

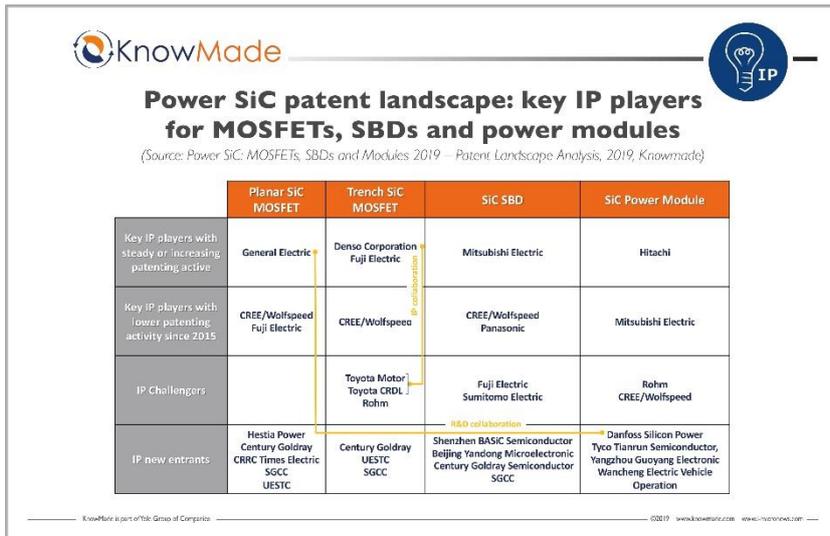


FOR IMMEDIATE RELEASE:

SiC¹ adoption is accelerating: is the industrial supply chain ready?

Extracted from: Power SiC: MOSFETs, SBDs and Modules 2019 – Patent Landscape Analysis from Knowmade | Power SiC 2018: Materials, devices and applications from Yole Développement

LYON, France – March 4, 2019: “The 2016-2018 period has been crucial for the whole SiC industry,” asserts **Rémi Comyn, PhD., Patent & Technology Analyst at Knowmade**, the Technology Intelligence and IP² strategy consulting company. “SiC MOSFETs, commercially available for several years, are gaining the confidence of numerous customers and have clearly begun to penetrate into different applications”. The IP landscape confirms the trend with the strong leadership of the Japanese companies, the entrance of the Chinese players, as well as an impressive penetration rate within the automotive industry.



By 2018, Knowmade’s team was certain. The SiC market is going to grow. The question today is more on how big the market will grow in the next five years, than whether the market will increase. **Yole Développement (Yole)**, sister company of Knowmade, predicts a US\$ 1.5 billion market in 2023, with a 31% CAGR³ between 2017 and 2023⁴.

As a consequence, numerous players are wondering if the supply chain is ready to embrace such market acceleration. “Attracted by the market potential, there are plenty of players who want to enter the market together with heated competition from power device giants”, comments **Hong Lin, PhD., Senior Technology & Market Analyst at Yole**. The competition has intensified”.

What exactly is the status of the IP ecosystem? Who are the current leaders? Who will have the best IP in the coming years?... Knowmade’s analysts provide an up-to-date overview of the SiC IP ecosystem.

¹ SiC: Silicon Carbide

² IP : Intellectual Property

³ CAGR : Compound Annual Growth Rate

⁴ Source : [Power SiC : Materials, Devices and Applications report](#), Yole Développement, 2018

Knowmade identified a remarkable acceleration in patent filing related to SiC MOSFETs between 2011 and 2015, concomitant with the commercialization of the first SiC MOSFET products. Japanese integrators, especially Denso and Fuji Electric, have taken the lead in SiC MOSFET related patenting activity.

In parallel, China has entered the SiC MOSFET patent landscape in recent years, starting with R&D players in 2011. These were followed by major state-owned integrator companies in 2015, such as State Grid Corporation of China (SGCC), CRRC and SiC pure player IDM⁵ Century Goldray, which was established in 2010 to address the whole power SiC supply chain. *“The common feature of these new entrants is that they intend to develop IP on both planar and trench MOSFET structures”*,

explains Rémi Comyn from Knowmade.

