Si Photonic WDM in the Datacenter

Session 3-WE7: Perspectives on Silicon Photonics
(An Honest Forum)
DesignCon 2015
Santa Clara, CA
28 January 2015

Chris Cole

CELEBRATING 20 YEARS
DESIGNCON® 2015
WHERE THE CHIP MEETS THE BOARD

Finisar®

WDM in the Datacenter

Bit Rate = Fiber Pairs * Lambdas * Baud Rate * Bits/Baud

Standard	Bit Rate	Fiber Pairs	λ	Baud Rate	Bits /Baud	Type
1GbE-LR, SR	1G	1	1	1G	1	Serial
10GbE-LR, SR	10G	1	1	10G	1	Serial
40GbE-SR4	40G	4	1	10G	1	Parallel
40GbE-LR4	40G	1	4	10G	1	WDM
100GbE-SR4	100G	4	1	25G	1	Parallel
100GbE-LR4, CWDM4, CL4	100G	1	4	25G	1	WDM
100G PSM4	100G	4	1	25G	1	Parallel

WDM = Wavelength Division Multiplexing

Why WDM?

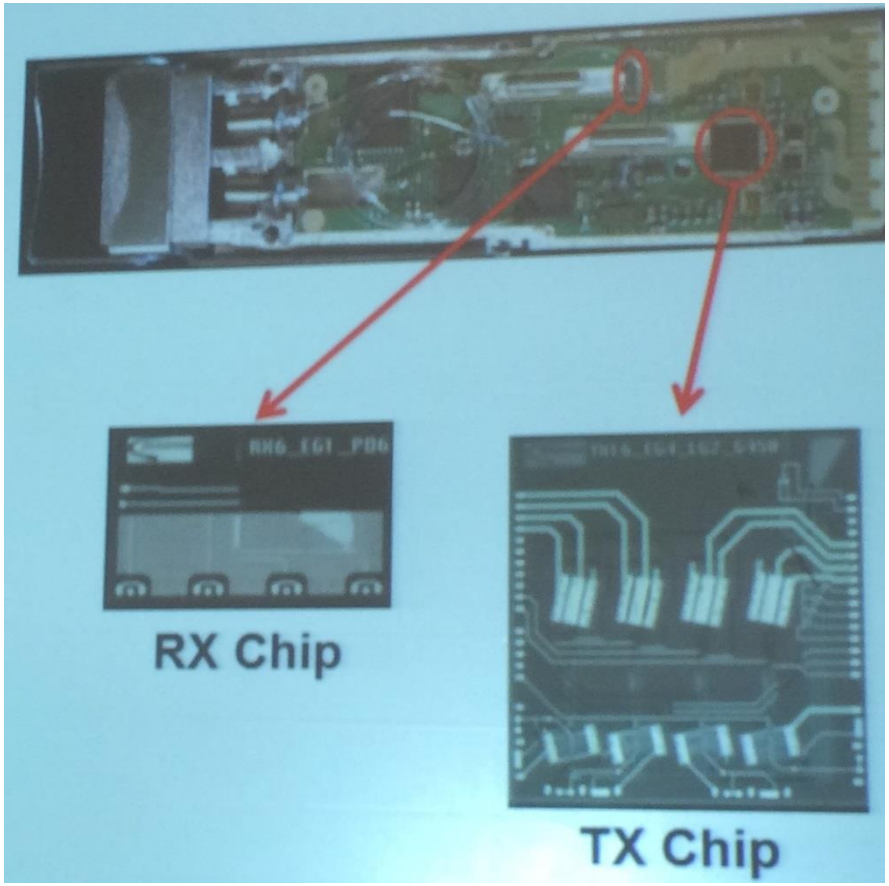
- SMF channel:
  - 1310nm (O) band ~100nm wide → BW = ~15THz:
    Nyquist limit = ~ 30TBaud
  - 1310nm window Mitra & Stark SMF non-linearity study:
    Shannon limit = ~100Tb/s
- Long Haul SMF pair 1550nm (C) band DWDM (Dense WDM) example:
  - 64 channels * 100Gb/s per channel = 6.4Tb/s
- Today datacenter SMF pairs carry 10, 25, 40 or 100Gb/s
  i.e. SMF does not limit bit rate
- One SMF pair is better than multiple parallel SMF pairs
  if WDM can be implemented cost effectively

Why Si Photonic WDM?

