Rise and Rise of SiC and GaN in Power Electronic Industry

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Abstract

In the dynamic power electronic business, wide gap materials Silicon Carbide (SiC) and Gallium Nitride (GaN) have made remarkable entry over the last years and continue their market ascension. Emergence of EV/HEV market has impacted significantly the wide SiC industry, numerous carmakers adopt SiC devices in main inverters, on-board chargers (OBC) and DC/DC converters. On the other hand, GaN has found a sweet spot in high volume consumer rapid charging and future EV applications. This paper provides an overview of SiC and GaN device technology and ecosystem, including Yole Développement's understanding of the market's current dynamics and future evolution of wide band gap materials compared to mainstream Silicon power electronics market.

INTRODUCTION

In the last couple of decades, the worldwide SiC and GaN scene has been characterized by development, growing industry acceptance and the promise of billion-dollar revenues. The first commercial SiC device hit the scene in 2001 in the form of a Schottky diode from Germany's Infineon. Rapid development has followed, and this industry sector is now poised to reach over $4 billion dollar market by 2026.

Meanwhile, GaN first wowed industry pundits in 2010 when US-based EPC delivered its super-fast switching transistors. Market adoption hasn't yet matched that of SiC but come 2026, power GaN revenues could hit $1 billion as shown in Figure 1.

MARKET OPPORTUNITIES FOR GAN

Following the adoption of GaN HEMTs for Oppo's in-box fast charger at the end of 2019, the penetration of this wide bandgap material boosted. In the consumer market, GaN enjoyed a successful period in 2020-21 thanks to several companies such as Xiaomi, Lenovo, Samsung, Realme, Dell and LG, as well as other Chinese aftermarket companies that adopted GaN technology. Also, other players such as Samsung and Xiaomi have opted for GaN accessory chargers. Very recently, in Q4-2021, Apple has also started using 140W GaN technology in its Mac Book Pro paving the way for higher penetration in this segment.

EV/HEV market is to be watched as well for GaN technology. Even though it's early days for GaN in this segment, many power GaN players have developed and auto-qualified 650 V GaN devices for OBC and DC/DC conversion in EVs/HEVs, with myriad partnerships already formed with automotive businesses.

For example, Transphorm, US, has teamed up with automotive supplier, Marelli, to provide devices for onboard charging and DC/DC conversion. And STMicroelectronics is expected to supply its yet-to-be auto-qualified devices to Renault for on EV applications. Also, US-based EPC, supplier of automotive qualified low voltage GaN, is working with French-based Brightloop to develop affordable power supply converters for off-high way and commercial vehicle. In 2020, Texas Instruments and Nexperia also qualified its 650V GaN devices for automotive applications. While VisIC Technologies of Israel partnering with German auto-supplier, ZF, to develop GaN semiconductors for 400 V driveline applications, GaN Systems signed a $100 million deal with

