Data Communication and Optical Modules used in Data Center

Sky Loyal Technology (Shenzhen) Co., Ltd
Intra Data Center Interconnection

Data Centers need 10G/40G/100G/120G optical modules and active optical cable (AOC), DAC to realize high speed interconnection.
## Product Summary

<table>
<thead>
<tr>
<th></th>
<th>Module</th>
<th>10G, 300M</th>
<th>10G, 10KM</th>
<th>10G, 100M</th>
<th>40G, 100M</th>
<th>40G, 100M</th>
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<td>QSFP+ SR4</td>
<td>QSFP+ AOC</td>
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1. Systematicness: All the TO and optical components are independent researched and produced in our company. The whole process is under quality control.

2. Compatibility: Compatible with the mainstream switches and server, including Cisco, Huawei, H3C, Intel82599, ZTE, ALU, FiberHome and so on.

3. Reliability: 2 years quality guarantee, functionally stable in high temperature.

## SL Target Markets

<table>
<thead>
<tr>
<th>Datacom</th>
<th>Telecom</th>
<th>FTTX</th>
<th>STB</th>
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</thead>
<tbody>
<tr>
<td>Data links, High speed I/O file servers, Data storage networks</td>
<td>SONET/SDH telecom equipments, Rack to rack system interconnects, Metro/Access Networks</td>
<td>PON transceivers, Video Receivers</td>
<td>HD Set top box, HD media player, Smart TV box</td>
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</table>

![Datacom](image1.png) ![Telecom](image2.png) ![FTTX](image3.png) ![STB](image4.png)
Vertical Integration

- Except VCSEL, other critical process and components are own developed. PD/APD, PLC and IC are provided by supplier and partners.
Wafer Technologies

- 2.5G/10G FP/DFB/EML lasers & PIN/APD PD in full production.
- State of the art device design capabilities.
- MOCVD EPI growth at multiple locations.
- In house production covering end-to-end front and back end processes.
• Keep leading position in the PON Market
Vertical Integration in PON Products

- Vertical Integration capability from Epi growth to laser chip, OSA package, transceiver and Sub-system.
## FTTX Product Portfolio

- Providing complete solution for EPON, GPON, 10G PON, 40G PON, P2P BIDI

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<th>EPON</th>
<th>GPON</th>
<th>10G EPON</th>
<th>XG-PON1</th>
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- **Mass Production**: SFP, SFP+, XFP, CFP4
- **Under Development**: SFP+ XFP 10G 10KM

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10
Datacom/Telecom Product Portfolio

- Full covering Fiber Channel, Ethernet, Infiniband, Wireless (4G LTE, product line up 5G) & Sonet/SDH

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- Mass Production
- Under Development

- 10G SFP
- 10G XFP
- 1.25G SFP
- 10G SFP+
- 10G SFP+
Datacom Product Strategy

- Providing Total Optical Solution for
  - Fiber Channel applications
  - Ethernet applications
  - Infiniband applications
  - High Performance Computing applications
  - Customer made Optical Engine
Products Classification

Datacom Products

- 120G CXP AOC
- 10G CFP4 LR4
- 40G/56G/100G QSFP+ SR4
- 40G/56G/100G QSFP+ AOC
- 40G QSFP+ LR4
- 100G QSFP28 2km CWDM4
- 120G CXP SR10
- 24x 25G Optical Engine
# New Products Roadmap

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**Wireless Product Portfolio**

- Providing total solutions for wireless applications.

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**NOTE:**
1. Specific transmission distance depends on the type of Multi-mode Fiber.
2. 9.830Gbps is for 2km reach application.
3. Bi-Direction transmission module.
How These High Speed Optics are Being Used in DC
Corporate Overview

Fiber Optic Solutions for High-Speed Networks
Broad Product Portfolio and Customer Base

SFP
SFP+
XFP
X2/XENPAK
CFP2
Optical Engine (BOA)
CXP
QSFP
Quadwire/C.wire
SFPwire
SFP
XFP
WSS
ROADM line card
Tunable laser
300-pin
WDM passives
Interleavers
RF-over-Fiber
PON
High speed components
Amplifiers
Data Center Containers Customers
Industry’s Broadest Product Portfolio

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- **Fibre Channel**
- **Ethernet**
- **Parallel**
- **Active Cables**
- **SONET/SDH**
- **CUD/MWDM**
- **Wireless**
- **FTTX**
- **WSS**
- **Passives**
- **Amplifiers**
- **RF over Fiber**
10G is the new 1G!

◆ 1G volume ~ 10G volume!

