

OPTICAL TRANSCEIVERS FOR DATACOM & TELECOM MARKET 2021

Market & Technology Report - July 2021

Growth in optics is driven by expanding datacom infrastructure and accelerating deployment by Chinese suppliers.

WHAT'S NEW

- Market forecast update
- Other market analyses
- Market share update for datacom and telecom
- Extended roadmaps for optical transceivers and related technologies
- Challenges of pluggable optical transceivers
- Co-packaged optics
- Key parts of optical transceivers and their cost estimates
- Impact of US - China trade war and COVID-19 analysis

REPORT'S KEY FEATURES

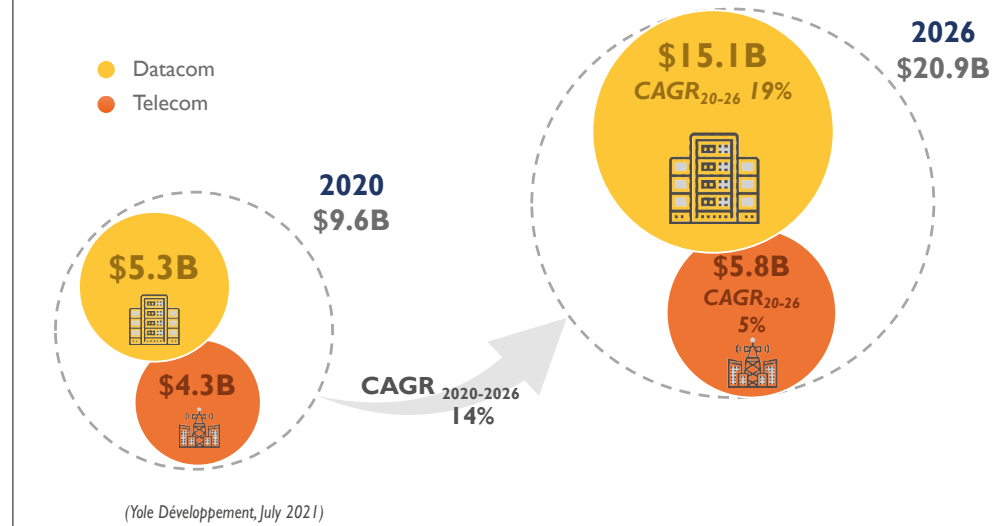
- Drivers of network traffic growth
- Macro trend analyses for both datacom and telecom
- Review of trends in data centers impacting the optical module market
- Detailed market revenue and volume of optical transceivers for 2017-2026 split by applications and data rates
- Detailed ASP evolution
- Comprehensive technology analysis of optical transceivers highlighting the trends for application from intra-data centers up to long-haul
- Comparison technology platforms – InP and silicon photonics in terms of technology and market dynamics
- Status of 400G/800G for datacom and telecom
- Outlook for future technologies - CPO
- Optical transceiver industry analysis

HUGE DEMAND FOR CAPACITY DUE TO EXPANDING DATA CENTER

For the past 50 years, mobile technology innovations have been rolled out each decade. Mobile bandwidth requirements have evolved from voice calls and texting to ultra-high-definition (UHD) video and a variety of augmented reality/virtual reality (AR/VR) applications. In spite of deep implications of the COVID-19 outbreak for the telecom infrastructure supply chain, consumers and business users worldwide continue to create new demand for networking and cloud services. Social networking, business meetings, video streaming in UHD, e-commerce and gaming will drive the continued application growth. The average number of devices connected to the internet per household and per capita is increasing. With the advent of new digital devices

with increased capabilities and intelligence, we observe higher adoption rates each year. Expanding machine-to-machine applications, such as smart meters, video surveillance, healthcare monitoring, connected drives, and automated logistics, contribute in a major way to device and connection growth and push the expansion of data center infrastructure. Revenue generated by the optical transceiver market reached around \$9.6B in 2020 and is expected to reach \$20.9B in 2026 at a 14% Compound Annual Growth Rate for 2020-2026 (CAGR₂₀₂₀₋₂₀₂₆). This growth is driven by high volume adoption of high data rate modules above 100G by big cloud service operators and national telecom operators to increase in fiber-optic network capacity.

