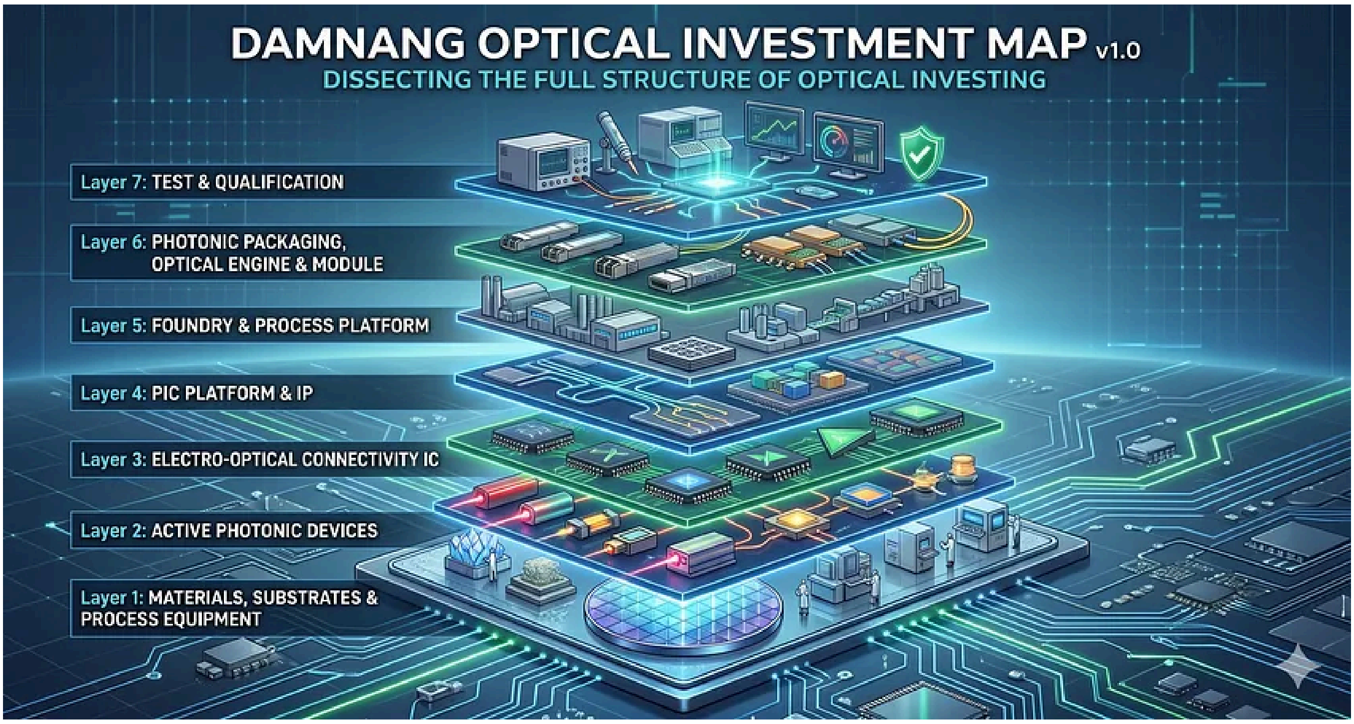
丹南光学投资地图 v1.0 - 丹南的 Substack --- Damnang's Optical Investment Map v1.0

substack.com/@damnang/p-194722823

Substack



These days the market is drowning in words like optical, silicon photonics, and CPO. But most investors know the keywords without actually seeing the full picture of the value chain behind them.
如今市场上充斥着"光通信"、"硅光"、"CPO"等热词，但多数投资者只知概念，却看不清背后完整的产业链图景。

Some people look at Coherent and Lumentum and think they understand optics. Others hear CPO is the future and go hunting for related stocks. But optics is not a theme that ends at a handful of laser names. It is a value chain that tangles together materials, photonic devices, connectivity ICs, PIC platforms, foundries, packaging, modules, and test. Which layer you look at completely changes the risk profile and the return structure.
有人看到 Coherent 和 Lumentum 就以为理解了光电子产业，也有人听闻 CPO 代表未来就追逐相关股票。但光电子绝非仅靠几家激光企业就能涵盖的主题，而是由材料、光子器件、连接芯片、光子集成电路平台、代工厂、封装、模块及测试等环节交织而成的价值链。观察的层级不同，风险特征与回报结构将截然不同。

This piece is a map built to show that whole picture in one shot.
本文构建的图谱旨在全景式呈现这一完整图景。

I've split the optical value chain into seven layers, overlaid the architecture evolution axis (FRO, LRO, LPO, NPO, CPO), and organized each company by where it sits in that structure.
我将光电子价值链划分为七个层级，叠加了架构演进轴线（FRO、LRO、LPO、NPO、

CPO），并根据各公司在结构中的位置进行归类。

This time I'm going one step further.
这次我要更进一步。

Over the past twelve months, optical-related stocks have run anywhere from +200% to +1,700%. Readers keep asking the same things.
过去十二个月里，光学相关股票涨幅从+200%到+1,700%不等。读者们反复询问着同样的问题。

Is it too late to get in?
现在入场还来得及吗？

What should I be watching?
我应该关注什么？

I'm answering those questions head-on in a paid-subscriber section that covers cycle diagnosis, the next five years' game-changers, and a scoring matrix that rates 22 names across 9 factors. The scoring methodology is fully disclosed, so you can re-weight it yourself.
我在付费订阅者专享部分直面这些问题，内容涵盖周期诊断、未来五年行业变革者，以及一个基于 9 项指标对 22 家公司进行评分的矩阵。评分方法完全公开，您可自行调整权重。

This map isn't going to be perfect. I might miss names or layers worth adding. If you spot something while reading, drop it in the comments and I'll update as I go.
这份投资地图并非完美无瑕。我可能遗漏了值得纳入的公司或维度。若您在阅读过程中有所发现，欢迎在评论区留言，我将持续更新完善。

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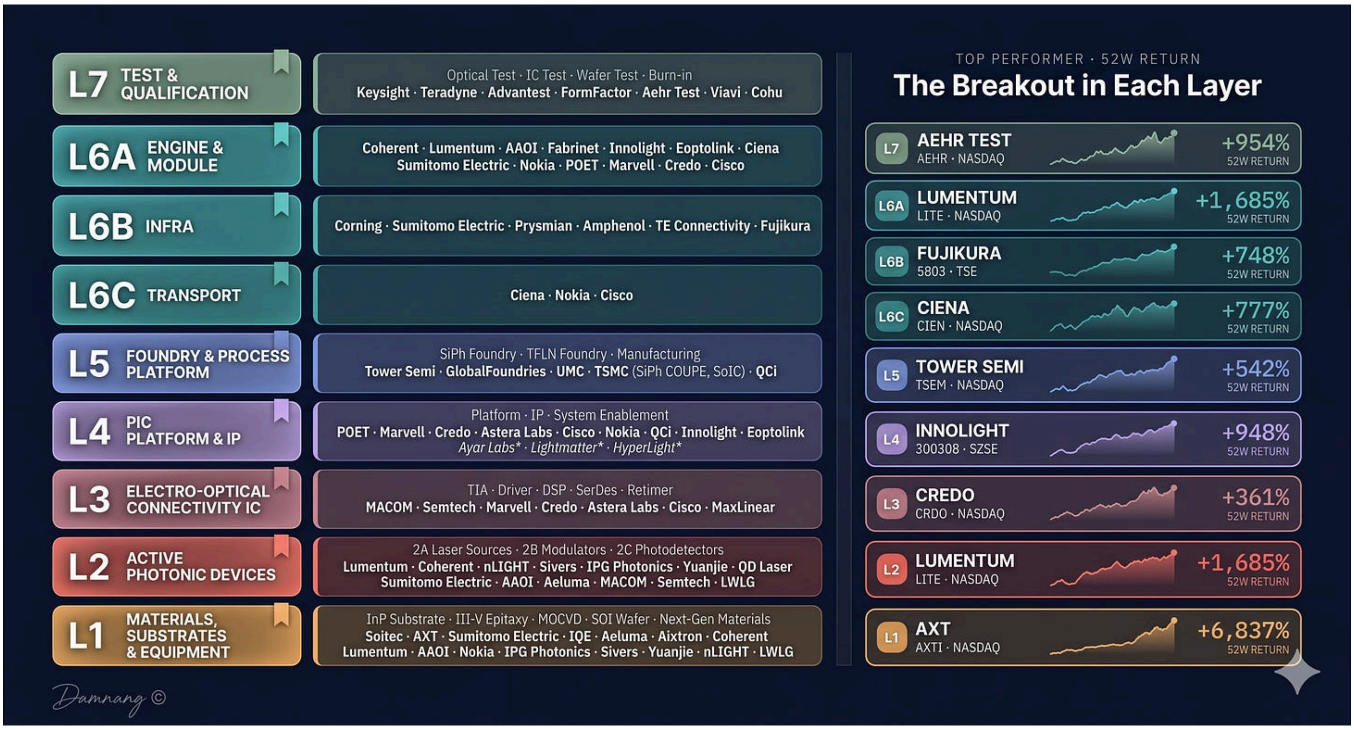
Market size estimates, 52-week returns, and financial figures are drawn from research firms and public disclosures, and may differ from actual values. Sections marked as personal speculation, along with forward-looking statements about product roadmaps, potential acquisitions, and competitive dynamics, carry inherent uncertainty. Past performance does not guarantee future results, and every security discussed carries the risk of loss of principal.
市场规模预估、52 周回报率及财务数据均引自研究机构报告与公开披露信息，可能与实际数值存在差异。标注为个人推测的章节，以及关于产品路线图、潜在收购和竞争态势的前瞻性陈述，均具有固有不确定性。过往表现不预示未来结果，所讨论的每项证券均存在本金损失风险。

Investment decisions should be made independently based on your own financial situation and risk tolerance. Any gains or losses from investments made based on this article are solely your responsibility. This article is current as of April 17, 2026, and its contents may become outdated quickly as conditions change.

投资决策应基于您自身的财务状况和风险承受能力独立作出。依据本文进行投资所产生的任何收益或损失均由您自行承担。本文内容截至 2026 年 4 月 17 日有效，随着形势变化，其内容可能迅速过时。

The 7-Layer Value Chain 七层价值链



All 52-week returns in the tables below are estimates versus one year ago as of April 17, 2026.
以下表格中所有 52 周回报率均为截至 2026 年 4 月 17 日相较于一年前的估算值。

Layer 1: Materials, Substrates & Process Equipment
第一层：材料、基板与工艺设备

The raw materials for optical devices, plus the core equipment that processes them.
光器件的原材料，以及加工这些材料的核心设备。

InP / III-V Epitaxy / MOCVD.
磷化铟 / III-V 族外延 / 金属有机化学气相沉积。

The raw-material family for laser chips. Epitaxial films are grown on InP substrates to build laser wafers. Three things are involved: substrate manufacturing, epi growth, and MOCVD equipment.
激光芯片的原材料家族。在 InP 衬底上生长外延薄膜以制造激光晶圆。涉及三个方面：衬底制造、外延生长和 MOCVD 设备。

SOI Wafer. SOI 晶圆。

The substrate for silicon photonics (SiPh). Every time SiPh foundry capacity expands, SOI wafer demand scales alongside it.
硅光子学（SiPh）的衬底。每次 SiPh 代工厂产能扩张，SOI 晶圆需求也随之增长。

Next-Gen Modulator Materials.
下一代调制器材料。

TFLN and EO polymer. Both offer higher modulation efficiency than silicon MZM but are still early and unvalidated at volume. TFLN is starting to see volume production in China (Liobate, AFR, and others).
TFLN 与 EO 聚合物。两者均提供比硅基 MZM 更高的调制效率，但目前仍处于早期阶段，尚未实现规模化验证。TFLN 在中国已开始规模化生产（Liobate、AFR 等企业）。

TFLN-based PIC designers and foundries (QCi, HyperLight) are covered in L4 and L5.
基于 TFLN 的 PIC 设计商和代工厂（QCi、HyperLight）在 L4 和 L5 层级中已涵盖。

This layer is won on supply bottleneck and manufacturing difficulty. It is the first layer to reflect the early capex cycle of the AI optical buildout.
这一层的竞争关键在于供应瓶颈和制造难度。它是首个反映 AI 光学建设早期资本支出周期的层级。

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Layer 1 — Materials, Substrates & Process Equipment
Supply Bottleneck + Process Entry Barrier Plays

Company	Ticker	Role	52W Return
Soitec	[SOI / SLOIF]	SOI wafer dominant supplier	+88%
AXT	[AXTI]	InP/GaAs bulk substrate	+6,837%
Sumitomo Electric	[5802.T]	InP/GaAs/GaN substrates, global leader	+71%
IQE	[IQE]	III-V epitaxial wafer supplier	+393%
Aeluma	[ALMU]	III-V-on-silicon 12-inch wafer	+138%
Aixtron	[AIXA]	MOCVD equipment, InP leader	+341%
Coherent	[COHR]	InP epitaxy/fab integrated, 6-inch platform	+562%
Lumentum	[LITE]	Greensboro NC InP fab acquired, 2028 ramp	+1,685%
AAOI	[AAOI]	In-house MBE/MOCVD epitaxy, Sugar Land TX	+1,486%
Nokia	[NOK]	Infinera InP fab + Aixtron MOCVD, 6-inch	+103%
IPG Photonics	[IPGP]	In-house GaAs fab + fiber preform	+141%
Sivers	[SIVE.ST]	In-house InP100 4-inch fab, Glasgow	+224%
Yuanjie	[688498.SS]	In-house MOCVD epitaxy, IDM, China	~+900%
nLIGHT	[LASR]	In-house GaAs fab + fiber	+896%
Lightwave Logic	[LWLG]	EO polymer, pre-revenue	+1,203%

Source: Company filings, industry checks | Damnang Investment Research | 2026-04-17

Layer 2: Active Photonic Devices
第二层：有源光子器件

The pure photonic-device layer. The things that create light (lasers), modulate light (modulators), and detect light (photodetectors).
纯光子器件层。包括产生光（激光器）、调制光（调制器）和探测光（光电探测器）的器件。

2A Laser Sources. 2A 激光光源。

DFB, EML, VCSEL, CW lasers. The single most important bottleneck in the whole value chain.
分布式反馈激光器、电吸收调制激光器、垂直腔面发射激光器、连续波激光器。这是整个价值链中最关键的瓶颈环节。

