Status of Power Electronics Industry 2015
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COMPANIES CITED IN THE REPORT

OVERALL POWER ELECTRONICS MARKET

2014 – 2020 value chain analysis: system, device, wafer

The power electronics market perspectives are very optimistic with a CAGR superior than 6% for the period 2014-2020

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The 6” (150mm) wafers are the most sold ones, but 200mm wafers will considerably increase its market share.
The overall inverter market in 2014 exceeded the $xx B

Drivers for inverter innovation:
- Size reduction
- Weight reduction
- Efficiency improvement
- Cost reduction

Inverter markets:
- PV inverter: $xx B, +2.2%
- Rail traction: $3.3 B, +5.2%
- Wind turbines: $2.7 B, -2.1%
- Motor drives: $xxx B, +8%
- UPS: $10 B, +0.9%
- EV/HEV: $xxxx B, +15%

Drivers for application growth:
- Increase of CO₂ emission taxes
- Demand and regulations for clean energy generation
- Need for mass transportation
- Need for efficient transportation
- Regulation on energy efficiency
- Data center and data storage market increase
- Utility grid stress increasing due to the use of clean energy

Depending on applications:
- Wind turbines
- Motor drives
- UPS

And others...
# Four Main Devices for Power Electronics

## Silicon

**SJ MOSFETs**

- **Production status in 2014:** mass production
- **Market size in 2014:** ~$\text{xxxxM}
- **Main players involved:** Infineon, STMicroelectronics, Toshiba, Fairchild, Vishay
- **Main applications:** Laptop adapters, xxxx, xxxx, xxxx, xxxx,...
- **Power range:** up to 20 kW
- **Voltage range:** up to xxxxV

## Compound Semiconductors

**Ga\text{N} HFETs**

- **Production status in 2014:** early stage of production
- **Market size in 2014:** ~$\text{xxxxM}
- **Main players involved:** IR, EPC, GaN Systems, Transphorm, Freescale, Infineon, Fuji Electric, Powdec, SanKen, Renesas, etc.
- **Main applications:** xxx xxxx (not yet), xxxx(not yet), xxxx, xxx.
- **Power range:** up to 100 kW
- **Voltage range:** up to xxxx V

**Si\text{C} FETs**

- **Production status in 2014:** growing stage of production
- **Market size in 2014:** $\text{xxxxM}
- **Main players involved:** CREE, Infineon, Powerex, Rohm, Microsemi, GeneSic, STMicroelectronics
- **Main applications:** xxx (for diodes), xxxx, xxxx (not yet), xxxx (not yet), xxxxxx (for switches)
- **Power range:** 10 kW to MW range
- **Voltage range:** 1.2 kV to xxxkV (up to xxx kV so far)
SEMICONDUCTOR EVOLUTIONS

Power device technology positioning

WBG devices are primarily positioned in high-end applications.

Product range

High end

Low end

Voltage

200 V

600V or less

1200V or more

3.3kV and more

MOSFET

Triacs

Bipolar

... 

IGBT

SiC

GaN

IGCT

Thyristor

Home appliances

Consumer systems

Industry, Energy Mass transportation

3.3kV and more

Yole Développement - December 2014

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• **SiC diodes** today are already in production, mainly coupled with IGBT technology.

• Penetration of **SiC in Wind turbines will happen xxxx.** For all other segments, Yole Développement roadmaps have been confirmed. Use of SiC in industrial motor drives is still unclear.
Characteristics of GaN-based inverters will be:

- They will primarily target medium voltage applications (in the 200 – 600V range)
- GaN targeted applications will be very different from SiC, at first. We will observe a competition in xxxx. For the EV/HEV, xxxxxxx.
- GaN devices are excluded from high-voltage applications such as wind turbines and rail traction.
Several new players have arrived, and they will bring more competition in this market.
COMPETITIVE PACKAGING TECHNOLOGY

Improvement aspects in packaging, with examples…

All applicable to Si and SiC

Improvements in packaging can be made in 3 different aspects:

- **Die interconnection**, which is searching for innovative wire bonding or no-wires connection for better lifetime and reliability
- **Die attach**, which uses new materials for better lifetime
- **DBC+baseplate**, which uses new materials and suppress layers for improved cooling and smaller size

Many innovations are taking place in power module packaging.
Description and market trends of each application are presented on this report.
New players are trying to find their position in the PV market.

In 2014, PV inverter manufacturers focused mainly on four target areas:

1. Microinverters (~250W)
2. Small-size (residential roofs) (3-10kW)
3. Medium-size inverters (20-50 kW)
4. Large inverters (500kW+)

Establishment in the PV inverter business
Chinese players are rapidly growing within China and looking for foreign markets. Some Chinese players have chosen the strategy of JV with key EU technology players in order to speed-up their development.

