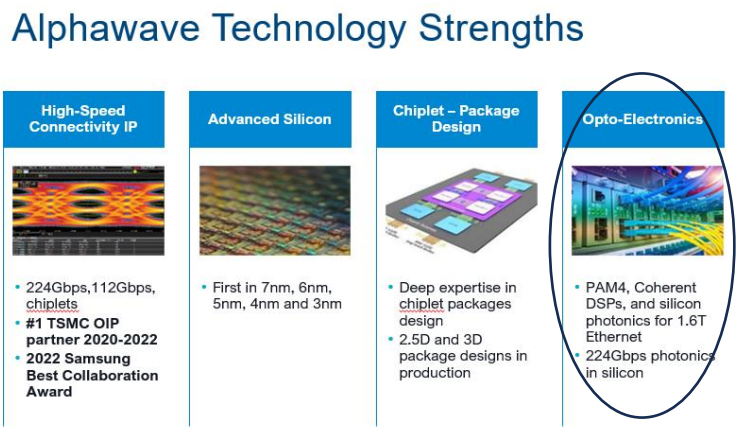
CTO Webinar 6 July 2023, Optical Connectivity in The Data Center

Executive summary

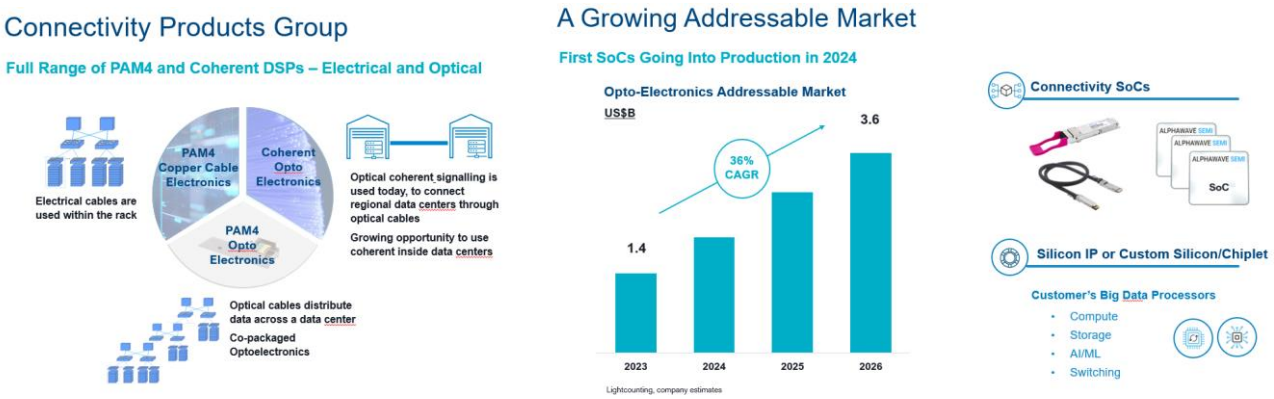
Optical connectivity is playing a growing role in data centres as higher data rates limit the reach of copper cables. High-bandwidth low-latency connectivity over longer distances is required by the scale-out of more compute driven by AI and the adoption of new network architectures. Pluggable optical modules are a workhorse of data centre optical connectivity. The Digital Signal Processing (DSP) semiconductor is the key component in pluggable optical modules, making them robust, reliable and backward & forward compatible.

Alphawave Semi's IP has been deployed by our customers in a range of solutions enabling electrical (copper cables) and optical connectivity throughout data centers. Our leading-edge capabilities and technologies ensure we can deliver the fastest connectivity solutions, including opto-electronics.



Source: Capital Markets Day, 13 January 2023

Alphawave Semi has a full range of PAM4 and Coherent DSPs for electrical and optical solutions. In 2024, the Company will start production of a new range of opto-electronic products (Connectivity Products Group) into a multibillion-dollar market growing at 36% CAGR over the 2023-2026 period. Our first customer is a leading North American hyperscaler (announced 13 October 2022).



