



IEEE 802.3 *High Speed Study Group* 100GbE Silicon Photonics Platform Considerations

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Outline

- 100Gbps technology options considerations
- Technical feasibility
 - 4x25Gb/s, 5x20Gb/s and 10x10Gb/s
- Silicon photonics challenges & opportunities
- Summary



Technology Options: Multiple Ways to 100GbE

- 4x25Gbps
 - Optics Mux/demux compatible with LX4
 - External modulator required for 25Gbs
 - Traveling waveguide photodiode preferred
 - Digital electronics challenging and expensive
- 5x20Gbps
 - Optics Mux/demux not a comment platform
 - External modulator required for 20Gbs (less challenge)
 - Digital electronics less challenging than first option
- 10x10Gbps
 - Optics Mux/demux more loss and cost above
 - 10 lasers on one chip, yield decrease,
 - Direct modulation for 300m, external modulation for up to 40Km
 - Digital electronic speed a commonality
 - RF cross-talk need to be managed, reduce receiver sensitivity
 - Power dissipation high, dictate package module type Xenpack

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Technical Feasibility

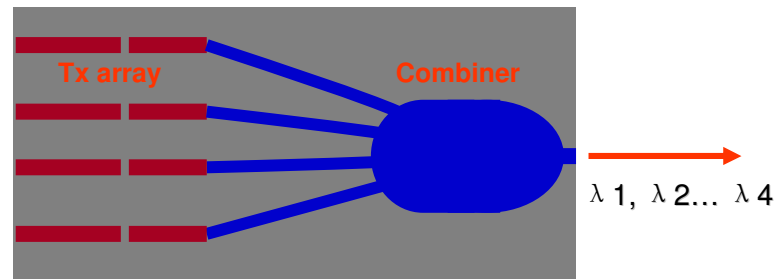
- Front-end photonics integrated circuit (PIC)

Key function	Material	Technology
Laser array	InP	VCSEL/Edge Emitter
Modulator array	InP /Silicon	EAM/MZI
Mux/Demux	InP /Silicon	Combiner/Interleaver/AWG
Receiver	InP	Surface PD/TWPD

- Back-end electronics
 - Laser drivers and transimpedance amplifiers (TIA's) could be hybrid integrated with PIC inside one package

100GbE (4x25Gbps)

Function	4x25Gbps	Comment
Laser array	1300nm band	Un-cooled
Modulator array	InP EAM/MZI	Silicon up to 10G today
PD array	Traveling Wave	40G demonstrated
Mux/Demux	CWDM Interleave IL < 3dB PDL < 0.4dB	Compatible with LX4
Driver and TIA array	SiGe/GaAs	Expensive
Chip foot print Transmitter/receiver	3x4mm ²	Xenpack



4x25Gbps Transmitter

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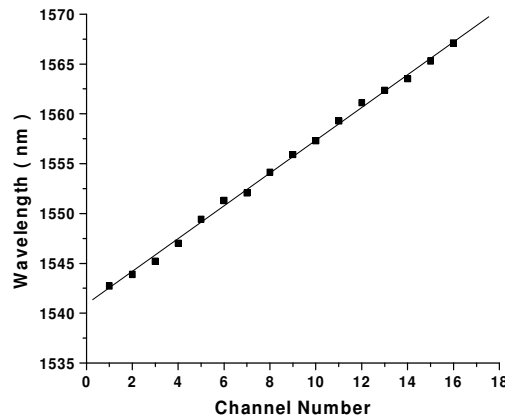
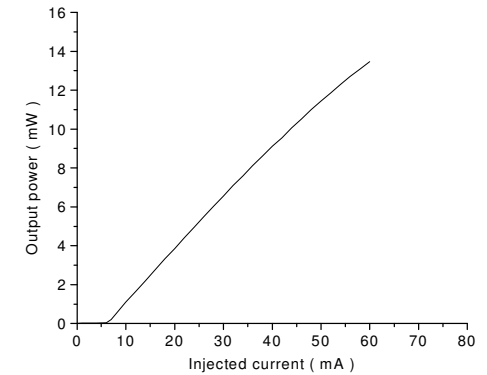
100GbE (10x10Gbps)