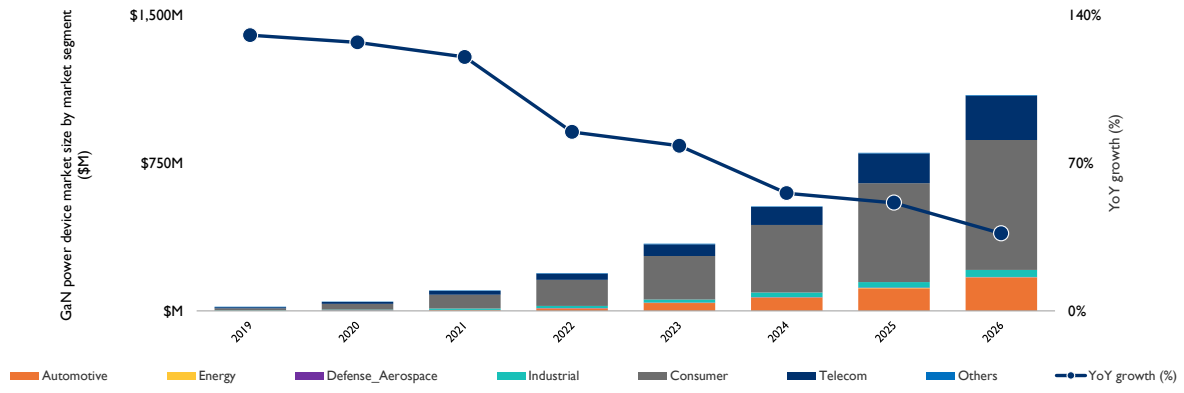

Fig. 1. Power GaN market evolution

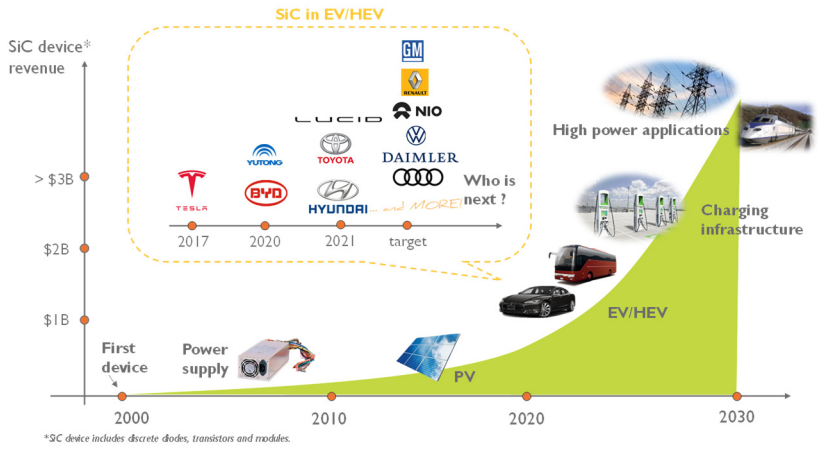

Fig. 2. Power SiC market evolution and roadmap

BMW to provide the capacity to manufacture GaN power devices for the German auto-maker's electric vehicles. Solid evidence appears that OEMs are serious about GaN.

Market Opportunities for SiC

The secret of future market success for each technology lies in electric and hybrid electric vehicles (EVs/HEVs). Indeed, for SiC, the EV/HEV market is truly the sweet spot right now, with more than 60% of the total market, more than $ 2.5B anticipated revenue set to come from this sector.

Tesla kick-started the SiC power device market in 2017 when it became the first carmaker to add SiC MOSFETs, sourced from STMicroelectronics, in an in-house main inverter design in its Model 3. Other automotive players have been quick to follow in EV giant's footsteps, Hyundai, BYD, Nio, General Motors, Geely and many others have also waded into the market.

For example, in 2020, China-based electric bus manufacturer, Yutong, revealed it is to use SiC power modules manufactured by StarPower, China, in the power trains of its buses. These modules use SiC devices from Wolfspeed, US.

Also from China, Geely Automobile recently announced collaborating with ROHM, Japan on SiC-based traction inverters for its EVs, and NIO – China's answer to Tesla – is to implement a SiC-based electric drive system in its vehicles. At the same time, OEM automaker and semiconductor manufacturer, BYD, has been developing SiC modules for its entire line of EVs.

Over in Korea, Hyundai has turned to Infineon's SiC-based power module for the 800 V battery platform of its electric vehicles while in Japan Toyota is using SiC booster power modules from Denso in its Mirai fuel cell electric vehicles. And in the US, General Motors has just signed up Wolfspeed to supply SiC for its EV power electronics.

Europe tells a different story, where car manufacturers have been slower to embrace SiC, but change is afoot. In June 2021, Renault and STMicroelectronics joined forces to develop SiC and GaN devices for EVs and HEVs, and more announcements are expected soon from Daimler, Audi and Volkswagen.

Along the way, the thorny issue of cost is also being addressed. Without a doubt, at the component level, silicon IGBTs are vastly cheaper than the SiC equivalent, and are not going to disappear from power applications anytime soon. But Tier one manufacturers and OEMs have indicated that implementing high power density SiC into, say, an inverter design, cuts costs at a system level thanks to the space- and weight-savings that could stem from the need for fewer components.

Conclusions

The power electronics and automotive industry are ongoing a remarkable transition in technology platforms. Traditional Silicon is being replaced by wide band gap materials with successful adoption stories year over year. Both EV/HEV and consumer smartphone fast charging markets show a strong growth potential for SiC and GaN technologies. The ecosystems get shaped, and many investments are to come in the next years.

[1] Yole Report: Power GaN Market: Applications, Players, Technology, and Substrates 2021
[2] Yole Report: Power SiC Market: Applications, Players, Technology, and Substrates 2020
[3] Yole Report: Power Electronics for Electric & Hybrid Electric Vehicles 2021
[4] Yole's - Compound Semiconductor Monitor Service Q3-2021: Module I: Power SiC and Power GaN

Acronyms

EV/HEV: electric vehicles/ hybrid electric vehicles
BEV: battery electric vehicles
OEM: original equipment manufacturer