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EQUITY: TECHNOLOGY

Optical communication chip market trend

Laser, modulator, materials supply chain – what to watch?

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Global optical communication chip market trend: "Fast and Narrow" vs "Slow and Wide", Siph takes a leading role, VCSEL / MicroLED gain traction

We think the global optical communication chip market will continue to enjoy solid demand from high-end optical transceivers (i.e. 800G and 1.6T), as well as near-filed or co-packaged optics (NPO / CPO) solutions in the next 3-5 years. We believe SiPh (Silicon Photonics) powered by CW (continuous wave) laser is taking a leading role in the scale-out and scale-up of optical networks, and gaining share from EML ((Electro-Absorption Modulated Laser), driven by diversified supply chain and cost-effectiveness. Currently, the major optical chip solutions (including SiPh and EML) follow the **"Fast and Narrow" architecture, using the small number of ultra-fast data lanes**, and the speed upgrade (i.e. from 200G to 400G) of optical chips is crucial to support the innovation cycle. Meanwhile, we note technology leaders in the optical chip market are proactively developing **"Slow and Wide" solutions (multi-channel, medium-low speed lanes)**, which could accelerate the technology upgrade in the optical chip market. We see industry leaders are proactively developing solutions including VCSEL and MicroLED for the upcoming NPO / CPO markets (*Fig. 7*), and we have identified the key players in *Fig. 8*, *Fig. 10*, *and Fig. 11*.

We believe the modulation technology trend is worth monitoring, as it plays an important role in future technology innovation for the optical chip market. Traditional IM-DD (Intensity Modulation Direct Detection) solutions have certain limits such as signal distortion over long distance and bandwidth constraints, and we note Coherent / Coherent Lite modulation is gaining traction in the scale-across and scale-out of networks. For instance, **Google (GOOG US, Not rated) might start to deploy 2.4T coherent-lite from 2027E**.

In terms of materials, major types of lasers, including FP, DFB, EML, and CW lasers, all use **InP as an upstream material**, leading to buoyant demand from InP substrate, in our view. GaAs is another class III-V compound semi material for light-emitting, which can be used for VCSELs and MicroLEDs (*Fig. 12*). Moreover, **the role of Thin-film lithium niobate (TFLN) and Barium Titanate oxide (BTO)** could become more important in the next-generation optical communication technology, in our view.

Optical chip supply chain dynamics: supply of mid-to-low end optical chips will ease, but high-end lasers still in shortage; InP substrate still a key bottleneck, new materials such as TFLN / TBO are under development

For InP laser chip, we estimate total shipment volume of InP laser chip, including EML, VCSEL, CW, will grow from 480mn units in 2026F to 1,542mn units in 2028F (*Fig. 2*). We think mid-to-low end optical chips, including 70mW / 100mW CW lasers, 100G EMLs should have more sufficient supply in the next 1-2 years, led by the rising penetration of Chinese players such as **Yuanjie Technology (688498 CH, Neutral), and Source Photonics (Unlisted) in the global market**. However, high-end optical chips, such as 200mW+ CW lasers, 200G+ EML lasers, as well as high speed VCSEL chips are still dominated by global players, and we think there will still be a supply gap in 2026-2027F, due to slow capacity expansion, long equipment lead time, and yield rate issues. We believe InP substrate is still a key bottleneck for the optical chip supply chain, as the three major players – **Sumitomo Electric (5802 JP, Buy, covered by Yuji Matsumoto), JX Advanced Metal (5016 JP, Buy, covered by Daiki Ban), and AXT (AXTI US, Not rated) dominate the high-end InP substrate supply chain**, and policy control (i.e. China's export control on InP substrate and raw materials) could take a toll on effective supply in the global market.

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See Appendix A-1 for analyst certification, important disclosures and the status of non-US analysts.

Competition landscape: Chinese players play crucial roles in the optical transceiver market, and we see diversification effort in the XPO / NPO / CPO market; regulatory risk needs to be closely monitored

We believe China has the most well establish optical communication supply chain, and key transceiver players i.e. InnoLight (300308 CH / 3308 HK, Buy) already dominate the pluggable transceiver market, leading to market share gain opportunities for China's optical chip companies. Meanwhile, we think global players are striving to diversified optical supply, and a recent example is **NVIDIA (NVDA US, Not rated) and Cisco (CSCO US, Not rated) jointly launching the USFP (Ultra Dense Small Form Factor Pluggable) design for 3.2T+ pluggable transceivers, in partnership with TE Connectivity (TEL US, Not rated) and Amphenol (APH US, Not rated)**. We think there will be multiple optical communication solutions in the next 2-3 years including XPO / NPO / CPO, and large global CSP (cloud service providers) and AI customers will require customized solutions. Therefore, we think China's leading solution providers such as InnoLight would still play a crucial role, led by their strong innovations and effective supply chain management. However, regulatory risk remains, especially for the optical chip segments, as China's optical chip-makers are still in the early stage of global market expansion.