2020-2026 optical transceiver revenue growth forecast by market segment



NEW TECHNOLOGY REQUIREMENTS PAVE THE WAY FOR CO-PACKAGED OPTICS

The evolution of multiple technologies has enabled data rates of 400G, 600G, 800G and beyond across data center infrastructure as well as in long-haul and metro networks. 400GbE deployments are ramping across data center networks. Many cloud providers and telecom operators are now looking to 800Gbps optical ecosystem to increase bandwidth capacity and keep pace with the growing demand for data. 800G optical modules can support more

configurations, for example 2x 400GbE, 4x 200GbE or 8x 100GbE. Today's Ethernet switch Application Specific Integrated Circuits (ASICs) are running at a 50Gbps lane rate driven by 50G PAM-4 modulation technology. In line cards, a retimer is typically needed to synchronize PAM-4 data from the switch to the optical interface. In 400G optical modules, an additional silicon gearbox chip can be used to convert 50G PAM-4 electrical inputs and

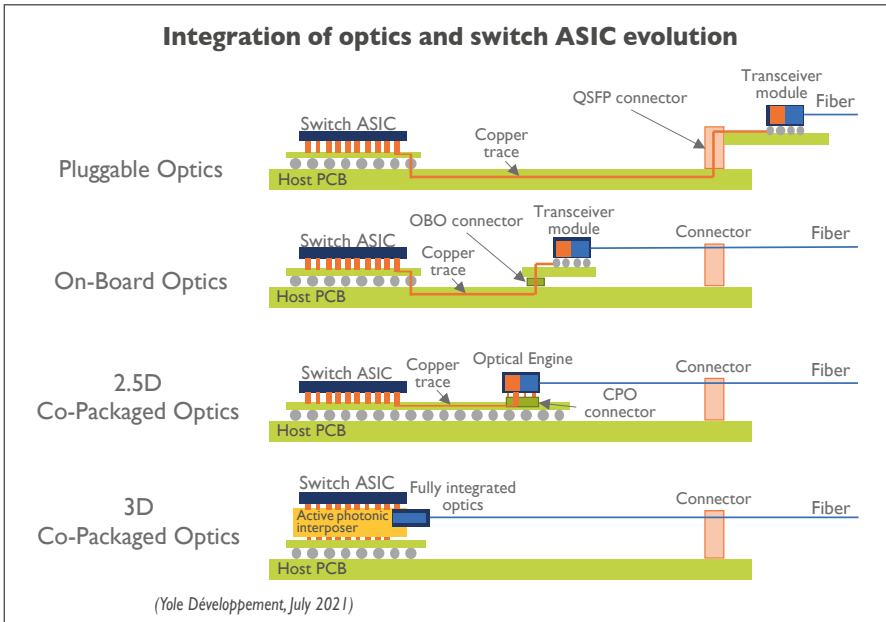
outputs (I/Os) to 100G per wavelength optical I/Os in order to connect to 100G optics. Depending on the application and transmission reach 400G offer various optical interfaces, including 400G SR4, 400G DR4, 400G FR4 and 400G LR4.

We anticipate high popularity of 800G modules as they take advantage of 100G single-wavelength optics already proven in 400GbE systems and thus can be technically and cost-effectively implemented in QSFP-DD and OSFP form factors.

Current form factors will be limited in their ability to support more than 800G capacity in terms of required electrical and optical densities and thermal aspects. Power consumption is another challenge. The largest contributor is the electrical interface between the switch ASIC and optical module, particularly for QSFP-DD and OSFP. As a result of discrete electrical device implementation power dissipation and thermal management are becoming limiting factors for future pluggable optics.

Co-Packaged Optics (CPO) is a new approach that brings the optics and the switch ASIC close together and aims to overcome challenges mentioned above. Furthermore, CPO technology is considered as a new deployment model of the whole ecosystem and alternative to the pluggable optics.

Detailed information on CPO can be found in our brand-new report *Co-Packaged Optics for Data Centers*, which will be released in October 2021.



