POWER SIC 2018: MATERIALS, DEVICES AND APPLICATIONS

Market & Technology report - July 2018

Automotive is putting SiC on the road. Is the supply chain ready?

WHAT'S NEW

- Update of market size for discrete diodes, diodes in hybrid modules, discrete transistors and full SiC modules
- Update of market size for the diode and transistor bare die market
- Update of voltage analyses of SiC power devices: 650V, 1200V, 1700V and over 1700V
- Update of player status
- Discussion of SiC penetration in EV/HEV in detail
- Discussion of SiC penetration in the PV market under the impact of new policy in China
- Estimation of SiC wafer investment and analysis of short supply situation
- SiC epiwafer market
- A new chapter about the reliability discussion
- A new chapter about the SiC materials and device IP landscape

KEY FEATURES OF THE REPORT

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- Yole's deep understanding of SiC penetration in different applications including xEV, xEV charging infrastructure, PFC/power supply, PV, UPS, motor drives, wind and rail
- State-of-the-art SiC-based devices, modules, and power stacks, including product charts for each
- Description of the SiC power industrial landscape from materials to systems, and discussion of SiC power market dynamics
- SiC power device market value projections to 2023, including bare die market with transistor/ diode split, device market split by application and device market with discrete/ module split
- SiC power device voltage analysis
- Market value and volume projections for the SiC wafer and epiwafer market through 2023
- SiC power industry roadmap

AUTOMOTIVE IS DRIVING THE SIC POWER MARKET

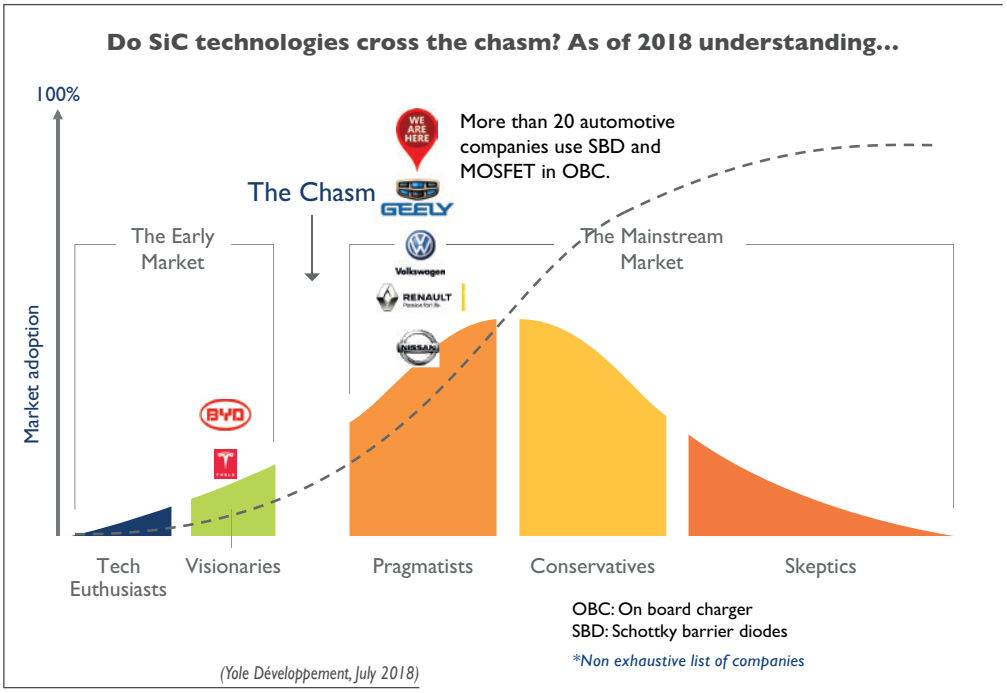
Following 2017's trend, SiC transistors are clearly being adopted, penetrating smoothly into different applications. Yole Développement's (Yole) forecast for the value of the SiC power semiconductor market is more than $1.5B by 2023 with a compound annual growth rate (CAGR) of 31% for 2017-2023. Today the market is still being driven by diodes used in power factor correction (PFC) and photovoltaic (PV) applications. However Yole expects that in five years from now the main SiC device market driver will be transistors, with an impressive 50% CAGR for 2017-2023. This adoption is partially thanks to the improvement of the transistor performance and reliability compared to the first generation of products, which gives confidence to customers for implementation.

