

From Copper to Light

Rewiring the AI Factory — Photonics, Connectivity and the Deep Technologies Behind Them

\$6.5B+

Committed by NVIDIA to photonics suppliers since March 2026

\$23.8B

Global sales of optical transceivers in 2025 (LightCounting)

~5,000

Copper cables inside a single NVIDIA rack-scale system today

2028

When optics beside the processor are expected to reach volume

Issues 01 to 03 followed the money into chips, compute and power. This issue follows the wires. AI chips are now so fast that the copper cables between them have become the limit. The answer is to send data as light — a shift that began between buildings, moved between racks, and is now moving onto the chip itself. We close on Ayar Labs, one of the companies building that last step.

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01 — EXECUTIVE SUMMARY

The network is now the bottleneck

Core thesis: an AI data centre is thousands of chips working as one machine, and how well they work together depends on how fast they can talk to each other. That conversation still runs largely on copper, and copper is reaching its limit. Whoever controls the lasers, the optical chips and the packaging will hold one of the next bottlenecks of the AI build-out.

FIVE HEADLINE FINDINGS

01 Copper has hit a physical wall

The faster a signal travels through copper, the shorter the distance it survives and the more power it wastes as heat. One NVIDIA rack already holds about 5,000 copper cables.

02 Light is moving toward the chip

Optical links already connect racks. In 2026 they moved inside the switch. The next step puts them beside the processor, with volume expected from 2028.

03 The largest buyer is funding its suppliers

Since March, NVIDIA has committed at least \$6.5B to Coherent, Lumentum, Marvell and Corning, with purchase commitments and rights to laser capacity attached.

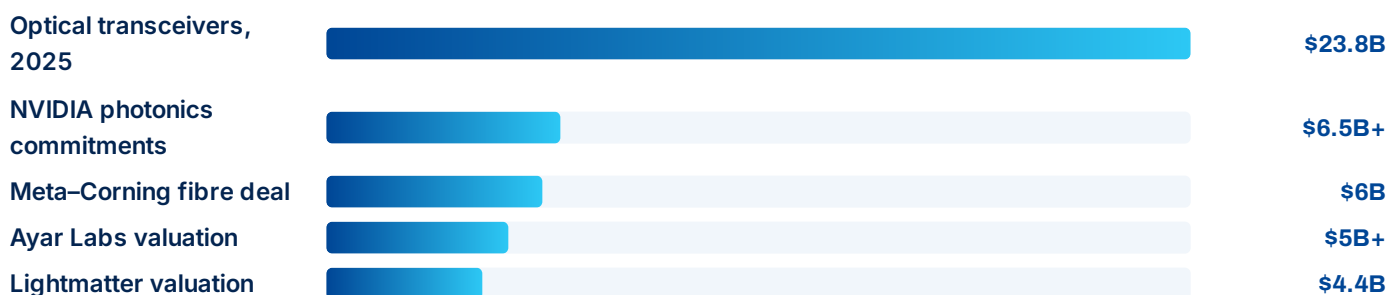
04 Deep technology is queuing behind it

New materials, new lasers, micro-LEDs, optical switching and hollow-core fibre are moving from the laboratory to the data centre. About 70 venture-backed startups are chasing them.

05 For the Gulf, this is a power story

Issue 03 showed that electricity is the binding constraint. Optics that halve the power spent on networking raise the output of every megawatt the region has planned — and Gulf capital is already on the cap table of the leading companies.

Where this issue's numbers sit (US\$ billions)



Sources: LightCounting; company announcements; Reuters. Shown for scale only — a market, two contracts and two company valuations are different kinds of number.

What an allocator should take from this issue. Connectivity is becoming a bottleneck of the same kind as chips and power. Proven revenue today is in lasers, modules and fibre. The venture upside is in the step beside the processor, which is about two years from volume and which the large incumbents intend to own. Copper has outlasted every forecast of its end, so timing matters more than direction.

