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# Integrated Photonics: Game Changer or Just Another Tool?


Moderator:
Mitchell Fields, Avago Technologies

Panelists:
Frank Chang, Inphi
Chris Cole, Finisar
Arlon Martin, Mellanox

# Disclaimer

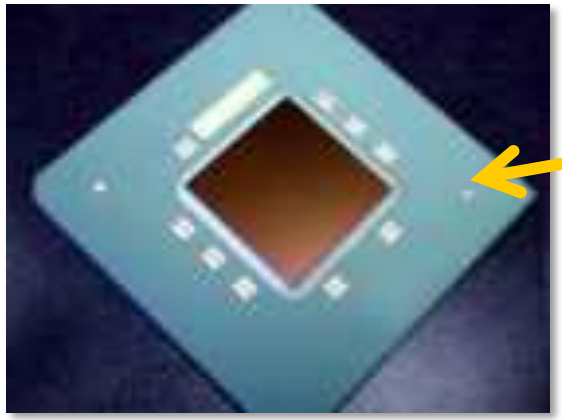


- The views WE ARE expressing in this presentation are our own personal views and should not be considered the views or positions of the Ethernet Alliance.

# Why do we integrate?

- To achieve target metrics:
  - Cost
  - Size
  - Power
  - Performance

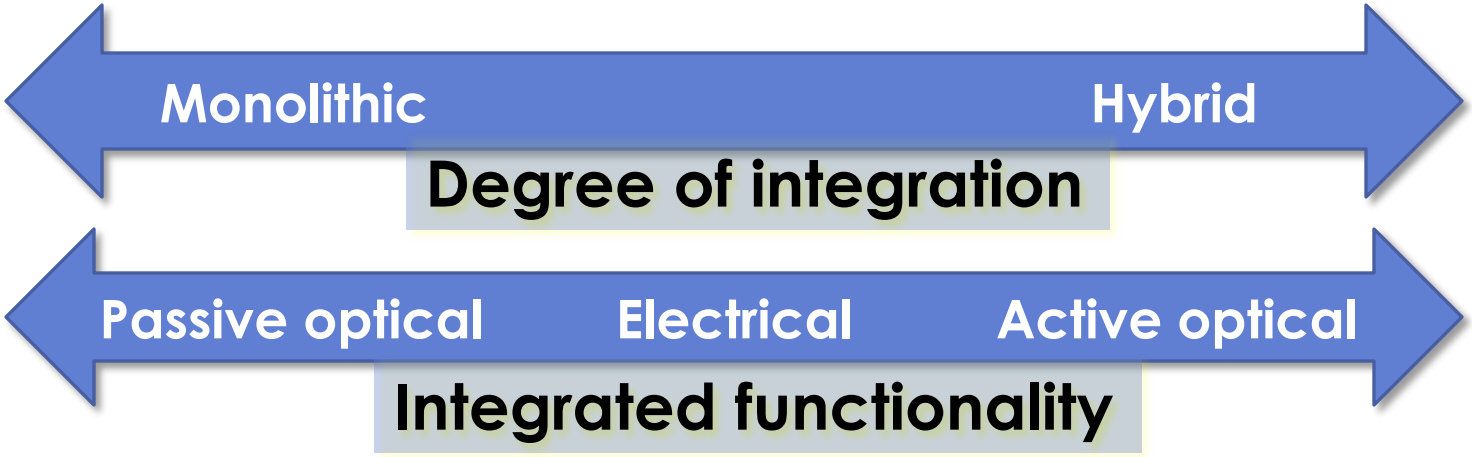
- Classic example is the integrated circuit.



Lot's functionality in there!

# What do we mean by Integrated Photonics?

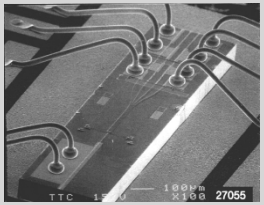
- Integrated = put together
- Photonics = optical/electrical components *(sources, modulators, VOAs, mux/demux, splitters/ combiners, detectors, …)*
- Integrated Photonics = putting together a selection of electro-optic components into a single package.



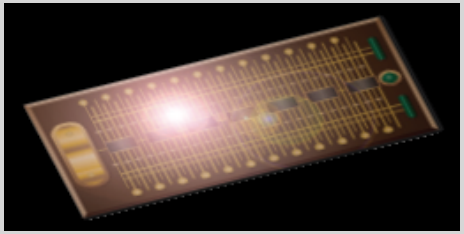
# Integration overview

## Monolithic integration:

12x GaAs VCSEL array



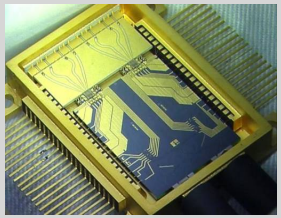
InP tunable laser with VOA



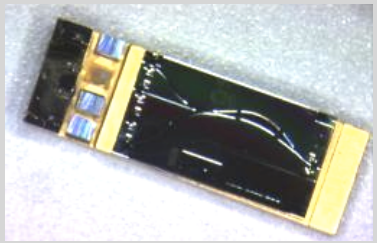
Infinera InP PIC

IBM CMOS photonics (no laser)

## Hybrid Integration



Coherent Rx
PLC + PDs + ICs



LR4 TOSA
PLC + LDs + ICs


ASIC+ optics

# Game changer or not?



- Some key questions:
  - Where does integration make sense?
  - Which type of integration is best?
  - Is there a one-size-fits-all solution?

