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800V High Voltage Platform Research Report, 2023

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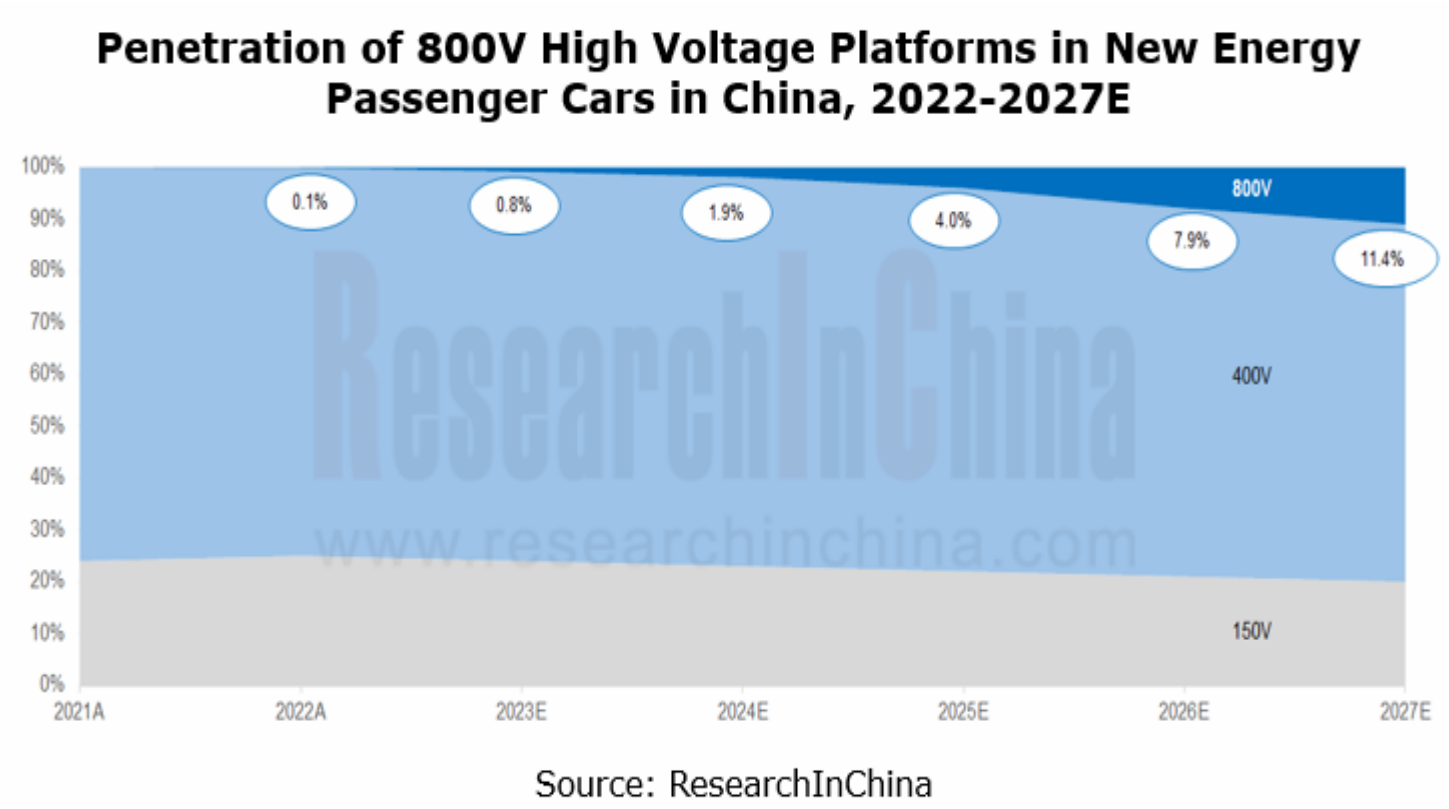
How to realize the commercialization of 800V will play a crucial part in the strategy of OEMs.

As new energy vehicles and battery technology boom, charging and battery swapping in the new energy vehicle industry chain have become weak links for the development of new energy vehicles. Inconvenient charging and short cruising range have become sore points that plague every consumer buying electric vehicles. In this context, 800V high-voltage charging for new energy vehicles has been a spotlight. 2022 is the first year for the development of 800V high-voltage platforms in China. In particular, a large number of 800V high-voltage platform models will go on sale during 2023-2024.