Holy Grail of Si Photonics:

- Single (or dual) chip CMOS transceiver
- All optics on-chip:
  - Lasers
  - Modulators
  - WDM Mux
  - WDM DeMux
  - PINs (or APDs)
- All electronics on-chip:
  - Drivers
  - TIA's
  - *CDRs (optional)*

Ex: Skorpios 4x25G (100G)



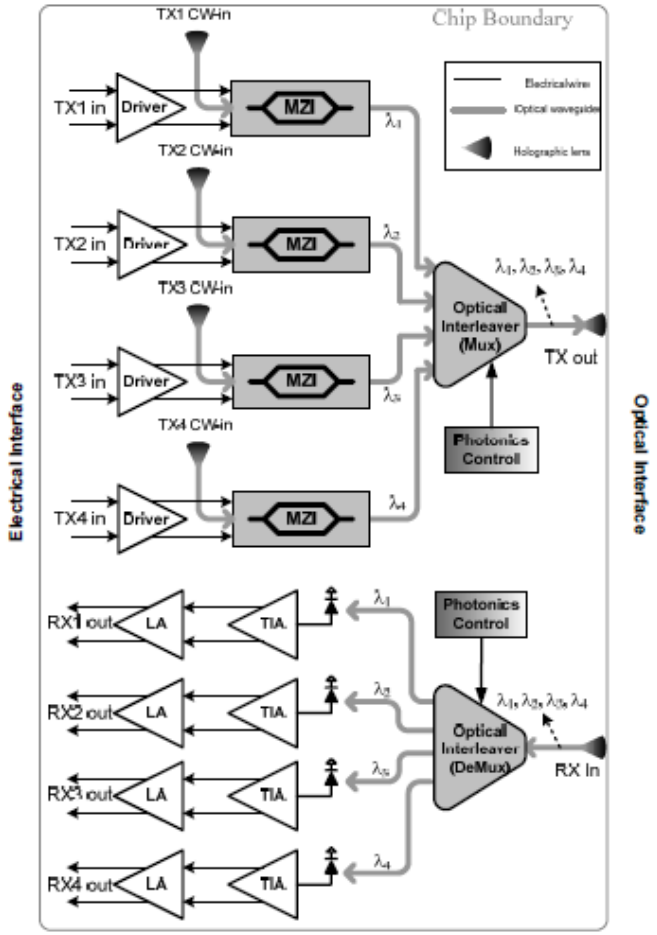
A. Viglienzoni, "Skorpios Delivers on the Promises of Silicon Photonics", Photonic Integration Market Focus Panel, ECOC 2014, 22 Sep. 2014