Global optical communication chip market landscape

Optical transceiver and chips in scale-out, scale-up and scale across networks

With the continuous penetration of optical interconnect technology in AI networking, optical chips play an increasingly important role in various AI data center architectures. At the scale-up layer, as SerDes evolves toward speeds of 448G and above, signal attenuation in copper cables becomes increasingly severe, so copper cables' transmission distances becomes a physical bottleneck for building larger-scale GPU clusters. As a result, NPO/CPO technology is gradually penetration into the scale-up network, moving the optoelectronic conversion interface near to the chip to meet the high-speed data transmission needs of high-density AI clusters. **Currently, the mainstream optical chip technology for NPO / CPO is Silicon Photonics**. However, **in the short-range scale-up network, VCSEL lasers are becoming more attractive** for their advantages of low power consumption, high maintenance flexibility, and relatively complete supply chains.

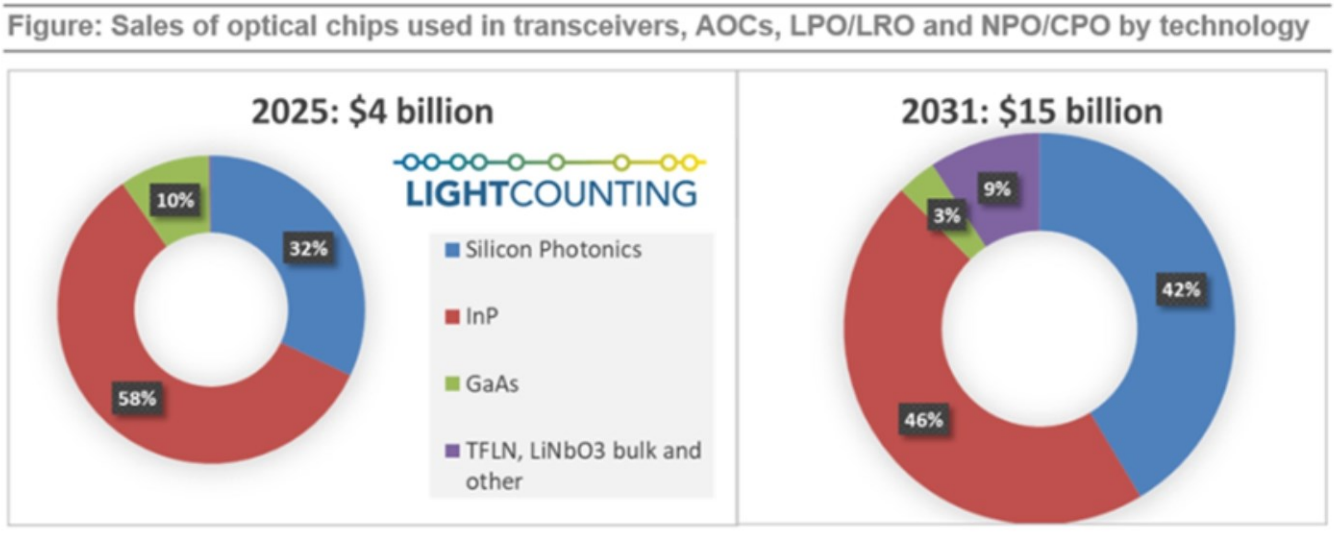
At the scale-out layer, 800G / 1.6T pluggable optical transceivers remain mainstream solutions for AIDC, and the **penetration rate of silicon photonics (SiPh) transceivers based on CW lasers could reach 60-70% by 2027F**, with the remainder being EML-based optical transceivers, in our view. To extend the lifecycle of pluggable transceivers, **Cisco (CSCO US, Not rated) and NVIDIA (NVDA US, Not rated) recently jointly announced the USFP (Ultra Dense Small Form Factor Pluggable) design solution**, aiming to provide high-bandwidth upgrades for next-generation AI Ethernet architectures while supporting existing operations and maintenance systems. According to NVIDIA, the partners for USFP include **TE Connectivity (TEL US, Not rated) and Amphenol (APH US, Not rated), for the USFP cages, connectors, and modules**. USFP supports 200G and 400G SerDes systems and ASICs, compatible with the deployment, replacement, and supply chain systems of existing pluggable optical transceiver ecosystems, without disrupting existing operating models, enabling smooth evolution from current 1.6T networks to higher specifications. USFP's basic specification is configured with 16 channels, each channel could support up to 400G Gb/s, and module aggregated bandwidth up to 6.4T. Its architecture can be scaled to 32 channels, achieving up to 12.8T aggregated bandwidth. Meanwhile, NPO/CPO solutions can also be used in scale-out scenarios, packaged in the form of optical engines within switches, and ultra-high power CW laser with SiPh chips are the main solutions now.

In scale-across scenarios, traditional IM-DD (Intensity Modulation Direct Detection) solutions are limited by fiber dispersion and loss, making them unsuitable for long-distance interconnects, making coherent optical communication technology an inevitable choice. Mainstream coherent optical transceivers solutions include SiPh solutions, indium phosphide (InP) solutions, thin-film lithium niobate (TFLN) solutions, or the combination of these technologies using heterogeneous integration. The main optical chips used in coherent optical transceivers include modulator chips, narrow-linewidth tunable lasers, and high-power CW DFB lasers.

