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How onsemi is Moving Towards a Mature SiC Ecosystem

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Designers of end equipment using electronic components have become accustomed to having a broad array of supporting tools and resources made available to them by semiconductor manufacturers. Apart from mandatory datasheets whose formats continue to evolve, products are now regularly accompanied by evaluation boards/kits, SPICE models and simulation tools, reference designs, selection guides, application notes and other supporting collateral intended to make it easier than not for designers to include one of their parts in the bill of materials. In addition, designers are further reassured by the fact that most manufacturers have strong supply chains, either in-house or by using high-capacity offshore fabrication facilities, and offer devices with various package options.

In contrast, despite being around for several decades, but possibly because of its association with more recent applications like electric vehicles (EV) and solar inverters, silicon carbide (SiC) is perceived as a ‘new’ technology without the same mature ecosystem of supports enjoyed by silicon products. This article shows measures onsemi is taking to dispel this myth, demonstrating the broad suite of supports in development for power electronics designers considering using SiC devices on their application boards.

Figure 1: SiC is assumed to be ‘new’ because of its association with applications like EVs

Depth of SiC product offering
Many designers assume that SiC providers only offer a range of discrete diodes, MOSFETs, or modules, limiting their use to niche power applications. In contrast, onsemi recently progressed to its third generation of EliteSiC device family and now offers more than 120 single and common-cathode SiC diodes with operating

voltages ranging from 650V to 1700V (responding to the trend for increasing voltage to reduce charging currents) and multiple packaging options, including DPAK, D2PAK, TO and PQFN. It also offers a similar number (100+) of 650V, 900V, 1200V and 1700V SiC MOSFET variants (M1, M2, M3S) in a choice of D2PAK and TO packages.

Furthermore, onsemi offers over 30 EliteSiC power integrated modules (PIM) containing SiC MOSFETs and SiC diodes with voltage ratings up to 1200 V. Finally, more than 20 hybrid Si IGBT and SiC device modules leverage the best features of SiC and silicon technologies are also available. This comprehensive offering has been optimized for performance and high-temperature operation in industrial and automotive-grade packaging temperatures for various power applications. SiC switching devices have special drive requirements relating to common mode transient immunity (CMTI), and onsemi offers several gate drivers, like the NCP51705 and NCP51561, which have been designed to drive SiC MOSFETs.

Figure 2: The latest EliteSiC products – 1200 V M3S SiC MOSFETs and SIC Module in standard F2 package

Evaluation boards and reference designs

Like their silicon counterparts, onsemi's EliteSiC product portfolio is fully supported by evaluation boards, allowing designers to quickly and efficiently evaluate the features and benefits of devices. In addition, onsemi is continuously developing reference designs demonstrating prototype product solutions like the SEC-25KW-SIC-PIM-GEVK reference design kit for a 25kW DC fast EV charger based on a SiC power integrated module. This complete SiC solution consists of power factor correction (PFC) and DC-DC stages featuring multiple 1200V, 10 mΩ half-bridge NXH010P120MNF1 SiC modules, with low $R_{DS(ON)}$ and parasitic inductance to reduce conduction loss and switching loss significantly.

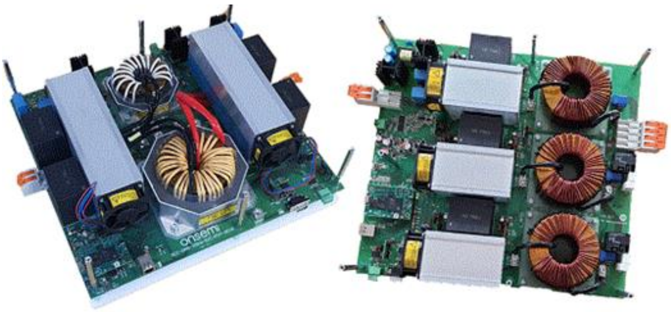

Figure 2: onsemi’s SEC-25KW-SIC-PIM-GEVK DC charger reference design (left - Dual Active Bridge Stage right – PFC Stage)

Design and simulation tools

Power electronics designers often use simulation tools to verify how a design will function before committing to the cost and effort of designing and building a board. Software simulators use device SPICE models to mathematically predict how a circuit behaves. For designers who have not previously worked with SiC devices, this represents a critical enabler for them to gain confidence in a technology with which they are unfamiliar. onsemi has developed physically based, scalable SPICE models for its SiC devices. In addition, its Elite Power Simulator provides engineers with an accurate representation of how their circuit will work when using the EliteSiC family of products, including manufacturing corner cases of the technology. Typical industry system-level simulators that employ PLECS models are valid only for hard-switching, rendering simulation results for soft-switching applications highly inaccurate. However, onsemi has developed advanced PLECS models that are valid for hard and soft switching applications such as LLC and CLLC Resonant, Dual Active Bridge, and Phase Shifted Full Bridge. The robust models are valid across multiple SPICE simulation platforms like PSpice, LTspice, Simetrix, Spectre, ADS, SABER, and Simplorer.

onsemi’s Self-Service PLECS Model Generator delivers power electronics engineers the power and freedom to create custom high fidelity system level PLECS models. Engineers can use generated models directly in their simulation platform or upload it to Elite Power Simulator to simulate. The models are generated based on typical or worst-case conditions to let the customer design within the technology boundaries. The capability to define application-specific parasitics ensures that the generated PLECS models provide highly accurate results for the customer’s system-level simulations.

