

InP WAFER, EPIWAFER AND DEVICE MARKET 2021: PHOTONICS AND RF APPLICATIONS

Market & Technology Report - September 2021

With a potential InP market of \$5.2B in 2026, ever-more companies are trying to take part.

WHAT'S NEW

- Introduce bare die market size and market projection by device type and by photonics application
- Key bare die players' market shares and analysis
- Update of applicative market dynamics
- Update of wafer and epiwafer market size by application, and player market shares
- COVID-19 and US-China trade tension impact analysis
- Update of player and market status, with a focus on new players
- Discussion of recent investments, M&As, the competitive advantages of key players, market opportunities, and market dynamics

KEY FEATURES

- Yole Développement's deep understanding of InP penetration in different applications, including telecom, datacom, wearables, automotive LiDAR, 3D sensing, medical and high-speed RF
- Market projections for bare die InP devices in all applicative photonics markets
- State-of-the-art InP-based photonics and RF devices
- Overview of the InP industrial landscape, from wafer, epitaxy, and design to device processing
- Discussion of InP market dynamics
- Status of InP wafer and epi growth technology
- Technical description and analysis of challenges of InP wafer and epi growth technology, InP RF and photonics devices
- Key players market shares and analysis
- Wafer and epiwafer suppliers - Market shares
- Device price breakdown and analysis
- Wafer, epiwafer, and bare die market size and market forecast through 2026, in \$M and units

NEW InP OPPORTUNITIES IN THE EMERGING SENSING APPLICATIONS

The unique properties of InP photonic devices give them a key advantage in the emission and detection at the 13xxnm and 15xxnm wavelengths. Based on the well-established telecom & datacom industry, we are likely to see attractive sensing applications creating new opportunities and a second wave for InP photonic devices. With Apple's interest in working with Rockley Photonics to develop silicon photonic (SiPh) modules that can measure healthcare biological parameters for wearable consumer applications, we expect an initial slight market penetration of InP in 2022, followed by a significant increase to \$255M in 2026 with a CAGR₂₀₂₂₋₂₀₂₆ (Compound Annual Growth Rate) of 112%. For LiDAR applications, InP could be promising, enabling eye safety at higher wavelengths. Players such as Volvo, ZF, Continental, Daimler, etc. are interested in adopting InP-based LiDAR.

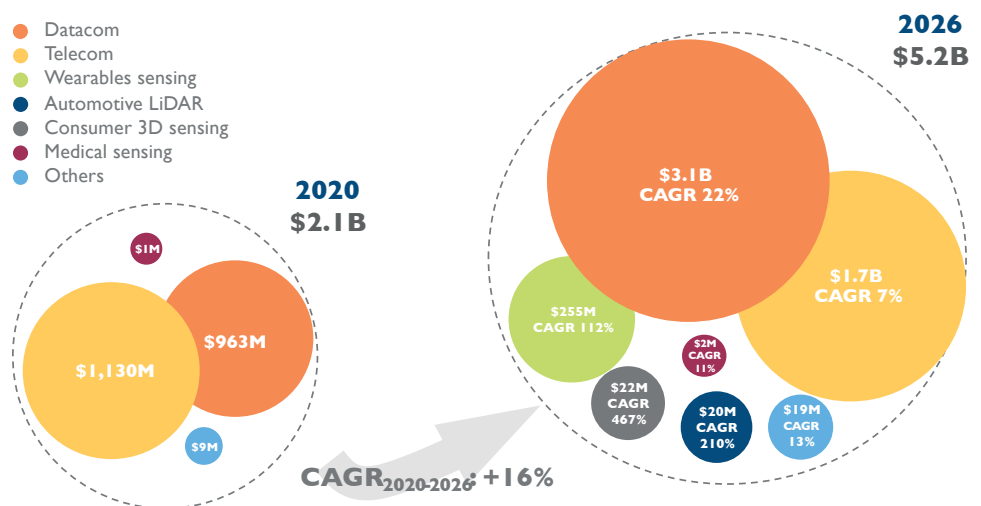
For smartphones, OLED displays are transparent at wavelengths in the range of 13xx to 15xxnm. OEMs interested in removing the camera notch on mobile phone screens and integrating the 3D-sensing modules under OLED displays are considering moving to InP EELs, replacing the current GaAs VCSELs. Even though this trend is currently in an early R&D phase, we see strong interest from several players, such as ams,

Infineon, STMicroelectronics and several laser manufacturers and sensor players.