- Attractive, direct WDM expansions of main stream 10GbE
- Present challenge for laser and PD arrays yield
- WDM channel spacing 100GHz vs. 200GHz
 - Single chip WDM laser array
 - 100GHz yield low very
 - 200GHz yield higher, more economical
- Silicon array waveguide gratings (AWG)
 - IL around 6dB
 - PDL ~0.4dB
- RF cross-talk reduce receiver sensitivity
- Benefits from 10GbE standard

100GbE (10x10Gbps)

Power dissipation and wavelength accuracy

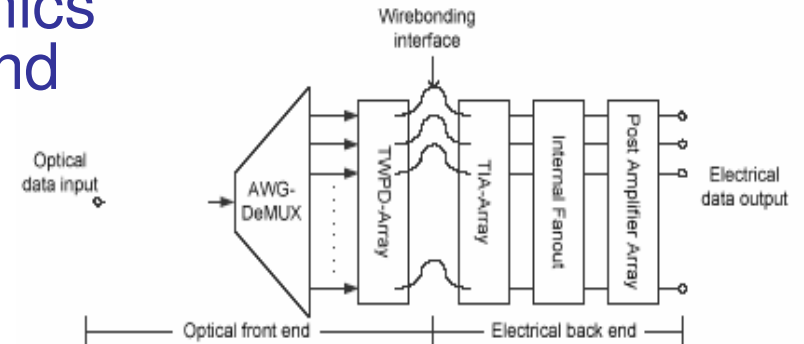
- Module power budget
 - laser array power dissipation become very important
- WDM wavelength accuracy
 - DFB/DBR laser grating fabrication pitch resolution tolerance very challenging +/- 0.01nm for 100 GHz channel spacing



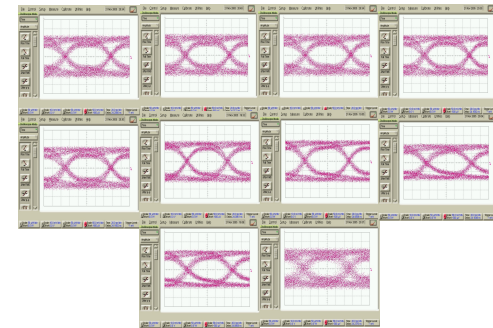
Channel Number	Threshold current (mA)	Operating voltage at bias of 40 mA (V)	Slope efficiency (mW/mA)
1	7.2	1.10	0.23
2	7.2	1.09	0.26
3	7.2	1.09	0.26
4	7.3	1.09	0.25
5	7.4	1.09	0.25
6	7.2	1.09	0.25
7	7.2	1.10	0.25
8	7.1	1.22	0.25
9	6.9	1.13	0.28
10	6.8	1.14	0.25

100GbE (10x10Gbps)

- Hybrid integration of silicon photonics demux, photodiode array (PDA) and digital electronics
- Demux
 - loss 6dB
 - PDL ~ 0.4dB
- RF cross-talk need to be managed
 - Reduce receiver sensitivity
 - Dark current 0.1uA (~nA single ch.)
- High sensitivity to ground
- ESD issue



Functional block diagram
NxN Gb/s receiver



100GbE (10x10Gb/s)
WDM eye diagrams



Benefits of Silicon PIC

- Lower cost Mux/Demux, lower than PLC
- Smaller footprint size
- Ability to integrate optics and electronics inside one small package
- 100G on XFP size module?



Technical Feasibility of 100GbE

Front-end photonics integrated circuit (PIC)

Key function	4x25Gbps	5x20Gbps	10x10Gbps
Laser array	DFB/DBR 1300/1550nm	DFB/DBR 1300/1550nm	DFB/DBR 1550nm
Modulator array	Ext. Mod. EAM/MZI	Ext. Mod. EAM/MZI	DML/ EAM/MZI
Mux/Demux	Combiner/Interleave	Combiner/Interleave /AWG	AWG
PD array	Traveling wave PD	Traveling wave PD	PD/APD
CWDM/WDM	CWDM	CWDM	WDM, 200GHz

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Summary

- Issues to consider
 - Power dissipation limit desirable module type
 - Integrated WDM channels cross-talk
 - RF cross-talk is more severe than optical
- 4x25Gbps is a valuable solution for 100Gbps
 - PIC mux/demux compatible with LX4
- 10x10Gbps attractive, benefits from 10GbE standard
 - Present challenge for laser diode and PD arrays yield
 - Electronic cross-talk
- Silicon photonics platform could provide cost effective solution to make 100Gbps successful