Units Shipped

2013

1G

10G

SFP+
SMF vs. MMF in the Data Center

- MMF dominates today’s data centers’ optical cabling
- Some enterprise networks use SMF exclusively
  - Standardize to lower operational costs (uniform SKUs, training, etc.)
  - More emphasis on avoiding technology mix over cost
- Recently, SMF for <1km in data centers is being debated as data centers plan for larger facilities and future bandwidth requirements.
SL Optics For the Data Center

### Ethernet Networking Applications

**Intra-rack**
- **10G SFPwire®**
  - 1m/3m/5m/7m/10m/20m

**Inter-rack**
- **10G SFP+ SR**
  - 300m OM3 MMF

**Long span/Inter-building**
- **10G SFP+ LR/Bidi/CWDM**
  - 10km SMF
- **40G QSFP+ LR4**
  - 10km SMF

- **100G CFP LR4**
  - 10km SMF
- **100G CFP DWDM**
  - SMF, Low-latency

**10G Intra-rack**
- **10/40/100G Inter-rack**
- **10/40/100G Long span/Inter-building**
10G Copper Direct Attach SFP+ Cable Trends

- Cost of copper metal highly volatile
- Cable quality concerns
- Shipping cost is high on copper cables (weight of the product)
- EMI/ground-loop concerns in high-density environments
- Passive DAC may require length-dependent customized signal conditioning
- Passive up to ~7m, active >7m; different technologies

Copper Commodity Price
$/metric ton
10G SFPwire® : SFP+ Active Optical Cable

- **PRODUCT FEATURES**
- Lighter, thinner (better airflow), tighter bend radius than copper
- Meets SFF-8431 SFP+ limiting high-speed electrical specs
- No special host equalization/pre-emphasis required
- Finisar 850nm VCSEL
- Stiff push/pull-tab (not a flimsy pull tab)
- EEPROM Identifier
- Operating case temperature: 0°C to 70°C
- xx=01/03/05/07/10/20m standard lengths
- Bulk packaging option (P/N “B”) available
- In Production
Active Optical Cables Primer

Optical-to-Electrical conversion is inside the cable end-plugs

- Compared to Copper Cables
  - Longer reach
  - Lower weight and tighter bend radius, means easier cable management
  - Thinner cables allow better airflow for cooling
  - Lower power consumption, with no power-hungry conditioning ICs required on the host board

- Compared to Optical Transceivers
  - Cost-optimized: Not constrained by optical interface specifications driven by longer-reach applications
  - Datacenter/Consumer friendly: No cleanliness issues in optical connector
  - Disadvantage: Cannot be routed through optical patch panels
Focus on Low Power Consumption SFP+

- Power Level I Limit
- $V_{+5\% \text{ at } 75\degree C}$ (module spec is 70°C)
- Typical
- Margin over temperature and lifetime
- Best in class Power Dissipation
- Finisar key in-house Technology lowers power consumption: SFP+ LR/LRM/ER

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100G Ethernet Market Snapshot

◆ 100GE is already here
  - Many thousands of 100GE links are already deployed in the field
  - The vast majority are CFP modules – Finisar has >60% market share on 100G-LR4 CFP.

◆ 100GE customer base is rapidly expanding
  - New IEEE optical/electrical standards (SR4, CAUI-4, 500m)
  - New higher density 100GE module form factors: CFP2, CFP4, QSFP28
  - Designs for high port-count 100GE systems have started
  - Many 100GE products will also be used for high-density 10GE and 40GE applications in high volume (e.g., in data center switches)
10G SFP+ for Inter/Intra-Rack & Long Spans

SFP+ Products utilized in Data Center environments

- **SR-Lite**
- **LRM**
- **SR**
- **LR**
- **ER**
- **ZR/SONET**
- **DWDM**

**Commercial Temp.**
- -50 to 70°C

**Industrial Temp.**
- -40 to 85°C

**Extended Temp.**
- -50 to 85°C

**OM3 MMF**
- 100m
- 220m
- 300m
- 10km
- 40km
- 80km

**LAN-Metro**

**Access/Wireless Backhaul**

---

**Sky Loyal**

---

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## 40G QSFP+ Transceivers

**Typical Application**
- Link between Top-Of-Rack Switch to the Aggregation/Cluster Switch

### Key Features
- 100 meters
- OM3 MMF
- Parallel fiber
- 10 km
- SMF
- Duplex fiber

### QSFP+ 40G

#### Products in Production
- **40GBASE-SR4**
  - QSFP+ Module
  - Optics: 4x10G Parallel Array
  - Electrical interface: XLPPI

#### Products under Development (NPI)
- **40GBASE-LR4**
  - QSFP+ Module
  - Optics: 4x10G CWDM
  - Electrical interface: XLPPI
100G CXP Transceivers

- Typical Application
- High-end router inter-chassis connections
- High Performance Computing cluster switch links
- In full production today
- Deployed in many Data Centers today

CXP 12x10G

- 100 meters
- OM3 MMF
- Parallel fiber

100GBASE-SR10

CXP Module
Optics: 12x10G Parallel Array
Electrical interface: CPPI
40G: QSFP-Based Active Optical Cables

