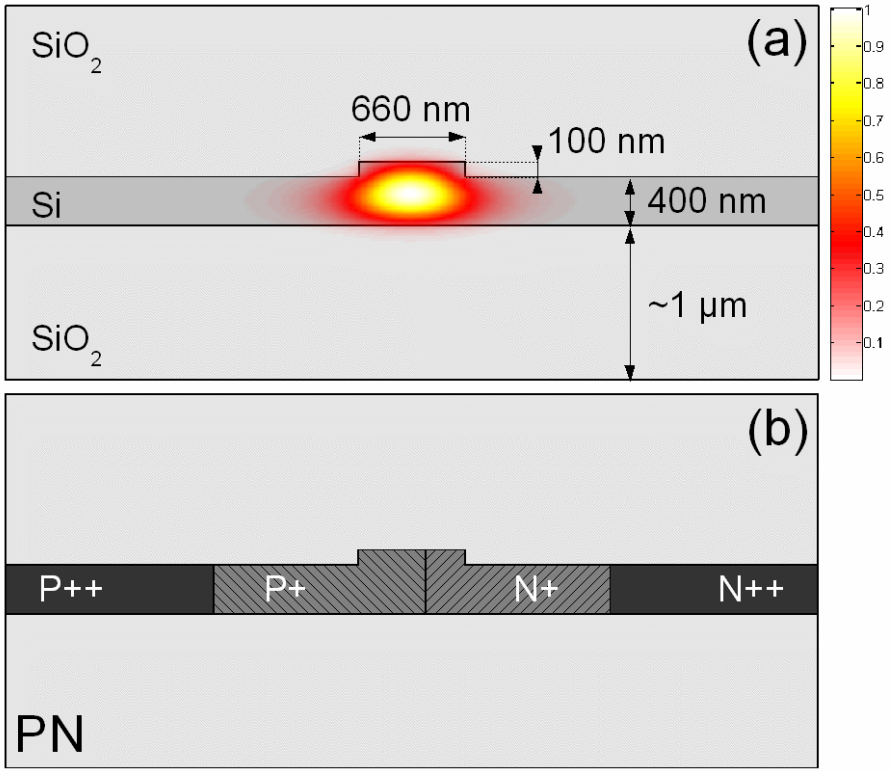
Optical modulation within CMOS photonic IC

Modulating the free carrier concentrations:

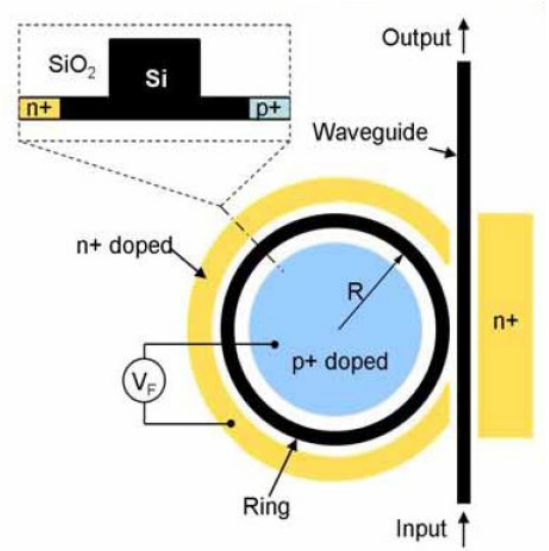
$$\Delta n = -8{,}8.10^{-22}\Delta N - 8{,}5.10^{-18}\Delta P^{0{,}8}$$

