GaN-on Si: many opportunities are driven by microLED, power electronics and RF electronics...¹

OUTLINES:
- GaN-on-Si² IP³ landscape: historical players stepping back, leading to a substantial reconfiguration of the ecosystem.
- Emerging applications in optoelectronics & photonics are driving the IP activity.
- RF⁴ electronics: Macom and Intel have taken the lead on GaN-on-Si RF technology.

“2015-2020 period has shown tremendous and decisive changes within the GaN-on-Si landscape, especially the strategy of players involved,” affirms Nicolas Baron, CEO and Co-founder of KnowMade. He adds: “For example, Toshiba’s withdrawal from white LED market and the acquisition of IR⁵ by Infineon Technologies in 2015⁶. (Read a dedicated article focused on the power electronics consolidation on i-Micronews.com).

¹ Extracted from: GaN-on-Silicon – Patent-Landscape Analysis, KnowMade, 2020
² GaN-on-Si : GaN-on-Silicon
³ IP: Intellectual Property
⁴ RF: Radio Frequency
⁵ IR: International Rectifier
At that time, Toshiba and IR were already leading the GaN-on-Si patent landscape, while several historical IP players including Panasonic, Sanken Electric, Toyoda Gosei, etc. had already slowed down their patenting activity in this field. Furthermore, after IR, Transphorm, Panasonic and GaN Systems started sampling/commercializing their first GaN-on-Si power devices between 2010 and 2015, a second wave of companies has entered the playground in the last few years: ON Semiconductor, Dialog, Navitas, VisIC. More companies, such as STMicroelectronics, are expected soon, demonstrating the growing interest for GaN-on-Si technology in the power electronics business.

Yole Group of Companies, including Yole Développement, KnowMade and System Plus Consulting, are deeply engaged in the analysis of the overall GaN industry. The three 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 overview of the transformation of this industry.

In addition, the Group proposes a special focus on the power electronics industry with a dedicated online event on January 30: “First Milestone for GaN Power Devices”. This webcast powered by Yole, System Plus Consulting and KnowMade is a great opportunity to understand and get a better vision of the GaN ecosystem and its supply chain, collect market figures and trends and discover a spotlight on the IP strategy of the key players. Register today!

“Intel and Macom are leading the GaN-on-Si patent landscape for RF electronics applications,” says Remi Comyn, PhD, Compound Semiconductors and Electronics at KnowMade.

Intel’s RF GaN-on-Si patent portfolio mainly relates to III-N transistors used in SoC⁶, RF switches, ultra-short channel lengths, field plates, and III-N/Silicon monolithic IC⁷. Still, about 75% of Intel’s portfolio are composed of pending patent applications distributed mainly between USA with 17 patents and Taiwan with 20 patents.

Fujitsu with more than 40 patents and Macom with more than 20 patents for its side, are leading the patent landscape in terms of enforceable IP in the field of GaN-on-Si RF. Fujitsu’s portfolio focused on GaN-on-Si materials, especially on buffer layers, with inventions that might be implemented on other substrates including SiC⁸ or for other applications. Likewise Intel, Fujitsu has adopted a global patenting strategy. In contrast Macom’s portfolio is more focused on GaN-on-Si devices for RF, addressing specific technological challenges at epitaxy, device, module and package levels. For instance, a strong patenting effort was made in 2015 in order to address the parasitic channel via counter dopants in HEMT⁹ epi-structures. KnowMade’s analysts identified more than 10 related patent applications in its new GaN-on-Silicon patent analysis. Furthermore, Macom’s patenting activity related to GaN-on-Si is essentially focused on US, although it has now requested foreign extensions for a significant number of newly published inventions.

Regarding the power electronics field, Rémi Comyn from KnowMade comments: “The growing interest in GaN-on-Si technology for power applications has not translated into a remarkable acceleration of the patenting activity. However, we observed a steady patenting activity from Infineon following IR’s acquisition, and a remarkable strengthening of Transphorm’s portfolio after Fujitsu’s decision to transfer its power supplies businesses to the US startup”.

