Dean&Francis
ISSN 2959-6157

The Application of Wide Bandgap Semiconductors in Electric Vehicles

Kaiming Jiang

Beijing Royal school, Beijing, 111000, China
*Corresponding author: 15546504679@163.com

Abstract:
As the global electric vehicle (EV) industry rapidly develops towards higher range, higher power density, and higher reliability, traditional silicon-based power semiconductor devices can no longer meet the stringent requirements of power electronic systems due to inherent characteristics such as narrow bandgap and low breakdown electric field.The advantages of electric vehicles, such as power response and cost of use, are constrained by their dependent battery performance, range and energy replenishment, which directly affect their adaptability in different application scenarios.Targeted research can resolve the above contradictions, not only providing technical references for the upgrading of power electronic systems, but also facilitating industrial development through the closed loop of "pain point resolution - advantage enhancement - application expansion".This paper systematically studies the development status of wide-bandgap semiconductor devices, conducts in-depth analysis on the structural principles, commercial parameters, key technical bottlenecks, and solutions of SiC and GaN devices, and compares the characteristic differences between these three types of devices and traditional silicon devices. On this basis, it focuses on exploring the application scenarios and architectures of wide-bandgap semiconductors in core EV systems such as motor drives, DC-DC converters, and on-board chargers, and elaborates on efficiency improvement strategies such as soft switching technology and interleaved parallel structure, as well as electromagnetic interference (EMI) suppression technical measures.

Keywords: Wide-bandgap Semiconductor; Electric Vehicle; Silicon Carbide; Gallium Nitride

1. Introduction

With increasing global attention to environmental protection and sustainable development, EVs (Electric Vehicles), as clean and efficient means of transportation, have gradually become the mainstream direction of future transportation development. The core of an EV is the power electronic system, which is responsible for the conversion, control, and distribution of electrical energy, and plays a crucial role in vehicle performance, efficiency, and reliability. To meet the evolving demands of the EV industry, power electronic systems are required to meet stringent and specific performance criteria. These include: high power density to fit within the limited space of vehicle chassis while delivering sufficient power for propulsion; high energy efficiency (typically above 95%) to maximize the driving range by minimizing energy loss during power conversion; fast dynamic response to adapt to rapid changes in driving conditions such as acceleration, deceleration, and regenerative braking; wide temperature adaptability to operate stably in extreme environments ranging from -40°C to 125°C; and excellent reliability and durability to withstand long-term vibrations, voltage fluctuations, and thermal cycles throughout the vehicle's lifespan (usually 8-15 years or 150,000-300,000 kilometers). Traditional silicon devices have obvious limitations in EV applications: in high-power scenarios, silicon devices have high on-resistance, leading to a large amount of heat generation during power conversion, which not only reduces system efficiency but also increases heat dissipation costs and system complexity; their low switching frequency also limits the improvement of power density of power electronic systems. Facing the growing demand for high power and high efficiency in EVs, traditional silicon devices can no longer meet the requirements. Wide-bandgap semiconductors have emerged as a new solution for EV development due to their unique physical properties. Therefore, researching their application in electric vehicles has important practical significance and urgency [1].

Wide-bandgap semiconductors generally refer to semiconductor materials with a bandgap width greater than 2 eV, and they have a series of excellent characteristics compared with traditional silicon (Si), which show significant targeted application value in the field of electric vehicles (EVs).

First, high breakdown voltage. The breakdown electric field strength of silicon carbide (SiC) is about 10 times that of silicon (Si: ~0.3 MV/cm; SiC: ~3 MV/cm), while gallium nitride (GaN) reaches ~3.3 MV/cm, which is about 11 times that of Si. This characteristic is crucial for the power battery management system (BMS) and on-board charging module of electric vehicles. In the on-board charger (OBC), higher breakdown voltage allows the semiconductor device to withstand higher input voltages (such as the 800V high-voltage platform increasingly adopted by new energy vehicles) without increasing the volume of the device. Taking the 800V fast-charging system as an example, Si-based devices need to adopt a multi-device series structure to meet the voltage requirements, which not only increases the complexity of the circuit but also reduces the conversion efficiency. In contrast, SiC/GaN devices can realize high-voltage resistance with a single chip, which simplifies the circuit design, reduces the volume and weight of the OBC (by about 30%-50% compared with Si-based OBC), and further promotes the lightweight of the whole vehicle while improving the fast-charging efficiency.and GaN is also several times that of silicon, enabling devices to operate at higher voltages, reducing the number of series devices, lowering system complexity and cost. In the high-voltage power system of EVs, it can improve voltage conversion efficiency and power density. Second, high switching frequency [2]. Wide-bandgap semiconductors have high electron mobility and faster switching speed. For example, GaN devices can achieve MHz-level switching frequencies, much higher than the tens to hundreds of kHz of silicon devices, which can reduce the volume and weight of magnetic components such as inductors and transformers, improve system power density, and reduce EMI. Third, excellent high-temperature performance. SiC and GaN have high thermal conductivity, and their wide bandgap results in low intrinsic carrier concentration at high temperatures, allowing stable operation above 20(silicon devices are usually limited below 15) [3]. In the high-temperature environment of EVs, this can improve system reliability and reduce the burden on the heat dissipation system [4].