In addition, Taiwan has a long-standing R&D player in SiC MOSFETs with ITRI, but there was no industrial player until 2016 when Hestia Power emerged, focusing on cost effective planar JBS⁶ diode-integrated

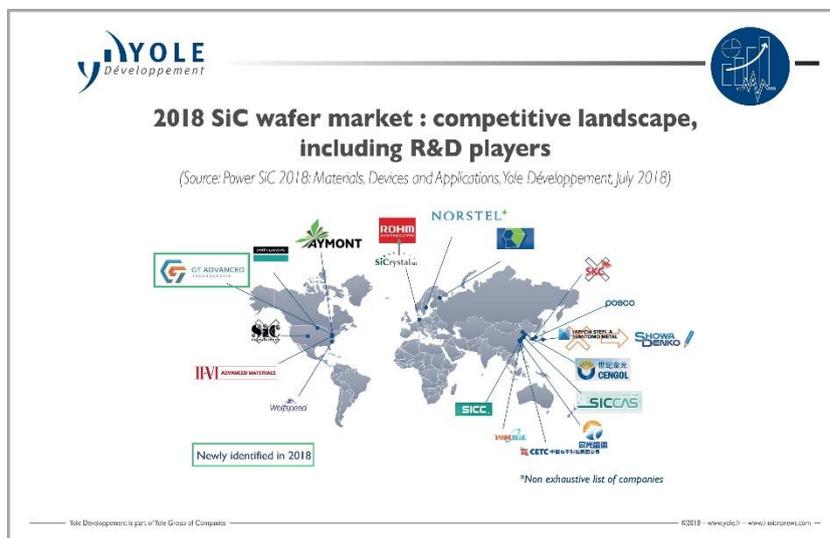
MOSFET structures. *“We note that current leading SiC device makers like Cree/Wolfspeed, Rohm, Infineon Technologies and STMicroelectronics own*

some key patents but do not necessarily have strong IP leadership,” adds Rémi.

IP analysis from Knowmade includes dedicated sections focused on planar/trench SiC MOSFETs, SiC Schottky Barrier Diodes as well as SiC power modules.

As a consequence of this growth, the industrial SiC supply chain is constantly evolving. For power devices, the foundry and IDM model are both developing. Between 2017 and 2018, Yole’s analysts highlight the following trends:

- The foundry model is clearly developing. This industry evolution is facilitating the SiC fab-less and fab-lite companies in launching SiC products and making the technology more accessible to the industry. Other foundries such as CLAS SiC wafer fab and Episil Technologies are also entering the market. *“We now offer 4” SiC foundry services for 600V SBD⁷ and*



⁵ IDM : Integrated Device Manufacturer

⁶ JBS : Junction Barrier Schottky

⁷ SBD : 1200V Schottky Barrier Diodes

*MOSFETs and are establishing a 6" SiC line, which can be ready for customer pilot production in the second half of 2019..." says **Andy Chuang/ 莊淵棋, President/ 總經理, Episil Technologies Inc./ 漢磊科技股份有限公司** in an interview conducted by Yole and published on [I-Micronews.com](#).*

- As for the IDMs, the semiconductor giants are more and more active. Infineon Technologies ramped up MOSFET production in 2017. On Semiconductor and STMicroelectronics were also ramping up MOSFET production in 2018...

With a unique market positioning, Knowmade provides a deep understanding of the competitive landscape and technology developments from a patent perspective. Its collaboration with Yole's team allows the development of relevant and accurate analyses combining market, technology and IP expertise.

Under this dynamic ecosystem, Knowmade has released a dedicated patent landscape analysis, [Power SiC: MOSFETs, SBDs and Modules](#). This report provides a detailed picture of the industrial & research IP ecosystem for SiC-based power electronic products, from MOSFETs to Schottky barrier diodes including power modules. Covering worldwide patents published up to October 2018, it offers a comprehensive analysis of more than 1,600 patent families. A detailed description of the SiC IP analysis is available today on the [Knowmade website](#).

Both partners, Knowmade and Yole Développement, are part of the Yole Group of Companies. Together, they will once again take part in the SCAPE - Stockholm Conference on Applications of Power Electronics, in 2019. The conference takes place on May 13&14 in Stockholm. Detailed agenda, speakers list and more will be available soon.

For more information, please contact [Camille Veyrier](#).