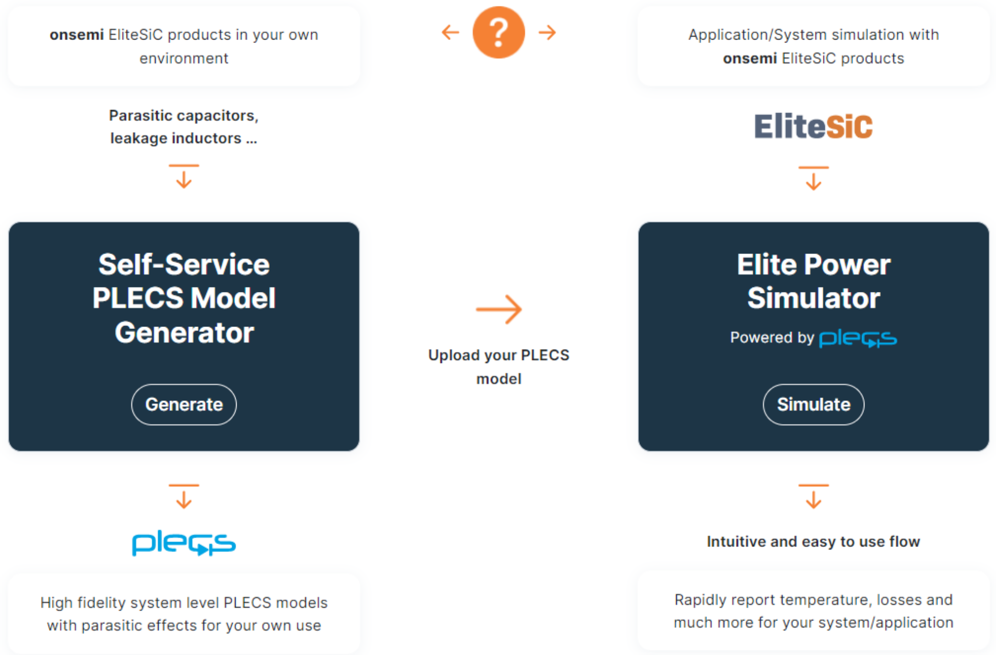

Figure 3: How to Choose Elite Power Simulator and Self-Service PLECS Model Generator

Materials quality
While the physical properties of SiC make it one of the most exciting semiconductor materials for manufacturing high−power electronic devices, the specific challenges of SiC materials are subject to several potential process−related reliability hazards, even when exacting the highest levels of product reliability. Eliminating these requires understanding failure modes and mechanisms, tracing them using failure analysis techniques to identify process weaknesses, and implementing appropriate corrective actions which become embedded in the manufacturing process. This can be done through extensive wafer and product qualification, and onsemi has developed a comprehensive and cross−functional methodology to assess its SiC products before releasing them safely to the market. This combination of a rigorous design methodology, strict production monitoring, manufacturing control, appropriate screening, and robust qualification procedures is the foundation for the robust and reliable SiC products onsemi supplies and stands over.

Vertically integrated supply chain
One of the biggest concerns for designers considering switching to using SiC devices in their designs is the availability (or lack thereof) of products on a timely basis and as required. This is based on the misperception that SiC products are difficult to manufacture with limited available production capacity. onsemi's SiC supply chain begins by growing single crystal silicon carbide material at its Hudson, New Hampshire facility, where wafer substrates are first produced. A thin epi layer is then grown on these, followed by several device processing steps before the final stage when products are packaged. This entire manufacturing process is vertically

integrated end-to-end, with exhaustive reliability and quality testing at each step to ensure near-zero defect products. A vertically integrated supply chain brings several advantages, like scalability, superior quality, and production cost control. onsemi qualifies all of its SiC products at 100% rated voltage and a temperature of 175°C. Devices are also 100% avalanche rated, have intrinsic gate oxide reliability, and undergo cosmic radiation testing. Furthermore, additional quality assurance is provided by defect scanning, which is performed before and after epitaxial growth. Vertical integration also helps ensure that production volumes can be rapidly scaled up and processes are optimized by quickly feeding back status information at each value chain stage. onsemi is the only large-scale supplier of SiC and solutions with end-to-end supply capability.

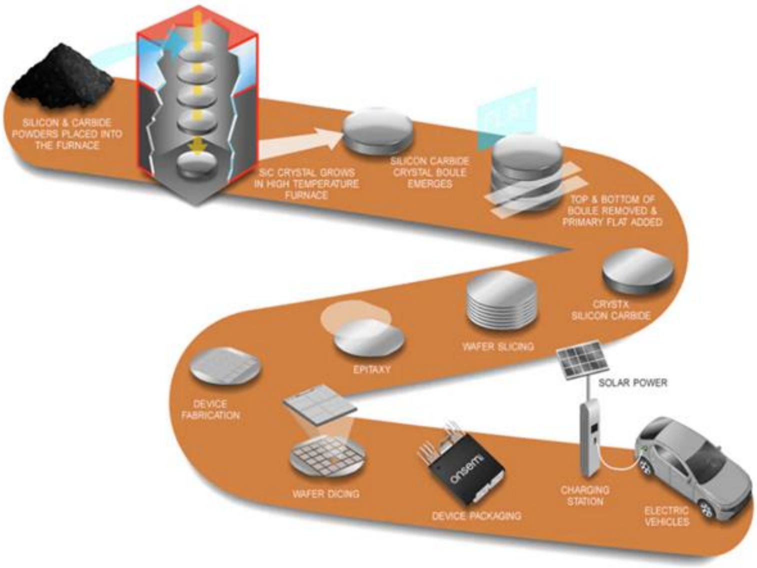

Figure 4: onsemi's vertically integrated supply chain

Conclusion

onsemi is taking several steps to dispel in the minds of power electronics designers the myth that SiC is a 'new' and poorly supported technology compared to silicon. onsemi is continuously maturing the ecosystem of supports for its already broad (and growing) SiC discrete and module product offerings, including evaluation boards, reference designs, simulation models and tools, efficient and thorough material quality control and a dependable, vertically integrated supply chain.

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