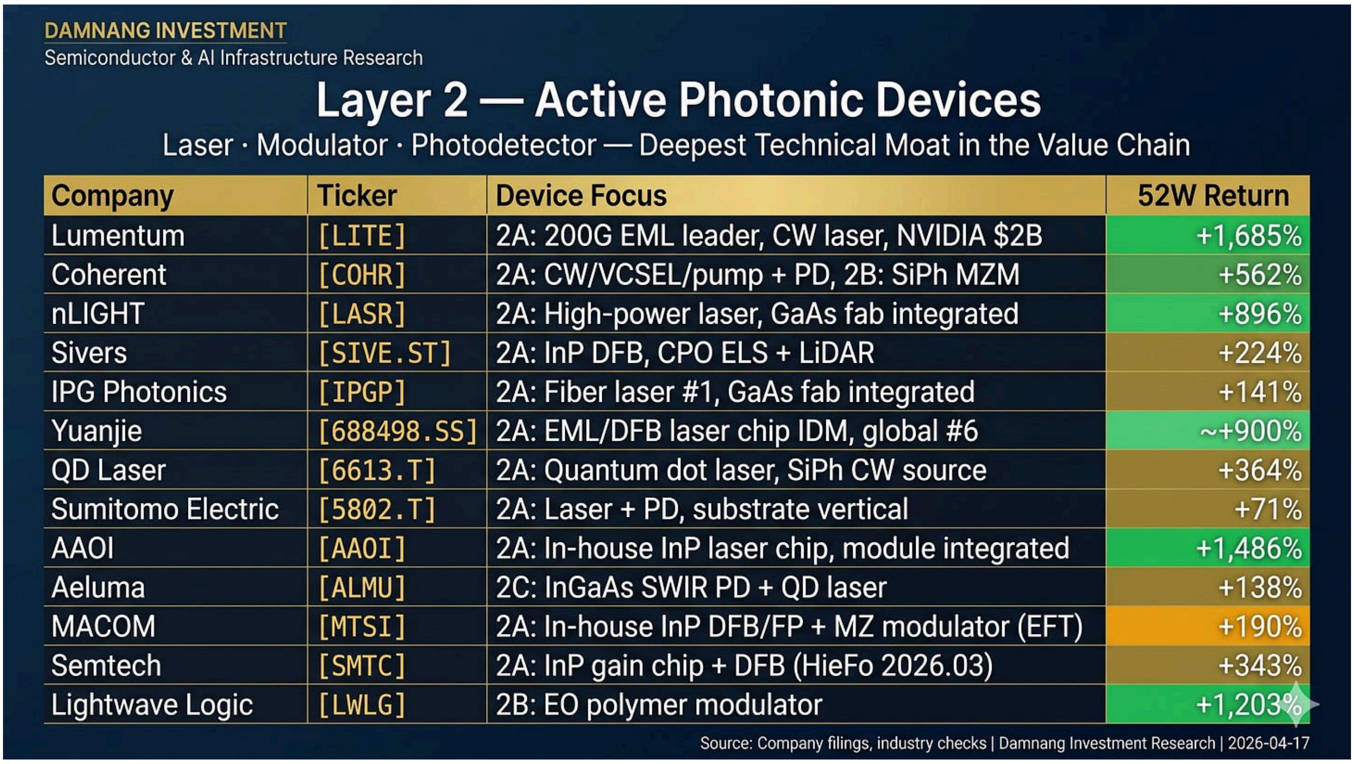
Industry checks say 200G/lane EML supply is tight, and CPO brings another wave of demand for external light source (ELS) CW lasers.
行业调研显示，200G/通道的电吸收调制激光器供应紧张，而共封装光学技术为外置光源的连续波激光器带来了新一轮需求。

Japanese majors like Sumitomo Electric and Mitsubishi Electric also supply EMLs, but those are business units inside conglomerates and hard to classify as pure plays.
住友电气和三菱电机等日本大型企业也供应电吸收调制激光器，但这些业务隶属于集团内部，难以归类为纯业务板块。

2B Modulators. The device that rides data onto light. Silicon MZM is mainstream. TFLN and EO polymer are the challengers. Most of them get integrated into PICs (L4) or modules (L6), so very few trade as standalone names. LWLG’s EO polymer (L1) also hits this layer as a modulator material. Chinese TFLN modulator makers like Liobate and AFR have started volume production, but they are still early and mostly private.
2B 调制器。将数据加载到光上的设备。硅基马赫-曾德尔调制器是主流，薄膜铌酸锂和电光聚合物调制器是挑战者。它们大多被集成到光子集成电路（第四层）或模块（第六层）中，因此极少作为独立产品交易。LWLG 的电光聚合物（第一层）也作为调制器材料涉足这一层级。中国的薄膜铌酸锂调制器制造商如 Liobate 和 AFR 已开始量产，但仍处于早期阶段且多为非上市公司。

2C Photodetectors. The device that converts light back into an electrical signal. Almost all of them sit inside PICs, so there are no meaningful standalone names.
2C 光电探测器。将光转换回电信号的设备。它们几乎都内置于光子集成电路中，因此没有具有重要意义的独立产品。

This layer has the deepest technical moat. For lasers in particular, the supplier pool is narrow enough that pricing power moves directly with the supply-demand balance.
这一层级拥有最深厚的技术护城河。特别是激光器领域，供应商池足够狭窄，定价权直接随供需平衡而变动。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Layer 2 — Active Photonic Devices

Laser · Modulator · Photodetector — Deepest Technical Moat in the Value Chain

Company	Ticker	Device Focus	52W Return
Lumentum	[LITE]	2A: 200G EML leader, CW laser, NVIDIA $2B	+1,685%
Coherent	[COHR]	2A: CW/VCSEL/pump + PD, 2B: SiPh MZM	+562%
nLIGHT	[LASR]	2A: High-power laser, GaAs fab integrated	+896%
Sivers	[SIVE.ST]	2A: InP DFB, CPO ELS + LiDAR	+224%
IPG Photonics	[IPGP]	2A: Fiber laser #1, GaAs fab integrated	+141%
Yuanjie	[688498.SS]	2A: EML/DFB laser chip IDM, global #6	~+900%
QD Laser	[6613.T]	2A: Quantum dot laser, SiPh CW source	+364%
Sumitomo Electric	[5802.T]	2A: Laser + PD, substrate vertical	+71%
AAOI	[AAOI]	2A: In-house InP laser chip, module integrated	+1,486%
Aeluma	[ALMU]	2C: InGaAs SWIR PD + QD laser	+138%
MACOM	[MTSI]	2A: In-house InP DFB/FP + MZ modulator (EFT)	+190%
Semtech	[SMTC]	2A: InP gain chip + DFB (HieFo 2026.03)	+343%
Lightwave Logic	[LWLG]	2B: EO polymer modulator	+1,203%

Source: Company filings, industry checks | Damnang Investment Research | 2026-04-17

Layer 3: Electro-Optical Connectivity IC
第三层：光电连接集成电路

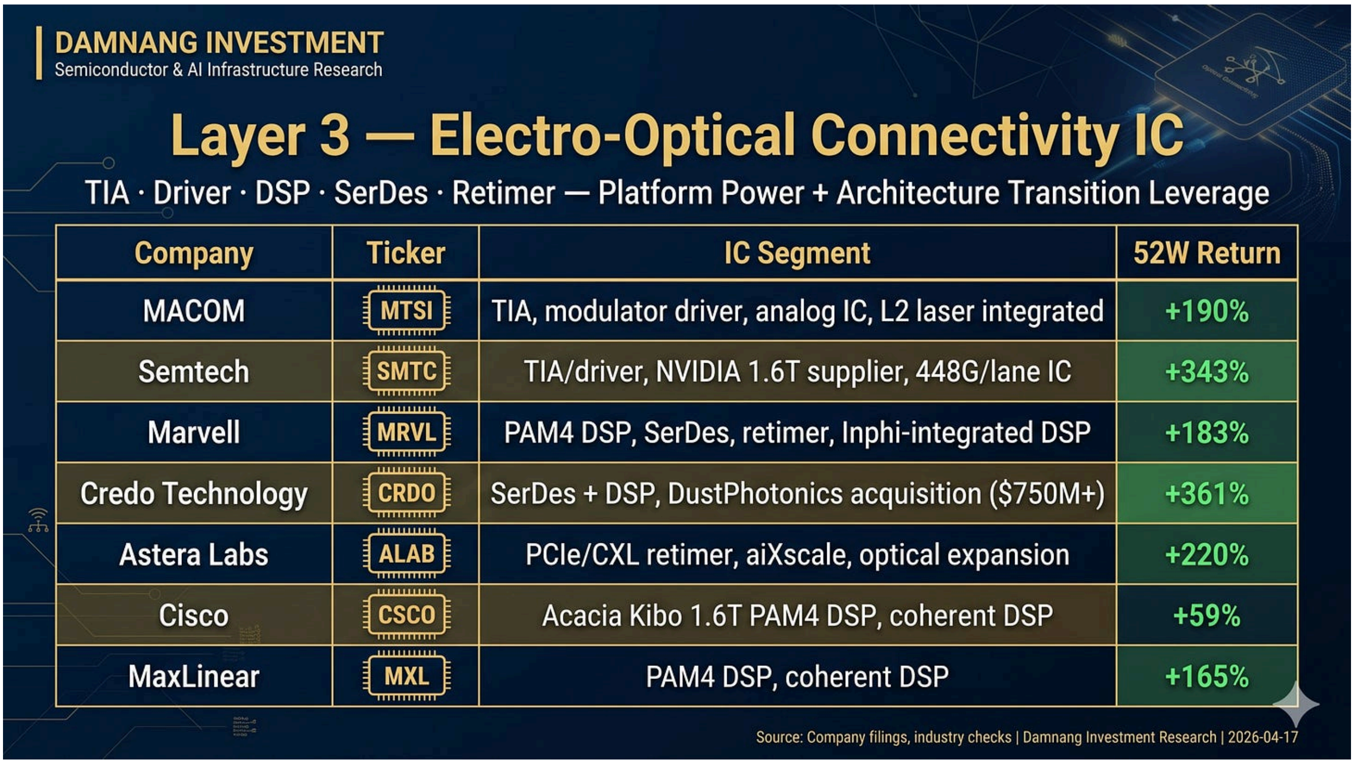
Electrical semiconductors that bridge the photonic devices (L2) and the digital system. TIAs, modulator drivers, DSPs, SerDes, and retimers all live here.
连接光子器件（第二层）与数字系统的电子半导体。跨阻放大器、调制器驱动器、数字信号处理器、串行器/解串器以及重定时器均属于此范畴。

These sit inside optical modules, but fundamentally they handle electrical signals, not light.
这些组件位于光模块内部，但从本质上处理的是电信号而非光信号。

The faster the line rate, the harder this IC becomes.
线速率越快，这款芯片的制造难度就越高。

Going from 400G to 800G to 1.6T, analog performance requirements explode, and the list of companies that can actually build these chips is short.

You can swap module vendors and still end up with the same company’s IC inside.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Layer 3 — Electro-Optical Connectivity IC

TIA · Driver · DSP · SerDes · Retimer — Platform Power + Architecture Transition Leverage

Company	Ticker	IC Segment	52W Return
MACOM	MTSI	TIA, modulator driver, analog IC, L2 laser integrated	+190%
Semtech	SMTC	TIA/driver, NVIDIA 1.6T supplier, 448G/lane IC	+343%
Marvell	MRVL	PAM4 DSP, SerDes, retimer, Inphi-integrated DSP	+183%
Credo Technology	CRDO	SerDes + DSP, DustPhotonics acquisition ($750M+)	+361%
Astera Labs	ALAB	PCIe/CXL retimer, aiXscale, optical expansion	+220%
Cisco	CSCO	Acacia Kibo 1.6T PAM4 DSP, coherent DSP	+59%
MaxLinear	MXL	PAM4 DSP, coherent DSP	+165%

Source: Company filings, industry checks | Damnang Investment Research | 2026-04-17

Layer 4: PIC Platform & IP

This is not just PIC design. It is the platform layer that includes optical integration IP, coupling technology, photonic fabric, and other forms of system-level photonics enablement.

The core story here is the **M&A war**.

Marvell bought Celestial AI.

Credo bought DustPhotonics.

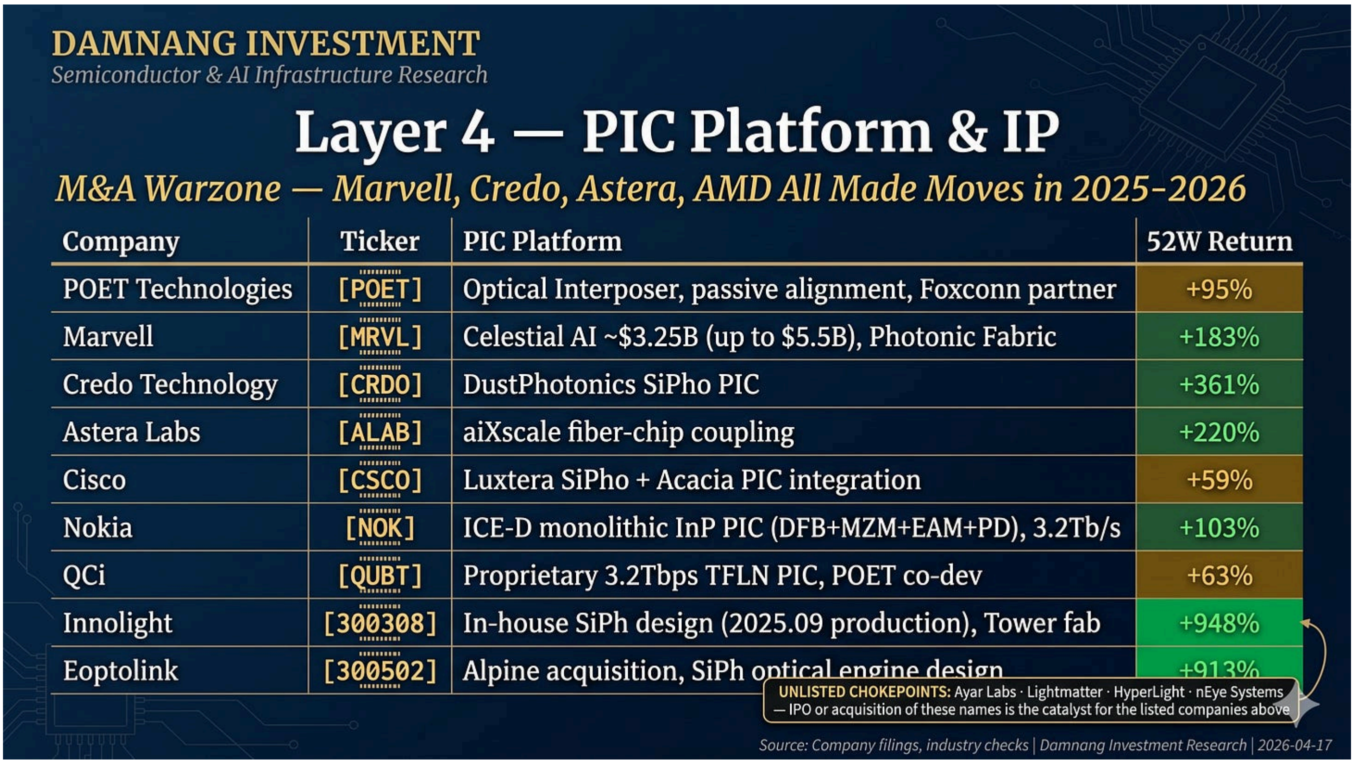
Astera Labs bought aiXscale.

AMD bought Enosemi.

All in 2025-2026. The pure-play optical PIC names that have not been acquired yet could be the next targets.

There are not many public pure plays in this layer, so the right lens right now is M&A premium.

