Industrial Power Control Business Update

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Division President Industrial Power Control

Dr. Peter Friedrichs
Senior Director Silicon Carbide Technology

7 May 2020
Agenda

1. IPC Division business update
2. Acquisition of Cypress creates new opportunities
3. Update on Infineon’s silicon carbide activities
Impact of the Coronavirus on IPC’s businesses

Manufacturing and supply chain
› All IPC related frontend and backend fabs are back to full operation and can fulfill the demand
› Raw materials available, selected subcons face problems

Distribution and logistics
› Distributors well stocked and stock reach actively managed
› Logistics challenging but working with additional efforts

Investments
› Capex: Investments slightly reduced
› R&D: No significant delays in IPC’s main projects for IGBT and SiC

Customer demand
› Downswing in home appliances and photovoltaic; quick rebound expected
› Delayed impact in drives, traction and wind followed by slow recovery according to market research reports
Corona pandemic will impact H2 FY20 significantly

IPC revenue and Segment Result margin

- IPC revenue and Segment Result margin
- IPC half-year revenue development
- Q2 book to bill is hovering around 1
- Inventories in the distribution chain improved by almost 2 weeks to 14 weeks
- Q3 and Q4 revenues are expected to remain flat
- Due to idle cost the FY20 SR-Margin is expected to be below FY19 level
## Market outlook for main applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Market outlook for H2 FY20</th>
<th>Market outlook for FY21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Drives</td>
<td>Industrial Drives expected to contract due to push-outs in manufacturing equipment investments</td>
<td>Industrial Drives highly correlated to GDP; recovery earliest in late FY21</td>
</tr>
<tr>
<td>Solar</td>
<td>Disruptions in supply and lockdowns will delay PV installations</td>
<td>Steep recovery and catch-up of lost installations expected, possibly supported by incentives</td>
</tr>
<tr>
<td>Wind</td>
<td>Growth may be not as strong as expected due to installation delays but higher than in FY19</td>
<td>Self sustainable growth due to long-term drivers and increasing competitiveness</td>
</tr>
<tr>
<td>Home appliance</td>
<td>Household budget uncertainties and construction delays lead to softening market</td>
<td>Catch-up of delayed purchases and energy efficiency incentive programs will drive growth</td>
</tr>
<tr>
<td>Traction</td>
<td>Stable growth expected despite minor manufacturing delays during lockdowns</td>
<td>Long-term drivers ensure steady growth</td>
</tr>
</tbody>
</table>
Our products and innovations together with an efficient production are key elements to deal with climate change.

We contribute a CO₂ reduction of more than 54 million tons

CO₂ burden¹
Around 1.40 million tons of CO₂ equivalents

Ratio around 1:40

CO₂ savings²
Around 56 million tons of CO₂ equivalents

Net ecological benefit: CO₂ emissions reduction of more than 54 million tons

Our net ecologic CO₂ benefit is equal to...

The savings of a 1,795 km² photovoltaic powerplant.³)

The average annual electricity consumption of about 86 million people living in Europe.⁴)

48,700 fully occupied flights of an Airbus A380 from Munich to Singapore.⁵)

For footnotes please see appendix page 25
Infineon will become carbon-neutral by 2030

70% CO₂ emissions reduction target in 2025
(Scope 1 and 2 emissions)

1. Avoiding direct emissions and further reducing energy consumption
2. Purchasing green electricity with guarantees of origin for unavoidable emissions
3. Compensate the smallest part by certificates that combine development support and CO₂ abatement

Abatement of Perfluorinated Compounds (PFC's)¹ is one of the most important measures avoiding direct emissions.

Normalized PFC emissions rate in tons of CO₂ equivalent per square meter wafer

Historically, Infineon's normalized emission rate has been below WSC 2020 target of 2.2 in tons of CO₂ per square wafer

¹) Namely perfluorinated and polyfluorinated carbon compounds, sulfur hexafluoride (SF₆) and nitrogen trifluoride (NF₃)
Acquisition of Cypress creates new opportunities
The new Infineon offers an unrivaled portfolio that perfectly links the real and the digital world.