As an indispensable building block for high-speed and long-range optical transceivers, InP laser diodes remain the best choice for telecom & datacom photonic applications. However, following the COVID-19 outbreak and the US-China trade tensions, telecom infrastructure deployment was disrupted, resulting in a minor InP market slowdown in 2020. Nevertheless, the requirement for more data transfer at higher speed in datacom is increasing, with technology migrating to single InP lasers targeting state-of-the-art 100 Gbps output, making them preferable in 400Gbps and 800Gbps transceivers. Driven by high volume adoption of high data rate lasers, the datacom bare die market reached around \$963M in 2020 and is expected to be worth \$3.1B in 2026 at a 22% CAGR₂₀₂₀₋₂₀₂₆. Meanwhile, the cyclic InP telecom market will continue its growth thanks to 5G deployment and will see an increase from \$1.1B in 2020 to \$1.7B in 2026 at a CAGR₂₀₂₀₋₂₀₂₆ of 7%.

This report provides an overview of the InP wafer and epiwafer market volumes and sizes, a forecast for the RF and photonics markets, as well as a bare die analysis of the photonics market. Yole Développement (Yole) addresses the COVID-19 and trade tension impact on the InP markets.

2020-2026 InP photonics bare-die market forecast, split by application



Consumer 3D sensing CAGR is calculated for 2024-2026
Wearable sensing CAGR is calculated for 2022-2026

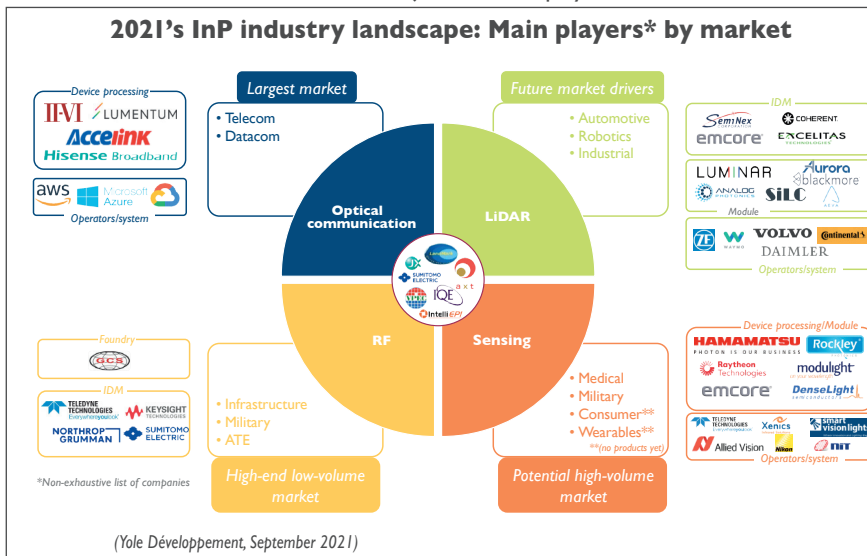
MERGERS & ACQUISITIONS: A DYNAMIC MARKET FOR PLAYERS TO GAIN SHARE AND OPPORTUNITIES FOR NEW PLAYERS TO ENTER THE InP INDUSTRY

The InP industry is fragmented, with numerous players at the device level. Two American players lead the InP market: II-VI and Lumentum. Both have increased their market share and strengthened their position thanks to strategic M&A. II-VI acquired Finisar in 2019, and Lumentum acquired Oclaro in 2018. II-VI and Lumentum both have vertically integrated business models: they generate revenues at bare die, device, and module-level (II-VI also offers epiwafer products). Their combined bare die market share is around 30%. Major Chinese players like Hisense and Accelink

are in the global top five and are increasing their share of the market, taking advantage of the US-China trade tensions and the massive 5G transceiver deployment in Asia.

