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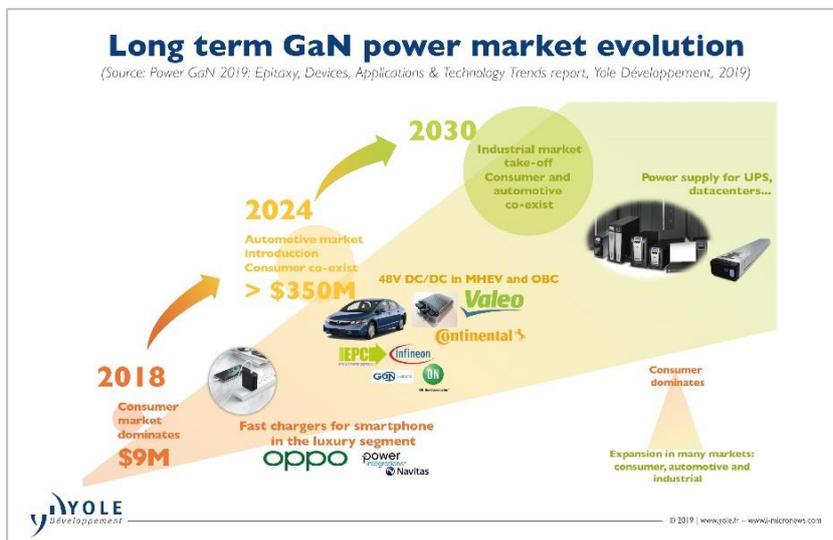
Power GaN¹ achieves its first milestone

Extracted from the following reports:

- Power GaN 2019: Epitaxy, Devices, Applications & Technology Trends report, Yole Développement, 2019
- Medium Voltage GaN HEMT vs SuperJunction MOSFET Comparison, System Plus Consulting, 2019
- GaN-on-Sapphire HEMT Power IC by Power Integrations report, System Plus Consulting, 2019
- Power GaN Patent Landscape, Knowmade, 2019

LYON, France – December 3, 2019: It is now a fact. GaN starts playing the big league. Indeed few weeks ago, thanks to a reverse engineering & costing report performed by System Plus Consulting's team, [GaN-on-Sapphire HEMT² Power IC³ by Power Integrations](#), the power electronics industry discovered with surprise the use of GaN within an Anker's wall charger.

"Beyond Anker and its innovative GaN-based charger, we clearly see today a shift of the power electronics & compound semiconductor industry", comments **Ezgi Dogmus, Technology & Market Analyst at Yole Développement (Yole)**.



Leading players, OPPO and Power Integrations are now reshuffling the cards of this market. Yole Group of companies including Yole and System Plus Consulting had the opportunity to exchange with **Doug Bailey, VP Marketing at Power Integrations** and debate about GaN adoption. The interview "GaN starts playing the big league... – An interview with Power Integrations" is

available on i-Micronews.com.

Yole and [System Plus Consulting](#) are so deeply engaged in the analysis of the power GaN industry. Both companies are working together day by day to get a deep understanding of the market and its status. They follow innovations, evaluate their impact on the market and analyze the strategy of the leading players. Their aim is to get a comprehensive

¹ GaN: Gallium Nitride

² HEMT : High Electron Mobility Transistor

³ IC: Integrated Circuit

overview of the transformation of the industry. This month, Yole and System Plus Consulting are proud to announce two dedicated reports related to GaN technologies, respectively [Power GaN 2019: Epitaxy, Devices, Applications & Technology Trends](#) and [Medium Voltage GaN HEMT vs SuperJunction MOSFET Comparison](#). Both reports are a smart combination of Yole and System Plus Consulting technical and market expertise.

So where do we stand now? How big is the power GaN market? How will it evolve? GaN vs. Si, GaN-on-Sapphire, GaN-on-Si... Which technology will dominate the world? And which company will earn the biggest slice of pie?... Yole and System Plus Consulting analysts take you today to get a relevant comprehension of this industry and disclose the technical and market issues.

“Over the last decade, the GaN power market has been driven mostly by high-end, high performance applications offering high-frequency switching, low on-resistance, and smaller form factor at system level”, comments Ezgi Dogmus from Yole. *“But things are changing for GaN power in 2019...”* GaN is now entering mainstream consumer applications! Following its inclusion in several aftermarket chargers, Chinese OEM⁴ Oppo announced the adoption of a GaN HEMT device in its 65W inbox fast-chargers for its new Reno Ace flagship model. This is the first time GaN power devices have entered a high-volume smartphone market, and it is likely to be a real game-changer for GaN power.