$$\Delta \alpha = 8{,}5.10^{-18}\Delta N + 6{,}0.10^{-18}\Delta P$$

at λ=1.55μm

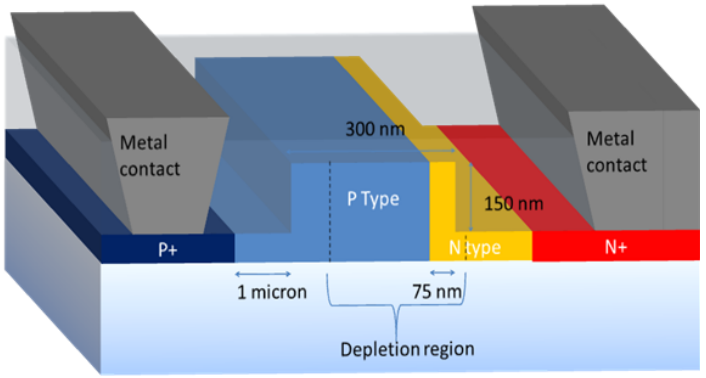


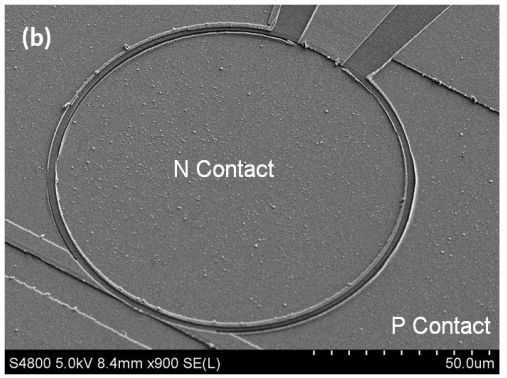
Carrier injection (es del ring resonator)



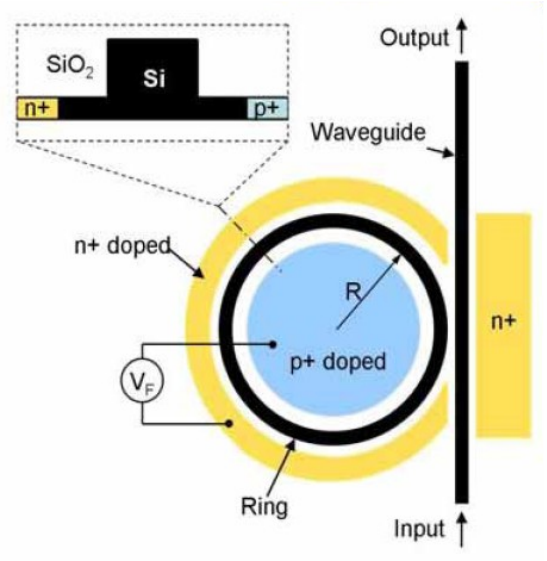
Carrier depletion (es del ring resonator)