> **Private chokepoints:** Ayar Labs, Lightmatter, HyperLight, nEye Systems. The IPOs or acquisitions of these companies will be the catalysts for the listed names.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Layer 4 — PIC Platform & IP

M&A Warzone — Marvell, Credo, Astera, AMD All Made Moves in 2025-2026

Company	Ticker	PIC Platform	52W Return
POET Technologies	[POET]	Optical Interposer, passive alignment, Foxconn partner	+95%
Marvell	[MRVL]	Celestial AI ~$3.25B (up to $5.5B), Photonic Fabric	+183%
Credo Technology	[CRDO]	DustPhotonics SiPho PIC	+361%
Astera Labs	[ALAB]	aiXscale fiber-chip coupling	+220%
Cisco	[CSCO]	Luxtera SiPho + Acacia PIC integration	+59%
Nokia	[NOK]	ICE-D monolithic InP PIC (DFB+MZM+EAM+PD), 3.2Tb/s	+103%
QCi	[QUBT]	Proprietary 3.2Tbps TFLN PIC, POET co-dev	+63%
Innolight	[300308]	In-house SiPh design (2025.09 production), Tower fab	+948%
Eoptolink	[300502]	Alpine acquisition, SiPh optical engine design	+913%

UNLISTED CHOKEPOINTS: Ayar Labs · Lightmatter · HyperLight · nEye Systems
— IPO or acquisition of these names is the catalyst for the listed companies above

Source: Company filings, industry checks | Damnang Investment Research | 2026-04-17

Layer 5: Foundry & Process Platform

The manufacturing layer that takes PIC and photonic-device wafer production on contract. SiPh demand has surged to the point where capacity has become the bottleneck.
承接光子集成电路和光子器件晶圆生产的制造层。硅光需求激增，产能已成为瓶颈。

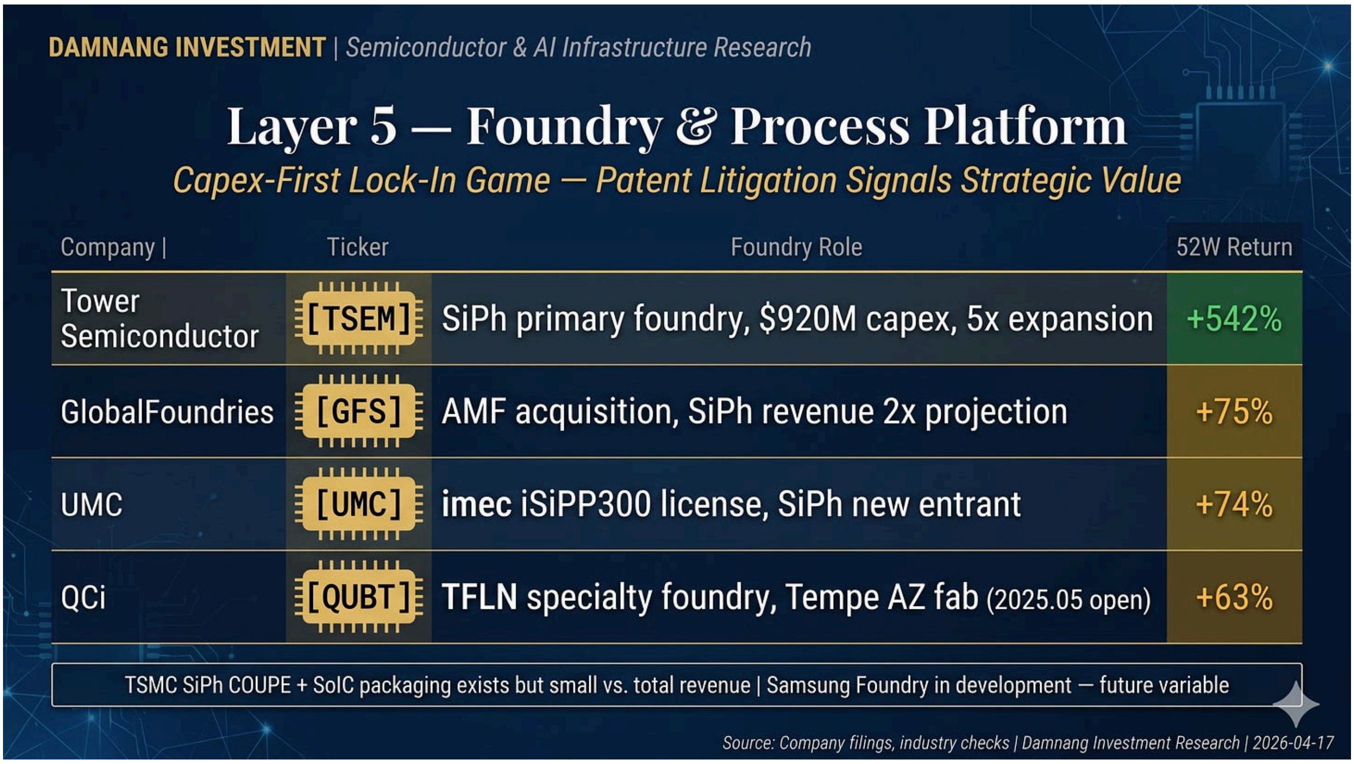
Tower Semiconductor is the main supplier. GlobalFoundries and UMC are pushing in.
Tower Semiconductor 是主要供应商。GlobalFoundries 和 UMC 正在积极布局。

TSMC also offers a SiPh COUPE platform and SoIC advanced packaging for CPO, but its revenue share is tiny relative to the total company, so it is hard to treat as a pure photonics play.
台积电也提供硅光子 COUPE 平台和用于 CPO 的 SoIC 先进封装技术，但其营收占公司总营收的比例微乎其微，因此很难将其视为纯粹的光子学业务。

Samsung Foundry is also developing SiPh processes, a variable that could reshape the competitive landscape of this layer down the road.
三星晶圆代工厂也在开发硅光子工艺，这一变量未来可能重塑该技术层的竞争格局。

On the specialty side, QCi operates the first U.S. TFLN-only foundry, in Tempe AZ.
在专业领域，QCi 在亚利桑那州坦佩市运营着美国首家仅专注于薄膜铌酸锂的晶圆厂。

The company that puts capex in first locks in customers. Strategic value is high enough that foundries are suing each other over patents.
率先投入资本支出的公司能够锁定客户。其战略价值之高，足以让代工厂商因专利问题相互提起诉讼。



Layer 6: Photonic Packaging, Optical Engine & Module

The layer that packages and assembles PIC die into final form. This is the highest-revenue-volume layer in the chain, and at the same time, architecture-transition positioning here will decide the next two to three years of returns.
将光子集成电路芯片封装组装成最终形态的环节。这是产业链中营收规模最大的环节，同时，此处的架构转型定位将决定未来两到三年的收益走向。

Layer 6-A: Optical Engine & Module
第六层-A：光引擎与光模块

Within this sub-layer, architecture is evolving, and that evolution is also the **investment timeline**.
在这一子层中，架构正在演进，而这种演进也构成了投资的时间线。

FRO (Fully Retimed Optics). Transceivers with integrated DSP plus retimer. Most optical module revenue right now comes out of this architecture.
FRO（全重定时光学器件）。集成 DSP 加重定时器的收发器。目前大多数光模块收入来源于这种架构。

LRO (Linear Retimed Optics). Retiming kept, DSP replaced with a linear driver. The middle step between FRO and LPO.
LRO（线性重定时光学器件）。保留重定时功能，用线性驱动器替代 DSP。这是 FRO 和 LPO 之间的中间步骤。

LPO (Linear Pluggable Optics). Retimer removed entirely. 30-50% power savings. L3 analog IC performance determines the module’s overall behavior.
LPO（线性可插拔光学器件）。完全移除重定时器。可节省 30-50%的功耗。L3 模拟集成电路的

性能决定了模块的整体行为。

NPO (Near-Packaged Optics). Optical engine placed on the switch board but still in a separate package.
NPO（近封装光学）。光引擎放置在交换机板上，但仍处于独立封装中。

CPO (Co-Packaged Optics). Optical engine 3D-bonded into the same package as the ASIC. Important, but right now this is a section where option value comes before revenue.
CPO（共封装光学器件）。将光引擎与 ASIC 三维堆叠封装在同一模块中。这很重要，但目前这个领域仍处于期权价值优先于实际营收的阶段。

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Layer 6-A — Optical Engine & Module

Largest Revenue Volume + Architecture Transition Defines 2–3yr Returns

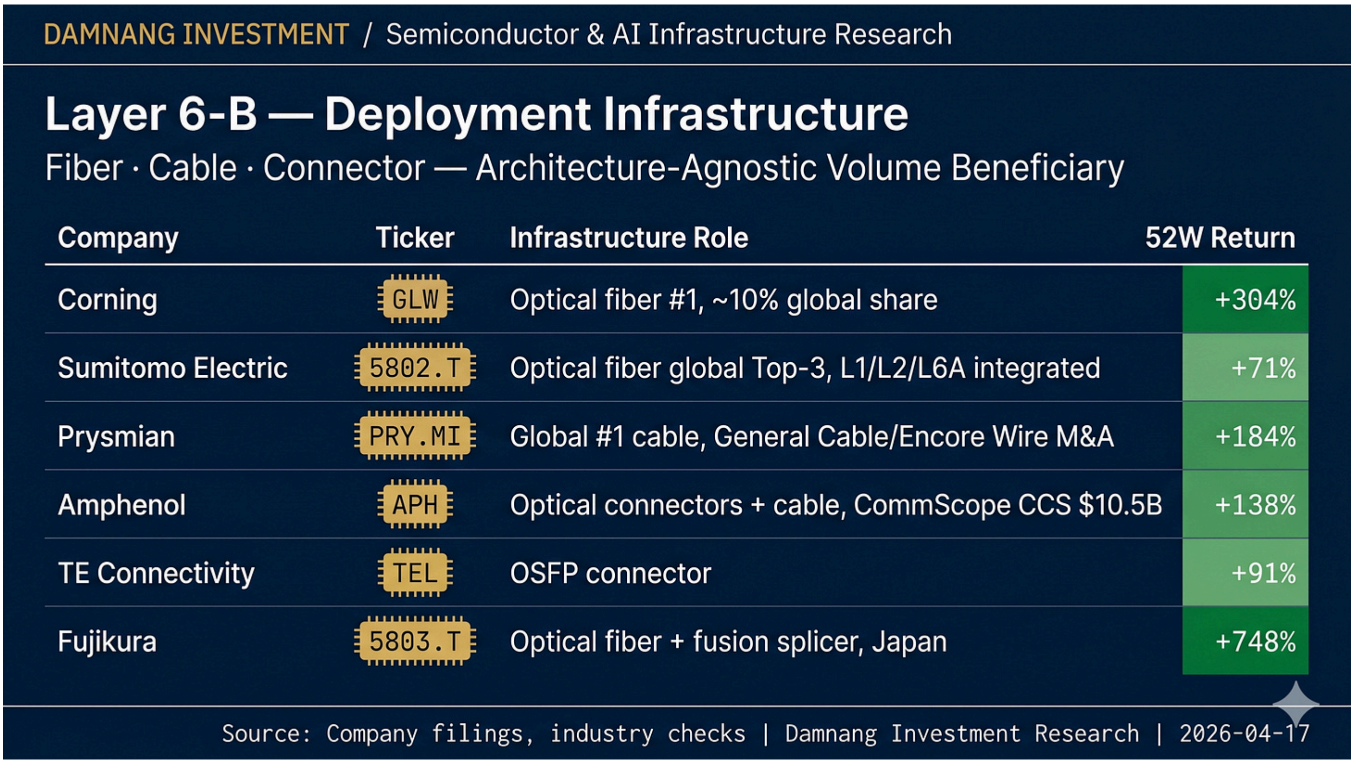
FRO (today) → LRO → LPO (2026–27) → NPO → CPO (2028–30)

Company	Ticker	Architecture	52W Return
Coherent	Ticker chip: [COHR]	FRO/LRO/LPO/CPO, vertically integrated	+562%
Lumentum	Ticker chip: [LITE]	FRO/LRO/LPO + CPO(ELS), integrated	+1,685%
AAOI	Ticker chip: [AAOI]	FRO + LPO, in-house InP laser, US manufacturing	+1,486%
Fabrinet	Ticker chip: [FN]	FRO EMS, architecture-agnostic manufacturing	+300%
Innolight	Ticker chip: [300308]	FRO/LPO, China #1, largest NVIDIA supplier	+948%
Eoptolink	Ticker chip: [300502]	FRO/LPO, ~20% NVIDIA 800G LPO share	+913%
Sumitomo Electric	Ticker chip: [5802.T]	FRO, Japan optical flagship	+71%
Nokia	Ticker chip: [NOK]	ICE-D 3.2Tb/s intra-DC, monolithic InP PIC	+103%
POET Technologies	Ticker chip: [POET]	Optical engine platform, CPO enabler	+95%
Ciena	Ticker chip: [CIEN]	NPO/CPO boundary, Vesta 200 6.4T CPX	+777%
Marvell	Ticker chip: [MRVL]	CPO, Photonic Fabric	+183%
Credo Technology	Ticker chip: [CRDO]	CPO/NPO, DustPhotonics SiPho, 3.2T roadmap	+361%
Cisco	Ticker chip: [CSCO]	800G/1.6T ZR pluggable, Acacia coherent	+59%

Source: Company filings, industry checks | Damnang Investment Research | 2026-04-17

Layer 6-B: Deployment Infrastructure
第六层-B：部署基础设施

The physical path light actually travels through. Optical fiber, cable, connectors. Whether the architecture is FRO or CPO, every transceiver shipped ships with fiber and connectors alongside. Architecture-agnostic beneficiaries.
光信号实际传输的物理路径。光纤、光缆、连接器。无论架构是 FRO 还是 CPO，每台出货的光模块都必然伴随光纤与连接器。这是不受架构影响的受益环节。



DAMNANG INVESTMENT / Semiconductor & AI Infrastructure Research

Layer 6-B — Deployment Infrastructure

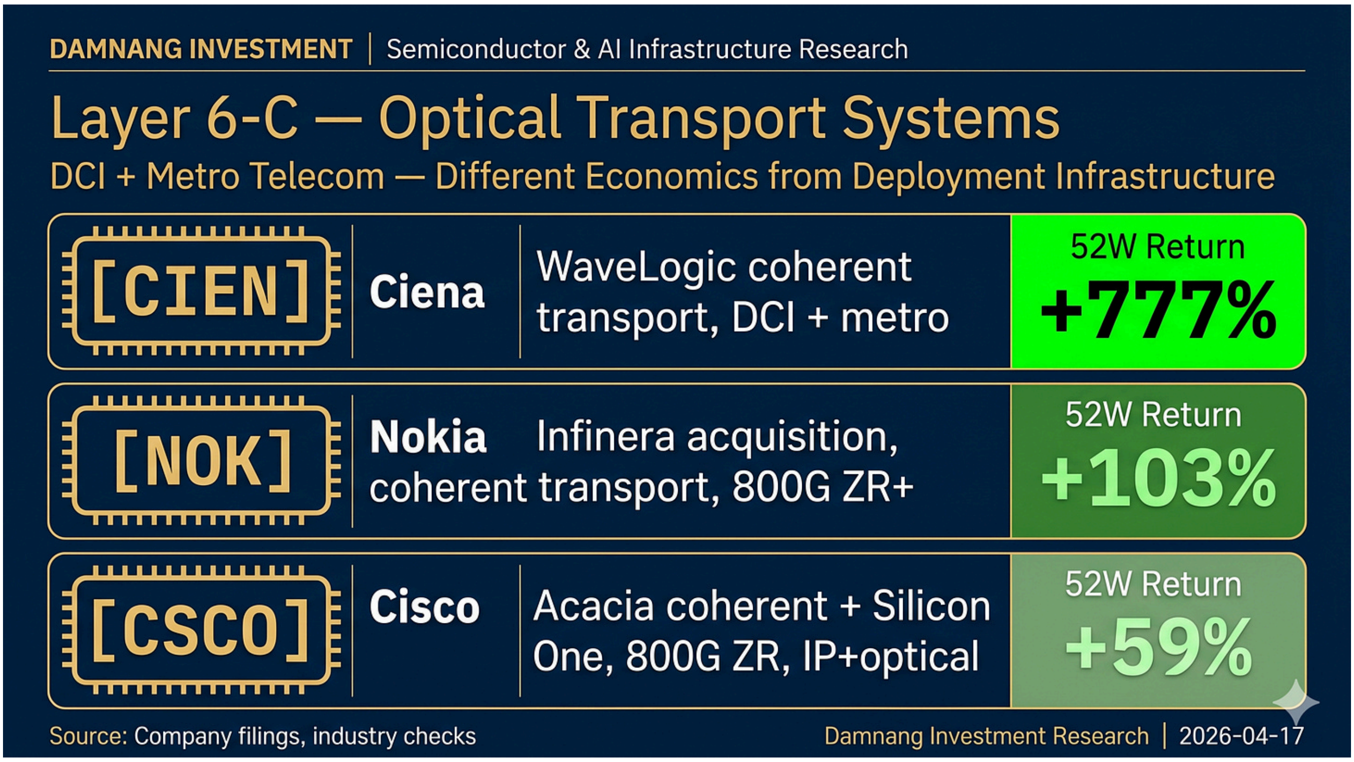
Fiber · Cable · Connector — Architecture-Agnostic Volume Beneficiary