- **Real-world applications**: Battery-powered devices, Power supplies, Industrial IoT, Drives, Consumer IoT, 5G, Automotive.
- **Digital world**: Information and data about the real world, Connectivity: Wi-Fi, Bluetooth, USB.

**Value addition and optimized use of resources**

- **Sense**: sensors
- **Compute**: microcontrollers, memories
- **Actuate**: power semiconductors
- **Software Ecosystem**
- **Security solutions**

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With the combined portfolio the new Infineon can now offer full system solutions

Example: air-conditioning

What makes system solution attractive to customers?

› Ease of design
  ➞ combined portfolio covers all relevant system components

› Superior quality
  ➞ integrated solution ensures MCU, power stage and peripherals work perfectly together

› Faster time-to-market
  ➞ no additional integration or software development costs
Industrial Internet of Things integrates control and connect and is offering new opportunities

An increasing share of today’s industrial system solutions is integrated in cloud-based services

Reliable wireless connectivity is now part of automation equipment, e.g. cobots, automated-guided vehicles

Wireless integration into cloud-based services, e.g. predictive maintenance, remote diagnostics
Update on Infineon’s silicon carbide activities
Infineon’s SiC business so far dominated by industrial, additional potential for automotive

Cumulated SiC design-ins of ~€1.8bn*

- automotive: diodes, MOSFETs, MOSFET modules
- industrial (IPC): diodes, MOSFETs, hybrid modules, MOSFET modules
- industrial (PSS): diodes, MOSFETs

* as per end of FY19; as a cautious assumption, lifetime of all projects is capped after five years.
** only customers with > €10k revenue considered

Strong growth in SiC business; very balanced product and customer portfolio

- CAGR(FY17-FY20): ~50%
- 60% – 80%

- >150 different CoolSiC™ products as of today
- >100 different customers** expected in FY20
Strong CoolSiC™ portfolio expansion: by packages and by voltages

<table>
<thead>
<tr>
<th>package options</th>
<th>voltages</th>
<th>Industrial</th>
<th>Automotive grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CoolSiC™ Diode</td>
<td>CoolSiC™ Hybrid</td>
</tr>
<tr>
<td>Discrete</td>
<td>600 V</td>
<td>Discrete</td>
<td>Module</td>
</tr>
<tr>
<td></td>
<td>650 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1200 V</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1700 V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continuous expansion of portfolio
Comparison of SiC product portfolio for Infineon and its competitors

SiC product portfolio*

- **FC: Full SiC Modules**
  - Full SiC Modules
  - SiC Discrete MOSFETS

- **FC: SiC Discrete MOSFETS**

- **FC: SiC Hybrid**
  - SiC Hybrid
  - SiC Diodes

- **FC: SiC Diodes**

<table>
<thead>
<tr>
<th></th>
<th>Infineon</th>
<th>Comp. A</th>
<th>Comp. B</th>
<th>Comp. C</th>
<th>Comp. D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>152</td>
<td>130</td>
<td>144</td>
<td>69</td>
<td>178</td>
</tr>
<tr>
<td>FC: Full SiC Modules</td>
<td>18</td>
<td>18</td>
<td>9</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>FC: SiC Discrete MOSFETS</td>
<td>26</td>
<td>40</td>
<td>22</td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>FC: SiC Hybrid</td>
<td>9</td>
<td>72</td>
<td>70</td>
<td>46</td>
<td>107</td>
</tr>
<tr>
<td>FC: SiC Diodes</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: Product data collected from each company’s website & IFX SiC Forecast for product releases FY20; w/o Bare Die – as per May 04, 2020
Our technologies enable world’s most powerful 1,500 V string inverter; 250 kW PV solution by Sungrow

**Sungrow SG250HX string inverter**

- Enables flexible block design of up to 6.75 MW
- Power density of approximately 1 kW/liter
- Only 99 kg in weight
- Ideal solution for utility scale photovoltaic applications

**Latest Infineon chip and module technology**

- Enabling significant reduction of heat sink size and weight → EasyPACK™ 3B power modules
- Achieving very high conversion efficiency → latest TRENCHSTOP™ and CoolSiC™ technology
Second generation (2\textsuperscript{nd} Gen.) CoolSiC™ Trench MOSFET will increase the addressable market