PN diode



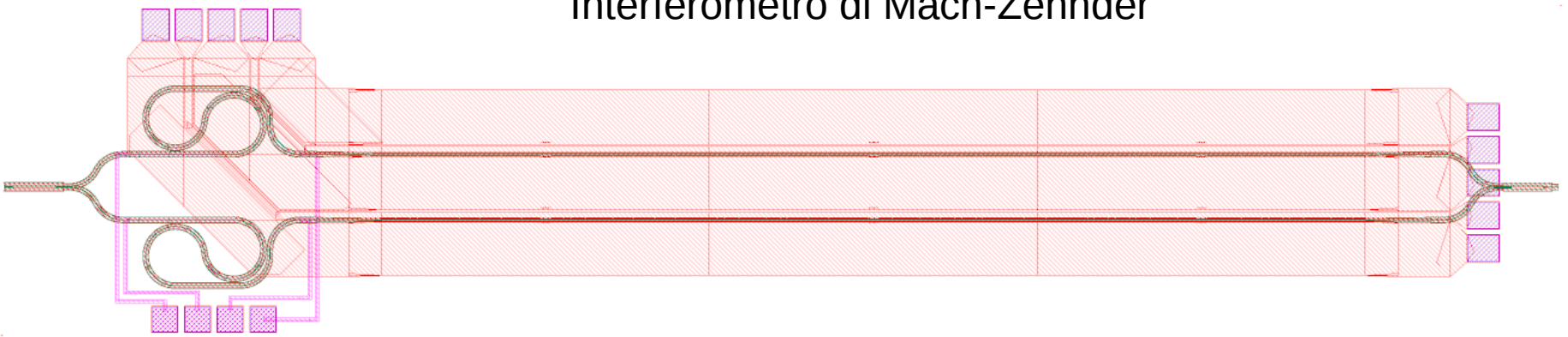


I modulatori



Ring resonator

Interferometro di Mach-Zehnder

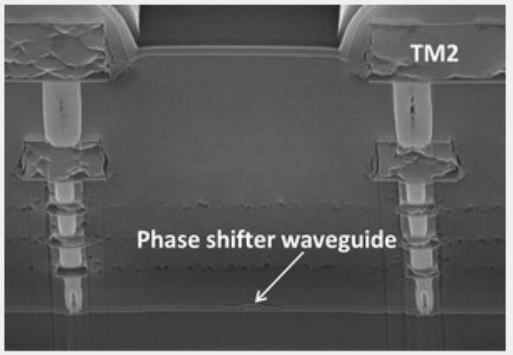


IHP technology @ Europractice

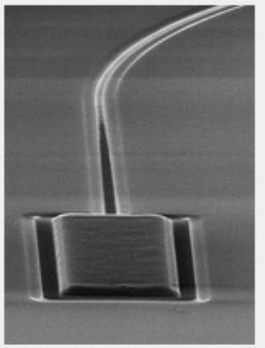
- Technology
  - imec - Passives
  - imec - ISIPP25G+
  - LETI-Passives with Heaters
  - IHP-Passives Ge photodiode
- Runschedule & Pricing
  - Runschedule
  - Pricing
  - NDA-DKLA
- Info
  - Design info
  - Practical info
  - NDA-DKLA
- Photonics Packaging
  - Technology description
  - Packaging Prices

Basic characteristics

- Passive waveguide structures
- Three ething levels (220nm, 70nm, 120nm)
- Two waveguide doping levels
- 5 metal layer backend (3x metal + 2x top metal)
- Modulator building block
  - 15GHz bandwidth
  - 15dB insertion loss
  - Vpi=6V
  - 5mm long
- Germanium photodiode building block
  - 40GHz bandwidth@-2V
  - 0.6A/W responsivity
- Optional localized backside etching
- 248nm DUV stepper lithography



Cross section of a modulator waveguide



Germanium photodiode without backend

Indicative performance

Device	Specification	
Strip waveguide	Loss	<3dB/cm
Rib waveguide (70nm etch)	Loss	<1.5dB/cm
Rib waveguide (120nm etch)	Loss	<2dB/cm
1D Fiber coupler (14°, TE)	Insertion loss	<5dB

2016 price and schedule (Europractice)

- IHP SG25 PIC: 1300 Euro / mm2
- IHP SG25H_EPIC: 4550 Euro / mm2
- IHP SG25H4: 3750 Euro / mm2

IHP	J	F	M	A	M	J	J	A	S	O	N	D
IHP SGB25V 0.25µ SiGe:C Ft=75GHz@BVCEO 2.4V	25							1		31		
IHP SGB25VGD 0.25µ SiGe:C Ft=75GHz@BVCEO 2.4V + RF HV-LDMOS GD-Module 22V	25									31		
IHP SG25H1 0.25µ SiGe:C Ft/Fmax=190GHz/220GHz 5M/MIM	25				2			1				
IHP SG25H3P 0.25µ Complementary SiGe:C Ft/Fmax (npn)110/180GHz / (pnp)90/120GHz 5M/MIM										31		
IHP SG25H3 0.25µ SiGe:C Ft/Fmax= 110/180GHz 5M/MIM	25				2					31		
IHP SG25H4 0.25µ SiGe:C Ft/Fmax= 200/220GHz 5M/MIM	25				2			1		31		
SG25H_EPIC (based on SG25H4)										31		
IHP SG13S SiGe:C Bipolar/Analog/CMOS Ft/Fmax= 250/300GHz 7M/MIM			29					29				5
IHP SG13C SiGe:C CMOS 7M/MIM			29					29				5
IHP SG13G2 SiGe:C Bipolar/Analog Ft/Fmax= 300/500GHz 7M/MIM			29					29				5
IHP SG25 PIC (Photonics, Ge Photo-diode, BEOL)					30							