Source: ResearchInChina

Development trends of 800V platforms

In current stage, 800V platforms are still facing a situation of loud thunder but small raindrops. ResearchInChina's statistics about the insurance data show that insured vehicles with 800V platforms in China were still less than 10,000 units in 2022. The low cost performance and poor ultra-fast charging experience offered by 800V models are the major flaws criticized by consumers. The industry boom still requires the lower cost of upstream materials and systems, and the gradual deployment of downstream 480kW/500kW ultra-fast charging piles to cover key use scenarios, so that 800V models can be pulled into the market explosion node which is expected to come around 2024 according to the plans of large automakers.

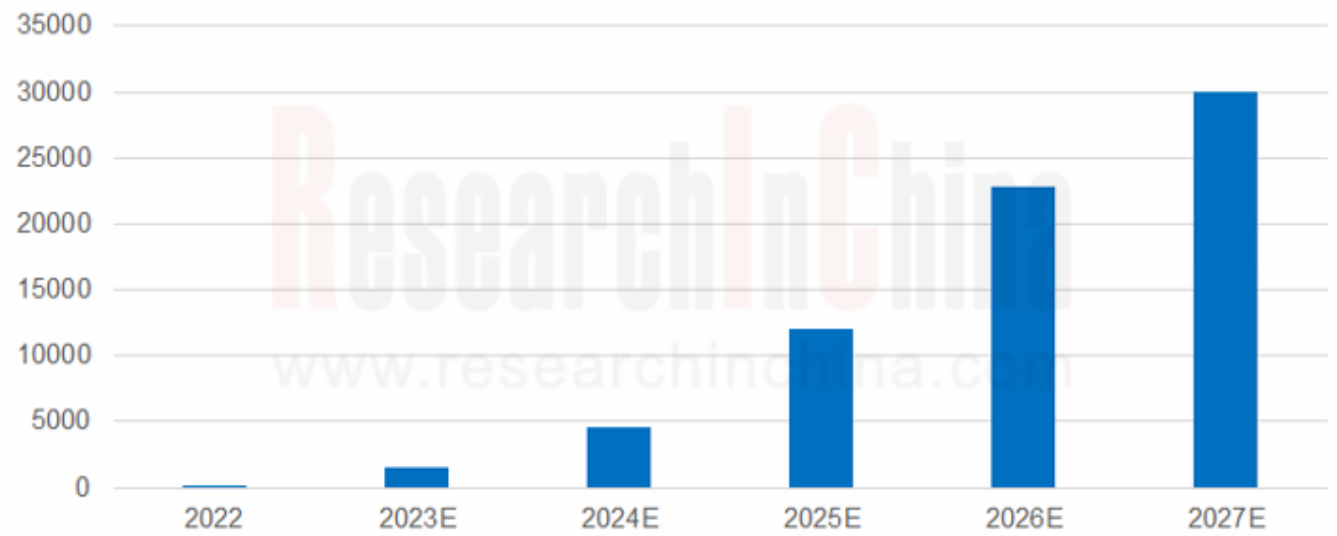
Brand	2020	2021	2022	2023	2024-
小鹏	In November, G9 a model based on the 800V SiC platform made its debut;		In 2022Q3, G9 was mass-produced and launched on market;	In 2023, Xpeng will launch G6, a model based on the 800C SiC high-voltage electric drive platform;	
LOTUS			In October, Lotus ELETRE was officially launched on market;	Enter the Chinese market in 2023	
ARCFOX			In May, the new HI edition of ARCFOX αS was officially launched on market;		
PORSCHE	In 2019, Porsche released the 800V high-voltage platform-based model Taycan;			From 2023 to 2024, Porsche will launch the Macan BEV edition equipped with an 800V high-voltage platform and built on the PPE platform;	
Audi		In February, the J1 high-performance BEV platform Audi RS e-tron GT was released;		In 2023, Audi will release A6 Avant e-tron, with 800V fast charging;	
Polestar极星			In June 22, the prototype of Polestar 5 was officially unveiled. The new car is positioned as a 4-door GT coupe BEV and is planned to marketed in 2024;		
长城汽车 Great Wall		In November, the Great Wall Saloon Mecha Dragon made its debut;	A limited number (101 units) of Mecha Dragon cars are expected to be delivered within this year;		
AION埃安		In August, the A480 supercharger was released, with the peak voltage up to 1000V; In September, AION V Plus 70 ultrafast charging edition was launched on market;			
长安汽车 CHANGAN		In August, the 800V electric drive platform was released;	In August, the 750V model Avtar 11 was launched on market;		