\textbf{1\textsuperscript{st} Gen. CoolSiC™ Trench MOSFET is the leading technology today}

\textbf{2\textsuperscript{nd} Gen. CoolSiC™ Trench MOSFET is in advanced development phase}

\textbf{1\textsuperscript{st} Gen. with lowest losses}

\begin{itemize}
  \item Enhanced power handling capability by 25\% – 30\%
  \item Enhanced safe operating area without compromising quality
  \item Enabling SiC in further high volume applications
\end{itemize}

\textbf{2\textsuperscript{nd} Gen. will expand the lead}

\textbf{1\textsuperscript{st} Gen. CoolSiC™ Trench MOSFET has set the industry benchmark}

\textbf{2\textsuperscript{nd} Gen. CoolSiC™ Trench MOSFET will significantly enlarge the market size for SiC MOSFETs}

SiC raw wafer remains major cost driver

SiC 150 mm raw wafer price development

<table>
<thead>
<tr>
<th>Year</th>
<th>Price [US$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>1300</td>
</tr>
<tr>
<td>2018</td>
<td>1100</td>
</tr>
<tr>
<td>2019e</td>
<td>900</td>
</tr>
<tr>
<td>2020e</td>
<td>800</td>
</tr>
<tr>
<td>2021e</td>
<td>700</td>
</tr>
<tr>
<td>2022e</td>
<td>600</td>
</tr>
<tr>
<td>2023e</td>
<td>500</td>
</tr>
<tr>
<td>2024e</td>
<td>400</td>
</tr>
<tr>
<td>2025e</td>
<td>300</td>
</tr>
</tbody>
</table>

Average frontend cost breakdown

- SiC blank raw wafer: 65%
- Yield loss: 18%
- Process: 10%
- Epitaxy: 7%

Siltecreta:
Status of implementation of Cold Split technology

Process tools
› Design and production of semi-automated process tool park completed in Dresden

Clean room
› Clean room ready for manufacturing by end of calendar year 2020

Process flow
› Integration of individual process steps into complete work flow

1/3 of the industrialization journey accomplished

Wafer splitting by 2022
› Wafer for splitting are already available
› Increases # of wafers by a factor of 2

Boule splitting by 2023
› Boules start to become available
› Increases # of wafers by a factor of 2.0 in a first step, with potential for a factor of 2.6

Combining boule splitting and wafer splitting will make the most efficient process
Cold Split technology extended from wafer splitting to boule splitting

<table>
<thead>
<tr>
<th>Crystal</th>
<th>Technology</th>
<th># of wafers</th>
<th>Surface finish</th>
<th># of wafers</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiC boule 4 cm crystal length</td>
<td>Sawing</td>
<td>~50</td>
<td>Lapping /grinding</td>
<td>~50</td>
</tr>
<tr>
<td>300 µm kerf loss</td>
<td>450 µm wafer thickness</td>
<td>100 µm loss</td>
<td>350 µm wafer thickness</td>
<td></td>
</tr>
</tbody>
</table>

| 2023 | Splitting | ~100 | Grinding | ~100 |
| SiC boule 4 cm crystal length | No kerf loss | 400 µm wafer thickness | 50 µm loss | 350 µm wafer thickness |

| ~2025 | Splitting | ~130 | Grinding | ~130 |
| SiC boule 4 cm crystal length | No kerf loss | 300 µm wafer thickness | 50 µm loss | 250 µm wafer thickness |
Infineon is ready to support and shape the growing SiC device market

**Today**

- Leading Infineon technology with 1\(^{st}\) Gen. CoolSiC™ Trench MOSFET
- Already broad, fast growing portfolio
- System expertise and customer access

**Strategic projects to support growth**

- 2\(^{nd}\) Gen. CoolSiC™ Trench MOSFET
- Cold Split: wafer and boule
- Manufacturing lines already capable of processing 200 mm diameter

**SiC device market size**

- Acceleration of revenue growth from 2023 onwards

Part of your life. Part of tomorrow.
Dr. Peter Wawer
Division President Industrial Power Control