02 — FROM COPPER TO LIGHT

Moving the light closer to the chip

For forty years, making chips faster was the hard part and connecting them was routine. That has reversed: the chips can now produce data faster than copper wire can carry it between them.

~5,000

Copper cables inside one NVIDIA rack-scale system (CNBC)

1–2 m

Rough reach of a passive copper cable at today's fastest speeds

50%+

Power saved by co-packaged optics against plug-in modules (industry estimate)

100 Tb/s

Capacity of one NVIDIA Spectrum-X Photonics switch

Why copper is running out

Distance: push a signal faster and it fades sooner.

Heat: every watt spent moving data is a watt not spent computing. **Space:** thousands of thick cables per rack leave no room for more. AI makes all three worse, because the chips in a cluster exchange data constantly.

Two networks to fix

Scale-out connects racks across the hall and is already optical. **Scale-up** connects chips inside a rack so they act as one computer. It is still copper, it carries the most traffic, and replacing it is the prize.

FOUR STEPS, EACH SHORTENING THE COPPER

1

Plug-in modules

An optical unit plugs into the front of a switch. Proven and easy to replace. Today's standard.

2

Linear plug-ins

The same module with its most power-hungry chip removed. Up to half the power; harder to tune.

3

Co-packaged optics

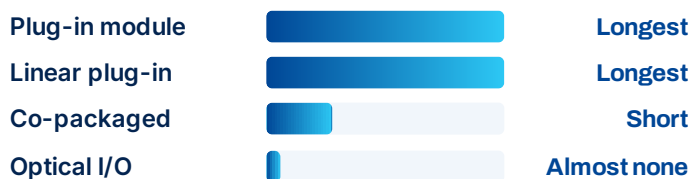
Optics move inside the switch. NVIDIA ships from H2 2026; Broadcom is already shipping.

4

Optical I/O

Optics sit beside the processor and replace copper inside the rack. Volume from 2028.

How much copper is left in the path (illustrative)



Illustrative: direction of travel, not a measurement.

Power used by the optical link (plug-in module = 100)



Indexed from industry claims: linear plug-ins cut module power by up to half (Signal AI); co-packaged optics save 50% or more (industry estimate). Not a like-for-like test.

A caution from the industry itself. Pat Gelsinger, former Intel chief executive and now on Ayar Labs' board, has said he declared the death of copper two decades too early. Copper will stay wherever it still works; the case for optics is strongest where copper has physically run out.

03 — THE MONEY AND THE MARKET **SNAPSHOT · SEPTEMBER**

NVIDIA is paying its suppliers to build

The clearest signal in any supply chain is a customer paying in advance. In three months this year, the company that sets the design of most AI data centres did exactly that across lasers, optical chips and glass.

\$6.5B+

NVIDIA photonics commitments since March 2026

\$23.8B

Optical transceiver sales in 2025 (LightCounting)

~60%

Forecast market growth in 2026 (LightCounting)

\$2.5B+

Optical switching market by 2029 (Signal AI)

NVIDIA's announced photonics commitments, 2026 (US\$ billions)

Corning		up to \$3.2B
Coherent		\$2.0B
Lumentum		\$2.0B
Marvell		\$2.0B

Corning is the maximum under two share warrants, alongside purchase agreements. The \$6.5B total counts \$2B each for the other three plus Corning's \$500M equity element.

What the money buys

These are not passive stakes. The Lumentum and Coherent deals carry multi-billion-dollar purchase commitments and rights to future laser capacity; Corning is building three US plants. The largest customer in the market is paying suppliers to build before it needs the capacity. That is what a real bottleneck looks like.

Latest reported quarterly revenue, selected suppliers (US\$)

Innolight (China)		\$1.87B
Coherent		\$1.2B
Lumentum		\$808M

Innolight Q4 2025 (+105%). Coherent data-centre and communications segment, Q4 2025. Lumentum quarter to March 2026 (+90%). Scope differs; for scale only.

Where the forecasts point (US\$ billions)

Transceivers 2025		\$23.8B
Transceivers 2031		~\$60B
Datacom parts 2025		\$18B+
Datacom parts 2029		~\$30B

Transceivers: LightCounting (2031 via trade press). Datacom components: Signal AI. Different definitions; do not add.