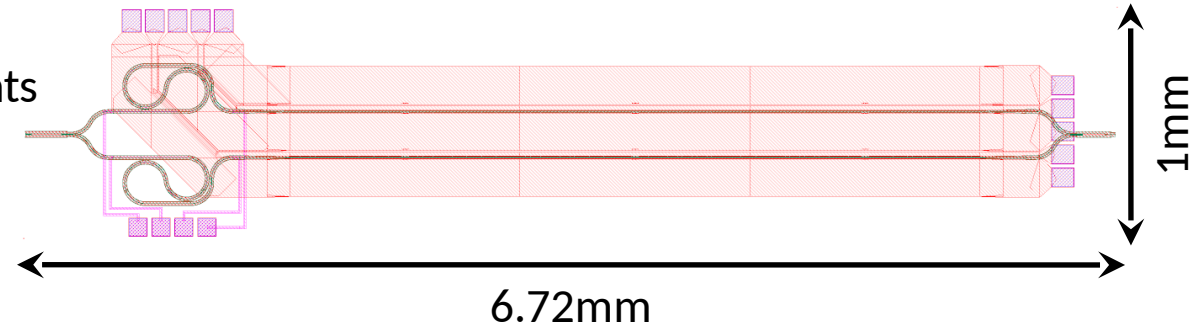
Bumping available for all IHP technologies with extra charge, limited to 200 bumps

Layout size (MZ standard)

Overall estimation
At least: 8.48mm × 1.11mm

Most inner modulator part

- 5mm phase shifter
- Thermal heating tuning elements
- Travelling wave electrode
- 1 port left side
- 2 ports right side

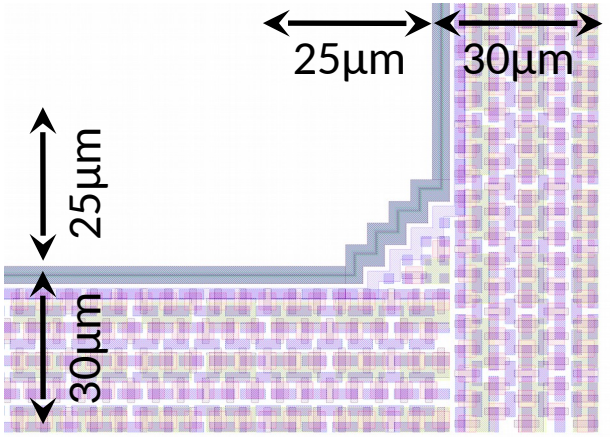


In- and output

- Standard grating coupler + taper = 0.75mm
- SBends for separation at right side <=0.16mm
  - worst case +1.66mm in length

Seal ring

- Recommended inner distance to sealring >=25µm
- Sealring width (including outside filler area) =35µm