Company	Ticker	Infrastructure Role	52W Return
Corning	GLW	Optical fiber #1, ~10% global share	+304%
Sumitomo Electric	5802.T	Optical fiber global Top-3, L1/L2/L6A integrated	+71%
Prysmian	PRY.MI	Global #1 cable, General Cable/Encore Wire M&A	+184%
Amphenol	APH	Optical connectors + cable, CommScope CCS $10.5B	+138%
TE Connectivity	TEL	OSFP connector	+91%
Fujikura	5803.T	Optical fiber + fusion splicer, Japan	+748%

Source: Company filings, industry checks | Damnang Investment Research | 2026-04-17

Layer 6-C: Optical Transport Systems
第六层-C：光传输系统

Long-haul data-center interconnect (DCI) and telecom metro network equipment. Different economics than deployment infra.
长途数据中心互联（DCI）和电信城域网设备。其经济模式与部署基础设施不同。



Layer 7: Test & Qualification
第七层：测试与认证

The layer that validates performance at every step: devices, modules, and systems. Test complexity ramps sharply with line rate. In the CPO era, wafer-level test and burn-in become even more important.
验证每一步性能的层级：器件、模块和系统。测试复杂度随线路速率急剧上升。在 CPO 时代，晶圆级测试和老化测试变得更为重要。

Whichever architecture wins, whichever transceiver company wins, the test gear is unavoidable. A structure that rides market growth without taking on technology risk.
无论哪种架构胜出，无论哪家光模块公司获胜，测试设备都是不可或缺的。这是一种既能乘市场增长之势，又无需承担技术风险的结构。

DAMNANG INVESTMENT
Semiconductor & AI Infrastructure Research

Layer 7 — Test & Qualification
Picks-and-Shovels Play — Rides Every Architecture Without Betting on One

Company	Ticker	Test Segment	52W Return
Keysight	[KEYS]	Optical test leader, 1.6T validation	+154%
Teradyne	[TER]	ATE top-tier, optical IC test	+445%
Advantest	[ATEYY / 6857]	ATE top-tier, HBM to optical IC expansion	+374%
Viavi	[VIAV]	Optical coating/filter + network test	+356%
FormFactor	[FORM]	Production-ready SiPh wafer test cell	+449%
Aehr Test	[AEHR]	SiPh WLBI wins (2026.03 announcement)	+954%
Cohu	[COHU]	Semiconductor test handler	+189%

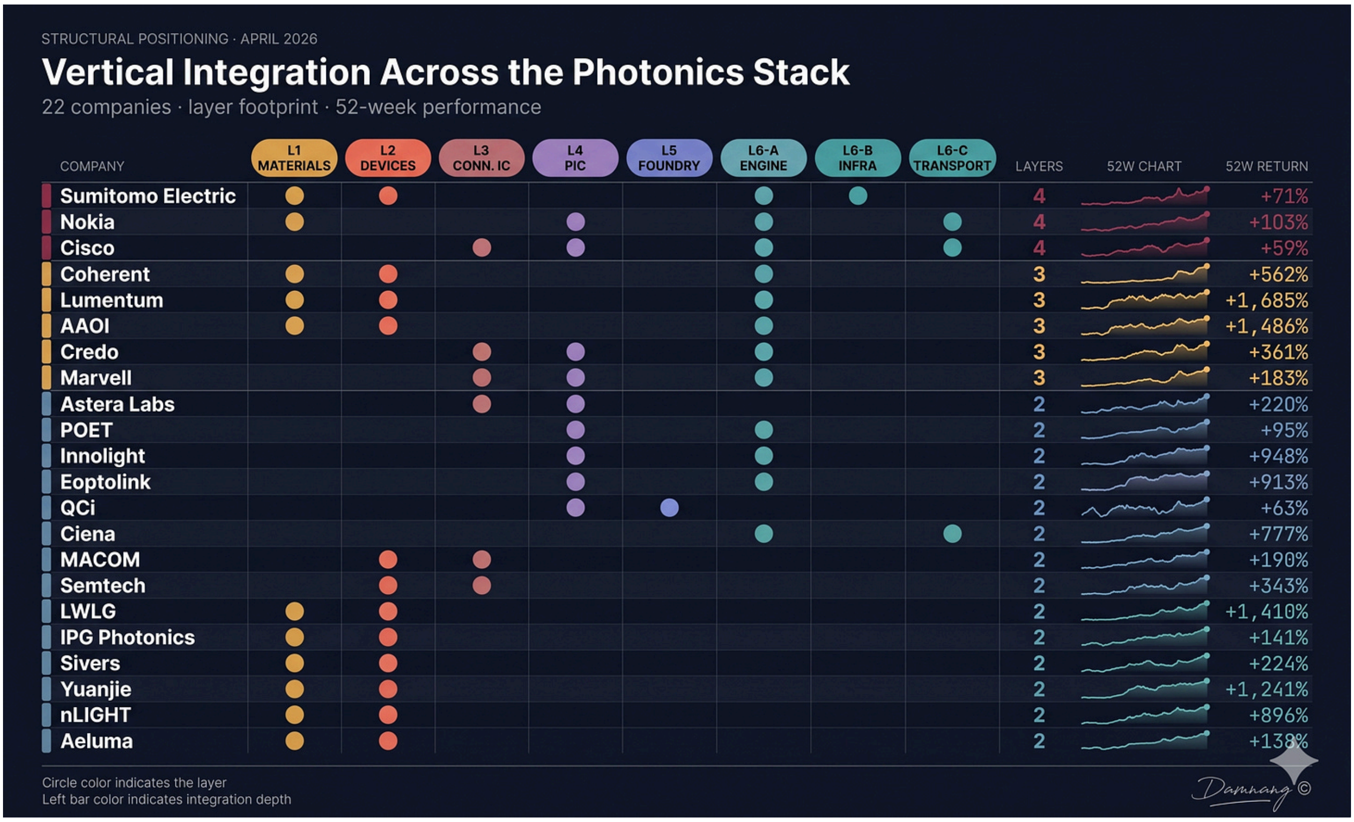
Source: Company filings, industry checks | Damnang Investment Research | 2026-04-17

Vertical Integration Cross-Reference
垂直整合交叉参考

This section collects the companies that span two or more layers.
本节汇集了横跨两个或多个业务层级的公司。

Vertical integration is a structural-moat indicator. Tying multiple layers inside a single company reduces upstream supply risk, stacks margins across layers, and deepens customer lock-in.
垂直整合是结构性护城河的指标。将多个环节整合于单一企业内部，能降低上游供应风险、叠加各环节利润并深化客户黏性。

That said, **vertical-integration depth does not automatically translate into stock performance.** In the current cycle, it's actually the opposite in places. I'll come back to that at the end of the section.
但垂直整合的深度并不直接等同于股价表现。在当前周期中，某些领域甚至呈现相反态势。我将在本节末尾再作阐述。



Positions count the dots in the matrix.

L6 gets counted as separate positions because the sub-layers (6A/6B/6C) are genuinely different businesses.

Directions of Vertical Integration

Vertical integration splits into several directions.

Upstream integration (L1 or L2 → L6).
上游整合（L1 或 L2 → L6）。

Starting from L1 materials or L2 devices and reaching down to L6 modules. Coherent, Lumentum, AAOI, and Sumitomo are the archetypes. Most are decades-old optical-communications natives.

Downstream integration (L3 → L4 → L6).

Starting from L3 ICs and expanding into L4 PIC and L6 modules through M&A. Cisco, Credo, and Marvell fit this. All relatively recent arrivals in optical communications.

Materials-devices integration (L1 + L2).
材料与器件集成（L1 + L2）。

The two core upstream layers only. IPG, Sivers, Yuanjie, nLIGHT, Aeluma, LWLG. The common thread is owning their own wafer fab.
仅包含两个核心上游层级。IPG、Sivers、源杰、nLIGHT、Aeluma、LWLG。共同点在于拥有自己的晶圆厂。

IC-laser integration (L2 + L3).
集成电路与激光器集成（L2 + L3）。

Analog IC companies that also own their own laser chip. MACOM and Semtech. A real differentiator in today's EML shortage.
同时拥有自身激光芯片的模拟集成电路公司。MACOM 和 Semtech。在当前 EML 短缺背景下，这是一个真正的差异化优势。

Middle integration (L4 + L6).
中游集成（L4 + L6）。

PIC design and module manufacturing bundled together. POET, Innolight, Eoptolink. Fab-lite plus in-house PIC design.
PIC 设计与模块制造捆绑。POET、Innolight、Eoptolink。轻晶圆厂加内部 PIC 设计。

Specialty integration. 专业集成。

QCi (L4 + L5, own PIC plus TFLN foundry). Ciena (L6-A + L6-C, engine plus transport).
QCi（L4 + L5，自有 PIC 加 TFLN 代工）。Ciena（L6-A + L6-C，引擎加传输）。

What we've done up to this point is the structural map of the optical value chain. 50 names, which layer they play in, which role they play, and how 22 vertically integrated companies connect across the map. But what investors actually want to know isn't the map. It's what comes next.
截至目前，我们所完成的是光电子产业链的结构图谱。50 家企业，它们所处的层级、扮演的角色，以及 22 家垂直整合企业如何在这张图谱中相互连接。但投资者真正想知道的并非图谱本身，而是接下来的走向。

- **The sector is already up more than +1,000%. Is it still investable?**
  该板块涨幅已超 1000%，是否仍具投资价值？
- **Which inning is this cycle in? Will this turn into the 2001 dotcom optical crash?**
  当前周期处于哪个阶段？这会演变成 2001 年互联网泡沫时期的光学产业崩盘吗？
- **Beyond the names already visible, who leads the next five years?**
  除了已显山露水的企业，未来五年将由谁引领风骚？

22 Companies in Detail 22 家公司详解

Walking through the 22 companies in the vertical integration matrix in order of integration depth. 4-position down to 3-position down to 2-position, then the special cases that fall outside the standard patterns at the end. Within the same depth, companies are grouped by integration direction (upstream vs downstream).

4-Position: Optical divisions inside large caps

Sumitomo, Nokia, and Cisco are all large caps with another core business that reached the deepest integration in optical. Structural moat is the largest, but photonics share is small, which means all three carry conglomerate discount.

Sumitomo Electric has the deepest vertical integration in the industry. Global leader in InP/GaAs/GaN compound semiconductor substrates (L1), in-house laser and photodetector (L2), optical transceiver modules (L6-A), and top-3 global optical fiber (L6-B). The parent, however, is a Japanese electrical conglomerate, and automotive wire harnesses account for more than half of revenue. Photonics is a minority division, which makes the pure-play approach hard.

Nokia runs depth comparable to Sumitomo's. The Infinera acquisition ($2.3B, closed Feb 2025) brought in the Sunnyvale InP wafer fab (L1), which is now expanding to 6-inch InP with an Aixtron G10-AsP MOCVD. Out of that fab, Nokia designs and manufactures the ICE-D monolithic InP PIC (L4), which integrates DFB laser, MZM, EAM, and photodiode onto a single chip. ICE-D is productized as the 3.2Tb/s intra-DC module (L6-A), and WaveLogic-based coherent transport (L6-C) ships separately as telecom gear. Nokia emphasizes its positioning as "the only vertically integrated Western optical vendor."

Cisco has similar vertical depth. The Acacia acquisition brought L3 (Kibo 1.6T DSP, coherent DSP) and L4 (Acacia SiPho PIC), and the Luxtera acquisition added another L4 SiPh platform. At L6-A, Cisco supplies 800G/1.6T ZR pluggables to hyperscalers. At L6-C, it sells Silicon One-based optical transport gear. Cisco is also an enterprise networking conglomerate, which keeps the optical share small.
思科具备类似的垂直整合深度。收购 Acacia 带来了 L3（Kibo 1.6T DSP、相干 DSP）和 L4（Acacia 硅光 PIC）技术，而收购 Luxtera 则增加了另一个 L4 硅光平台。在 L6-A 层面，思科向超大规模数据中心供应 800G/1.6T ZR 可插拔模块。在 L6-C 层面，它销售基于 Silicon One 的光传输设备。思科同时是企业网络巨头，这使得其光学业务占比较小。

3-Position Upstream: Optical Communications Natives

Coherent, Lumentum, and AAOI are decades-old optical-communications natives, all sharing the L1+L2+L6-A pattern. This group captured +560% to +1,685% returns in the current cycle.

Coherent runs InP wafer fabs in two locations: Sherman, Texas and Järfälla, Sweden. In 2024 it became the first in the world to secure a 6-inch InP wafer platform, and it received CHIPS Act support. 60 years of focus on a single field, lasers, gives it the deepest IP portfolio in the group.

Lumentum is moving the same direction. In March 2026, it acquired Qorvo's Greensboro, North Carolina fab for $18M and announced plans to manufacture 6-inch InP wafers in-house, targeted at CW laser and ultra-high-power laser applications with NVIDIA as a customer. Production ramp is expected in mid-2028. On 200G EML it holds what's effectively a near-monopoly supply position.

AAOI has a different structure from Innolight and Eoptolink. Those two are fab-lite, sourcing external InP lasers and assembling modules. AAOI runs its own MBE/MOCVD epitaxy fab (Sugar Land, Texas) and builds InP laser chips in-house. Most of the industry uses MOCVD only, but AAOI has a proprietary MBE process. Its U.S.-based production footprint is also a differentiator on policy risk.

3-Position Downstream: From IC to Optical

Credo and Marvell were originally IC companies (L3) that expanded through M&A into L4 PIC and L6-A modules. Downstream pattern. Astera Labs is following the same path but hasn't reached L6 yet.

Credo acquired DustPhotonics ($750M + stock/earnout) to bring SiPho PIC in-house, landing at L3+L4+L6-A across 3 layers. SerDes + DSP with a PIC layer on top gets them to a 3.2T roadmap. Optical track record is barely a year long.

