

GaAs WAFER AND EPIWAFER MARKET: RF, PHOTONICS, LED, DISPLAY AND PV APPLICATIONS 2020

Market & Technology Report - June 2020

Photonics applications boost the GaAs wafer and epiwafer market with double digit growth.

WHAT'S NEW

- Covid-19 impact analysis
- Updated wafer and epiwafer market segmentation
- Detailed analysis of GaAs wafer and epiwafer market in display, LED and microLED
- Overview of VCSEL and EEL technologies
- Supply chain update with newly identified players

KEY FEATURES

- Market size for GaAs wafers to 2025 in \$M and units, split by RF, photonics, LED, display and PV applications
- Market size for GaAs epiwafers to 2025 in \$M and units, split by RF and photonics applications such as VCSELs and EELs
- GaAs wafer and epiwafer ASP
- Description of the industrial landscape covering GaAs wafer suppliers, epiwafer suppliers and GaAs devices suppliers, split by RF, photonics, LED, display and PV applications
- Outline of RF, photonics, LED, display and PV applications

THE GaAs WAFER AND EPIWAFER MARKET OUTLOOK IS PROMISING

In the past few years, the GaAs wafer market has been dominated by Radio Frequency (RF) applications. But as of 2019, photonics and LEDs represent the main drivers for this market. The total GaAs market will increase from \$200M in 2019 to more than \$348M by 2025, with a Compound Annual Growth Rate (CAGR) of 10%.

RF is the historical market driver for GaAs wafers. In 2019 it represented 33% of market volume and 37% of market value. RF represents 67% of the GaAs epiwafer open market. GaAs RF demand is mainly driven by handset evolution, with the transition to 5G resulting in greater penetration of GaAs power amplifiers (PAs) for the high-end sub-6GHz phones.

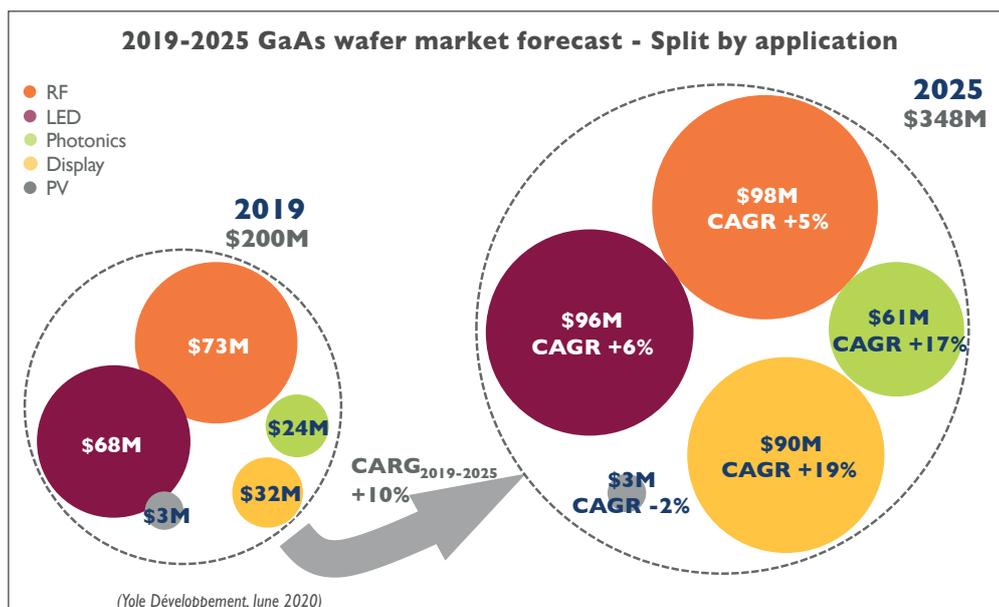
Photonics has a 5% share of wafer volume, corresponding to a \$24M market. However, the photonics market will have a double digit CAGR, with GaAs Vertical Cavity Surface Emitting Laser (VCSEL) technology strongly dominating this market. The importance of the photonics applications means that they represent 32% of the GaAs epiwafer open market.