One of the topics that has been discussed in all Yole's exchanges with industrial players is SiC adoption for automotive applications over the next 5-10 years. Its implementation rate differs depending on where SiC is being used. That could be in the main inverter, in the on-board-charger (OBC) or in the DC/DC converter. By 2018, more than 20 automotive companies are already using SiC Schottky barrier diodes (SBDs) or SiC MOSFET transistors for the OBC, which will lead to 44% CAGR through to 2023. Yole expects SiC adoption in the main inverter by some pioneers, with an inspiring 108% market CAGR for 2017-2023. This will be possible because nearly all carmakers have projects to implement SiC in the main inverter in coming years. In particular, Chinese automotive players are strongly considering the adoption of SiC.

PV has also caught our attention during recent months. China claimed almost the half of the world's installations in the last year. This segment could have therefore helped grow the SiC device market, but new governmental regulations mean Yole has lowered its expectation for the segment.

System manufacturers are interested in implementing cost effective systems which are reliable, without taking into account if the power devices are silicon or SiC based. Therefore, even if it's certified that SiC performs better than silicon, system manufacturers still get questions about long term reliability and the total cost of the SiC inverter.

This report gives an overview of SiC power device markets, including electric and hybrid electric vehicles (EV/HEV), charging



infrastructure, PV, power supply, rail, motor drives and uninterruptible power supplies (UPS) and wind. It also has an overview on the current reliability status and comparison on the added cost of a SiC system compared to silicon IGBTs.

SIC ADOPTION IS ACCELERATING: IS THE SUPPLY CHAIN READY?

In 2018, Yole is confident that the market is going to grow. The question for the SiC device market today is how big it will be in five years, rather than whether the market will increase. Another question is whether the supply chain is ready to embrace the market acceleration? Wafer supply is one of the bottlenecks as of 2018.

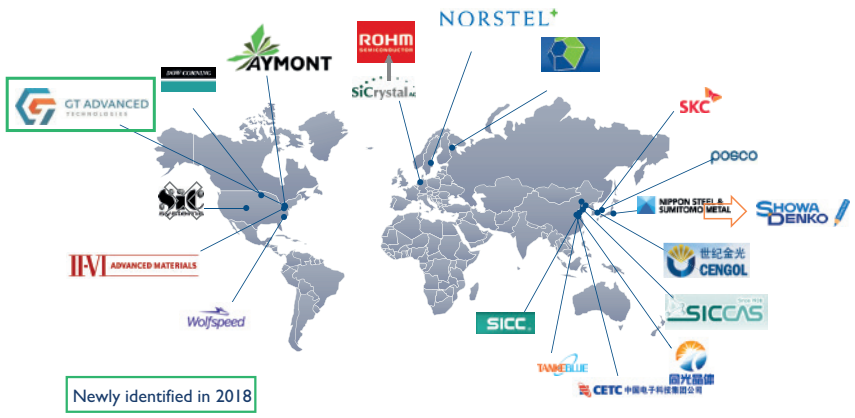
Analysts have to talk about the short SiC wafer supply situation, which has been in place since late 2016. Some expected the situation to be resolved in the second half of 2017. But we are in the middle of 2018 and the supply issue remains. Two main reasons account for the current situation. First, the transition from 4" to 6" wafers is much faster than suppliers expected. Second, the wafer demand increase is also faster than expected.

Will the situation continue? Some say that it is temporary and quite normal and typically happens when shifting to larger wafer sizes. Others consider the situation to be critical. It's a good problem for wafer suppliers as the supply constrained situation allows them to maintain high wafer prices. But they are also investing heavily to satisfy demand from numerous clients. Yole estimates that several hundred million US dollars will be invested in coming years. The leading SiC wafer suppliers, Cree-Wolfspeed, II-VI and Dow, are all investing to expand their capacity.

At the epiwafer level, the market has struggled to take off several years, but the situation is evolving quickly. For example, Yole's analysts have seen Showa Denko expand its capacity consecutively in 2015, 2016 and 2018 as the technology becomes more mature and the outsourcing ratio is increasing.

Yole invites you to read its analysis about the short wafer supply situation and its impact, as well as forecasts for the wafer and epiwafer markets.