- Our expert panel will give their thoughts:
  - Chris Cole: "*Integrated Photonics: Enabling Pluggable Modules*"
  - Arlon Martin: "*Integrated Photonics: Silicon Photonics for Embedded Applications*"
  - Frank Chang: "*IC Vendor Perspective: Photonic Integration to Enable Versatile, Low-cost Next-gen Optical (Coherent) links*"

- Then we open it up to debate!

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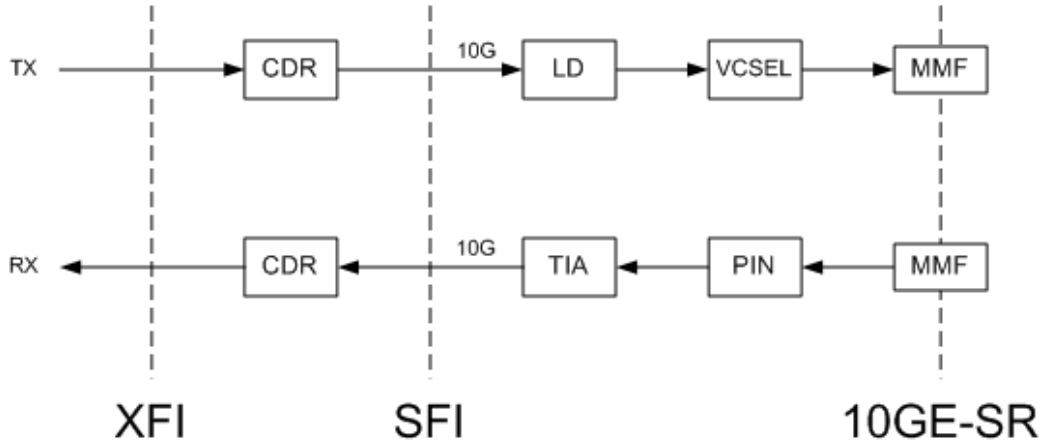
# Integrated Photonics: Enabling Pluggable Modules

Chris Cole
25 September 2013
Finisar

# 10G Discrete Optics



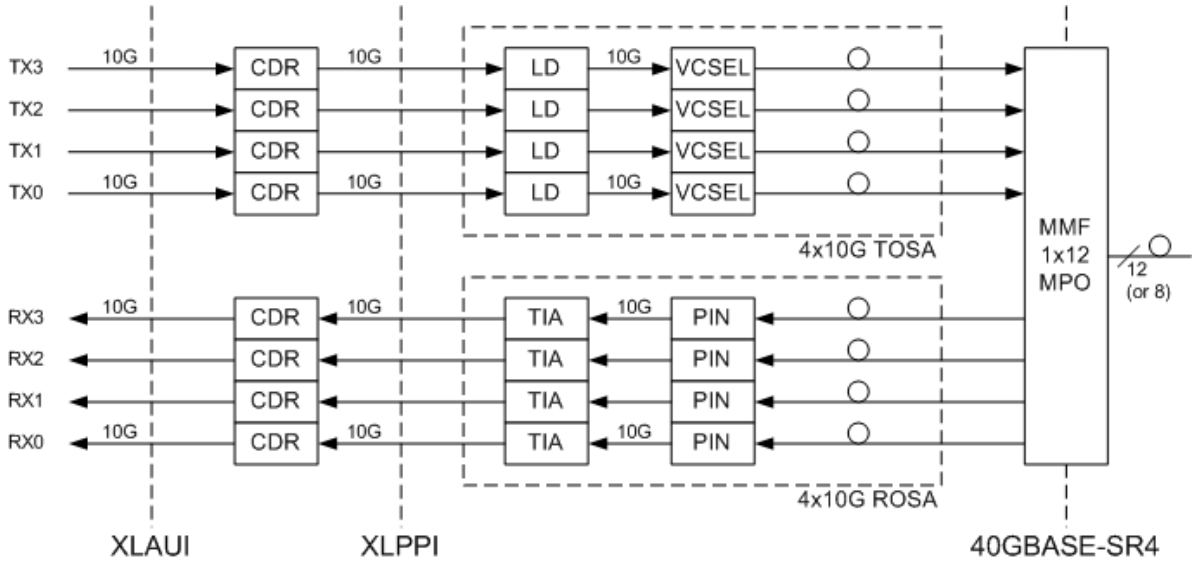

- 10Gb/s MMF 850nm VCSEL SR SFP+
- Also 10 Gb/s SMF 1310nm DFB laser LR SFP+
- 48x 10Gb/s ports in 1 RU card

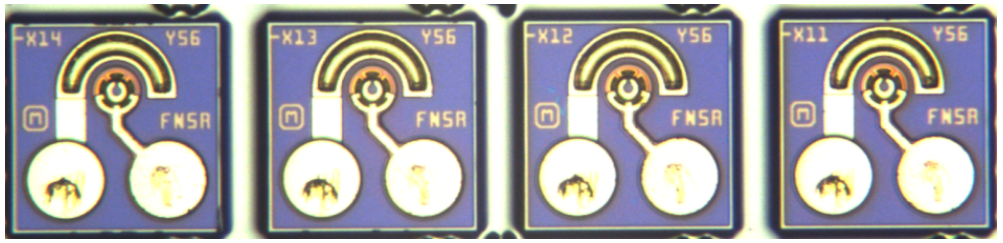
# Why pluggable modules?



