

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

Market & Technology report - July 2018

Photonics applications are driving the GaAs wafer and epiwafer market into a new era.

KEY FEATURES

- Market size for GaAs wafer, up to 2023 (\$M and units), split by RF, photonics, LED, and PV applications
- Market size for GaAs epiwafer, up to 2023 (\$M and units), split by RF and photonics applications (VCSEL, EELs, etc.)
- GaAs wafer and epiwafer ASP
- Description of the industrial landscape covering GaAs wafer suppliers and epiwafer suppliers
- Outline of RF, photonics, LED, and PV applications
- MOCVD market estimate

AFTER FINDING SUCCESS IN THE GaAs RF MARKET, GaAs PHOTONICS IS NOW A RISING STAR

As one of the most mature compound semiconductors, GaAs has been ubiquitous as the building block of power amplifiers in every mobile handset. In 2018, the GaAs RF business represents more than 50% of the GaAs wafer market. However, market growth has slowed down in the past couple years due to the handset market's gradual saturation and shrinking die size. With the transition from 4G to 5G, Yole Développement expects GaAs to remain the mainstream technology for sub-6 GHz instead of CMOS, owing to GaAs' high power and linearity performance as required by carrier aggregation and MIMO technology.

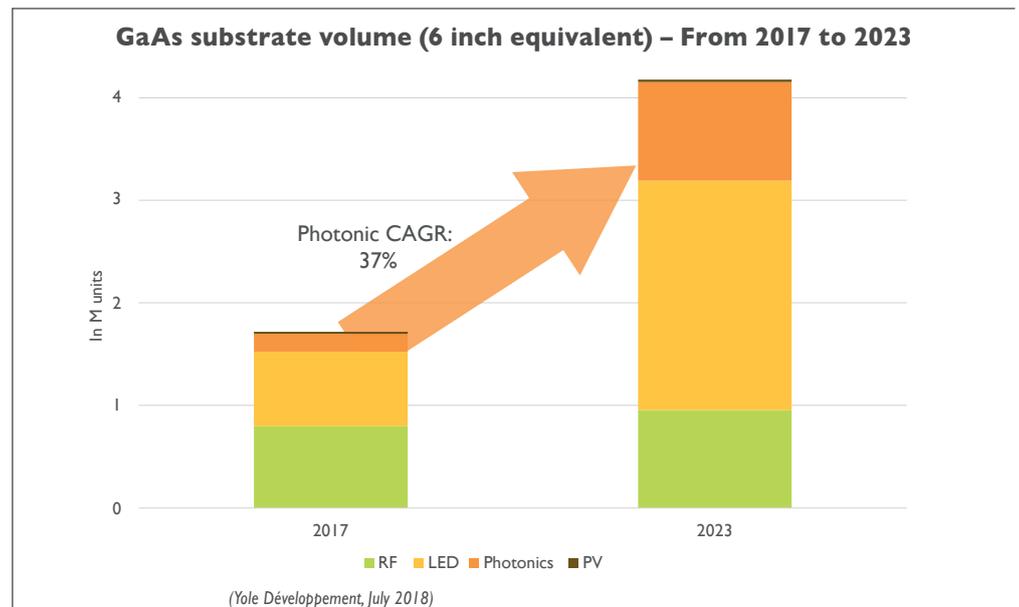
Since 2017, GaAs wafer has been particularly notable in photonics applications. When Apple introduced its new iPhone X with a 3D sensing function using GaAs-based lasers, it paved the way for a significant boost in the GaAs photonics market. Yole Développement (Yole) expects GaAs wafers for photonics applications to grow at a CAGR of 37%

from 2017 - 2023 (in units), reaching around \$150M by 2023.

GaAs-based red-orange-yellow (ROY) and infrared LED applications have also caught our attention. Yole expects an impressive 21% CAGR from 2017 - 2023 (in units) for the total GaAs LED market, surpassing more than half of GaAs wafer volume by 2023.