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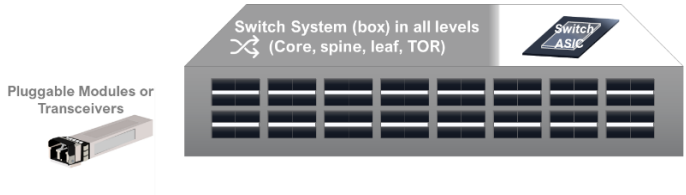
Source: Capital Markets Day, 13 January 2023

Optical connectivity in the data center

Artificial Intelligence is bringing changes to the data center. The scaling of processing power requires high bandwidth and low latency connectivity technology. As data rates increase from 100Gbps to 200Gbps per lane, electrical cables are likely to be limited to reaches of 1-2 meters so there will continue to be a trend towards the increasing use of optical links.

The switch is a key network component in data centers. Switch systems (box) receive and retransmit data streams towards their intended destination. The key semiconductor component is a switch application-specific integrated circuit (ASIC). Optical modules receive electrical signals and retransmit them optically and vice versa. This is why they are sometimes called transceivers. They come in standard sizes with standard connectors so they can be inserted removed and replaced.

Figure 1. Illustrative example, 50 Tbps Switch system (64 ports, 800G)



Bandwidth, reach, power consumption and latency are key considerations in modern pluggable transceivers. Optical modules combine several engineering disciplines into a compact package. There are high-speed electronics and photonics working together under demanding thermal conditions. Layers of sophisticated software and firmware run inside the module. They are manufactured in high volumes with tight tolerances and high-quality standards. Companies such as InnoLight Technologies, Coherent and Acacia were the leaders in optical modules in 2022.

Figure 2. Optical module

The total throughput of modern state-of-the-art pluggable modules ranges from 400G to 1.6T in each direction. The traffic may be carried over one or multiple fibres, depending on the module. For example, one type of 800G optical pluggable module uses 8 fibres, each carrying a nominal data rate of 100Gbps, in each direction for a total of 16 fibres. On the other side, 8 electrical connections in each direction carry 100Gbps data traffic each to and from the printed circuit board into which the module is plugged.

Inside each pluggable there are several components (see Figure 3) and the DSP semiconductor is central to the success of optical modules. There are different ways to construct these modules. Depending on the use case some of the silicon and optical components can combined (integrated) in different ways (see Figure 4), depending on the use case.

Figure 3. Anatomy of an optical module

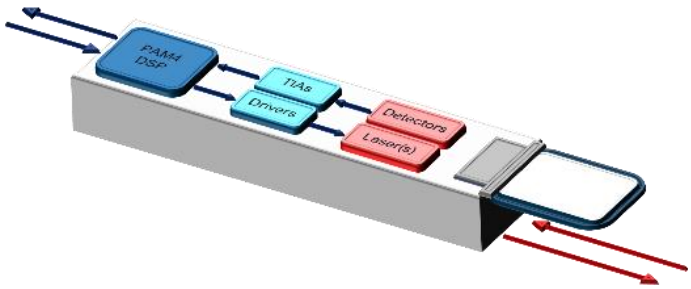
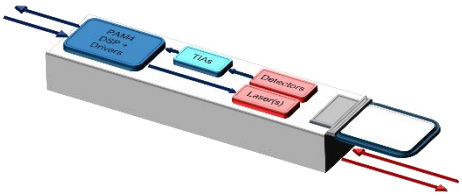
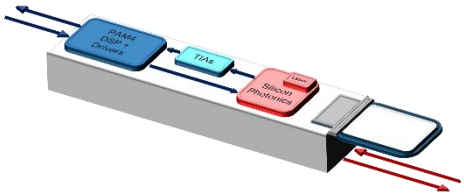


Figure 4. Alternative anatomies of an optical module

4.1 Integrated driver in DSP



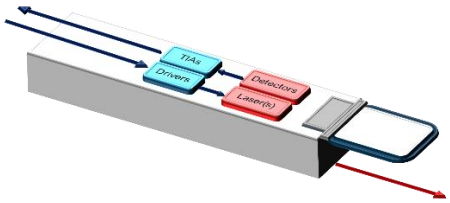
4.2 Integration of several optoelectronic components into a single silicon photonics die



All the module anatomies showing above require DSP technology although LPO and uses a combination of conventional discrete optoelectonic components or even with silicon photonics.