- Multiple applications
- Pay as you go
- Confined replaceable failures
- Common market
- Specialized R&D production
- Port density parity with Switch ASICs

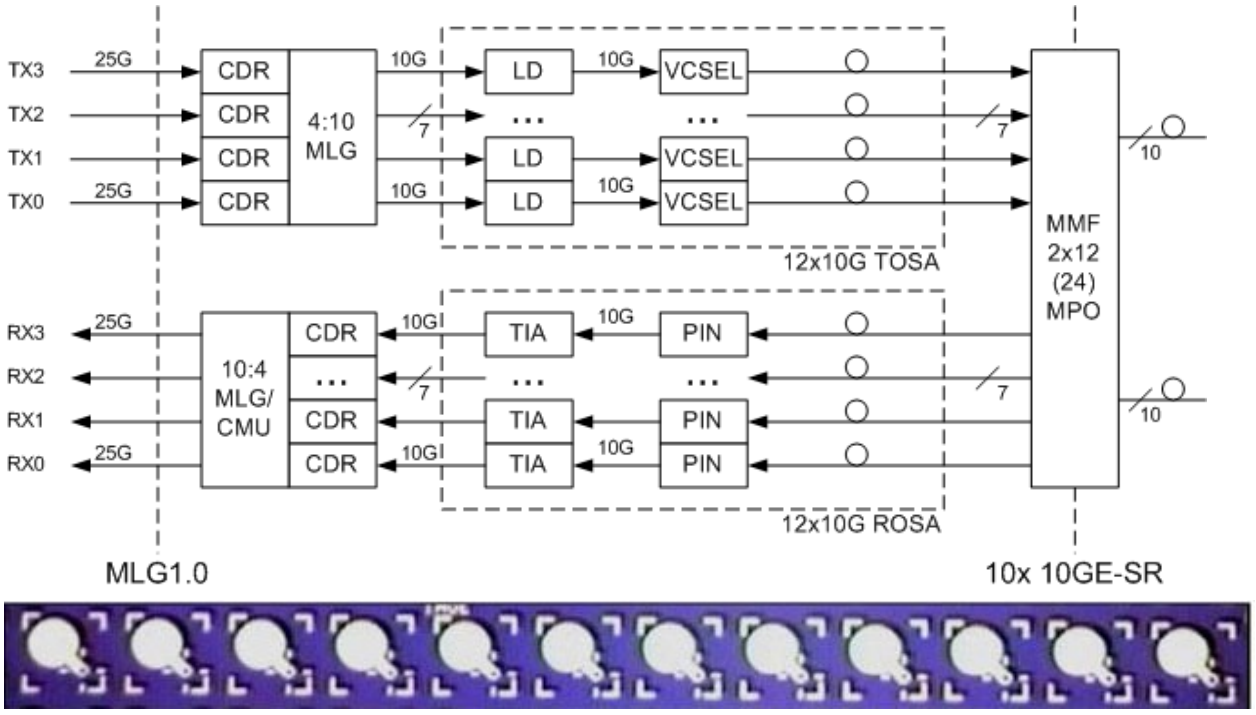
# 40G Photonic Integration



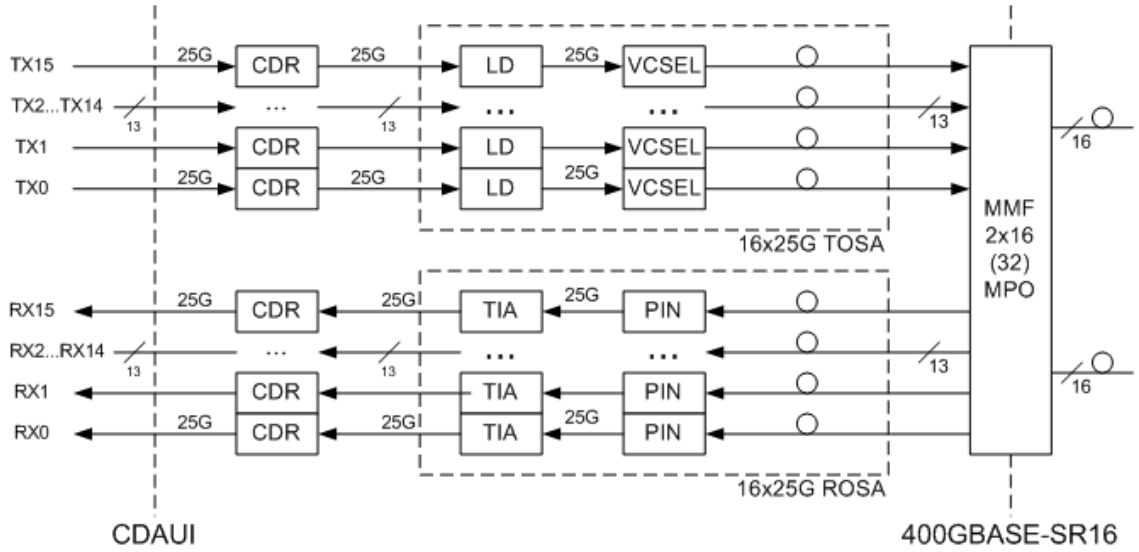

- 40 Gb/s MMF 850nm VCSEL PIC SR4 QSFP+
- Also 40 Gb/s SMF 1310nm DFB laser PIC LR4 QSFP+
- 144x 10 Gb/s or 36x 40 Gb/s ports in 1 RU card