LightCounting estimates the market size of optical chips used in optical communication was about USD4bn in 2025E, and will grow to USD15bn in 2031E. Silicon photonics chips accounted for 1/3 of all in 2025 and it will be contributing 42% (or USD6.3bn) to the total market for optical chips in 2031F, according to LightCounting. InP was the largest segment of the optical chip market, as it accounted for 58% of the total in 2025, and will account for 46% (or USD6.9bn) of the total by 2031F. We think InP EML chips will continue to lose market share to SiPh chips, but the market for InP lasers, including CW lasers for pluggable transceivers and CPO/NPO as well as tunable lasers and InP PIC for coherent transceivers, will continue to grow, in our view. **For InP laser chip, we estimate that shipment volume of total InP laser chip, including EML, VCSEL, CW, will grow from 480mn units in 2026F to 1,542mn units in 2028F**.

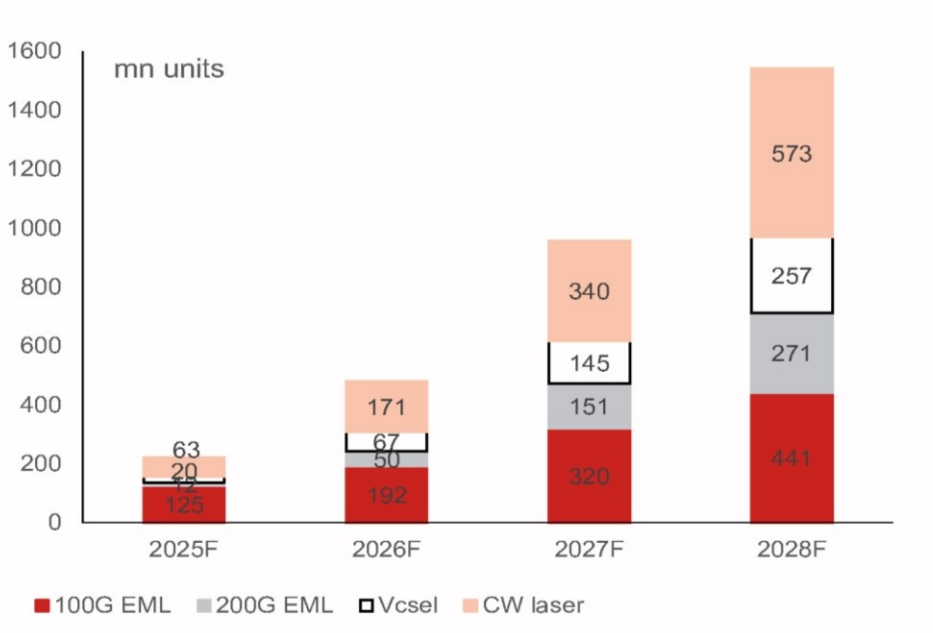


Fig. 1: Sales forecast of optical chips by material



Source: Lightcounting, Nomura research

Fig. 2: Laser chip shipment volume forecast



Source: Nomura estimates

Comparison of optical communication chips: type of laser and modulation technologies

Optical communication chips can be divided into laser chips (LD) at the transmitting end and detector chips (PD) at the receiving end, with InP as the main compound semi material. Laser chips convert electrical signals into optical signals, while detector chips convert optical signals back into electrical signals. Among laser chips, mainstream chips include: 1) FP chip - simple structure and low cost, used for low-speed, short-range scenarios; 2) DFB chip - built-in Bragg grating, covering speeds from 10G to 100G; 3) EML - integrates DFB laser with electromagnetic absorption modulator, which is a mainstream choice for high-speed long-distance devices of 100G and above; 4) CW laser - provides a stable external light source for SiPh modulators; and 5) VCSEL - light is emitted perpendicular to the chip surface, mainly used for interconnection in data centers less than 100 meters.

Fig. 3: Major types of optical chips

Category	Type	Wavelength (nm)	Major Applications	Advantages	Disadvantages
Transmitters	LED	1310	Speed: 155Mbps, Distance: ~2km	Good linearity, good temperature characteristics, low cost, long life	Wide spectral line, low coupling efficiency
	VCSEL	850	Speed: 155Mbps~16Gbps, Distance: ~500m	Narrow spectral line, low power consumption, high modulating speed, high coupling efficiency, low cost	Bad linearity, bad temperature characteristics
	FP LD	1310~1550	Speed: 155Mbps~10Gbps, Distance: ~40km	Narrow spectral line, high modulating speed, low cost	Low coupling efficiency, high cost
	DFB LD	1270~1610	Speed: 2.5Gbps~40Gbps, Distance: ~80km	Narrow spectral line, high modulating speed, good wavelength stability	Low coupling efficiency, high cost
	EML	1310~1550	Speed: higher than DFB, Distance: higher than DFB	Low power consumption, small size	High cost
Receivers	GaAs / InGaAs PIN PD	830~860 / 1100~1600	Speed: 155Mbps ~ 40Gbps, Distance: ~40km	Low noise, long life, low cost	Low sensitivity
	InGaAs APD	1500	Speed: 1.25Gbps~10Gbps, Distance: long distance	High sensitivity	High noise, high cost

Source: Nomura research

Modulators: EAM vs MZM vs MRM, is MRM the future choice?

