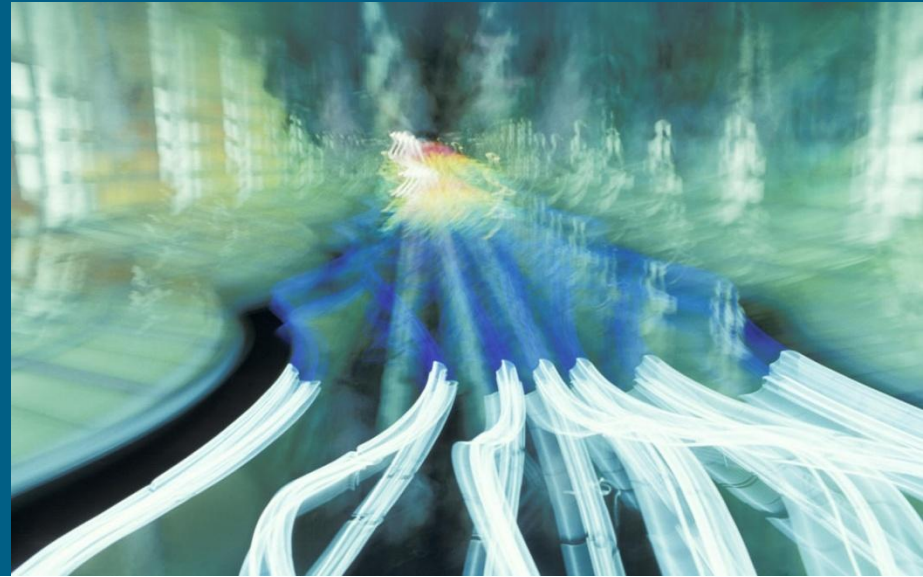


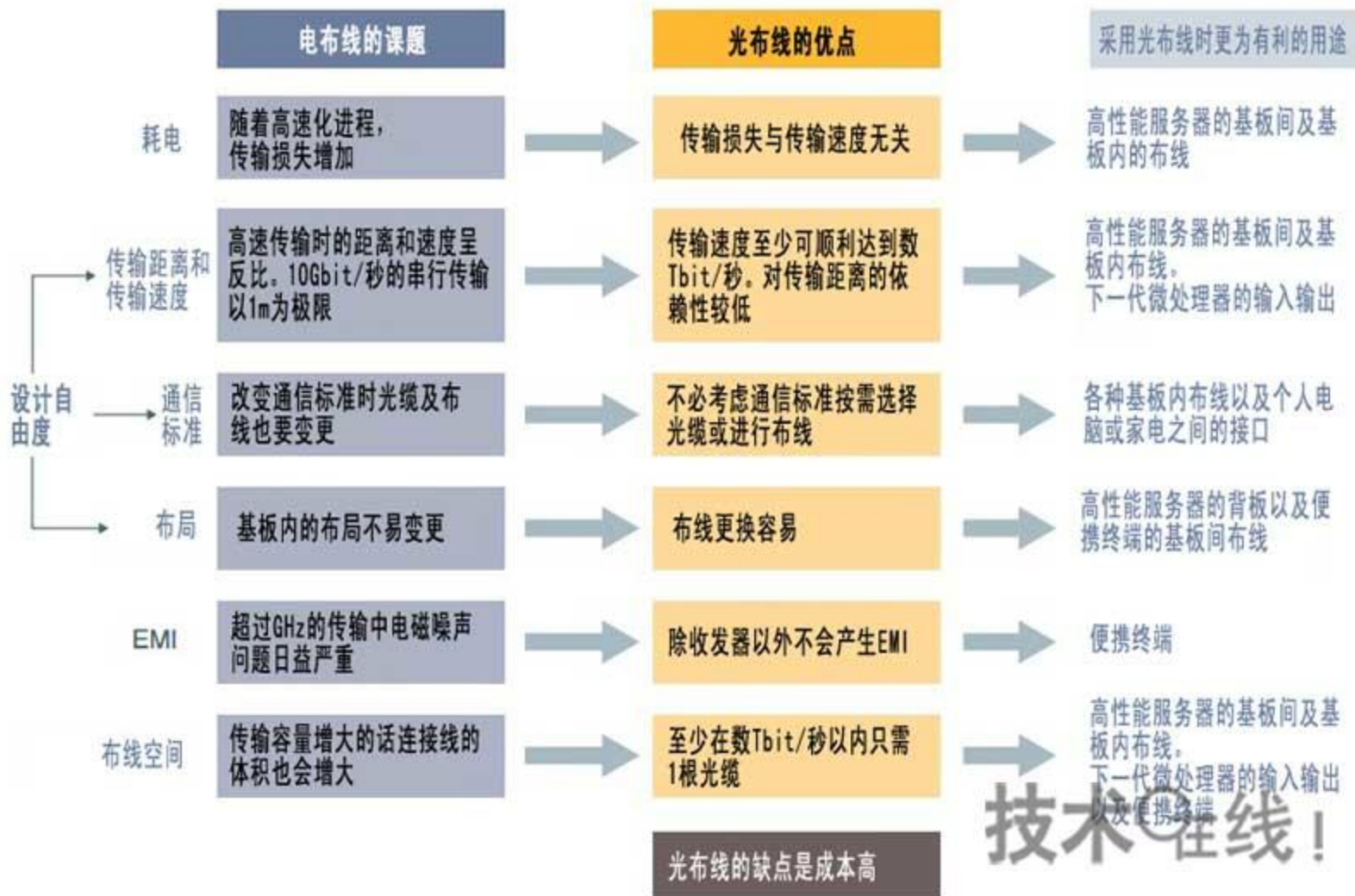


# Cisco 面向未来的核心 竞争力硅光子技术和产 品简介



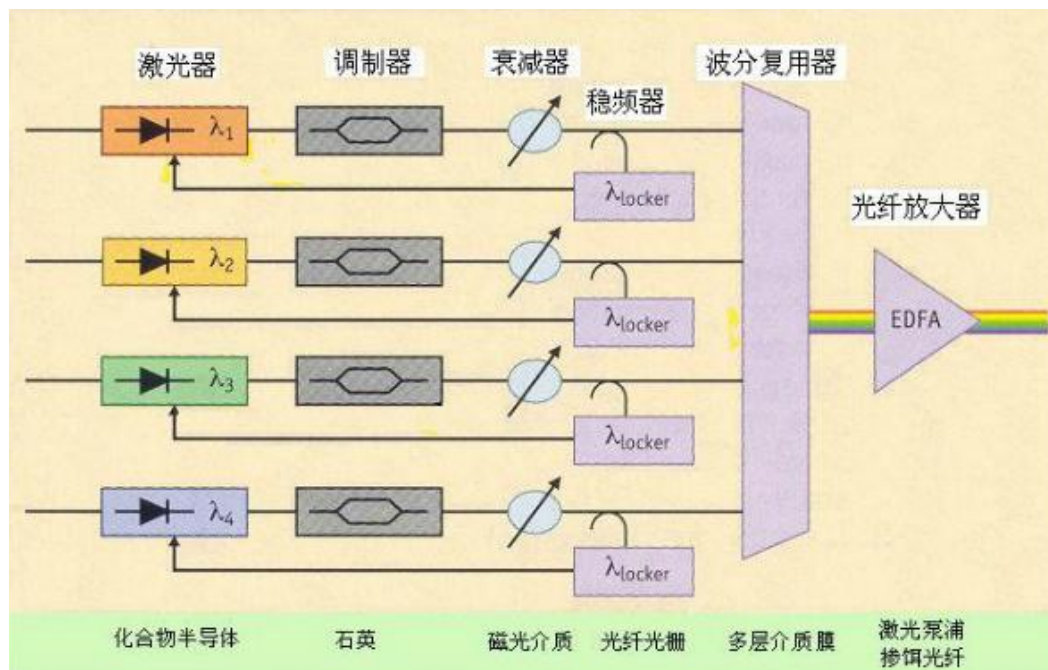
蒋星  
思科解决方案架构师

# 电传 vs. 光传送



技术在线!

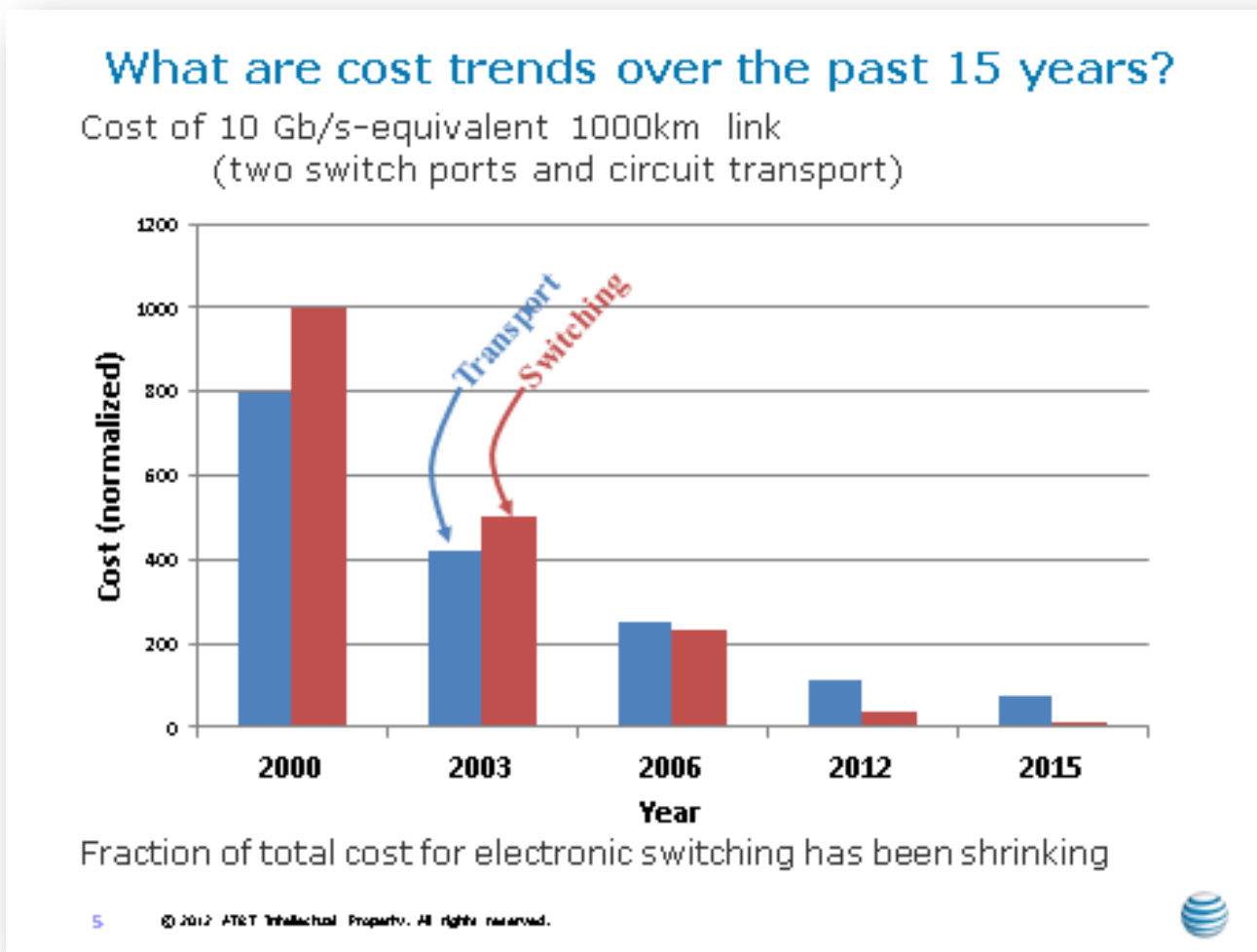
# 光传送面临的挑战



- 采用多种介质和技术
- 需要大量的手工组装过程,如光轴对齐等
- 成本高

# Main network challenge: cost of optics

- Cost of optics drops slower than the rest of the system



# CMOS meets Photonics

## Optical Network Connectivity Requirements

- Very High Bandwidth: 40G/ 100G & beyond
- Increase in Switch & Router Port Density
- Green Enterprise Initiatives
- Complete Portfolio of interface reaches

## CMOS IC Manufacturing

- High Volume, low cost
- Highly integrated
- Highly scalable
- Automated Manufacturing tools



## CMOS PHOTONICS

- Leverages **Silicon/ Moore's law**: low-cost CMOS Manufacturing
- Simplifies** manufacturing complexity
- Integrates **optical and digital** functions
- Eliminates the discrete divide between optical and electrical components
- Highly integrated design** yields smaller footprint
- Low power dissipation**