ISSN 2959-6157

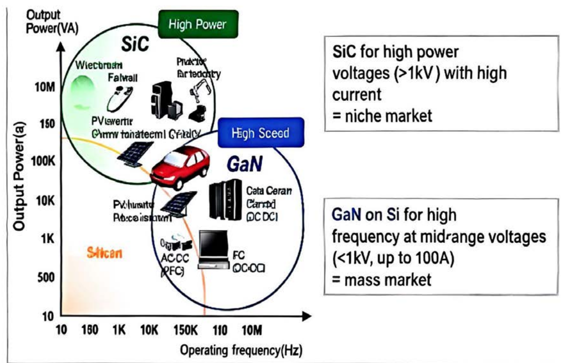

Fig 1. wide-bandgap semiconductor

This research is of great significance for the technological development and industrial upgrading of EVs: At the technical level, the research on the application of wide-bandgap semiconductors helps break through the performance bottlenecks of traditional silicon devices, promotes technological innovation in EV power electronic systems. Through in-depth research on device characteristics, application technologies, and system integration optimization, more efficient, reliable, and compact power electronic systems can be developed, providing support for improving vehicle range, dynamic performance, and charging speed [5]. At the industrial level, the application of wide-bandgap semiconductor technology will drive the transformation and upgrading of the EV industry chain, promote the development of related industries such as materials, device manufacturing, and system integration, and form new economic growth points. At the energy and environmental level, wide-bandgap semiconductors can further improve the energy efficiency of EVs, reduce energy loss, help achieve energy conservation and emission reduction goals, and alleviate the energy crisis and environmental pollution problems [6].

2. Development status of wide band gap semiconductor devices

With the continuous development of EV technology, the performance requirements for power semiconductor devices are increasingly high. Wide-bandgap semiconductor devices have become a research hotspot in the EV field due to their high breakdown voltage, high switching frequency, and high-temperature operation capability. This chapter elaborates on the development status of SiC and GaN power semiconductor devices in detail, and compares the characteristics of Si, SiC, and GaN devices [7].

2.1 SiC power semiconductor devices

2.1.1 Device structure and operating principle

Common structures of SiC power semiconductor devices include Schottky barrier diodes (SBD) and metal-oxide-semiconductor field-effect transistors (MOSFET). SiC Schottky barrier diodes form a metal-semiconductor contact between metal and n-type SiC semiconductor, and realize conduction and turn-off by using the Schottky barrier. They have no minority carrier storage effect, fast switching speed, and low reverse recovery loss. SiC MPS diodes add a P-type injection region on the basis of the Schottky structure. During forward conduction, minority carriers are injected to reduce the on-resistance, and during reverse cutoff, leakage current is suppressed, which has both high-frequency characteristics and high voltage withstand capability. The working principle of SiC MOSFET is similar to that of silicon MOSFET. It controls the on-off of the channel through gate voltage, uses an n-type SiC substrate, has higher saturated electron mobility and wide bandgap, and can work stably at higher voltages and temperatures with fast switching speed and low loss [8].