With the transition of LEDs from low-end applications to high-end applications, such as

horticulture lighting or automotive, LEDs still represent the highest GaAs wafer market volume with 41% share. Automotive will be the main driver for visible LEDs and infra-red (IR) LEDs, with a dynamic 6% CAGR envisaged from 2019 to 2025.

GaAs will find another source of growth in the display market, driven by hot new applications such as microLEDs. Yole Développement (Yole) analysts forecast the CAGR of the display market to be 19% in the 2019-2025 timeframe.

Given the Covid-19 outbreak at the beginning of 2020, the market outlook is strongly impacted by sales of mobile, consumer and automotive end systems. This report includes three different scenarios and presents the impact of each scenario on the market evolution and production recovery. It conveys Yole's understanding of GaAs implementation in different market segments. It also includes an overview of different applications, specifically RF, LED, display, photonics, and photovoltaics (PV). Furthermore, Yole shares its view of the wafer and epiwafer market's current dynamics and future evolution.



VCSELS AND MICROLEDS WILL DRIVE THE GaAs MARKET

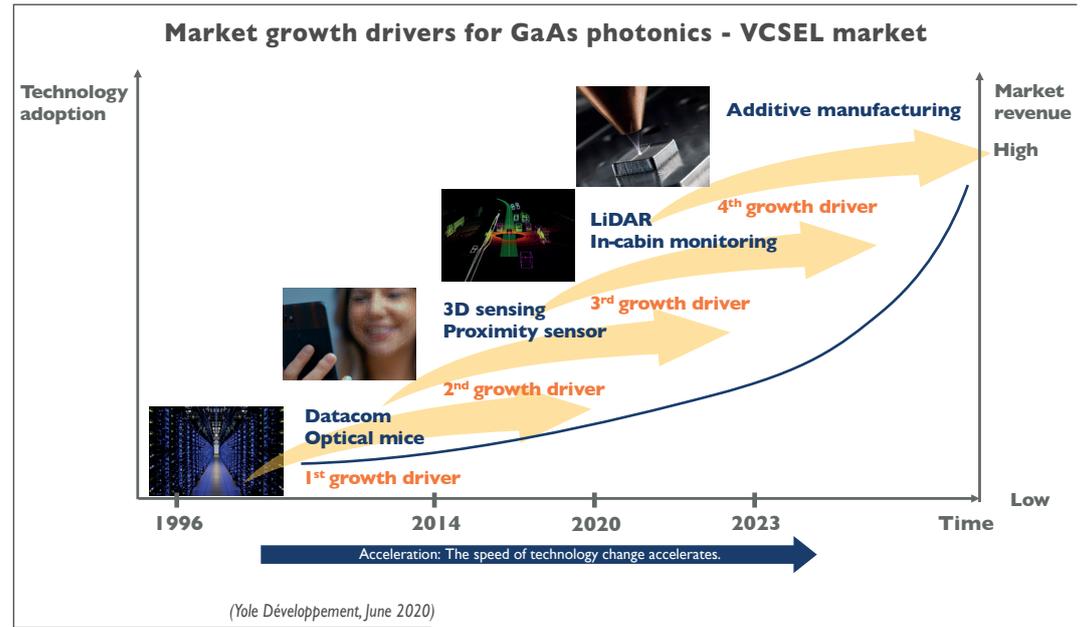
Historically, GaAs photonics was a relatively small market mainly focused on datacom applications. However, since the introduction of a 3D-sensing function in the iPhone X by

Apple in 2017 and following the adoption of GaAs VCSELs by Android platforms, the VCSEL market has seen a surge in related GaAs wafer and epiwafer production. Along with 3D

sensing, VCSELs and Edge Emitting Lasers (EELs) have great potential to be used in Light Distance and Ranging (LiDAR) technology for automotive applications, where they are both competing for short and mid-range detection. Today, VCSELs have paved the way for the GaAs wafer market to grow significantly by entering big consumer markets such as cellphones and automotive. Yole analysts expect the VCSEL GaAs wafer market to grow at a remarkable CAGR of 18% from 2019 to 2025.