# 硅光子技术-Silicon Photonics

## 硅光晶体和硅光波导器件

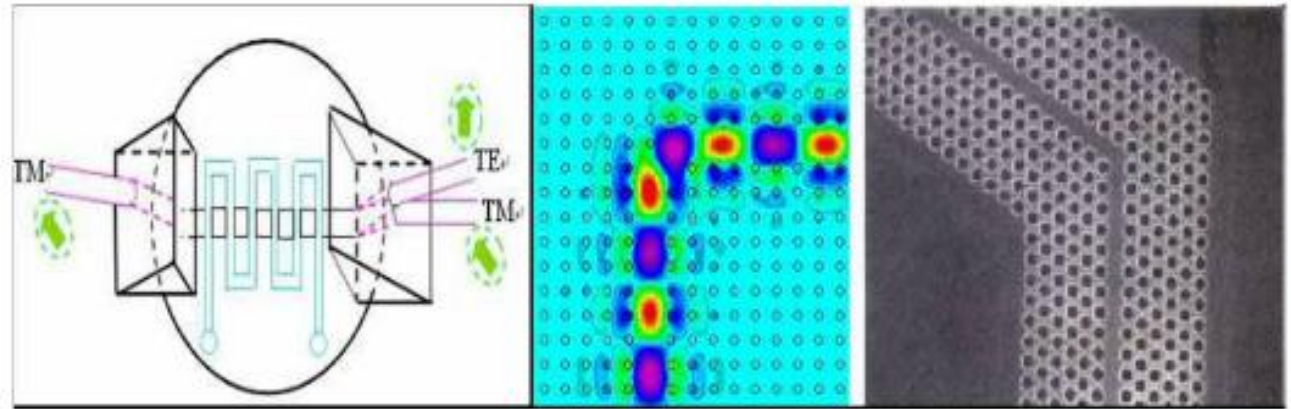
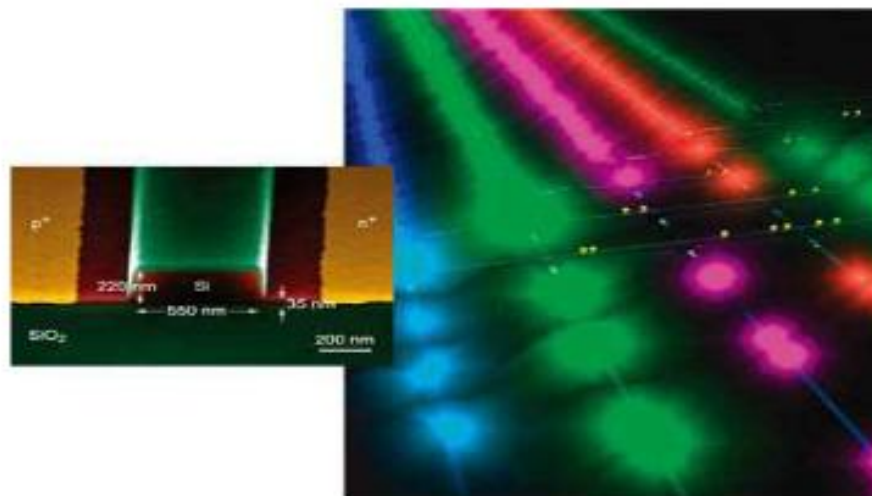
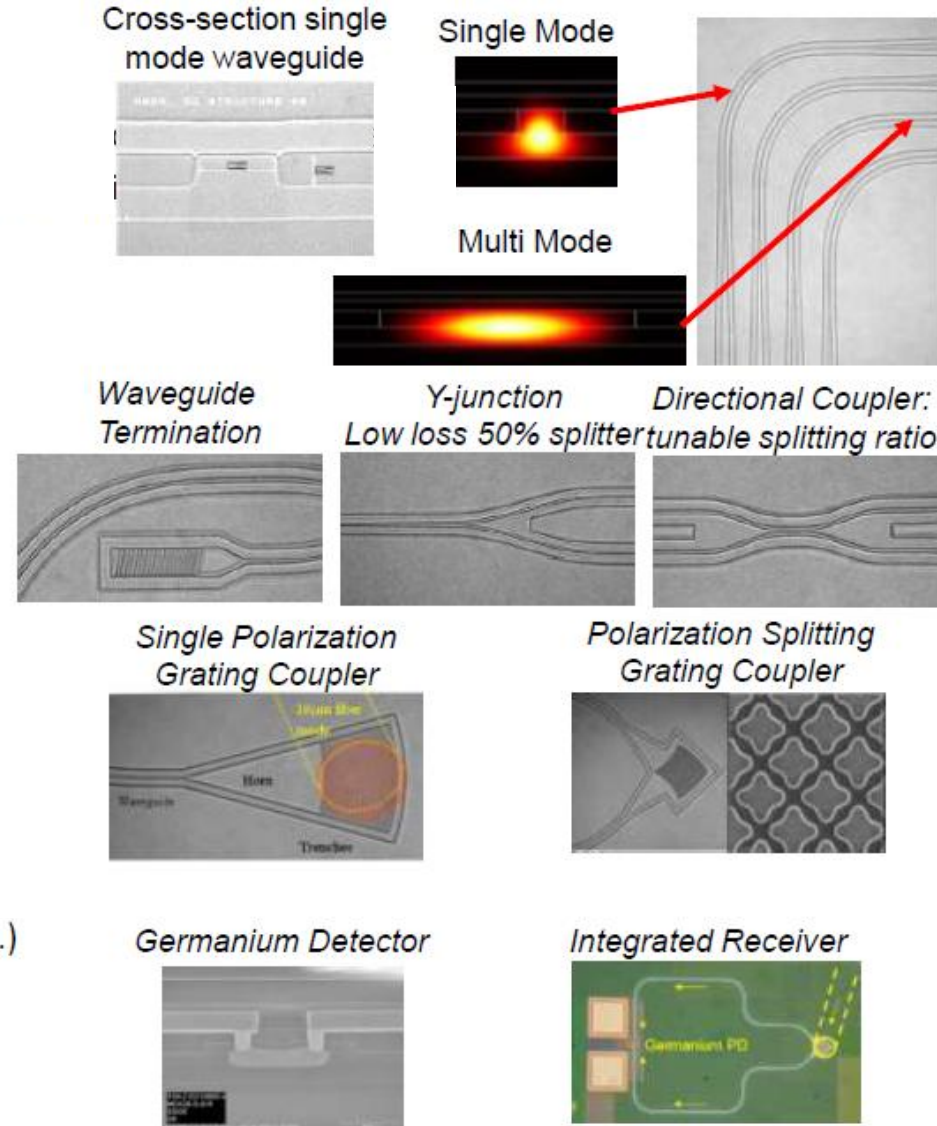


图 13



# What is Silicon Photonics?

- Enables:
  - Easier fabrication of (passive) photonic devices
  - Easy interfacing of electronics and (active) photonics devices
  - Optical chip to chip interconnect
- Applications:
  - Passive devices
  - Modulators
  - Lasers
  - Receivers


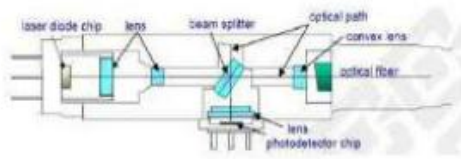


# 光电集成技术的发展

## - 分立器件/混合集成电路/单片集成电路

### Discrete Optics

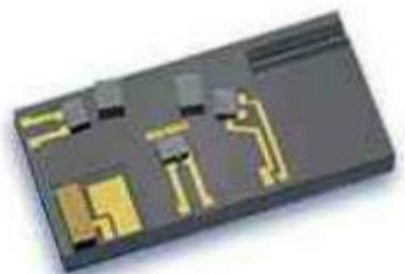
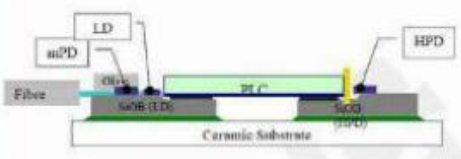
optics assemblies from off-the-shelf discrete components



- discrete actives and passives
- up to 20 parts to assemble

### Planar Lightwave Circuit


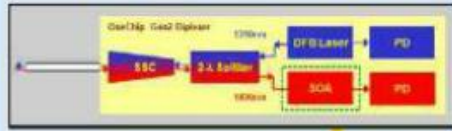
hybrid integrated SiO<sub>2</sub>-Si based PLC (only passive)



- discrete actives
- up to 10 parts to assemble

### OneChip approach

Photonic Integrated Circuit (passive & active)



- no discretes
- all functions in one part

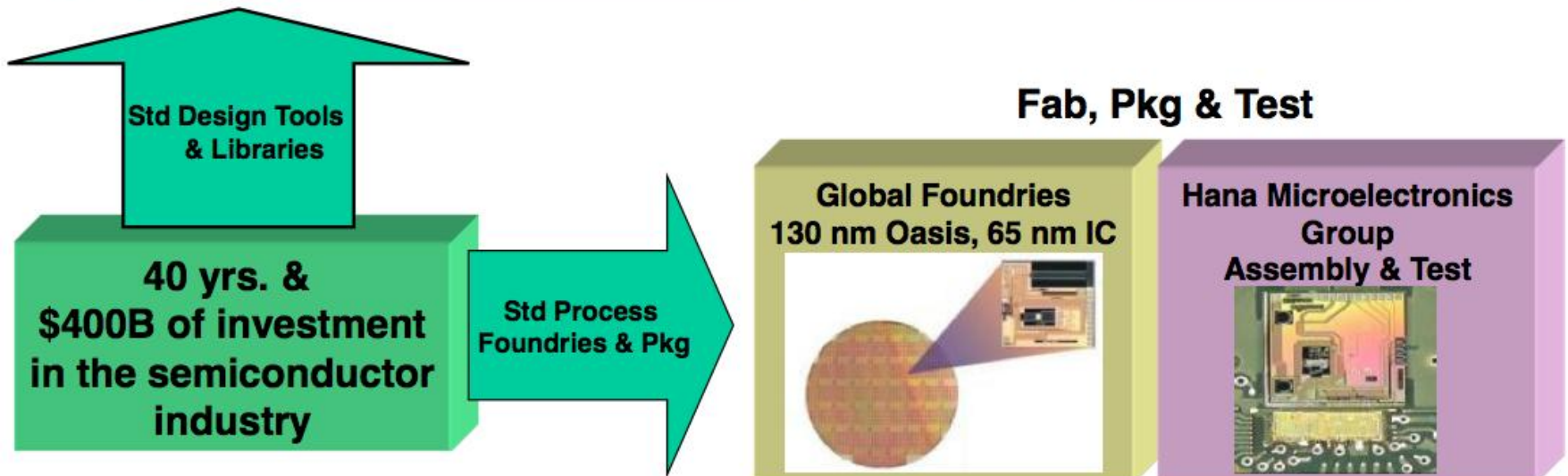
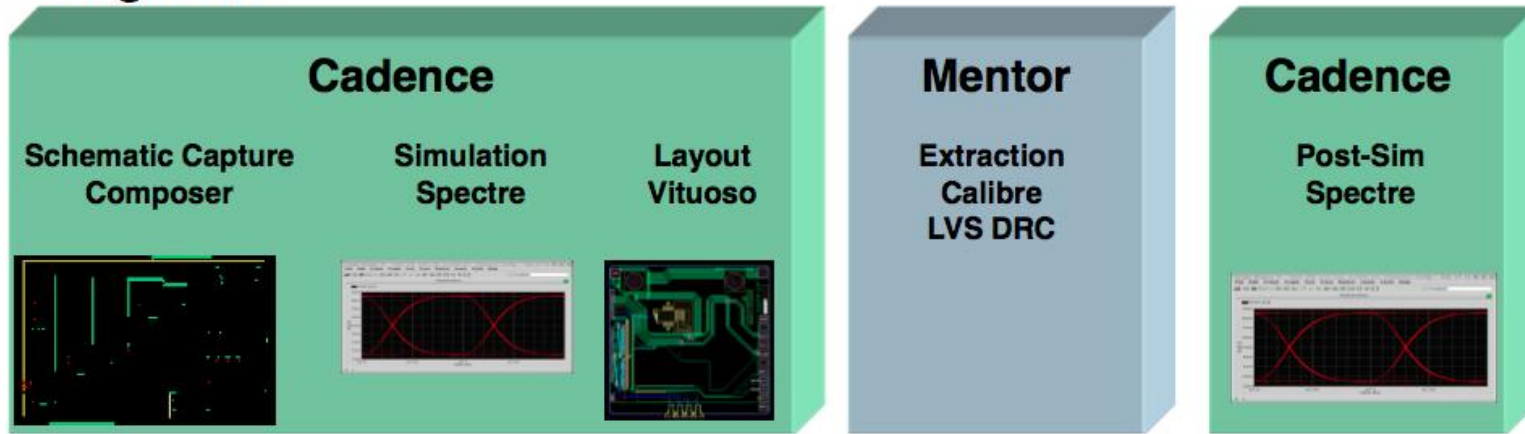
需要大量人工装配  
体积大,能耗高

采用集成电路制造工艺  
体积超小,能耗低



# 硅光子技术的设计和制造流程

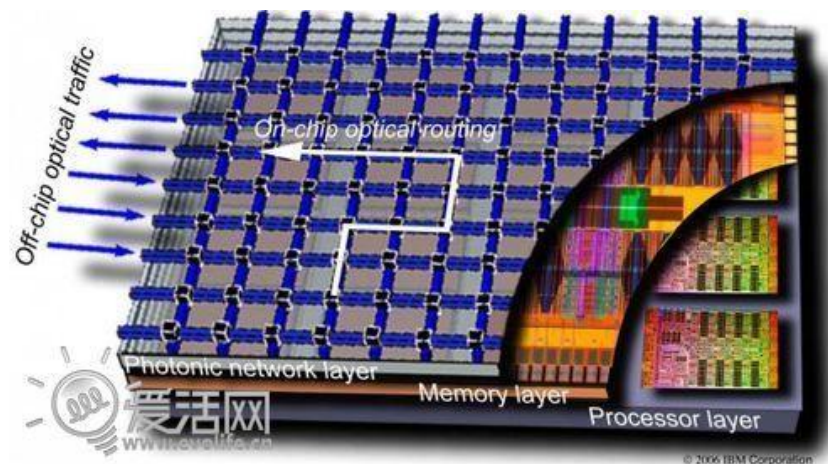
## Design Flow



***Using the same reliable tools and processes from the semiconductor industry***

# 硅光子技术的应用场景

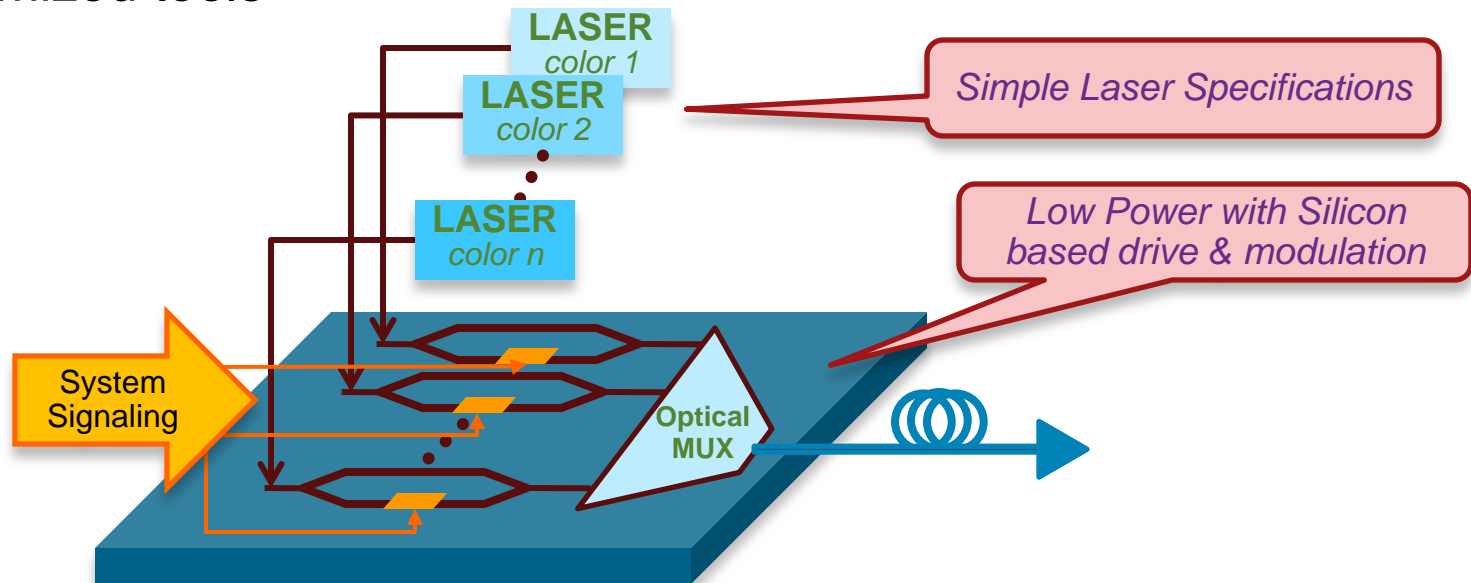
- IBM – 大规模高性能计算
- Intel – CPU互联和高速接口
- Data Center on a chip
- Super computer on a chip
- 网络用户侧高速接口
- 100G/400G/1T 波分系统
- 路由器多机箱互联,芯片,板卡互联等