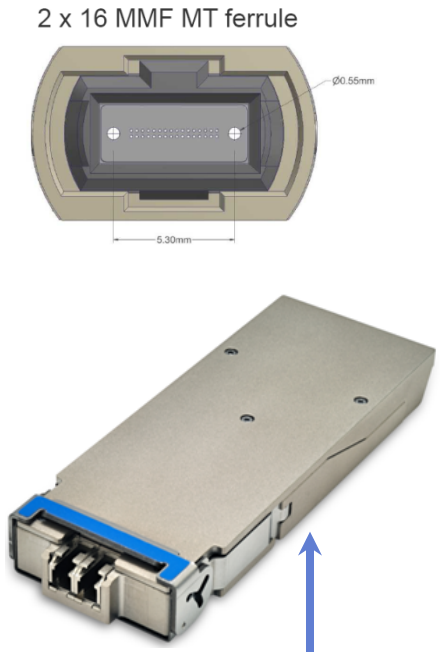
# 100G Photonic Integration




- 100 Gb/s MMF w/ 850nm VCSEL PIC SR10 CFP4
- Also100 Gb/s SMF 1310nm (InP/SIP) PIC LR4 CFP4
- 320x 10 Gb/s, 64x 40 Gb/s, or 32x 100 Gb/s ports (requires MLG I/O) in 1 RU card

# 400G Photonic Integration




- 400 Gb/s MMF 850nm VCSEL PIC SR16 CFP2
- Also 400 Gb/s SMF 1310nm (InP/SIP) PIC LR4/8 CFP2
- 100x 40 Gb/s, 40x 100 Gb/s, or 10x 400 Gb/s ports (requires MLG I/O) in 1 RU card

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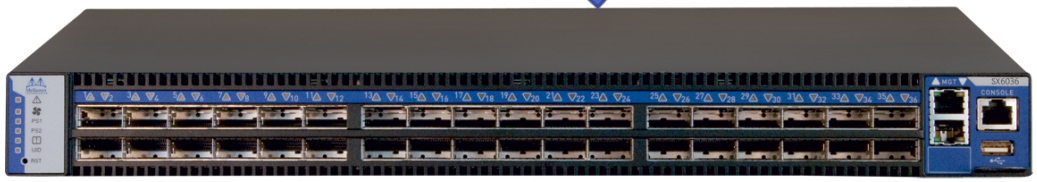
# Integrated Photonics: Silicon Photonics for Embedded Applications

Arlon Martin
Senior Director, Marketing
Mellanox

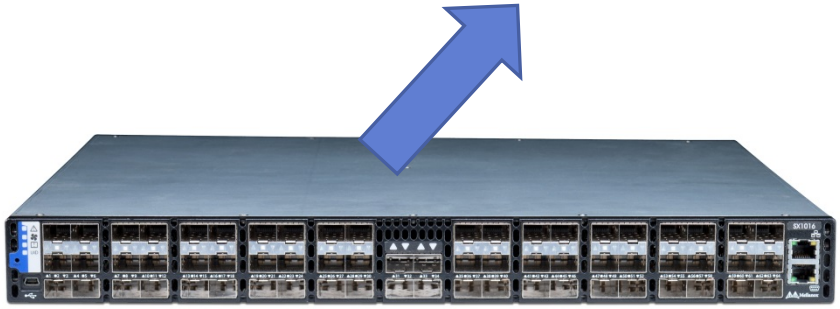
# Why do we integrate?

- **Density!**

**Many Terabit Switch**



SX6036 – 2 Tb/s: 36 Port QSFP+ Switch

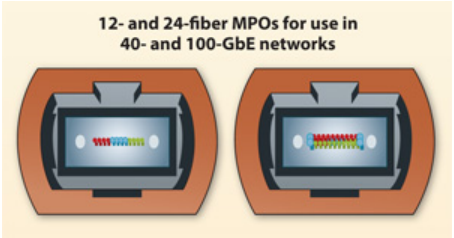


SX1016 – 640 Gb/s: 64 Port 10 GE Switch

SFP and QSFP pluggable transceivers provide excellent front panel density, but they do have limits

# Embedded Optics

- Front panel is no longer a row of transceivers
- MPO connectors provide 10-100x more density on the front panel
- WDM would increase the density another 10-100x
- Putting the optics next to the switching chip reduces power and board space
- Eliminates the need to incorporate multiple electrical transceivers between switch and front panel ports