Marvell runs the most aggressive optical M&A program. The Inphi acquisition ($10B, closed April 2021) internalized DSP; the Celestial AI acquisition (~$3.25B, up to $5.5B with contingents) added Photonic Fabric. Photonic Fabric targets 2027 production.
Marvell 执行着最激进的光学并购计划。收购 Inphi（100 亿美元，2021 年 4 月完成）实现了 DSP 内部化；收购 Celestial AI（约 32.5 亿美元，或有对价最高达 55 亿美元）则增添了光子架构技术。光子架构技术目标于 2027 年投入生产。

Astera Labs‘ core business is PCIe/CXL retimer, and the aiXscale acquisition gave it fiber-chip coupling. No L6 module product yet, so it sits at 2-position. Whether Astera enters L6 through the photonic scale-up roadmap becomes the next re-rating catalyst.
Astera Labs 的核心业务是 PCIe/CXL 重定时器，通过收购 aiXscale 获得了光纤-芯片耦合技术。目前尚无 L6 层模块产品，因此其定位属于 2 层。Astera 是否通过光子集成扩展路线进入 L6 层，将成为下一轮价值重估的催化剂。

2-Position: Fab-Lite Modules (POET / Innolight / Eoptolink)
2 层定位：轻晶圆厂模块（POET / 光迅科技 / 中际旭创）

Midstream integration combining L4 PIC design with L6-A module manufacturing. All three share a “fab-lite + in-house PIC design + module” structure.
中游整合，将 L4 级 PIC 设计与 L6-A 级模块制造相结合。三者均采用“轻晶圆厂+自研 PIC 设计+模块”的结构。

POET Technologies designs the Optical Interposer platform (L4) and productizes it as modules. Passive alignment is the core technology, and Foxconn is a partnership. The positioning play is CPO volume-production enabler.
POET Technologies 设计光学中介层平台（L4 级）并将其产品化为模块。被动对准是核心技术，富士康是其合作伙伴。其定位策略是成为 CPO 大规模生产的推动者。

Innolight is China's #1 module company. It publicly confirmed in-house SiPh chip mass production in September 2025. Actual fabrication runs on Tower Semi, but the design is in-house. Its position as NVIDIA's largest supplier is the core of the moat.
中际旭创是中国第一大模块公司。该公司公开确认将于 2025 年 9 月实现自研硅光芯片量产。实际制造由 Tower Semi 代工，但设计为自主研发。作为英伟达最大供应商的地位是其护城河的核心。

Eoptolink picked up SiPh optical engine design through the Alpine Optoelectronics acquisition. It unveiled 6.4T SiPh NPO at OFC 2026 and holds roughly 20% share in NVIDIA 800G LPO.
新易盛通过收购 Alpine Optoelectronics 获得了硅光引擎设计能力。该公司在 OFC 2026 上发布了 6.4T 硅光 NPO 产品，并在英伟达 800G LPO 市场中占据约 20%的份额。

2-Position: IC-Laser Integration (MACOM / Semtech)
2-定位：IC-激光器集成（MACOM / Semtech）

L2+L3 pattern where analog IC companies also secured in-house laser chips. With EML supply tight, this structure differentiates them on response time to module customers.
采用 L2+L3 模式，模拟 IC 公司同时掌握了内部激光器芯片技术。在 EML 供应紧张的情况下，这种结构使它们在响应模块客户需求时更具时效优势。

MACOM operates an in-house InP wafer fab (Etched Facet Technology, EFT), producing DFB/FP laser, photodiode, and MZ modulator directly, and sells them paired with TIA/driver ICs (L3). It has maintained this structure for more than a decade.
MACOM 运营着内部磷化铟晶圆厂（蚀刻面技术，EFT），直接生产 DFB/FP 激光器、光电二极管和 MZ 调制器，并将其与 TIA/驱动器 IC（L3）配对销售。这种结构已持续运营超过十年。

Semtech joined the same structure in March 2026 through the HieFo acquisition ($34M, Alhambra, California), bringing InP gain chip and DFB laser chip in-house. It also holds a parallel position as NVIDIA 1.6T IC supplier.
Semtech 于 2026 年 3 月通过收购 HieFo（3400 万美元，位于加利福尼亚州阿尔罕布拉）加入同一结构，将磷化铟增益芯片和 DFB 激光器芯片纳入内部生产。同时，它还作为英伟达 1.6T 集成电路供应商占据平行地位。

2-Position: Materials-Device Integration (IPG / Sivers / Yuanjie / nLIGHT / Aeluma / LWLG)
第二定位：材料-器件一体化（IPG / Sivers / 源杰科技 / nLIGHT / Aeluma / LWLG）

L1+L2 pattern. The first five hold the moat of owning their wafer fab, but none of them reach down to L6 modules. That leaves them without direct exposure to the module cycle, keeping them in the laser/device supplier position. LWLG joins the same position slot but at a pre-commercial stage, so it's grouped here structurally rather than commercially.
L1+L2 模式。前五家公司因拥有自己的晶圆厂而具备护城河，但均未向下延伸至 L6 模块层级。这使得它们无法直接参与模块周期，仍处于激光器/器件供应商的位置。LWLG 虽处于同一位置，但尚在商业化前阶段，因此从结构而非商业角度被归入此类。

IPG Photonics makes semiconductor lasers in its own GaAs wafer fab and draws optical fiber from its own fiber preform. The end market is industrial/defense, so it doesn't connect directly to data center L6-A.
IPG Photonics 在其自有的 GaAs 晶圆厂生产半导体激光器，并从其自有的光纤预制棒中拉制光纤。终端市场为工业/国防领域，因此不直接与数据中心 L6-A 连接。

Sivers runs the InP100 4-inch wafer fab through its Glasgow CST Global acquisition. Etched-facet DFB laser + on-wafer coating + testing all in-house. Its position as Ayar Labs SuperNova ELS supplier and POET co-development partner is a differentiated asset inside the CPO supply chain.
Sivers 通过收购格拉斯哥 CST Global 运营 InP100 4 英寸晶圆厂。蚀刻面 DFB 激光器+晶圆上镀膜+测试全部内部完成。作为 Ayar Labs SuperNova ELS 供应商和 POET 联合开发伙伴，其在 CPO 供应链中具有差异化优势。

Yuanjie runs an IDM model with MOCVD epitaxy fab and full InP DFB/EML laser chip production. It's the #6 laser chip supplier globally and #2 for SiPh laser chips. A rare position that can address both Chinese domestic and global supply.
源杰采用 IDM 模式，拥有 MOCVD 外延晶圆厂和完整的 InP DFB/EML 激光芯片生产能力。它是全球第六大激光芯片供应商，也是硅光激光芯片第二大供应商。这一独特地位使其能够同时满足中国国内和全球供应链需求。

nLIGHT officially frames its vertical integration as "semiconductor chips to full laser systems." High-power laser is the core product with a heavy defense share.
nLIGHT 将其垂直整合正式定义为"从半导体芯片到完整激光系统"。高功率激光器是其核心产品，国防领域占比较高。

Aeluma makes III-V-on-silicon 12-inch substrates together with InGaAs SWIR photodetectors and quantum dot lasers. The only player doing 12-inch III-V-on-Si, which makes the substrate platform itself a differentiated asset.
Aeluma 生产基于硅基的 12 英寸三五族化合物衬底，同时制造 InGaAs 短波红外光电探测器和量子点激光器。这是唯一一家生产 12 英寸硅基三五族化合物衬底的企业，这使得其衬底平台本身成为一项差异化资产。

LWLG sits in this group by structure but is a different kind of case: EO polymer functions as a material (L1) and as a modulator (L2) at the same time, so a single material spans two layers. Still pre-commercial (FY2025 revenue around $237K), which means this looks more like a technology demo than vertical integration. The position slot is L1+L2 on paper, but none of the commercial characteristics of the other five names here apply.
从结构上看，LWLG 属于这一类别，但属于不同类型：电光聚合物同时作为材料（L1 层）和调制器（L2 层）发挥作用，因此单一材料横跨两个层级。目前仍处于商业化前阶段（2025 财年收入约 23.7 万美元），这意味着这更像技术演示而非垂直整合。理论上其定位属于 L1+L2 层，但此处列出的其他五家企业的商业特征均不适用于该公司。

Special Cases (QCi / Ciena)

Two companies that fall outside the standard integration patterns.

QCi runs the unusual L4+L5 combination. The first TFLN-dedicated foundry in the U.S. (L5) opened in Tempe, Arizona in May 2025, and at the same time the company designs its own 3.2Tbps TFLN PIC (L4). In November 2025, QCi announced joint development of a 3.2Tbps optical engine with POET. Unlike Tower and GlobalFoundries, this is a structure where the foundry also does in-house PIC design. 2024 revenue under $0.4M, though, so story premium accounts for most of the valuation.

Ciena straddles two sub-layers inside L6: 6A (optical engine) and 6C (transport systems). Vesta 200 CPX is the engine product (6A); WaveLogic is the transport product (6C). No other layers are touched, which makes this strictly a vertical diversification case inside L6.

The Paradox of Vertical Integration: Depth and Returns Move Inversely

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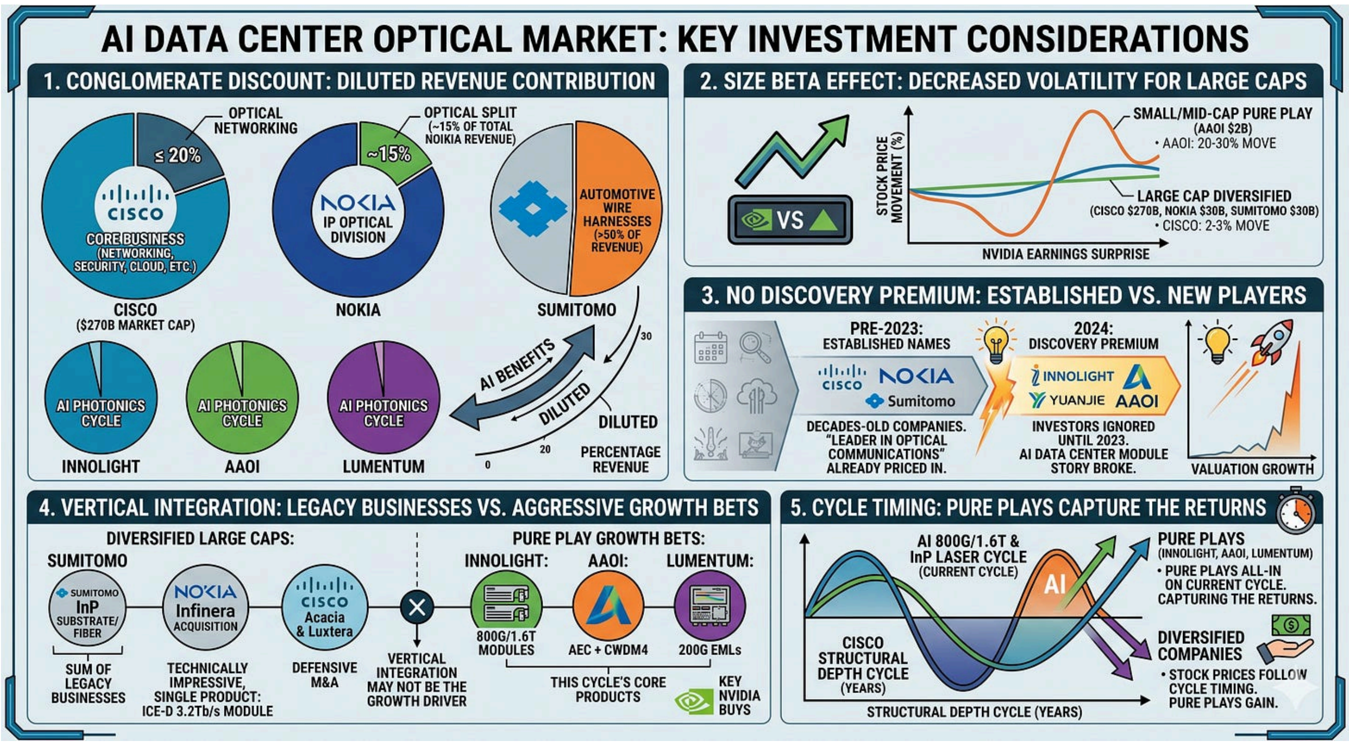
Look at the table above and one pattern jumps out: the deeper the vertical integration, the lower the stock return.

The 4-position group (Sumitomo/Nokia/Cisco) averages a 52-week return of **+78%**. These are the “most complete” companies, covering three layers and diversified inside L6, and yet they’ve returned the least.

The 3-position group (Coherent/Lumentum/AAOI/Credo/Marvell) averages **+855%**.

The 2-position pure play group averages more than +600%, and the top names (AAOI/Innolight/Eoptolink/Lumentum) sit at +900% to +1,700%.
纯光器件板块的平均涨幅超过+600%，头部企业（AAOI/中际旭创/新易盛/Lumentum）涨幅达+900%至+1,700%。

Five reasons drive this. 五大因素驱动此现象。



First, conglomerate discount. The 4-position names are all diversified large caps. Cisco has a market cap around $270B but optical networking is under 20% of revenue. Nokia's core is 5G wireless networks, with optical split into the Nokia IP Optical division at roughly 15% of the total. Sumitomo has automotive wire harnesses at more than half of revenue. The AI photonics cycle benefit gets diluted in the corporate-level numbers.
其一，集团折价效应。四家综合型企业均为多元化巨头。思科市值约 2700 亿美元，但光网络业务收入占比不足 20%。诺基亚核心业务是 5G 无线网络，其 IP 光网络部门仅占整体营收约 15%。住友电工超半数收入来自汽车线束业务。人工智能光子周期红利在企业整体财报中被稀释。

Second, the size beta effect. The 4-position names are all large caps. Cisco $270B, Nokia $30B, Sumitomo $30B. Unlike small-cap pure plays, their stocks don't move as violently. The same NVIDIA earnings surprise that sends AAOI ($2B) up 20–30% moves Cisco 2–3%.
其二，规模贝塔效应。四家企业均属大盘股：思科 2700 亿美元、诺基亚 300 亿美元、住友电工 300 亿美元。相较于小盘纯光器件股，其股价波动相对平缓。同样面对英伟达业绩超预期，AAOI（20 亿美元市值）可能暴涨 20-30%，而思科仅波动 2-3%。

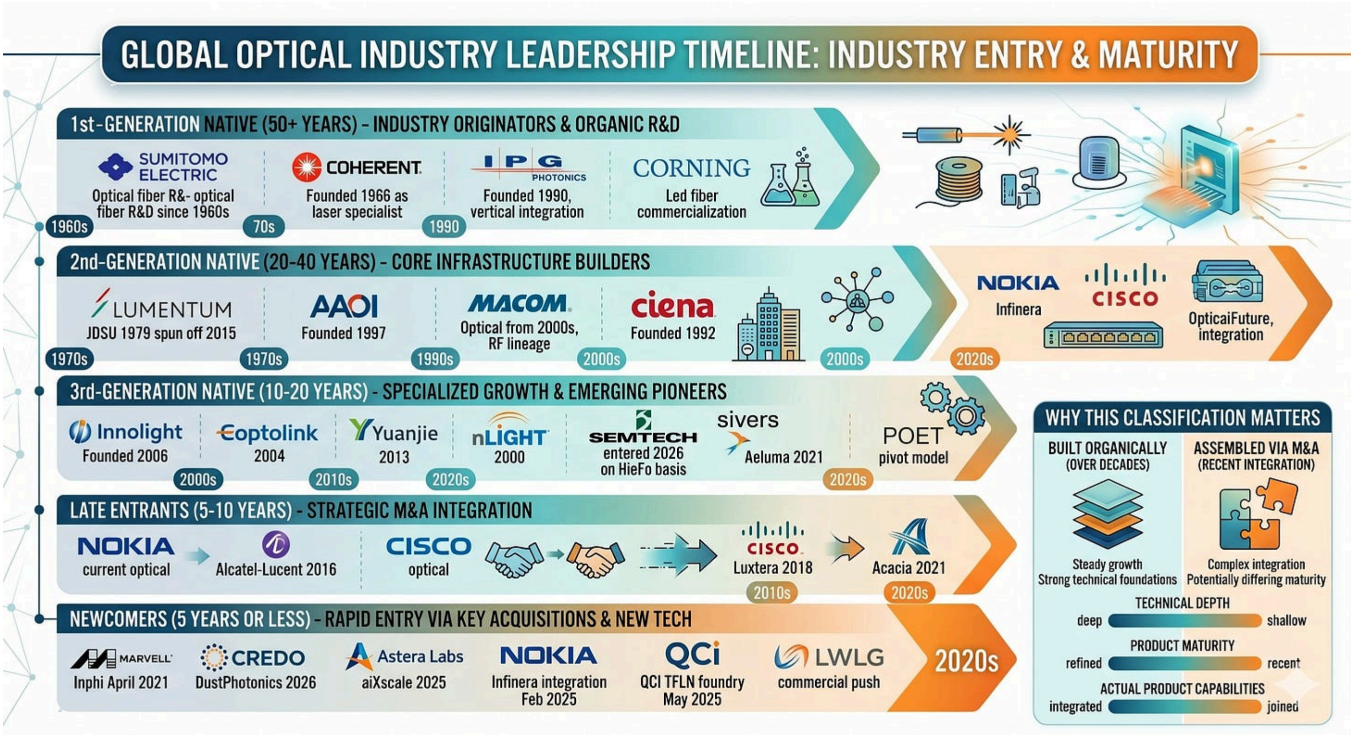
Third, no discovery premium. Cisco, Nokia, and Sumitomo are decades-old companies. "Leader in optical communications" is already priced in. Innolight, Yuanjie, and AAOI, on the other hand, were names most investors didn't bother with until 2023. The AI data center optical module story broke in 2024 and the discovery premium exploded.
第三，无发现溢价。思科、诺基亚和住友都是拥有数十年历史的公司。"光通信领导者"的地位早已被市场定价。而中际旭创、源杰科技和 AAOI，在 2023 年之前是大多数投资者根本不会关注的名字。AI 数据中心光模块的故事在 2024 年爆发，发现溢价随之飙升。

