Overview of SiC market and the supply chain evolution

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OUTLINE

- Power SiC market overview
- Power SiC supply chain evolution
- Capacity expansion of SiC at different level of Power SiC
- The era of 8” SiC is coming?
Power SiC market overview
POWER SiC INDUSTRY - PERFORMANCE SCORECARD
Source: Power SiC 2023 - Yole Intelligence

Market value & growth – US$

1.1B

+62%

1.8B

SiC wafer shipment 6”-eq. units

2021  2022

364,874  576,300

Top 3 SiC power device market shares*

STMicroelectronics

37% (US$450M)

32% (US$700M)

Infineon

20% (US$242M)

17% (US$360M)

Wolfspeed

14% (US$165M)

14% (US$299M)

*In revenue
Power SiC device market is forecast to grow nearly to $9B with continuing penetration of SiC in automotive, along with industrial applications.
Power SiC supply chain evolution
As of 2023, BYD outsources epiwafers.

*Non-exhaustive list

*Showa Denko, the leading SiC epiwafer supplier, is currently Resonac.
FOCUS ON THE CHINESE POWER SiC ECOSYSTEM

CETC Institute 13 and 55 and Shanxi Semicore Crystal co. (named as SEMISiC)
CETC Institute 2 has internal substrate capacity, mainly for SiC Si substrates

Some Chinese companies don’t have the same name in Chinese and English. The following is a word for word translation of well-known companies’ Chinese names for ease of reference for non-Chinese speakers.

TankeBlue: Tianke Heda
SICC: ShanDong Tianyue
Synlight: Hebei Tongguang

GZSC: Guangzhou Nansha
HDSC: Huada Semiconductor
Epiworld: Haotian Tiancheng

TYSTC: Dongguan Tianyu
Global Power Technology: Tyco Tianrun
IVCT/Inventchip: Shanghai Zhanxin Electronic Technology
WASMC: AnHui ChangFei, renamed from TUS-Semi in Q2-22

ASMC: Shanghai Advanced Semiconductor Manufacturing
CR Micro: Hua-Run Microelectronics
SMEC: ShaXing Zhong Xing
ASC or AcenPower: Xin Yue Neng, a joint-venture of AccoPower and Geely.

There are more than 50 companies in the Chinese SiC ecosystem ... and MORE!
BUSINESS EXTENSION IN POWER SiC

To extend the business to another level of supply chain:
1. to better control the quality
2. to increase the value captured
3. to open up new market

Internalizing SiC wafer
Key enabler to establish 8"

To leverage advantages of SiC materials, the pioneer of 8” SiC

Partnership to deal with $1B investment

Focus on device manufacturing
With the capacity expansion at the SiC wafer level and the transition of device generation, the wafer cost is expected to account for a smaller share of the total device cost.

**The Trend of Wafer Cost Share in SiC Device**

- **2022**
  - SiC device market ~$1.8B
  - SiC Wafer market ~$2.1B
  - Wafer-to-packaged device cost ratio (%): ~30%
  - Source: Power SiC 2023, Yole Intelligence

- **2028**
  - SiC device market ~$9B
  - SiC Wafer market ~$2.1B
  - Wafer-to-packaged device cost ratio (%): ~24%
  - CAGR_{2022-2028} +31%
  - CAGR_{2022-2028} +25%

- More MOSFET Planar → Trench 650V → 1,200V wafer ASP erosion
- High-quality wafer in tight supply

**Wafer-to-packaged device cost ratio (%)**

- 100%
- 543M

**SiC device market scenarios**

- **2022** ~$1.8B
- **2028** ~$9B

**SiC Wafer market scenarios**

- **2022** ~$2.1B
- **2028** ~$2.1B

Source: Power SiC 2023, Yole Intelligence
Are we heading to over-capacity of SiC wafer and epiwafer?
THE BULLWHIP EFFECT IN POWER SiC
As of 2023 in China

SiC wafer capacity in China
>800k 6”-eq.
(announcement-base)

Demand ~800k 6”-eq. SiC wafer globally

Epiwafer capacity in China
>750k 6”-eq.
(Install-base)

At the level of equipment and consumables, the demand is even higher!!
The announced investments in Power SiC in China were >10B RMB (>1.5B) in 2022-2023/Q3. It illustrates the strong momentum in this country to be deeply involved in the ecosystem and to develop a domestic supply chain to build strategic positions.

Multiple financing activities and investments at this level have been announced as well. It helps to create an end-to-end domestic supply chain in China.

**Financing activities**
- Capacity expansion or new facility build-up
- New fab for 8” wafer (~7B RMB)
- Pre-IPO series
- Pre-B series >100M RMB

**Non-exhaustive list**
- IPO
- Shanghai fab opening
- Pre-IPO series
- Pre-B series >100M RMB
- A+ series
- IPO suspension
- JV company with STMicroelectronics
- 400M RMB investment
- Pre-B series >100M RMB
- B series >100M RMB
- Financing >300M RMB
- Synlight
- BYD Semiconductor
- IPO
SIC WAFER AND DEVICE CAPACITY OF CHINESE PLAYERS

Massive expansion in SiC wafer

SiC wafer and device capacity* expansion

* Real production refers to the total volume shipped by wafer and device manufacturers. It’s a function of total capacity, utilization rate, product mix of 6” and 8”, production yield, lead-time...etc.