# Near term benefits:

## Si Photonics Transmitter – How it works

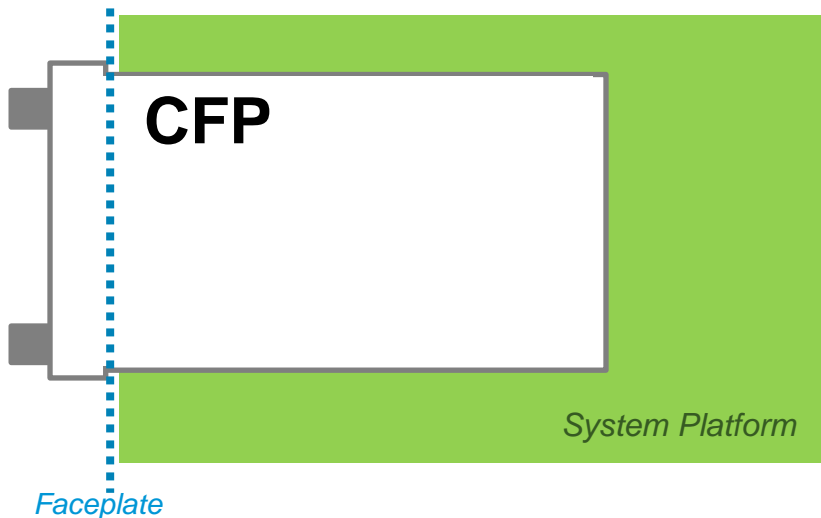
- CMOS Photonics designed using standard IC design tools
- CMOS Photonics grown in Silicon fab like other commercial ICs
- Continuous Wave Power (DC in electricity) supplied by laser
- Light is modulated in CMOS photonics & coupled into fiber for transmission
- Traditional photonics is designed with analog approximations & customized tools



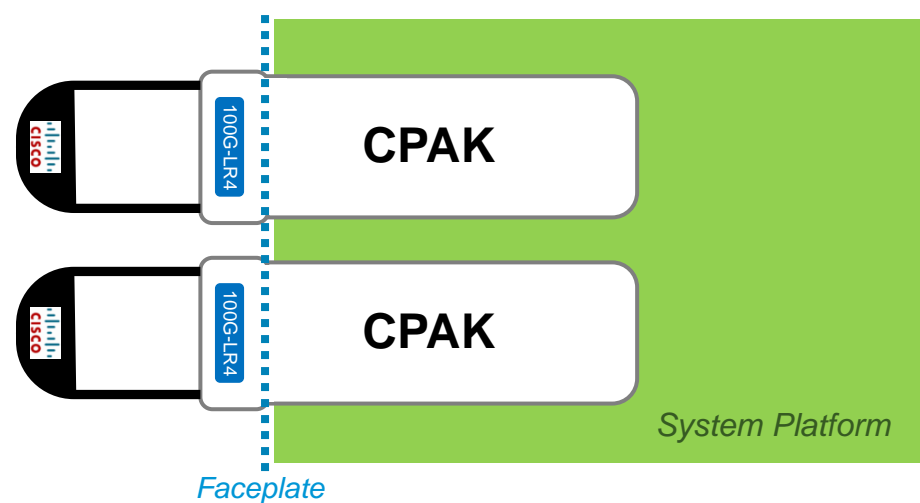
# Near term benefits:

## Cisco CPAK vs CFP port density

### Generation 1



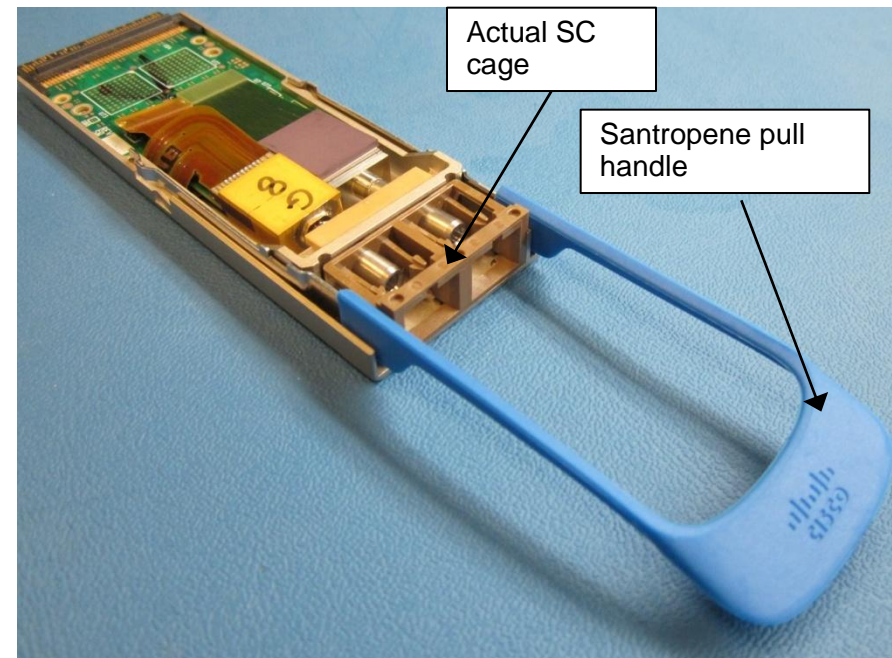
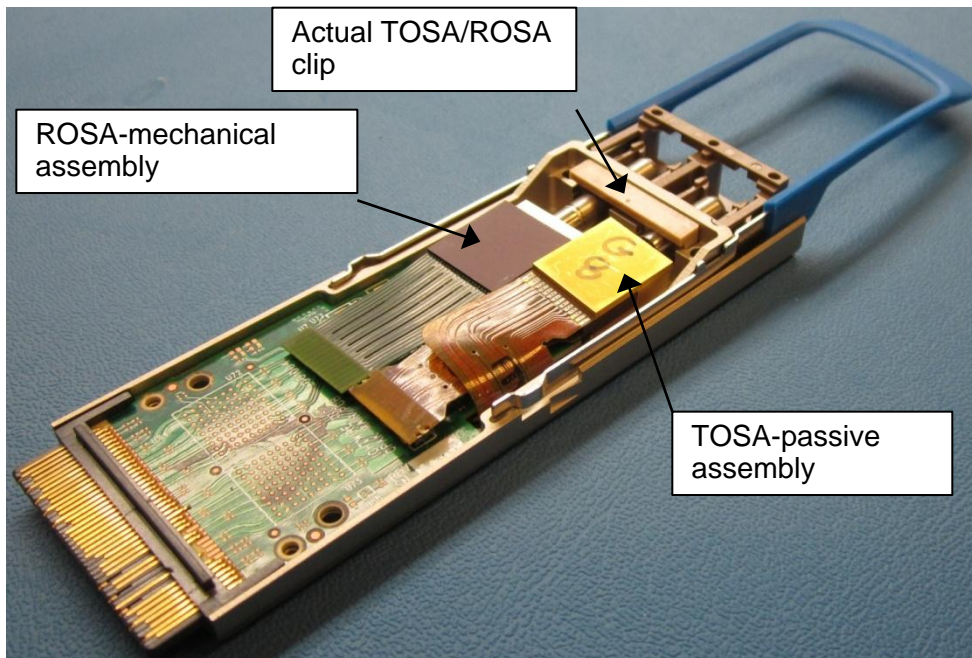
### Generation 2



- IEEE Compliant interfaces
- 10x 10G electrical interface only
- Power Consumption: < 24 W
- Size: W = 82; L = 145; H = 13.6 mm
- Density: 1 or 2 port systems

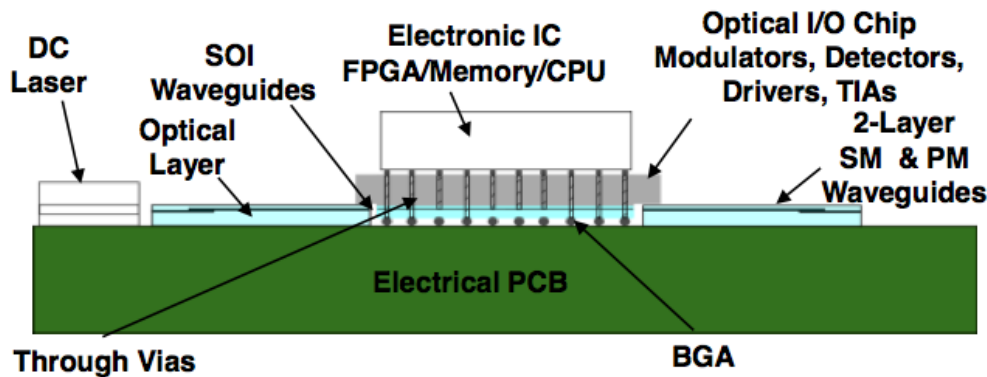
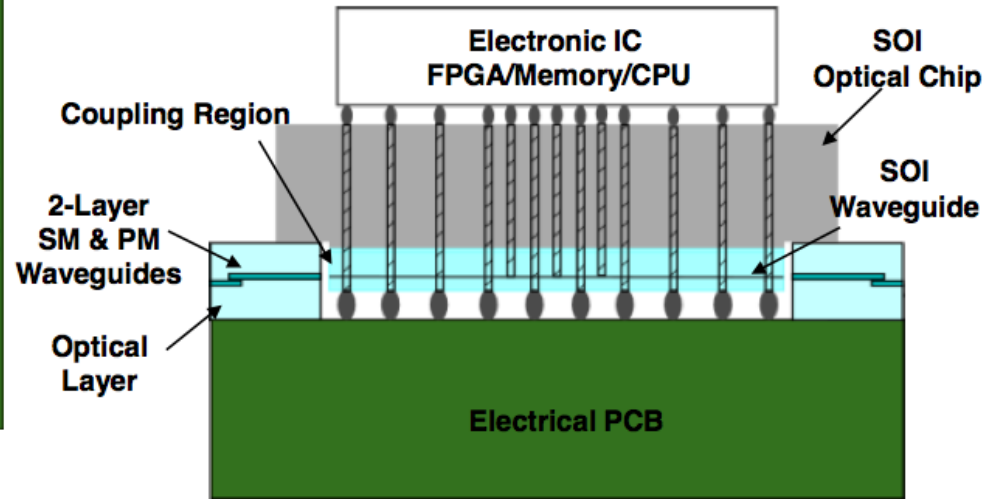
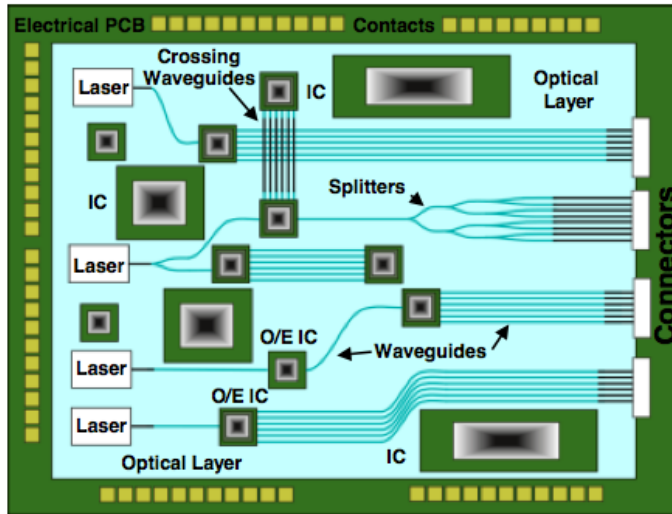
- IEEE Compliant Interfaces
- 4x 25G & 10x 10G interface
- Power Consumption: < 7.5 W
- Size: W = 35; L = 101; H = 11.6 mm
- Density: ≥10 port systems

# More details on CPAK





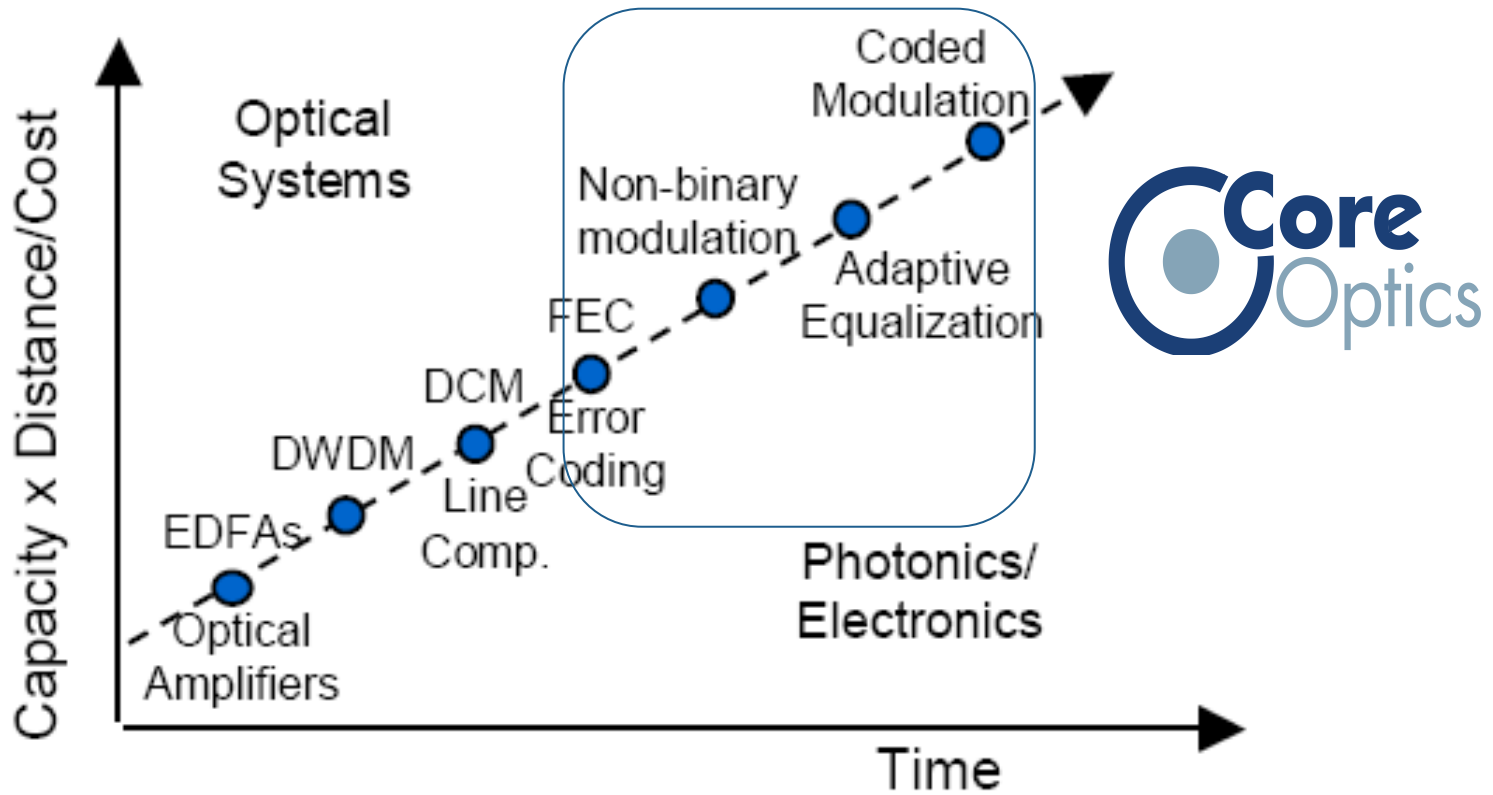
# Future: optical PCB



- Optical Waveguides:**
- Single mode
  - Polarization maintaining
  - Scalable to future bandwidth needs