Optical modulators are responsible for "writing" the transmitted electrical signals onto light waves. They are the core devices that convert electrical signals into optical signals. Mainstream optical modulators include EAM (Electro-Absorption Modulator), MZM (Mach-Zehnder Modulator), and MRM (Micro-Ring Modulator). EAM changes the semiconductor material's ability to absorb light by applying a reverse voltage, offering advantages such as low driving voltage and fast modulation speed, but requires integration of heterogeneous materials. MZM splits the input light into two channels, changes the phase of one (or both) of the light by applying voltage, and then merges the two channels. MZM has good temperature stability, excellent signal transmission quality, and supports high-order modulation formats (such as PAM4), but it is larger and consumes more power. MRM is based on an optical resonator cavity, changing the resonant wavelength of the loop by applying voltage. MRM is small form factor and low in power consumption, making them ideal for high-density integration and naturally suitable for wavelength division multiplexing (WDM) systems. However, it is very sensitive to temperature and require feedback control circuits to increase stability, results in more complex system.

Fig. 4: Comparison of EAM, MZM, and MRM

Dimension	EAM	MZM	MRM
Modulation mechanism	Electromagnetic absorption changes light intensity	Two channel change intensity/phase	Microring resonance wavelength shift
Material	InP, InP/InGaAsP	$LiNbO_3$, Si, InP, TFLN	Si, SiGe
Light source	DFB	CW laser	CW laser
Size	Small to medium	Medium to relatively large	Smallest
Driving voltage	Low to medium	Medium to relatively high	Low
Insertion loss	Lower, but there is absorption loss	Usually higher	Lower
Linearity	Medium	Best	Weaker and relying on calibration
Temperature control requirements	Medium	Medium	High
Application	800G/1.6T pluggable optical transceivers	Coherent communication, DCI, SiPh-based optical engine	CPO, optical I/O, inter-chip interconnection
Main bottleneck	InP capacity, yield, cost	Size, power consumption, packaging	Thermal tuning, system reliability

Source: Nomura research

According to QYResearch, modulators and waveguide processes account for about 14% of the 100G EML cost structure. EAM modulator suppliers are basically the same as EMLs, mainly overseas companies such as Broadcom (AVGO US, Not rated), Lumentum (LITE US, Not rated), and Mitsubishi Electric (6503 JP, Covered by Masaya Yamasaki, Buy), while domestic companies like Yuanjie Technology (688498 CH, Neutral), Everbright (688048 CH, Not rated), and Shijia Photonics (688313 CH, Not rated) have mass production capabilities for 100G EML chips. EML chips at different speeds have internal EAM modulators that differ in electrode structure, waveguide size, and capacitor design. As speed increases, EAM must continuously break through bandwidth bottlenecks while maintaining sufficient extinction ratios.

The MZM modulator structure is mainly integrated into SiPh chips and TFLN chips for CPO technology. Broadcom has adopted the mature MZM solution in its CPO products. Compared to Nvidia's micro-ring modulator (MRM) used in CPO, MZM occupies more chip space, but the technology is more mature and have low thermal sensitivity, reducing the need for precise temperature control. MZM modulators' players are diverse, spanning multiple technology platforms such as TFLN, InP, SiPh, and hybrid integration. Major global manufacturers include Versawave (Unlisted), Synopsys (SNPS US, Not rated), NeoPhotonics (Unlisted), MACOM (MTSI US, Not rated), Fujitsu (6702 JP, Covered by Masaya Yamasaki, Buy), and Lumentum. While Tower Semiconductor (TSEM US, Not rated) and GlobalFoundries (GFS, Not rated) offer 200 mm / 300 mm SiPh foundry platforms for data center interconnections, emphasizing open process services, we

believe the MZM supply landscape is shifting from "independent modulator vendors" to system competition of "silicon photonics platform + packaging".

MRM are mainly used in silicon optical engines, and NVIDIA has used MRM solutions in its CPO switches, and AMD plans to adopt it in next-generation AI accelerators. MRM diameters are typically only about 100 microns (traditional MZMs typically measure 1-5 millimeters), greatly saving chip space. Thanks to the micro resonator structure, MRMs require lower capacitance and drive voltage, significantly improving energy efficiency. However, MRM operates based on the principle of optical resonance, and its resonant wavelength is highly sensitive to temperature changes. Temperature fluctuations easily cause wavelength drift, requiring complex thermal control circuits to maintain stability. Ayar Labs' (Unlisted) products explicitly use MRM technology and CMOS-compatible silicon photonic manufacturing, positioning them for GPU-to-GPU, CPO, and optical I/O scenarios.