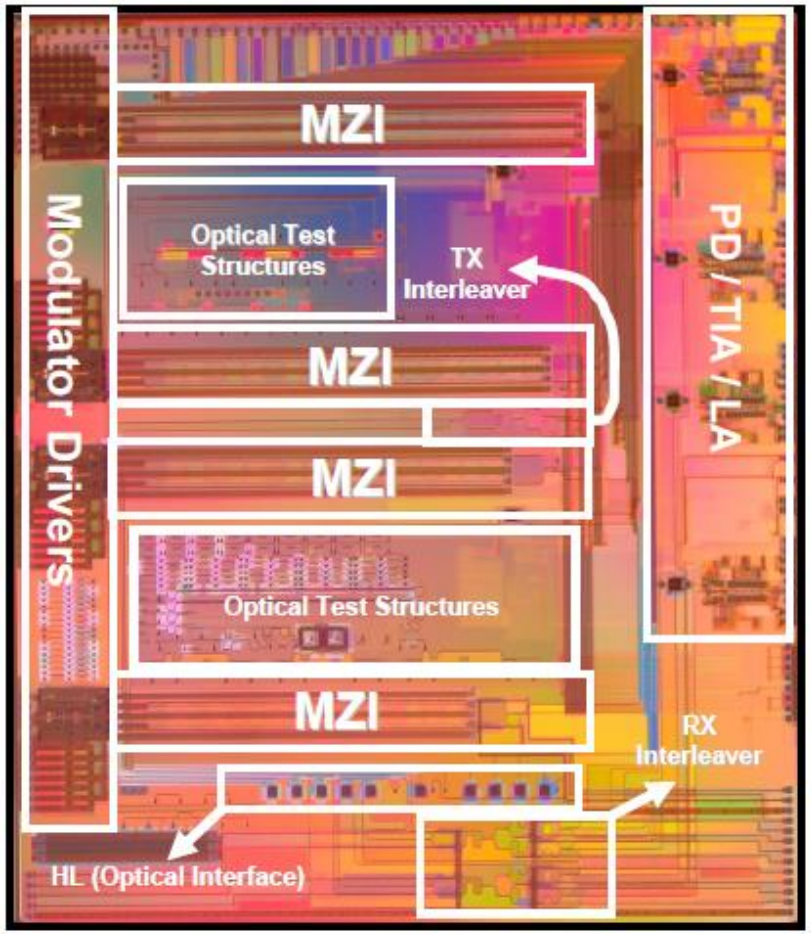
Luxtera 4x10G (40G) WDM Si Photonics

October 2006 press announcement:

> “Luxtera Inc., the world leader in CMOS photonics, today announced its new technology that multiplexes four 10Gbps wavelengths onto a single fiber, on a production CMOS die – resulting in a single fiber 40Gbps link. This advance reduces cost for high bandwidth interconnect over traditional parallel fiber solutions and paves the technological way for next generation 100Gbps Ethernet data center connectivity.
>
> Luxtera is currently sampling prototypes to development partners and the company will launch a commercial transceiver product line based on this underlying technology in 2007 – years ahead of the competition.”

