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# CPO Raises the Stakes: Building a Reliability-First External Laser Platform

## Built on Proven Raman Pump Laser Heritage for High-Reliability Optical Networks

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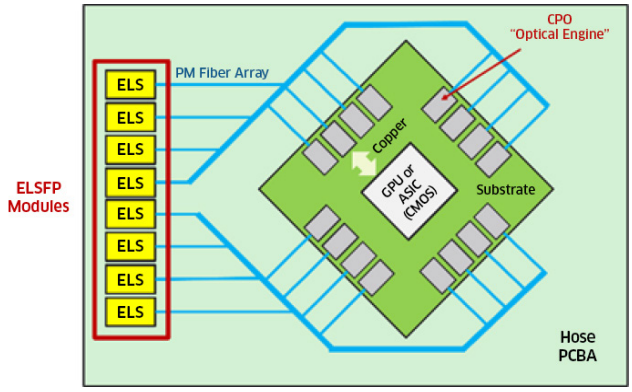
### Introduction

As artificial intelligence transforms the data center landscape, the race to support large GPU clusters is fundamentally reshaping network infrastructure. At the heart of this transformation lies co-packaged optics (CPO), a technology that integrates optical engines directly onto switch ASICs to deliver unprecedented bandwidth density and power efficiency. But that architectural shift also changes the reliability equation. When optics are integrated tightly with high-value ASIC hardware, failures have bigger "blast radius," field serviceability is harder, and the tolerance for surprises is lower. That is exactly why the external light source (ELS) and its form factor (ELSFP) are emerging as important building blocks: keep lasers serviceable, keep heat away from the ASIC neighborhood, and still enable the low-power benefits of co-packaged optical engines.

**The CPO Era: Market Inflection and Commercial Deployment**




The data center industry has long recognized that co-packaged optics would carve out a substantial share of the optical interconnect market, complementing traditional pluggable transceivers in high-performance applications - the question was always 'when,' not 'if.' In 2025, we witnessed the commercial deployment of CPO switches from both Broadcom and NVIDIA, marking the beginning of what analyst's project will be a $26+ billion market by 2026 for AI-related optics alone.[2]

### The CPO Market: A Multi-Billion Dollar Opportunity

The business case for CPO has never been stronger. According to LightCounting's January 2026 forecast, the market for optics in AI infrastructure alone is projected to reach $26.1 billion in 2026, growing at a 21.2% CAGR through 2031 to reach $52.1 billion.[1]

Breaking down the forecast by segment:

| Segment | 2025 | 2026 | 2031 | CAGR 2025 - 2031 |
|---|---|---|---|---|
| AI Scale-Out | $12.8B | $21.7B | $30.1B | 15% |
| AI Scale-Up | $3.9M | $33.9M | $10.6B | 273% |
| Total AI Optics | $16.4B | $26.1B | $52.1B | 21% |

Source: LightCounting, January 2026

The growth in AI scale-up networking, where CPO will dominate - represents a 273% CAGR, transforming from a negligible market in 2025 ($3.9M) to over $10 billion by 2031. This is the segment where external laser sources are critical, as these ultra-high-bandwidth, short-reach connections cannot tolerate the power consumption or reliability profiles of pluggable optics.

LightCounting's January 2026 forecast projects that leading hyperscalers will deploy hundreds of thousands of CPO ports at 800G, 1.6T, and 3.2T speeds by 2026, scaling to over 3 million ports by 2031. Each of these ports requires an external laser source, and reliability will be one of the deciding factors in vendor selection.[1]

### Reliability and Power Efficiency – Two Sides of the Same Coin

The traditional value proposition for CPO has centered on power efficiency. By removing the long 10 to 15 inch electrical traces between switch ASICs and pluggable transceivers, which can add about 22 dB of signal loss, CPO cuts per port power from about 30 W to about 9 W, or roughly 3.5 times more efficient.2 For hyperscalers running million-GPU clusters, these savings translate to tens of megawatts of reduced power consumption and millions of dollars in operational costs.

But December 2025 brought a paradigm shift. NVIDIA reported that CPO switches delivered a 10x improvement in AI cluster resiliency compared to systems using pluggable optics, translating

to a 5x improvement in GPU utilization efficiency.[3] This revelation has reframed the entire CPO value proposition: Reliability is equally important as power. When a single optical failure can cascade through thousands of GPUs, costing hours of training time worth hundreds of thousands of dollars, preventing that one failure is worth as much as months of power savings.

Similarly, Broadcom announced in October 2025 that its CPO platform had achieved one million cumulative 400G-equivalent port device hours of flap-free operation at Meta ("flap-free" refers to operation without any link-up/link-down toggling events that disrupt network traffic), demonstrating 65% power reduction and higher link reliability than pluggable modules.[4] These field results validated what engineers had theorized: by reducing component count and eliminating connectors, CPO doesn't just save power, it brings about a large improvement in system reliability.

## The Use of External Laser Source

CPO architecture faces a fundamental thermal challenge: optical engines must sit millimeters away from switch ASICs that generate 500W[5] or more of heat. Early CPO designs attempted to integrate laser sources directly within optical engines, but this approach proved untenable for high-power applications. The heat from both the ASIC and the laser itself creates a hostile thermal environment that degrades laser performance and shortens lifetime.

