Advances in optical packaging for the design of datacenter transceivers

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Photonics Days
Berlin Brandenburg
innovationconference

MASSTART

virtual conference session:
Data Center Interconnects – Towards Mass Manufacturing

online / October 6th 2020 / 4 – 7pm

dust photonics

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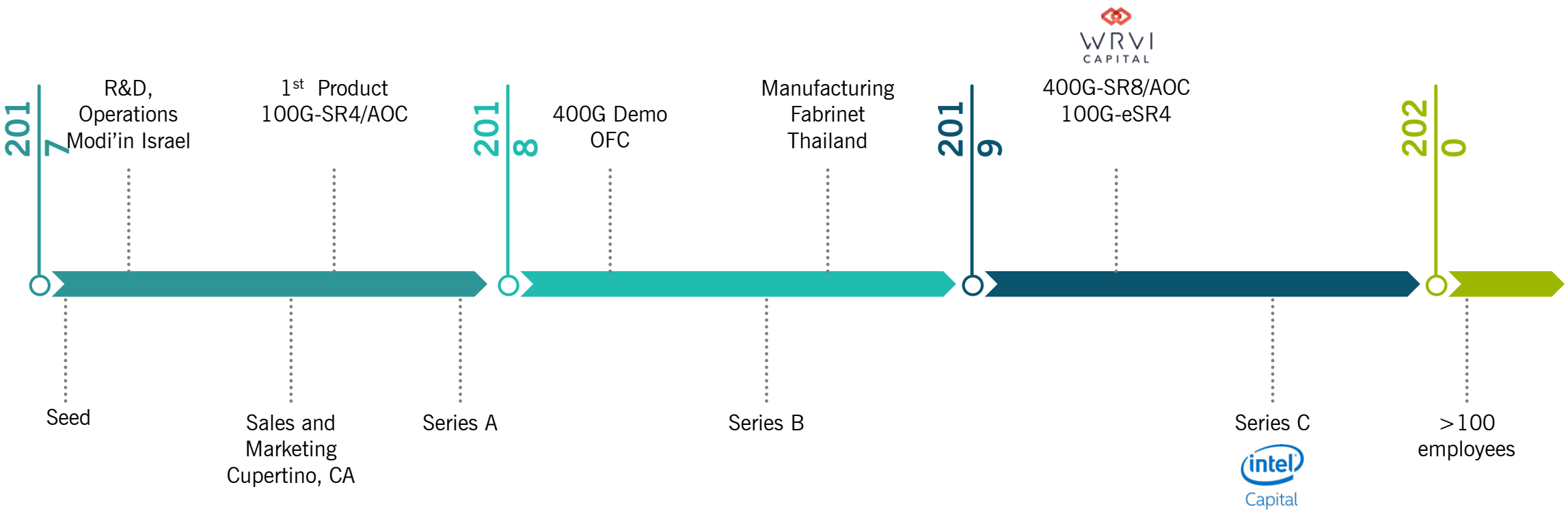
Kobi Hasharoni

October 2020

DustPhotonics

Electro-Optical Alignment Technology for High Value Interconnections



MISSION

Enabling next generation optical assemblies with advanced optical alignment techniques by providing higher levels of integration, lower power dissipations, improved product yields and reducing overall cost of ownership.