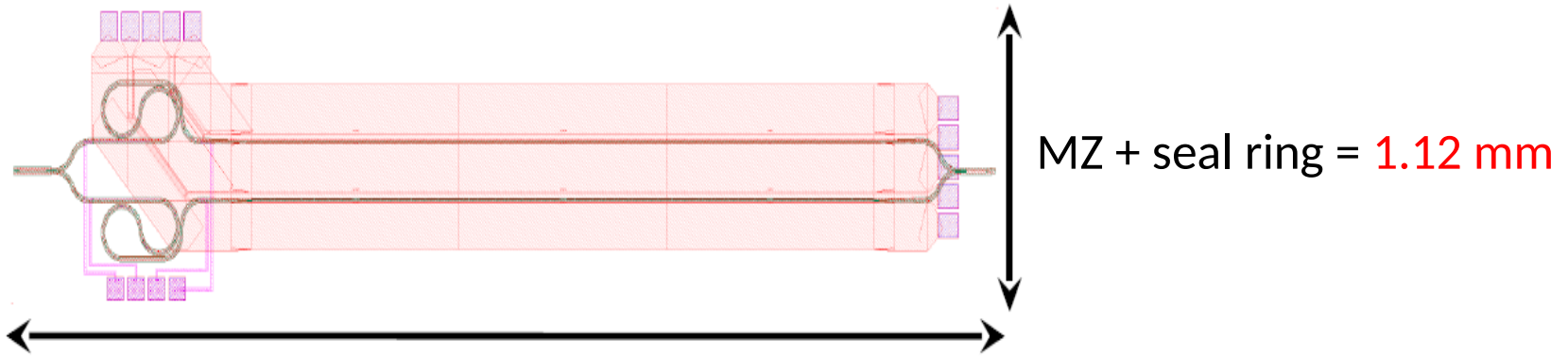


~10 mm2 per la sola parte fotonica senza considerare l'elettronica @ 4550Euro+IVA / mm2: IMPOSSIBILE → dobbiamo ridurre le dimensioni del modulatore

Proposal

- May 2017 PIC run (@ 1300Euro+IVA/mm2): “large” photonics test chip: 2 MZ interferometers + 2 ring resonator
- October 2017 EPIC run (@ 4550Euro+IVA/mm2): 1 “small” MZI OR 1 ring res. + preliminary electronics
- May 2018 PIC run (@ 1300Euro+IVA/mm2): ?
- May 2018 only uE run (@ 3750Euro+IVA/mm2): ?
- October 2018 EPIC run (@ 4550Euro+IVA/mm2): “final” demonstrator

Mach-Zehnder –standard version



MZ standard version

A=9.52mm²

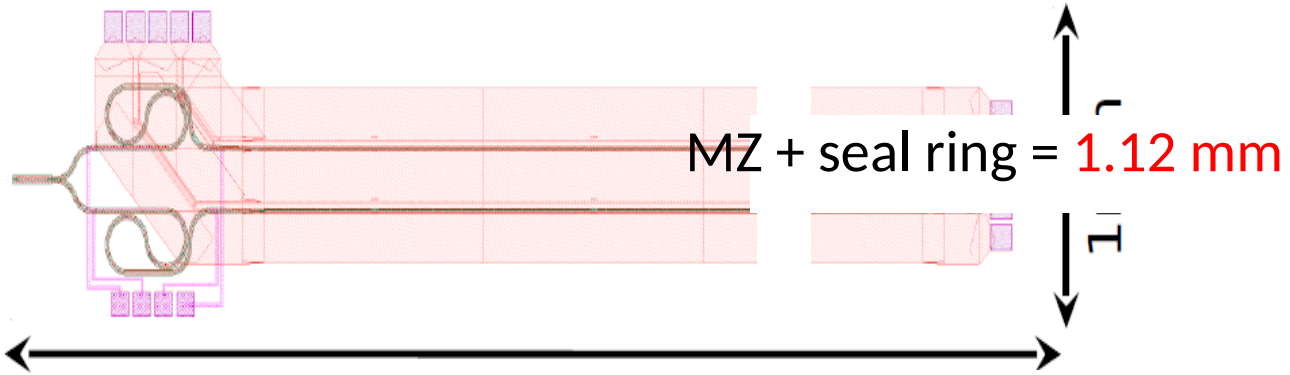
- 12376 Euro

(PIC run)

- 43316 Euro

(EPIC run)

