RF GaN

Patent Landscape Analysis – November 2020

The last 2 years marked a turning point for RF GaN patenting activity now driven by China and moving on technical issues further down the value chain.

REPORT OUTLINE

- RF GaN
- Patent Landscape Analysis
- November 2020
- PDF >230 slides
- Excel file with >6,300 patents
- €6,490 for a multi-user license
- Ref.: KM20008

KEY FEATURES

- Main IP dynamics and key trends.
- IP leaders, most active players and newcomers.
- IP portfolio strength of key players, and their technology/application focus.
- Time evolution of patents filings by company, countries, and technology.
- IP collaborations and IP transfers between key organizations.
- Insights into the status of RF GaN patented technologies, identifying trends for each technology and application.
- Extensive Excel database of over 3,000 patent families with all patent information and technology segmentation.

LINKED REPORTS & MONITORS

- GaN Power & RF Patent Monitor
- GaN-on-Silicon Patent Landscape 2020
- Power GaN Patent Landscape 2019
- RF Acoustic Wave Filters Patent Landscape 2019

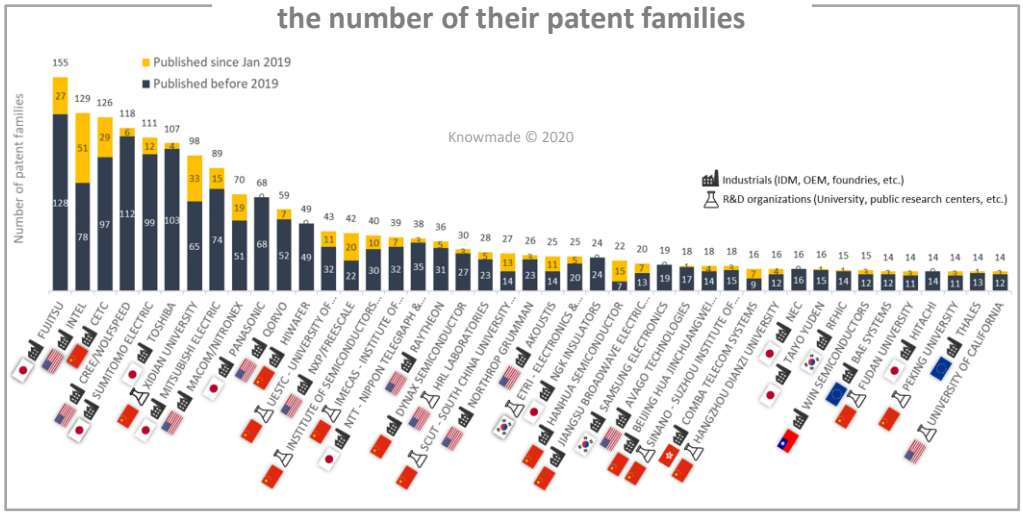
RF GaN intellectual property (IP) activities continue to grow, driven by next-gen telecom and military technologies requirements

The **radio frequency (RF) GaN market** is experiencing impressive growth, mainly driven by telecom and military applications. The overall GaN RF market is expected to increase from **$740M** in 2019 to more than **$2B** in 2025, with a CAGR of 12%, according to Yole Développement.

In this report, Knowmade's Semiconductor team gives a thorough description and analysis of the **patent landscape related to GaN-based RF electronics**, covering the whole value chain from epitaxial structures to RF semiconductor devices, circuits, packages, modules and systems.

Analysts have selected and analyzed more than **6,300 patents** published worldwide up to August 2020, representing more than **3,000 patent families** (inventions) filed by more than 500 different organizations. This 2020 edition comprises 2x more patent families and more than 100 new players compared to the 2019 edition.

Ranking of patent applicants according to the number of their patent families



The first RF GaN patent applications were filed in the 1990s. The level of activity took off in 2004 and accelerated significantly from 2015. Today, the IP dynamics are driven by two major factors: (1) China, and (2) the shift of IP further down the value chain.

Chinese IP activity has been accelerating since 2015. Over the last 2 years, we witnessed a remarkable increase in **patents coming from China** and many **Chinese newcomers** entering the RF GaN IP landscape. In 2019-2020, the Chinese organizations represented more than 40% of the patent applicants (Americans = 23%, Japanese = 10%, Europeans = 3%). The rise in RF GaN patents from China-based companies follows a more general trend as the country transitions from a manufacturing to an innovation-driven economy. This trend also reflects the situation in the RF industry, with a Chinese market that shows exploding demand for commercial wireless telecom applications and Chinese companies already developing next-gen telecom networks. Moreover, following the US-China trade war, numerous China-based companies are trying to develop GaN RF for 5G infrastructures internally.