2.1.2 Commercial device parameters and application range

Commercial SiC devices have rich parameters. Taking SiC Schottky barrier diodes as an example, the voltage withstand range is usually 600V-1700V, and the current ranges from several amperes to tens of amperes. For example, a 650V/20A device has a forward conduction voltage lower than 1.0V and a reverse recovery time close to zero, which is widely used in switching power supplies, photovoltaic inverters and other fields. SiC MOSFET has a voltage withstand range of 600V-1200V and a current capability of tens to hundreds of amperes. For example, a 1200V/100A device has an on-resistance as low as tens of milliohms. In EVs, it is mainly used in motor drive systems and high-power DC-DC converters, which can improve motor efficiency and power density and realize efficient voltage conversion [9].

2.1.3 Key technical problems and solutions

The key technical problems faced by the application of SiC devices in electric vehicles include: EMI problems caused by high-frequency switching. This issue not only affects the normal operation of on-board sensitive electronic equipment (such as battery management systems and vehicle controllers) but also may interfere with the external electromagnetic environment. To address this challenge, targeted solutions need to be designed in combination with specific application scenarios of electric vehicles, while considering practical constraints such as cost and process to ensure feasibility. the influence of parasitic parameters on switching performance, using low stray inductance packaging technologies such as flip-chip and planar interconnection to reduce bonding wires and

pins; high-temperature heat dissipation problems, selecting high thermal conductivity packaging materials such as aluminum nitride (AlN) ceramic substrates, combining double-sided heat dissipation technology, and optimizing the design of thermal management systems such as liquid cooling and air cooling to ensure that the device works within a safe temperature range.

2.2 GaN Power Semiconductor Devices

2.2.1 Device structure and operating principle

Common structures of GaN power semiconductor devices include high electron mobility transistors (HEMT), gate injection transistors (GIT), and cascode structures. GaN HEMT adopts an AlGaN/GaN heterojunction structure, uses the two-dimensional electron gas (2DEG) at the heterojunction interface to realize current conduction, and controls the potential well depth and 2DEG concentration through gate voltage, thereby adjusting the drain current. The cascode structure is formed by series packaging of a low-voltage enhancement-mode Si MOSFET and a high-voltage depletion-mode GaN HFET. It uses the normally-off characteristic of Si MOSFET and has high voltage withstand, low on-resistance, and good gate drive characteristics.

2.2.2 Commercial device parameters and application range

Commercial GaN devices are mainly HEMTs, with a voltage withstand range mostly below 650V and a current of several amperes to tens of amperes. For example, a 650V/30A GaN HEMT has an on-resistance lower than tens of milliohms, fast switching speed, and can work at MHz-level frequency. In EVs, GaN devices are mainly used in on-board chargers and low-power DC-DC converters. For example, a 7.2kW on-board charger using GaN devices can achieve a power density of 10kW/L and a peak efficiency of 97.8%, and the low-power DC-DC converter can provide a stable and efficient power supply for on-board low-voltage electrical appliances [10].

2.3 Comparison of Si, SiC and GaN Device Characteristics

As shown in Fig 2, key parameters of Si, SiC, and GaN devices differ significantly: Si has a 1.1 eV bandgap, ~3×10^5 V/cm breakdown electric field, and ~1500 $cm^2/V\cdot s$ electron mobility; SiC has a 3.26-3.33 eV bandgap, 2.5×10^6 V/cm breakdown electric field, and ~900 $cm^2/V\cdot s$ electron mobility; GaN has a ~3.4 eV bandgap, ~3.3×10^6 V/cm breakdown electric field, and ~2000 $cm^2/V\cdot s$ electron mobility. Combined with EV scenarios, these guide device selection: for powertrain inverters, SiC/GaN's larger band gap and higher breakdown electric field reduce on-resistance/switching losses, enabling smaller, more efficient inverters that extend range by 5%-10% vs. Si. For on-board chargers (OBC), GaN's high mobility suits high-frequency compact modules, while SiC excels in high-temperature reliability. Non-technically, Si has mature supply chains and low cost (1/5-1/10 of SiC), dominating low-voltage auxiliary systems; SiC has improved supply chain maturity but high cost, used in mid-to-high-end powertrains; GaN lacks supply chain support and has high packaging costs, in trial for high-end OBCs. This "technical + practical" comparison provides a systematic basis for subsequent EV device scenario analysis.the breakdown electric field is 2×10^6 V/cm-3×10^6 V/cm, and the electron mobility is 400 $cm^2/V\cdot s$-1000 $cm^2/V\cdot s$; the bandgap of GaN is 3.4 eV, the breakdown electric field is 3.3×10^6 V/cm, and the electron mobility is 1000 $cm^2/V\cdot s$-2000 $cm^2/V\cdot s$. The wide bandgap and high breakdown electric field of SiC and GaN make them suitable for high-voltage and high-temperature scenarios, while the high electron mobility of GaN gives it more advantages in high-frequency applications. Each of the three has its applicable scenarios. With the development of technology and cost reduction, the application prospect of wide-bandgap semiconductors in the EV field will be broader.