1 Multimode

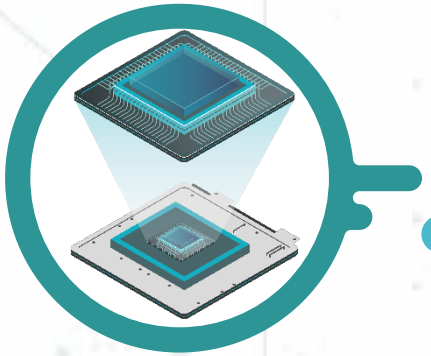
2 Single Mode

3 Silicon Photonics

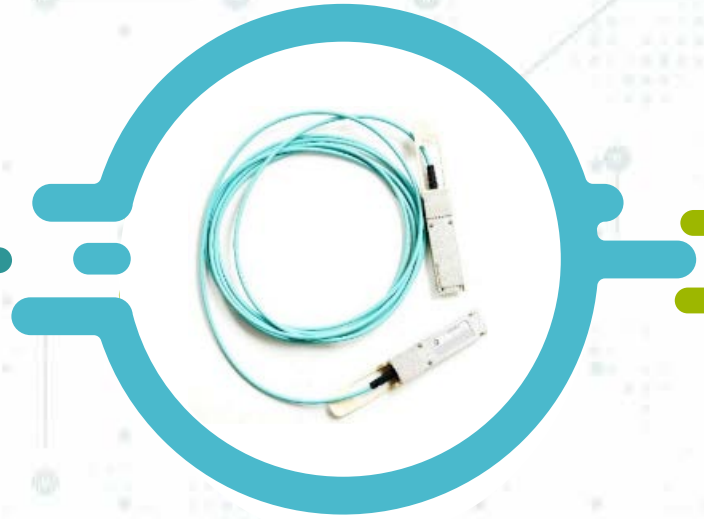
4 Co-Packaging

Our Markets and Products

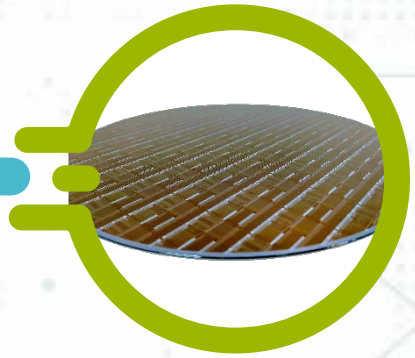
5G Data Centers,
Front/Backhaul



Co-package



High Speed Optical Assemblies



SiPhotonics

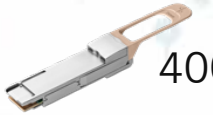
Data Centers and OEM

Routing and Switching

HP Computing

100G

SR4
eSR4
iSR4



400G

SR8
SR4.2

800G

SR8

400G

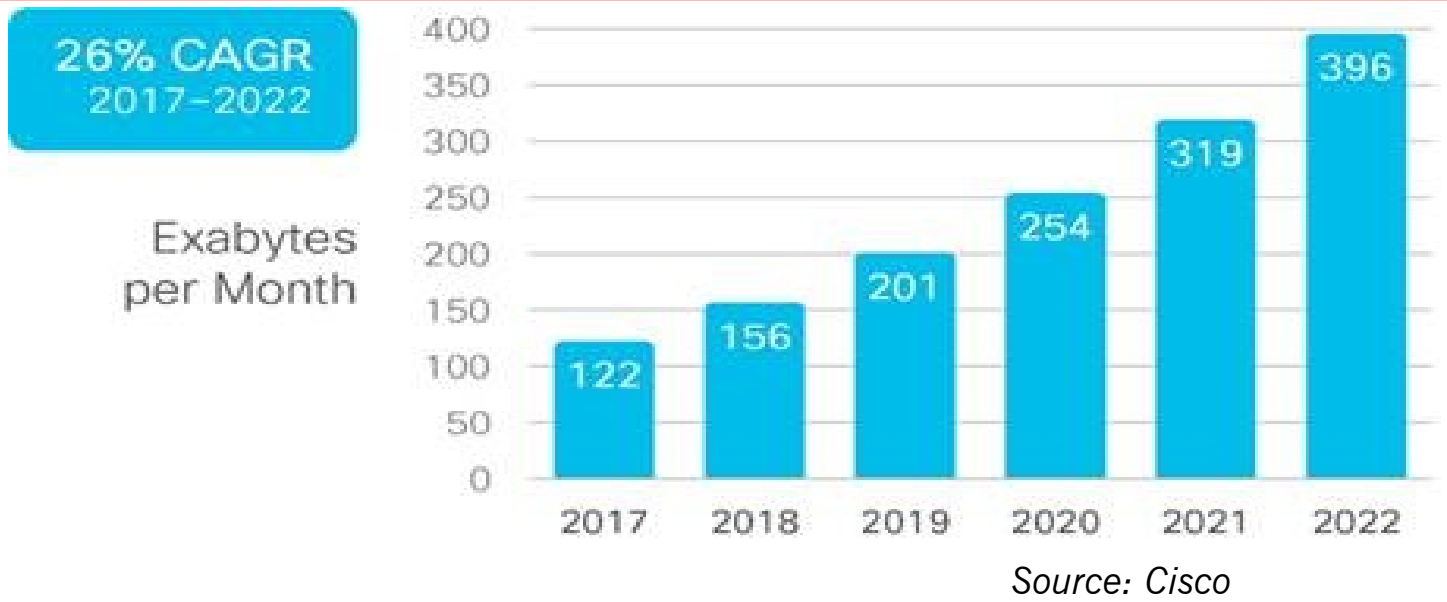
DR4
DR1
FR4

800G

DR8
FR8

Data center network

- Traffic in the data center keeps growing at an almost exponential rate
  - Social media
  - Big data analytics
  - AI

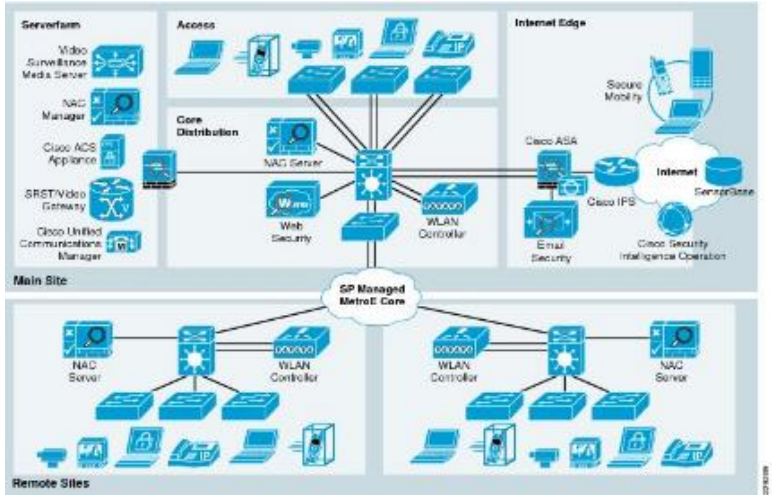


Source: Cisco

Data center network

Market segments

Enterprise networks

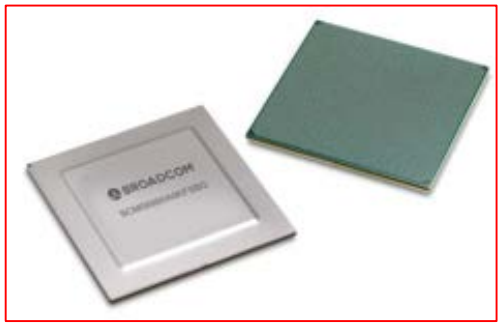


High performance computing

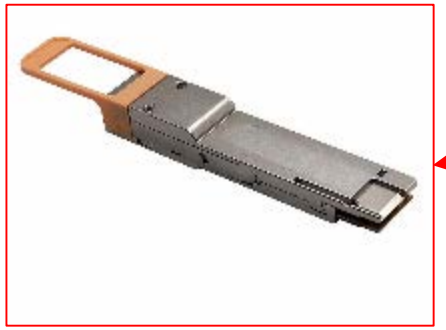
Cloud applications

Data center network

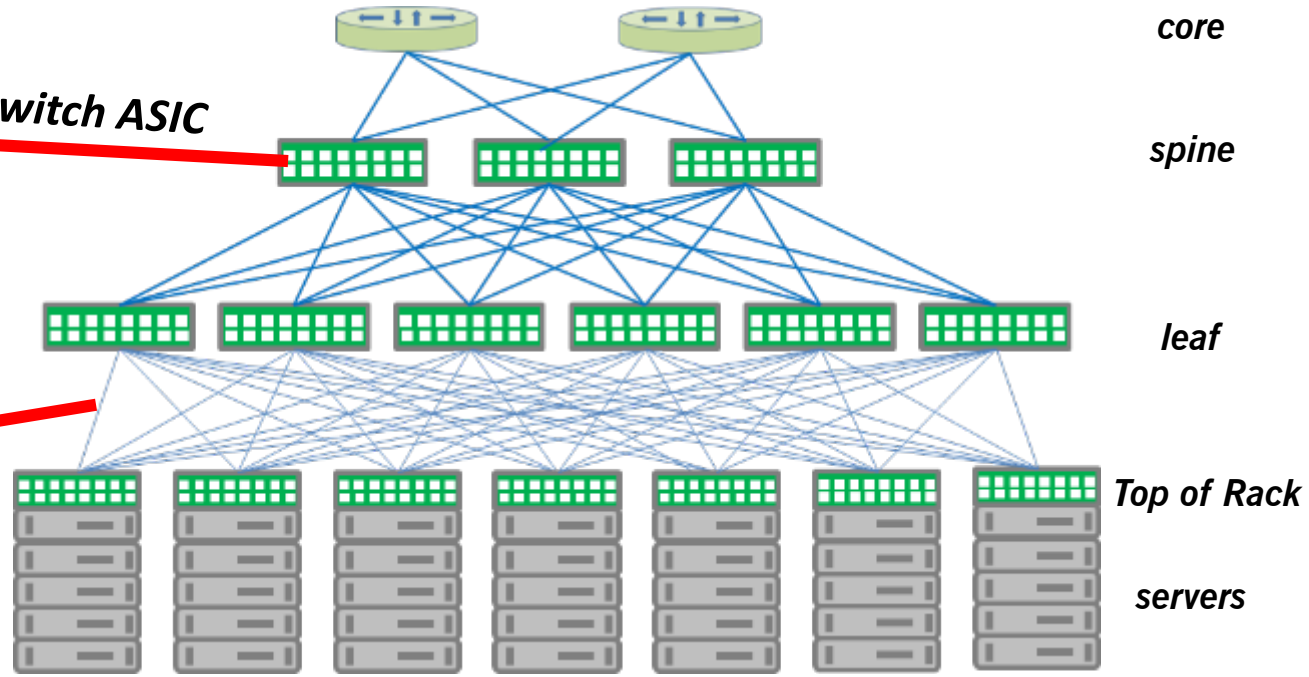
- A server is connected to all other servers (full mesh topology)
- Servers are connected via the DC network composed from Ethernet switches
- The data center network is hierarchical – adding a new switch layer when running out of capacity
- Optical connectivity between switch hierarchies