DSP optical modules are a workhorse in optical connectivity. The DSP semiconductor is the key component in pluggables, making them robust, reliable and backward & forward compatible. These modules allow for flexible deployment supported by a robust ecosystem of vendors.

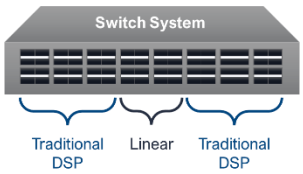
Figure 5. Linear Pluggable Optics (LPO)



There have been many public pronouncements recently regarding linear pluggable optical modules (LPOs). In practice, LPOs are more challenging to deploy because they remove the DSP, as shown above, and thereby create an end-to-end link where every connection and component is interdependent. LPOs could be useful in some sockets (ports) where for example the electrical links on the circuit board are electrically short.

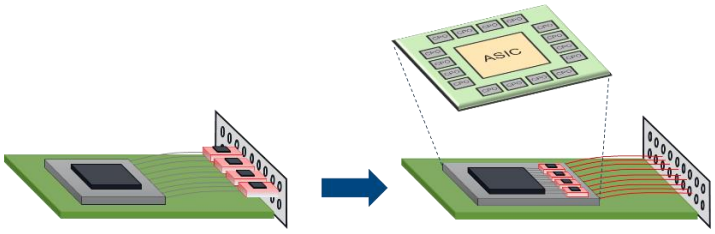
If combined within a single switch system (box) (Figure 5) LPO design and deployment requires careful planning as it reduces flexibility to change links from one type to another, i.e. it makes it very difficult to be interoperable, backward and forward compatible, or to deploy gradually.

Figure 6. Switch system combining different types of modules



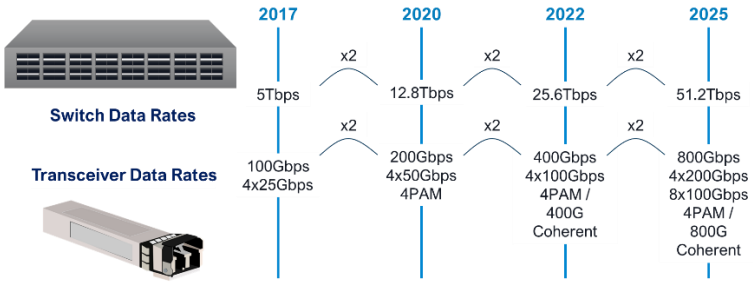
Co-packaged optics (CPO) brings the optical/electrical conversion from the front panel of the switch system to within a few millimetres of the main compute or switch ASIC chip, eliminating the optical modules entirely. CPO relies on having an optical DSP in the package, either directly on the compute or switch chip, or on a chiplet between the ASIC and the optics. This approach concentrates system complexity, power and R&D effort in the ASIC.

Figure 7. Co-packaged optics



As compute demands continue to increase, there is enough opportunity and market to support more different solutions. A mix of 100G, 200G, and coherent optics will coexist inside datacentres in 2025 and beyond. Co-packaged optics will also be playing a role. Each of these technologies offer a different combination of reach, power consumption, latency, and cost so that the best technology will depend on the target application.

Figure 8. Evolution of data rates



Alphawave Semi connectivity solutions for electrical and optical links can be found throughout the datacentre:

- Connectivity Silicon IP is used by our customers to establish these links on their own semiconductors
- In custom (bespoke) connectivity and compute semiconductors, including chiplets
- From 2024, Alphawave will also provide the semiconductors inside optical modules.

Figure 9. Alphawave Semi Solutions