The rest of the field

Broadcom is the open alternative to NVIDIA and already ships co-packaged switches. **Marvell** bought Celestial AI for about \$3.25B upfront. **AMD** bought Enosemi and **Ciena** bought Nubis. **TSMC** supplies the packaging most designs depend on.

Who earns the money today

Revenue is in the proven parts: plug-in modules, lasers and fibre. Co-packaged optics and optical I/O are still a rounding error beside them. Their investment case rests on 2028 and after, not on current sales.

A WARNING ON CO-PACKAGED OPTICS FORECASTS

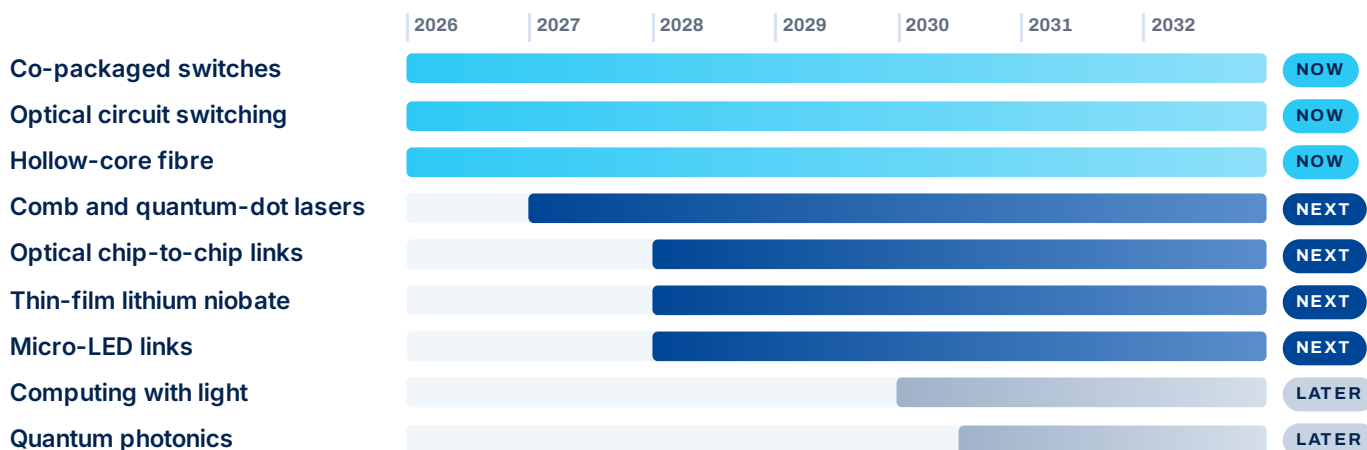
Published estimates for 2026 range from about \$165M to over \$300M, and ten-year forecasts from about \$3B to more than \$20B (Mordor Intelligence, Fortune Business Insights, IDTechEx). We treat the direction as better established than the size.

04 — EMERGING DEEP TECHNOLOGIES

What comes after today's optics

Today's optical chips are made of silicon and lit by conventional lasers. Both are approaching limits of their own. Behind them is a second wave of technologies at very different stages of readiness.

When each technology is expected to matter in AI data centres



Start dates are Singular Link's judgement from analyst and company sources and show first meaningful deployment, not peak volume. **Now** 2026–27 · **Next** 2028–30 · **Later** after 2030.

