Future-Proofing Your Silicon Carbide Design

A Guide for Automotive Manufacturers

BRD8094/D
Rev. 0, Sep-2023

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The Future Is Silicon Carbide (SiC)

Rapid growth in the market for electric vehicles (EV) is fueling demand for next-generation-power semiconductors, especially those made with silicon carbide (SiC). Indeed, demand for SiC power devices is likely to outstrip supply until at least the second half of the decade.

Automotive OEMs and their tier 1 suppliers are now in a race to find reliable sources of SiC. But they face a number of unique challenges in doing so.

The first challenge is that automotive companies typically must source their SiC devices from suppliers who are not vertically integrated in their manufacturing. Some suppliers offer devices but do not have the ability to manufacture SiC boules in-house (they purchase boules and substrate wafers in the open market). Other suppliers offer internal SiC boules but lack packaging capability in-house. The consequence for automotive companies is that they end up with unoptimized solutions (the chips overheat, for example, or have high electrical resistance or poor thermal conductivity). They also incur increased costs for first-generations of product, and discover that products are lower quality, often containing parasitics.

Another challenge is that suppliers, who outsource elements of the SiC production process or employ Greenfield expansion, lack the ability to quickly scale to meet industry demands.

Finally, there is the challenge of risk. Geopolitical instability, global pandemics, supply chain disruptions and other factors increase the level of risk for automotive OEMs and tier 1 suppliers. When their sources of SiC power devices depend upon multiple sub-suppliers, this places their SiC supply at elevated risk.

The Rise of Silicon Carbide (SiC) in Electric Vehicles

As the EV industry gains momentum, manufacturers are turning to a transformative technology to enhance vehicle performance and efficiency: SiC chips. SiC chips are gradually replacing traditional silicon chips due to their exceptional electrical properties.

SiC, a compound of silicon and carbon, offers numerous advantages over its silicon counterpart. SiC chips can operate at higher temperatures and efficiently handle higher voltages, leading to improved power density and thermal management in EVs. This enables faster charging, longer driving ranges and enhanced overall performance.

SiC chips also exhibit significantly lower power losses, especially the switching losses, compared to silicon chips, resulting in higher energy efficiency. The reduced power losses translate into less waste heat, allowing for more compact cooling systems and lighter vehicle designs.

By embracing SiC technology, EV manufacturers are paving the way for faster, more efficient, and longer-range electric vehicles. The adoption of SiC chips signifies a major step forward in achieving the electrification goals of the future.

The Solution to SiC Unpredictability: Vertical Integration

Forward thinking automotive OEMs and tier 1 suppliers of electric vehicles are discovering that a more reliable way to optimize performance, reduce costs and mitigate risk is to source their SiC power devices through vertically integrated suppliers. Vertical integration is essentially a three-sided solution of boule, dies and packages. A supplier that is truly vertically integrated is optimized around Capability, Capacity and Cost.

Capability

Suppliers of SiC power devices to the electric vehicle market require a diverse range of expertise to meet the demanding requirements of this rapidly evolving industry. First, they must possess in-depth knowledge of semiconductor materials and fabrication processes specific to SiC. This includes expertise in crystal growth, epitaxy, and wafer processing techniques to ensure high-quality chip production.

A thorough understanding of power electronics and circuit design is also crucial. SiC power devices are used in high-voltage and high-power applications, so suppliers must be well-versed in designing and optimizing circuits for efficient power conversion and management.

Just as essential is expertise in thermal management. Given the higher current densities of SiC chips, suppliers must have expertise developing effective cooling solutions to maintain optimal chip performance and reliability.

A deep understanding of the unique requirements and standards of the EV market is vital. Suppliers need to consider factors such as automotive safety, durability and compatibility with other EV components, ensuring their SiC power devices meet the stringent demands of electric vehicle manufacturers.

Vertically integrated SiC suppliers have core application expertise and technical competencies in materials, dies and packages. Each of the technology development teams in these parts of production collaborate with their colleagues in the other teams. They take advantage of fast feedback to ensure quality and process optimization. This collaboration drives innovation and helps ensure that they deliver superior customer support and products aligned to market needs.

