



FOR IMMEDIATE RELEASE:

RF industry: how can GaN win the battle?

Extracted from:

- RF GaN market: applications, players, technology, and substrates report, Yole Développement, 2019
- RF GaN 2019, Patent landscape analysis report, Knowmade

LYON, France – June 24, 2019: Over recent years, GaN¹ has been significantly adopted by the RF² industry owing to its higher power output at high frequencies, and its smaller footprint.

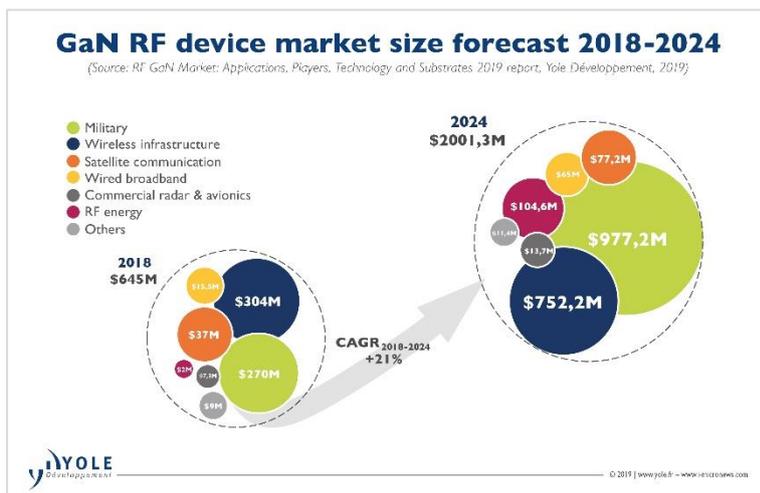
“The overall GaN RF market is expected to reach US\$2 billion by 2024, driven by two main applications: telecom infrastructure and defense”, asserts **Ezgi Dogmus, PhD. Technology & Market Analyst at Yole Développement (Yole).**

And **Antoine Bonnabel, Technology & Market Analyst**, also part of the Power & Wireless team at Yole comments: “Worldwide investment in telecom infrastructure has remained stable in the past decade, with a recent increase coming from Chinese government efforts. But in this steady market, the trend toward higher frequencies offers a sweet spot for RF GaN in PA³ in 5G network at frequencies below 6GHz, in RRH⁴.”...

Yole Group of companies, including Yole and Knowmade investigates GaN technologies for RF applications to propose each year up-to-date technology, market and patent analyses.

Under their new RF GaN report, [RF GaN market: applications, players, technology, and substrates](#), Yole’s analysts offer a deep understanding of GaN implementation in different market segments. Indeed it delivers an extensive overview of 5G’s impact on the wireless infrastructure and RF FEs⁵, and the GaN based military market, including current market dynamics and future evolution.

In addition, Knowmade, based on its IP expertise, reveals the related competitive landscape from a patent perspective. Key patent owners,



¹ GaN : Gallium Nitride
² RF : Radio-Frequency
³ PA : power amplifiers
⁴ RRH : Remote Radio Heads
⁵ FE : Front-End

IP & technology strategies, and future intents have been deeply analyzed by the analysts in the [RF GaN 2019, Patent landscape analysis report](#).

What are the benefits of GaN technologies, compared to existing technologies, such as GaAs⁶ and LDMOS⁷? What is the status of RF GaN device technologies on different substrates, silicon, SiC⁸ and diamond? Who is doing what? What are the current technical issues and market challenges? Analysts invite you to discover the RF GaN ecosystem.

Since the apparition of first commercial products 20 years ago, GaN has become a serious rival to LDMOS and GaAs in RF Power applications, with a continuous improvement of performance and reliability at lower cost.

The first GaN-on-SiC and GaN-on-Si devices appeared at almost at the same time, but GaN-on-SiC has become more technologically mature.

Currently dominating the GaN RF market, GaN-on-SiC penetrated the 4G LTE⁹ Wireless infrastructure market and is expected to be deployed in RRH¹⁰ architectures in 5G's sub-6Hz implementations.

Nevertheless, in parallel, there has also been remarkable progress in cost-efficient LDMOS technology, which is likely to challenge GaN solutions in 5G sub-6Ghz active antennae and massive MIMO¹¹ deployments. In this context, GaN-on-Si stands as a potential challenger with possible expansion to production on 8-inch wafers, and promises cost efficient solutions for commercial markets. Even though, as of Q1-2019, GaN-on-Si remains in small volume manufacturing, it is expected to challenge the existing LDMOS solutions in the BTS¹² and RF energy market.

Another target of GaN-on-Si companies is the high-volume consumer 5G handset PA market, which can open up new market opportunities in coming years if successful. With eventual ramp-up of GaN-on-Si products, a coexistence of both GaN-on-SiC and GaN-on-Si in the market would be possible.

Last but not least, innovative GaN-on-Diamond technology is entering the competition, promising very high power output density with smaller footprint compared to its GaN rivals. This technology targets performance-driven applications, such as in high power BTS, military and satellite communication.