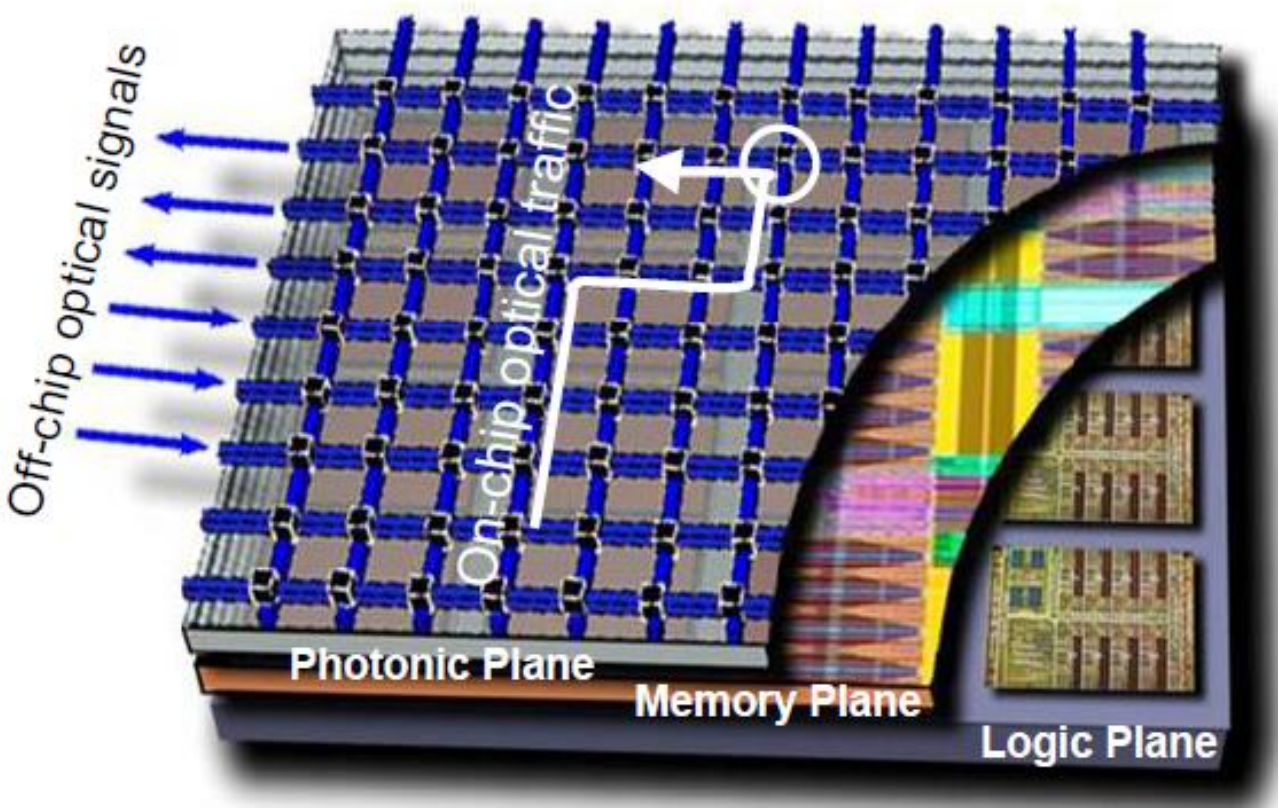
Luxtera 4x10G (40G) WDM Si Photonics





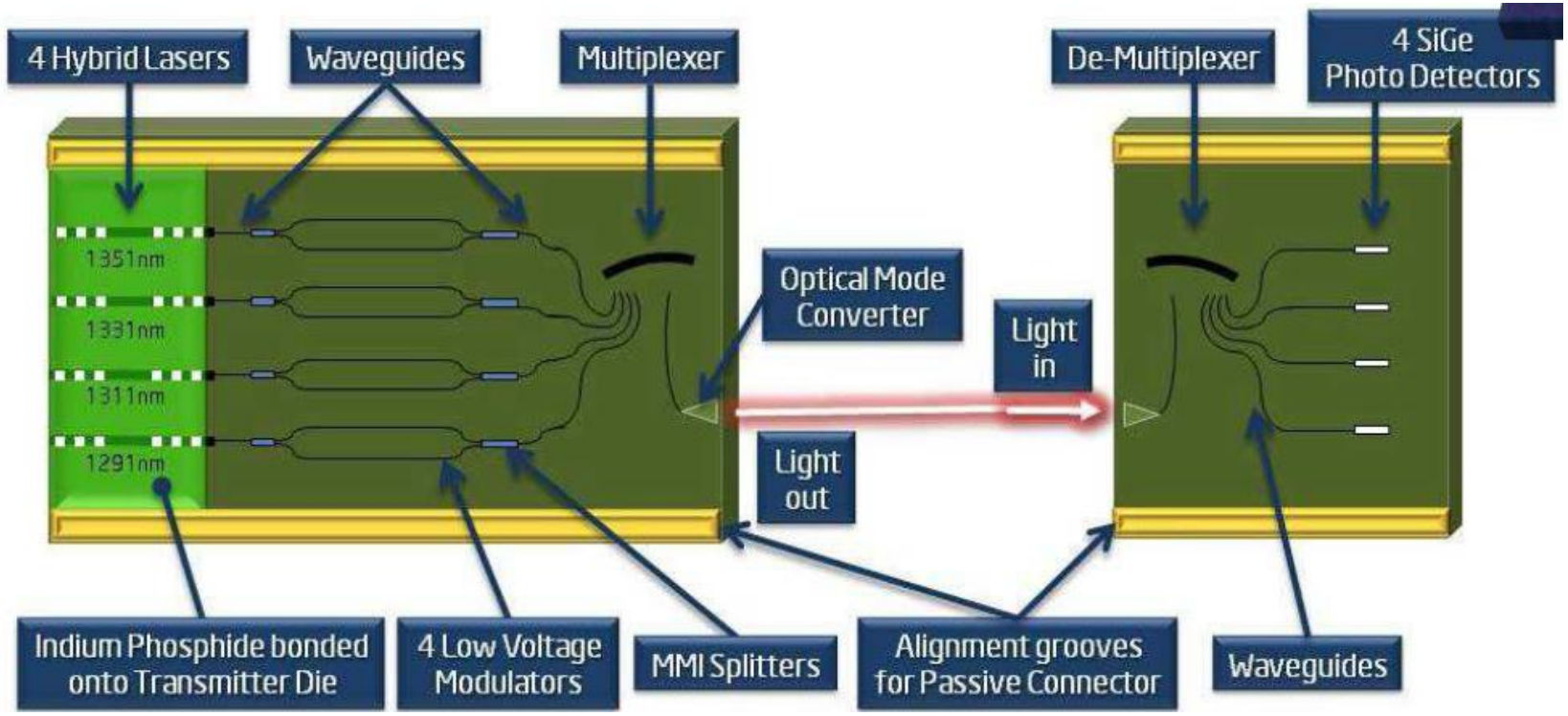
A. Narasimha, et. al, "A Fully Integrated 4x10Gb/s DWDM Optoelectronic Transceiver in a standard 0.13um CMOS SOI, ISSCC 2007, 2.1