Ethernet switch ASIC



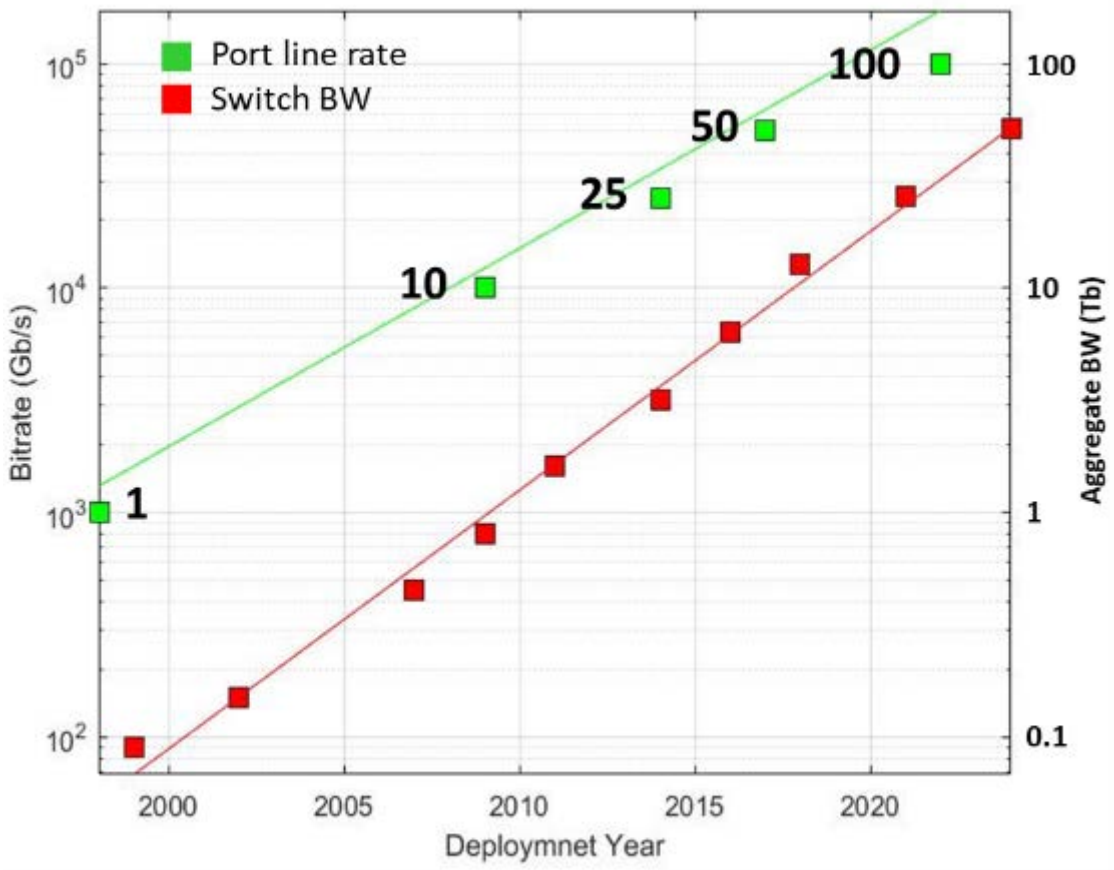
Optical interconnects



Data center network

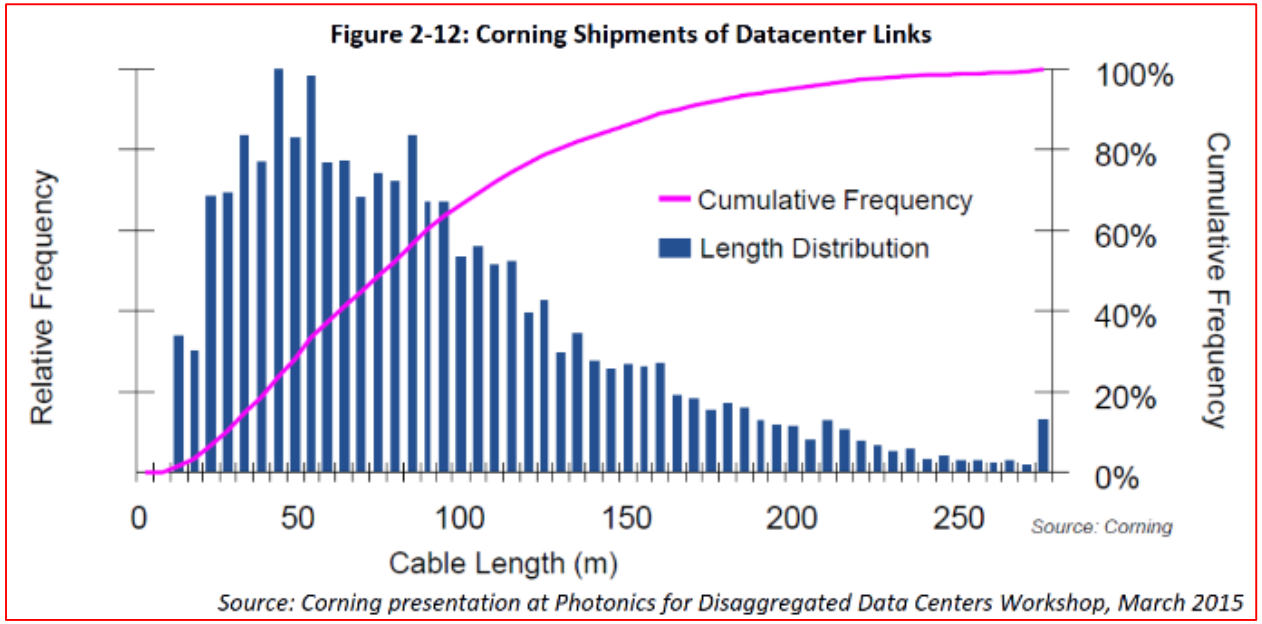
The transceiver data rate follows the ethernet switch port speed

Switch Bandwidth [Tb/s]	Chip Radix	SerDes speed [Gb/s]	Ports	Port Speed [Gb/s]
0.64	64	10	64	10
1.28	128	10	32	40
3.2	128	25	32	100
6.4	256	25	64	100
12.8	256	50	32	400
25.6	256	100	64	400
51.2	512	100	64	800



Adapted from A. Ghiasi Opt. Exp. 2015

MM vs. SM transceivers

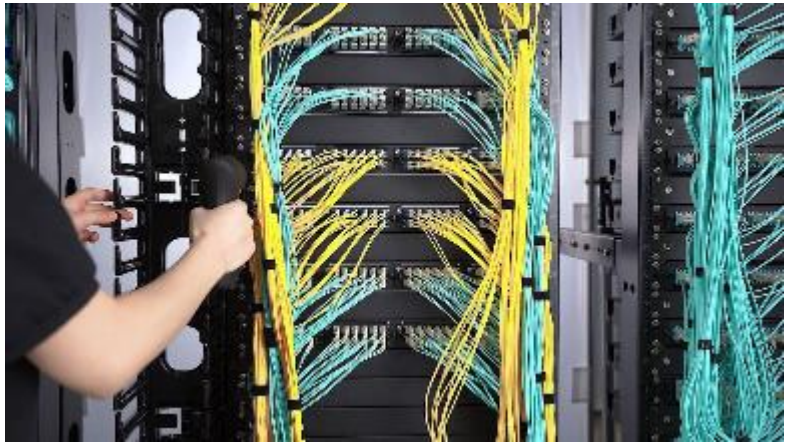


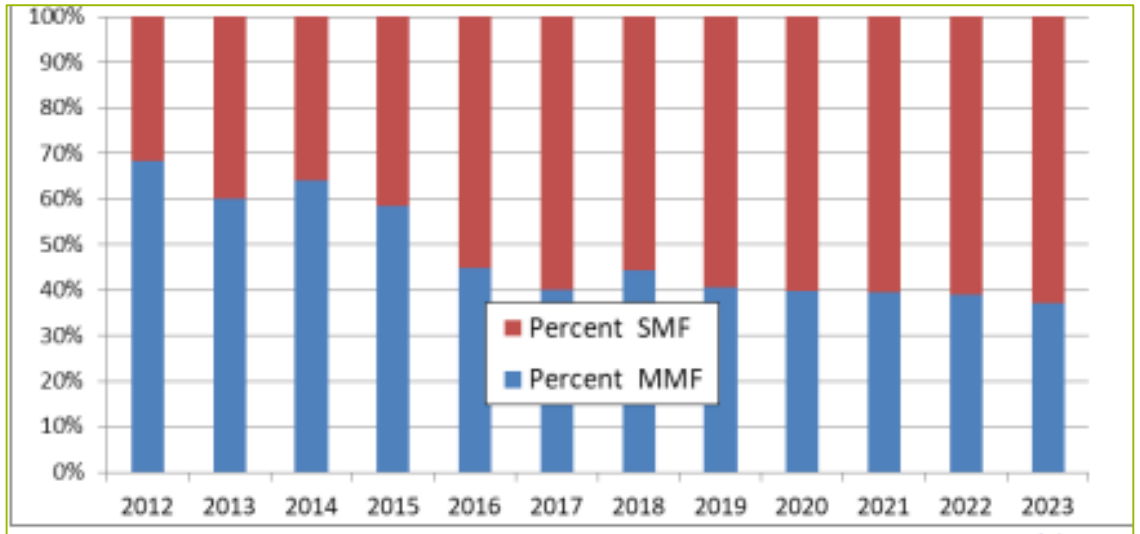
Source: Corning presentation at Photonics for Disaggregated Data Centers Workshop, March 2015