Fourth, vertical integration may not be the growth driver. This is the core point. Sumitomo's InP substrate business and fiber business are just the sum of decades-old legacy businesses. Nokia's Infinera acquisition is technically impressive, but the actual revenue contribution comes from a single product, the ICE-D 3.2Tb/s intra-DC module. Cisco's Acacia and Luxtera acquisitions were defensive M&A, not aggressive growth bets. Innolight, AAOI, and Lumentum, on the other hand, are companies that went all in on "this cycle's core product." Innolight's 800G/1.6T modules, AAOI's AEC + CWDM4, and Lumentum's 200G EMLs are exactly what NVIDIA is buying right now.
第四，垂直整合可能并非增长驱动力。这是核心观点。住友的磷化铟衬底业务和光纤业务只是数十年传统业务的简单叠加。诺基亚对英菲尼拉的收购在技术上令人印象深刻，但实际营收贡献仅来自单一产品——ICE-D 3.2Tb/s 数据中心内部模块。思科对 Acacia 和 Luxtera 的收购属于防御性并购，而非进取型增长押注。相比之下，中际旭创、AAOI 和 Lumentum 是全力押注"本轮周期核心产品"的企业。旭创的 800G/1.6T 模块、AAOI 的 AEC+CWDM4 方案以及 Lumentum 的 200G EML 激光器，正是英伟达当前采购的核心产品。

Fifth, cycle timing. Cisco's structural depth is overwhelmingly greater than Innolight's, but stock prices follow cycle timing. This cycle is 800G/1.6T modules and InP lasers, and the pure plays that went all in on that are capturing the returns.
第五，周期时机。思科的结构性深度远超旭创，但股价走势遵循周期节奏。本轮周期的主旋律是 800G/1.6T 模块与磷化铟激光器，那些全力押注该赛道的纯玩家正在收获周期红利。

Optical DNA: How long have they been in this business?
光学基因：企业在该领域积淀多久？

Just as important as the depth of integration is the question of when each company started doing optical. This determines product maturity and technical depth. Re-sort the 22 companies by when they entered optical and a different picture emerges.



1st-generation native (50+ years): Sumitomo Electric (optical fiber R&D since the 1960s), Coherent (founded 1966 as a laser specialist), IPG Photonics (founded 1990, originator of fiber laser vertical integration), Corning (led fiber commercialization in the 1970s).

2nd-generation native (20–40 years): Lumentum (JDSU 1979 → spun off 2015), AAOI (founded 1997), MACOM (1950s RF lineage, optical from the 2000s), Ciena (founded 1992).
第二代本土企业（20-40 年历史）：Lumentum（前身 JDSU 成立于 1979 年，2015 年分拆独立）、AAOI（成立于 1997 年）、MACOM（源自 1950 年代射频技术，2000 年代涉足光学领域）、Ciena（成立于 1992 年）。

3rd-generation native (10–20 years): Innolight (founded 2008), Eoptolink (2004), Yuanjie (2013), nLIGHT (2000), Semtech optical (entered 2026 on HieFo acquisition basis, but Semtech itself has long experience in module ICs), Sivers, Aeluma (2021), POET (older but with a current business model pivot).
第三代原生企业（10-20 年）：旭创科技（2008 年成立）、光迅科技（2004 年）、源杰科技（2013 年）、nLIGHT（2000 年）、Semtech 光通信部门（基于收购 HieFo 于 2026 年进入，但 Semtech 自身在模块集成电路领域经验丰富）、Sivers、Aeluma（2021 年）、POET（成立较早但当前正进行商业模式转型）。

Late entrants (5–10 years): Nokia's current optical business (Alcatel-Lucent acquisition 2016), Cisco's optical business (Luxtera 2018, Acacia 2021).
后期进入者（5-10 年）：诺基亚当前的光学业务（2016 年收购阿尔卡特朗讯），思科的光学业务（2018 年收购 Luxtera，2021 年收购 Acacia）。

Newcomers (5 years or less): Marvell (Inphi acquisition April 2021), Credo (DustPhotonics 2026), Astera Labs (aiXscale 2025), Nokia's Infinera integration (Feb 2025), QCi TFLN foundry (opened May 2025), LWLG's actual commercialization push.
新进者（5 年以内）：Marvell（2021 年 4 月收购 Inphi），Credo（2026 年收购 DustPhotonics），Astera Labs（2025 年收购 aiXscale），诺基亚整合 Infinera（2025 年 2 月），QCi TFLN 代工厂（2025 年 5 月开业），LWLG 的实际商业化推进。

Why this classification matters. A company that "assembled" vertical integration through M&A and one that "built" it organically over decades have different actual product capabilities.
为何这种分类至关重要。一家通过并购"拼凑"垂直整合的公司，与一家数十年间有机"构建"垂直整合的公司，其实际产品能力存在差异。

Cisco has 4-position integration at L3+L4+L6-A+L6-C, but the whole stack was stitched together from 2018 to 2021 M&A. There was no internal optical R&D organization; they brought in Luxtera and Acacia engineers. Integration takes time, and the technology roadmap is piecemeal. Nokia is similar. Infinera has only been part of the company for a year. Coherent has been doing optical for 60 years, Lumentum for 45, AAOI for 27. Same "L1+L2+L6-A" 3-position label, but the depth of technology is in a different league.
思科在 L3+L4+L6-A+L6-C 四个层级实现整合，但整个技术栈是在 2018 年至 2021 年间通过并购拼合而成。其内部没有光学研发组织，而是引入了 Luxtera 和 Acacia 的工程师。整合需要时间，技术路线图也显得零散。诺基亚情况类似。Infinera 并入公司仅一年时间。而 Coherent 深耕光学领域 60 年，Lumentum 有 45 年历史，AAOI 也已发展 27 年。虽然同样标注"L1+L2+L6-A"三个层级，但技术深度完全不在同一量级。

Credo and Astera Labs follow the same logic. Both are classified as L3+L4, but their optical track record is barely a year long. The DustPhotonics acquisition closes in 2026, and the aiXscale deal happened in 2025. For now, these are companies that "have acquired optical assets," not companies that "do optical." The DustPhotonics PIC share of Credo's revenue is still minimal.
Credo 和 Astera Labs 遵循相同逻辑。两者均被归类为 L3+L4 级别，但其光通信业务记录仅约一年。DustPhotonics 收购将于 2026 年完成，而 aiXscale 交易发生在 2025 年。目前，这些公司属于"已收购光通信资产"的企业，而非"从事光通信业务"的企业。DustPhotonics 的 PIC 业务在 Credo 营收中占比仍微乎其微。

Marvell is in the same category. Inphi acquisition (April 2021, $10B) brought in optical DSP; Celestial AI acquisition (2025, Photonic Fabric) added L4. A 5-year optical company, in effect. The parent Marvell is still a storage/networking IC company, and optical is a minority.
Marvell 属于同一类别。Inphi 收购（2021 年 4 月，100 亿美元）带来了光 DSP 技术；Celestial AI 收购（2025 年，光子结构）则补充了 L4 层级。实际上，这是一家拥有五年光学业务的公司。母公司 Marvell 本质上仍是存储/网络集成电路企业，光学业务占比较小。

Investment Lens: Structural Moat vs Stock Returns
投资视角：结构性护城河与股票回报

The conclusion: vertical integration is a “structural quality” indicator, not a “stock performance” indicator.
结论：垂直整合是“结构性质量”指标，而非“股票表现”指标。

The two are actually inversely correlated.
两者实际上呈负相关。

Strengths of deeply integrated companies:
深度整合型企业的优势：

- Resilient to supply shocks. Lower dependence on external wafers and lasers.
  抵御供应冲击能力强。对外部晶圆和激光器的依赖度较低。
- Stable long-term margins. Intermediate margins are internalized.
  稳定的长期利润率。中期利润率已内部化。
- Accumulated R&D assets. 积累的研发资产。
- Hard to be an M&A target (large, complex).

Weaknesses of deeply integrated companies:

- Valuation multiples are lower due to conglomerate discount.
- Pure-play growth gets diluted by diversified businesses.
- Limited re-rating headroom (already well-known names).
  有限的重新评级空间（已是众所周知的名字）。
- Size beta is low, so they move less in a cycle rally.
  规模贝塔值较低，因此在周期反弹中波动较小。

What made money in this cycle was focused pure plays.
本轮周期中赚钱的是专注单一赛道的纯粹玩家。

Innolight went all in on 800G modules. AAOI focused on DCI and AEC.
Innolight 全力押注 800G 模块。AAOI 专注于 DCI 和 AEC。

Lumentum focused on EML lasers.
Lumentum 专注于 EML 激光器。

Paradoxically, Cisco has a much deeper structural moat than Innolight, but Innolight’s stock has outperformed by more than 20x.
矛盾的是，尽管思科的结构性护城河远比中际旭创深厚，但中际旭创的股价表现却超出前者 20 倍以上。

My take: there are two points in the 2026–2027 cycle where this dynamic could flip.
我的观点是：在 2026 至 2027 年的周期中，有两个时间点可能引发市场格局的转变。

First, once CPO adoption gets real, vertical integration's edge comes back. CPO isn't a single-module product; it's a systems integration game, which favors full-stack players like Cisco, Nokia, and Sumitomo.
首先，一旦 CPO 技术真正得到应用，垂直整合的优势将重新显现。CPO 并非单一模块产品，而是一场系统集成的博弈，这更有利于思科、诺基亚和住友这类全栈型厂商。

Second, if the pure plays fail to transition to the next cycle product, their current premium bleeds out.
其次，如果纯玩家未能过渡到下一代产品周期，其当前溢价将逐渐流失。

If AAOI can't secure the next product after 800G and 1.6T, multiple contraction follows. This is a call that needs to be made on roadmap signals, not on reported financials.
若 AAOI 在 800G 和 1.6T 之后未能锁定下一代产品，估值倍数将面临收缩。这一判断需基于技术路线图信号作出，而非已公布的财务数据。

Cycle Diagnosis: Is it still investable?
周期诊断：是否仍具投资价值？

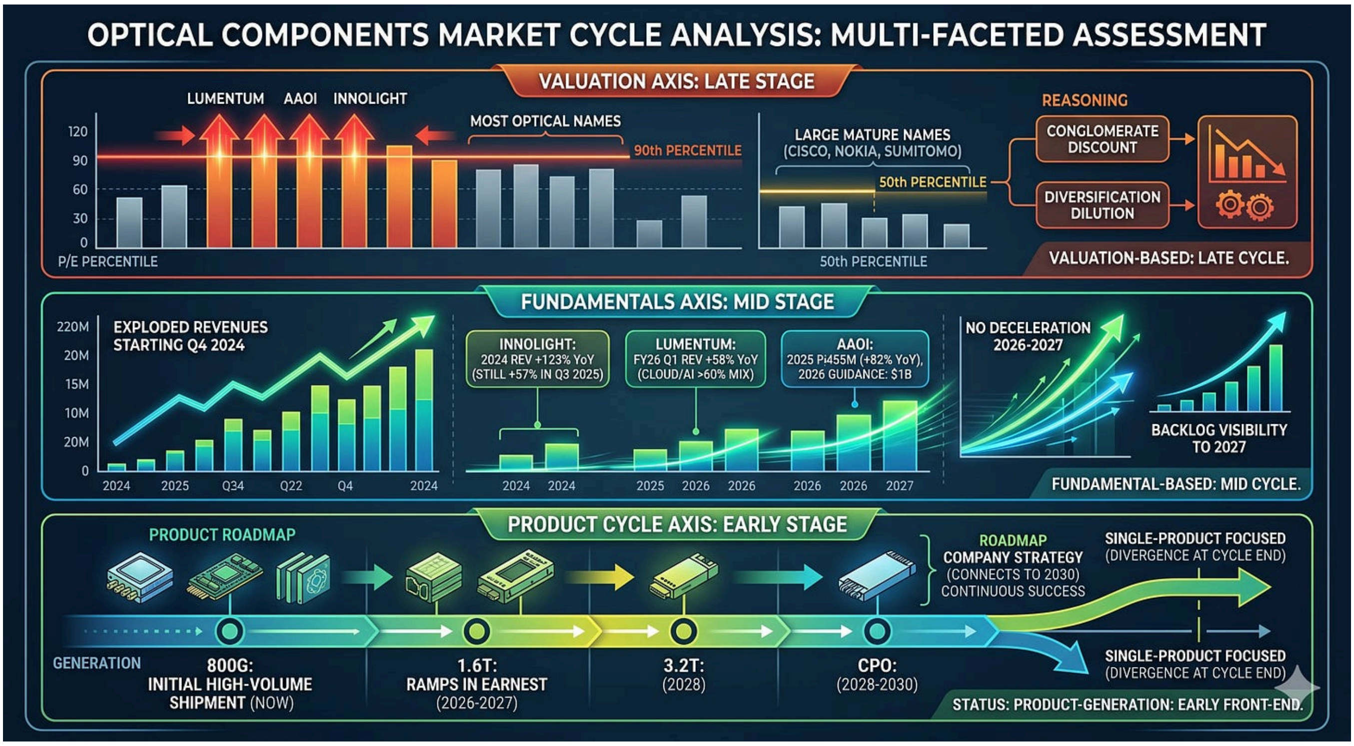
I think this is the section most readers will care about. Optical-related names have run up to +1,700% in a year. People thinking about entering are wondering "am I too late." People already in are wondering "should I get out."
我认为这是大多数读者最关心的部分。光模块相关标的在一年内涨幅高达+1700%。考虑入场的人在想"我是不是来晚了"，已经入场的人则在纠结"该不该离场"。

Straight to the point:　直入主题：

Valuation is Late, Fundamentals are Mid, Product cycle is Early.
估值已处高位，基本面处于中期，产品周期尚在早期。

Every name has a different combination of these three axes. Judging "the sector" on an average number will mislead you.
每个标的在这三个维度上的组合各不相同。仅凭平均数值来判断"行业"会误导你的判断。

The 3-Axis Diagnosis of This Cycle
本轮周期的三维诊断



Valuation axis: Late stage
估值轴：后期阶段

Forward P/E for most optical names sits above the 80th percentile of their own 10-year histogram. Lumentum, AAOI, and Innolight are above the 90th. On valuation alone, this is late cycle. That said, the large mature names (Cisco, Nokia, Sumitomo) are still around the 50th percentile. They trade below the cycle average because of conglomerate discount and diversification dilution.
大多数光通信企业的远期市盈率已超过自身十年历史分布的 80 百分位。其中 Lumentum、AAOI 和 Innolight 更是突破 90 百分位线。仅从估值角度看，当前已处于周期高位阶段。不过值得注意的是，大型成熟企业（思科、诺基亚、住友电工）的估值仍徘徊在 50 百分位附近。这些企业因集团折价效应与业务多元化稀释，其交易估值低于行业周期平均水平。

Fundamentals axis: Mid stage
基本面轴：中期阶段

Optical revenues actually exploded starting in Q4 2024 through 2025.
光通信行业收入实际上从 2024 年第四季度开始至 2025 年呈现爆发式增长。

Innolight 2024 revenue +123% YoY (with +57% still running into Q3 2025).
中际旭创 2024 年营收同比增长 123%（截至 2025 年第三季度仍保持 57%的同比增长）。