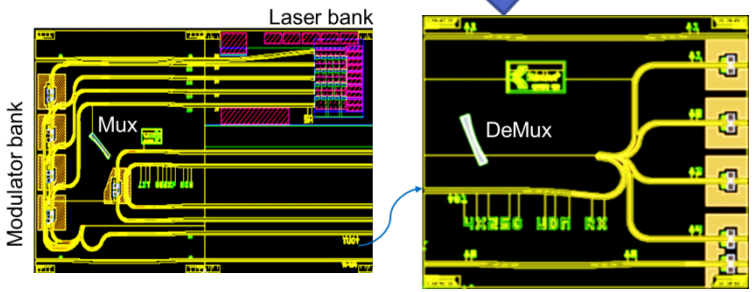


# Silicon Photonics Integration Roadmap

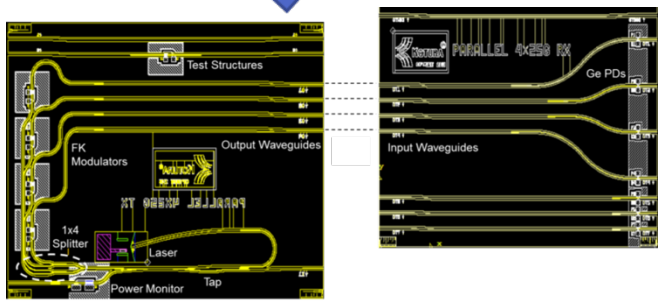
**Modulation speed**: 25G→40G→50G+
**WDM**: 1→4→8→40+
**Fibers**: 2→8→16+
**Advanced modulation:** OOK→PAM4→?

1.6 Tb/s Tx

1.6 Tb/s Rx



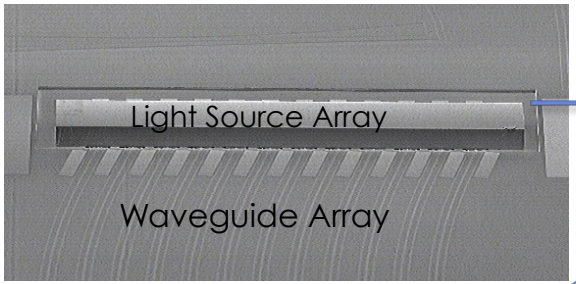

100 G WDM(4x25G)

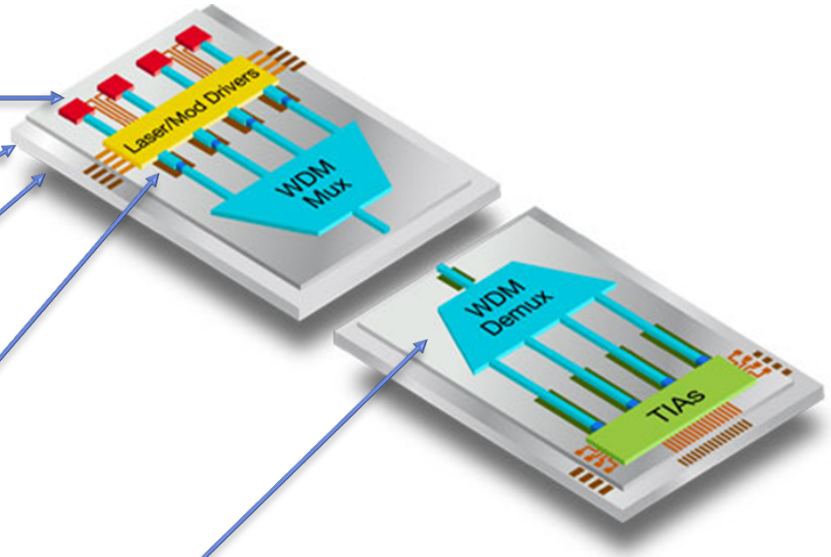



100 G Parallel (4x25G)

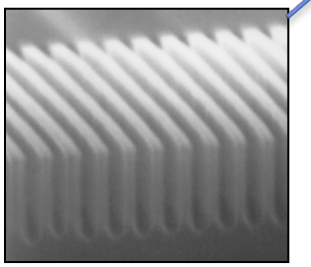
Wave Division Multiplexing uses wavelength specific lasers to allow multiple transmission paths over the same fiber. It allows 100GE transmission over the same SMF duplex fibers used for 10GE

# Silicon Photonics Integration: more than just a modulator

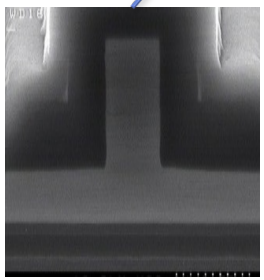


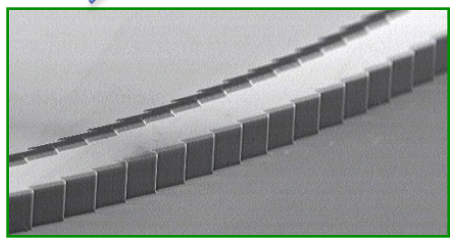

Generic GE-style gain chips create WDM external cavity lasers after bonding. They can be easily made in arrays.



Laser Grating



Modulator



WDM Mux/Demux

# Embedded Optics Checklist

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- √ Use CMOS where ever possible
- √ No WDM specific lasers, no laser sub-assembly (no isolators, beam collimators, lens cap, etc.)
- √ Flip-chip laser array bonding
- √ No hermetic packages
- √ No active laser alignment
- √ No detector sub assembly
- √ No TEC
- √ No WDM assembly
- √ Die attach driver array
- √ Die attach TIA array

# Silicon photonics

- Scales to many terabits with the switching chips
- Solves front panel density problem
- Eliminates the cost and power of electrical transceivers on board
- Integrates into standard electronics board assembly process
- Best short and long term solution