Over the last few years, the level of creativity to address all the technology and manufacturing roadblocks for GaN RF devices has been impressive. More recently, **IP developments are accelerating on topics further down the value chain**: RF circuits, packaging, and modules/systems. The current patent activity suggests that manufacturing and technology issues still need to be solved in **monolithic integration** of different RF semiconductor devices; **thermal management** at epi-stack, semiconductor device and package levels; **linearity** at semiconductor device and circuit levels; and protection, matching and distortion compensation at circuit level.

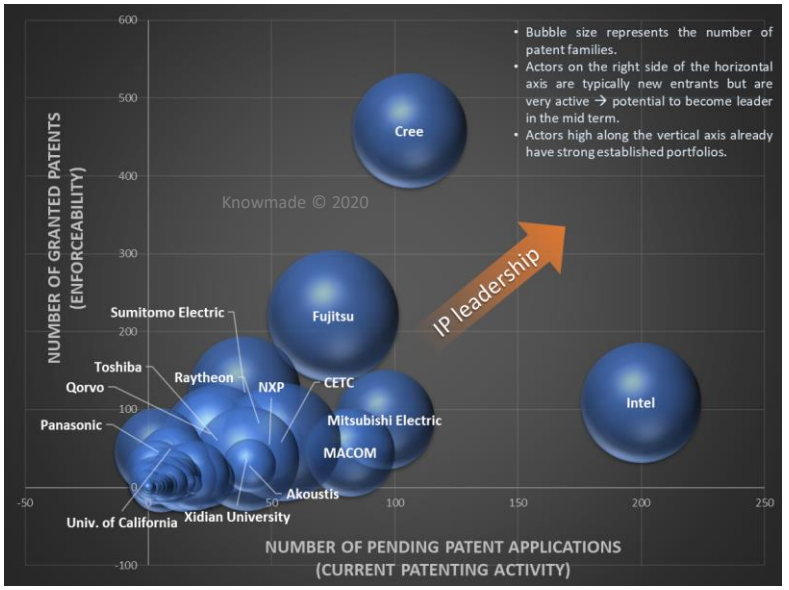
GaN RF leading companies should not underestimate China's IP as it is changing the landscape

The RF GaN patent landscape is currently dominated by American and Japanese companies such as **Cree**, **Fujitsu**, **Sumitomo Electric**, **Mitsubishi Electric**, **Intel**, **MACOM**, **Toshiba**, **Qorvo** and **Raytheon**. The IP competition has been stronger in the US, as demonstrated by a much higher number of granted patents (1,200+) in contrast with China (640+), Japan (440+) and Europe (250+). However, the patenting activity is now focused on China.

Cree has the stronger IP position thanks to numerous fundamental patents, especially for GaN-on-SiC technology. Over the past 5 years, inventive activity at **Cree**, **Sumitomo Electric** and **Toshiba** stalled. These IP leaders have developed broad patent portfolios covering a wide range of RF GaN technology nodes. The reduced IP activity could be a sign of confidence in their already robust RF GaN patent portfolio. **Intel** and **MACOM** have strongly increased their IP activity since 2017, especially for GaN-on-Silicon technology. **Intel** is currently the most active patent applicant in the RF GaN field, with a record-high level of activity of patenting new inventions over the last couple of years which could, down the road, position it ahead of **Sumitomo Electric**, **Fujitsu** or **Cree** in terms of IP leadership.

In China, **CETC** and **Xidian University** have the most prolific inventive activity. Other players such as **HiWafer**, **Dynax, Hanhua** and China's top public research entities **UEST**, **IMECAS**, **SCUT** and **Institute of Semiconductors** have built sizeable RF GaN IP portfolios, and ambitious new players are entering the IP landscape (**Boxin**, **Reactor Microelectronics**, **TUS-Semiconductor**, **Hatchip**, **Nexgo**, **Bosemi**, **HC Semitek**, **A-INFO**, **RDW**, **Chippacking**, **China Mobile**, **Gaxtrem**, etc.). European RF players **Thales**, **BAE Systems**, **Infineon**, **Ampleon**, **Ericsson**, etc. are only playing a small part in the current RF GaN IP dynamics. In Taiwan, the foundries **Win Semiconductors**, **TSMC** and **GlobalWafers** entered the RF GaN IP landscape first in the mid-2010s, followed by others such as **VIS** and **Wavetek** in 2018. South Korean entities are not very active. **ETRI** continued to file few new inventions every year over the past decade. In 2016, **RFHIC** acquired GaN-on-Diamond-related patents from **Element Six**, then we observed the entry of **Wavice**, **U-Tel** and **Wavepia** more recently.