Next generation transceivers need to support:

- Line rate of 112Gb/s and 224Gb/s
- Device capacity of 800Gb/s and 1.6Tbp/s
- Support short (<300m) and longer reach (2000m) in the DC
- Capacity for integration with electronics

Both SM and MM transceivers are needed



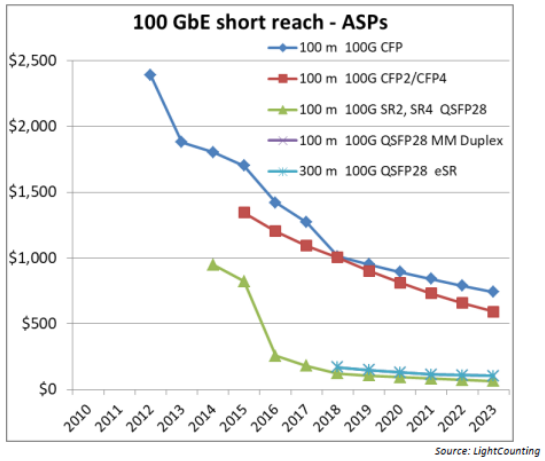


Source: LightCount

DC transceiver metrics

Lower Cost

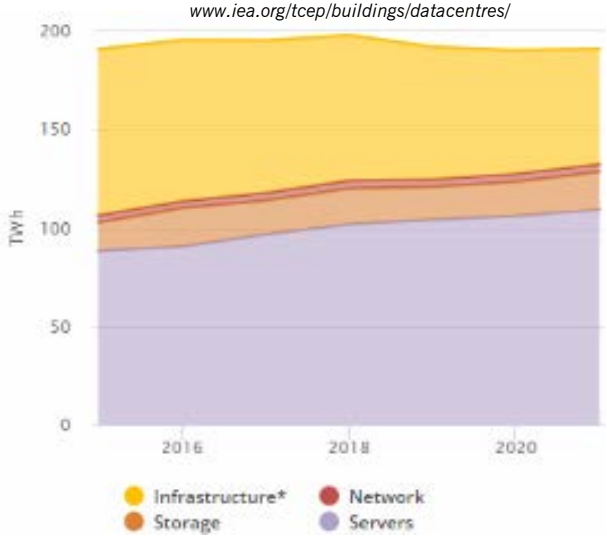
Sub $1/G is an industry-wide goal



Lower Power

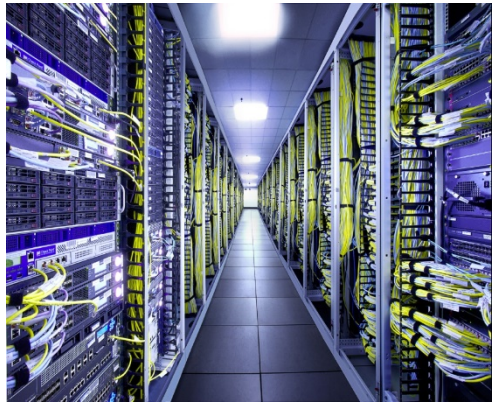
Optical interconnects power consumption amounts to ~2% of the total DC power; however, within a rack they are critical.

www.iea.org/tcep/buildings/datacentres/



Higher Reliability

Transceiver failures in the DC requires constant maintenance

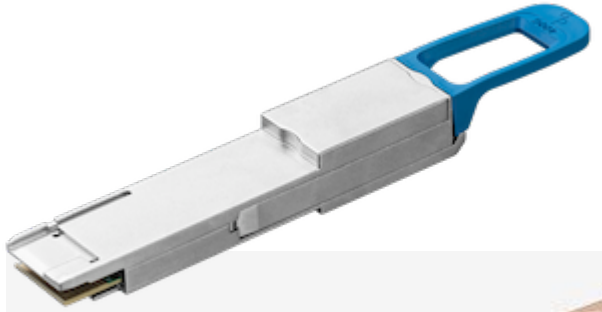


Transceiver design

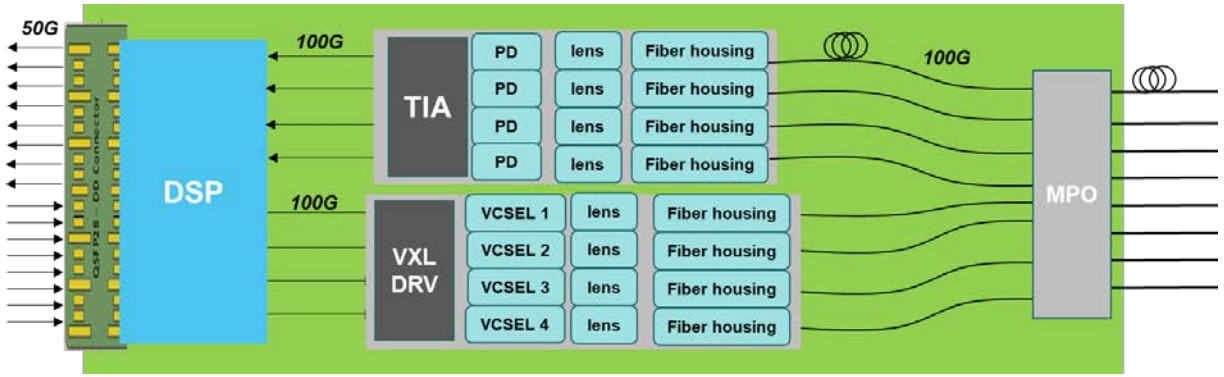
Cost, power and reliability optimization require:

- Design for high volume manufacturing, **fully- or mostly-passive**
- Design for reduced BOM
- Eliminate labor-intensive alignment steps (COGS)
- Support extended reach, high temperature with single design
- Support all data rates with a single optical design