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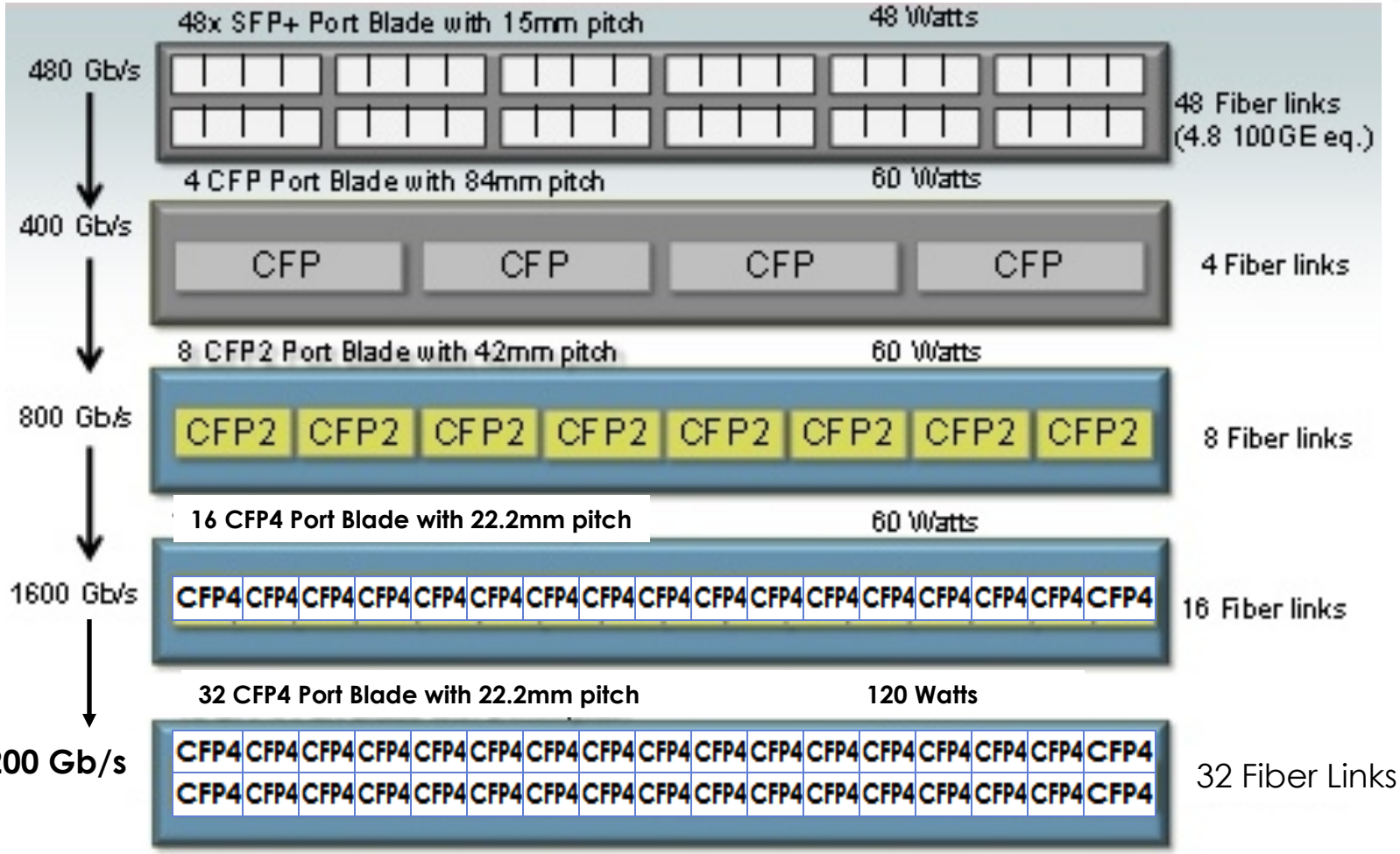
# IC Vendor Perspective: Photonics Integration to Enable Versatile, Low-cost Next-gen Optical (Coherent) links

Frank Chang
September 25th, 2013
Inphi Corporation

Inphi

# Faster, Cheaper, Smaller




***Integration substantially shrink 100/400G pluggable module form factor – KEY to reduce size and power***

# Possible Advanced Modulations for 400GbE

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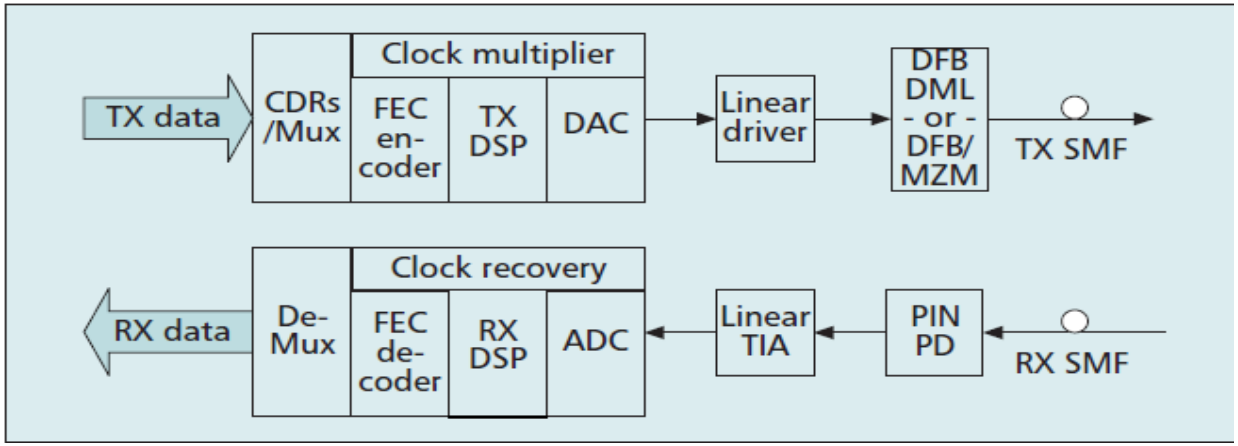
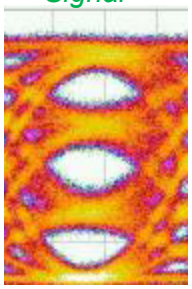
- Optical PAM (Pulse Amplitude Modulation)