Capability also includes testing and quality assurance. Manufacturing with SiC is a complex process that introduces defects and parasitics. Vertical integration means the supplier identifies defects right at the start of the line, at the crystal growth stage, discovering which dies have defects before they advance any further in production. Because vertically integrated suppliers own the entire SiC chain, they use testing, traceability and quality assurance from the start to reduce early life failures.

Vertical Integration

Capacity

Manufacturers of SiC power devices must have the capacity to quickly scale production to meet the growing demand driven by the electric vehicle market.

Consequently, as the adoption of electric vehicles accelerates worldwide, the demand for SiC power devices is expected to soar. To capitalize on this opportunity, manufacturers must be able to rapidly increase their production capacity to meet rising market needs. Scaling production ensures that they fulfill orders in a timely manner, preventing supply shortages and meeting customer expectations.

Scaling production also leads to economies of scale. By increasing output, manufacturers spread fixed costs across a larger number of units, reducing the per-unit production costs. This makes SiC power devices more cost-effective, ultimately driving their wider adoption in the EV industry.

Scaling production also provides manufacturers a greater opportunity to invest in research and development, process optimization and innovation. It enables them to allocate resources and increase engineering fab capacity towards improving chip performance, increasing yields and enhancing manufacturing processes that lead to better overall quality and reliability.

As the electric vehicle market evolves, manufacturers need the agility to adapt to changing customer requirements and technological advancements. A scalable production capacity enables them to quickly respond to market dynamics, introduce new chip variants and customize solutions to meet the challenging system targets of emerging EV applications.

Vertically integrated suppliers already have the capacity, in-house, to rapidly scale up production within constraints of equipment lead time, while meeting quality and performance targets.

Scaling to meet demand involves two metrics: volume, and speed. Vertically integrated SiC suppliers have the capacity to ship more units on demand. They also have the capacity to increase the speed of production because they have boule capacity and fab capacity in-house.

Vertically integrated suppliers, by definition, are not constrained by the challenges that face suppliers who must outsource parts of their SiC manufacturing. They have flexibility in capacity already, and are in a position to re-allocate resources, and adjust their mix of products and processes, to allow greater volumes of SiC production. Greater capacity flexibility means greater agility in speed to assembly and reliably meeting specifications. It also means more complete visibility into market requirements.

Vertical Integration

Cost

Vertically integrated manufacturers of SiC power devices for the electric vehicle market have a distinct advantage in being able to lower costs while maintaining product quality and performance. By vertically integrating various stages of the production process, these manufacturers streamline operations, optimize efficiency and reduce overall expenses.

One key benefit of vertical integration is the control over the entire supply chain. From sourcing raw materials to chip design, fabrication, testing and assembly, these manufacturers exercise greater control over cost drivers and quality control at each stage. This eliminates the need to rely on external suppliers, reducing costs associated with intermediaries and potential supply chain disruptions.

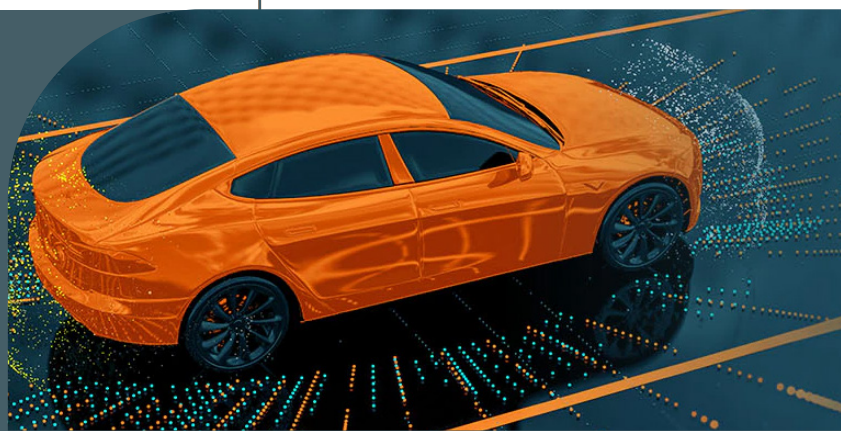
Vertical integration also better enables for process optimization and economies of scale. Manufacturers optimize each step of the production process to maximize efficiency and yield. By scaling up production volumes, they achieve cost savings through bulk purchasing of raw materials, equipment and automation technologies. They then are able to pass these cost efficiencies on to customers, resulting in more affordable SiC power devices for EV manufacturers.