Lumentum FY26 Q1 revenue +58% YoY with cloud/AI expanding to 60%+ of the mix.
Lumentum 2026 财年第一季度营收同比增长 58%，云/人工智能业务占比扩大至 60%以上。

AAOI 2025 full-year revenue +82% YoY to $455M, with 2026 guidance at $1B.
AAOI 公司 2025 年全年营收同比增长 82%至 4.55 亿美元，2026 年营收指引达到 10 亿美元。

The numbers are still accelerating. No deceleration signal has appeared for 2026–2027 growth rates. Backlog visibility runs into 2027.
数字仍在加速增长。2026-2027 年的增长率尚未出现减速信号。积压订单可见性已延伸至 2027 年。

Product cycle axis: Early stage
产品周期坐标：早期阶段

The main product is the 800G module. It's only just starting high-volume shipment. 1.6T ramps in earnest in 2026–2027, 3.2T in 2028, CPO in 2028–2030.
主要产品是 800G 光模块。目前刚进入大规模出货阶段。1.6T 产品将在 2026-2027 年正式放量，3.2T 于 2028 年推出，CPO 技术预计在 2028-2030 年间实现商用。

In product-generation terms, we're fully at the front end. Even if 800G peaks, transition to 1.6T should happen naturally. This is conditional on having a roadmap, though. Companies with a roadmap out to 2030 and companies that went all in on 800G will diverge at cycle end.
在产品周期方面，我们完全处于前端阶段。即使 800G 达到顶峰，向 1.6T 的过渡也应是自然发生的。但这取决于是否有明确的技术路线图。拥有 2030 年前路线图的企业与全力押注 800G 的企业，将在周期结束时出现分化。

Mapping the three axes by name changes the investment calculus. Putting all 22 companies into a single table:
通过更名来映射三大轴心，改变了投资的计算方式。将所有 22 家公司整合到一个表格中：

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Cycle Diagnosis Matrix — Where Every Optical Stock Sits on 3 Axes

Company		Valuation	Fundamental	Product Cycle	Read
Lumentum	LUM	Late (85th)	Mid	Early-to-Mid	Sustains through late cycle
Coherent	CHH	Late (80th)	Mid	Early-to-Mid	Sustains through late cycle
Marvell	MAR	Mid (70th)	Early	Early	Late-cycle re-rating potential
Credo	CRO	Late (80th)	Mid	Early-to-Mid	PIC integration not yet priced in
AAOI	AAI	Late (95th)	Mid	Early	Strong mid-cycle, fragile late
Innolight	INN	Late (90th+)	Mid	Early	Strong mid-cycle, fragile late
Eoptolink	EPO	Late (90th+)	Mid	Early	Stronger 6.4T roadmap than AAOI
Yuanjie	YUA	Late (90th+)	Mid	Early	AAOI-like, China domestic hedge
nLIGHT	ITH	Late (85-90th)	Mid	Early	Defense cycle, indirect AI exposure
Cisco	CIC	Early (40th)	Early	Mid	CPO transition re-rating candidate
Nokia	NOK	Mid (55-65th)	Mid	Mid	CPO transition re-rating candidate
Sumitomo	SUM	Mid (50-60th)	Mid	Mid	Conglomerate discount persists
Ciena	CIN	Late (80th)	Mid	Early	Early Vesta 200 ramp
Astera Labs	BSC	Late (85-90th)	Early	Early	L6 entry is the catalyst
Semtech	75H	Mid-Late (75th)	Early	Early	HieFo integration early stage
Sivers	SVR	Late (85-90th)	Early	Early-to-Mid	CPO ramp beneficiary candidate
LWLG	N/A	N/A	Pre-cycle	Very Early	Outside normal cycle framework
QCi	N/A	N/A	Pre-cycle	Very Early	Outside normal cycle framework
Aeluma	NLU	Late (90th+)	Pre-commercial	Very Early	Tech validation stage
POET	RET	Late (90th+)	Pre-commercial	Very Early	Story premium driven
MACOM	MAC	Mid (65-75th)	Mid	Mid-to-Late	Stable growth, limited upside
IPG Photonics	IPG	Mid (50-60th)	Late	Mature	Industrial cycle mature, weak AI

Valuation percentile estimated from each stock's 10-year Forward P/E histogram. Pre-revenue names marked N/A.

Group A — Quality Leader
Sustains through late cycle

Lumentum, Coherent, Marvell, Credo

Valuation already elevated but Product Cycle sits at Early-to-Mid with roadmap visibility into 1.6T and CPO. Likely leaders in the next cycle transition.

Group B — Max Upside, Late Risk
Strong now, fragile later

AAOI, Innolight, Yuanjie, nLIGHT

Fundamental Mid + Product Early, 800G revenue exploding but next-gen roadmap thinner than Group A. Post-1.6T visibility is both catalyst and risk. Eoptolink is more durable within the group thanks to 6.4T NPO roadmap.

Group C — Re-rating Candidates
Underappreciated quality

Cisco, Nokia, Sumitomo

Valuation Mid/Early + Fundamental Mid. Pressed by conglomerate discount but could re-rate as full-stack plays when CPO transition accelerates. Marvell partially shares this character from a pure-play angle.

Group D — Early Integration
Waiting for catalyst

Astera Labs, Semtech, Sivers

Acquired photonics assets in the last 1-2 years but revenue impact still minimal. Re-rating catalyst lands when integration completeness is proven.

Group E — Outside Normal Cycle
Story-driven, size limit required

LWLG, QCi, Aeluma, POET

Pre-commercial or Very Early. Stock price driven by narrative and tech validation rather than fundamentals. Position sizing discipline matters most here.

Group F — Mature, Limited AI Exposure
Outside this photonics wave

IPG Photonics, MACOM

Already in mature product cycle with limited direct AI datacenter exposure. Dependent on industrial laser / telecom cycles, so this AI photonics cycle offers constrained elasticity.

Source: Company filings, LightCounting, Yole, Dell'Oro, industry checks | Damnang Investment Research | 2026-04-17

Traps to Avoid When Entering Now
当前入市需规避的认知陷阱

Trap 1: “Up a lot, so expensive” as a simple read.
陷阱一：将"涨幅大=估值高"简单挂钩

Stock returns are a composite of earnings, multiple, and theme, so the return alone can’t diagnose overvaluation. Marvell is up +183% and still at a 70th-percentile P/E. Cisco is up +59% and still in a cheap zone.
股票回报是盈利、估值倍数和主题的综合体现，仅凭涨幅无法判断是否高估。Marvell 上涨 183%后市盈率仍处于 70 分位，Cisco 上涨 59%后仍处估值洼地。

Trap 2: “Up less, so cheap” as a simple read.
陷阱二：将"涨幅小=估值低"简单挂钩

Cisco, Nokia, and Sumitomo are up less for structural reasons, mostly diversification dilution. Without a clear optical-transition catalyst, this discount persists.
思科、诺基亚和住友电工因结构性因素涨幅有限，主因业务多元化稀释光学业务权重。在缺乏明确的光学转型催化剂前，估值折价将持续存在。

Trap 3: Entering at a 52-week high.
陷阱三：在 52 周高点入场。

Optical names have high fundamental beta, so corrections tend to be 20–40%. Pure plays like Innolight, AAOI, and Eoptolink can gap down 20% on a single hyperscaler capex guidance print. If you’re entering, scale in gradually and wait for corrections.
光模块板块具有较高的基本面贝塔值，因此回调幅度通常在 20%-40%区间。如中际旭创、AAOI、新易盛等纯正标的，单次超大规模资本开支指引公布就可能引发 20%的跳空下跌。若计划建仓，建议分批入场并等待回调时机。

Trap 4: Names running on narrative without fundamentals.
陷阱四：依赖叙事炒作而缺乏基本面支撑的概念股。

LWLG and QCi move on story, not earnings. When the theme cools, those names drop more than 50%. Position size has to stay limited.
LWLG 和 QCi 的股价走势取决于题材而非业绩。当市场热点降温时，这类股票跌幅常超 50%。持仓规模必须严格控制。

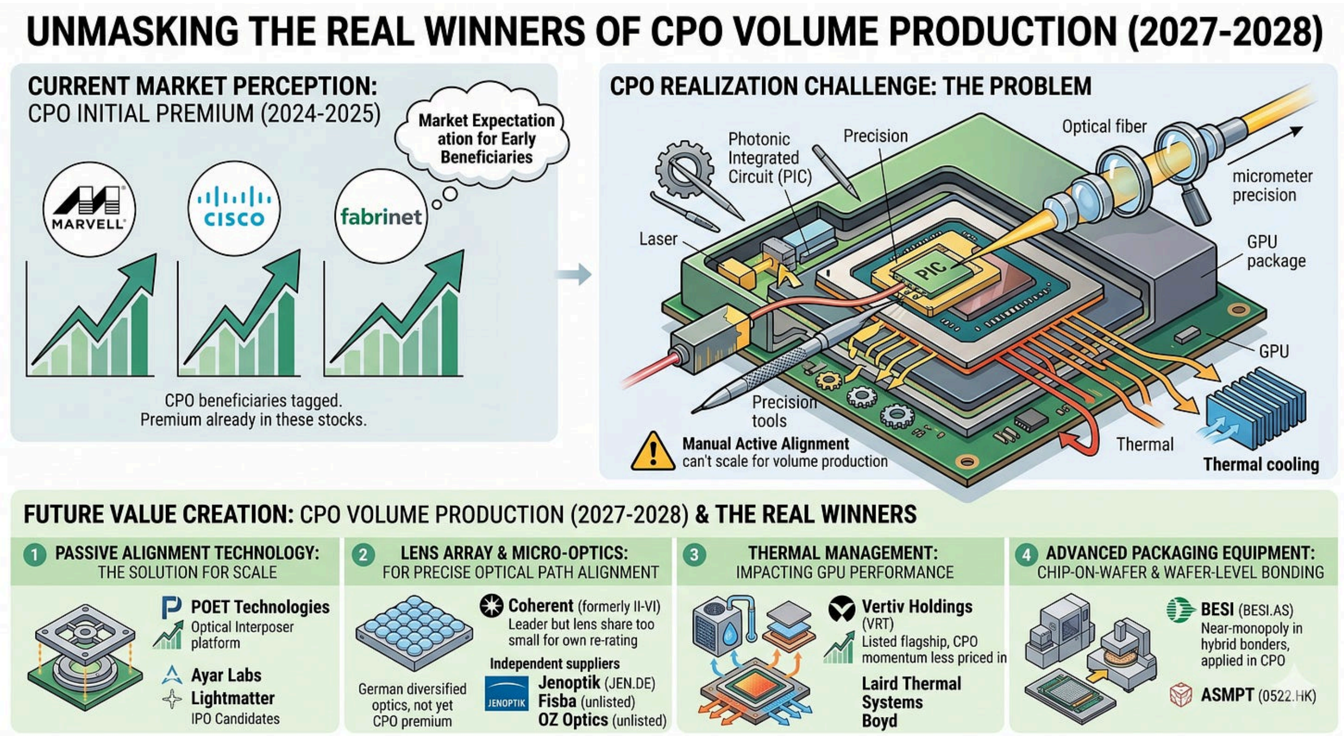
Game-Changers for the Next Five Years
未来五年的行业变革者

Current optical names ran on the 800G module ramp story. But returns over the next five years are more likely to come from places that aren’t yet in focus. Following on to names already up +1,000% gives you less asymmetry than finding the next wave’s game-changers in places where the theme premium hasn’t yet been priced in.

当前的光学概念股主要围绕 800G 模块升级的故事展开。但未来五年的投资回报更可能来自尚未被市场充分关注的领域。追逐那些已经上涨超过 1000%的标的，其不对称性收益空间远不如在主题溢价尚未被充分定价的领域寻找下一轮变革者。

Five directions are visible.
可见五个发展方向。

1. The real beneficiaries of CPO adoption
1. CPO 技术应用的真实受益者



The current names tagged as CPO beneficiaries are Marvell, Cisco, and Fabrinet. The CPO premium is already in those stocks. But CPO actually enters volume production in 2027–2028. The real winners at that point are likely to come from component and process companies that aren't getting attention right now.
目前被视为 CPO 受益者的公司包括 Marvell、Cisco 和 Fabrinet。这些股票的 CPO 溢价已经体现。但 CPO 实际量产要等到 2027-2028 年。届时真正的赢家很可能来自当前未被关注的组件和工艺公司。

Passive alignment technology. CPO requires aligning laser, PIC, and fiber with micrometer precision. Manual active alignment can't scale for CPO volume. Whoever solves this problem is whoever actually makes CPO real. Among listed names, POET Technologies implements passive alignment through the Optical Interposer platform. Ayar Labs and Lightmatter are unlisted but IPO candidates. One more to watch is Fabrinet, which is the most likely candidate for fiber attach and module assembly in NVIDIA CPO production.
被动对准技术。CPO 需要将激光器、PIC 和光纤以微米级精度对准。手动主动对准无法满足 CPO 的量产需求。谁能解决这个问题，谁才能真正实现 CPO。在上市公司中，POET

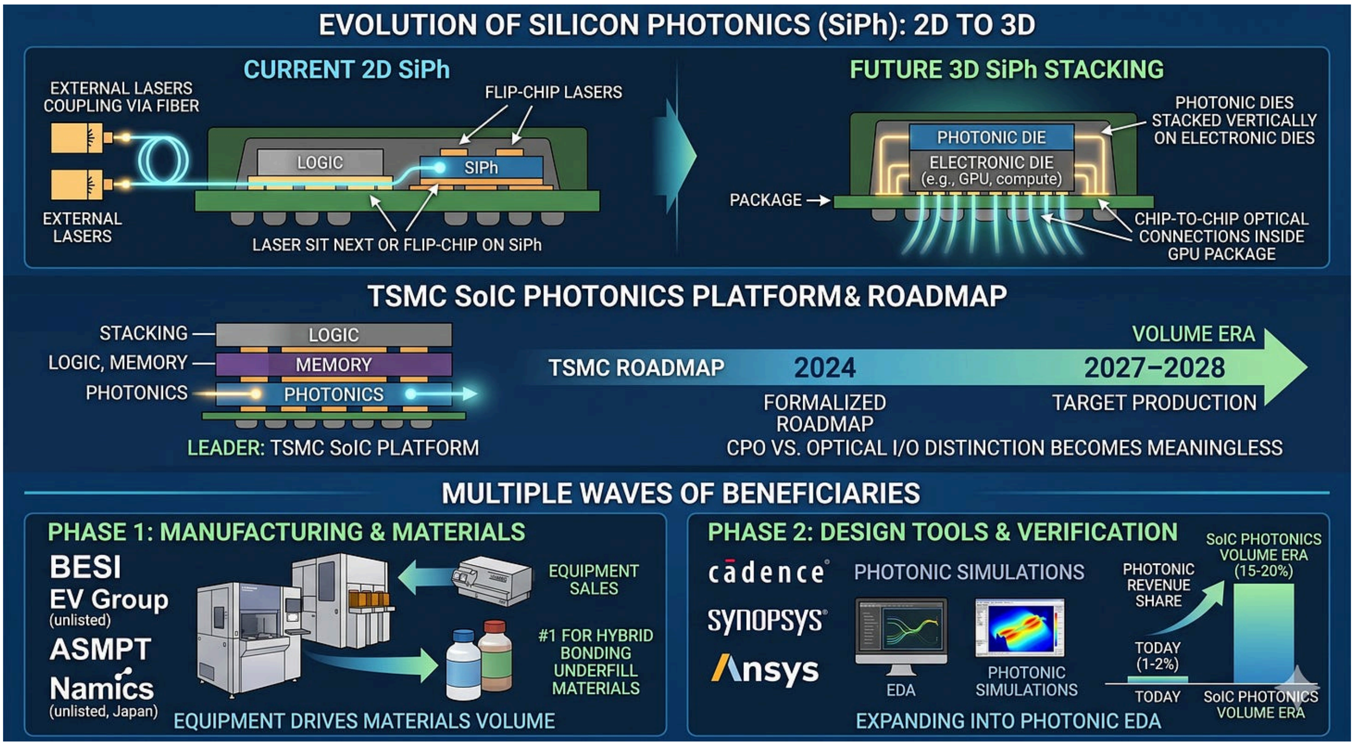
Technologies 通过光学中介层平台实现了被动对准。Ayar Labs 和 Lightmatter 未上市但具备 IPO 潜力。另一个值得关注的是 Fabrinet，它最有可能成为英伟达 CPO 生产中光纤连接和模块组装环节的供应商。