Fig. 5: Competitive landscape of modulators by type

Modulator type	Major player	Competitive characteristics
InP EAM Modulator	Coherent, Lumentum, Broadcom, Mitsubishi Electric, Sumitomo Electric, NTT Electronics, Source Photonics	High technical and customer certification barriers; 100G/lane is already relatively mature, while 200G/lane has entered the phase of scaling up and certification
SiPho MZM	Intel, Cisco, Marvell, Coherent, GlobalFoundries, Tower Semiconductor	Relies on 200/300mm CMOS compatible processes, PDKs, and packaging ecosystems
TFLN MZM	Advanced Fiber Resource, Ciena, HyperLight	Large-scale manufacturing and cost optimization are still ongoing
MRM	Intel, Ayar Labs, Lightmatter, Ranovus, GlobalFoundries, Tower Semiconductor	The technology focuses on CMOS compatibility, low power consumption, stability of array, and high-density interconnects

Source: Company data, Nomura research

Modulation: IMDD vs Coherent / Coherent Lite

Modulating electrical signals to optical carriers is mainly divided into two main approaches: Intensity Modulation-Direct Detection (IMDD) and Coherent Detection. IMDD dominates short-distance high-speed data center applications, while Coherent technology is mainly used in long-distance high-capacity telecom and data center interconnections. Coherent modulation is a system-level solution that uses multiple dimensions such as light amplitude, phase, and polarization to carry information. At the receiving end, the coherent detection produces the complete field information of the light by mixing the signal light with a local oscillator laser, and then the DSP chip compensates for transmission damage. The advantages of coherent modulation are high spectral efficiency, high reception sensitivity, and the ability to effectively compensate for dispersion through DSP. But on the opposite side, its system is more complex, with higher cost and power consumption.

Coherent-lite is designed to work at shorter distances (＜20km) than traditional coherent transceivers, uses cheaper and less complex DSPs and optics to bring the benefits of coherent optics to campus and intra-datacenter interconnect. Based on our industry channel check, we expect Google to start deploy 2.4T coherent-lite from 2027F. Coherent DSP and high-end optical chips are dominated by US manufacturers, while module assembly heavily depends on Chinese companies such as Innolight (300308 CH / 3308 HK, Buy).

Fig. 6: comparisons of IMDD and Coherent technology

Dimension	IMDD	Coherent
Parameter	Amplitude	Amplitude, Phase, Frequency
Receiver	Photodiodes (PD)	Local oscillator, Mixer, PD, DSP
Cost	Low	High
Spectrum efficiency	Low (PAM4)	High (QPSK, 16QAM)
Application scenario	short-distance (DR, FR, LR)	long-distance (100-800G/ZR/ZR+)

Source: Nomura research

The future optical communication chip roadmap and market trend

From 1.6T pluggables to NPO / CPO to OIO: rising technology barriers for optical chips

Currently, the major demand driver for optical communication chip is the 800G / 1.6T pluggable optical transceiver. 800G to 1.6T transceiver upgrade drive EML chip upgrade from 100G per lane to 200G per lane, and CW laser from 70mW to 100mW. Meanwhile, optical transceivers are evolving from pluggable forms to NPO and CPO, driving future demand for high-power CW lasers (120mW+). High-power laser products (i.e. 300mW+) require low relative noise intensity, narrow linewidth, and output stability, which raise the bar for newcomers in the market.

Based on different transmission distances and cost-based power consumption constraints, three different optical chip technologies have emerged for the NPO / CPO solutions in scale-up network: silicon photonics, MicroLED, and VCSEL. SiPh uses mature CMOS semiconductor processes to fabricate optical waveguides on a silicon substrate, paired with external or integrated InP laser sources - ultra-high power CW lasers, following a “fast and narrow” (using a small number of ultra-fast lanes) architecture, which is suitable for long-distance (100 meters+) transmission. VCSEL uses multiple VCSEL arrays made of compound semiconductor materials, following a "slow and wide" (multi-channel, medium-low speed modulation) architecture, which is suitable for medium-distance transmission (10-100 meters). MicroLED uses high-density micro LED arrays to directly modulate optical signals, also adopting a “wide and slow” architecture, suitable for ultra-short moments (＜ 10 meters).

Compared with NPO / CPO, OIO further pushes optical engines toward advanced chip-level packaging, integrating compute chips (such as GPUs, CPUs, and XPUs) with optical chips onto the same substrate / interposer through advanced chiplet-level packaging, directly replacing traditional electronic I/O. The primary goal of OIO is to match the I/O throughput capabilities of computing chips, which requires optical chips to have extremely high bandwidth density and meet ultra-low power consumption and highly integrated requirements.

Fig. 7: Technology comparison of SiPh CPO，MicroLED CPO and VCSEL CPO

Evaluation Criterion	Silicon Photonics CPO	MicroLED CPO	VCSEL CPO
Technology principle	Silicon photonic integrated circuit (PIC) co-packaged with the switch ASIC; typically uses external laser, modulators, waveguides, and photodetectors.	Dense arrays of sub-50 µm microLED emitters integrated with CMOS drivers; uses many slower, highly parallel optical channels.	Vertical-cavity surface-emitting laser arrays with photodiode arrays and driver/TIA electronics integrated near the ASIC.
Primary light source	CW laser	MicroLED emitter array	VCSEL array
Typical channel strategy	Fewer high-speed lanes; CWDM/DWDM can increase fiber capacity.	Many parallel lower-speed channels; optimized for 'slow and wide' interconnects.	Parallel multimode channels; 2D arrays increase lane count and bandwidth density.
Energy efficiency	Low link power enabled by very short electrical paths; roughly 3.5x power savings versus pluggables.	Published estimates commonly target approximately 1–2 pJ/bit.	Generally better than copper and pluggables for short reach; published estimates around 3–6 pJ/bit.
Reach profile	From 100m to several kms	10-100m	<10m
Integration and packaging	Most mature CPO integration path; requires PIC/EIC co-integration, fiber attach, advanced packaging, and test.	Requires precise microLED-to-driver bonding, massive parallel alignment, and yield management for very small emitters.	Requires precise VCSEL/PD array attach, driver/TIA placement, fiber-array coupling, and high-density packaging.
Key advantages	Strong ecosystem; WDM capability; scalable lane rates; broad reach options; compatible with advanced silicon packaging.	Lowest potential energy per bit; compact emitters; high parallelism; can reduce or eliminate DSP in selected short links.	Established VCSEL supply chain; low-cost emitters; compact arrays; strong fit for short-reach multimode links.
Key challenges	External laser supply and reliability; thermal coupling; fiber attach; package repairability and field serviceability.	Mass-transfer yield; emitter uniformity and lifetime; optical coupling; limited reach; immature ecosystem and standards.	Thermal rollover; multimode reach limits; array coupling and alignment; scaling lane count and package serviceability.

