Power Semiconductors in Emerging Applications

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STMicroelectronics
Power semiconductors at the heart of all energy conversion systems

More energy with less resources

More performance with less energy

More mobility with fewer emissions

More connectivity with less interruption
ST technology and solutions enable customers to increase energy efficiency everywhere & support the use of renewable energy sources.

- Over 30% global electricity demand increase from 2020 to 2030
- 45% CO₂ emission reduction from 2010 to 2030 to limit warming to 1.5°C
- Electrical energy from renewal sources from ~10% in 2020 to ~20% in 2030

Rising demand for and usage of electrical energy
Decrease carbon emissions to reduce global warming impact
Increase use of renewable energy

Sources: IEA, IPCC, BP
Our products and solutions enable customer innovation

<table>
<thead>
<tr>
<th>MEMS for sensors &amp; micro-actuators</th>
<th>Smart Power: BCD (Bipolar - CMOS - Power DMOS)</th>
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<tbody>
<tr>
<td>FD-SOI CMOS</td>
<td>Discrete, Power MOSFET, IGBT</td>
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<td>FinFET through Foundry</td>
<td>Silicon Carbide, Gallium Nitride</td>
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<td>Analog &amp; RF CMOS</td>
<td>Vertical Intelligent Power</td>
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<td>eNVM CMOS</td>
<td>Optical sensing solutions</td>
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Packaging technologies
Leadframe – Laminate – Sensor module – wafer level
Power transistor markets and applications

**Sources:**
- Omdia - Power Discrete and Module Market 2022, Nov 2023
- Yole Power GaN, Aug 2023
- Yole Power SiC, Aug 2023

**Industrial**
- +8.3% CAGR (2023-27)
- From 14B$ to 19.6B$
- • Motor control and appliances
- • SMPS and LED lighting
- • 5G & datacenter power supplies
- • Solar and energy storage
- • Charging stations

**Automotive**
- +14.1% CAGR (2023-27)
- From 8.8B$ to 17.2B$
- • Electric vehicles
  - Traction inverters
  - DC-DC converters
  - On-board chargers
  - Traditional automotive

**Industri:** includes home appliance, motor control, power supply, renewable energy, others

<table>
<thead>
<tr>
<th>Year</th>
<th>SiC MOSFET</th>
<th>IGBT</th>
<th>GaN Power Transistor</th>
<th>IPM (All)</th>
<th>Power Bipolar</th>
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<th>Year</th>
<th>Power Module (All)</th>
<th>MOSFET (LV+HV)</th>
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**2022**
- Si MOSFET discrete (LV+HV)
- GaN power transistor
- IPM (all)
- Power Bipolar
- 23 B$

**2023**
- SiC MOSFET
- 37 B$

**2027**
- +10.8% CAGR (2023-27)
- +8.3% CAGR (2023-27) From 14B$ to 19.6B$

**2037**
- +14.1% CAGR (2023-27) From 8.8B$ to 17.2B$
Silicon Carbide properties

Compared to silicon:

- **Wide bandgap**: 3x
- **Higher critical electrical field**: 10x
- **Higher voltage at same size**: 10x
- **Smaller size at same voltage**: 10x
- **Lower resistance at same voltage**: 90%
- **Faster switching**: 10x
SiC MOSFET manufacturing flow from powder to final product

Substrate Technology
- SiC ingot
- Slicing & polishing

Front-End Technology
- Epitaxy
- Device Fabrication: Litho, deposition, etching, Thermal treatment, metallization, etc.

Testing
- Wafer testing: (Electrical Wafer Sorting)

Backend Technology (Assembly)
- Dicing (singulation)
- Packaging

Device Fabrication
- starting epitaxy
- deposition
- lithography
- etch
- ion implant & thermal treatment
- metal deposition
- lithography
- metal etch
- Thinning & Backside finishing
Silicon Carbide Benefits For Key Application

Addressing energy efficiency in Automotive and Industrial applications

### Key Advantages of SiC for Automotive

- **Longer driving range**: > 600km with SiC
- **Faster charging**: SiC charging station handles 2x the Energy
- **Car weight reduction**: 1% saving in the overall weight and space of an EV

### Key Advantages of SiC for Industrial

#### **Increased Power Efficiency**
- 50% lower losses and with 5x frequency

#### **Reduced Total Cost of Ownership**
- Reduction of 20%

#### **Smaller, more compact machined**
- Size/weight by 70%/80% with an average 50% reduction
System Solution Go-to-market Strategy

1. Establish **value add** proposition
2. Organize lab and marketing collaterals with a **consistent** message
3. Intimate **customer engagement**
4. Prioritization of resources and opportunities
5. **Customer collaboration** through to design production
Our technology starts with You

Find out more at www.st.com