ISSN 2959-6157

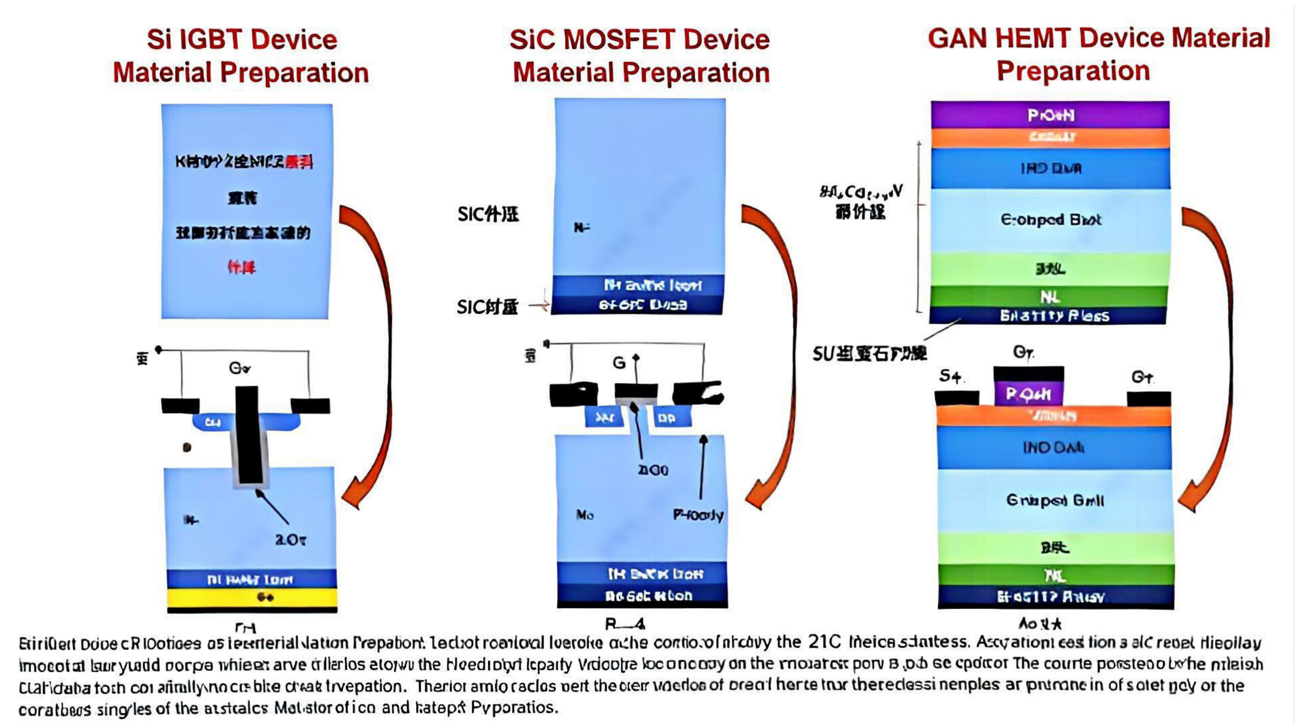

Fig 2. Comparison of Device Characteristics Among Si, SiC and GaN

3. Application of Wide Bandgap Semiconductor in Electrodynamic Vehicle System

3.1 Application scenarios and system architecture

3.1.1 Application of SiC in electric vehicles

SiC is widely used in key components of EVs, especially in motor drives and high-power DC-DC converters, where it has significant advantages. Taking the Tesla Model 3 as an example, its drive motor adopts 24 650V/100A SiC MOSFET modules with a three-phase bridge topology and a liquid-cooled heat dissipation scheme, which ensures stable operation under high power. Compared with traditional silicon devices, the conduction loss is reduced by about 50%, and the high switching frequency enables more precise motor control, improving dynamic performance and driving comfort; although the initial cost of SiC devices is higher, the comprehensive benefits such as reduced battery capacity configuration, extended cruising range and improved energy efficiency make the application scheme have significant long-term value.In high-power DC-DC converters, the high voltage withstand characteristic of SiC devices reduces the number of series devices, and the low on-resistance and high switching frequency improve conversion efficiency and reduce the burden on the heat dissipation system [11].