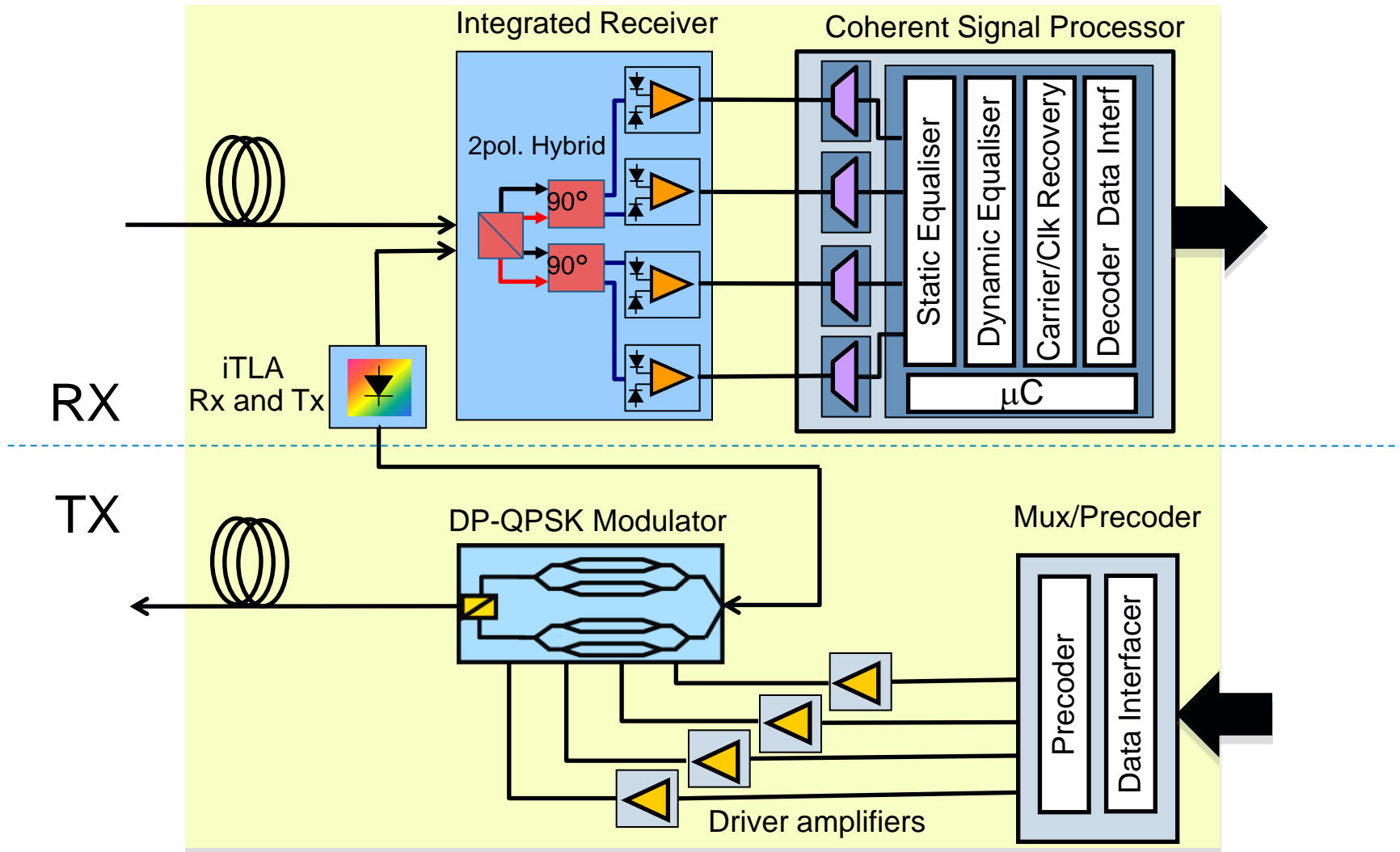
Optical for all High Speed Signals  
 Electrical for Power/Ground & Control Only

# Rationale for acquiring CoreOptics



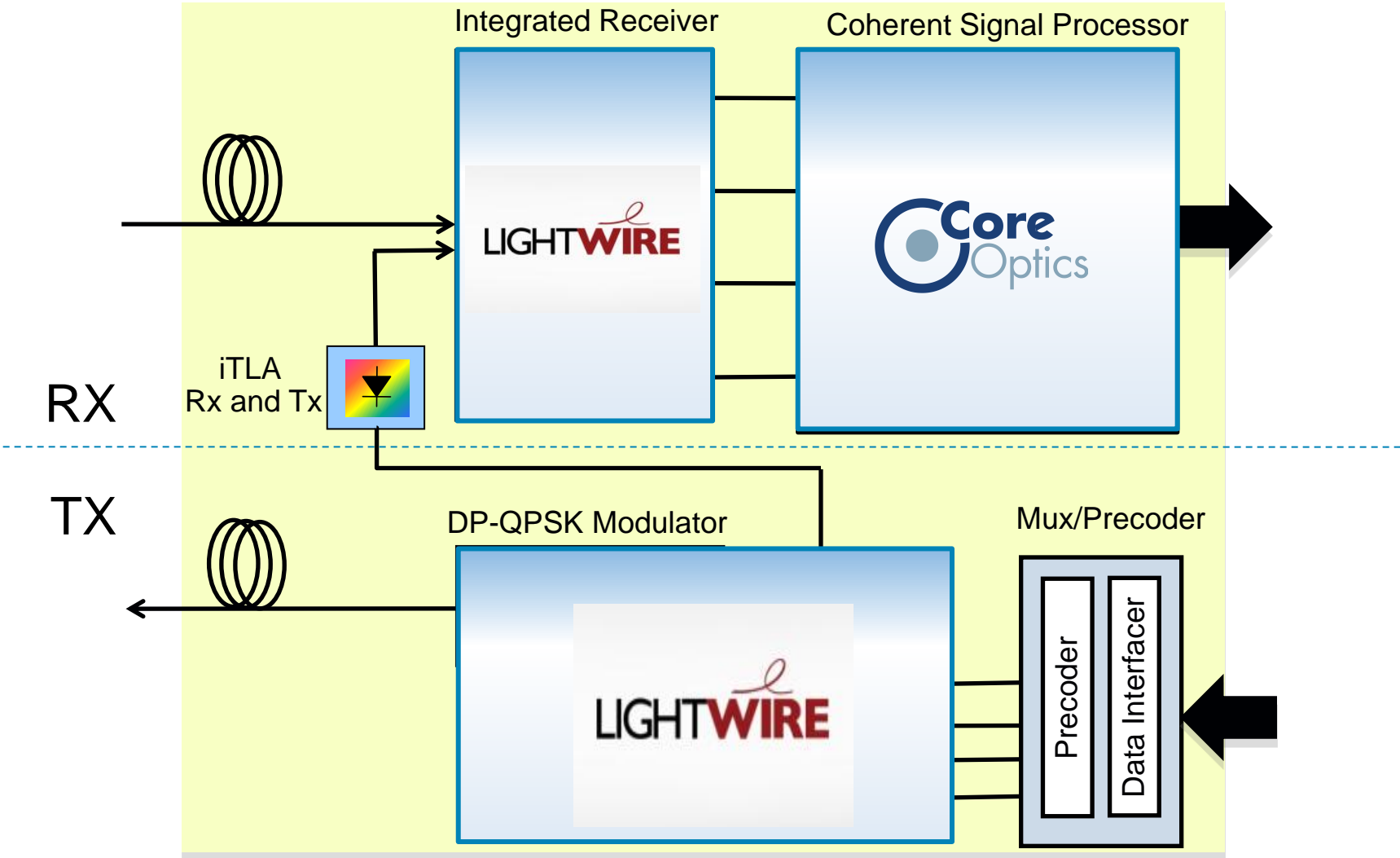
# Dual Pol. Differential QPSK 100G Module

Best in class 100G LH today



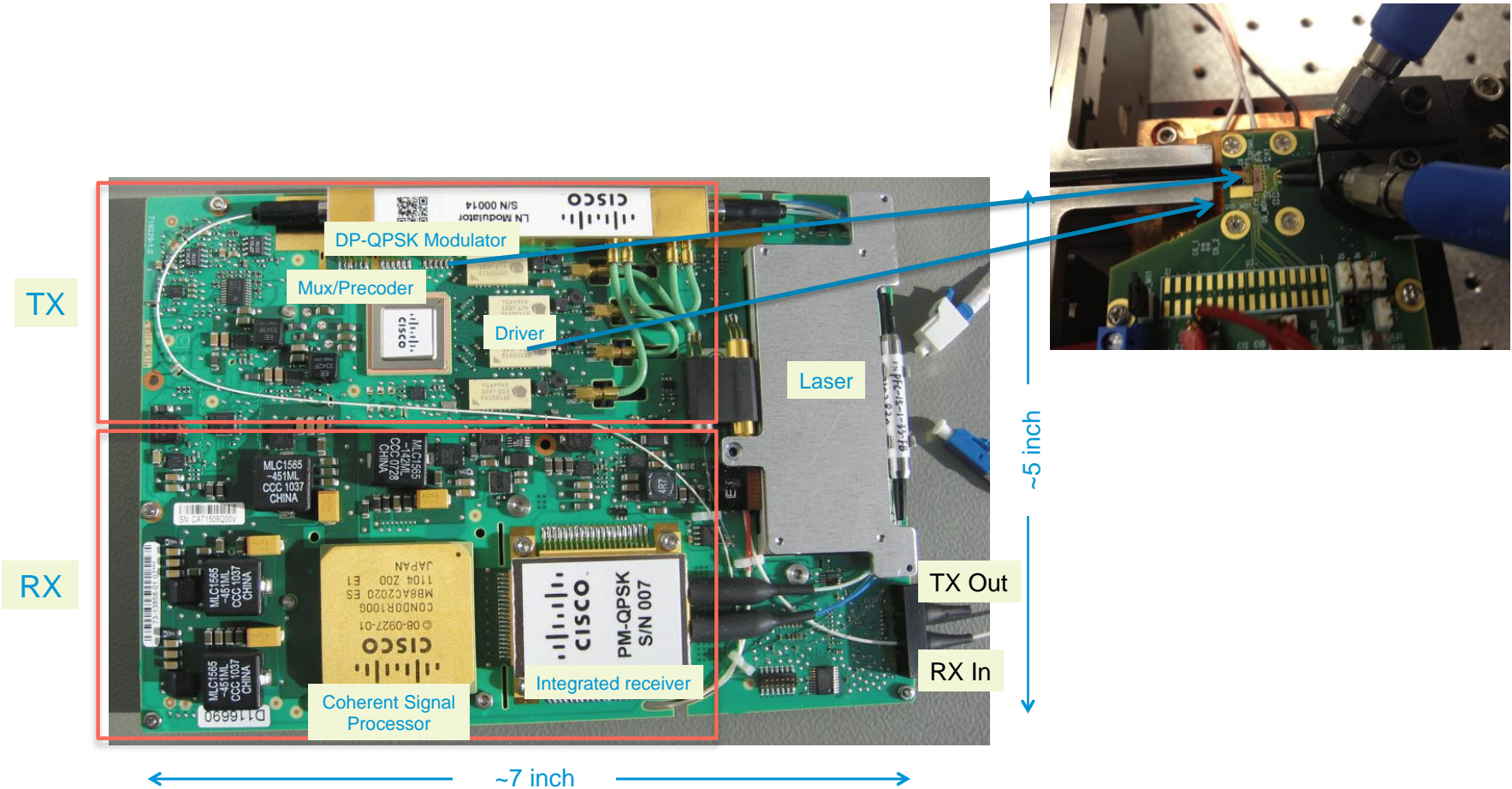
# Future 100G+ Module

Synergy between CoreOptics and LightWire technology



# Future 100G+ Module

How LightWire technology reduces the size of the modulator+driver





# Beyond 100G+

## - The Superchannel Concept

### ■ PROBLEM:

sending >200G over a single carrier is not reasonable today

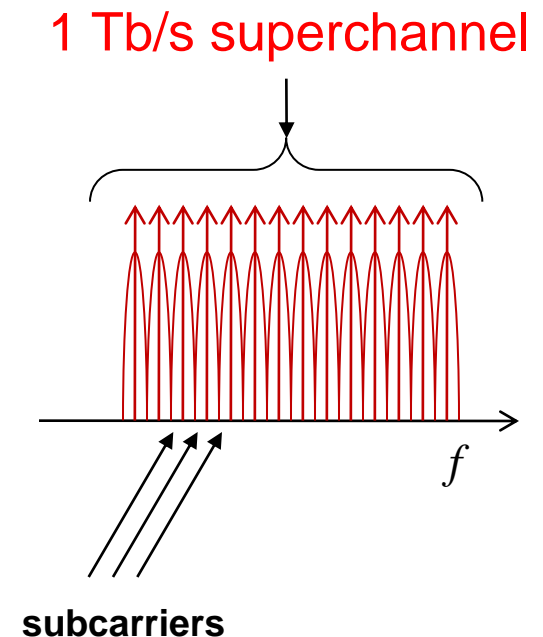
even with future 100 GS/s ADC technology it would require PM-1024QAM

→ poor sensitivity, phase noise problems, non-linearity impact, hardware problems, very short reach