2018 SiC wafer market : competitive landscape, including R&D players



*Non exhaustive list of companies

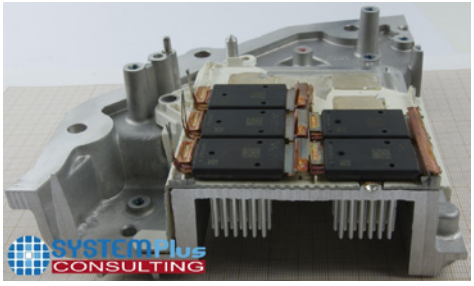
(Yole Développement, July 2018)

AUTOMOTIVE-GRADE SIC POWER DEVICE EXAMPLE : TESLA & STMICROELECTRONICS*

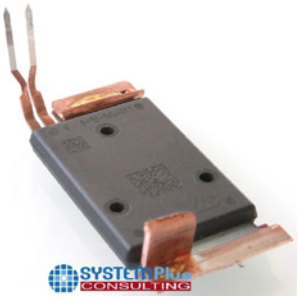
A fast-evolving market is seeing plenty of activity from its participants, with several important events in 2017-2018. In February 2018, Cree announced a 180° turnaround in its strategy on its investor day, after the abortive sale of its Wolfspeed business to Infineon. The company decided to instead focus on Wolfspeed which, despite being Cree's smallest business, is the market leader in both the SiC wafer and SiC power device markets as of 2017. This strategy pivot will allow Cree to invest more into its SiC activities, expanding wafer, epiwafer and device capacity and prepare for market growth. On the other side of the abortive acquisition, Infineon has also developed its SiC power business. The company signed a long term SiC wafer supply agreement with Cree and began to actively promote its CoolSiCTM MOSFETs at different power electronic tradeshows and conferences in 2018.

Meanwhile, excitement surrounds Tesla's adoption of SiC MOSFETs in its electric vehicles. This had been rumoured since 2016, but without detailed information about whether it would be in the OBC and/or main inverters. Confirmation came through reverse engineering, which shows that the Model 3 uses STMicroelectronics' 1-in-1 top lead frame module, containing two SiC MOSFETs.

Automotive-grade SiC power device Example : Tesla & STMicroelectronics*



SiC MOSFET one in one module:
- 2 dies of 650V, 100A



* Extracted from System Plus Consulting report : Tesla Model 3 Inverter with SiC Power Module from STMicroelectronics, June 2018

(Yole Développement, July 2018)

A foundry model is clearly forming which facilitates fabless and fab-lite companies to launch SiC products and make the technology more accessible. But there was also short supply of foundry services in 2017. A new 6" wafer foundry, Clas-SiC Wafer Fab Limited (6") was founded in 2017, with the entire SiC team from Raytheon, which has stopped its SiC activities. Taiwanese foundry Episil is also now active.

This report provides an overview of the SiC power industry, covering the value chain from material to epitaxy to module. It also outlines Yole's understanding of the market's current dynamics and future evolution.

TABLE OF CONTENTS (complete content on i-Micronews.com)

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OBJECTIVES OF THE REPORT

- Provide a clear understanding of the SiC power industry, covering markets from wafer to discrete and module level, with valuations in units and $M.
- Analyze the market drivers and bottlenecks of the SiC power industry by studying SiC adoption by different end applications and supply chains.
- Understand the status of SiC power device technology
- Describe the industry landscape

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Find more details about this report here:

Dr. Hong Lin and Dr. Ana Villamor, all part of the Power & Wireless division at Yole Développement co-authored the Power SiC 2018: Materials, Devices and Applications report:

AUTHORS

Dr. Hong Lin works as a Technology and Market Analyst, Compound Semiconductors since 2013. She is specialized in compound semiconductors and provides technical and economic analysis. Before joining Yole Développement, she worked as R&D engineer at Newstep Technologies. She was in charge of the development of cold cathodes by PECVD for visible and UV lamp applications based on nanotechnologies. She holds a Ph.D in Physics and Chemistry of materials.

Dr. Ana Villamor serves as a Technology & Market Analyst, Power Electronics & Compound Semiconductors. She is involved in many custom studies and reports focused on emerging power electronics technologies at Yole Développement, including device technology and reliability analysis (MOSFET, IGBT, HEMT, etc). In addition, Ana is leading the quarterly power management market updates released in 2017.

Previously Ana was involved in a high-added value collaboration related to SJ Power MOSFETs, within the CNM research center for the leading power electronic company ON Semiconductor. During this partnership and after two years as Silicon Development Engineer, she acquired a relevant technical expertise and a deep knowledge of the power electronic industry.

Ana is author and co-author of several papers as well as a patent. She holds an Electronics Engineering degree completed by a Master in micro and nano electronics, both from Universitat Autonoma de Barcelona (SP).

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