Transphorm’s IP position has been further reinforced following the licensing agreement established in 2014 with Furukawa Electric, a key IP player in GaN-on-Si patent landscape. Likewise, Infineon Technologies closed an important IP licensing agreement with another historical player of GaN-on-Si and power electronics patent landscapes, Panasonic. Furthermore, KnowMade will keep monitoring closely GaN-on-Si IP activity in the next month, since another major power electronics player.

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⁶ SoC : System-On-Chip
⁷ IC : Integrated Circuit
⁸ SiC: Silicon Carbide
⁹ HEMT: High Electron Mobility Transistors
STMicroelectronics, announced in 2018 an extensive R&D program in collaboration with CEA Leti a well-positioned player in the GaN-on-Si patent landscape.

From a technical point of view, Ezgi Dogmus, PhD, Technology & Market Analyst Compound Semiconductors & Emerging Materials at Yole asserts: “Over the last years, in the power electronics industry, we have witnessed an increasing interest for GaN HEMTs, which bring attractive performance and cost-competitive compared to Si MOSFETs. In addition to innovative start-up companies, almost all integrated device manufacturers in the Power Electronics business propose currently GaN-on-Si devices enabling systems with higher power, higher efficiency and smaller footprint than their Si MOSFET solutions.”

In power electronic sector, GaN-on-Si devices are direct competitors of Silicon SJ MOSFETs at medium voltage.

“SJ MOSFETS are still cost effective and technologically interesting,” explains Elena Barbarini, Head of Department Devices at System Plus Consulting. “But the increase of players as the development of attractive performances at GaN epitaxy level drove an acceleration of available solutions. Its regards die design, driver integration and packaging.” This competition is analyzed in details in the Medium Voltage GaN HEMT vs Superjunction MOSFET Comparison report performed by System Plus Consulting.

After a spotlight highlighting the GaN-on-Si patent activities in RF and Power electronics sectors, another interesting application has to be pointed out. Indeed, the increasing GaN-on-Si activity within the microLED activities is step by step becoming more attractive and leads to huge volume opportunities.

As of 2019, a significant contribution to the patenting activity (in terms of new inventions) stems from the development of a low cost and scalable GaN-on-Si nanowires-based microLED technology, which are promising for the next-generation display technology and smart lighting.
applications. Most microLEDs related patents included in the landscape are related to the fabrication of GaN nanostructures.

Eric Virey, PhD, Principal Analyst, Technology & Market, Displays at Yole tells us the story: “The technology was first developed and patented by glō between 2010 and 2016. However, glō’s patenting activity does not put the emphasis on GaN-on-Si, although it is a preferred embodiment”. For more information about glō’s developments, discover its interview conducted by Eric Virey and published on i-Micronews.

In parallel, since 2014, CEA and Aledia started patenting their own – jointly developed – technology with numerous requests for extending its priority patents worldwide indicating a global IP strategy/competition.

In this dynamic ecosystem, GaN-on-Si technologies look attractive and promising. This phenomenon is highlighted with the numerous patents incoming. Under this context, KnowMade, as a technology intelligence and IP strategy consulting company specialized in the analysis of patents and scientific information, and its partners, Yole and System Plus Consulting will pursue their investigations in this field and keep you updated about the latest technical innovations, patents and industrial news. Stay tuned!

All year long, Yole Group of Companies, including System Plus Consulting, KnowMade and Yole Développement, publishes numerous reports covering the GaN industry: more on i-Micronews.com. Yole Group’s power electronics & compound semiconductor teams announces an impressive agenda in 2020. Analysts will present their results and exchange with leading companies all year long, during a selection of key conferences & trade shows. Make sure to save the date right now!

- First Milestone for GaN Power Devices, online event (January 30)
- EVIHEV Cost vs. Performance Trade-off: A Battle on Multiple Fronts For Power Electronics, TechDay (February 18, Hilton garden inn hotel, Stuttgart, Germany)
- APEC, Conference (March 15-19, New-Orleans, LA, USA)
- Mobile World Congress – MWC (February 24-27, Barcelona, Spain)

Press contacts

Sandrine Leroy, Director, Public Relations, sandrine.leroy@yole.fr
Marion Barrier, Assistant, Public Relations, marion.barrier@yole.fr

Le Quartz, 75 Cours Emile Zola – 69100 Villeurbanne – Lyon –France – +33472830189
www.yole.fr - www.i-micronews.com – LinkedIn – Twitter
About our analysts

As Head of Department Devices, Elena Barbarini is in charge of costing analyses for MEMS, IC and Power Semiconductors. She has a deep knowledge of Electronics R&D and Manufacturing environment. Elena holds a Master in Nanotechnologies and a PhD in Power Electronics.