Deployment of 800V ultra-fast charging

Xpeng: for the top ten cities by orders for G9, concentrate on building S4 ultrafast charging stations. In 2023, S4 stations will be used to provide energy replenishment in key cities and along key highways; it is estimated that in 2025, in addition to the current self-operated 1,000 charging stations, Xpeng will build another 2,000 ultrafast charging stations.
GAC: in 2021, GAC introduced a fast charging pile with maximum charging power up to 480kW. It is predicted that in 2025, 2,000 supercharging stations will be built in 300 cities across China.
NIO: in December 2022, NIO officially released a 500kW ultrafast charging pile with maximum current of 660A supporting high-power charging. The fastest charging time for 400V models is only 20 minutes; for 800V models, the fastest charge from 10% to 80% takes 12 minutes.
Li Auto: in 2023 Li Auto has started the construction of 800V high-voltage supercharging piles in Guangdong, and its goal is to build 3,000 supercharging stations in 2025.
Huawei: in March 2023, the 600kW supercharging pile exclusively for AITO came out in Huawei Base in Bantian Street, Shenzhen. This charging pile, named FusionCharge DC Supercharging Terminal, adopts single-pile single-gun design. The manufacturer is Huawei Digital Power Technologies Co., Ltd. Its external dimensions are 295mm (L) x 340mm (W) x 1700mm (H), and the product model is DT600L1-CNA1. The charging pile features output voltage range of 200-1000V, maximum output current of 600A, maximum output power of 600kW, and liquid cooling.

Due to the high construction cost of 480kW ultrafast charging piles, generally speaking, an ultrafast charging station is equipped with just 1 or 2 480kW supercharging piles and several 240kW fast charging piles, and supports dynamic power distribution. Overall, according to the plans of automakers, it is conceivable that in late 2027, the ownership of 800V high-voltage platform models will reach 3 million units; the ownership of 800V supercharging stations will number 15,000-20,000; the ownership of 480/500kW supercharging piles will outnumber 30,000.

Ownership of 480/500kW Supercharging Piles in China, 2022-2027E (Unit: Piles)



Source: ResearchInChina

Tier 1 suppliers race to unveil their 800V component products

As well as charging piles, in the evolution of architecture from 400V to 800V, the implementation of vehicle engineering also remains very complicated. It needs simultaneous introduction of the entire system covering from semiconductor devices and battery modules to electric vehicles, charging piles, and charging networks, and poses higher requirements for reliability, size and electrical performance of connectors. It also requires technology improvements in mechanical, electrical and environmental performance.

Tier 1 suppliers race to unveil their 800V component products. Most of the new products will become available during 2023-2024.

Leadrive Technology: in 2022, the first SiC-based "three-in-one" electric drive system jointly developed by Leadrive Technology and SAIC Volkswagen went into trial production and made a debut at the Volkswagen IVET Innovation Technology Forum. Tested by SAIC Volkswagen, this "three-in-one" system equipped with Leadrive Technology's silicon carbide (SiC) ECU can increase the cruising range of the ID. 4X model by at least 4.5%. Additionally, Leadrive Technology and Schaeffler will co-develop electric drive assembly products including 800V SiC electric axle.

Vitesco Technologies: the highly integrated electric drive system product EMR4 is projected to be mass-produced in China and supplied to global customers in 2023. EMR4 will be spawned at Vitesco Technologies' factory in Tianjin Economic-Technological Development Area and delivered to automakers inside and outside China.

BorgWarner: the new 800V SiC inverter adopts Viper's patented power module technology. The application of SiC power modules to 800V voltage platforms reduces the use of semiconductors and SiC materials. This product will be mass-produced and installed on vehicles between 2023 and 2024.

800V is still in the ascendant, but the battle for silicon carbide (SiC) production capacity has begun.

In new 800V architecture, the key to electric drive technology is the use of third-generation SiC/GaN semiconductor devices. While bringing technical benefits to new energy vehicles, technology iterations also pose many challenges to automotive semiconductors and the entire supply chain. In the future, 800V high-voltage systems with the third-generation SiC/GaN semiconductors as the core will usher in a period of large-scale development in the fields of automotive electric drive system, electronic control system, on-board charger (OBC), DC-DC, and off-board charging pile.

In particular, silicon carbide (SiC) is at the core of the high-voltage platform strategy of OEMs. Although 800V is still growing at present, the war for SiC production capacity has actually started. OEMs and Tier 1 suppliers compete to form strategic partnerships with suppliers of SiC chips and modules or set up joint ventures with them for production of SiC modules so as to lock in SiC chip capacity.

