**KEY FEATURES**

- The power device market expanded by 13.9% in 2018 compared to 2017, leading to a second consecutive high growth year in the power electronics market after a couple of flat years.
- The power electronics semiconductor market reached $17.5B in 2018, not including power ICs.
- In 2018 there was a shortage of 200mm wafers arising from high demand for power electronics devices.
- 2019 started positively, but customer demand is falling because major customers still have device inventory from last year.
- Main players are investing in enlarging their manufacturing capabilities, investing in 300mm fabs for power devices.
- The IGBT and MOSFET markets will continue to increase but part of the market will go to SiC, especially when talking about modules for EV/HEVs. However, SiC remains small compared to the Silicon market, still accounting for less than a 10% share by 2024.
- The power module market is expected to increase its share in coming years compared to discrete devices.

**POWER ELECTRONICS MANUFACTURERS ARE EXPANDING THEIR FAB CAPABILITIES TO 300MM**

The power electronics industry is experiencing a shift in its dynamics. The shift comes from the increase of demand predicted for coming years, which translates into a move for 300mm wafer-based production. In 2018 there was saturation of 200mm wafer demand, leading to wafer price rise instead of wafer supply. As of today, more than seven power electronics players have announced investments in new fabrication capabilities, to be in production from 2021.

Infineon has invested $1.9B in Villach to build a second fab for power devices on 300mm wafers. STMicroelectronics has also started the expansion of its Agrate site for 300mm production, for Bipolar CMOS-DMOS, power MOSFETs and IGBTs. Another example is Bosch, which has also started building its 300mm fab in Dresden, preparing for the imminent increase in volumes for both automotive and Internet of Things (IoT) applications. Chinese players have also started the expansion to 300mm, like Silan Microelectronics or GTA Semiconductors, the latter having confirmed that it is working on its automotive-grade IGBT production line.

A concern with these moves might be the equipment delivery time. This is one of the reasons why players such as ON Semiconductor and Diodes Inc have acquired an existing fab. Such acquisitions also require lower investments. The ramp up for production for ON Semiconductor will therefore be in 2020 with advanced CMOS technology. Once that transfer is complete in 2022, the equipment can be used for a possible ramp up in power devices, depending on demand, as the equipment will already be established. A choice must be made.

We will have to keep a close eye on the next steps of the power electronics players as they shape the power semiconductor industry in coming years. An overview of the full power supply chain and a focus on the 300mm transition is included in this report.

**ELECTRIC GRATICATION IS STILL THE KEY MARKET DRIVER OF THE POWER ELECTRONICS INDUSTRY**

The power electronics market comprised $53.4B for power inverters in 2018, and $17.5B for power semiconductor devices. Key driving factors include electrical power conversion optimization and expansion, driven by electrification trends in transportation, CO₂ emission reduction goals, the development of clean electricity sources, and industrialization. We can say that the main driving application with a huge market potential and technological innovation is electric and hybrid electric vehicles (EV/HEVs). But let’s not forget that
there are other applications that are boosted by electrification needs and by EV/HEVs. This is the case in renewable energy, which is boosted by clean driving trends and growing electricity consumption. More grid lines also need to be deployed to sustain greater amounts of required energy. Similarly, more energy storage systems need to be deployed for better distribution of the energy to the grid. The grid must also reach newly installed EV charging stations outside cities, enabling many cars to be plugged in at the same time with an acceptable charging time. Moreover, if we take into account automated driving and long term vehicle-to-everything (V2X) communication, more data centers could be required, more LiDAR systems, along with other supporting technology. Hence, we are living an era where established applications are boosted by electrification and also by the EV/HEV transition, making the power electronics market very interesting to follow.

How are these applications evolving? Which are the main drivers? How is this translating to power semiconductors? And to Silicon substrates? All of these topics are discussed in this report.

**SEMICONDUCTOR MARKET EVOLUTION TOWARDS HIGHER POWER OFFERS**

**MODULES A BOOST**

The module market is today motivated by high power efficiency and density requirements from the main power applications. Still today, modules represent 23% of the total market. But we now see the push from end-user demand for new applications such as energy storage, charging infrastructure or EVs. These applications, and conventional ones like renewable energy and motor drives, will use modules with different power levels and reliability requirements. This will lead to a vast choice of power modules in the coming years. Power modules are being developed with new substrates, die attach materials or new semiconductor materials. Different players are focusing on innovation for modules and pushing production to enter this market. On the other hand, established players are fighting for their position in the market through innovation and delivering good product offerings.

The power electronics semiconductor market is in a growth period, which started in 2017 and continued in 2018. It is now saturated for some segments, specifically MOSFETs in 2019, but high demand is expected to continue. Yole Développement (Yole) expects a 4.5% Compound Annual Growth Rate (CAGR) from 2018-2024 for IGBT modules, while discrete IGBT parts’ CAGR will be 2.7%. These forecasts are directly linked with investments in manufacturing lines from different players mentioned previously. Note also that the IGBT module market will be directly affected by the penetration of SiC during coming years, with a big push in the EV segment. This is indeed a worthy market to follow!