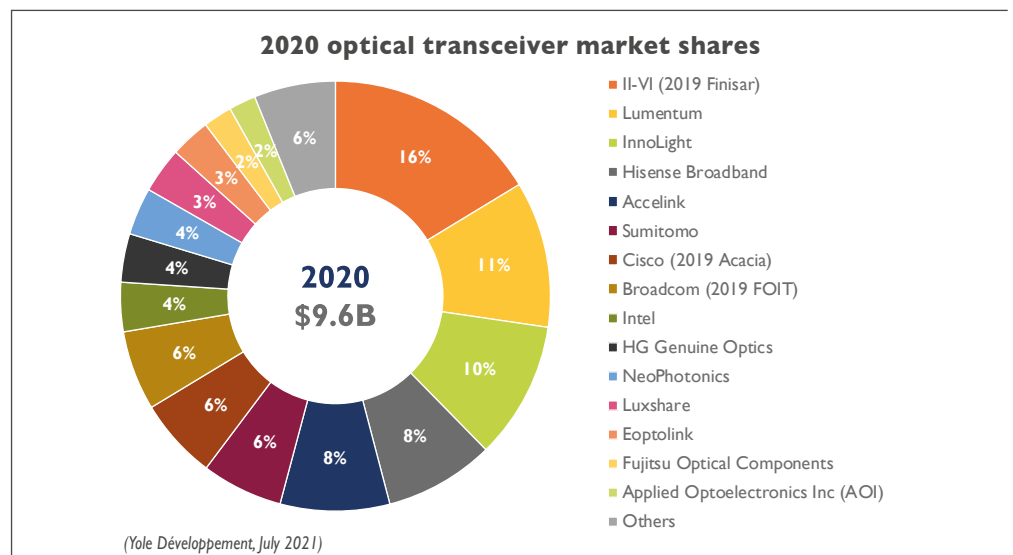
CAN CHINA CATCH UP WITH THE US ON OPTICAL TRANSCEIVERS?

The global optical transceiver industry has been impacted by deteriorating US-China relations. The US government has entered into a trade war, with the ban on ZTE and Huawei, to limit the impact of China on the global economy. For many laser and photonics companies, China represents one of the largest markets and growth opportunities.

As tension between the US and China escalates, China wants to maintain its economic growth by ensuring a secure and controllable technology supply chain as well as building domestic technology sectors to be self-sufficient in those US parts impacted by tariffs. American companies cannot sell in China because they would become targets of consumer boycotts.

The loss of revenue for American photonic companies will far exceed that of their Chinese counterparts.

China also plays an irreplaceable role in the global industrial chain thanks to its value in manufacturing. It would be very difficult to break down the manufacturing chain into high-end devices that might present national security concerns and lower-end devices for which intellectual property sharing and joint-ventures would remain permitted. Yet if the US imposes new tariffs this decoupling may happen, and it will adversely affect the whole optical communication supply chain.



COMPANIES CITED IN THE REPORT (non exhaustive list)

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RELATED REPORTS, MONITORS & TRACKS



- Silicon Photonics 2021
- Edge Emitting Lasers – Technology and Market Trends 2021
- InnoLight’s 400G QSFP-DD Optical Transceiver
- Intel Silicon Photonic 100G PSM4 QFSP28 Transceiver
- Intel Silicon Photonic 100G CWDM4 QFSP28 Transceiver

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REPORT OBJECTIVES

- Understand the global landscape of fiber-optic communication and classify its technologies for newcomers to this field
- Provide straightforward and easy to understand explanations of the technology of optical transceivers
- Examine the application landscape, and associated technologies
- Review the optical transceiver industry and future trends
- Provide detailed market forecasts from 2017 to 2026 for optical transceivers in datacom and telecom