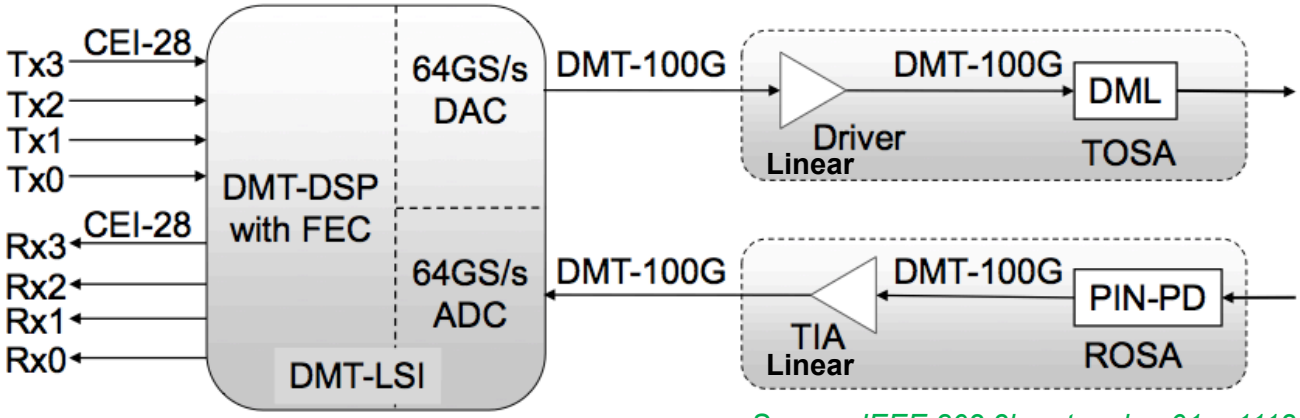


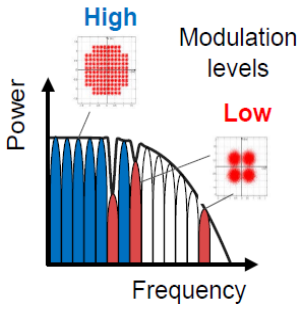

*PAM4 Optical Signal*



*Source: IEEE Comm.Mag, Mar. 2013*

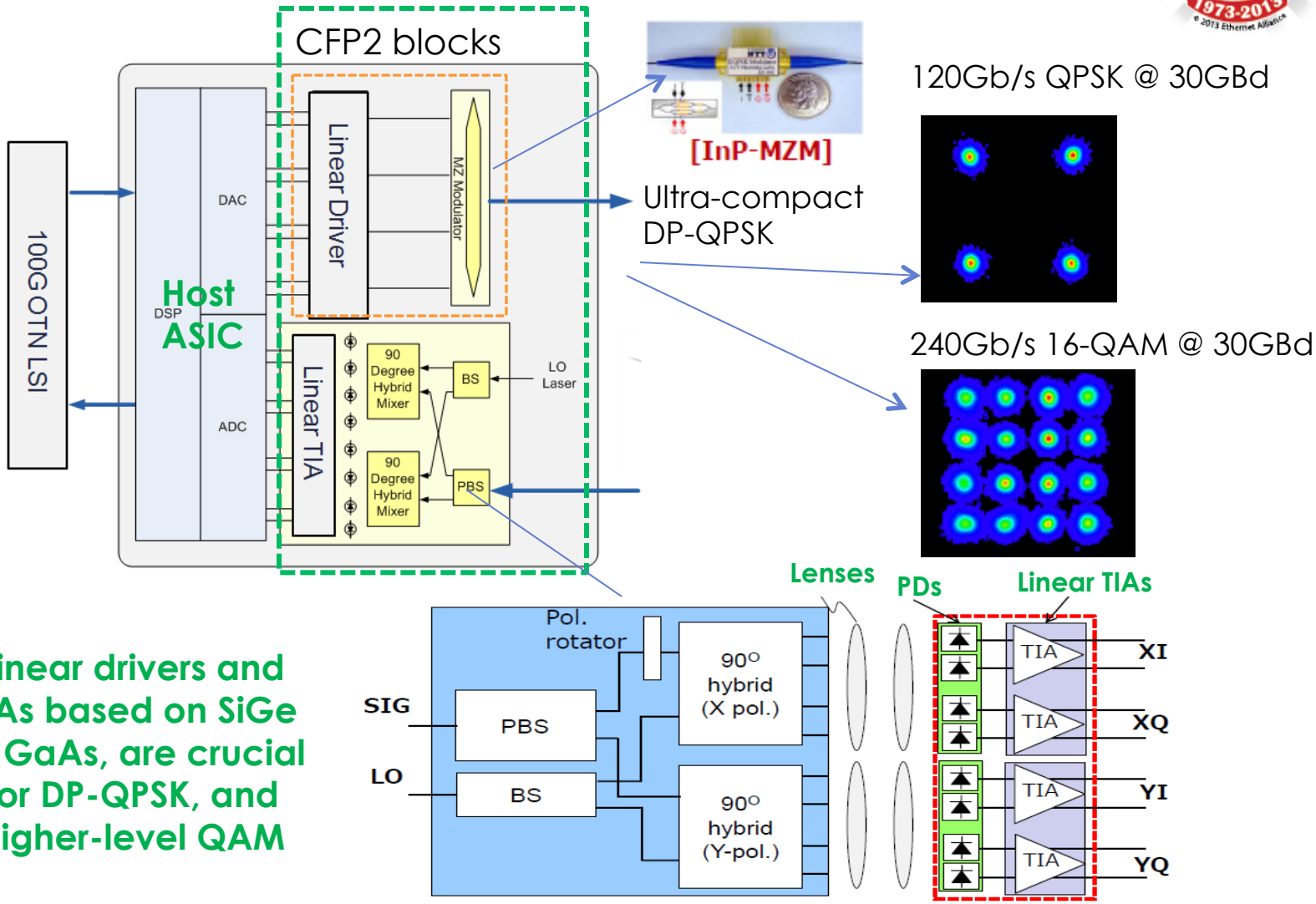
- Optical DMT (Discrete Multi-Tone)