In this report, Yole summarizes the different markets in the power semiconductor area, from the silicon wafer to the discrete device, module and inverter.

**Power electronics landscape: key players* and repartition of their activities**

*Non-exhaustive list of companies

(Yole Développement, August 2019)
REPORT OBJECTIVES

• Assess the market for wafers, devices, modules and inverters
• Understand the market dynamics for the whole power electronics industry
• Identify the key drivers that will shape the market in the future
• Have an overview on the different components used in power electronics and its integration
• Understand the main technological challenges to overcome and the solutions developed so far
• Provide a clear overview of the different applications driving the power electronics business
• Present data ranking the power electronics industry leaders, describing supply chain consolidation, the latest M&A activity and future trends in the power player landscape

COMPANIES MONITORED IN THE PRODUCT

TABLE OF CONTENTS (complete content on i-Micronews.com)

What we got right, what we got wrong 16
Executive summary 17
Context 56
Market forecasts 66
> Overall power electronics market
> Wafer market forecast
> Power device market
> Power MOSFET market
> Power IGBT market
> SiC and GaN market share
> Global discrete market share
> IGBT module market
> Global module market and shares
> Si vs SiC vs GaN
> Discrete packaging materials market
> Inverter market
Market trends 90
> Market trends: by market
> EV, rail, charging infrastructure, PV, wind, UPS, computing, power supply, motor drives, consumer, home appliances, telecom, energy storage
> Market trends: by product
> Wafer, MOSFET, IGBT
> Fab capacity focus
Market shares and supply chain 127
> Key power electronics players
> Overall revenue ranking
> Power revenue ranking
> Power electronics landscape
> Supply chain analysis
> Silicon wafer landscape and market shares
> Power MOSFET market shares
> IGBT discrete and module market shares
> Packaging supply chain and players including main material players
> Passives supply chain
> Li-Ion battery supply chain
> Inverter and power stack supply chain
> M&A, collaboration, fundraising
> Focus on China
Technology trends 171
> Challenges, main requirements and innovation axes
> Integration
> Harsh environments
> Current sensors
> Packaging
> Discrete, module, packaging trends, integration, SiC packaging, GaN packaging
> Wide band gap
> Highlights, commercial devices, SiC inverters, passive needs for WBG, packaging for WBG, reliability analysis
> Batteries
> Batteries for EV, other driving applications, manufacturing trends
Outlooks 226
Yole corporate presentation 233

WHAT’S NEW

• Update on power electronics wafer level market from 2018 to 2024
• Update on power electronics’ major discrete and module segments, specifically IGBT and MOSFET, from 2018 to 2024
• Updated global SiC and GaN markets
• Forecast comparison for discretes and modules by type of device and material
• Update of power electronics inverter market from 2018 to 2024
• Market and technology trends for each power electronics application
• Company revenues in 2018
• Power electronics player ranking and landscape analysis for 2018
• Analysis of the latest M&A activity
• Overview of technology status for power electronics
• Focus on packaging trends
• Wide band gap update

RELATED REPORTS

Benefit from our Bundle & Annual Subscription offers and access our analyses at the best available price and with great advantages

• Status of the Inverter Industry 2019
• Discrete Power Device Packaging: Materials Market and Technology Trends 2019
• Status of Rechargeable Li-ion Battery Industry 2019
• Power SiC 2019: Materials, Devices, and Applications
• Power Electronics for EV/HEV 2018

Find all our reports on www.i-micronews.com

AUTHOR

Ana Villamor, PhD serves as a Technology & Market Analyst, Power Electronics & Compound Semiconductors within the Power & Wireless division at Yole Développement (Yole). She is involved in many custom studies and reports focused on emerging power electronics technologies at Yole Développement, including device technology and reliability analysis (MOSFET, IGBT, HEMT, etc). In addition, Ana is leading the quarterly power management market updates released in 2017. Previously Ana was involved in a high-added value collaboration related to $I$ Power MOSFETs, within the CNM research center for the leading power electronic company ON Semiconductor. During this partnership and after two years as Silicon Development Engineer, she acquired a relevant technical expertise and a deep knowledge of the power electronic industry. Ana is author and co-author of several papers as well as a patent. She holds an Electronics Engineering degree completed by a Master and PhD. in micro and nano electronics from Universitat Autonoma de Barcelona (SP).
**ORDER FORM**

**Status of the Power Electronics Industry 2019**

**BILL TO**

<table>
<thead>
<tr>
<th>Name (Mr/Ms/Drs/Pr)</th>
<th>Job Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>City:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Postcode/Zip:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

*VAT ID Number for EU members:

<table>
<thead>
<tr>
<th>Tel:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Email:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**PAYMENT**

**BY CREDIT CARD**

<table>
<thead>
<tr>
<th>Visa</th>
<th>Mastercard</th>
<th>Amex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of the Card Holder:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credit Card Number:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Card Verification Value (3 digits except AMEX: 4 digits):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expiration date:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**BY BANK TRANSFER**