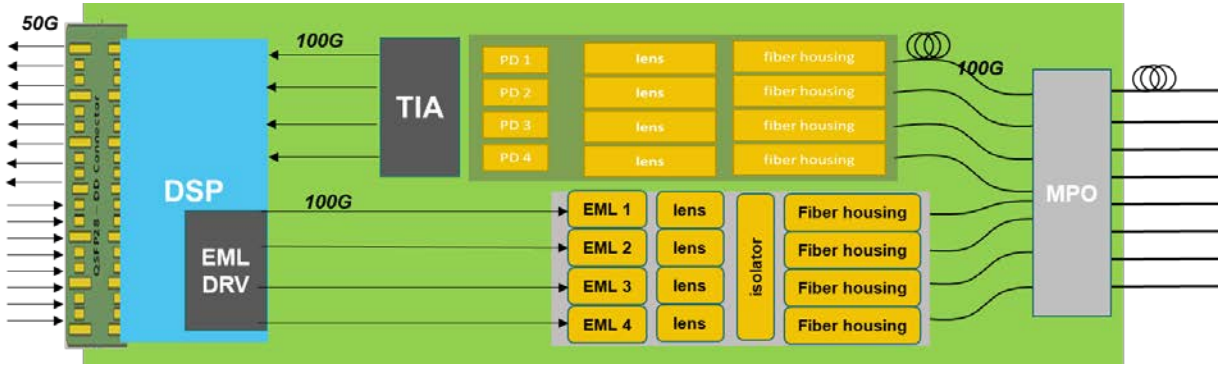
Innovation in Optical Packaging



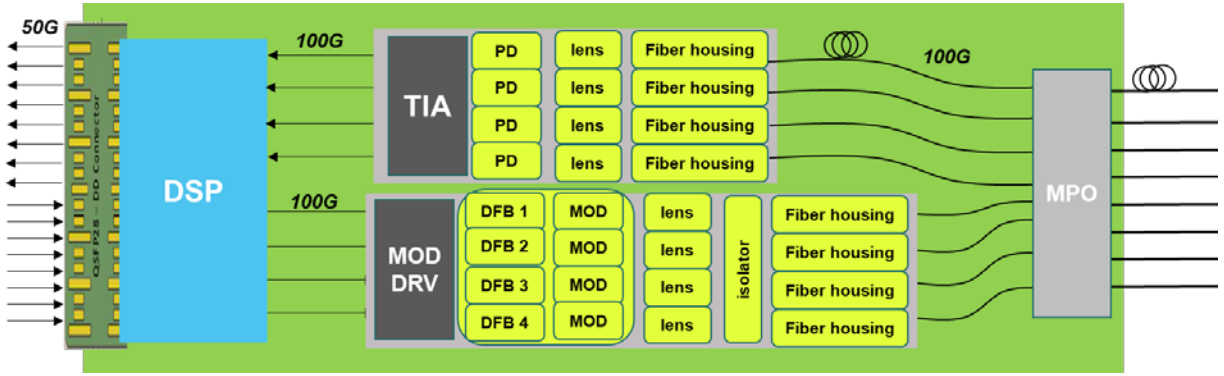
Transceiver design



400G SR8
VCSEL-based



400G DR4
EML-based



400G DR4
SiP-based

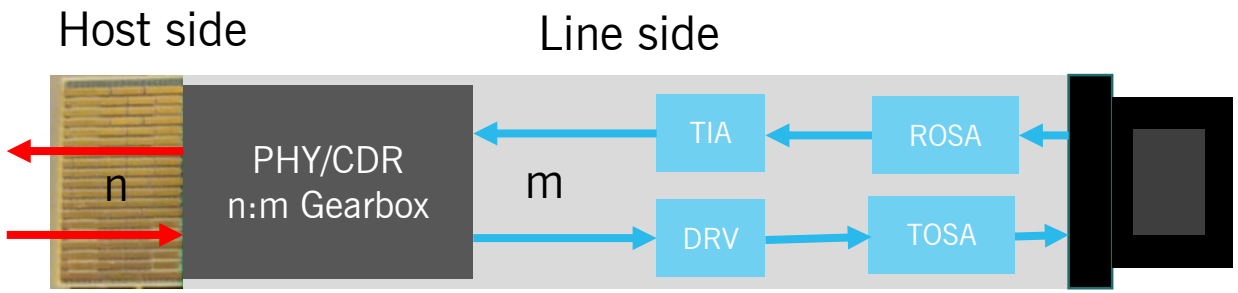
Optical Package Tasks

VCSEL → MMF
MMF → PD

EML → SMF
SMF → PD

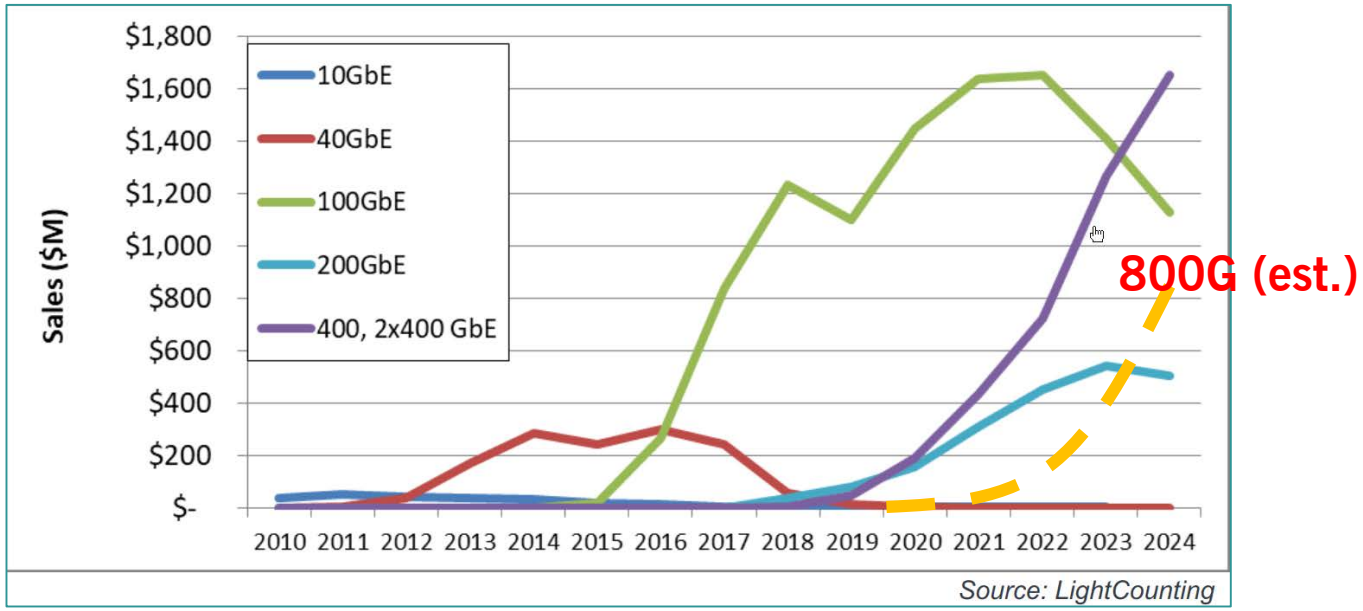
DFB → Tx PIC
PIC → SMF
SMF → Rx PIC

Next generation transceivers



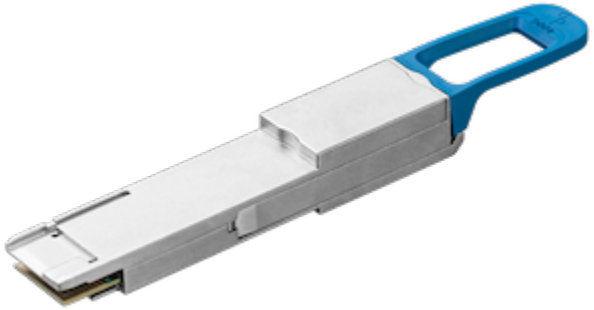
DSP is at optimum when n = m

8×112G electrical : 8×112G optical

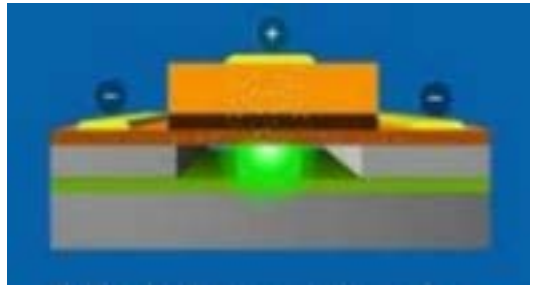


- 800G transceivers are expected to dominate the market as their cost/G will be optimal
- The time gap from 400G to 800G will be significantly shorter compared to 10G – 40G - 100G – 400G
- Both SM and MM 800G devices are needed