TECHNOLOGY	WHAT IT DOES, IN PLAIN LANGUAGE	WHO IS BUILDING IT	WHEN
Optical circuit switching	Routes the light itself, with no conversion back to electricity at each switch	Google (in-house), Lumentum, Coherent; nEye, iPrionics, Oriole	NOW
Hollow-core fibre	Light travels through air inside the fibre, about half as fast again as through glass, so sites can sit further apart	Microsoft, with Corning and Heraeus	NOW
Comb and quantum-dot lasers	One source produces many colours of light, so one fibre carries many times more data	Xscape, Scintil, Pilot Photonics; Quintessent, Ranovus	NEXT
Optical chip-to-chip links	Replaces the copper between processors inside a rack	Ayar Labs, Lightmatter, Marvell (Celestial)	NEXT
Thin-film lithium niobate	A material that switches light faster than silicon, at lower voltage	Hyperlight, Lightium, Rapid Photonics	NEXT
Micro-LED links	Arrays of tiny LEDs send many slow signals side by side, using far less power than lasers	Avicena	NEXT
Computing with light	Uses light to do the calculation, not only to move the data	Lightelligence, Neuropbos, Akhetonics, Lumai	LATER
Quantum photonics	Quantum computers built from particles of light	PsiQuantum, Xanadu	LATER

How to read this list. The nearer a technology is to an existing standard and an existing factory, the sooner it earns revenue. Optical switching and hollow-core fibre are being bought today. New materials and light sources slot into the next product generation. Computing with light asks customers to change how they build computers, which is why it has always been ten years away.

05 — STARTUPS AND SUPPLY CHAIN

Seventy startups, five tight links

Money has followed the bottleneck. Most optical startups will not reach volume on their own, and the supply chain they depend on is younger and more concentrated than the one that makes processors.

~70

Venture-backed optical component startups tracked by Cignal AI

\$5B+

Ayar Labs valuation in a September 2026 secondary sale

\$4.4B

Lightmatter valuation, Series D, October 2024

3

Advanced optical-chip startups acquired in about a year

Approximate total funding raised (US\$)

Press and data-provider reports; approximate. Celestial AI before its acquisition.

Latest valuation or purchase price (US\$ billions)

Ayar Labs: secondary sale, Sept 2026. Lightmatter: Oct 2024 round. Celestial AI: upfront price paid by Marvell, with more tied to milestones.

The exit so far is acquisition

Celestial AI went to Marvell, Nubis to Ciena and Enosemi to AMD — each to a large chip or networking company, and each before meaningful revenue. Buyers are paying for technology and engineers they cannot build in time.

What separates the leaders

A manufacturer will not risk an unproven part in the middle of a boom, and a part cannot be proven until one does. The companies that have broken through have their customers as shareholders. It is the first thing we look for.

THE OPTICAL SUPPLY CHAIN — FIVE LINKS

1**Materials**

Indium phosphide for lasers. Raw supply concentrated in China.

2**Lasers**

The scarcest part. Capacity is being bought in advance.

3**Optical chips**

Made in ordinary chip factories — their main advantage.

4**Packaging**

Joining fibre to chip. Slow, costly, centred on TSMC.

5**Modules, fibre**

Assembly in Asia; fibre from a few makers such as Corning.

Lasers and packaging are short

A co-packaged switch needs far more laser power than a plug-in module, which is why NVIDIA's deals include rights to future laser capacity. Attaching glass fibre to a chip at volume is still closer to watchmaking than to chip manufacturing.

Materials are the strategic risk

Laser raw material and the largest module maker are both in China. In response, Lumentum, Coherent and Corning are all adding US capacity, partly with NVIDIA's money. Capacity outside the existing centres is being actively sought.

06 — COMPANY FOCUS

Ayar Labs: light beside the processor

Ayar Labs in one paragraph. Founded in 2015 and based in San Jose, California, Ayar Labs makes the parts needed to replace copper with light directly beside a processor. It is one of three leading approaches to the scale-up network, and the one with the broadest set of chip makers among its investors.

\$5B+

Valuation in a \$225M secondary share sale, September 2026

\$650M

Primary capital raised during 2026

~\$1.0B

Total raised since founding in 2015

Ayar Labs valuation (US\$ billions)

March 2026: \$500M primary round led by Neuberger Berman.
September 2026: sale of existing shares led by Antero Peak Group at Artisan Partners, reported by Reuters at above \$5B; a secondary sale prices existing shares and brings no new money to the company.