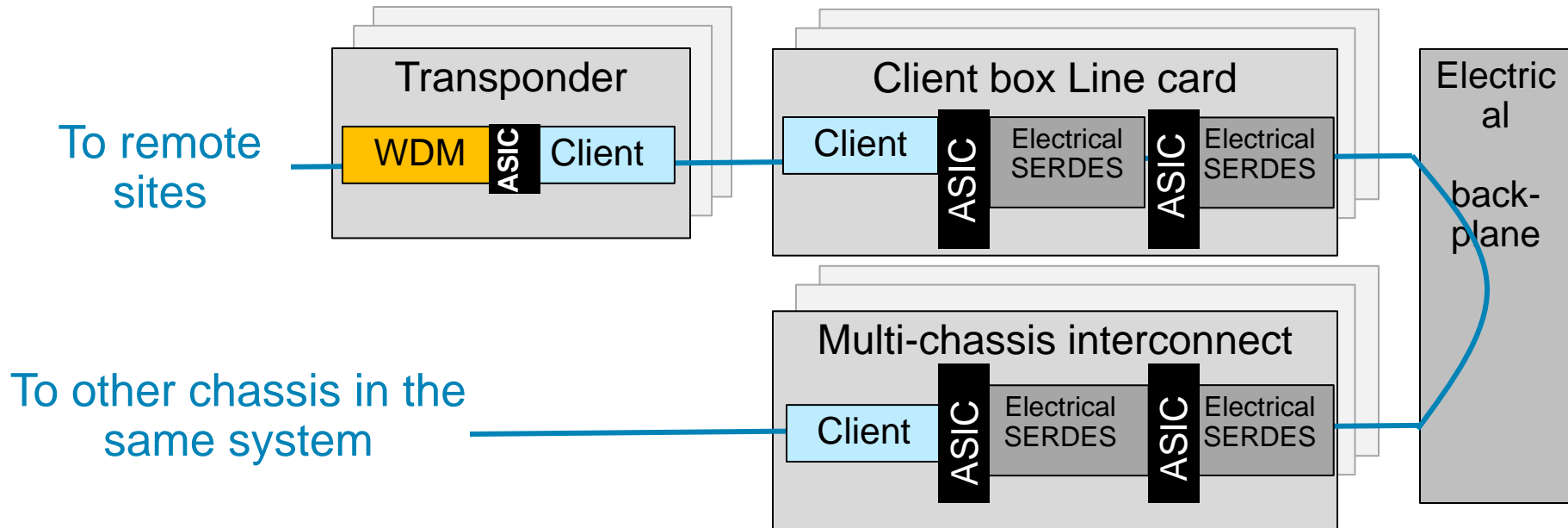
### ■ SOLUTION:

information distributed over a few **subcarriers** spaced as closely as possible forming a variable rate **superchannel**

each subcarrier working at a lower rate, compatible with current ADCs and DSPs

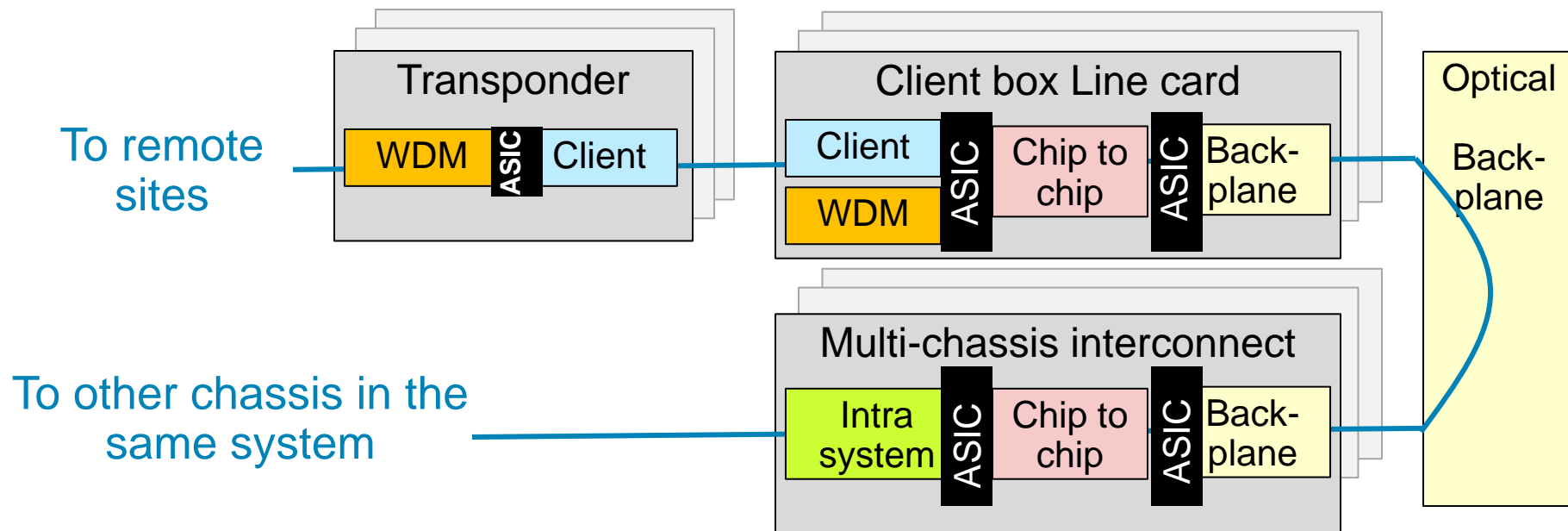


# Role of optics in the IP network – in the past



- SERDES between ASICs
  - 10G → 25G → 50G?
  - Harder to keep signal integrity
  - Getting more expensive & power consuming
- Non-optimized optics:
  - WDM (off the shelf)
  - Client (off the shelf)
  - Intra system (same as client optics)

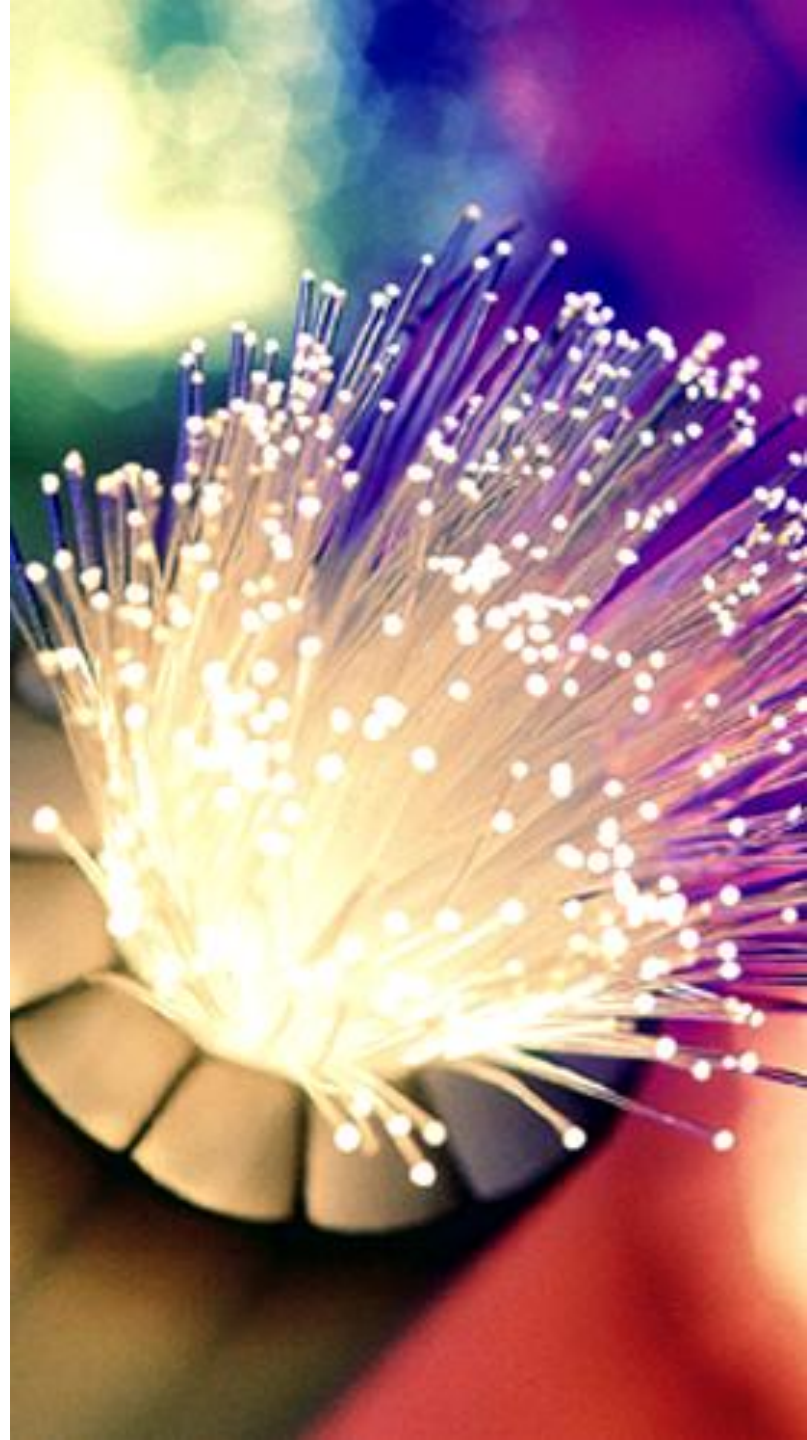
# Role of optics in the IP network – now and future



## ■ Optimized optics:

- WDM (CoreOptics - now)
- Client (LightWire - now)
- Intra system (LightWire – near term)
- Backplane (LightWire – mid term)
- Chip to chip (LightWire – long term)

# Cisco 硅光子 相关产品简介



# 40G/100G Industry Standards

- **IEEE 802.3ba:** 40Gb/s and 100Gb/s Ethernet Task Force  
40G and 100G Ethernet  
Physical interfaces for Backplane, Copper, Fiber PMDs **Ratified**
- **IEEE 802.3bg:** 40Gb/s SMF Ethernet Task Force  
40G Serial PMD optimized for carrier applications **Ratified**
- **ITU Study Group 15:** Optical and Transport Networks  
OTU4 frame format  
Single mapping for 40GE/100GE into OTU3/OTU4  
OTL protocol enabling OTU3/4 over multi-lane (low cost) optics **Ratified**
- **OIF:** 100G Long-distance DWDM Transmission  
Industry consolidation around a single 100G DWDM solution **Ratified**

- ❑ Multiple suppliers at all levels of the Eco-system
  - ❑ Suppliers for network equipment (Routing/ Switching/ Transport), Test equipment etc

## 40G/100G Ready for Field Deployment



# Cisco's Efforts in 40/100G Standards

## ▪ IEEE

- Initiated standardization efforts for higher speed Ethernet (CFI, July 2006)
- Defined 40G/100G architecture frame work (with Sun, BCM, Intel, AMCC)
- Defined MLD protocol – fundamental to the multi-lane 40G/100G standards
- Defined “Phy error monitoring” – ‘OTN like’ PMs for Ethernet
- Chaired 802.3ba architecture sub-group
- Chaired 802.3bg (40G serial) Task Force

## ▪ ITU

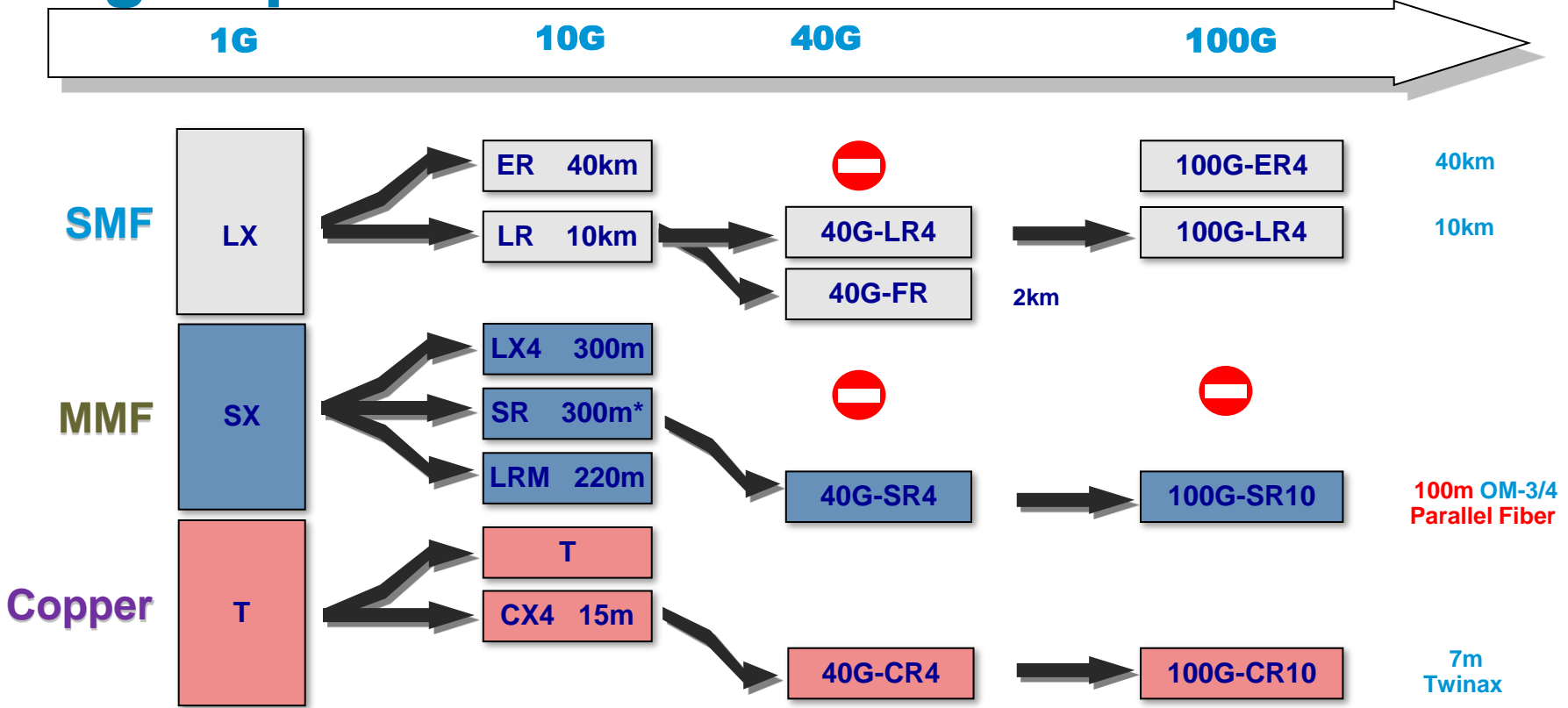
- Original contribution on OTL protocol (enables low cost optics)

## ▪ OIF

- Initiated (along with Ciena) 100G DWDM project(s)
- Drove to a single modulation scheme – PM-QPSK

Continued industry leadership from Cisco

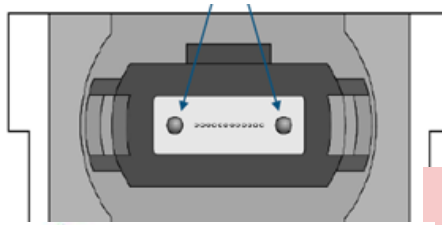
# High Speed Ethernet Standard Interfaces