Sensing applications targeting the mass consumer and automotive markets are attracting new players. Yole has identified several players interested in entering this market: a) Vertically integrated InP players with the know-how and an already established structure, as they can easily switch to sensing applications as soon as the market becomes bigger (e.g., II-VI and Lumentum); b) GaAs players with foundry capabilities could leverage the existing GaAs tools to switch to similar InP processes (e.g., ams and Trumpf); and c) emerging foundries or companies already working on InP-based solutions. In the last category, we witnessed an increase in private investments and SPACs in the last year. These include, in Q4-2020, Luminar, a start-up that makes LiDAR sensors for cars, raised \$590M and went public, then acquired the exclusive InGaAs chip manufacturer OptoGration; in Q2-2021, Aeva, a LiDAR start-up, went public with an initial valuation of \$1.7B; and in Q2-2021, Rockley Photonics announced its intention to go public at an initial valuation of \$1.2B with an Apple supported project for smartwatches.

This report presents an overview of the InP industry covering wafer, epiwafer, and IDM players.

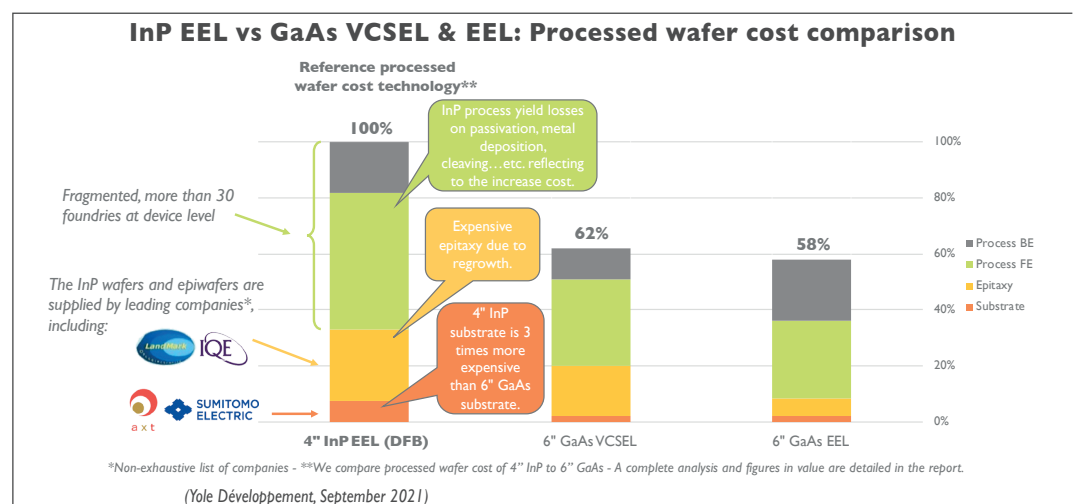


MOVEMENTS IN THE VALUE CHAIN: OPPORTUNITIES AT THE DEVICE LEVEL TO ADD MORE FUNCTIONALITY WHILE WAFER AND EPIWAFER REMAIN CONCENTRATED

The bare die market shows a significant growth rate of 25% year-on-year (YoY) in 2020, compared to the single-digit YoY at wafer and epiwafer markets. The increasing demand for higher data rates contributes to higher \$/Gbps at the laser markets. Due to the diversified needs, the ecosystem at the device level is highly fragmented. Moreover, we identified more than 30 foundries supplied by only a few leading companies, mainly Sumitomo and AXT with more than 80% combined market share at the

wafer level, and Landmark, with 67% of the market at the epiwafer level. This is very well correlated with the cost chart, where the processing cost at the foundry level is more than 67% of the total cost. A complete analysis of price and cost in value are detailed in the report.

A mainstream feature of InP lasers is their distributed feedback (DFB) structure. The complex etching and regrowth lead to yield losses and higher costs compared to GaAs lasers. InP is mainly processed



on 3” and 4” platforms with a much lower wafer volume compared to GaAs’s 6”. These factors also make InP a technology to target high-end, high-margin, and niche applications.