Mach-Zehnder –smaller version



MZ smaller version

A=4.51mm²

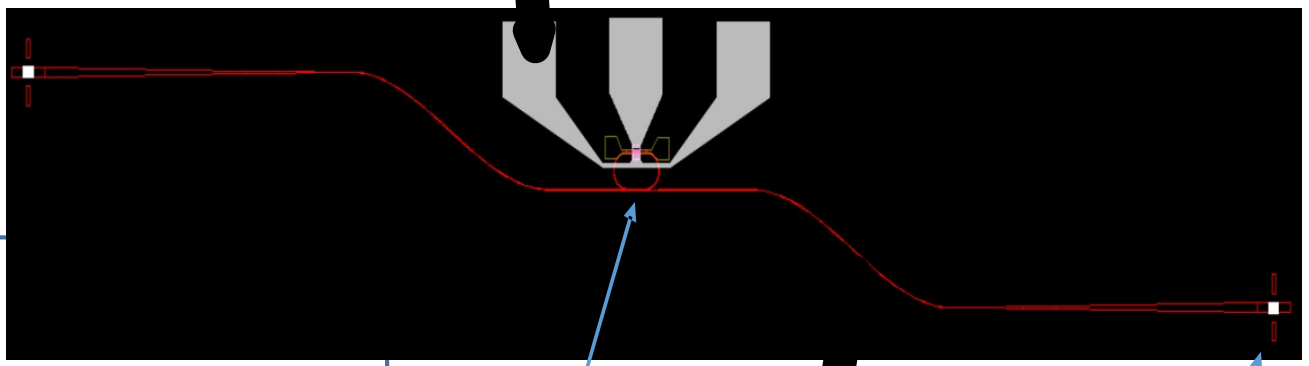
- 5863 Euro

(PIC run)

- 20520.5 Euro

(EPIC run)

Ring Resonator

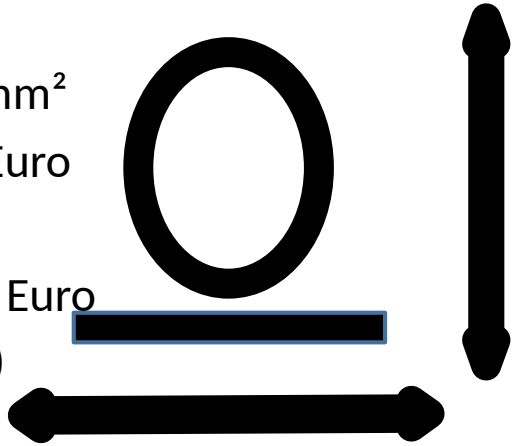


Version 1

A=0.684mm²

889.2 Euro
(PIC run)

3112.2 Euro
(EPIC run)



RR + seal ring
= 0.36 mm

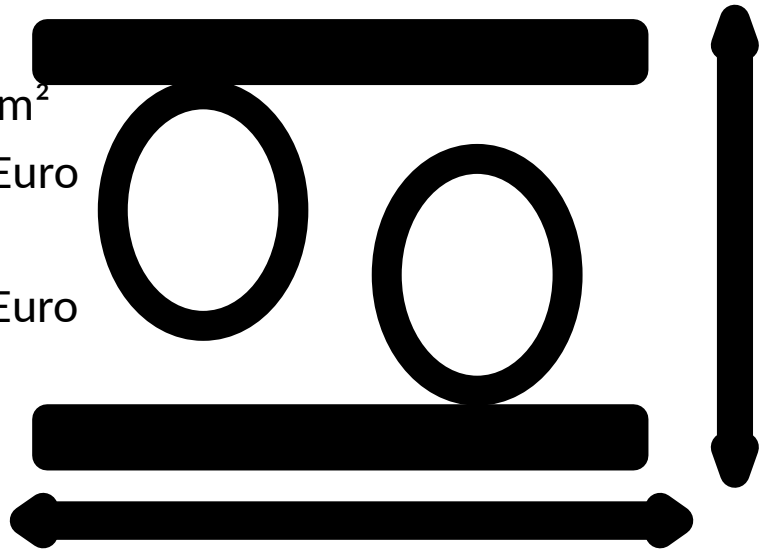
RR + grating coupler+ s-band
+ seal ring = 1.9 mm