SOP Plans of Major Global Silicon Carbide (SiC) Device Companies

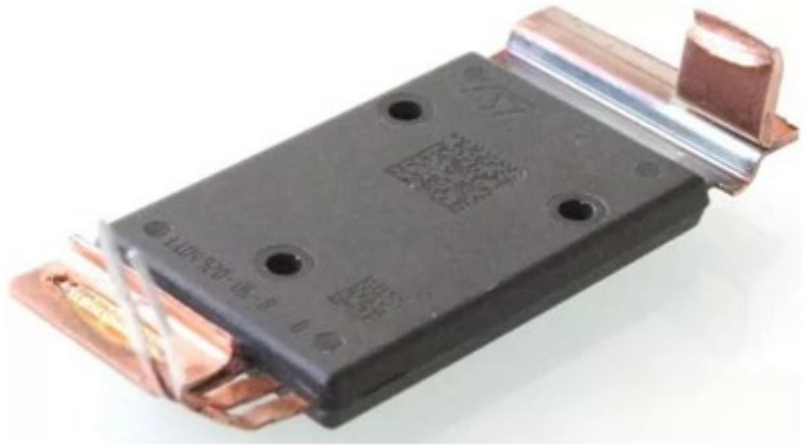
Self-built Production Line		
Company	**Product Layout**	**Product Development Stage**
BYD	Started self-developing IGBT in 2005 and SiC in 2020	IGBT has iterated to 5.0, and SiC power modules are used in Han EV
BIO	A SiC power module process experiment line	Designed annual capacity of 5000 sets of modules
BorgWarner	IGBT module and SiC Mosfet module	3 Viper packaging and testing lines for the Phase II of Suzhou factory project
UAES	IGBT power module	Bosch produces SiC chips
Vitesco Technologies	IGBT and SiC modules	Packaging line in Tianjin factory
Denso	SiC power module	Applied to Toyota fuel cell vehicle Miral
Leadrive Technology	IGBT and SiC power modules	Plan to self-build production lines
Equity Cooperation		
Company	**Product Layout**	**Product Development Stage**
SAIC	IGBT module	Established joint venture SAIC Infineon Automotive Power Modules (Shanghai) Co, Ltd. together with Infineon
	Automotive chip	Initiated the establishment of the Shanghai Automotive Chip Engineering Center together with the Shanghai Industrial μTechnology Research Institute; to build an automotive chip pilot test line and a production line
Geely	SiC chip	Established joint venture AscenPower together with AccoPower among others
Dongfeng Motor	IGBT module	Established joint venture Zhixin Semiconductor together with CRRC Times
FAW	IGBT and SiC modules	FAW Fund as the leading investor established a joint venture together with eMotor Advance, and founded wholly-owned subsidiary eMotor Semiconductor in Suxiang Cooperation Zone
Li Auto	SiC chip, module	Established a joint venture with Sanan Semiconductor
GAC	IGBT module	Established joint venture Guangzhou Qinglan Semiconductor Co., Ltd. together with CRRC Times
Zhenghai Group	SiC module	Established joint venture HAIMOSIC together with ROHM Semiconductor