<b>Fiber Infrastructure</b>	Multimode 40G-SR4/ 100G-SR10	Need parallel ribbon fiber 12-strand for 40G-SR4 24-strand for 100G-SR10	Fiber Infrastructure for 10G-SR interface needs only Duplex fiber (2-strand)
<b>Reach</b>	Multimode 40G-SR4/ 100G-SR10	Defined for a shorter reach 100m OM3/ 150m OM4 multimode fiber	10G-SR interface defined for 300m OM3 /400m OM4 multimode fiber
<b>Complexity</b>	Singlemode 40G-LR4/ 100G-LR4	Complex & Expensive optical design	No changes from 10G-LR in Fiber infrastructure & reach

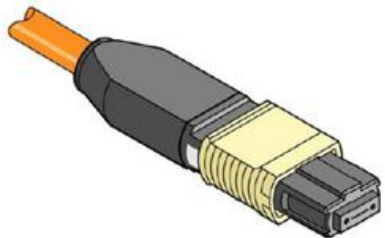
**Customers should consider fiber infrastructure & reach when upgrading to 40G/100G**

# Parallel ribbon fiber for 40G/100G interfaces



40G MPO interface  
(one row of 12 fibers)

40G 12-strand ribbon fiber  
(4 fibers in the middle left unused)



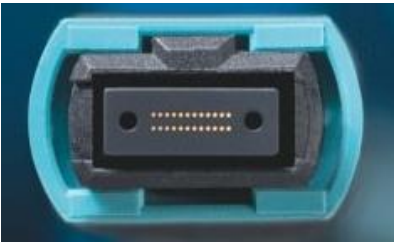
MPO Optical Connector



MPO to MPO patch cable

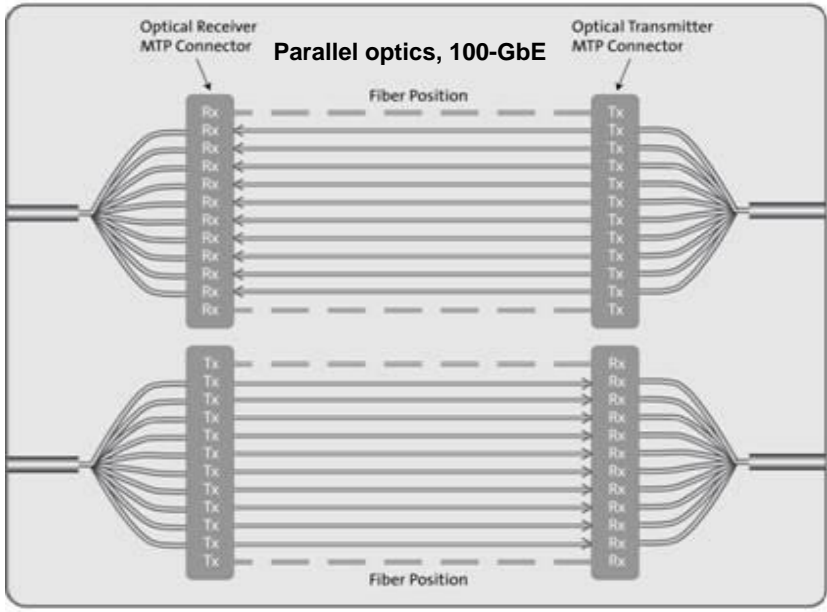
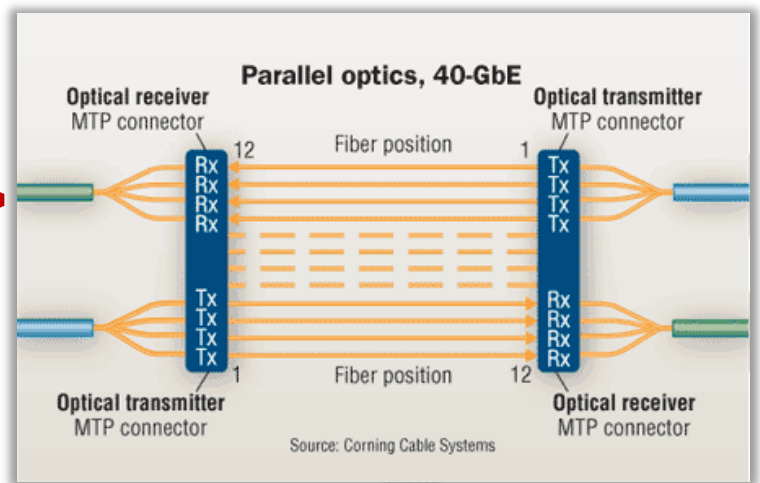


Inside a ribbon fiber



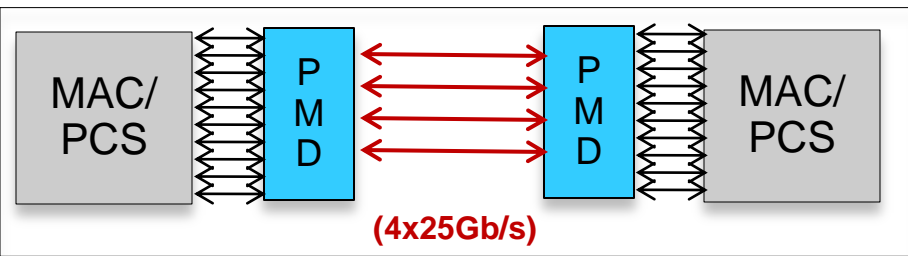
100G MPO interface  
(2 rows of 12-fibers)

100G 24-strand ribbon fiber  
(4 fibers in the left unused)

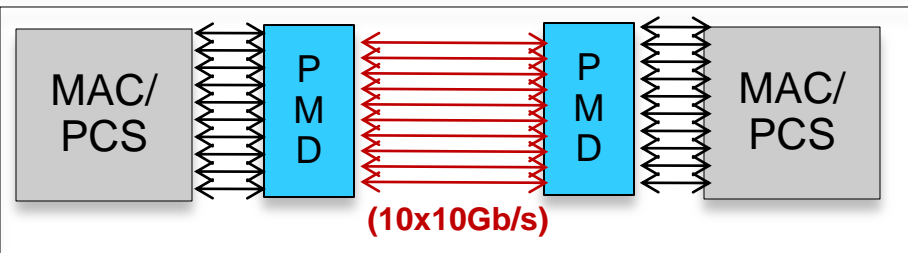


MPO is a generic name for a ribbon optical connector, while MTP is a brand name

# IEEE 802.3: Parallel Data Streams



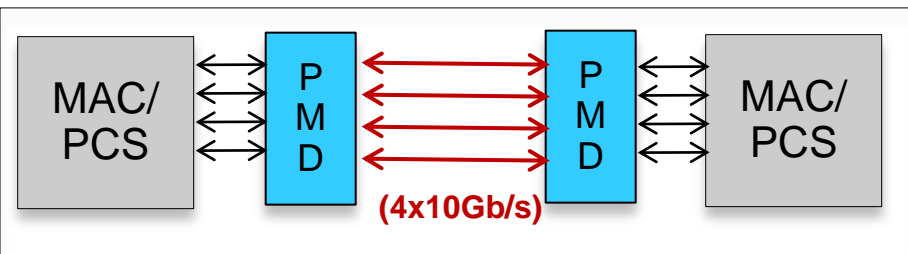
Singlemode  
100Gb/s  
Ethernet



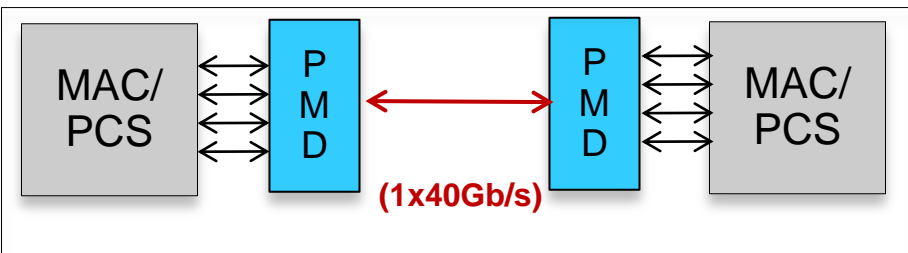
Multimode  
100Gb/s  
Ethernet

↔ Electrical data lane 10Gb/s (black)

↔ Optical data lane (red)



40Gb/s  
Ethernet  
(802.3ba).  
Singlemode &  
multimode



40Gb/s  
singlemode fiber  
PMD (2km)  
(803,2bg)

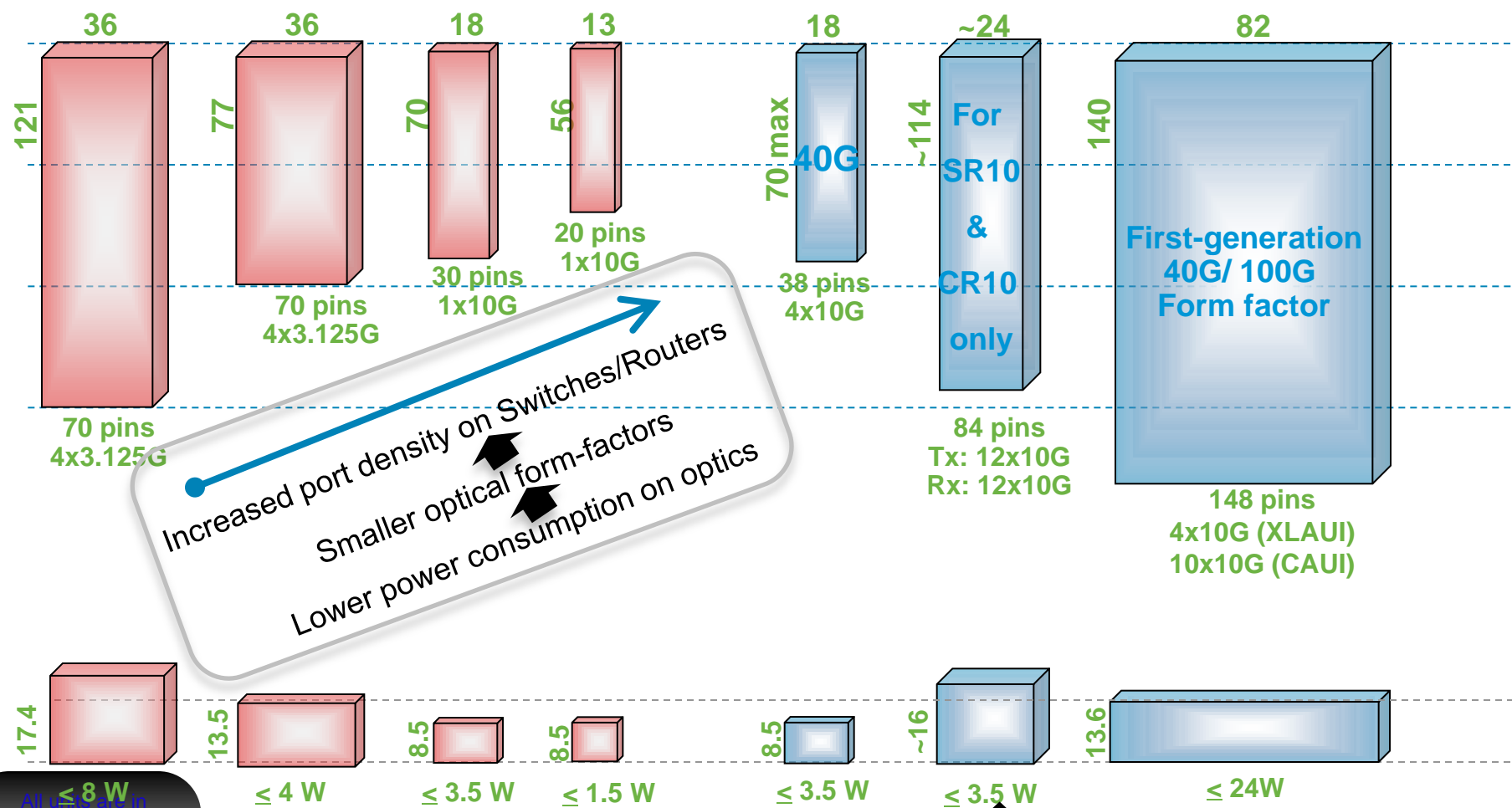
- ❑ Device interfaces in Switches & Routers (ASICs) currently cannot handle single 40Gb/s and 100Gb/s data streams (only 10Gb/s)
- ❑ IEEE has defined 'parallel lanes' to handle flow of data
- ❑ Multi-lane Distribution (in the PCS layer) provides a simple way to map 40G/100G to physical interfaces of different lane widths – with Virtual lanes
- ❑ Data from any particular virtual lane will reside on the same electrical and optical lane across the link – No skew introduced between bits within the virtual lane