BANK INFO: HSBC, 1 place de la Bourse,
F-69002 Lyon, France,
Bank code: 30056, Branch code: 00170
Account No: 0170 200 1565 87,
SWIFT or BIC code: CCFRFRPP,
IBAN: FR76 3005 6001 7001 7020 0156 587

**RETURN ORDER BY**

- MAIL: YOLE DÉVELOPPEMENT, Le Quartz,
  75 Cours Emile Zola, 69100 Villeurbanne/Lyon - France

**SALES CONTACTS**

- Western US & Canada - Steve Laferriere:
  +1 310 600-8267 – laferriere@yole.fr
- Eastern US & Canada - Chris Youman:
  +1 919 607 9839 – chris.youman@yole.fr
- Europe & RoW - Lizzie Levenez:
  +49 15 123 544 182 – levenez@yole.fr
- Japan & Rest of Asia - Takashi Onozawa:
  +81-80-4371-4887 – onozawa@yole.fr
- Greater China - Mavis Wang:
  +886 979 336 809 – wang@yole.fr
- Korea - Peter OK:
  +82 10 4089 0233 – peter.ok@yole.fr
- Specific inquiries: +33 472 830 180 – info@yole.fr

(1) Our Terms and Conditions of Sale are available at www.yole.fr/Terms_and_Conditions_of_Sale.aspx
The present document is valid 24 months after its publishing date:
August 6, 2019

**PRODUCT ORDER - Ref YD19036**

Please enter my order for above named report:

- [ ] One user license*: Euro 5,990
- [ ] Multi user license: Euro 6,490

- The report will be ready for delivery from September 9, 2019
- For price in dollars, please use the day’s exchange rate. All reports are delivered electronically at payment reception. For French customers, add 20% for VAT

I hereby accept Yole Développement’s Terms and Conditions of Sale (1)

Signature:

*One user license means only one person at the company can use the report.

**SHIPPING CONTACT**

<table>
<thead>
<tr>
<th>First Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Last Name:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Email:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**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 and well as IP and patent analysis. 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, KnowMade and Blumorpho, supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

**CONSULTING AND ANALYSIS**

- Market data & research, marketing analysis
- Technology analysis
- Strategy consulting
- Reverse engineering & costing
- Patent analysis
- Design and characterization of innovative optical systems
- Financial services (due diligence, M&A with our partner)

*More information on www.yole.fr*

**MEDIA & EVENTS**

- i-Micronews.com website, application & related e-newsletter
- Communication & webcast services
- Events: TechDays, forums…

*More information on www.i-micronews.com*

**REPORTS**

- Market & technology reports
- Patent investigation and patent infringement risk analysis
- Structure, process and cost analysis and teardowns
- Cost simulation tool

More information on www.i-micronews.com/reports

**CONTACTS**

For more information about:

- Consulting & Financial Services: Jean-Christophe Eloy (eloy@yole.fr)
- Reports & Monitors: David Jourdan (jourdan@yole.fr) & Fayçal Khamassi (khamassi@yole.fr)
- Marketing & Communication: Camille Veyrier (veyrier@yole.fr)
- Public Relations: Sandrine Leroy (leroy@yole.fr)
1. SCOPE

1.1 The Contracting Parties undertake to observe the following general conditions which apply to the order of the Buyer and the Seller, in addition to any ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS IN ANY OTHER DOCUMENTS ISSUED BY THE SELLER WHICH ARE HEREBY OBLIGE TO THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.

1.2 This contract becomes valid and enforceable between the Contracting Parties after clear and non-equivalent consent by any duly authorized person representing the Buyer. For these purposes, the Buyer accepts these conditions of sales when signing the purchase order which mentions “I hereby accept Yole Développement’s Terms and Conditions of Sale”.

2. Mailing of the products

2.1 Products are sent by email to the Buyer:
   - Within a few days from the order for Products already released and in stock.
   - Within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best efforts to forward 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 in release or in the delivery of the data, including in the event of force majeure, unforeseeable, or other events beyond the control of the Seller. The Seller undertakes to remove the defective products as far as the supplies allow and without indemnities or compensation of any kind for labour costs, delays, loss caused by this delay, delay in the delivery of the reports, any limitation of the useful life, or any other damage caused by the inaccuracy of the data, except for non-acceptable delays exceeding 3 months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4. LIABILITIES

4.1 The Buyer or any other individual or legal person acting on its behalf, being a user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpreting he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces from them.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement.

4.3 In the event of non-performance of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, sell, or publish the Product, or any part of it to any other party other than employees of its company (only in the country of the primary user). The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as: • Information storage or transmission system; • Recordings and re-transmissions over any network (including any local area network); • Recording, time-sharing, service bureau, bulletin board or similar arrangement or public display; • Posting any Product to any other online service (including bulletin boards or the Internet); • Licensing, leasing, selling, offering for sale or assigning the Product.

7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part or postpones the date of delivery, the Buyer will 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 borne by the Seller, following this decision. In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery or latest update which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensees, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer. Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party. The Seller may, from time to time, update these Terms and Conditions. In which case, the Seller will have the right to update the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out of or related to these Terms and Conditions or to any of the contract documents which is not settled amicably by the parties shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.