IP leadership of patent applicants

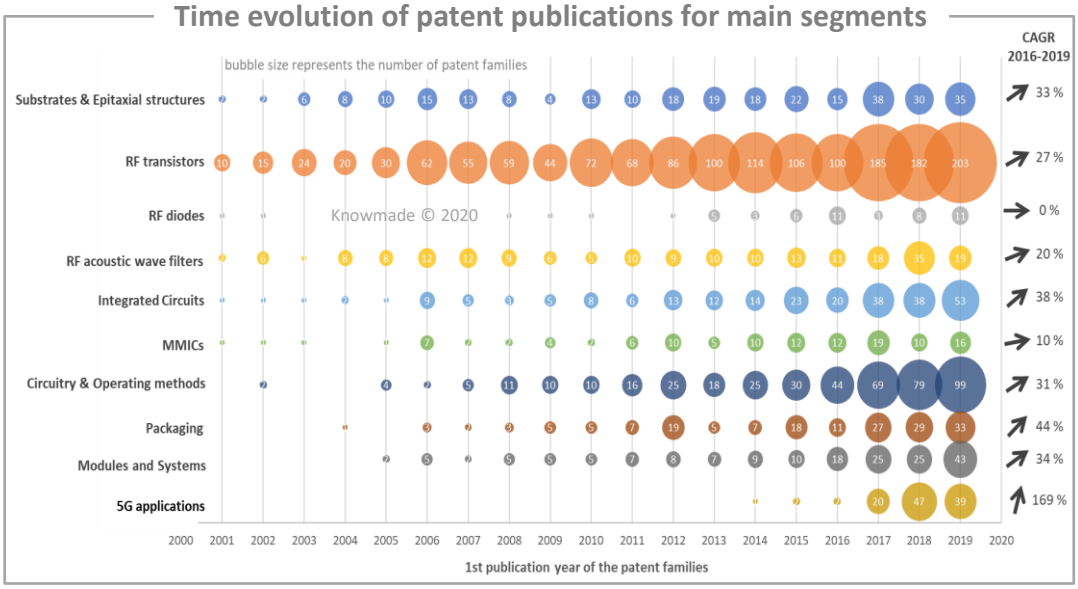


Strategic and technological paths followed by leading companies and newcomers for RF GaN technologies

This report provides the main **IP dynamics** of the RF GaN field and offers a **complementary vision** of the **RF GaN competitive landscape** through patenting activity. In this report, we give deep insights on the **IP portfolios and strategies** of **key RF GaN players** and **newcomers**. We analyze their **patented technologies**, **IP strength**, markets of interest and future intents, and we highlight the **strategic and technological paths** they are following for RF GaN technologies.

In this 2020 edition, we detail the **IP landscape** and **recent patents** of note related to **GaN-on-SiC**, **GaN-on-Silicon**, **GaN-on-Diamond** and **GaN-on-Sapphire**. We analyze and describe the IP activity related to **RF transistors** (HEMT, HBT, E-mode, etc.), **RF diodes** (varactor, RTD, IMPATT, etc.) and **RF acoustic wave devices** (SAW, TC-SAW, FBAR, BAW-SMR). Furthermore, the report includes a section dedicated to GaN-based **MMIC**-related patents. Overall, we highlight patents dealing with **manufacturing and technology issues** still of interest to IP players (heat dissipation, monolithic integration, linearity, impedance matching, etc.), and/or targeting **MW/mmWave** frequency ranges or **5G applications**.

Time evolution of patent publications for main segments



Useful Excel database

This report also includes an extensive **Excel database with the 3,000+ patent families** analyzed in this study. This useful patent database **allows for multi-criteria searches** and includes patent publication numbers, hyperlinks to the original documents, priority date, title, abstract, assignees, current legal status and **technological and application segments** (epitaxial structures, RF transistors, RF diodes, RF acoustic wave devices, MMIC, GaN-on-SiC, GaN-on-Si, GaN-on-Diamond, PA, RF switch, RF filter, Microwaves, mm-waves, 5G, etc.).

COMPANIES MENTIONED IN THE REPORT (NON-EXHAUSTIVE)

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Nicolas 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), Strasbourg, France.

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ABOUT KNOWMADE

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.

Knowmade's analysts combine their strong technology expertise and in-depth knowledge of patents with powerful analytics tools and methodologies to turn patents and scientific information into business-oriented report for decision makers working in R&D, Innovation Strategy, Intellectual Property, and Marketing. Our 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 watch service.

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