Version 2

A=0.874mm²

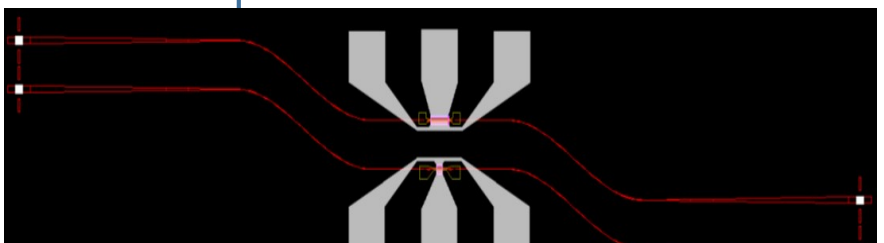
1136.2 Euro
(PIC run)

3976.7 Euro
(EPIC run)



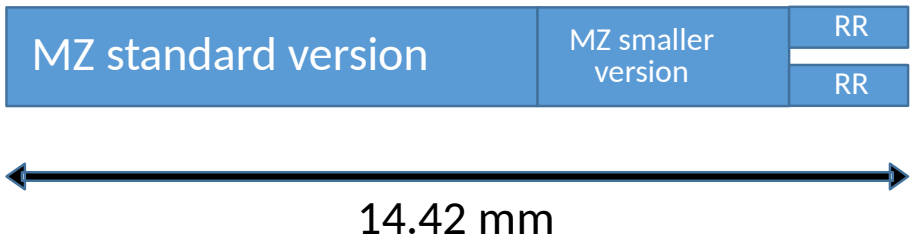
RR + seal ring
= 0.46 mm

RR + g. coupler+ s-band + s. ring = 1.9 mm



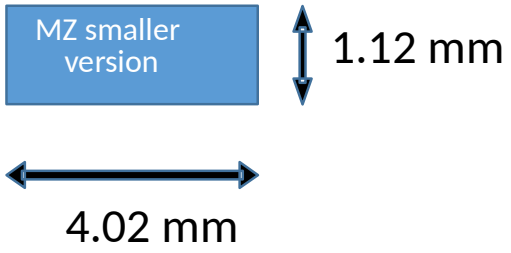
Chip size estimation

PIC run



▭ 16.15 mm²
▭ 20995 Euro + IVA

EPIC run



▭ 4.51 mm²
▭ 20069.5 Euro + IVA

Richieste economiche 2017

- 1 run di fonderia (PIC) 25 kEuro + packaging 3 kEuro (consumo)
- 1 run di fonderia (EPIC) 30 kEuro + packaging 3 kEuro (consumo SJ)
- 1 laser @ 1550 nm + photodetector 30 kEuro (inventario SJ)
- Produzione PCB 3 kEuro (consumo)
- Minuteria da laboratorio 1 kEuro (consumo)
- Microprobes 5 kEuro (inventario SJ)
- Missioni 5 kEuro

Anagrafica 2017

SPE

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Modulo EC/EN 7

A cura di: A

Ricercatori

	Nome	Età	Contratto	Qualifica	Aff.	%
1	**De Matteis Fabio**				CSN V	**40**
2	**Prosposito Paolo**				CSN V	**40**
3	**Salamon Andrea**		Dipendente	Ricercatore	CSN I	**40**
				Numero Totale Ricercatori	3	FTE: 1.2

Tecnologi

	Nome	Età	Contratto	Qualifica	Aff.	%
1	**Bonaiuto Vincenzo**		Associato	Prof. Associato	CSN I	**30**
2	**Sargeni Fausto**		Associato	Prof. Associato	CSN I	**30**
				Numero Totale Tecnologi	2	FTE: 0.6

Tecnici

	Nome	Età	Contratto	Qualifica	Aff.	%
1	**Badoni Davide**		Dipendente	Collaboratore Tecnico E.R.	CSN I	**20**
				Numero Totale Tecnici	1	FTE: 0.2

Annotazioni

Mauro Casalboni – Professore Ordinario – Dip. Ing. Industriale 40%
Patrick Steglich – Dottorando – Dip. Ing. Industriale 40%

Set

Osservazioni del direttore

Mod. EC/EN7

Visualizza per la stampa