In addition to the exciting consumer market, GaN is attracting lots of attention from various OEMs and Tier 1s, i.e. Valeo and Continental in the automotive industry. Indeed, GaN is very interesting for emerging 48V DC/DC in mild hybrid electric vehicles and on-board chargers in electrified vehicles. Players like EPC⁵ and Transphorm have already obtained AEC⁶ qualification, and GaN Systems, which benefits from its BMW i Ventures investment, expects qualification by next year. According to Yole, these device manufacturers are working closely with packaging companies like ASE, AT&S, and Schweitzer to enter the OEM supply chain and enjoy increasing volumes starting in 2023 – 2024.

GaN is also expected to penetrate industrial and telecom power supply applications including datacom, base stations, UPS, and industrial LiDAR applications. Following the first small-volume adoption of GaN-based power supplies by Eltek, Delta, and BelPower over the last few years, Yole's expect broader penetration of GaN in the near future, with increasing efficiency requirements in data centers benefiting from enhanced GaN device maturity + cost-competitiveness.

Overall, compared to Yole's 2018 power GaN technology & market report and its two market scenarios, this year's market forecast is

⁴ OEM : Original Equipment Manufacturer

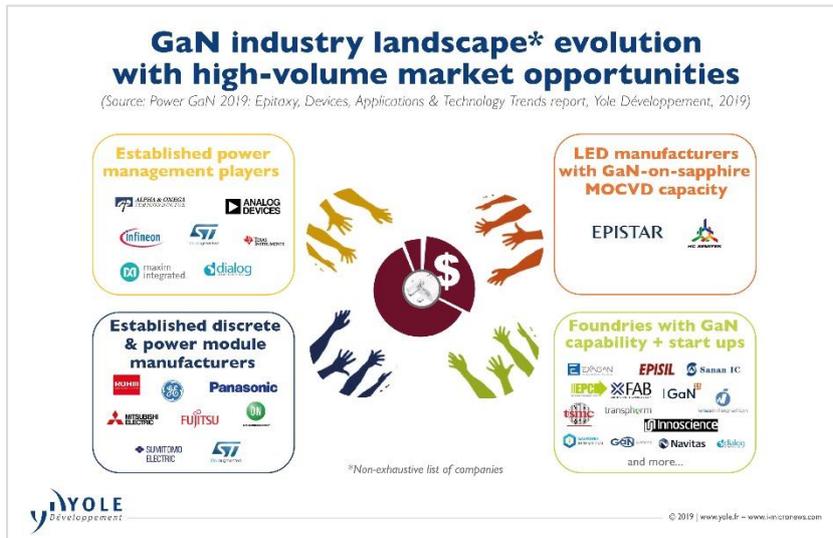
⁵ EPC: Efficient Power Conversion

⁶ AEC: Automotive Electronics Council

much brighter than 2018's base-case thanks to GaN's adoption in Oppo's inbox fast chargers. Driven mainly by such consumer fast-charger applications, Yole's power & wireless team projects that the GaN power business will exceed US\$350 million by 2024, with 85% CAGR⁷ between 2018 and 2024.

Out of all the GaN-based power supply applications, inbox fast-charging is likely to be the killer application for the GaN power device market. Over the last two years, SoC⁸ and SiP⁹ primarily from Navitas, along with power integrations, have managed to enter at least 50

aftermarket fast charger brands, including Ravpower, Anker, and Aukey. As mentioned earlier, one of the year's most significant developments was Oppo's adoption of GaN HEMTs for 65W inbox fast charging in its high end model. In addition, very recently the leading OEM Samsung has also shown its interest in high power fast charging based on GaN technology, by adopting



45W fast chargers in its mobile accessory. What other possible market scenarios exist for GaN adoption in this mass market?

At Yole, analysts anticipate proliferation of Chinese OEM challengers such as Oppo, Vivo, and Xiaomi in the emerging 5G luxury smartphone business, which demands significant technology differentiation. Oppo's SuperVOOC 2.0 meets these demands, with its reduced charging time and charger size. Other Chinese OEMs have also announced very high-power fast charging (beyond 100W), and could potentially adopt GaN devices in the coming years. In light of these prospective achievements, the overall GaN device market is nominally expected to surpass Yole's market estimation announced previously.