Nicolas Baron, PhD, Nicolas is CEO and co-founder of KnowMade. He manages the development and strategic orientations 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 Strasbourg), France.

Ezgi Dogmus, PhD, As a Technology & Market Analyst, Compound Semiconductors, Ezgi Dogmus 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).

Elena, Ezgi and Nicolas will reveal the status of GaN-on-Silicon technologies and their vision of the industry and patent landscape during First Milestone for GaN Power Devices webcast taking place on January 30. Register today!

Rémi Comyn, PhD, Rémi works for KnowMade in the field of Compound Semiconductors and Electronics. He holds a PhD in Physics from the University of Nice Sophia-Antipolis (France) in partnership with CRHEA-CNRS (Sophia-Antipolis, France) and the University of Sherbrooke (Québec, Canada). Rémi previously worked in compound semiconductors research laboratory as Research Engineer.

Eric Virey, PhD, serves as a Principal Display Market and Technologies Analyst within the Photonics, Sensing & Display division at Yole Développement (Yole). Eric has spoken in more than 50 industry conferences over the last 10 years and has been interviewed or quoted in multiple media including: The Wall Street Journal, CNN, Fox News, CNBC, Bloomberg, Financial Review, Forbes, Technology Review, etc. Prior to joining Yole, Eric held R&D, engineering, manufacturing and marketing positions with Fortune 500 Company Saint-Gobain in France and the United States. Eric received a PhD in Optoelectronics from the National Polytechnic Institute of Grenoble. He is based in Portland, OR.

About the reports

GaN-on-Silicon - Patent Landscape Analysis – 2020
GaN-on-Silicon activity is now driven by micro-LED, GaN Power and GaN RF applications. Who are leading the IP competition on these different battlefields? Who are the emerging players? - Performed by KnowMade

Companies cited
Toshiba, Sharp, Panasonic, Sanken Electric, Infineon / International Rectifier, Intel, Samsung, University Beijing, Transphorm, Fujitsu, Lattice Power, FMIC - Founder Microelectronics, TSMC, Osram Opto Semiconductors, CETC - China Electronics Technology Group Corporation, Nanjing University of Posts & Telecommunications, Zhongtuo Optoelectronics Technology, Innoscience, Shenzhen Jing Xiang Technology, Showa Denko, Aledia, LG Innotek, Qromis, Institute of Semiconductors (CAS), Sumitomo Electric, HRL Laboratories and many more...

And related 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

RF GaN Market: Applications, Players, Technology and Substrates 2019
GaN RF market growth is fed by military and 5G wireless infrastructure applications – Performed by Yole Développement

RF GaN 2019 – Patent Landscape Analysis
The RF GaN market is developing fast, driven by mm-wave, 5G and defense applications. Do current leading market players have the right IP portfolios to face huge opportunities for GaN devices? – Performed by KnowMade

**Power GaN – Patent Landscape Analysis**
Which patent owners are ready to dominate the GaN power market in coming years? – Performed by KnowMade

**GaN Power & RF – Patent Monitor Service**
Get updated data on GaN-related patent activity for RF & Power electronics: new patents, patents expired or abandoned, latest patent transfers and patent litigation. – Performed by KnowMade

**Medium Voltage GaN HEMT vs Superjunction MOSFET Comparison 2019**
Compare the technology and cost of 600/650V GaN-on-Si HEMTs vs Superjunction MOSFETs from 13 manufacturers. – Performed by System Plus Consulting

**MicroLED Displays**
Significant progress over the last 18 months, but many challenges remain before ramping up for large volume consumer applications. – Performed by Yole Développement

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KnowMade is a technology intelligence and IP strategy consulting company specialized in analysis of patents and scientific information. The company helps innovative companies and R&D organizations to understand their competitive landscape, follow technology trends, and find out opportunities and threats in terms of technology and patents… More

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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, & technology trends to grow their business… More

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