IBM 70Tbps on-chip WDM Si Photonics



Yuri Vlasov, Silicon Photonics for Next Generation Computing Systems," ECOC 2008 Tutorial, 22 Sep. 2008

Intel 4x10G (40G) WDM Si Photonics



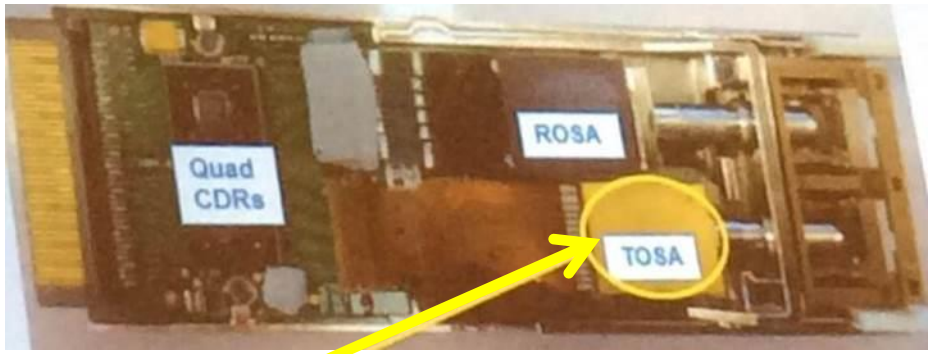
A. Alduino, “Demonstration of a High Speed 4-Channel Integrated Silicon Photonics WDM Link with Hybrid Silicon Lasers”, Intel, 2013

- Intel announced in 2014 that they will ship 4x25G (100G) CWDM QSFP28 production modules by the end of the year

