How Semiconductors are enabling Electric Vehicle revolution

SIA Webinar, June 8th, 2021

Sayeed Ahmed - Senior Director, Vehicle Motion
Infineon at a glance

**Business Segments Revenue***

- **Automotive** (ATV) 43%
- **Power & Sensor Systems** (PSS) 29%
- **Connected Secure Systems** (CSS) 14%
- **Industrial Power Control** (IPC) 14%

**Employees**

- **46,700** employees worldwide
  - **EMEA** 19,100
  - **Americas** 5,200
  - **Asia/Pacific** 22,400

**54** R&D locations
**21** manufacturing locations

**Financials**

<table>
<thead>
<tr>
<th></th>
<th>[EUR m]</th>
<th>FY 16</th>
<th>FY 17</th>
<th>FY 18</th>
<th>FY 19</th>
<th>FY 20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenue</strong></td>
<td>6,473</td>
<td>7,063</td>
<td>7,599</td>
<td>8,029</td>
<td>8,567</td>
<td></td>
</tr>
<tr>
<td><strong>Segment Result</strong></td>
<td>15.2%</td>
<td>17.1%</td>
<td>17.8%</td>
<td>16.4%</td>
<td>13.7%</td>
<td></td>
</tr>
</tbody>
</table>

*Fiscal Year 2020 (as of 30 September 2020)

**Market Position**

- **Automotive**
  - # 1
  - Strategy Analytics, May 2020**
- **Power**
  - # 1
  - Omdia, September 2020
- **Security ICs**
  - # 1
  - ABI Research, October 2020

**Note:**
- **# 1** based on the combined market share 2019 of Infineon and Cypress based on their individual figures

For further information: [Infineon Annual Report 2020](#)

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Our core beliefs reflect the automotive megatrends as cars become cleaner, safer and smarter.

- Zero CO$_2$ becomes real
- A driver becomes a passenger
- A car becomes a smarter car
Three essential ingredients for enabling the EV revolution

- Dependable Electronics
- System cost reduction
- Faster time to market
- Supply security
High Voltage Inverter for EV

**Application Scope**

Main Inverter enables the bi-directional power conversion between HV battery and e-motor:

- **DC** from HV battery → **AC** for e-motor
- Regenerative braking → power back to battery
- Enable vehicle motion upon torque request
Infineon offers **key components** for inverters → System cost focus

- Microcontrollers
  - AURIX™
- Memory
- Power Supply
  - OPTIREG™ PMIC
- Gate Driver
  - EiceDRIVER™
- Power Module
  - HybridPACK™ Drive
- Current sensors
  - XENSIV™
- Position sensors
  - XENSIV™
Market development → Power is over 80% of an EV inverter BOM

2020 average xEV semiconductor content by degree of electrification

<table>
<thead>
<tr>
<th></th>
<th>48 V / Mild Hybrids</th>
<th>Full &amp; Plug-in Hybrids and Battery Electric Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Powertrain*</td>
<td>$396</td>
<td>$396</td>
</tr>
<tr>
<td>ICE Powertrain</td>
<td>$61</td>
<td>$38</td>
</tr>
<tr>
<td>xEV Sensors</td>
<td>$7</td>
<td>$14</td>
</tr>
<tr>
<td>xEV Power**</td>
<td>$17</td>
<td>$23</td>
</tr>
<tr>
<td>xEV Others**</td>
<td>$90</td>
<td>$330</td>
</tr>
<tr>
<td>Total semi BoM</td>
<td>$572</td>
<td>$834</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Vehicles</th>
<th>Non-Powertrain*</th>
<th>ICE Powertrain</th>
<th>xEV Sensors</th>
<th>xEV Power**</th>
<th>xEV Others**</th>
<th>Total semi BoM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>2.3m</td>
<td>$396</td>
<td>$61</td>
<td>$7</td>
<td>$17</td>
<td>$90</td>
<td>$572</td>
</tr>
<tr>
<td>2022e</td>
<td>5.8m</td>
<td>$396</td>
<td>$38</td>
<td>$7</td>
<td>$14</td>
<td>$23</td>
<td>$330</td>
</tr>
<tr>
<td>2025e</td>
<td>18.8m</td>
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<td>$14</td>
<td>$23</td>
<td>$330</td>
<td>$834</td>
</tr>
</tbody>
</table>