# 10G/ 40G/ 100G Transceiver form factors

40G → GEN 2

40G → GEN 1  
100G → GEN 1

XENPAK    X2    XFP    SFP+    QSFP+    CXP    CFP



For SR10 & CR10 only

First-generation 40G/ 100G Form factor

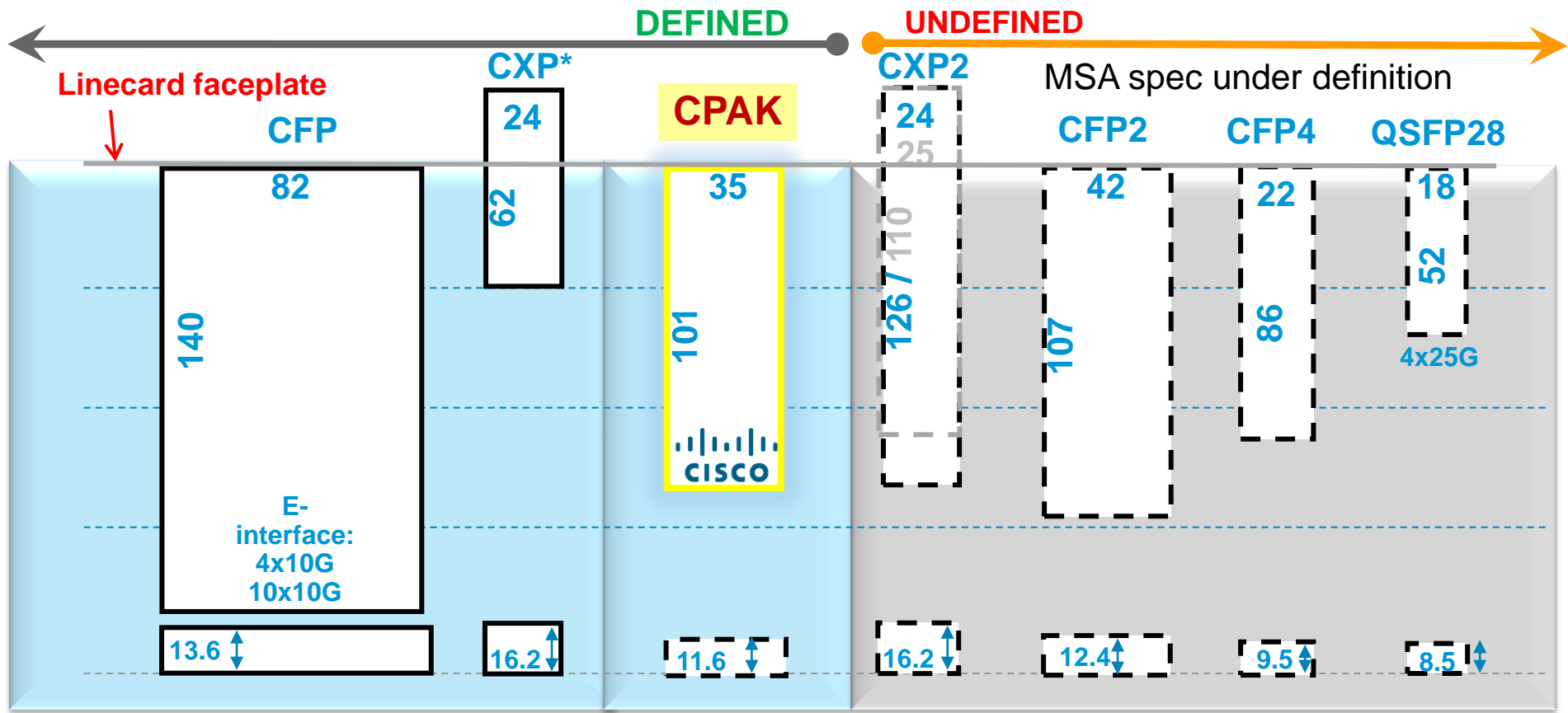
All units are in rounded to millimeters

Singlemode not available

100G GEN 2 → CPAK



# 100G Module Form Factors Evolution

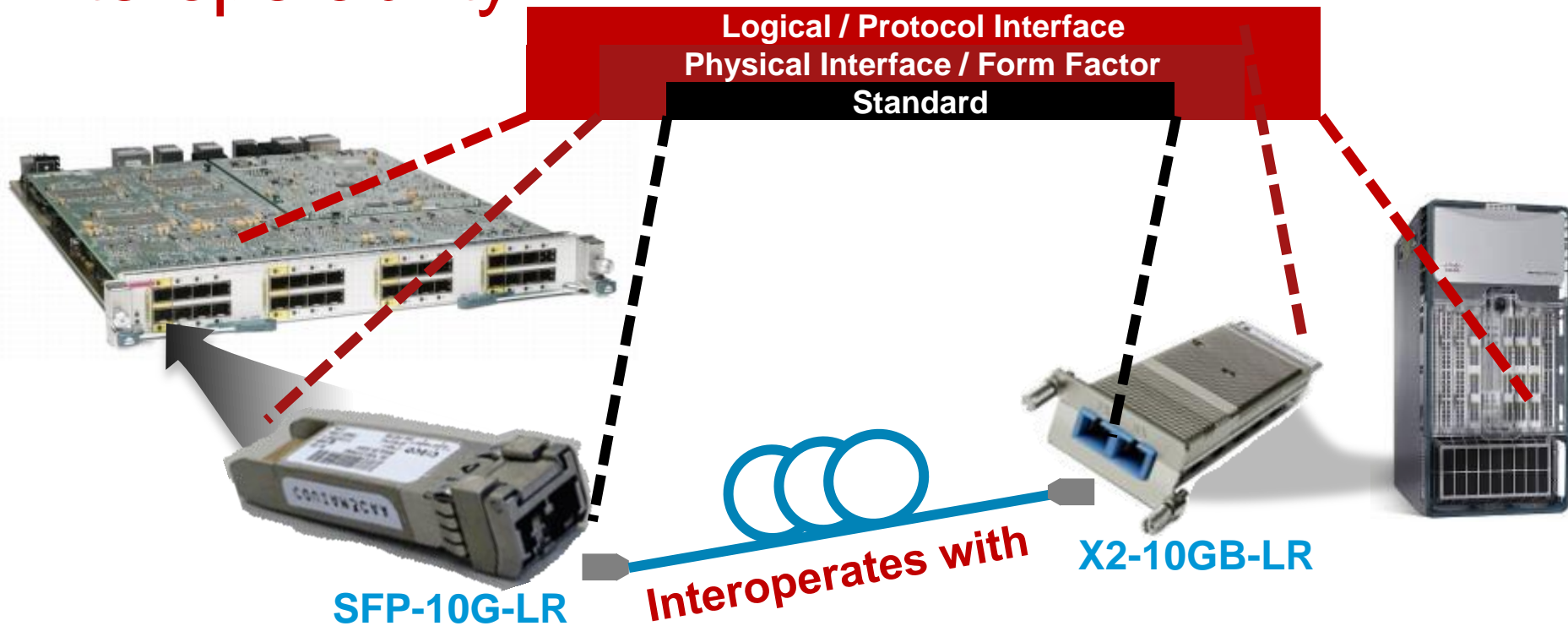


Power consumption (limited by SIZE)	≤ 32 W	≤ 4 W?	< 7.5 W	< 6 W?	≤ 8 or 12 W?	≤ 5 W?	≤ 3.5 W?
Interface Support 4x25G 10x10G	Yes Yes	No Yes	Yes Yes	No Yes	Yes Yes	Yes No	Yes No
Availability	Shipping now	Shipping now	1HCY13 Production	Unknown	Protos in CY13	Unknown	Unknown

**CPAK offers the highest port density, lowest power consumption and complete portfolio of 100G optics among form factors that support 4x25G and 10x10G interfaces**

# IEEE Physical Interface Standard

## Interoperability



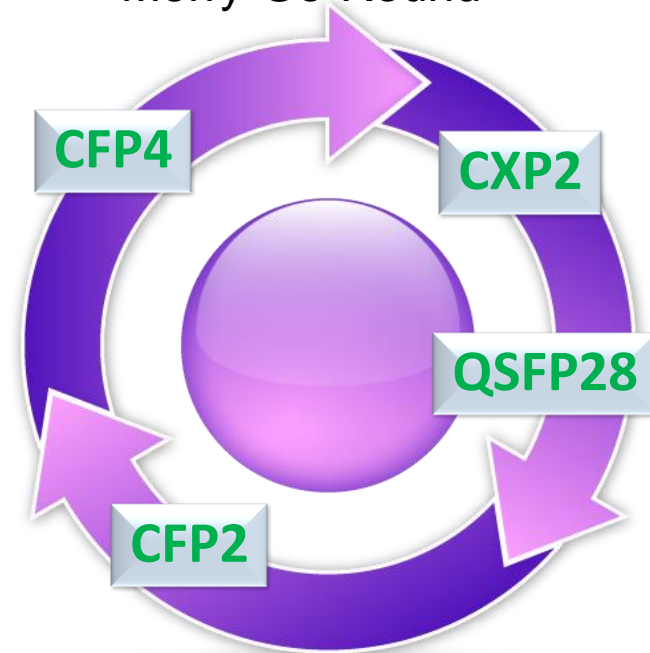
**Why is this important? .... helps to understand Cisco's CPAK100G transceiver strategy**

- ❑ Cisco's CPAK100G is a non-MSA form factor designed by Cisco, for use on Cisco Switch & Router ports
- ❑ CPAK100G transceivers will be designed to meet all existing and future 100G IEEE interface standards
- ❑ CPAK100G transceivers will interoperate with all other 100G transceivers available in the industry (such as CFP100G, CFP2/CFP4/QSFP28 etc)

# Next gen 100G form factor

- Multiple 100G MSA Form Factors discussed in the industry
- Too many form factors removes economies of scale due to form factor proliferation
- Proposed MSA solutions DID NOT MEET  
Cisco schedule for product release  
Cisco's power & port density requirements on switches and routers
- Cisco needed a 100G optics solution to meet our port density requirements driven by our customers

## Next Gen Form Factor Merry-Go-Round



## Cisco's SOLUTION

**Definition of a new Cisco CPAK100G form factor  
&  
Lightwire CMOS Photonics acquisition**

# Introducing the Cisco Next Gen 100G Transceiver

Modern Industrial Design



- **Standards Compliant**

- IEEE standards compliant interfaces
- OTU4 compliant
- Electrical interface OIF compliant (CEI-28G-VSR)

- **High Density**

- CPAK100G yields >70% size Reduction

- **Low Power Consumption**

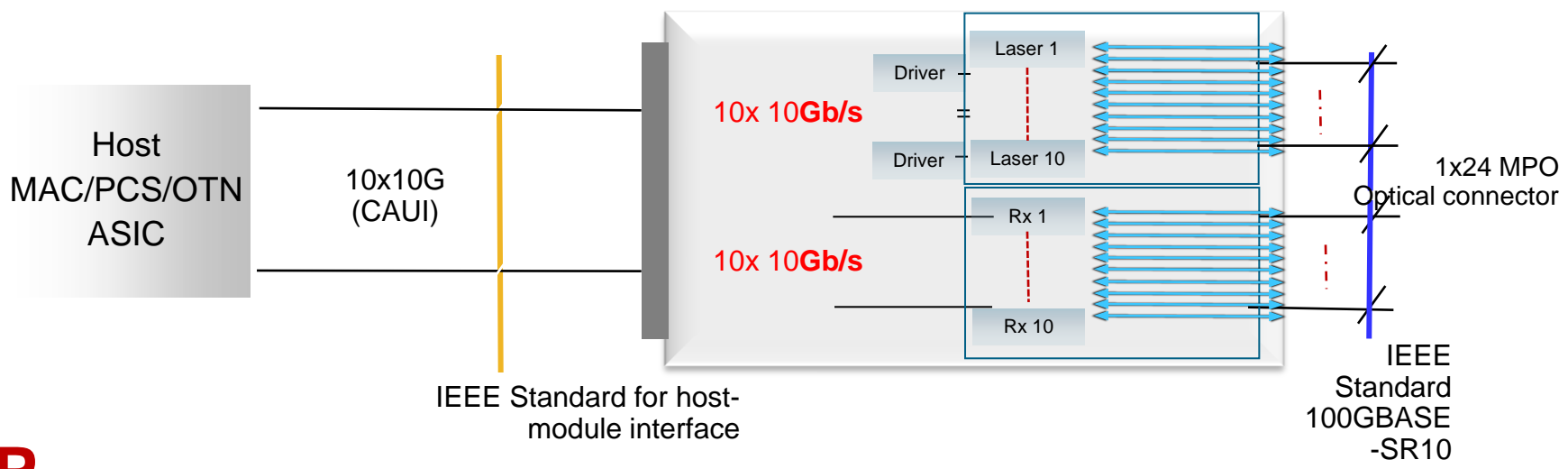
- CPAK yields a 70% decrease in power consumption

## What makes CPAK possible at Cisco?

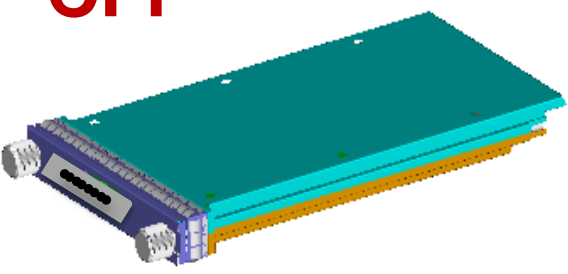
- >> Next gen optics technology & next gen IC technology for efficiency
- >> **CMOS photonics from the Lightwire acquisition** on Single mode reaches for best in class power consumption

**Cisco's customers benefit from CPAK: Lower power consumption & Smaller footprint Switches/ Routers with increased port density**

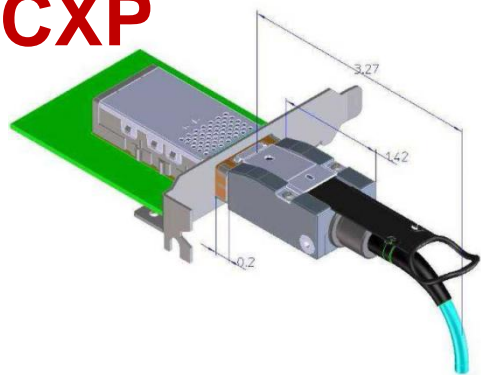
# 100GBASE SR10



## CFP

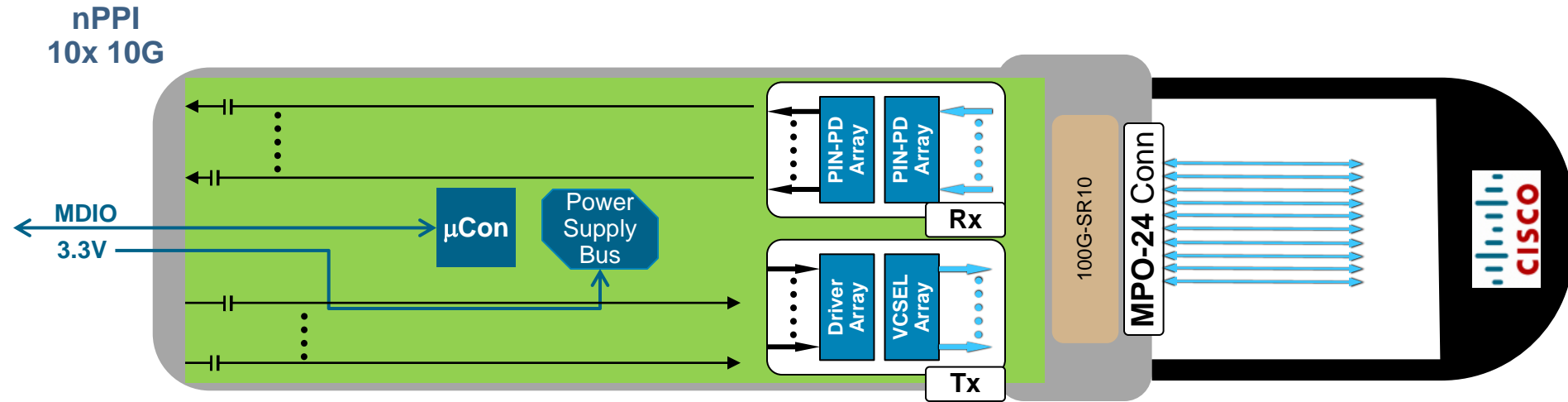


## CXP



Standards	100GBASE-SR10 Also interoperable with 10GBASE-SR (upto 100m OM3)
Electrical interface	10 x 10G
Media Type	Multimode Ribbon fiber
Optical Technology	850nm VCSEL technology/ array
Reach	100m OM3 MMF
Optical interface	24-fiber MPO/ MTP