Quadwire® QDR AOC:
• 4 lanes x 10 Gb/s (Tx and Rx)
• Standard QSFP cable ends
• Supports link distances up to 300 meters
• 1.5W maximum per cable end; <1W typical

Quadwire® FDR AOC:
• 4 lanes x 14 Gb/s (Tx and Rx)
• Standard QSFP cable ends
• Supports link distances up to 100 meters
• 1.5W maximum per cable end; <1W typical
100G: CXP-Based Active Optical Cable

- C.wire™ QDR AOC: FCBGD10CD1Cxx
  - 12 lanes x 10 Gb/s (Tx and Rx)
  - Standard CXP cable ends
  - Supports link distances up to 300 meters
  - 3.5W maximum per cable end; <3W typical
  - 12x10G product fully released to production
SL Optics for Data Center Router/WAN Links

10G Interfaces
SFP+ LR
10km SMF

SFP+ LR Bi-Di
10km SMF

SFP+ ER
40km SMF

SFP+ ZR/DWDM
80km SMF

40G Interfaces
40G CFP SR4
100m OM3 MMF
150m OM4 MMF

40G CFP LR4
10km SMF

100G Interfaces
100G CFP SR10
100m OM3 MMF
150m OM4 MMF

100G CFP LR4
10km SMF

100G CFP DWDM
~500km SMF
10km Bidirectional SFP+ LR

- 10km reach full-duplex on SMF single strand
- Doubles existing fiber bandwidth (e.g., inter-building)
- Finisar 1271/1331 nm DFB laser, PIN receiver
- <1W power dissipation
- 10GBASE-LR/LW
- Full RoHS-6 compliance (lead-free)
- SFI Limiting receiver electrical interface

![Diagram showing bidirectional and conventional 10km SFP+ LR connections]
40G CFP Products

- Typical Application
- Link between core router and metro/long-haul DWDM client interface

<table>
<thead>
<tr>
<th></th>
<th>100 meters</th>
<th>10 km</th>
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<tbody>
<tr>
<td>CFP Module</td>
<td>OM3 MMF</td>
<td>SMF</td>
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<tr>
<td>Electrical</td>
<td>Parallel fiber</td>
<td>Duplex fiber</td>
</tr>
<tr>
<td>Interface</td>
<td>XLAUI</td>
<td>XLAUI</td>
</tr>
</tbody>
</table>

Products in Production

CFP 40G
40GBASE-SR4
CFP Module
Optics: 4x10G VCSEL Array
Electrical interface: XLAUI

Products under Development (NPI)

40GBASE-LR4
CFP Module
Optics: 4x10G CWDM
Electrical interface: XLAUI
## 100G CFP Products

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</table>

### CFP Module 100GBASE-SR10
- Optics: 10x10G VCSEL Array Electrical interface: CAUI

### 100GBASE-LR4 CFP Module
- Optics: 4x25G LAN WDM Electrical interface: CAUI
100GE CFP Module Form-Factor Evolution

- **CFP** 4 ports/chassis
- **CFP2** 8 ports/chassis
- **CFP4** 16 ports/chassis

Today: [Size]

Time:
Low Latency 100G Metro DWDM 4x28G CFP Module

- Main Product Features
  - Supports 103Gb/s to 112Gb/s over ~500km (for amplified, FEC-based applications)
  - Uses four 28G DWDM transmitters
  - ODB Modulation Format
  - Tunable C-band channels on the 50GHz ITU-T grid
  - 4 duplex LC connector pairs

- Utilizes existing fiber network infrastructure
- Hot-pluggable CFP footprint
- CFP MSA Compliant
- CAUI/OTL4.10 electrical interface
- Built-in digital diagnostic functions (MDIO)

- Case temperature range: 0° C to 70° C
- Maximum power dissipation 24W

Provides a lower cost, lower power and higher density alternative than 100G Coherent to transport 100G in the Metro.
New Technologies and Ideas for Data Center

Fiber Optic Solutions for High-Speed Networks
10G and 25G BOA

10G

25G
What is a BOA?

BOA = Board-mounted Optical Assembly
= Optical Engine
= Mid board optical module (MBOM)
= Embedded optical module (EOM)
Primary Advantages of BOAs

◆ Superior signal integrity
  • BOA can be placed next to customer ASIC
  • Optical traces will replace copper traces in customer box
◆ Density
  • Board density
  • Faceplate density
◆ Low power per Gbps
◆ Low cost per Gbps
  (a.k.a. lowest cost per bit)
Primary Advantages of BOAs

◆ 10G BOA was designed with 25G in mind
  • Same footprint
  • Same pad size
  • Same electrical interposer
  • Same optical interface if desired
  • 25G requires a custom heat sink
Thanks