Source: Berxel Optoelectronics, Microsoft, Nomura research

VCSEL: coming back in scale-up network?

VCSEL was primarily used for industrial applications (i.e. LiDAR) or consumer electronics (i.e. FaceID), and was losing momentum in the optical communication market in the past few years, as AIDC's scale started to become larger. However, VCSEL might regain popularity in the scale-up network, in our view, and some first movers are already making progress for adopting VCSEL in scale-up network. Lumentum demonstrated a VCSEL-based CPO platform at OFC 2026, which can be directly integrated next to the ASIC without relying on remote external light sources. Broadcom's VCSEL NPO solution is based on Broadcom's mature single-lane 100G VCSEL, focusing on low power consumption and low cost, with transmission distances reaching up to 30m. Recently, 1060nm VCSELs have attracted attention at ECOC 2026. Unlike traditional 850nm solutions, the 1060nm band is more suitable for developing back-emission, flip-chip soldering, and high-density array packaging, which can simultaneously improve bandwidth, heat dissipation, reliability, and integration. Three companies announced breakthrough progress in 1060nm VCSELs at ECOC 2026, representing three technical paths for VCSEL: high-performance single-transistor optimization, high-density array integration, and ultra-high-speed single-mode/dual-mode compatibility. The joint demonstration by Berxel Optoelectronics (Unlisted) and the Chinese University of Hong Kong focused on cost-effective back-emitting VCSEL solutions for NPO scenarios, verifying compatibility between 1060nm devices and standard multimode fiber. Coherent's (COHR US, Not rated) demonstration route focused on high-bandwidth density array solutions for CPO scenarios, using silicon interposer flip-soldering to integrate 2×9 back-emitting VCSEL arrays, with a total bandwidth of up to 2.3T. The 1060nm VCSEL jointly released by Tokyo University of Science, Azhar University in Egypt, and Ambition Photonics (Unlisted) adopts a metal aperture coupling cavity structure, achieving a record 62GHz bandwidth of 3dB, while supporting long-distance single-mode fiber transmission and multi-mode fiber-free transmission. We believe that the future application space of VCSELs in NPO/CPO should not be ignored, and VCSELs may cover both short-distance NPO/CPO scenarios and long-distance high-speed transmission.

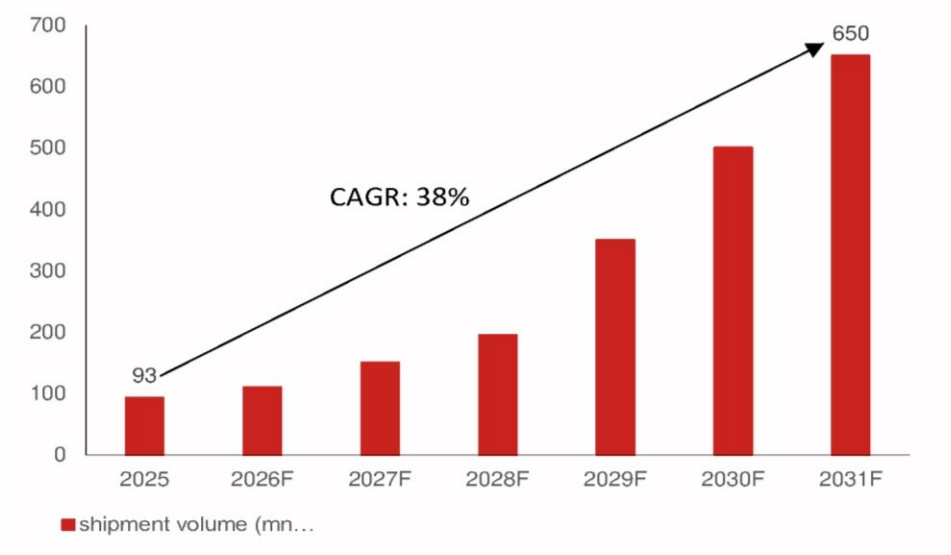
Fig. 8: Comparison of three technology routes for VCSEL