The solution: External Laser Sources (ELS). As detailed in the Optical Internetworking Forum's Co-Packaging Implementation Agreement, ELS architectures physically separate the laser from the switch ASIC, enabling:[6]

- **Faceplate serviceability:** Failed lasers can be replaced without removing the switch from operation, dramatically reducing mean time to repair (MTTR).
- **Thermal isolation:** Lasers operate in a controlled thermal environment away from ASIC hotspots, improving both laser reliability and switch ASIC performance.
- **Independent optimization:** Laser design can focus purely on optical performance and reliability without being constrained by ASIC integration requirements.

The OIF specification sets aggressive reliability targets for CPO systems: 50 FIT (failures in time per billion device hours) for laser sources, more than 5x better than the ~300 FIT typical of pluggable optical modules.[7] Meeting this target requires a fundamentally different approach to laser design and manufacturing. The OIF Co-Packaging Framework Document provides directional reliability guidance reflecting the industry's recognition that laser source reliability is foundational to CPO system success. Achieving the module-level target requires laser diode components with sufficiently low per-laser FIT rates, along with robust system-level design, qualification, and burn-in.

## Lumentum's Edge: Reliability-by-Design

The conventional path to CPO laser reliability involves multiple design iterations and extensive field testing to gradually reach production specifications. Lumentum took a different approach: building reliability into the design from day one by leveraging proven technology with an unmatched field track record.

### The Raman Pump Heritage

Lumentum's UHP/ELSFP laser technology is built on the company's Raman high power (600 mW) pump laser platform, a product line with more than two decades of deployment in the world's most demanding optical networks. The track record speaks for itself:

**Market leadership:** Market leader in Raman pump lasers globally with nearly half a million pump lasers deployed with >20 billion pump laser device hours in the field to date.

**Exceptional reliability:** <1 FIT with zero laser diode field failures since 2014.

**Proven scalability:** High-volume manufacturing with mature processes and supply chains.

The reliability heritage behind Lumentum's CPO laser platform is grounded in more than a decade of Raman pump laser deployments in long-haul and submarine optical networks - among the most demanding environments in the industry. Figure 1 shows representative life test data from the Raman pump laser platform, tracking operating current (Iop) at constant output power (600 mW, 35°C) across four independent test cells over periods approximately equal 30,000 hours. The near-flat current traces across all cells confirm minimal device degradation over time, which directly corresponds to the <1 FIT field reliability achieved with zero laser diode failures since 2014. This same core laser technology, thermal management philosophy, and manufacturing heritage form the foundation of the UHP product designed for CPO applications.

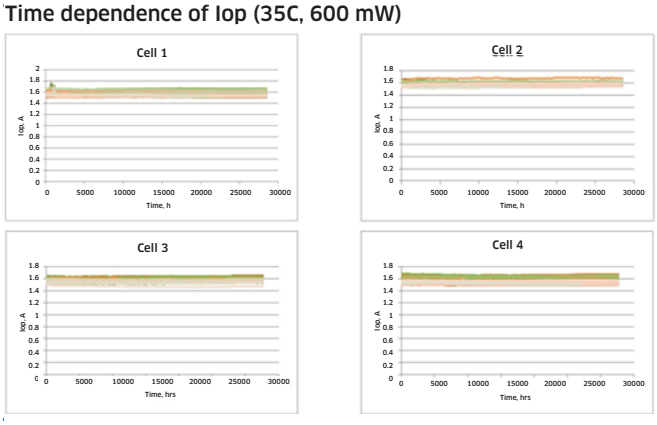



Figure 1: Time dependence of operating current (Iop) for Raman pump laser cells at 35°C, 600 mW – tracking 4 independent test cells over 30,000+ hours. Near-flat traces confirm minimal degradation, consistent with the <1 FIT field reliability record of the Raman pump platform since 2014.

## Four Pillars that Drive Reliability by Design Are:

**1. Thermo-Mechanical Design for Superior Thermal Performance**
The thermal design of a laser diode package is perhaps the single most critical factor determining its reliability. Lumentum's UHP lasers employ an advanced thermo-mechanical die attach configuration that minimizes the thermal path length between the active region and the heat sink, eliminating thermal barriers in the heat flow path.

The advantages are dramatic. Research by Ryu et al. demonstrated that this thermo-mechanical design achieves a two-fold reduction in junction temperature compared to junction-up configurations, with junction temperature rise of only ~13°C at >100 mW output power.[8] More recent studies on high-power laser diodes confirm that this optimized thermo-mechanical design can reduce thermal resistance by 50% or more.[9]

Why does this matter? Junction temperature is directly correlated with laser reliability. Every 10°C reduction in junction temperature can improve MTTF (mean time to failure) by 2-3x[10]. For CPO applications demanding high power per fiber – power levels that would stress conventional laser designs, this proprietary thermo-mechanical design provides the thermal headroom necessary to maintain acceptable junction temperatures and achieve the per-laser FIT rates required to support module-level reliability targets.