› since 2016: Division President Industrial Power Control
› 2012: Member of the Management Board of the Power Management & Multimarket Division (since 1 April 2020 renamed to Power & Sensor Systems)
› 2011: Senior VP Technology and Production at Q-Cells SE in Bitterfeld, Germany
› 2008 – 2011: Senior VP Technology at Q-Cells SE
› 1997 – 2008: various position at Infineon
› Dr. Peter Wawer was born in Berlin, Germany, in 1967. He holds a Diploma in Electrical Engineering from the Technical University in Berlin where he also received his PhD.
› He joined Infineon (Siemens AG until 1999) in 1997.
Dr. Peter Friedrichs
Senior Director SiC Technology

› since 2011: Senior Director SiC Technology
› 2004 – 2011: Managing director of SiCED (Joint venture of Infineon and Siemens)
› 1996 – 2004: various positions at Siemens and SiCED

› Dr. Peter Friedrichs was born in Aschersleben, Germany, in 1968. He holds a Diploma in Microelectronics from the Technical University in Bratislava, Slovakia, and received his PhD from the Friedrich Alexander University in Erlangen, Germany. In addition, he holds a Diploma in Industrial Engineering from the University in Hagen, Germany.

› He joined Infineon (Siemens AG until 1999) in 1996.
1) This figure considers manufacturing, transportation, function cars, flights, materials, chemicals, water/waste water, direct emissions, energy consumption, waste, etc. and is based on internally collected data and externally available conversion factors. All data relate to the 2019 fiscal year. Manufacturing service providers are not included.

2) This figure is based on internally established criteria, which are explained in the explanatory notes. The figure relates to the calendar year 2018 and considers the following fields of application: automotive, LED, induction cookers, server, renewable energy (wind, photovoltaic), mobile phone chargers as well as drives. CO₂ savings are calculated on the basis of potential savings of technologies in which semiconductors are used. The CO₂ savings are allocated on the basis of Infineon market share, semiconductor content and lifetime of the technologies concerned, based on internal and external experts' estimations.

3) Calculation based on average polycrystalline photovoltaic cells and the average yearly solar radiation of central Germany.

4) Based on the average electricity consumption of private households in Germany and official energy conversion factors.

5) Calculation based on average passenger capacity and direct flight route using externally available data and conversion factors.
IPC at a glance: well-balanced portfolio of applications

IPC FY19 revenue by application

- Traction
- Home appliances
- Renewable energies
- Drives
- Others

Distribution share: ~40%

IPC FY19 revenue by region

- Americas
- Japan
- Greater China
- EMEA
- APAC (ex GC and Japan)

US$ exposure: ~30%
Clear leader in discrete IGBTs and IGBT modules; market share gains in all categories

<table>
<thead>
<tr>
<th><strong>Discrete IGBTs</strong></th>
<th><strong>IPMs</strong></th>
<th><strong>IGBT modules</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>total market in 2018: $1.31bn</td>
<td>total market in 2018: $1.68bn</td>
<td>total market in 2018: $3.25bn</td>
</tr>
<tr>
<td>Infineon</td>
<td>Mitsubishi</td>
<td>Infineon</td>
</tr>
<tr>
<td>37.4% (+0.7-pt)</td>
<td>32.3%</td>
<td>34.5% (+1.7-pt)</td>
</tr>
<tr>
<td>ON Semi</td>
<td>ON Semi</td>
<td>Mitsubishi</td>
</tr>
<tr>
<td>9.6%</td>
<td>18.9%</td>
<td>10.4%</td>
</tr>
<tr>
<td>Fuji Electric</td>
<td>Infineon</td>
<td>Fuji Electric</td>
</tr>
<tr>
<td>9.5%</td>
<td>12.0% (+1.6-pt)</td>
<td>9.7%</td>
</tr>
<tr>
<td>Littelfuse*</td>
<td>Fuji Electric</td>
<td>Semikron</td>
</tr>
<tr>
<td>5.9%</td>
<td>10.0%</td>
<td>8.0%</td>
</tr>
<tr>
<td>STMicro</td>
<td>Semikron</td>
<td>Vincotech</td>
</tr>
<tr>
<td>5.4%</td>
<td>5.8%</td>
<td>4.9%</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>Sanken</td>
<td>Hitachi</td>
</tr>
<tr>
<td>5.0%</td>
<td>2.9%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Renesas</td>
<td>STMicro</td>
<td>Danfoss</td>
</tr>
<tr>
<td>4.8%</td>
<td>2.1%</td>
<td>2.4%</td>
</tr>
<tr>
<td>MagnaChip</td>
<td>Rohm</td>
<td>Starpower</td>
</tr>
<tr>
<td>3.8%</td>
<td>1.4%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Toshiba</td>
<td>Microchip</td>
<td>Toshiba</td>
</tr>
<tr>
<td>3.1%</td>
<td>0.6%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Microchip</td>
<td>Jilin Sino-Micro</td>
<td>ON Semi</td>
</tr>
<tr>
<td>1.6%</td>
<td>0.5%</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