3.1.2 GaN applications in electric vehicles

GaN performs prominently in on-board chargers and low-power DC-DC converters. A 7.2kW on-board charger adopts GaN devices, interleaved parallel, and dual active bridge (DAB) topology, with a power density of 10kW/L, a peak efficiency of 97.8%, a power factor of more than 0.99, and a total harmonic distortion (THD) of less than 4%, meeting the requirements of fast charging and miniaturization. In low-power DC-DC converters, such as INOSECO's INN040FQ043A GaN switch (40V voltage withstand, 4.3mΩ on-resistance), it realizes high-frequency and efficient conversion with a small package, providing a stable power supply for on-board low-voltage electrical appliances.

3.2 Technical strategies for improving system efficiency

3.2.1 Application of soft switching technology

Soft switching technology can effectively reduce the switching loss of wide-bandgap semiconductor devices. Among them, Zero Voltage Switching (ZVS) designs the resonance between the resonant inductor and the switch parasitic capacitor to reduce the voltage across the switch to zero before conduction. This technology has clear ad-

aptation scenarios in electric vehicles: for example, it can improve charging efficiency and power density in DC-DC converters, and reduce inverter loss and enhance operation stability in motor control systems. Its integration methods are mostly realized by optimizing resonant parameters and control strategies to achieve coordination with existing systems. However, there are potential problems in application such as large volume of resonant components and intensified electromagnetic interference at high frequencies. Corresponding countermeasures can be adopted, such as integrating and packaging resonant components, optimizing PCB layout and adding shielding measures, which provide a more comprehensive and rigorous technical reference for engineering practice.avoiding voltage and current overlap, reducing conduction loss and EMI, and is widely used in SiC MOSFET full-bridge converters. Resonant switching technology adds resonant components to make the switch work in a resonant state, reducing the voltage and current change rate during the switching process. For example, the LLC resonant converter uses a series-parallel resonant network to realize soft switching and improve conversion efficiency

3.2.2 Interleaved Parallel and Multilevel Circuit Structures

The interleaved parallel structure parallels multiple identical circuit modules and controls the switching signals in an interleaved manner, which can reduce the input and output current ripple. For example, the GaN on-board charger adopts a two-phase interleaved power factor correction (PFC) circuit, with a switching phase difference of 180°, reducing the demand for EMI filters and the size of inductors. The multi-level circuit structure realizes the gradual conversion of electrical energy by cascading circuits with different functions. For example, the high-voltage DC-DC converter of EVs adopts a two-stage structure of “PFC circuit + isolated DC-DC converter”. The front stage improves the power factor, and the rear stage realizes voltage conversion and isolation, ensuring high efficiency in the full load range [12].

4. System-level performance analysis and case studies

4.1 Performance Comparison of SiC and GaN in Electric Vehicle System

As shown in Fig3, In EV systems, SiC and GaN devices have their own advantages in indicators such as efficiency and power density. In high-power scenarios, such as motor drive systems, SiC MOSFETs have low on-resistance and high voltage withstand characteristics, and the rated power efficiency can reach more than 95%; in high-frequency low-power scenarios, such as on-board chargers, GaN HEMTs rely on high switching frequency, and the peak efficiency exceeds 97%. In terms of power density, GaN devices reduce the volume of magnetic components of on-board chargers by 30%, significantly improving power density; SiC devices in high-power DC-DC converters achieve a power density 20% higher than that of traditional silicon-based products through compact topology design. In summary, SiC is suitable for high-voltage and high-power scenarios, and GaN is suitable for high-frequency and low-power scenarios, and reasonable selection should be made according to system requirements [13].