**2. Optimized for High Power from the Ground Up**
Lumentum's UHP lasers were designed from inception, intentionally for 400 mW operation. The epitaxial structure, waveguide geometry, coatings, and packaging were all optimized for this power level. This matters because operating a laser near its design limit results in accelerated degradation. By building substantial thermal and optical margins, UHP lasers maintain stable performance even under worst-case thermal conditions in CPO environments.

**3. O-Band Wavelength Optimization Across Silicon Photonics Applications**
Through careful quantum well engineering, Lumentum has tuned its UHP lasers for O-band operation, with current production targeting 1311nm as required by leading silicon photonics CPO platforms. The O-band benefits from mature component ecosystems and well-characterized reliability models, reducing deployment risk. Lumentum expects its UHP lasers to demonstrate equally strong reliability performance across the O-band, and the platform can be targeted to other wavelengths within the band as required by customer specifications.

**4. Manufacturing Excellence Through Process Transfer**
Perhaps most importantly, Lumentum's UHP production leverages established manufacturing processes from the Raman pump business. Die bonding protocols, thermal management techniques, burn-in procedures, and quality control methodologies that were refined over decades transfer directly to UHP manufacturing. This eliminates the 'learning curve' penalties - yield losses, infant mortality, and process variability, that plague new product introductions.

## Accelerated Life Test Results: From Theory to Data

Design philosophy and heritage are important, but the proof is in the data. Lumentum has conducted extensive accelerated life testing on large sample populations of UHP lasers to validate reliability under CPO operating conditions. The results tell a compelling story.

The life test program evaluated thousands of production devices from multiple fabrication runs, assembled on automated production lines with standard burn-in procedures. Testing was performed at elevated temperature and current to rigorously stress the lasers and accelerate failure mechanisms while maintaining conditions representative of actual CPO field deployments. Devices were monitored continuously with periodic detailed characterization to track any degradation.

The scale of the effort was substantial: over 100 million accelerated device hours accumulated under stress conditions designed to compress years of field operation into months of laboratory testing.

The outcome? Zero failures throughout the extended test program.

Not a single laser failed catastrophically during the multi-thousand-hour stress test. This isn't just good luck, it's the result of reliability engineered into the design from day one through proprietary thermo-mechanical design, proven Raman heritage, and optimized epitaxial structures. Using standard statistical analysis methods, these results translate into calculated reliability metrics that exceed industry requirements by a wide margin:

- 9 FIT at 60% confidence level
- 23 FIT at 90% confidence level

For production deployment, Lumentum applies a conservative engineering approach, rating the UHP lasers at 20 FIT for 400 mW operation - a figure that provides substantial margin while still delivering performance. This per-laser FIT figure is the foundation from which ELSFP module-level reliability is architected. Note also that this FIT estimate is based on available accelerated device hours and represents a conservative engineering calculation. Based on Raman pump field data demonstrating <1 FIT with zero laser diode field failures since 2014, we expect the UHP laser to achieve a field FIT rate considerably lower than this conservative analysis – potentially approaching the <1 FIT reliability demonstrated by the Raman pump heritage platform.

Beyond zero failures, the devices also demonstrated consistent operating behavior throughout the test program, with no anomalous parametric trends observed across the monitored population.

For a hyperscale deployment with 10,000 laser sources operating 24/7, the difference between 100 FIT and 20 FIT translates to ~9 failures per year versus ~1.75 failures per year at the rated 20 FIT - a 5x reduction in service calls and network disruptions. In AI training clusters where every hour of downtime costs millions of dollars[11] in lost GPU time, this reliability delta is worth millions annually. Furthermore, based on our Raman pump field experience approaching <1 FIT, a 10,000-laser deployment operating 24/7 would be expected to see fewer than one failure per year in practice – a level of reliability that effectively eliminates laser-related downtime as an operational concern.

These results validate Lumentum's reliability-by-design approach: by building on proven Raman technology and optimizing thermal management, packaging, and wavelength from the ground up, we've achieved the reliability levels required for large-scale CPO deployments without the trial-and-error typically required to reach production specifications.

## Conclusion: The Reliability Revolution

The transition from pluggable to co-packaged optics represents the most significant architectural shift in data center networking since the move from copper to fiber. But unlike previous transitions driven primarily by bandwidth and reach requirements, the CPO revolution will be won on reliability and performance.

External laser sources sit at the heart of this reliability equation. They're not just another component - they're the enabling technology that makes CPO's reliability promise achievable. And within the ELS category, not all solutions are created equal.

Lumentum's UHP/ELSFP stands apart because reliability wasn't added - it was designed in from the start. Over a decade of Raman pump heritage, market leadership, <1 FIT with zero laser diode field failures since 2014, is driving product reliability that the industry needs.

As the CPO market scales from $34 million in 2026 to $10+ billion by 2031[1], hyperscalers will standardize on suppliers who can deliver both volume and reliability. In high-stakes AI infrastructure, there's no room for 'good enough.' When the million-GPU cluster depends on it, Lumentum can be your partner with proven technology, manufacturing excellence, and an unmatched track record.

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