Cisco 4x25G (100G) WDM Si Photonics

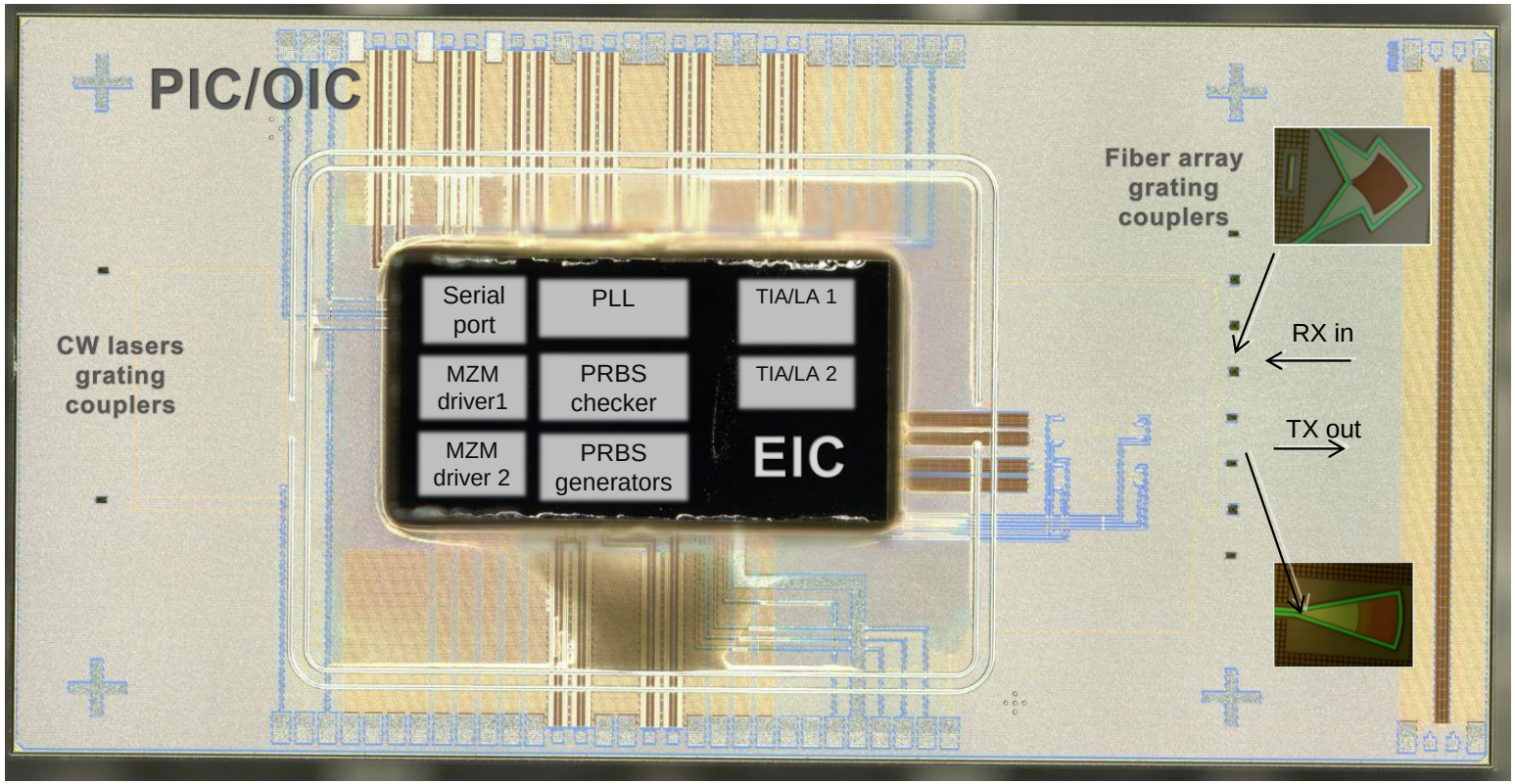
100G LR4 CPAK Module

Inside 100G LR4 Module



- LR4 TOSA using SiP WDM technology
- “Gold box” OSA packaging
- Comparable metrics to conventional DFB laser and EML based CFP2 modules
- Optics cost driven by packaging; SiP offers no advantage

Finisar 2x50G (100G) Si Photonics



- Finisar 2x50G PSM2 BiCMOS PIC fabricated at ST Micro
- WDM requires external CW Lasers, external WDM Mux and DeMux, and WDM grating couplers

Si Photonics WDM Reality in the Datacenter

- To date SiP WDM has had little impact on the Datacenter
- Successful SiP implementations have moved in the opposite direction of full integration:
  - separately packed and yielded external laser(s)
  - separate electronics flip chipped onto Si PIC
- However many companies are promising SiP WDM datacenter revolution just around the corner:
  - Intel
  - IBM
  - Skorpios
  - Mellanox (Kotura)
  - Aurrion
  - others

Si Photonic WDM in the Datacenter

Thank you