Dimension	Berxel	Coherent	Tokyo University of Science
Core structure	Oxides-confined back-emission VCSELs	Oxides-confined back-emission VCSELs array	Single-mode VCSEL with metal aperture coupling cavity
Form	Single tube	2x9 array + Flip-chip soldering of silicon interposers	Single tube; support SMF/MMF dual mode
3dB bandwidth	>37GHz	>27GHz	62GHz
Highest data rate per lane	106G PAM4	128G PAM4	256G PAM4
Transmission scenario	100m OM3 MMF	short-distance CPO	1km SMF/500m OM4 MMF
Key advantages	Low cost, high stability	High bandwidth density and excellent high-temperature performance	High speed, long range, dual-mode compatibility

Source: Berxel, Coherent, Tokyo University of Science, Nomura research

VCSEL, as another NPO/CPO technology route, is attracting more and more leading manufacturers investing in R&D, such as Lumentum, Furukawa Electric, Coherent, Broadcom, ams OSRAM, and HiSilicon. According to TrendForce's latest "2027 Infrared Sensing and Optical Communication Market Trends," VCSEL market demand is expected to reach 650mn units by 2031E, with a CAGR of 38% from 2025 to 2031E. QYResearch estimates that China's VCSEL chip market size will reach USD240mn by 2030E, with a CAGR of 13.9% over 2024-2030F.

Fig. 9: Global market forecast for VCSEL, shipment volume (mn units)



Source: TrendForce, Nomura research

MicroLED: a hype or a new technology trend?

MicroLED CPO pioneers include giant platforms like Microsoft and Marvell, as well as startups like Avicena (Unlisted) and Hyperlume (Unlisted). Microsoft's (MSFT US, Not rated) MOSAIC represents the "wide and slow" architecture. Traditional 800Gbps links are usually split into 8 100Gbps high-speed channels, while MOSAIC lays 400 2Gbps low-speed optical channels for parallel data transmission. Avicena's LightBundle solution uses a different path, combining a GaN-based MicroLED array with a PD receiver, leveraging TSMC's (2330 TT, Covered by Aaron Jeng, Buy) advanced process to optimize chip integration. The base bandwidth is 512Gbps, scalable upward to 896Gbps, with single-bit power consumption of 1~2pJ and a stable transmission distance of 5 meters, according to Avicena.

TrendForce estimates that the production value of MicroLED CPO will reach USD848mn by 2030E. At present, European and American giants and startups have already outlined the technical prototype of Micro LED CPO. However, there are significant differences among camps in chip specifications, receiver solutions, and system integration paths, and the final establishment of industry standards will still take time. The domestic LED industry chain is complete from upstream Epi wafer and production processes, to midstream driver IC integration, and downstream module packaging and testing, Chinese companies now possess end-to-end collaboration capabilities. Especially on the chip side, major LED manufacturers such as Sanan Optoelectronics (600703 CH, Not rated), BOE (000725 CH, Not rated), Xiamen Changelight (300102 CH, Not rated), and Shenzhen MTC (002429 CH, Not rated), have strong foundations in epitaxy and chip layers, providing stable light sources for domestic optical communication industry.

Fig. 10: Major overseas players in MicroLED CPO

Technology route	Camp
MicroLED + CMOS sensor array, 400 channels x 2G parallel architecture (20x20 array, area <1mm^2), maximum transmission distance 50 meters	Microsoft, MediaTek, Porotech, Innolight
GaN MicroLED+PD array, base bandwidth 512G, transmission distance 5 meters, single-bit energy consumption 1-2pJ	Avicena, ams OSRAM, TSMC
Pluggable ALC solution, 1pJ/bit, transmission distance of 30m, supports 1.6T and expandable up to 3.2T	Credo, Hyperlume
MicroLED + Marvell connectivity technology, sub-1pJ/bit, over 100T/mm^2 bandwidth	Marvell, Mojo Vision

Source: Company data, Nomura research

Fig. 11: MicroLED product development progress in China market

Company	Development progress
BOE HC SemiTek	MicroLED optical interconnect products have been sampled and are currently working with customers to optimize their products; In early 2026, it jointly develop MicroLED optical modules with New Vision Microelectronics
Shenzhen MTC	The MicroLED light source chip dedicated to CPO has entered the testing phase; A joint MicroLED CPO research laboratory has been established with Hunan Normal University, aiming for tape-out in 2026 and integrated sample delivery in 2027
Sanan Optoelectronic	Cooperated with Tsinghua University and China Mobile to develop MicroLED optoelectronic devices; Sent samples for validation to leading domestic and international companies
Changelight	In April 2026, it jointly developed MiroLED optical communication products with Hisense; In May, it reached an agreement with Jinghe Optoelectronic to cooperate in the fields of MiroLED for automotive lighting and optical interconnects
Leyard	Entered into R&D cooperation with the Chinese Academy of Sciences and has provided MicroLED optical module products; Acquired shares in Saphlux to acquire core technology resources for semipolar gallium nitride and MicroLED
Jingzhan Semiconductor	The company's 8-12 inch Si-based GaN MicroLED light source products have power consumption below 1pJ/bit

Source: Company data, Nomura research

Optical communication materials trend: InP vs GaAs vs SiGe vs TFLN vs BTO

In terms of optical chip materials, the main material systems include InP / GaAs / SiGe. Currently, major types of lasers, including FP, DFB, EML, and CW lasers all use InP as upstream material, leading buoyant demand from InP substrate, in our view. Meanwhile, the global high-end InP production capacity is highly concentrated among a few manufacturers such as Sumitomo (5802 JP, Covered by Yuji Matsumoto, Buy), JX Metals (5016 JP, Covered by Daiki Ban, Buy), and AXT (AXTI US, Not rated). In China, Yunnan Germanium (022428 CH, Not rated) and Guangdong Xiandao (Unlisted) have achieved mass production of substrates ranging from 2 to 3 inches, but the penetration into global market still low.