*Source: IEEE 802.3bm, tanaka_01a_1112*

# Beyond 100G CFP2 Coherent Flexible Transceiver




**Linear drivers and TIAs based on SiGe or GaAs, are crucial for DP-QPSK, and higher-level QAM**

# Hybrid Integration Implementations

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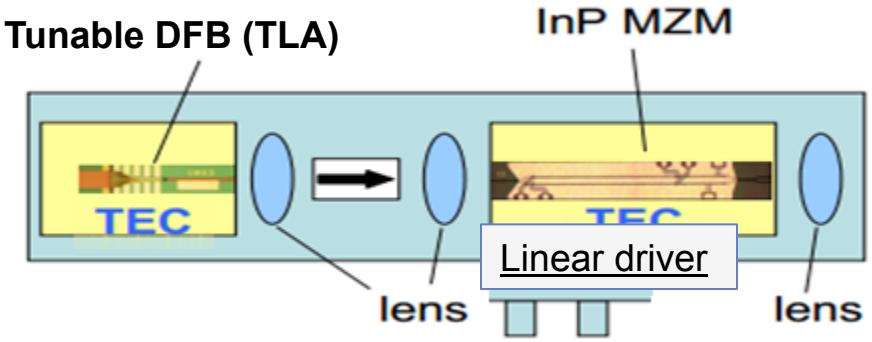
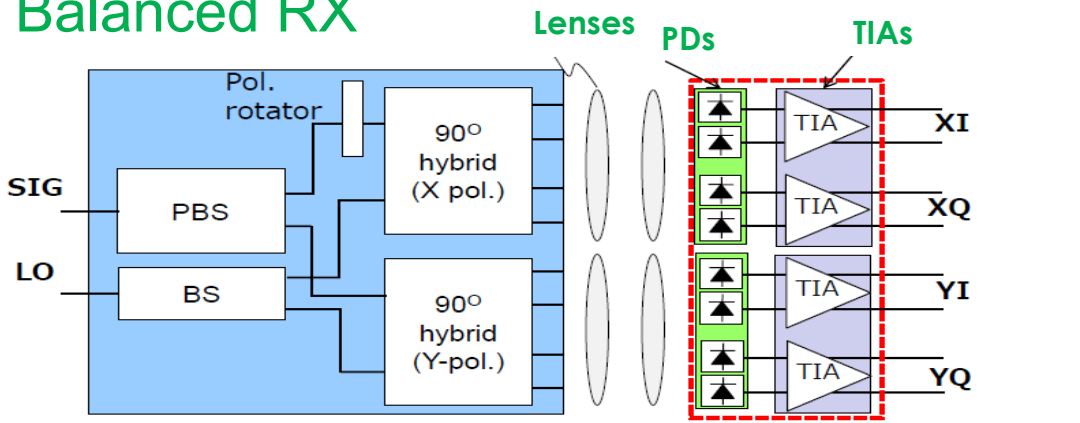
## Tx: Integrated Tunable Transmitter Assembly (ITTA):

- The selection of drivers is related to the MZM Vpi
- Package driver die into ITTA for further size reduction




## Rx: Coherent Balanced RX




Planar Lightwave Circuit

PLC = non-Si based

Chip level co-package O/E

# Summary

- Look for SFP+ equivalent of the 100/400G pluggable module for metro/long haul (believe that is CFP2 for telecom)
  - Tunable CFP2 coherent has an important role to play.
  - Rate-flexible transceiver for trade-off of capacity and reaches in metro – potential solution towards 400GbE
- Advanced modulation facilitates large-scale ASICs and integrated Optics – drives to lowest cost => more integration
- Hybrid integration - no "one size fits all" scenario for photonics
  - Application and material/process dependent
  - ASIC, InP and non-Si PLC all will likely have a role to play
- Integration is key to reduce size & power dissipation
  - Cost, cost, cost

# And now, the debate!