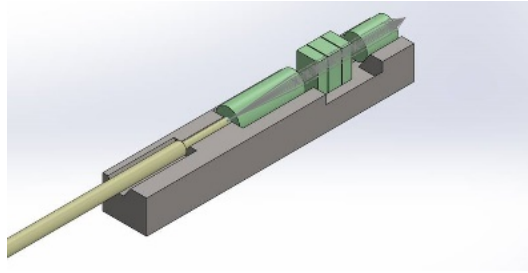
Silicon Photonics based transceivers



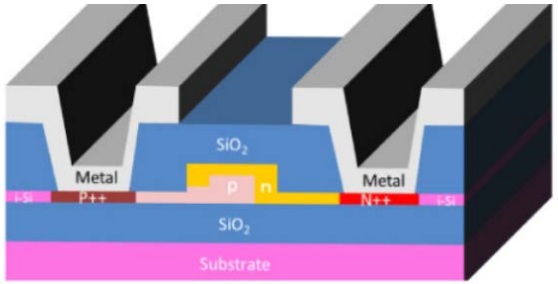
Laser Source



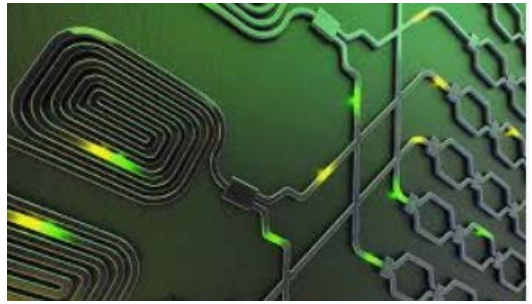
Fiber Coupling



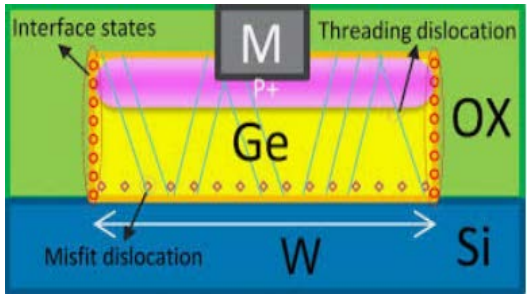
PAM4 Modulation



PIC Processing



SiGe Photodiode

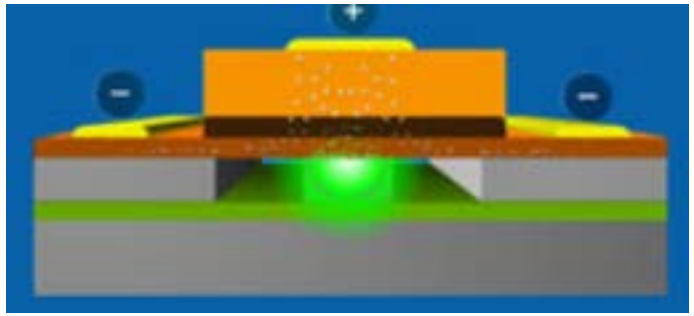


SiP laser coupling

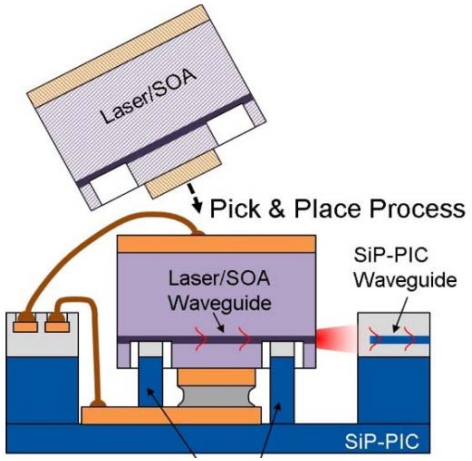
Hybrid integration
- Complex assembly
- Laser and PIC performance coupled
- Requires customized fab

Butt coupling
- Laser die in cavity
- Flipchip bonding limits alignment tolerances
- Sensitive to back reflections

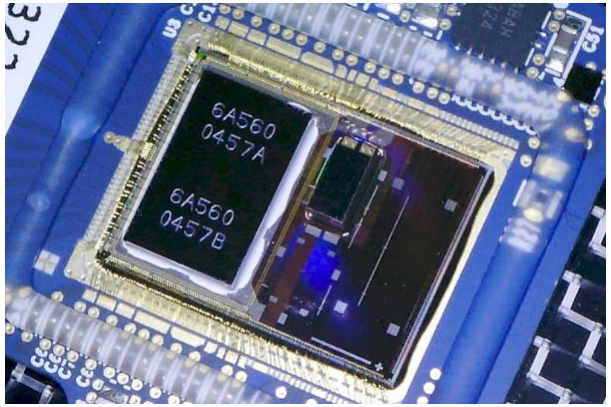
Optical bench
- Free space optical coupling
- Active alignment required
- Coupling efficiency dependent on the GC performance



Source: Intel



Source: H2020 BIG PIPES



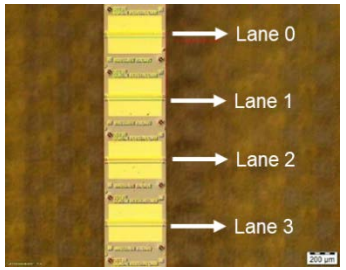
Source: Luxtera

Efficient laser coupling is the main barrier to high volume manufacture of SiP devices

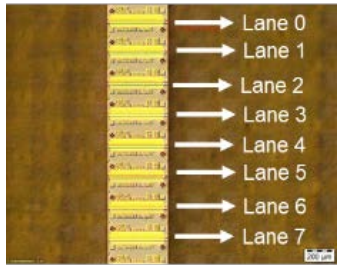
MASSTART – MASS manufacturing of TrAnsceiveRs for Terabit/s era

Efficient and low-cost design of a SiP transceiver
Free space coupling for lasers and fiber array