All players are looking for new market opportunities: some by developing large turbines in 6MW+ size for offshore applications other via focusing on promising new markets especially in South America.
ARCHITECTURES OF SMART POWER DISTRIBUTION SYSTEMS

HVDC & FACTS

HVDC and FACTS fulfil the needs for more power management and long distance transmission.

Power systems technologies

Power systems sub category

Main silicon device in use:

- HVDC: High Voltage Direct Current
- FACTS: Flexible Alternating Current Transmission System
- VSC: Voltage Source Converters ("IGBT Light" is a brand of ABB)
- SVC: Static VAR Compensator (VAR: Reactive Power)
- STATCOM (SVC light): Static Synchronous Compensator

HVDC : High Voltage Direct Current
FACTS : Flexible Alternating Current Transmission System
VSC : Voltage Source Converters ("IGBT Light" is a brand of ABB)
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STATCOM (SVC light) : Static Synchronous Compensator

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Integration trends

Tier 1 and chip makers are willing to acquire power module manufacturing. Pure power module makers have to develop their competences to stay in the game.

Car manufacturers see electric motors as a know-how to master, and are capturing competencies from tier ones → the goal is to manufacture the overall powertrain.

Some car makers are also working on batteries to complete this value chain integration.
DYNEX's acquisition by CSR is an example of Asiatic vertical integration.
• At the component level, we have observed two main trends:
  
  • **Adoption of power modules** in opposition to power discrete devices, for the low power segment:
    
    • xxxxx
  
  • **IGBT will be the most demanded device** for UPS business within the next five years:
    
    • xxxxxxx
    • xxxxxxx

<table>
<thead>
<tr>
<th>Power range</th>
<th>Number of devices</th>
<th>Topology</th>
<th>Device voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low power UPS</strong></td>
<td>xxxxx</td>
<td>• H-bridge topology</td>
<td>XXXX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Single phase</td>
<td></td>
</tr>
<tr>
<td><strong>Medium power UPS</strong></td>
<td>xxxxx</td>
<td>• IGBT rectifier</td>
<td>XXXX</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 3 phase</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cascaded H-bridge or NPC topologies</td>
<td></td>
</tr>
<tr>
<td><strong>High power UPS</strong></td>
<td>xxxxx</td>
<td>• IGBT rectifier</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• 3 phase</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Multi-level topologies</td>
<td></td>
</tr>
</tbody>
</table>
Many other M&A examples are analysed on the report.

### Europe and USA

- **Diversification** (also called horizontal integration):
  - Acquisition of competencies internally to build an overall system, for different motivations.
  - To grasp the entire value chain margin
  - To reach local markets also for some companies (example with CSR which bought Dynex in 2008 both to grasp EU market and outsourced Dynex’s manufacturing)

### Asia

- **Vertical integration:**
  - Acquisition of competencies internally to build an overall system, for different motivations.
  - To grasp the entire value chain margin
  - To reach local markets also for some companies (example with CSR which bought Dynex in 2008 both to grasp EU market and outsourced Dynex’s manufacturing)

#### Outsourced manufacturing:

Typically in Asia for low value levels of manufacturing

- **Proposition of advanced R&D services**
  - IMEC
  - APEI
  - Fraunhofer
  - PRIMES
  - GE Global Research

#### Product consolidation

- Cost reduction

#### Quality and reliability offers

- Domestic market protection
- Worldwide expansion
VERTICAL & HORIZONTAL INTEGRATION

A technological need

- The main purpose of power electronics continue to be integration.
- Therefore, establishing interactions and synergy dynamics among different players is necessary so that knowledge can be shared and the overall system improved. Acquisitions and partnerships are the key:

Vertical integration helps reducing costs. Diversification takes profit of different synergies to get a more compact system.

Possible by mastering both technologies (examples: SBE and Methode Electronics, Eagtop...)
Many Japanese chip manufacturers have accessed higher added value markets

- **Drivers for this integration are:**
  - Technology development: access to new skills
  - Partnering, developing sales network
  - Access to higher added value markets

- **Main risks are:**
  - Customers becoming competitors
  - Access new technologies, especially at the inverter level

- **Most concerned are** Japanese players
FOCUS ON CHINA

Vertical integration by Chinese companies: from toward to vertical backward

Huge Chinese companies are conquering their supply chain and their respective markets.

Strong R&D effort

- Power Chip
- Power module
- Inverter

Strong R&D effort enables access to power semiconductor technologies & reach local market. Dynex opened a 8” IGBT manufacturing line in China, in a CSR facility.

System

- Wind turbines
- PV inverter
- EV/HEV
- Rail

Dynex acquisition enables access to power semiconductor technologies & reach local market. Dynex opened a 8” IGBT manufacturing line in China, in a CSR facility.

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