If capacity is no more the concern, then cost, quality and stable supply are the keys to win the competition.
The era of 8” SiC
IS 8” THE MARKET FOR EVERYONE?
The initial volume of 8” started in 2022, mainly consumed by Wolfspeed

8” ramp-up relies on internal wafer supply in 2023-2025, due to limited access to 8” on the open market.

Challenges:
Lower yield and higher cost of 8” wafers.
Major capacity expansion on 6” will lead to economy of scale, potential to decrease the cost of 6” wafer to $7XX per unit.
Slower learning curve of 8”, due to less players engaged.

Our dedicated product, Power SiC/GaN Compound Semiconductor Market Monitor offer you a unique way to track the evolution on quarterly basis.
Special focus of 8” SiC - wafer sourcing strategies of major IDMs

As of 2023, 6” SiC wafer is the main platform for device manufacturing. With on-going or planned fab build-up for 8” SiC, majors IDMs are applying different sourcing strategies based on their positions in the ecosystem.

in-house wafer supply

external wafer supply

- Wolfspeed is the first-mover of 8” SiC, by leveraging their advantages of SiC wafer and epiwafer.
- STMicroelectronics, onsemi and Rohm are working on 8” SiC by using internal capability of 8” wafer.
- Infineon, Mitsubishi Electric and Bosch source 8” SiC from external supplier.

And the strategies for Chinese device players?

Source: Power SiC 2023, Yole Intelligence
6”→8” TRANSITION ALONE WILL NOT SOLVE THE SiC WAFER SUPPLY ISSUES

6” → 8” SiC wafer transition seems to be very straightforward and bring rapidly its benefits...

But there are some “hidden” challenges too.

**Thinner boule**
- 6”
- 8”

**Higher consumption of SiC boule material per wafer**
- 6”
  - Boule yield, wafer yield
- 8”
  - To avoid wafer bow

**Lower SiC boule and wafer yield**
- 6”
- 8”

**Higher defect density**
- 6”
- 8”

**8” wafer not available at the open market**
- Where to get the seeds for 8” boule growth?
- Where to get 8” wafers?

Moreover, the CapEx and R&D efforts needed might significantly impact the companies’ cash situation.

Source: Power SiC 2023, Yole Intelligence
In view of cost, technology maturity and supply chain

8" SiC wafer is expected to be more costly due to higher material costs, higher barriers to entering the technology, and fewer suppliers.

One sample could cost $4000 as of 2023

6" is in volume production with improved yield, while 8" is still in the phase of improving maturity.

8" capacity is mainly developed internally, only a few wafer suppliers on open market.

mm² cost parity comparing to 6" SiC wafer

Production starts

more material cost

Lower yield

Immature supply chain

Range of unit cost of 8" SiC wafer in mm²
TAKE-AWAYS AND OUTLOOK

Opportunities and challenges

- SiC device is forecast to be ~$9B by 2028, where automotive will account for >70%, followed by EV chargers and PV+BESS.
- In SiC supply chain, major players of SiC have adapted IDM business model, in order to secure SiC wafer and also to gain higher value.
- To gain higher value in Power SiC drives wafer or epiwafer players to enter another level of business.
- In China, the announcements of SiC wafer and epiwafer capacity expansions mean to build large scale of manufacturing. It reflects that cost is the key to compete in 6” SiC platform.
- Major IDMs will start 8” production in late 2024 or in 2025. However, 8” SiC requires a different sourcing strategy, and internal capability plays an important role.
- 8” SiC represents the opportunities for higher revenue and capability of scaling. More efforts are required, to make 8” cost-competitive.
OUR REPORT ACTIVITIES – COMPOUND SEMI. & EMERGING SUBSTRATES

Power SiC 2023
Market and Technology Report

Power GaN 2023
Market and Technology Report

RF GaN 2023
Market and Technology Trends

InP 2022
Market and Technology Report

GaAs Wafer and Epiwafer Market Version 2020
RF Photonics, LED, Display and PV Applications
Market and Technology Report 2020

Status of Compound Semiconductors 2022
Focus on Substrates and Epitaxial Industries

Emerging Semiconductor Substrates 2023
OUR CS MONITOR OFFERS – DIRECT AND UNLIMITED ACCESS TO ANALYST

- Market forecast for devices, wafers and epiwafers (revenue, shipments, ASP)
- Market segment including automotive, consumer, telecom, and energy (revenue & shipments)
  - Breakdown by technology including discrete, module and wafer size
- Market players supply chain, strategy and revenue analysis at device, epiwafer and wafer level.....
THANK YOU! ANY QUESTIONS?

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