# CPAK100G-SR10 for 100 m



## FEATURES

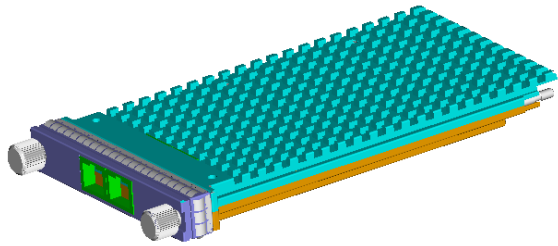
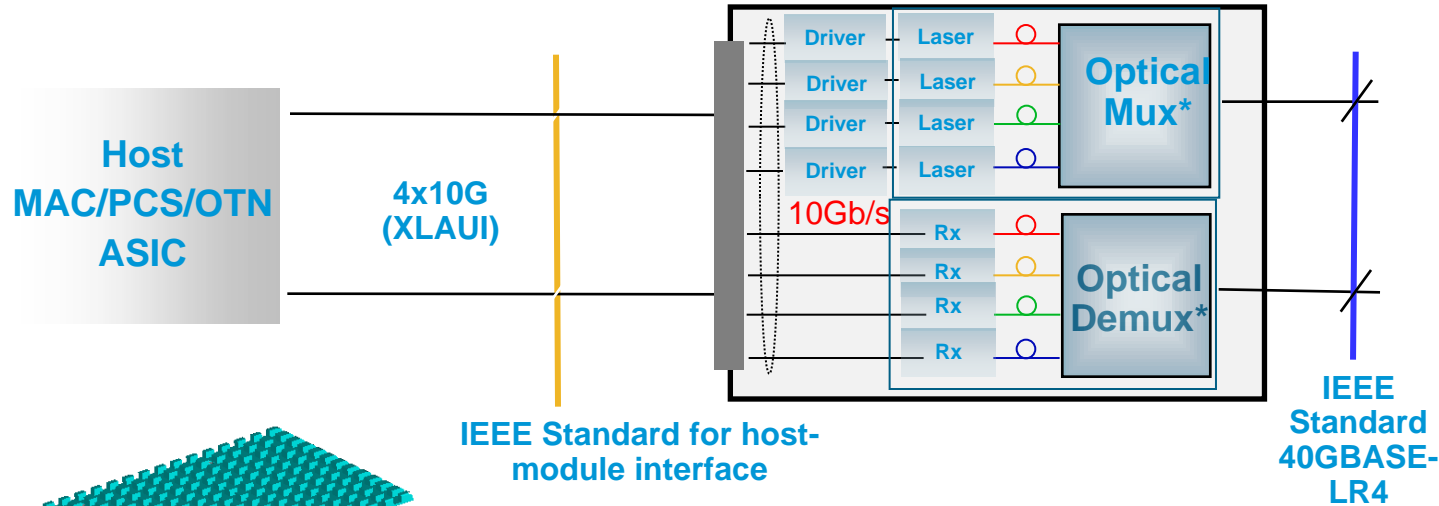
- IEEE 100GE Compliance
- Configurable to run in 10x10GSR mode
- Configurable to run in 2x40GSR4 mode
- Up to 100 m reach on MMF OM3
  - Up to 150 m reach on MMF OM4

Key Specs	CPAK100G-SR10
Standard	100GBASE-SR10
Connector	MPO-24
Reach	OM3: ≤ 100 m OM4: ≤ 150 m
Fiber	Multi Mode
Power Consumption	<7.5W



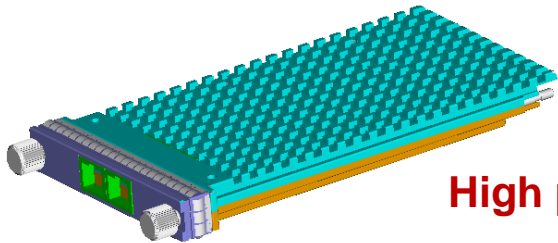
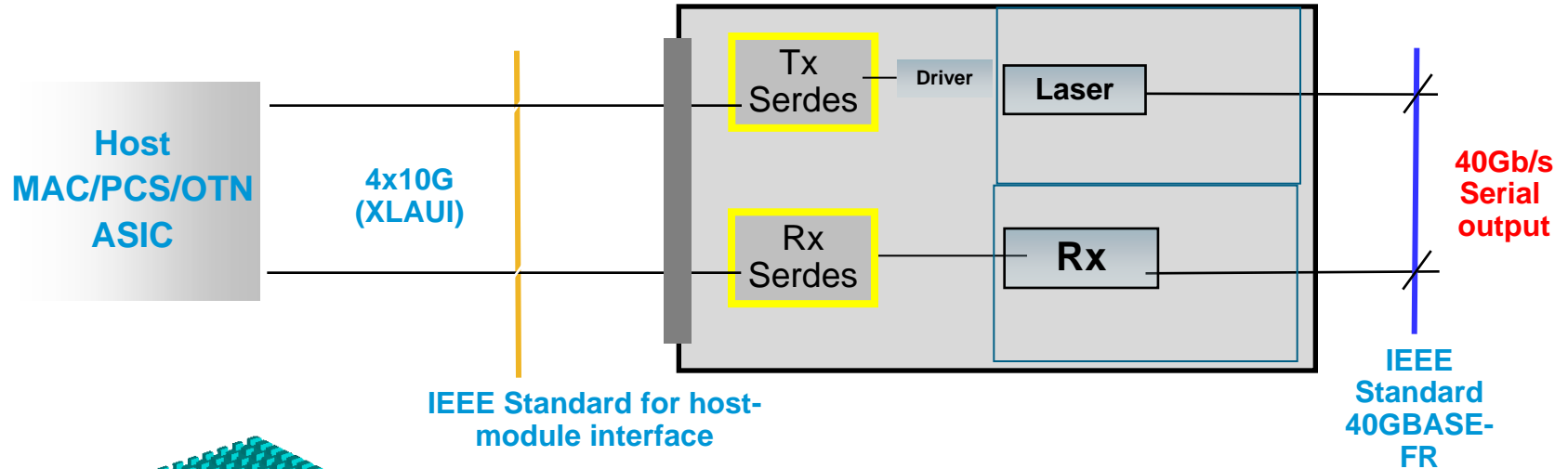
# CFP-40G-LR4

Shipping!



CFP

Standards	40GBASE-LR4
Electrical interface	4x10G XLAUI
Network Interface	4x10G <b>(ALSO support OTN)</b>
Media Type	Standard Single mode fiber
Optical Technology	1300nm <b>CWDM</b> laser technology Optical Multiplexer/ Demultiplexer
Reach	10km Single mode
Optical interface	SC Duplex connector



## Available in CFP40G Only

High power consumption IC for 40G serial to 4x10G XLAUI SERDES

- 40G Serial interface Transceiver, CFP form factor
- Compliant to IEEE802.3bg, 40GBASE-FR
- Interoperate with 40G ITU G.693 **VSR2000-3R2** 300-pin transponder, **legacy interfaces**
- **2km** reach, SMF fiber, with SC Duplex connector
- Will only be available in a CFP form factor (Power consumption **~8W**)

Optical interface	Electrical interface	Reference standard
40GE (41.25 Gbps)	XLAUI	IEEE802.3ba
OTU3, OTU3e2 (43.0 Gbps, 44.58 Gbps)	OTL3.4	ITU G.709

# Continued demand for 10G density

10G/40G/100G operation on the same linecard, by simply plugging in a different optic - **A very powerful solution for Cisco platforms.**

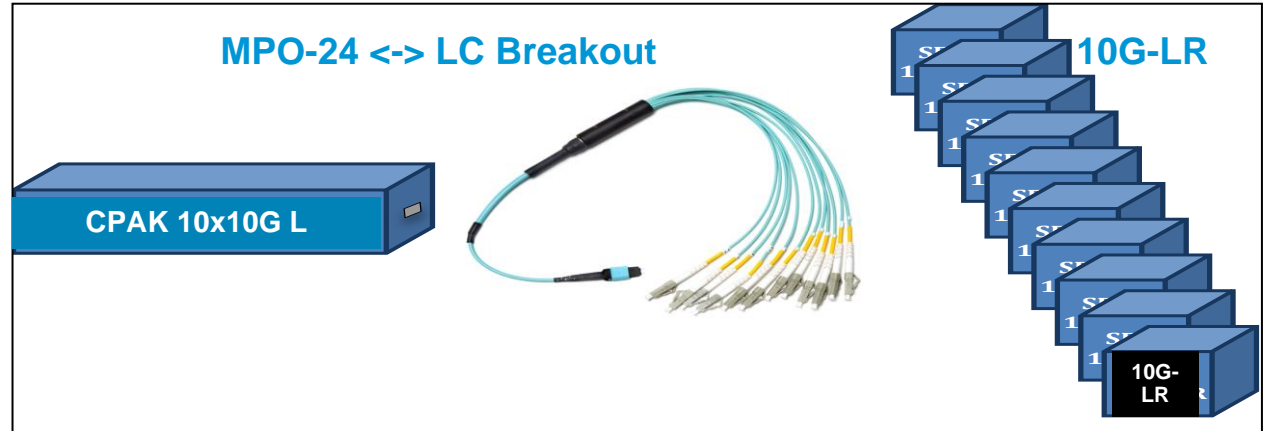
What enables this feature?

- ❑ IEEE 40G/100G interfaces were for nx10G host interface
- ❑ This enables a high-density 10G optic to plug this into a 40G or 100G port
- ❑ QSFP (4x10G) or a CPAK (10x10G) offers much **higher 10G density** than what can be achieved with SFP+ or XFP
- ❑ Cisco will release nx10G optics for **multimode (SR)** and **singlemode (LR)**
- ❑ Cisco specified the 40GBASE-SR4 and 100GBASE-SR10 optics to simultaneously meet two sets of specifications:
  - ❑ **Interoperate with IEEE 40GBASE-SR4 & 100GBASE-SR10 optics**
  - ❑ **Interoperate with 10GBASE-SR optics**
  - ❑ This required the optical interface specifications to be modified for Cisco optics
  - ❑ Without these modifications, there is risk of 10G SR link flaps or receiver damage
- ❑ High density single mode (nx10G LR) will use **Silicon Photonics** to meet the power consumption requirements

# 10G/40G/100G Connectivity

## Sample Configurations for Singlemode fiber

### 10GE Interconnect Options



### 10GE Interconnect Options



**40GBASE-LR4 interoperability with CPAK100G is not available**

# 10G/40G/100G Connectivity

## Sample Configurations for Multimode fiber

### 100GE Interconnect Options

MPO-24 <-> MPO-24



CPAK-100G-SR10

CPAK-100G-SR10

or


CFP-100G-SR10

or

CXP-100G-SR10

### 10GE Interconnect Options

MPO-24 <-> LC Breakout



CPAK-100G-SR10

CPAK-100G-SR10

10G-SR

SFP-10G-SR

### 40GE Interconnect Options

MPO-24 <-> MPO-12 Breakout



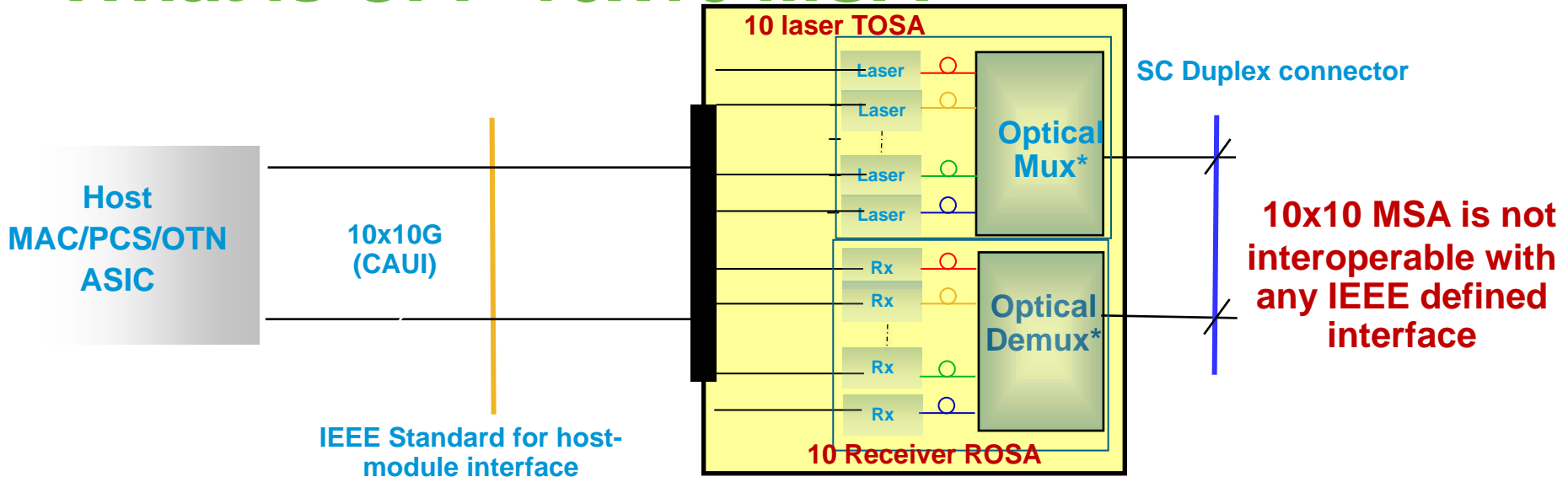
CPAK-100G-SR10

CPAK-100G-SR10

QSFP-40G-SR4

QSFP-40G-SR4

# What is CFP 10x10 MSA



Standards	No IEEE Standard
Electrical interface	10x10G CAUI
Network Interface	10x10G MSA (not an IEEE standard)
Media Type	Standard Single mode duplex fiber
Optical Technology	8nm spacing DWDM cooled laser & receiver array Includes optical mux and demux – <b>SINGLE SOURCED</b>
Reach	10x10 MSA defines 2km, 10km, 40km reaches
Optical interface	SC Duplex connector



# Summary of Key challenges with 10x10 MSA

## Immediate challenges:

- ❑ 10x10 MSA **not interoperable** with any IEEE defined interface
- ❑ 只有1个主流的10\*10光模块厂家(Santur), 产业链脆弱。不像LR4,主流器件厂家都支持(Finisar, Opnext, Sumitomo)

## Long term challenges:

- ❑ **Limited to CFP port density**; next-gen smaller form factors such as CPAK, CFP2 or CFP4 cannot support 10x10 MSA
- ❑ With no form factor evolution, 10x10 MSA could be a stranded network interface, for a **single generation**
- ❑ **随着SiP技术的发展, LR4功耗和成本具有优势**

## 行业动态

- ❑ **Google 以前大力推动, 目前已经转向LR4**

**Cisco has no plans to productize a CFP 10x10 MSA transceiver at this time**



**CISCO**