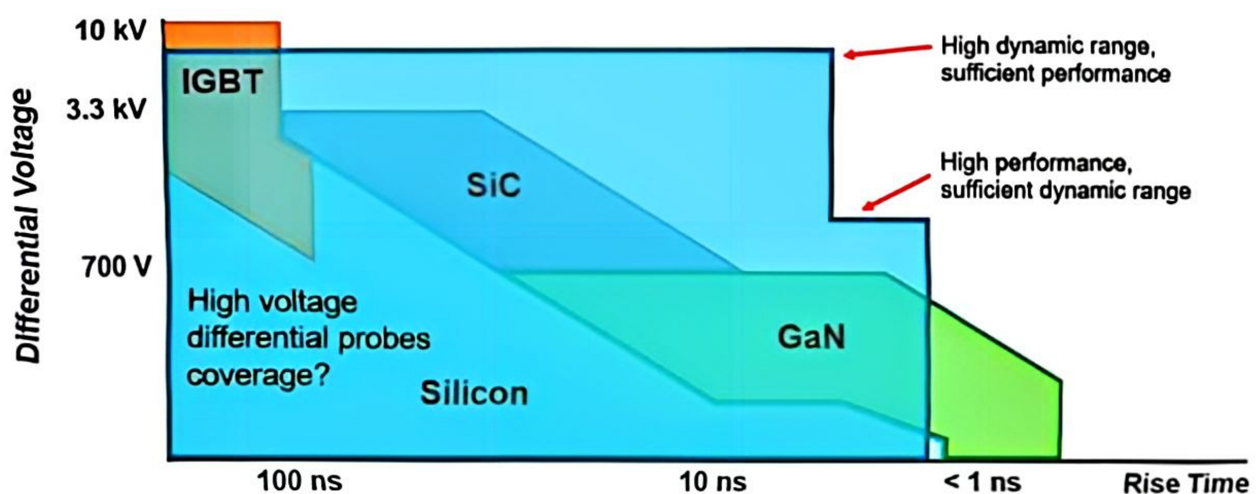

Fig 3. Performance Comparison Between SiC and GaN in Electric Vehicle Systems

ISSN 2959-6157

4.2 Deep analysis of typical application cases

4.2.1 An electric vehicle integrated DC-DC converter case

An EV integrated DC-DC converter adopts SiC MOSFET as the core device and achieves input-output electrical isolation via an isolated flyback topology. Utilizing SiC's high switching frequency, the flyback transformer's volume and weight are significantly reduced, with ZVS technology integrated to cut switching loss. It supplements test conditions for key parameters (200-400V DC input, 500W-1kW output, -40°C to 85°C ambient temp) to clarify data validity boundaries and boost performance indicator reference value, while analyzing compatibility with mainstream standards like ISO 15118 and GB/T 18487 and evaluating promotion potential in passenger EV/light commercial vehicle markets, providing more engineering guidance and implementation basis. In terms of performance, the full-load conversion efficiency exceeds 96%, which is 3-5 percentage points higher than that of traditional silicon-based products; the power density reaches 5W/cm³, an increase of about 40%. In practical applications, this converter reduces energy loss, extends vehicle range, the compact design provides flexibility for vehicle body layout, and high reliability ensures stable vehicle operation [14].

4.2.2 Modular resonant bidirectional converter case

An EV modular resonant bidirectional converter adopts LLC resonant topology, with GaN HEMT as the switching element. Using its high switching frequency and low on-resistance characteristics, the switching frequency exceeds 1MHz, significantly reducing the size of resonant components. As shown in Fig 4, during operation, the switch is controlled to work in a resonant state through the resonant network to realize soft switching, reducing loss and EMI. In terms of performance, the efficiency of the energy recovery process exceeds 95%, which can efficiently convert braking kinetic energy into electrical energy for storage; the charging process can also transmit power efficiently, with low EMI and no obvious interference to on-board electronic equipment.