* Littelfuse acquired IXYS Corporation in January 2018.
** Including standard (non-integrated) IGBT modules and power integrated modules (PIMs) / converter inverter brake (CIB) modules.
Source: Based on or includes research from Omdia, "Power Semiconductor Market Share Database 2018", September 2019.
“Every switch needs a driver”

Gate Driver ICs

total market in 2018: $1,47bn

<table>
<thead>
<tr>
<th>Company</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infineon</td>
<td>24.2% (+2.3%-pt)</td>
</tr>
<tr>
<td>STMicro</td>
<td>13.6%</td>
</tr>
<tr>
<td>Renesas</td>
<td>9.8%</td>
</tr>
<tr>
<td>TI</td>
<td>7.6%</td>
</tr>
<tr>
<td>ON Semi</td>
<td>5.6%</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>5.3%</td>
</tr>
<tr>
<td>Sanken</td>
<td>4.5%</td>
</tr>
<tr>
<td>NXP</td>
<td>2.5%</td>
</tr>
<tr>
<td>Microchip</td>
<td>2.1%</td>
</tr>
<tr>
<td>Rohm</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

Strong market share gains based on the broadest portfolio in the industry

By configuration:
- Low side
- High side
- Half bridge
- High and low side
- Full bridge
- Three phase

By isolation:
- Level shift
- Isolated
- Non isolated

By switch device:
- CoolSiC™ MOSFET gate drivers
- IGBT gate drivers
- CoolGaN™ HEMTs gate drivers

By application:
- Home appliances
- Industrial automation
- Data centers
- Electric transportation
- Energy management
- Renewable energy

Source: Based on or includes research from Omdia, “Power Semiconductor Market Share Database 2018”, September 2019.
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>btb</td>
<td>Book-to-bill ratio</td>
<td></td>
</tr>
<tr>
<td>epi</td>
<td>epitaxy</td>
<td></td>
</tr>
<tr>
<td>FiT</td>
<td>feed-in tariff</td>
<td></td>
</tr>
<tr>
<td>IPS</td>
<td>industrial power supply</td>
<td></td>
</tr>
<tr>
<td>IPM</td>
<td>intelligent power module</td>
<td></td>
</tr>
<tr>
<td>ITC</td>
<td>solar investment tax credit</td>
<td></td>
</tr>
<tr>
<td>IGBT</td>
<td>insulated-gate bipolar transistor</td>
<td></td>
</tr>
<tr>
<td>MCU</td>
<td>microcontroller unit</td>
<td></td>
</tr>
<tr>
<td>MOSFET</td>
<td>metal-oxide silicon field-effect transistor</td>
<td></td>
</tr>
<tr>
<td>PFC</td>
<td>power factor correction</td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>photovoltaic</td>
<td></td>
</tr>
<tr>
<td>PTC</td>
<td>production tax credit</td>
<td></td>
</tr>
<tr>
<td>RAC</td>
<td>residential air conditioning</td>
<td></td>
</tr>
<tr>
<td>SiC</td>
<td>silicon carbide</td>
<td></td>
</tr>
<tr>
<td>ToF</td>
<td>time of flight</td>
<td></td>
</tr>
<tr>
<td>xEV</td>
<td>all degrees of vehicle electrification (EV, HEV, PHEV)</td>
<td></td>
</tr>
</tbody>
</table>
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