COETZER OPTICAL SYSTEMS (Pty) Ltd

Can copper interconnects replace optical modules

Overview

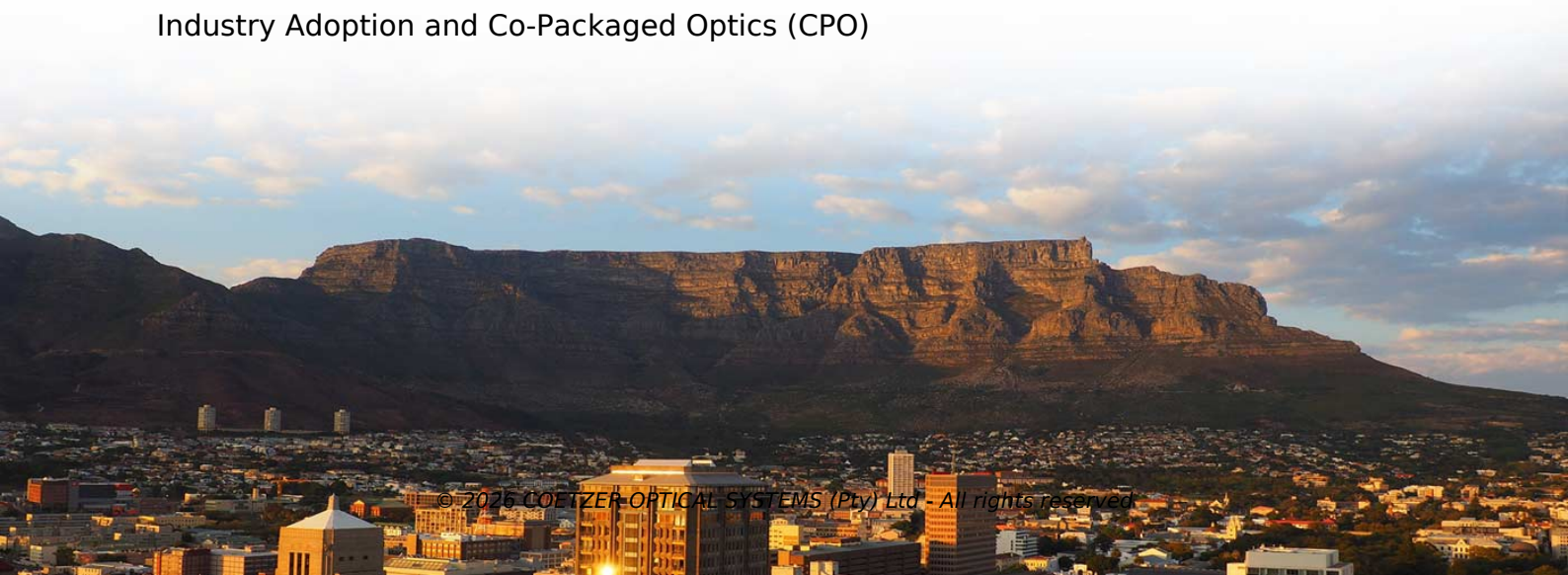
Optical Interconnects in Packages: Replacing Copper WiresDespite the promising advantages, the transition from copper to optical interconnects is not witho.

Key Takeaways

Optical interconnects are poised to replace copper in high-performance and AI data center applications due to superior bandwidth, lower power consumption, and reduced thermal constraints.Technical Advantages of Optical Interconnects

Copper interconnects have long been the standard for short-range connectivity, but they face significant limitations at high speeds. As operating frequencies increase, copper suffers from signal loss, skin effect, electromagnetic interference, and rising thermal dissipation, which constrain bandwidth and energy efficiency . Optical interconnects, by contrast, use photons instead of electrons, offering higher bandwidth, immunity to electromagnetic interference, and lower power per bit, making them ideal for dense, high-speed environments .

Industry Adoption and Co-Packaged Optics (CPO)



The industry is increasingly adopting co-packaged optics (CPO), which integrates optical components directly onto chip packages. This approach shortens electrical trace lengths, reduces power consumption, and enables higher density interconnects for GPUs and AI accelerators . Companies like Nvidia, Broadcom, and startups such as Ayar Labs are demonstrating optical links on chiplets, achieving terabit-per-second data rates while maintaining modularity and compatibility with existing electrical interfaces .

Data Center and AI Implications

AI workloads are driving exponential growth in data movement, where interconnect power can consume up to half of total system energy. Optical interconnects reduce cooling requirements and improve energy efficiency, which is critical for hyperscalers and high-density AI clusters . Experts predict that within the next five years, all high-bandwidth AI data center interconnects will become optical, leveraging silicon photonics, optical circuit switches, and co-packaged optics to meet scaling demands .

Limitations and Transition Challenges

Despite their advantages, optical interconnects face challenges such as integration complexity, cost, and fabrication precision. Advances in silicon photonics, wafer-level testing, and passive alignment are mitigating these issues, making large-scale deployment increasingly feasible [3^] . For ultra-short reach within racks, copper may still persist temporarily, but for high-speed, high-density, and energy-constrained applications, optics is rapidly becoming the preferred solution .

Conclusion

While copper will continue to serve in limited short-reach scenarios, optical modules and co-packaged optics are set to replace copper interconnects in high-performance computing, AI, and data center environments. The transition is driven by physics: light offers higher bandwidth, lower power consumption, and better thermal management, making it the future of high-speed interconnects .

Article Content

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Optical interconnects enable new solutions. Copper is simple and cheap and has been the mainstay of interconnect solutions for

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Copper Had a Great Run Copper is simple and cheap and has been the mainstay of interconnect solutions for over 100 years, but it

Overview of Optical Interconnect Technology

worldwide, optical interconnects are not much used commercially. In order to become a viable technology to replace electrical-based

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Optical Interconnect

The simplest example of low-cost optical interconnects is the active optical cable (AOC), which accepts the same electrical inputs

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