On the other hand, the direct view display market has seen growth driven by applications such as control rooms, corporate and indoor

home theatre. In this context, MicroLED microdisplays emerged as a potential technology that can provide high performance, in terms of brightness, form factor, color and contrast. The fast progress in the prototyping of microLEDs is appealing to many manufacturers. MicroLEDs have the possibility of driving GaAs wafer market growth, with a conservative case of \$46M in 2025, and an optimistic case where microLEDs could contribute tenfold more in 2025. In this report, Yole also highlights the challenges of microLED technology mass production for consumer grade products.



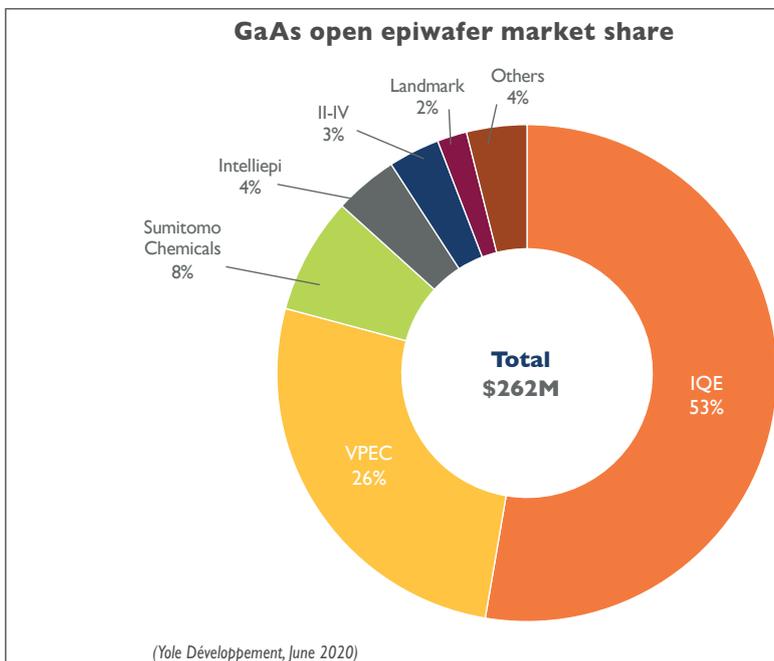
HOW IS THE GaAs WAFER AND EPIWAFER LANDSCAPE EVOLVING?

The GaAs epiwafer supply chain is constantly changing. In the photonics market, the epiwafer business model is application dependent. In datacom, it is mostly integrated, dominated by Finisar, Avago and II-VI. However, for 3D sensing

and other VCSELs for smartphones, manufacturers prefer to outsource the epitaxy, a less complicated strategy adopted by Apple, which is supplied by IQE. IQE remains the biggest epiwafer supplier, with 61% photonic epiwafer market share in 2019. But, with increased adoption of 3D sensing, numerous players such as VPEC, II-VI, Sumitomo Chemicals and Landmark are ramping up their production.

The RF GaAs epitaxy market is about 90% outsourced. Previously it was largely dominated by IQE, nevertheless it has lost share to the Chinese-Taiwanese supply chain. As of 2019, IQE and VPEC represent more than 80% of the RF epi market. The LED epiwafer market remains almost entirely integrated within very well established companies like Osram, San'an, Epistar, and Changelight.

In terms of GaAs wafer supply, Freiburger, Sumitomo Electric, AXT and Vital Materials lead the market in 2019. The top players have a bigger market share in high end applications, and due to stringent laser grade wafer specifications, they will keep their advantage for the next 5-8 years. The outlook for new Chinese GaAs suppliers is challenging, they recently entered the market with low-end products for LED. However, their transition to high-end



products and expansion out of China is risky due to potential IP infringement issues.

There are interesting questions outstanding. Will some LED suppliers enter the VCSEL market? What are the challenges for epi-houses who want to switch from LEDs to VCSELs or microLEDs?