In a more optimistic scenario, with Chinese OEMs deploying high-power fast chargers, GaN could also be adopted by other players in the inbox chargers. For example, in Q4-2019, the leading OEM Samsung has adopted GaN HEMT device in its 45W accessory fast-chargers. This is great news for GaN. In this context, a bigger market expansion in the consumer applications can be expected, once GaN achieves high maturity and market acceptance as well as cost-competitiveness compared to Si¹⁰ MOSFETs.

⁷ CAGR: Compound Annual Growth Rate

⁸ SoC : System-on-Chip

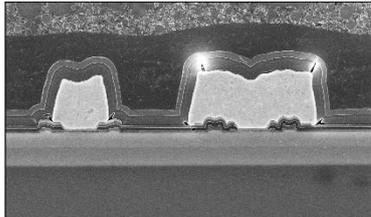
⁹ SiP : System-in-Package

¹⁰ Si : Silicon

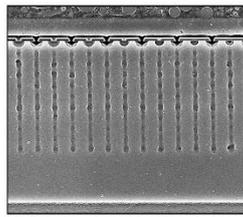
System Plus Consulting deeply investigated GaN competitive landscape and made a significant comparison with SJ MOSFET technologies. SJ¹¹ was commercially released for the first time in 1998 by Infineon

Infineon Technologies – Medium Voltage GaN HEMT vs SuperJunction MOSFET: die SEM view

Source: Medium Voltage GaN HEMT vs SuperJunction MOSFET Comparison, System Plus Consulting, 2019)



Infineon CoolGaN™ HEMT Cross-Section – Die SEM View



Infineon SuperJunction CoolMOS™ Cross-Section – Die SEM View



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Technologies. Today new players are entering the market, but the historical players keep their lead by decreasing production costs as much as possible or by introducing different technologies. The improvement of silicon SJ MOSFETs will keep these devices on the market and drive them towards standardization and popularization.

“GaN-on-Si HEMTs are good competitors for silicon SJ MOSFETs in the 600/650V power device range”, explains **Amine Allouche, Junior Costing Analyst at System Plus Consulting**. “Indeed they offer new capabilities, such as higher switching frequencies, higher power density and an increasingly competitive manufacturing cost.”...

The power GaN collection of reports from System Plus Consulting ? Knowmade and Yole is now available on i-Micronews.com.

¹¹ SJ: Superjunction

ABOUT THE REPORTS:

[Power GaN 2019: Epitaxy, Devices, Applications & Technology Trends](#)

First design-win for GaN HEMTs in the high-volume smartphone fast charging market
- Performed by Yole Développement

Companies cited in the report:

Aixtron, Allos, Alpha & Omega, Amec, Amkor, Apple, ASE, AT&S, BMW, Coorstek, Delta Electronics, Dialog Semiconductors, Dowa, Efficient Power Conversion, Egtronics, Enkris, Energous, EpiGaN, Episil, Epistar, Evatran, Exagan, Fairchild, Finsix, Ford, Fuji Electric, GaN Systems, GaN Power, Gener8, Huawei, Imec, Infineon, IQE, LG Electronics, Jedec, Kyma... and more



[Medium Voltage GaN HEMT vs Superjunction MOSFET Comparison](#)

A high added-value comparison of medium voltage GaN HEMTs vs Superjunction MOSFETs from 14 manufacturers including technology & costs analyses. - Performed by System Plus Consulting

The report includes detailed pictures of device structures, details on manufacturing processes and materials, comparison of electrical performance, and cost breakdown analysis of the process.



[GaN-on-Sapphire HEMT Power IC by Power Integrations](#)

The unique device with GaN-on-Sapphire technology in Anker's PowerPort Atom PD 1 wall charger. – Performed by System Plus Consulting, 2019

In this report, System Plus Consulting presents a deep teardown analysis of the SC1933C. Detailed optical and Scanning Electron Microscope pictures and cross-sections with energy-dispersive X-ray analysis are included to reveal Power Integrations' technical choices at the microscopic level of the IC and HEMT designs.