What it makes

The optical chip (TeraPHY) sits in the same package as a processor and turns its signals into light at the source. It is made in standard chip factories. **The light source** (SuperNova) sits in a cooler, reachable part of the rack and feeds the chips through fibre, which answers the reliability concern about lasers.

THE ROAD TO VOLUME**2026****Fund and build**

\$650M of new capital; engineering bases in Hsinchu and Bengaluru.

2027**Qualify**

Products ready for volume production by the end of the year.

2028–29**Ramp**

Expected customer volume, in line with the wider industry timetable.

Who backs it

Strategic investors include NVIDIA, AMD, Intel, MediaTek, Alchip and Wiwynn — competitors who rarely share a round. Financial investors include Neuberger Berman, ARK Invest, Insight Partners, 1789 Capital and the **Qatar Investment Authority**.

The open question

Analysts describe Ayar as further along than most peers but still to be proven at scale. **Watch for** qualification on schedule and a named processor shipping with the chip. **What could go wrong:** a large chip maker builds its own, or the ramp slips past 2029.

The Singular Link view. Ayar Labs is the most direct expression of this issue's argument: if copper inside the rack is the limit, the answer is light beside the processor. Its position rests on having the industry's main chip makers as shareholders at the same time. Our stance is constructive — the right problem, credible backers and a manufacturable design — but the company is unproven at scale and the valuation has moved ahead of revenue.

Singular Link has exposure to Ayar Labs. Commercial terms of that position are not disclosed in this publication. Facts are from public announcements, Reuters and independent analysts. Company names shown, including current portfolio positions, are illustrative of Singular Link's thematic focus and not a recommendation.

07 — THE GULF VIEW, RISKS & WATCH ITEMS

More compute from every megawatt

This section is Singular Link's own interpretation. Photonics bears directly on the three things the Gulf brings to AI: energy, new-build capacity and patient capital.

More output per megawatt

Power limits how much AI capacity can be built. Optics that halve networking power return that electricity to computing — a higher yield on every megawatt planned.

Build for light from day one

Most Gulf capacity is still to be built, so it can be specified for co-packaged optics from the start. Being late to build is, for once, an advantage.

A manufacturing opening

Lasers, materials and packaging are short and being relocated. They are a more achievable industrial entry point than a processor factory.

Gulf capital is already on the cap table

The Qatar Investment Authority is an investor in Ayar Labs. The leading optical companies are financed by their own customers and a small group of institutions; regional capital is welcome for the same reasons as in compute — patience, scale and a home market that will buy the product.

WHAT COULD CHANGE THE PICTURE**Our assessment of each risk (Singular Link judgement)**

Timing slips past 2028		High
Incumbents take the value		High
Copper keeps improving		Medium
Supply chain and geopolitics		Medium
Repair and reliability		Medium
No agreed standard		Lower

A qualitative ranking by likelihood and impact on an investor's return, not a measurement. Volume is a 2028 story and slips of a year or two are normal; NVIDIA, Broadcom and Marvell hold most design wins. All of it follows AI capital spending: a pause there reaches optics within a quarter or two.

WATCH ITEMS FOR ISSUE 05

- ✓ **Q4 2026:** first volume shipments of NVIDIA's Spectrum-X Photonics switches.
- ✓ **November:** Lumentum and Coherent results — is laser capacity still what limits revenue?
- ✓ **Design wins:** the first named processor to ship with optics in the package.

Sources. Company announcements and filings (NVIDIA, Lumentum, Coherent, Corning, Marvell, Ayar Labs) to 30 September 2026; Reuters; CNBC; The Next Web; optics.org; Forbes; Data Center Dynamics; Converge Digest; Signal AI Optical Components Report and Startup Tracker (July 2026); LightCounting (March 2026); market-size ranges from Mordor Intelligence, Fortune Business Insights and IDTechEx. Technology timing, risk ranking and the Gulf lens are Singular Link's own. Charts marked illustrative or indexed are not measurements.

Disclosure: Singular Link holds positions in this sector, including exposure to Ayar Labs.

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