Vertically integrated SiC suppliers also optimize their costs by streamlining their purchasing capability. They manufacture first-generation SiC solutions more cost effectively because everything is done under one roof. They also reduce their cost of manufacture because they already have fab capacity.

Ultimately, the vertical integration of SiC chip manufacturing for the EV market empowers manufacturers to lower costs, enhance quality control, drive innovation and deliver more cost-effective products. This integration fosters operational efficiency and flexibility, enabling them to maintain a competitive edge in the rapidly growing EV industry.

Driving Innovation

Another advantage of vertical integration is the ability to innovate more rapidly, and to customize products more quickly. Vertically integrated manufacturers of SiC power devices have direct access to all aspects of chip development and can quickly respond to market demands and evolving technology trends. By aligning chip design, manufacturing and testing processes, they develop tailored solutions that meet the specific requirements of the EV market, leading to improved system level performance and cost optimization.



Vertical Integration

Automotive OEMs and Tier 1 suppliers have compelling reasons to source their SiC power devices from vertically integrated suppliers. Here are five key considerations:

1. **Streamlined Supply Chain:** Vertically integrated SiC chip suppliers have control over the entire production process, from sourcing raw materials to chip design, fabrication and packaging. This streamlined supply chain reduces complexities and dependencies on multiple vendors, minimizing risks of disruptions and ensuring a more reliable and efficient supply of SiC power devices.

2. **Cost Efficiency:** Vertical integration allows suppliers to optimize processes, achieve economies of scale and eliminate intermediaries. By controlling the entire value chain, they streamline operations, reduce costs and pass on the benefits to customers. Sourcing SiC power devices from a vertically integrated supplier leads to more-competitive pricing, enabling OEMs and Tier 1 suppliers to enhance their cost-efficiency.

3. **Customization and Innovation:** Vertical integration fosters close collaboration and faster communication of customer requirements to the various steps in manufacturing. This facilitates customization and rapid product iteration, allowing OEMs and Tier 1 suppliers to tailor SiC power devices to their specific requirements. Additionally, vertically integrated suppliers are better positioned to invest in research and development, driving innovation and staying at the forefront of technological advancements.

4. **Quality Control:** With control over the entire production process, vertically integrated suppliers implement rigorous quality control measures at every stage. This ensures consistent and reliable performance of SiC power devices, meeting the stringent requirements of EV applications. OEMs and Tier 1 suppliers can have greater confidence in the quality and reliability of the sourced chips, reducing the risk of potential failures or performance issues.

5. **Technical Expertise and Support:** Vertically integrated suppliers often possess deep technical expertise across multiple domains, from semiconductor materials to chip design to packaging. This expertise translates into better technical support and collaboration, enabling OEMs and Tier 1 suppliers to address specific challenges, optimize chip performance and ensure seamless integration into their EV systems.

Sourcing SiC power devices from a vertically integrated supplier offers multiple advantages. These advantages significantly enhance the success of EV OEMs and Tier 1 suppliers in a rapidly evolving and highly competitive market.

About onsemi

onsemi is a top-10 global semiconductor supplier to the automotive industry, offering a comprehensive portfolio of discrete power and analog solutions, protections, sensing and connectivity.

We are a large-scale supplier of SiC solutions with end-to-end supply capability, which includes volume SiC boule growth, wafering, epitaxy, device fabrication, best-in-class integrated modules and discrete package solutions. Together with our end-to-end SiC manufacturing capabilities, **onsemi** EliteSiC products offer superior performance and meet exacting quality standards. With our deep application expertise in EV (on-board and off-board) and industrial, along with system level simulation tools, you count on us to deliver innovative solutions that provide you a competitive edge.

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