Lens array and microoptics. To align the optical path precisely inside a CPO module, micro lens arrays are essential. Coherent (formerly II-VI) is a leader here but the lens array business share is too small to be re-rated on its own. Among independent lens array suppliers, Jenoptik (JEN.DE), Fisba (unlisted), and OZ Optics (unlisted) are the names. Jenoptik is a German diversified optics company that hasn't yet gotten the CPO premium.
透镜阵列与微光学。为了在 CPO 模块内部精确对准光路，微透镜阵列至关重要。Coherent（前身为 II-VI）是这一领域的领导者，但其透镜阵列业务份额过小，难以单独获得重估。在独立的透镜阵列供应商中，Jenoptik（JEN.DE）、Fisba（未上市）和 OZ Optics（未上市）是主要厂商。Jenoptik 是一家德国多元化光学公司，尚未获得 CPO 溢价。

Thermal management. CPO modules sit inside the GPU package, so thermal performance directly impacts GPU performance. Liquid cooling solutions and thermal interface material suppliers benefit. Names like Laird Thermal Systems (unlisted) and Boyd (unlisted), and on the listed side, Vertiv Holdings (VRT) is the data center cooling flagship. VRT has already run a lot but the CPO momentum is less priced in.
热管理。CPO 模块位于 GPU 封装内部，因此散热性能直接影响 GPU 性能。液冷解决方案和热界面材料供应商将受益。例如莱尔德热系统（未上市）和博伊德（未上市），上市企业方面维谛技术（VRT）是数据中心冷却领域的龙头企业。VRT 股价已有较大涨幅，但 CPO 发展势头的溢价尚未充分体现。

Advanced packaging equipment. CPO demands difficult processes like chip-on-wafer and wafer-level bonding. Leaders here are BESI (BESI.AS, Netherlands) and ASMPT (0522.HK). BESI has a near-monopoly in hybrid bonders, and hybrid bonding is very likely to be applied in CPO as well. BESI is classified as a semiconductor packaging equipment stock and hasn't been awarded the optical premium.
先进封装设备。CPO 需要晶圆上芯片和晶圆级键合等高难度工艺。该领域领导者是 BESI（BESI.AS，荷兰）和 ASMPT（0522.HK）。BESI 在混合键合机领域近乎垄断，而混合键合技术极有可能应用于 CPO 领域。BESI 被归类为半导体封装设备股，尚未获得光学溢价。

2. 3D Photonics and Heterogeneous Integration



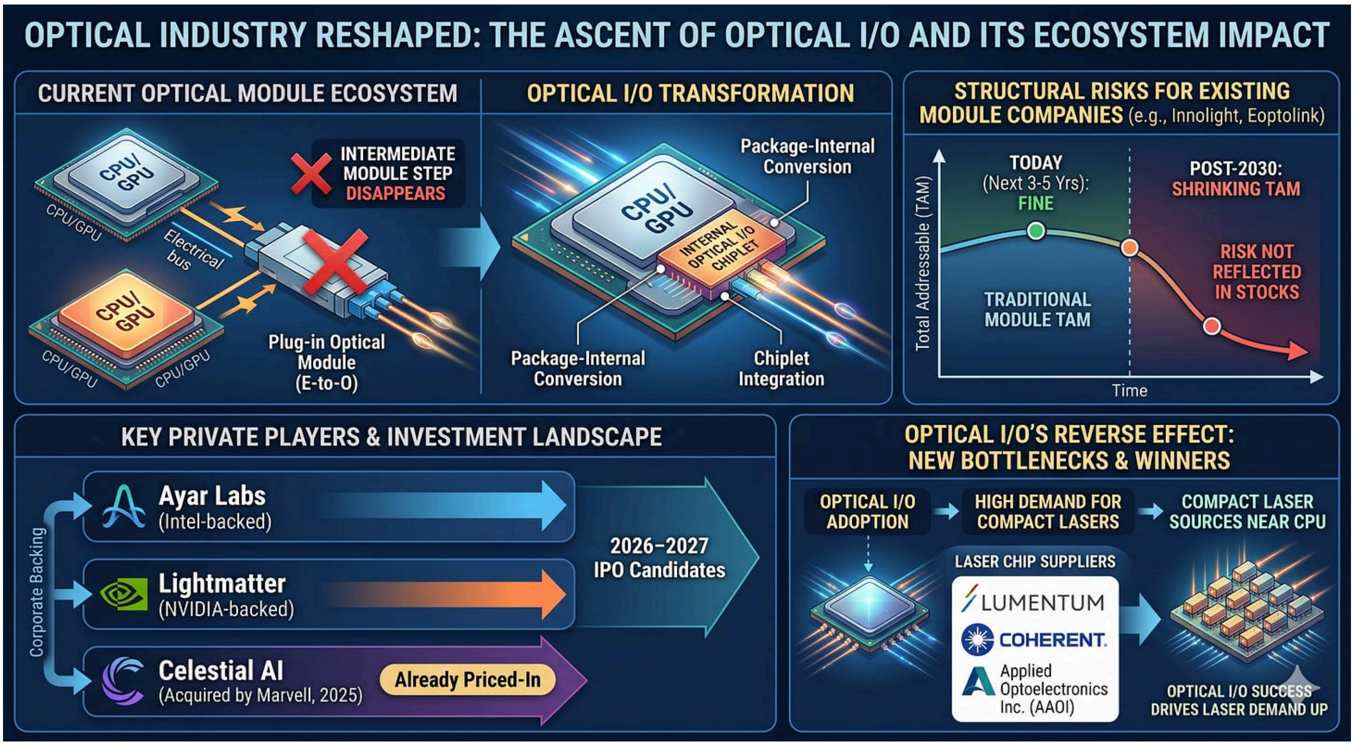
Most SiPh today is 2D. Laser chips sit next to the SiPh chip and couple via fiber, or are flip-chipped on. The next step is 3D stacking. Stacking photonic dies vertically on electronic dies brings chip-to-chip optical connections inside the GPU package.

The leader here is TSMC's SoIC platform. TSMC formalized the SoIC Photonics expansion roadmap in 2024, with production targeted for 2027–2028. If TSMC pulls this off, the distinction between CPO and Optical I/O becomes meaningless. Photonic dies get stacked inside the GPU package itself.

Beneficiaries: BESI, EV Group (unlisted), ASMPT, Namics (unlisted, Japan). Namics is the world's #1 for hybrid bonding underfill materials. When BESI/ASMPT sell the equipment, Namics sells the materials.

The moment TSMC SoIC Photonics enters production, another group of winners appears: design tools and verification companies. Cadence and Synopsys have roadmaps to expand into photonic EDA. Ansys is building position in photonic simulation. Today, photonic revenue at these three is 1–2% of the mix. In the SoIC Photonics volume era, that could rise to 15–20%.

3. Optical I/O and Direct CPU Coupling



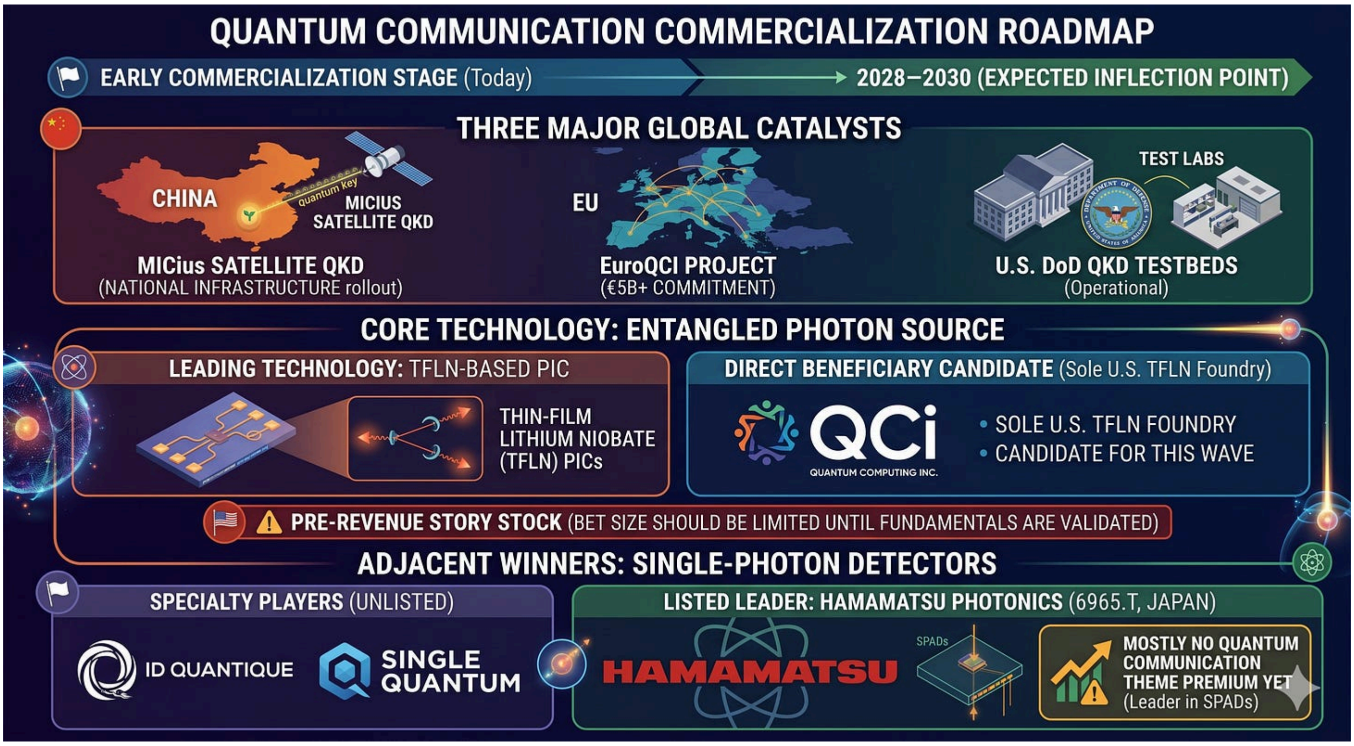
Putting optical I/O inside the CPU/GPU package reshapes the current optical module industry. Today's optical module converts electrical to optical outside the GPU. Optical I/O pulls that conversion inside the GPU package. The intermediate module step disappears.

The leaders here are private companies. Ayar Labs (Intel-backed), Lightmatter (NVIDIA-backed), Celestial AI (acquired by Marvell). Celestial AI was already priced in when Marvell acquired it in 2025. Ayar Labs and Lightmatter are 2026–2027 IPO candidates.

From an investor perspective, the thing to watch is the risk to the existing module companies. If Optical I/O takes off, the TAM for Innolight and Eoptolink could shrink. The next three to five years are fine, but post-2030 there's a structural downside risk. This risk isn't yet reflected in the stocks.

On the flip side, it pays to look at the layers that become the bottleneck for Optical I/O. For Ayar Labs and similar companies to succeed, they need compact laser sources that can sit near the CPU, and the companies that supply those are, again, Lumentum, Coherent, and AAOI. The more Optical I/O succeeds, the more laser chip demand goes up.
另一方面，审视成为光输入/输出瓶颈的层级也很有价值。要让 Ayar Labs 及类似公司取得成功，他们需要能够放置在 CPU 附近的紧凑型激光源，而提供这些激光源的公司同样是 Lumentum、Coherent 和 AAOI。光输入/输出技术越成功，激光芯片的需求就越大。

4. Quantum Communication Infrastructure (2028~)
4. 量子通信基础设施（2028 年~）



Quantum communication is still at an early commercialization stage, but 2028–2030 is the expected inflection point. Three catalysts. China is rolling out Micius satellite-based QKD as national infrastructure. The EU has committed more than €5B to the EuroQCI project. The U.S. Department of Defense is operating QKD testbeds.

The core component of quantum communication is the entangled photon source, and TFLN-based PIC is the leading technology for this. QCi is the sole U.S. TFLN foundry, making it a direct beneficiary candidate for this wave. That said, QCi is a pre-revenue story stock, so bet size should be limited until fundamentals are validated.

Adjacent winners are the single-photon detector companies. Specialty players like ID Quantique (unlisted) and Single Quantum (unlisted) sit in this space. Among listed names, Hamamatsu Photonics (6965.T, Japan) is the leader in single-photon avalanche diodes (SPADs). Hamamatsu has received almost no quantum communication theme premium yet.

5. The Second Wave of Chinese Optical

Innolight, Eoptolink, and Yuanjie are already the Chinese optical first wave. Behind them is a second wave of companies preparing to IPO or globally list. The list includes Accelink Technologies (002281.SZ, already listed), Hisense Broadband Multimedia (unlisted), Hengtong Optic-Electric (600487.SH, cable-focused), Henan Shijia Photons (688313.SH), and Bozhon Photonics (unlisted).

The most visible catalyst is the Hong Kong secondary listing wave. Yuanjie publicly filed for a 2026 Hong Kong listing, and that becomes the signal. Innolight and Eoptolink could follow with Hong Kong listings within 2027. As the A-share and Hong Kong valuation gap converges, the arbitrage opportunity is significant. Cambricon and SMIC showed this pattern historically.

The caveat is political risk. If U.S.-China friction extends into deep tech, Chinese optical names could be excluded from the NVIDIA supply chain. In that case, Innolight and Eoptolink go down, while Yuanjie benefits as a Chinese domestic-demand play. If you're running Chinese optical positions, splitting export-exposed from domestic-exposed names and hedging the mix is the right approach.

Closing: Map and Timing

Optical isn't a single stock; it's a value chain. Seven layers, each with a different revenue structure, and 22 vertically integrated companies each holding a different structural position. Understanding this as a map was step one.

Step two is timing. Knowing the map doesn't tell you when to enter. Cycle diagnosis and the next five years' game-changers are my view on that timing.

Three core messages.

First, vertical integration depth and stock returns move inversely. 4-position Cisco/Nokia/Sumitomo average +78%. 3-position group averages +855%. 2-position pure play tops sit at +900–1,700%. Conglomerate discount, size beta, lack of discovery premium, and cycle timing combine to produce this. What made money in this cycle was focused pure plays. Paradoxically, Cisco's structural moat is much deeper, but Innolight has outperformed the stock by more than 20x.

Second, the sector overall is Valuation Late, Fundamentals Mid, Product cycle Early. The three axes need to be split name by name. AAOI is Valuation Late + Product Early but has a weak roadmap post-800G. Marvell is Valuation Mid + Fundamentals Early + Product Early, with re-rating room for the late cycle. Cisco is Valuation Early, but the conglomerate structure keeps the discount in place until a CPO transition catalyst hits. Judging the sector on averages will mislead you.

Third, returns over the next five years are more likely to come from places that aren't in focus yet. CPO adoption's passive alignment, 3D photonics and heterogeneous integration, Optical I/O, quantum communication, and Chinese second wave. Beyond the 50 names covered in this piece, optical equipment/materials names like BESI, Jenoptik, Hamamatsu, Aixtron, and Soitec, plus unlisted chokepoints (Ayar Labs, Lightmatter, HyperLight), can end up at the center of the next wave.

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