In terms of the wafer and epiwafer businesses, each application requires a different size and quality when determining wafer and epiwafer prices. As a new entrant, photonics applications will impose new specification requirements compared to the well-established RF and LED wafer and epiwafers, creating significant ASP diversity.

This report provides an overview of the GaAs wafer and epi wafer market size and market forecast in four big applicative markets: RF, Photonics, LED, and PV. This report also outlines Yole Développement's understanding of the technical description of GaAs wafer and epiwafer growth, and the main challenges.



GaAs PHOTONICS: SMARTPHONES TODAY, AUTOMOTIVE TOMORROW?

Today the GaAs wafer and epiwafer markets are entering a new era, with optoelectronic taking the limelight from GaAs RF applications. Not too long ago, GaAs photonics was a relatively tiny market whose principal application was data centers. But ever since the introduction of a 3D

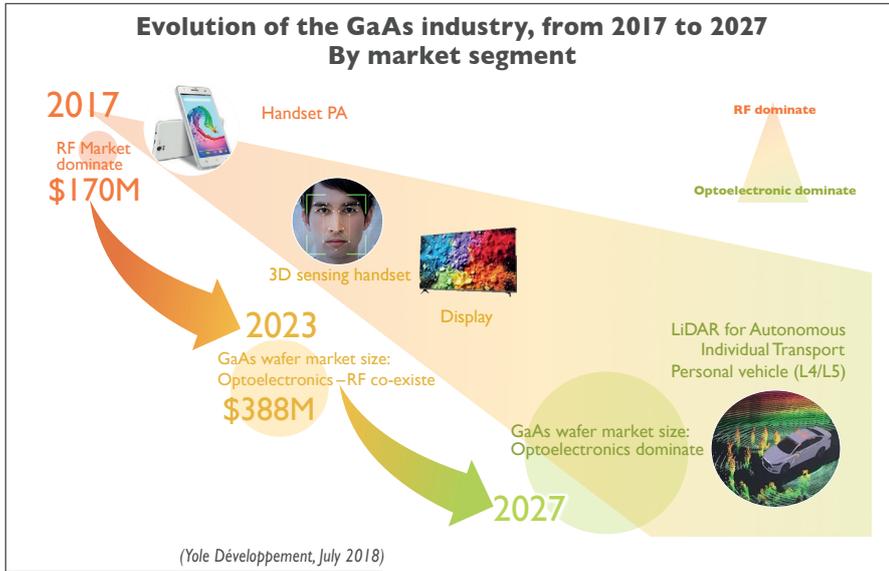
sensing function using GaAs-based VCSELs in Apple's iPhone X, GaAs VCSEL has attracted huge attention. Indeed, three sensor modules based on GaAs VCSELs are used in the iPhone X for facial recognition: 1) proximity sensor for activity/human detection; 2) flood illuminator for face and

eye detection in daytime or night; and 3) dot projector for facial recognition. With the potential adoption of this technology by Android platforms, Yole analysts' expect the GaAs wafer market segment to grow at a remarkable 58% CAGR from 2017 - 2023.

Moreover, the GaAs photonics market is not limited to VCSEL applications. LiDAR is a key technology allowing the creation of a 3D map of surroundings for autonomous vehicles and robotics. This emerging application uses high power and large-size, GaAs-based edge-emitting laser (EEL) devices, which will represent an incredible boost for the GaAs photonics wafer market.

Along with the GaAs photonics wafer market's remarkable growth, ROY and infrared LEDs on GaAs substrate are expected to evince strong growth potential. Large display, automotive, and horticultural lighting applications are main drivers for red LEDs, posting a CAGR 2017 - 2023 of 21% (in \$M) for the ROY GaAs wafer market. Similarly, GaAs-based IRLEDs used in medical sensors for blood pressure and blood sugar, as well as proximity sensors for gesture recognition in smartphones and automotive, are growing market segments.

Yole invites you to read its analysis and detailed description of each market segment, along with an overview of technology trends and ecosystem identification.