Source: ResearchInChina

The campaign for SiC cost reduction has also been launched

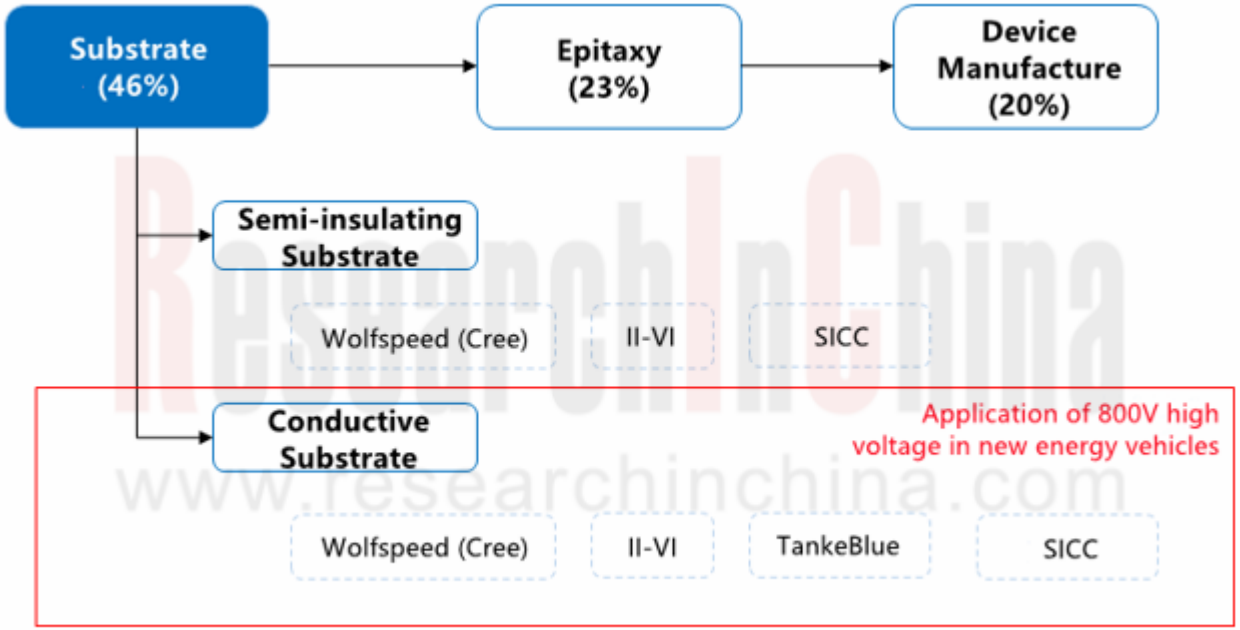
On the other hand, the campaign for SiC cost reduction has also been launched. At present, SiC power devices are extremely expensive. In Tesla's case, the value of SiC-based MOSFET per vehicle is about USD1,300; at the just-concluded annual investor day, Tesla announced the progress in development of its second-generation power chip platform, mentioning reduction of 75% silicon carbide devices (SiC usage), which attracted market attention.

Tesla's confidence lies in the fact that the automaker has independently developed TPAK SiC MOSFET module and takes a deep part in the chip definition and design. Each bare die in the TPAK can be purchased from different chip vendors to establish a multi-supplier system (ST, ON Semiconductor, etc.). TPAK also allows for application of cross-material platforms, for example, mixed use of IGBT/SiC MOSFET/GaN HEMT.



China has built a SiC industry chain, but with the technology level slightly lower than the international

(1) China has built a SiC industry chain, but with the technology level slightly lower than the international.
SiC is a compound semiconductor material composed of silicon and carbon elements. Power devices based on SiC monocrystal materials offer the benefits of high frequency, high efficiency, and small volume (70% or 80% smaller than IGBT power devices), and have been seen in Tesla Model 3.
From the perspective of value chain, substrate makes up more than 45% of the cost of silicon carbide (SiC) devices, and its quality also directly affects the performance of epitaxy and the final product. Substrate and epitaxy take a nearly 70% share of the value, so cutting their cost will be the main development direction of the SiC industry. SiC required by 800V high voltage for new energy vehicles is mainly conductive substrate silicon carbide crystal. The current major manufacturers include Wolfspeed (Cree), II-VI, TankeBlue Semiconductor and SICC.



Source: ResearchInChina

Global SiC technology development

In terms of global SiC technology development, the SiC device market is monopolized by giant vendors like STMicroelectronics, Infineon, Cree and ROHM. Chinese vendors already have large-scale production capacity, and are on par with the international development level. Their capacity planning and production time are almost the same with their foreign peers.
From the development level of SiC substrates, it can be seen that 6-inch substrate currently prevails in the SiC market, and 8-inch SiC substrate is the development priority globally. At present, only Wolfspeed in the world has achieved mass production of 8-inch SiC. Chinese company SEMISiC produced 8-inch N-type SiC polished wafers on small scale in January 2022. Most international companies plan production of 8-inch SiC substrates around 2023.