This report provides an overview of the GaAs industrial landscape, covering the value chain from wafer and epitaxy to device. This report also outlines Yole Développement's understanding of the market's current dynamics and future evolution.

REPORT OBJECTIVES

Determination of GaAs wafer and epiwafer market dynamics:

- Technical description of GaAs wafer growth and epi growth technology
- Wafer and epi wafer market size and market forecast, in \$M and Munits
- Ecosystem identification and analysis
- Key players by market
- Main technical challenges

Analysis and description of the markets and technologies involved:

- Technical market segmentation focused on "the big five" markets: RF, Photonics, LED, display, PV
- Market trends and forecast
- Technology trends
- Major players worldwide

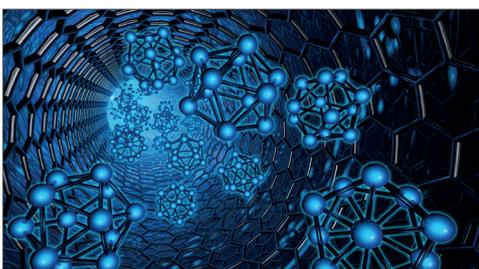
COMPANIES CITED IN THE REPORT (non exhaustive list)

AXT, Alight Technologies, Alta Devices, AMS, Apple, APT Electronics, Arima, Avago, AWSC, Broadcom, Bridgelux, Changelight, China Crystal Technologies, CMK, Dowa, Epistar, Epitex, Finisar, Flir, Freiburger Compound Materials, Fuji Xerix, GCS, HC Semitek, Hexawave, Hiwafer, Huntersun, II-VI Epiworks, Inneas, IntelliEPI, IQE, Landmark, Lasertel, Lumentum, Lumileds, Masimo., Mediatek, Microlink Devices, Mitsubishi Chemical, Nichia, Optowell Korea, Osram, Philips Photonics, Qorvo, Qualcomm, RayCan, RDA, Ricoh, Sanan IC, Santec, SCIOCS, Semiconductor Wafer Inc., Skyworks, Solaero, Sony, Sumitomo Chemical Advanced Technologies, Sumitomo Electric, Thorlabs, Trilumina, True Light Corp.,TT Electronics, UMS, Vanchip, Vertilas, Vital Materials, VPEC, Win Semiconductor, Xiamen Powerway, Yunnan Germanium, and more.

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RELATED REPORTS, MONITORS & TRACKS



- Compound Semiconductor Quarterly Market Monitor
- MicroLED Displays – Intellectual Property Status & Landscape 2020
- VCSELs – Market and Technology Trends 2019
- 5G's Impact on RF Front-End Module and Connectivity for Cell phones 2019
- RF Front-End Module Comparison 2020 – Volume 2

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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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- Marketing & Communication: Camille Veyrier (camille.veyrier@yole.fr)
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 - 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.

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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.

2.6 No return of Products shall be accepted without prior written notification from the Buyer to the Seller, even in case of delayed delivery. Any Product returned to the Seller without the Buyer providing prior notification to the Seller as required under Article 2.5 above shall remain at the Buyer’s risk. In no event shall the Seller incur any liability for Products erroneously ordered by the Buyer, or for any request from the Buyer to replace a Product previously ordered by a different Product.

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3.2 Payments due by the Buyer shall be sent by cheque payable to Yole Développement, or made by credit card or by electronic transfer to the following account:
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Bank code: 30056
Branch code: 00170
Account n°: 0170 200 1565 87
BIC or SWIFT code: CCFRFRPP
IBAN: FR76 3005 6001 7001 7020 0156 587

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.

3.4 The Seller publications (reports, monitors, tracks...) are due for delivery only after receipt by the Seller of any payment due by the Buyer prior to delivery.

3.5 In the event of termination of the contract by the Seller attributable to Buyer misconduct during the contract, the Seller will have the right to invoice all work performed at the time of termination, and to take legal action for damages.

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4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for the choice of the Products purchased as well as for the use and interpretations the Buyer makes of the documents it purchases, of the results the Buyer obtains, and of the advice and acts the Buyer bases thereon .

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4.3 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

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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 .

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