ABOUT THE REPORTS:**[Power SiC: MOSFETs, SBDs and Modules 2019 – Patent Landscape Analysis](#)**

The SiC power device market outlook is promising as market adoption is ongoing. Who are the current key IP players for MOSFETs, SBDs and power modules, and who will have the best IP position in the coming years? – Produced by Knowmade

Companies cited in the report:

Denso, Cree, Wolfspeed, Fuji Electric, Toyota Motor, Mitsubishi Electric, Sumitomo Electric, Rohm, General Electric, Hitachi, Toyota Central R&D Labs, Xidian University, Panasonic, Hyundai Motor, CRRC Times Electric, Century Goldray Semiconductor, Infineon, State Grid Corporation of China (SGCC), Hestia Power, Nissan Motor, Siemens, NXP, Toshiba, Philips, Microsemi, Littelfuse, IXYS, Monolith Semiconductor, Renesas Electronics, Bosch, ABB, Shindengen Electric Manufacturing, Showa Denko, Kansai Electric Power, On Semiconductor, Beijing Yandong Microelectronic, Tyco Tianrun Semiconductor Technology, Shenzhen Basic Semiconductor, Sharp, Guangdong Midea, Siemens, Danfoss Silicon Power...

Authors:

- **Rémi Comyn, PhD.** works for Knowmade in the field of Compound Semiconductors and Electronics. He holds a PhD in Physics from the University of Nice Sophia-Antipolis in France in partnership with CRHEA-CNRS, also located in Sophia Antipolis, France, and the University of Sherbrooke in Québec, Canada. Rémi has also worked in a compound semiconductor research laboratory as a research engineer.
- **Nicolas Baron, PhD.** is CEO and co-founder of Knowmade. He manages the development and strategic orientation of the company and personally leads the Semiconductor department. He holds a PhD in Physics from the University of Nice Sophia Antipolis, and a Master of Intellectual Property Strategies and Innovation from the European Institute for Enterprise and Intellectual Property (IEEPI) in Strasbourg, France.

[Power SiC 2018: Materials, devices and applications – Market & Technology report](#)

Automotive is putting SiC on the road. Is the supply chain ready? – Produced by Yole Développement (Yole).

Companies cited in the report:

ABB, Alstom, Ascatron, Aymont, Bombardier, Basic Semiconductor, Brückwell Technology, Caly Technology, Clas-SiC wafer fab, Cree, CRRC, Danfoss, Delphi, DENSO, Dow Corning, Epiworld, Episil, Fraunhofer IISB, Fuji Electric, GE, GeneSiC, Global Power Device, Global Power Technology, Hestia Power, Hitachi, IBS, II-VI, Infineon, MicroSemi, Mitsubishi Electric, Norstel, Northrop Grumman, NXP, ON Semiconductor, Panasonic, Philips, Powerex, Raytheon, RENESAS, ROHM, Sanrex, Schneider Electric, Semikron, Shindengen, SICCC, Siemens, SMA, STMicroelectronics, Toshiba, Toyota, United Silicon Carbide, WeEn, Wolfspeed, X-Fab, Yaskawa...

Authors:

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:

- **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 highadded 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 Autònoma de Barcelona (SP).

ABOUT YOLE GROUP OF COMPANIES



Knowmade is a Technology Intelligence and IP Strategy consulting company specialized in analysis of patents and scientific information. The company supports the business development of R&D organizations, industrial companies, and investors by helping them to understand the competitive landscape, follow the technology trends, and find out opportunities and threats in terms of technology and patents. Knowmade is involved in compound semiconductors, power electronics, batteries, RF electronics & wireless communications, solid-state lighting & display, photonics, MEMS sensors, memories, semiconductor manufacturing & packaging, medical devices, medical imaging, biotech/pharma, and agri-food.

Knowmade's experts provide prior art search, patent landscape analysis, scientific literature analysis, patent valuation, IP due diligence and freedom-to-operate analysis. In parallel the company proposes litigation/licensing support, technology scouting and IP/technology monitoring service. Knowmade's analysts combine their technical and patent expertise with powerful analytics tools and proprietary methodologies, delivering invaluable patent analyses and scientific reviews.

More info on <http://www.knowmade.com> and follow Knowmade on [LinkedIn](#).



Founded in 1998, Yole Développement has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services and well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide covering MEMS and image sensors, Compound Semiconductors, RF Electronics, Solid-state lighting, Displays, software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Nanomaterials, Power Electronics and Batteries & Energy Management. The "More than Moore" market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and KnowMade, support industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business. . For more information, visit www.yole.fr and follow Yole on [LinkedIn](#) and [Twitter](#).

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