Yole Développement’s InP report will answer numerous questions facing this industry. How can InP enter the consumer market? What does Yole expect for the overall InP market trend?

REPORT OBJECTIVES

- Provide a clear understanding of the InP industry, covering markets from wafers and epiwafers to bare dies – with sales in units and \$M
- Analyze the market drivers and bottlenecks of the InP industry by studying InP adoption for different end-applications and supply chains
- Assess the status and trends of InP device technology
- Describe the industry landscape and market dynamics
- Discussion of recent investments, M&A, and the competitive advantages of key players

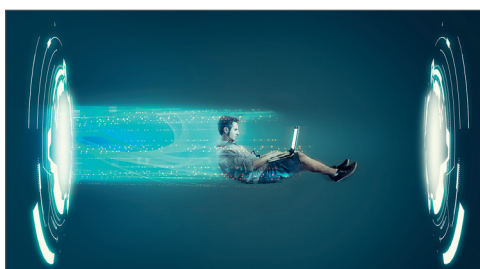
COMPANIES CITED IN THE REPORT (non exhaustive list)

Acacia, Accelink, Aixtron, Amazon, Apple, Alibaba, AOI, AXT, Broadcom, Cengol, Ciena, Cisco, Coherent, Daimler, Denselight, DXT Shenzhen, Duet Microelectronics, Elbana, Ericsson, Emcore, Epic, Facebook, FBH, Finisar, GCS, Google, Hamamatsu, Hisense Broadband, Huawei, II-VI, Imec, Infinera, Innolight, Intel, IntelliePI, IQE, InPact, InPhi, JX Nippon, Keysight, LandMark, Low Noise Factory, Luminar, Lumentum, Macom, Masimo, Microsoft, Mitsubishi Electric, MindSemi, Modulight, Northrop Grumman, NTT, Qorvo, Sanan IC, Sensors Unlimited, Severs, Skyworks, Smart Photonics, Sony, Source Photonics, Sumitomo Electric, Rockley, Teledyne, TrueLight, Veeco, Vertilas, Volvo, VPEC, Wafer Technologies, Win Semiconductor, Xenics, Yunnan Germanium, ZTE and more.

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RELATED REPORTS, MONITORS & TRACKS



- Optical Transceivers for Datacom & Telecom Market 2021
- 3D Imaging and Sensing – Technology and Market Trends 2021
- Silicon Photonics 2021
- II-VI/Finisar 100Gb CWDM4 Optical Transceiver
- Intel Silicon Photonic 100G CWDM4 QFSP28 Transceiver