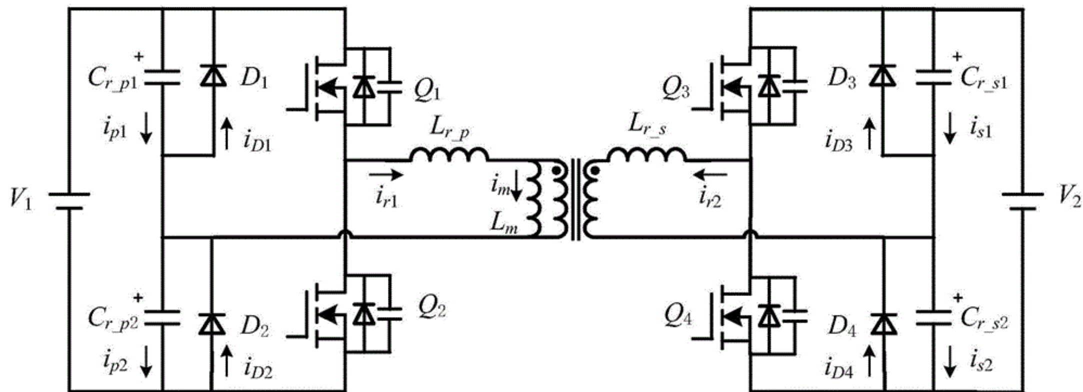

Fig 4. Modular Resonant Bidirectional Converter

4.2.3 Compound Boost Converter Cases

An EV compound boost converter uses SiC diodes and MOSFETs as key devices, and a two-stage boost structure realizes high voltage gain. The first stage achieves preliminary boosting through the fast switching of SiC MOSFET, and the second stage further boosts the voltage using the low forward conduction voltage and fast recovery characteristics of SiC diodes. Compared with traditional silicon-based devices, the full-load efficiency of this converter is increased by about 4 percentage points, reaching more than 94%, and the maximum voltage gain can reach 10 times. It provides a stable high-voltage power supply for motor drives, improves the output power and efficiency of the motor, enhances the dynamic performance of the vehicle, and at the same time, high reliability reduces the probability of failure [15].

5. Challenges and Future Research Directions

5.1 Current technological challenges and strategies

Wide-bandgap semiconductors demand low-delay, high-drive-capability drive circuits with matched output impedance to avoid signal reflection/oscillation, while fast switching in PCB layout risks EMI-induced signal integrity issues. Given electric vehicles' space constraints (e.g., limited battery pack/powertrain space), designs must balance compactness and thermal management, such as using integrated drive modules. For device-specific challenges: SiC requires precise voltage clamping for gate oxide reliability under high voltages, while GaN needs optimized

PCB routing to reduce parasitic inductance due to faster switching. These targeted strategies boost analysis practicality, offering differentiated guidance for EV applications.requiring reasonable device layout, shortened signal paths, and optimized impedance matching. Optimization strategies include using high-speed low-delay drive chips and totem-pole drive topology, selecting low-resistance and low-inductance components; using tools such as ANSYS HFSS to simulate PCB electromagnetic characteristics, adopting multi-layer board structure and reasonable power/ground layer distribution to improve electromagnetic compatibility.

Wide-bandgap semiconductors are prone to performance degradation in high-temperature, high-voltage, and high-current environments, and a large amount of heat generated by high-frequency switching intensifies the pressure of thermal management. Thermal management solutions include using efficient heat sinks and forced cooling methods such as liquid cooling and air cooling; optimizing the package structure, selecting high thermal conductivity packaging materials, and improving the internal heat conduction speed of the device. Improving reliability requires material optimization and process improvement to enhance the stability of the device under harsh conditions.

5.2 Future research trends and development prospects

Future packaging technologies will focus on improving heat dissipation performance and reducing parasitic parameters. For example, three-dimensional packaging technologies such as chip stacking and through-silicon vias (TSV) shorten the heat conduction path; low-temperature co-fired ceramic (LTCC) and embedded packaging reduce parasitic inductance and capacitance. In terms of system-level integration, integrating power devices, drive circuits, and control circuits into a system-in-package (SiP) reduces system volume and weight, and improves reliability and response speed.

System-level verification needs to test the entire electrical system of EVs such as motor drive, charging, and energy management, and evaluate the performance, reliability, and compatibility of wide-bandgap semiconductors [16]. At present, the industry lacks unified standards, leading to large differences in device interfaces and high system integration difficulty. In the future, it is necessary to accelerate the formulation of unified performance standards, test methods, and interface specifications to promote the healthy development of the industry, improve product quality and interchangeability, and reduce production costs [17].

6. Conclusion

To solve the technical bottlenecks of traditional semiconductors in EVs—high losses and low power density under high-power/high-frequency conditions—this research confirms the significant advantages of SiC and GaN wide-bandgap semiconductors: SiC reduces losses in motor drives and high-power DC-DC converters by over 5% via high breakdown voltage and temperature performance; GaN boosts on-board charger power density by >30% with efficiency over 97% due to high switching frequency. However, current research has limitations like insufficient low-temperature data; future focus should be on low-temperature performance testing and cost optimization to guide subsequent research and engineering. Soft switching technology, interleaved parallel structure, etc., further improve system efficiency by 2-3 percentage points, and EMI suppression measures such as multi-level PWM modulation reduce interference intensity by 10-15dB. Typical cases verify the application effects of wide-bandgap semiconductors, such as the integrated DC-DC converter with efficiency exceeding 96% and power density increased by 40%.