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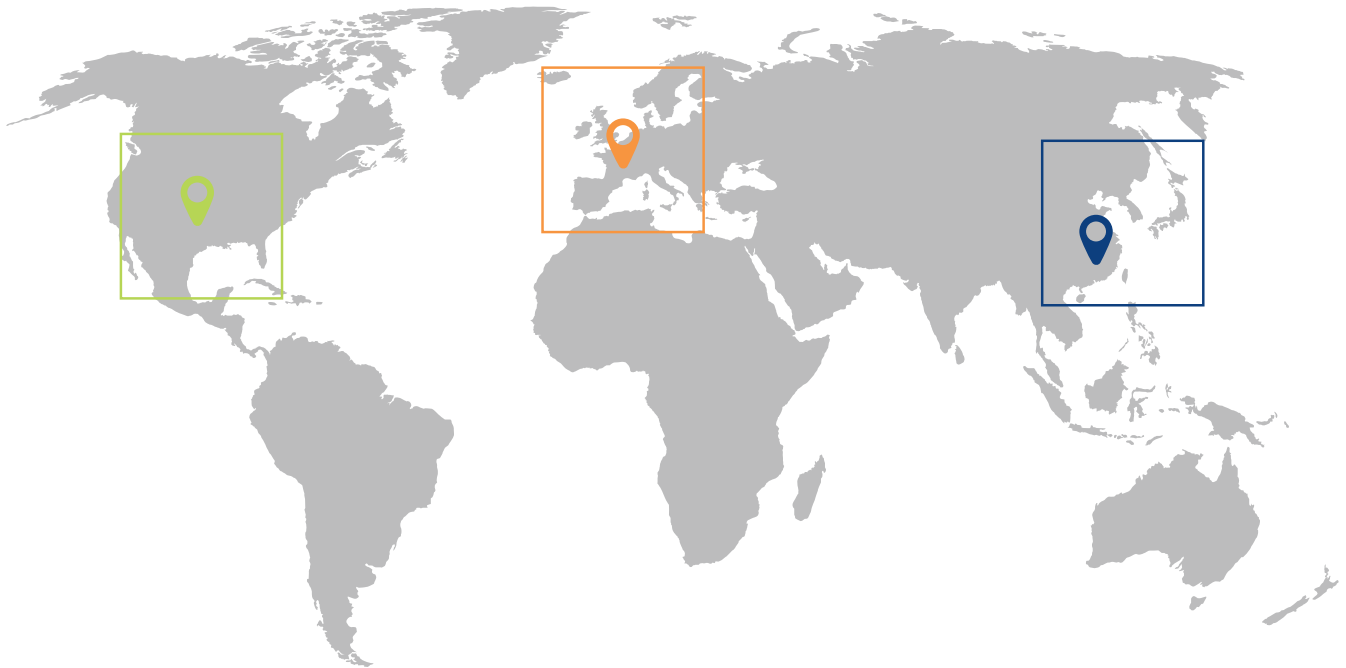
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Prior his mission at Yole, he worked at CEA (Grenoble, France), with a mission focused on the epitaxial growth of InGaN/GaN core-shell nanowire LEDs by MOCVD and their characterization for highly flexible photonic devices. Martin graduated from Academy of Sciences, Institute of Electrical Engineering (Slovakia) with an engineering degree in III-nitride semiconductors.



With more than 25+ years of experience within the semiconductor industry, **Eric Mounier, PhD.** is Fellow Analyst at Yole Développement (Yole). Eric is daily providing deep insights into current and future semiconductor markets and innovative technologies such as Si photonics, MEMS, quantum computing and new type of sensors. Based on a relevant methodology expertise and strong technological background, he is closely working with the overall teams at Yole to point out disruptive technologies and analyze business opportunities. Eric Mounier has a Semiconductor Engineering Degree and a Ph.-D in Optoelectronics from the National Polytechnic Institute of Grenoble (France).

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The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and Blumorpho, supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

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- 2.1 Products are sent by email to the Buyer after Seller’s confirmation:
 - Within a few days from the Seller’s confirmation of the order for Products already released and paid; or
 - Within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.
- 2.2 The Seller shall by no means be responsible for any delay pursuant to Article 2.1 above, in particular in cases where a new event or access to new contradictory information would require the Seller analyst to dedicate extra time to compute or compare the data in order to enable the Seller to deliver a high quality Product.
- 2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in Article 3 above.

2.4. The mailing is operated through electronic means either by email via the sales department or automatically online via an email/password. The Buyer is responsible for ensuring that the Buyers platform has the required capacities and authorisations to receive the Product(s) emailed by the Seller. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that the Seller is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity with the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

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Bank code: 30056
Branch code: 00170
Account n°: 0170 200 1565 87
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To secure the payments due to the Seller, the Seller reserves the right to request down payments from the Buyer. In such case, the need for a down payment will be mentioned on the corresponding order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except as otherwise specifically agreed in writing by the Buyer and the Seller. If the Buyer fails to pay at the due date and fails to request and obtain from the Seller a payment extension, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the “BCE” + 7 points, in accordance with article L.441-6 of the French Commercial Code.

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9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these General Terms and Conditions of Sale or to any Licenses or Products purchased in application thereof shall be submitted to the French Commercial Court of Lyon, which shall have exclusive jurisdiction upon such issues.

9.2 French law (without reference to any applicable conflict of law provisions) shall apply to these General Terms and Conditions of sale and any agreement between the Buyer and the Seller made pursuant thereto.