* Non-Powertrain: average semiconductor content in body, chassis, safety and infotainment application segments
** "power" includes voltage regulators and ASIC; "others" include opto, small signal discretes, memory

Sources: Infineon; based on or includes content supplied by IHS Markit, Automotive Group: *Alternative Propulsion Forecast,* July 2020; Strategy Analytics: *Automotive Semiconductor Demand Forecast 2018-2027* and *Automotive Sensor Demand 2018-2027.* July 2020
All power technologies are available in-house

Comparison of technologies

**Si**
- Si remains the mainstream technology
- Targeting 25 V – 6.5 kV
- Suitable from low to high power

**SiC**
- SiC complements Si in many applications and enables new solutions
- Targeting 650 V – 3.3 kV
- High power – high switching frequency

**GaN**
- GaN enables new horizons in power supply applications and audio fidelity
- Targeting 80 V – 650 V
- Medium power – highest switching frequency
System cost reduction → Infineon SiC Trench technology

**SiC Planar**
- Low complexity process
- Good shielding of oxide possible

**SiC Trench**
- Low channel resistance
- Shrink potential higher than in planar DMOS

**Infineon Trench**
- Low channel resistance
- Shrink potential higher than in planar DMOS
- Oxide corners shielded by folded double trench
- Long experience in trench know-how

- Sophisticated process know-how needed

- Very low channel mobility
- Limited shrink options

- Protection of oxide corners needed

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System cost reduction → Reduce chip size by superior technology

<table>
<thead>
<tr>
<th>GEN1 1200V, VGS=15V</th>
<th>GEN2 1200V, VGS=18V</th>
<th>GEN2 1200VP, VGS=18V</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
<td>255</td>
<td>215</td>
</tr>
</tbody>
</table>

Performance measured by Rdson active at room temp

Source: Infineon internal assessment, Oct. 2020

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### System cost reduction \(\rightarrow\) More chips/Boule by manufacturing technology

<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></td>
<td>300 µm kerf loss</td>
<td>450 µm wafer thickness</td>
<td></td>
<td>350 µm wafer thickness</td>
</tr>
</tbody>
</table>

- **Today**
  - SiC boule 4 cm crystal length
  - Sawing: 300 µm kerf loss
  - Lapping/grinding: 450 µm wafer thickness

- **2023**
  - SiC boule 4 cm crystal length
  - Splitting: No kerf loss
  - Grinding: 400 µm wafer thickness

### Cold split
- **Step 1:** Laser deposit
- **Step 2:** Deposit polymer
- **Step 3:** Cool down and split
- **Step 4:** Remove polymer

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Faster time to market → Field experience and scalable portfolio

› Field Experience: > 20 BEV platforms in production  
  › 17 out of 25 top selling EVs use Infineon Power device 
  › Shipped 18M power modules/packages → no field failures

› Scalable portfolio: Offer same package with power range from 120kW to 250kW 
  › Migration from Si to SiC is convenient 
  › 400V or 800V Bus voltage
Supply security → Full control of supply chain

- Global multi-sourcing strategy for SiC Wafers in place
- Major investment in In-house Frontend & Backend manufacturing
- Dual front and back-end site provide robust supply
- 40+ years experience in manufacturing power devices
Infineon's dependable electronics enables the EV revolution

- System cost reduction
- Faster time to market
- Supply security

- Innovation & technology focus
- Field experience & superior quality
- In-house manufacturing
- Broad product portfolio
- Scalable products
- Dual front and back-end

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