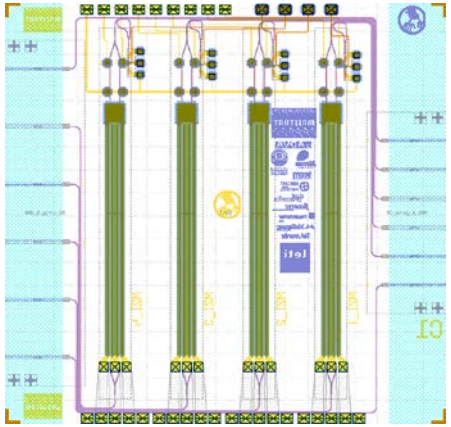
DFB

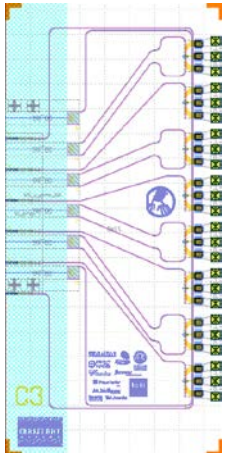


ALMAE

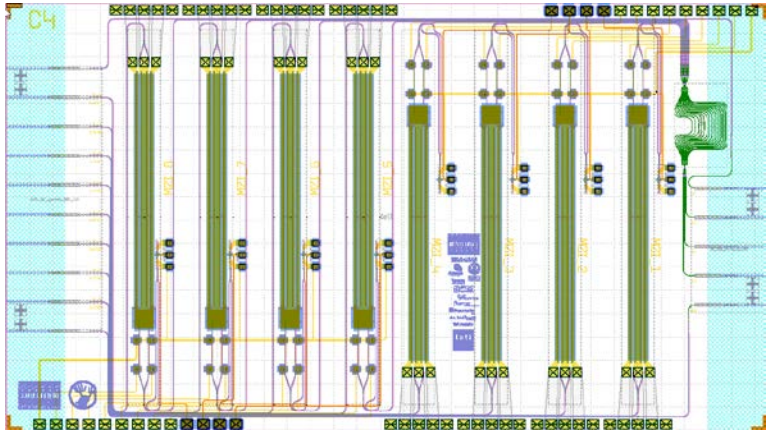


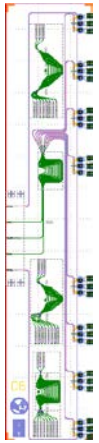
PIC



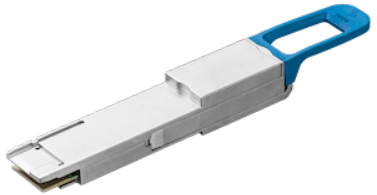


Bright Photonics/LETI





Optical Package



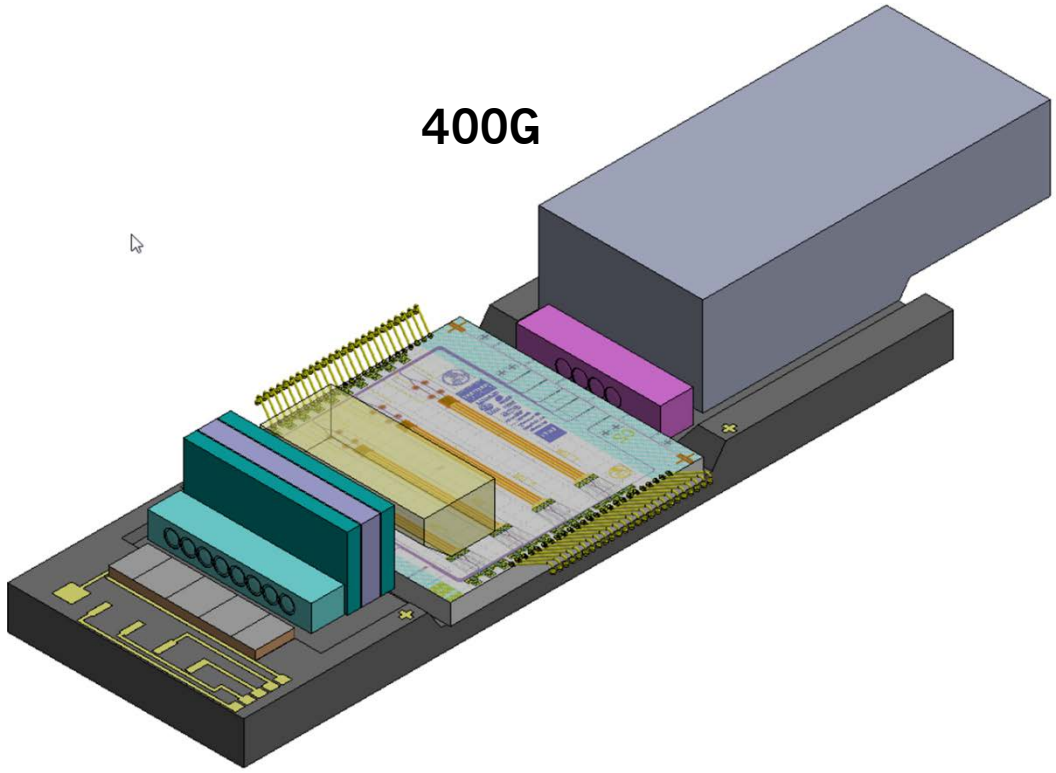
400G QSFP-DD DR4

DustPhotonics/FiconTec/Mellanox

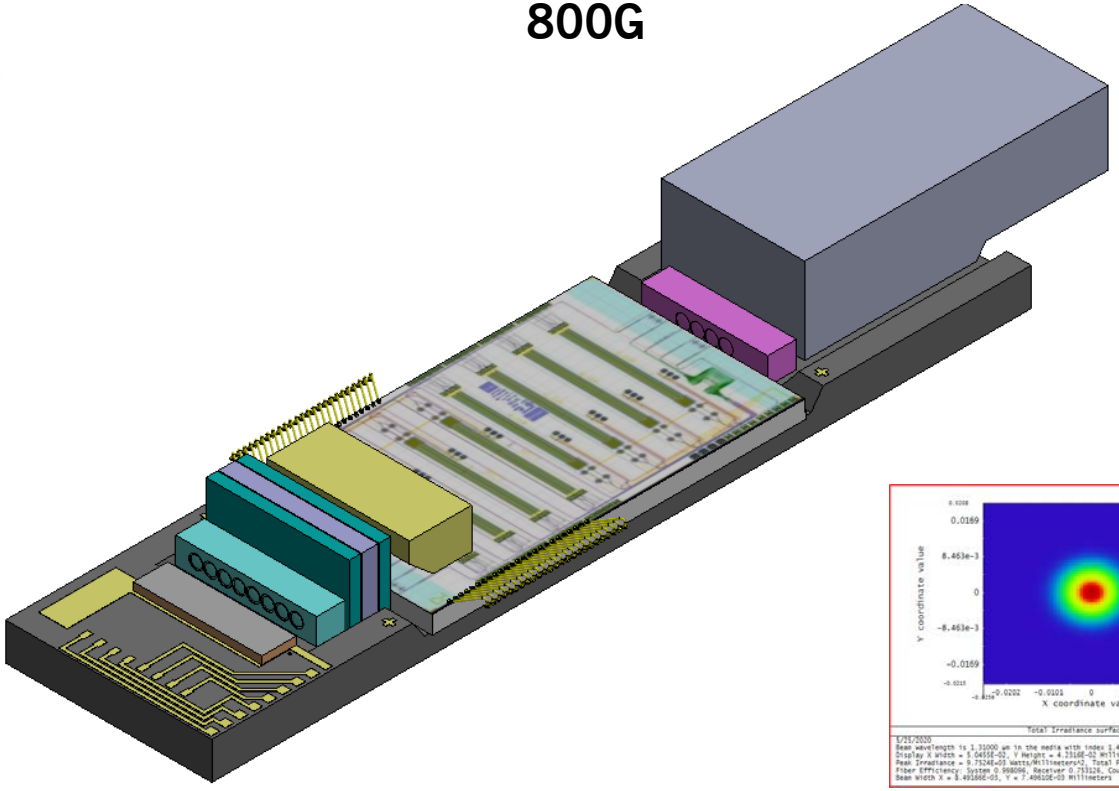
800G OBO FR8

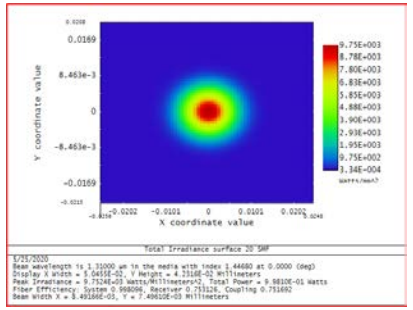
MASSTART – transmit module coupling

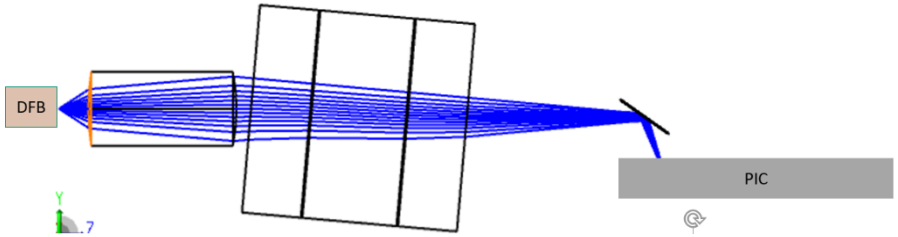
400G

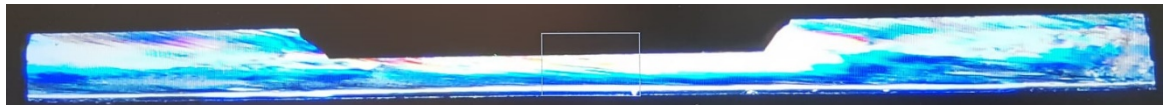


800G



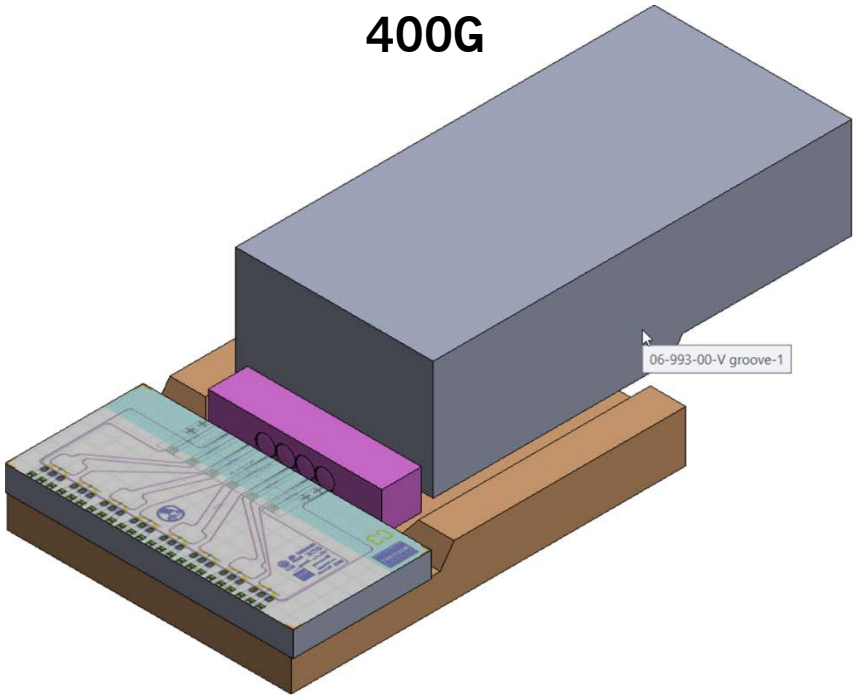




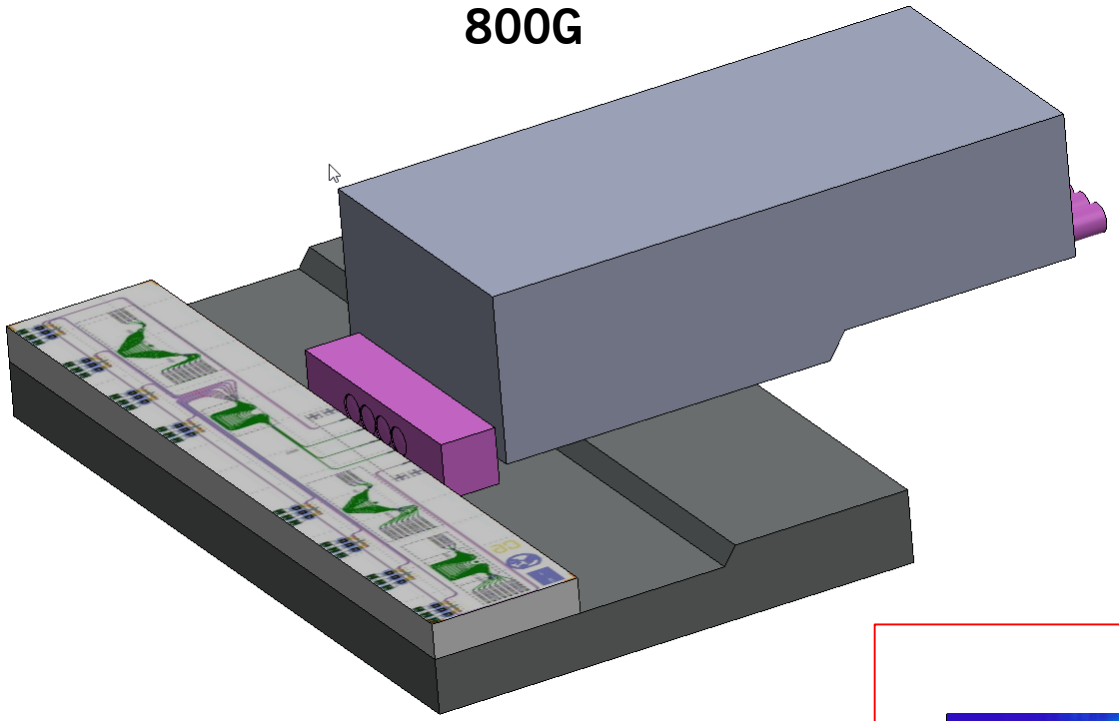


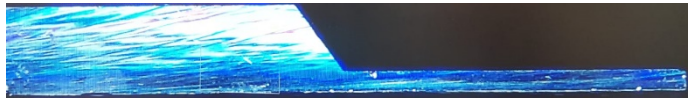
MASSTART – receive module coupling

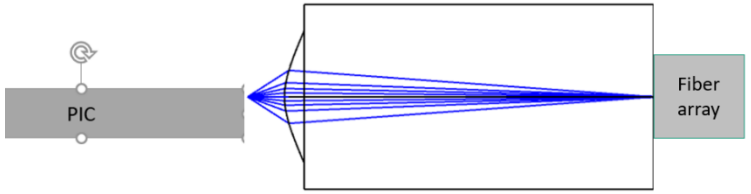
400G

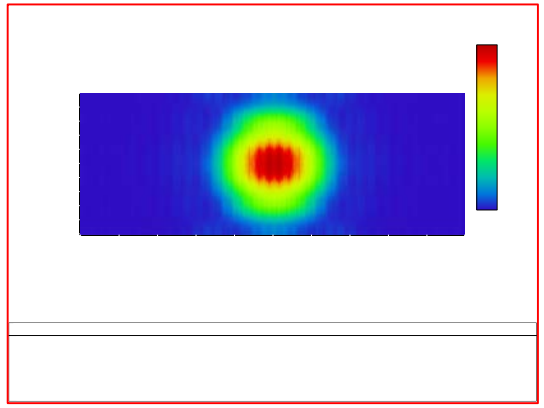


800G









Key Takeaways

Next generation DC optics

Both multimode and singlemode transceivers are required in the DC. Transition from 400G to 800G and 1.6T will occur faster than previously

Silicon Photonics

Enabling lower-cost next generation DC singlemode transceivers requires development of advanced package technologies for SiP that are HVM ready

Low cost laser assembly

Although inferior to hybrid or butt assembly, free space coupling is a simple, low cost coupling technology.

Optical package design using full automation is possible and will enable to further reduce the cost of SiP-based transceivers

dust photonics

THANK YOU

Acknowledgement

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Framework Programme of the European Union

MASSTART project is co-funded by the Horizon 2020 Framework Programme of the European Union with Grant Agreement Nr. 825109. https://cordis.europa.eu/project/rcn/219912/factsheet/en

MASSTART project is an initiative of the **Photonics Public Private Partnership** www.photonics21.org

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