[Power GaN Patent Landscape](#)

Which patent owners are ready to dominate the GaN power market in coming years?
– Performed by Knowmade

In the report we detail the IP landscape related to GaN-on-Silicon and GaN-on-Sapphire. The GaN-on-Silicon patent landscape is characterized by the presence of numerous GaN pure-play companies and numerous Chinese new entrants. In the GaN-on-Sapphire patent landscape, Power Integrations is the best-known player. However, numerous other players have also developed IP related to GaN-on-Sapphire for power applications, including CorEnergy, Powdec and Seoul Semiconductor.

About the authors:

- As a Technology & Market Analyst, Compound Semiconductors, **Ezgi Dogmus**, PhD is member of the Power & Wireless division at Yole Développement (Yole). She is daily contributing to the development of these activities with a dedicated collection of market & technology reports as well as custom consulting projects. Prior Yole, Ezgi was deeply involved in the development of GaN-based solutions at IEMN (Lille, France). Ezgi also participated in numerous international conferences and has authored or co-authored more than 12 papers. Upon graduating from University of Augsburg (Germany) and Grenoble Institute of Technology (France), Ezgi received her PhD in Microelectronics at IEMN (France).
- **Hong Lin**, PhD, is a Principal Analyst, Compound Semiconductors at Yole Développement (Yole), within the Power & Wireless division. Since 2013, Hong has been involved in analyzing the compound semiconductor market (including SiC, GaN, GaAs, InP, engineered substrates and other emerging materials) with dedicated technical, strategic, market and financial analyses.

Prior to Yole, she worked as an R&D Engineer at Newstep Technologies. Her mission was to oversee the development of cold cathodes made by plasma-enhanced chemical vapor deposition for visible and UV lamp applications based on nanotechnology.

Dr Hong Lin holds a PhD in physics and chemistry of materials from the University of Pierre & Marie Curie (Paris VI, France).

- **Ana Villamor**, PhD serves as a Technology & Market Analyst, Power Electronics & Compound Semiconductors within the Power & Wireless division at Yole Développement (Yole). 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 and PhD. in micro and nano electronics from Universitat Autònoma de Barcelona (SP).

- **Amine Allouche** is part of System Plus Consulting's Power Electronics and Compound Semiconductors team. Amine holds a Master's degree focused on Micro and Nanotechnologies for integrated Systems.
- **Dr. Youssef El Gmili** has joined System Plus Consulting's team in 2019 after ten years passed on high level research and development on microelectronics. He holds a Master Degree in Microelectronics, and a PhD. in Physics/Materials Science.
- **Véronique Le Troadec** has joined System Plus Consulting as a laboratory engineer. She holds a Master degree in Microelectronics from the University of Nantes.
- **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.

ABOUT YOLE GROUP OF COMPANIES



Specialized in the analysis of patents and scientific information, Knowmade provides technology intelligence and IP strategy consulting services. The company supports the business development of R&D organizations, industrial

companies, and investors by helping them understand the competitive landscape, follow the technology trends, and discern opportunities and threats in terms of technology and patents.

Knowmade operates in the following industrial sectors: compound semiconductors, power electronics, batteries, RF electronics & wireless communications, solid-state lighting & display, photonics, MEMS sensors, memory, semiconductor manufacturing, packaging & assembly, 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 services. Knowmade's analysts combine their technical and patent expertise with powerful analytics tools and proprietary methodologies, delivering invaluable patent analyses and scientific reviews.



System Plus Consulting specializes in the cost analysis of electronics, from semiconductor devices to electronic systems. Created more than 20 years ago, System Plus Consulting has developed a complete range of services,

costing tools and reports to deliver in-depth production cost studies and estimate the objective selling price of a product.

System Plus Consulting engineers are experts in Integrated Circuits - Power Devices & Modules - MEMS & Sensors - Photonics – LED - Imaging – Display - Packaging - Electronic Boards & Systems. Through hundreds of analyses performed each year, System Plus Consulting offers deep added-value reports to help its customers understand their production processes and determine production costs. Based on System Plus Consulting's results, manufacturers are able to compare their production costs to those of competitors. System Plus Consulting is a sister company of Yole Développement. More info on www.systemplus.fr and on [LinkedIn](#) and [Twitter](#).



Founded in 1998, **Yole Développement (Yole)** 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 & Sensors - Imaging - Medical Technologies - Compound Semiconductors - RF Electronics - Solid State Lighting - Displays - Photonics - Power Electronics - Batteries & Energy Management - Advanced Packaging - Semiconductor Manufacturing - Software & Computing - Memory and more...

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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