Compared with InP, GaAs is another class III-V compound semi material for light-emitting which can be used for VCSELs and MicroLEDs. The technology is mature and cost-efficient, suitable for short-distance interconnects in data centers. Currently, mainstream large-scale shipments of GaAs substrates in the market are still mainly 4-inch and 6-inch, while leading manufacturers like Sumitomo Electric and AXT already have production capacity for 8-inch GaAs substrates.

SiGe wafers and silicon-based germanium epitaxial materials are used in optical communications, to compensate the shortcomings of pure silicon materials in light emission and long-wavelength light absorption. SiGe wafers are mainly used in optical devices such as PD chips, Driver/TIA, and EAM. In recent development, Semtech's (SMTC US, Not rated) signal integrity product portfolio (such as TIA, laser drivers, etc.) will fully empower its cutting-edge high-speed optical interconnect applications including fully rescheduled optical devices (FRO), linear pluggable optical devices (LPO), and near-package optical devices (NPO), by leveraging Tower Semiconductor's advanced SiGe process. GlobalFoundries and Marvell (MRVL US, Not rated) also announced in

September 2026 that they will jointly expand the SiGe wafer capacity at the GlobalFoundries' Burlington wafer fab in Vermont, USA.

Fig. 12: InP vs. GaAs vs. SiGe

Dimension	InP	GaAs	SiGe
Optical communications applications	Coherent optical transceivers; tunable and fixed-wavelength telecom lasers; DFB lasers; EMLs; high-speed PD; telecom and datacom transmitters	850 nm VCSELs for datacenter; multimode-fiber transceivers; short-reach optical interconnects	Drivers; TIAs; clock/data recovery; SerDes; SiGe PD
Typical / suitable wavelength	O-band 1,310nm; C-band 1,530–1,565nm; L-band 1,565–1,625nm	Primarily 850nm; moving forward 1060nm	Commonly paired with 1,310nm or 1,550nm photonics, and sometimes 850nm VCSEL systems
Typical transmission distance	A few kilometers to 80–120+ km	Typically 100–300m over OM3/OM4/OM5 multimode fiber; up to 500m in optimized short-reach designs	From meters to kilometers
Key advantages	Direct bandgap enables efficient light emission; broad telecom-wavelength coverage; high-speed modulation and detection; strong fit for single-mode fiber and coherent systems	High-speed and efficient VCSEL operation; mature datacenter ecosystem; relatively low-cost wafer-scale manufacturing	High carrier mobility and strong RF performance; CMOS-compatible integration; enables compact, low-power, high-bandwidth electronics
Key disadvantages	Heterogeneous integration and thermal management can be complex	Less suitable for long-haul single-mode links; temperature and modal-dispersion constraints	Indirect-bandgap platform is not an efficient native light emitter; usually requires external III-V lasers or hybrid integration

Source: Nomura research

Thin-film lithium niobate (TFLN) could play a crucial role in the next-generation optical communication technology. The TFLN modulator is based on the unique linear electro-optic effect (Poopers effect) of lithium niobate crystals. When an external electric field is applied to the crystal, the internal refractive index changes linearly, precisely controlling the intensity, phase, and polarization direction of light in the optical path. TFLN modulators offer extremely high control accuracy, low delay during transmission and low signal deviation. Fujitsu is one of the few companies worldwide capable of mass-supplying telecom-grade lithium niobate high-speed modulator chips, having launched high-speed TFLN modulators above 110GHz and achieved mass delivery. Advanced Fiber Resources Technology (300620 CH, Not rated) launched 400G/lane PAM-4 TFLN modulator chips in 2025, compatible with DR4/FR4 (1.6T) and DR8/FR8 architectures (3.2T). HyperLight (Unlisted), as one of the technology pioneers in the TFLN field, partnered with TSMC's UMC for mass production of 8-inch wafers in March 2026, and showcased 110GHz products at OFC 2026.

Another new material for modulators is barium titanate, which offers excellent electro-optic response. Barium titanate has lower operating voltage, low loss, and compatibility with existing CMOS manufacturing infrastructure. However, challenges in manufacturing and epitaxy growth limit direct integration of barium titanate based devices on silicon substrates. European photonics company Lumiphase (Unlisted) has been continuously advancing the commercialization of high-speed barium titanate oxide (BTO) modulator chips with single-channel 400G and above; while the Tsinghua University team successfully designed and validated a prototype BTO electro-optic modulator chip based on the Mach-Zendl interferometer (MZI) structure, targeting CPO and 1.6T/3.2T optical transceiver applications.

Appendix A-1

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