References

[1] Manikanthababu N ,Karmakar S ,Shiam F I , et al. A comparative high-temperature electrical study of single crystal and amorphous ZnGa2O4 as a gate dielectric in β-Ga2O3 MOSCAP devices[J].Materials Research Bulletin,2026,194113791-113791.

[2] Li J ,Yousaf M ,Ahmed J , et al. Gd3Ga5O12: A wide bandgap semiconductor electrolyte for ceramic fuel cells, effective at temperatures below 500 °C[J].Journal of Rare Earths,2025,43(10):2248-2256.

[3] Yuan Chaoxin, Xu Dong, Song Chengjun, et al. Research progress of wide band oxide semiconductor ultraviolet photodetectors [J]. Sensors and Microsystems, 2025, 44 (10):1-6+ 1 - 6.

[4] Wang Tao, Zhang Lili, Yin Yanan, et al. Review of single event effect research in wide bandgap semiconductor gate structure devices [J]. China Integrated Circuits, 2025, 34 (09):12-20.

[5] Wu Xuan, Gao Runlong, Liu Zhiyu, et al. Research progress of wide bandgap semiconductor X-ray detectors [J]. Acta Luminorum Sinica, 2025, 46 (05):794-812.

[6] Zhao Zhengping. Recent Progress in Ultra-Wide Band Gap Semiconductor Ga 2O 3 Power Devices and Ultraviolet Photoelectric Devices (Continued)[J]. Semiconductor Technology, 2025, 50 (05):417-434.

[7] Lu Pudong, Wu Chao, Wang Shunli. Deep ultraviolet photodetector based on ultra wide band semiconductor gallium

ISSN 2959-6157

oxynitride and its arc detection application [J]. China Laser, 2025, 52 (01):58-65.
[8] Balasubramanian K ,Manna S ,Sankaranarayanan K S . Data driven insights into the characteristics of wide bandgap semiconductors in 2D materials[J].Computational Materials Science,2025,246113476-113476.
[9] Shangguan Q ,Lv Y ,Jiang C . A Review of Wide Bandgap Semiconductors: Insights into SiC, IGZO, and Their Defect Characteristics[J].Nanomaterials,2024,14(20):1679-1679.
[10] Lei Shasha, Gong Qiaorui, Zhao Chengchun, et al. Research progress of wide-band semiconductor ZnGa 2O 4 [J]. Acta Crystallographica Sinica, 2024, 53 (08):1289-1301.
[11] Cui Yanjun, Yan Chunguang, Ning Pingfan, et al. Patent Analysis of Ultra Wide Band Gap Semiconductor Gallium Oxide [J]. Henan Science and Technology, 2024, 51 (10):134-138.
[12] Wang Yawei. Atomic force microscopy analysis of gallium nitride based on wide band gap semiconductor materials [J]. Wireless Internet Technology, 2024, 21 (04):40-42.
[13] Zhao Zhengping. New Progress in Power Electronics of Ultra-Wide Bandgap Semiconductor AlN (Continued)[J]. Semiconductor Technology, 2023, 48 (06):453-462.
[14] Zhao Zhengping. New progress in power electronics of AlN ultra-wide band semiconductor [J]. Semiconductor Technology, 2023, 48 (05):361-374.
[15] Rao Zhangfei, Qin Kailiang, Xue Dong, et al. Study on Pulse Voltage Measurement and Calibration Technology of WBG Semiconductor Devices [J]. Aerospace Measurement Technology, 2022, 42 (06):13-21.
[16] Wu Weizhen, Yang Fan, Hu Bo, et al. A Study on the Connection Mechanism between Sintered Silver Paste and Metallized Substrate for WBG Semiconductor [J]. Locomotive Electric Transmission, 2022, (06):149-155.
[17] Chen Xing, Zhou Chang, Liu Kewei, et al. Progress in UV detectors based on WBG semiconductor oxide micro-nano materials [J]. China Optics, 2022, 15 (05):912-928.