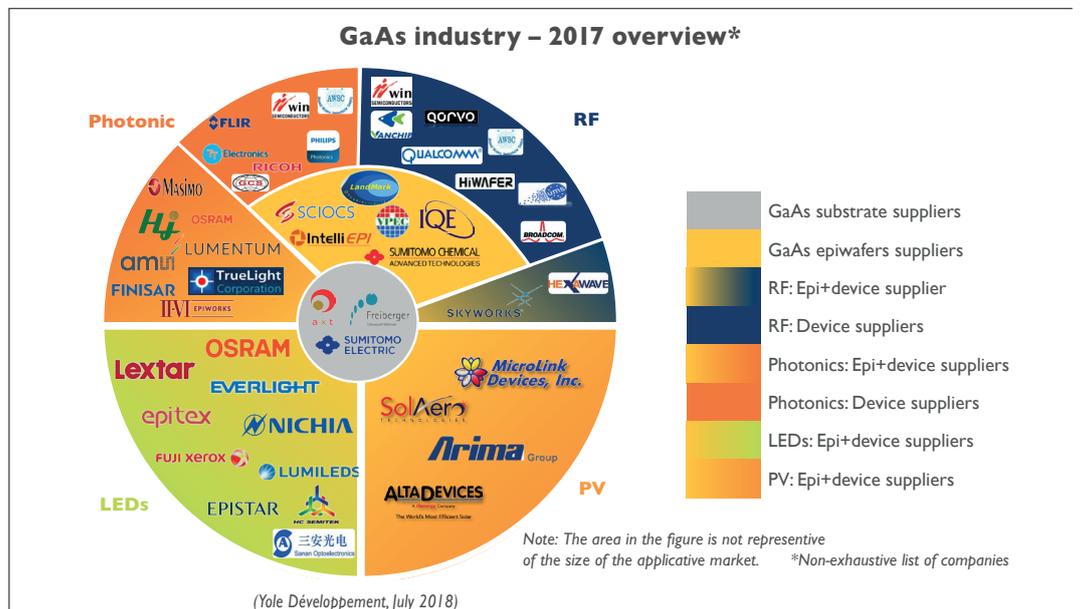
INDUSTRIAL PLAYERS ARE EMBRACING THIS NEW ERA

The GaAs photonics market's remarkable growth potential will offer plenty of value chain opportunities for wafer, epiwafer, and MOCVD equipment suppliers, as well as for investors.

In terms of GaAs wafer supply, Sumitomo Electric, Freiberger Compound Materials, and AXT lead the market with about 95% of market share collectively. And since new laser applications have very high specification requirements for GaAs wafer that are constantly evolving, Yole analysts' expect the top players to maintain their technical advantage for at least another 3 - 5 years. Meanwhile, Chinese GaAs wafer suppliers like Vital Materials, which have grabbed part of the LED market from the leading suppliers, are expected to increase their share thanks to LED markets.

For GaAs epiwafer production, there are different business models. The GaAs LED market is principally vertically integrated, with very well-established IDMs like Osram, San'an, Epistar, and Changelight. On the other hand, GaAs RF businesses outsource significantly from well-established epihouses. Over the last number of years, the GaAs RF epi business has gone through many consolidations, resulting in four major actors today: IQE, VPEC, Sumitomo Chemicals (including Sumitomo Chemical Advanced Technologies and SCIOCS), and IntelliEPI.

Regarding the GaAs photonics market, the epi business is still applications-dependent. The GaAs datacom market is mostly epi-integrated, with dominant IDMs like Finisar, Avago, and II-VI. For 3D sensing in smartphones, epi outsourcing is significant.



In 2017, Apple's supplier Lumentum used IQE as its VCSEL epi supplier. This resulted in an almost 10x increase in IQE's stock price. Other leading GaAs epihouses are in qualification or ramping up. Yole expects the photonic epiwafer market to behave similar to the GaAs RF epiwafer market.

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

OBJECTIVES OF THE REPORT

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 four big applicative markets: RF, Photonics, LED, PV
- Market trends and forecast
- Technology trends
- Major players worldwide

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