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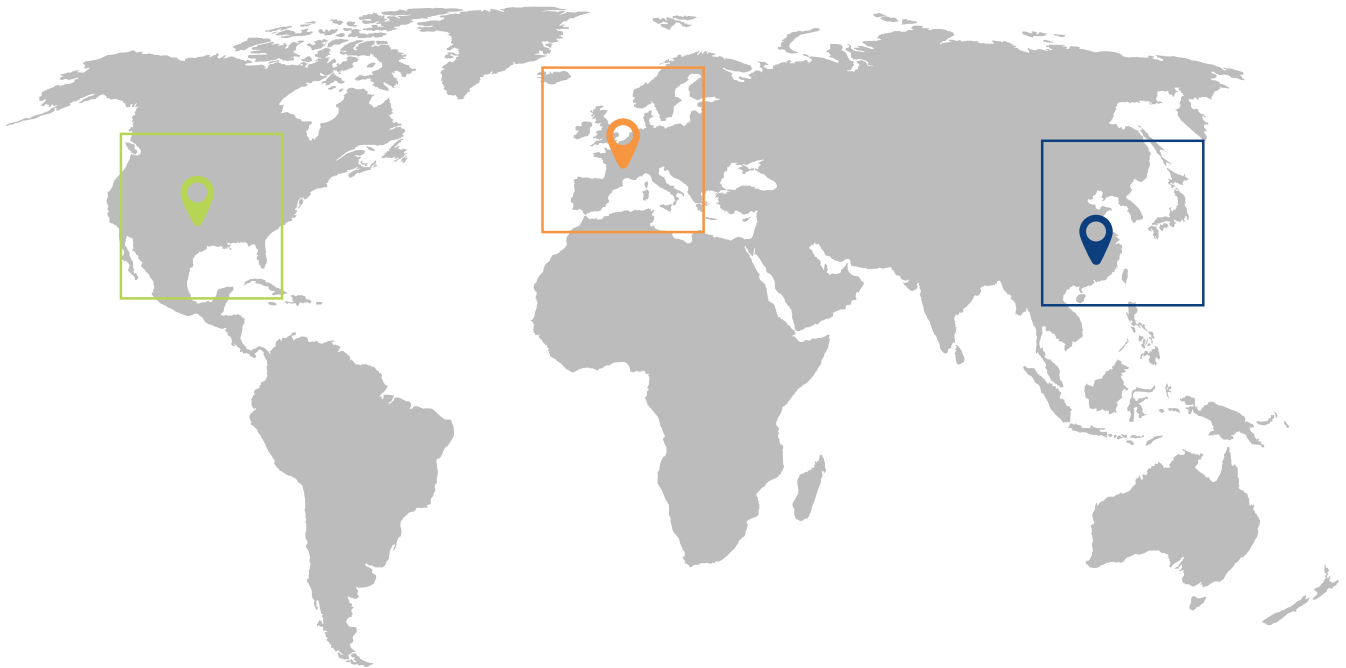
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ABOUT YOLE DEVELOPPEMENT

Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 120 collaborators worldwide covering MEMS and Image Sensors, Compound Semiconductors, RF Electronics, Solid-state Lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Power Electronics, Batteries & Energy Management and Memory.

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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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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6.3 If the Buyer would like to use data coming from a Product for presentations, press announcements and any other projects, the Buyer needs to contact Yole Développement’s Public Relations Director (info@yole.fr) to get an official authorization and confirm that the data are up to date. In return the Seller will make sure to provide up-to-date data under a suitable public format.

6.4 The Buyer shall be solely responsible towards the Seller for any infringement of the obligation described in Article 6.3 above, whether such infringement originates from the Buyer’s employees or any person to whom the Buyer has sent the Products. Furthermore, the Buyer shall initiate and personally take care of any related proceedings in coordination with the Seller, and the Buyer shall bear the related financial consequences in their entirety.

6.5 The Buyer shall define within its Company an identified user who shall serve as a contact person for the License purchased by the Buyer. This person will be the recipient of each new report. This person shall also be responsible on behalf of the Buyer, for compliance with all copyrights and other obligations relating to the protection of the Seller’s IP rights and general compliance with the terms of the License purchased by the Company. In the context of Bundle and Annual Subscriptions, the contact person shall decide within the Buyer which person(s) shall be entitled to receive the protected link that will allow the Buyer to access the Products.

6.6 It is acknowledged and accepted by the Buyer that whether purchased in the form of Bundles or Annual Subscription, all unselected reports will be deemed cancelled and lost after a period of 12 month following acceptance of the corresponding order by the Seller in accordance with provisions of Article 1.3 above .

6.7 It is further acknowledged and agreed by the Buyer that any investor in the Buyer Company, any external consultant of the Buyer Company or any joint venture done with a third party in which the Buyer Company is involved , is not entitled to use a Product, without paying to the Seller the full price for a license to the required Product..

7. TERMINATION

If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be incurred by the Seller, pursuant to such cancellation or postponement.

8. MISCELLANEOUS

8.1 All the provisions of these General Terms and Conditions of Sale are for the benefit of the Seller, but also for that of its licensors, resellers and agents. Each of them is entitled to assert and enforce these provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing and shall be effective upon receipt by the other Party.

8.2 The Seller may, from time to time, update these General Terms and Conditions of Sale, and the Buyer, shall be deemed to have accepted the latest version of such General Terms and Conditions of Sale, once they have been duly communicated to the Buyer by the Seller.

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.