	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025
Wolfspeed	1991: first substrate 1993: commercialization of 30mm substrate	1995: 50mm 1999: 4 inches		2009: 6-inch substrate		2015: 8-inch substrate	2022: fully spawned the 8-inch
II-VI			2004: produced the 3-inch		2012: displayed the 6-inch 2013: produced the 6-inch	2015: 8-inch conductive type 2019: 8-inch semi-insulating	2024: to spawned the 8-inch
ROHM			2000-2002: fundamental research on devices	2009: acquired SiCrystal	2011: spawned the 4-inch 2014: spawned the 6-inch		2021: 8-inch substrate 2025: to spawn the 8-inch
ST life.augmented						2019: acquired Norstel AB for 6-inch substrate capacity	2021: delivered 8-inch wafers
安森美半导体 ON Semiconductor						2021: acquired GTAT	2021: launched the 8-inch 2025: to spawn the 8-inch
TANKEBLUE 天科合达				2006: 2 inches 2008: 3 inches	2012: successfully developed the 4-inch	2017: spawned the 4-inch 2018: developed the 6-inch semi-insulating	2020: spawned the 6-inch 2023: to spawn the 8-inch
SICC					2012: spawned the 2-inch 2013: spawned the 3-inch	2015: spawned the 4-inch semi-insulating 2017: spawned the 6-inch conductive type 2019: spawned the 6-inch semi-insulating	
SEMISiC 烁科晶体				2009: SiC research		2020: spawned the 4 to 6-inch 2020: displayed the 8-inch	2021: produced 8-inch crystals 2022: produced 8-inch wafers
JSG							2022: displayed the 8-inch 2023: to spawn the 8-inch

Gallium nitride (GaN) is still at the early stage of application in automotive, and the layout pace of related manufacturers quickens

(2) Gallium nitride (GaN) is still at the early stage of application in automotive, and the layout pace of related manufacturers quickens.

Gallium nitride (GaN) is largely used in consumer electronics fields such as tablet PC, TWS earbuds and notebook computer fast charging (PD). Yet as new energy vehicles thrive, electric vehicles become a potential application market for GaN. In electric vehicles, GaN field effect transistors (FETs) are very applicable to AC-DC OBC, high-voltage (HV) to low-voltage (LV) DC-DC converters, and low-voltage DC-DC converters.

In the field of electric vehicles, gallium nitride (GaN) and silicon carbide (SiC) technologies complement each other and cover different voltage ranges. GaN devices are suitable for tens of volts to hundreds of volts, and in medium and low voltage applications (less than 1200V), their switching loss is 3 times less than SiC in 650V application. SiC is more applicable to high voltage (several thousand volts). Currently the application of SiC devices in a 650V environment is mostly to enable 1200V or higher voltage in electric vehicles.

China still has a big gap with foreign counterparts in development of gallium oxide (Ga2O3), and has yet to achieve mass production.

By virtue of large band gap, high breakdown field strength and strong radiation resistance, gallium oxide (Ga2O3) is expected to dominate in the field of semiconductor power electronics in the future. Compared with common wide-bandgap SiC/GaN semiconductors, Ga2O3 boasts a higher Baliga quality factor and lower expected growth cost, and has more potential in application to high-voltage, high-power, high-efficiency, and small-size electronic devices.

In policy's term, China also pays ever more attention to Ga2O3. As early as 2018 China has set about exploring and studying ultra-wide bandgap semiconductor materials including Ga2O3, diamond and boron nitride. In 2022, the Ministry of Science and Technology of China brought Ga2O3 into the National Key R&D Program during the "14th Five-Year Plan" Period.

On August 12, 2022, the Bureau of Industry and Security (BIS) under the U.S. Department of Commerce issued an interim final rule that establishes new export controls on four technologies that meet the criteria for emerging and foundational technologies, including: GAA technology, EDA software, PGC technology, and the two substrates of ultra-wide bandgap semiconductors, Gallium Oxide (Ga2O3) and diamond. The two export controls came into effect on August 15. Ga2O3 has drawn more attention from the global scientific research and industrial circles.

Although gallium oxide (Ga2O3) is still at the initial stage of R&D, China has made several breakthroughs within 15 months from 2022. Its gallium oxide preparation technologies from 2 inches to 6 inches in 2022, and then to the latest 8 inches are maturing. Chinese Ga2O3 material research units include: China Electronics Technology Group Corporation No.46 Research Institute (CETC46), Evolusia Semiconductor, Shanghai Institute of Optics and Fine Mechanics (SIOM), Gallium Family Technology, Beijing MIG Semiconductor, and Fujia Gallium Industry; listed companies like Xinhu Zhongbao, Sinopack Electronic Technology, Jiangsu Nata Opto-Electronic Material and San'an Optoelectronics; and dozens of colleges and universities.

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Contact

Beijing Headquarters
TEL: 010-82601561, 82863481
Mobile: 137 1884 5418
Email: report@researchinchina.com

Website:
www.researchinchina.com

WeChat: zuosiqiche

zuosiqiche

Chengdu Branch

TEL: 028-68738514
FAX: 028-86930659