⁶ GaAs : Gallium Arsenide

⁷ LDMOS : Laterally Diffused Metal Oxide Semiconductor

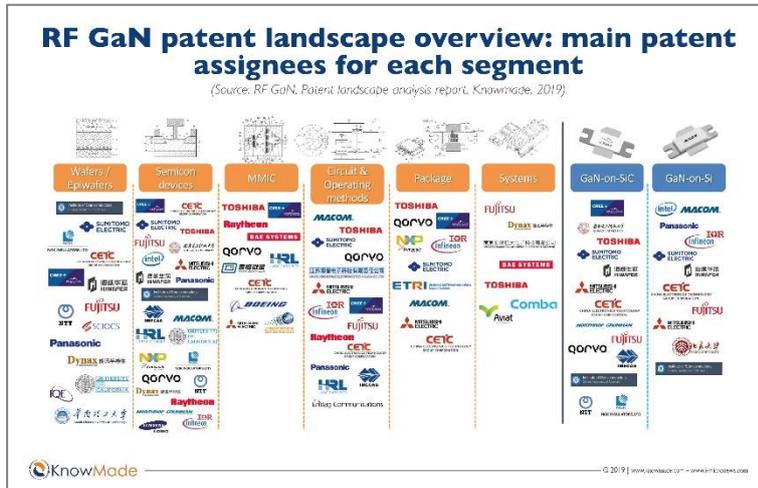
⁸ SiC : Silicon Carbide

⁹ LTE : Long-Term Evolution

¹⁰ RRH : Remote Radio Head

¹¹ MIMO : Multiple Input, Multiple Output

¹² BTS : Base Transceiver Station



But what is the status of the supply chain?

As a mature technology, GaN-on-SiC proposes today a well-established supply chain with numerous actors and different levels of integration.

At the RF component level, the top market players are:

- Sumitomo Electric Device Innovations (SEDI), Cree/Wolfspeed and Qorvo.
- Upon becoming a public

company, RFHIC has significantly increased its revenue since 2017.

- Leading compound semiconductor foundry Win Semiconductors is now actively offering GaN RF products.

In the GaN-on-Si RF industry, STMicroelectronics is a leading actor in collaboration with MACOM targeting global 5G base station applications with expansion of production capacity of 150mm GaN-on-Silicon and further expansion to 200mm. Furthermore, ST has announced its interest in GaN-on-Si handsets, which could open exciting new market opportunities for the GaN RF business. Yole and Knowmade had the opportunity to meet **Filippo Di Giovanni, Director Strategic Marketing, Innovation & Key Programs for New Materials and Power Solutions Division, Automotive Products Group, at STMicroelectronics**. They discussed about technology status and roadmap for the coming years. Discover the full interview on i-micronews.com.

Within the military market, countries and regions are individually strengthening their GaN RF ecosystem. GaN adoption is driven by strong players such as Raytheon, Northrop Grumman, Lockheed Martin in the USA, and is boosted in Europe with UMS, Airbus, Saab, and in China by leading vertically-integrated company, China Electronics Technology Group Corporation (CETC).

However, in the telecom market the situation is different. Strategic partnerships and/or mergers and acquisitions have marked 2018. The market leader SEDI and II-VI established a vertically-integrated 6-inch GaN-on-SiC wafer platform to address the increasing demand within 5G. In parallel, Cree acquired Infineon's RF Power Business including and packaging and test for LDMOS and GaN-on-SiC technologies.

A detailed description of GaN RF reports is available on i-micronews.com, [RF devices reports section](#).

ABOUT THE REPORTS:

RF GAN MARKET: APPLICATIONS, PLAYERS, TECHNOLOGY AND SUBSTRATES 2019

GaN RF market growth is fed by military and 5G wireless infrastructure applications. - Produced by Yole Développement.

Companies cited in the report:

Aethercomm, Aixtron, Akash Systems, Alcatel-Lucent, Ampleon, Anadigics, Arralis, AT&T, BAE Systems, Bell Laboratory, Cisco, CETC, China Mobile, China Telecom, China Unicom, Cree, Custom MMIC, Dynax, DragonWave-X, Dowa, EADS, Enkris Semiconductor, Epigan and more...



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? – Produced by Knowmade

Companies cited in the report:

Cree/Wolfspeed, Sumitomo Electric, Qorvo, Fujitsu, CETC (China Electronics Technology Group Corporation), Toshiba, MACOM, Mitsubishi Electric, Intel, Northrop Grumman, Panasonic, NXP/Freescale, Raytheon, Infineon/International Rectifier, HiWafer, NTT (Nippon Telegraph & Telephone), Beijing Huajin Chuangwei Electronics, Dynax Semiconductor, NGK Insulators, Samsung Electronics, NEC, HRL Laboratories, Japan Radio, TSMC, US Navy, WIN Semiconductors, BAE Systems, Lockheed Martin, Tiger Microwave, Boeing, UMS and more...

Authors:

- **Antoine Bonnabel** works as a Technology & Market Analyst for the Power & Wireless team of Yole Développement (Yole). He carries out technical, marketing and strategic analyses focused on RF devices, related technologies and markets.
Prior to Yole, Antoine was R&D Program Manager for DelfMEMS (FR), a company specializing in RF switches and supervised Intellectual Property and Business Intelligence activities of this company. In addition, he also has co-authored several market reports and is co-inventor of three patents in RF MEMS design.
Antoine holds a M.Sc. in Microelectronics from Grenoble Institute of Technologies (France) and a M.Sc. in Management from Grenoble Graduate School of Business (France).
- **Dr. Nicolas Baron** 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.
- 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).

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.

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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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