

GaN-on-Silicon

Patent Landscape Analysis – January 2020

GaN-on-Silicon activity is now driven by micro-LED, GaN Power and GaN RF applications. Who is leading the IP competition in these different areas? Who are the emerging players?



REPORT OUTLINE

- GaN-on-Silicon
- Patent Landscape Analysis
- January 2020
- Reference: KM20001
- PDF >200 slides
- Excel file >2,800 patents
- €6,490 for a multi-user license

KEY FEATURES

- **IP trends**, including time-evolution of published patents, countries of patent filings, etc.
- **Patent segmentation per application**: Optoelectronics and Photonics, Power, RF, PV and Sensors
- Ranking of **main patent assignees**
- **Key players' IP position and relative strength** of their patent portfolios
- **Established players and new entrants**
- IP profile of **key players**, their **key patents** and their **recent IP activity**
- Patents recently **expired** and patents **near expiration date**
- **Excel database** containing all patents analyzed in the report, including technology and application segmentations

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- [GaN-on-Si HEMT vs Superjunction MOSFET Comparison 2019](#)
- [Macom NPA1008 RF Power Amplifier with GaN-on-Si HEMT](#)
- [200V EPC2112 eGaN® HEMT with Monolithic Optimized Gate Driver](#)

GaN-on-Si intellectual property (IP): Historical players step back, leading to a substantial reconfiguration of the patent landscape.

The 2015-2020 period has shown tremendous and decisive changes regarding the strategy of players in the GaN-on-Si landscape, beginning with **Toshiba's** withdrawal from the white LED market and the acquisition of **International Rectifier (IR)** by **Infineon** in 2015. At that time, **Toshiba** and **IR** were already leading the GaN-on-Si patent landscape, while several historical IP players including **Panasonic**, **Sanken Electric** and **Toyoda Gosei** had already slowed down their patenting activity in the field. Furthermore, after **IR**, **Transphorm**, **Panasonic** and **GaNSystems** started sampling and commercializing their first GaN-on-Si power devices in 2010-2015, a second wave of companies has entered the playground in the last few years, including **ON Semiconductor**, **Dialog**, **Navitas**, **VisiC**. More companies, such as **STMicroelectronics**, are expected soon, demonstrating the growing interest for GaN-on-Si technology from players in the power electronics business.

In this report, Knowmade has thoroughly investigated the **patent landscape related to GaN-on-Si based optoelectronics and photonics, power electronics, radio frequency (RF) electronics, sensors and photovoltaics (PV)** covering the whole GaN-on-Si supply chain. Today, interestingly, the GaN-on-Si patent landscape exhibits strategies differing substantially between the numerous IP players currently aiming at consolidating their IP position.

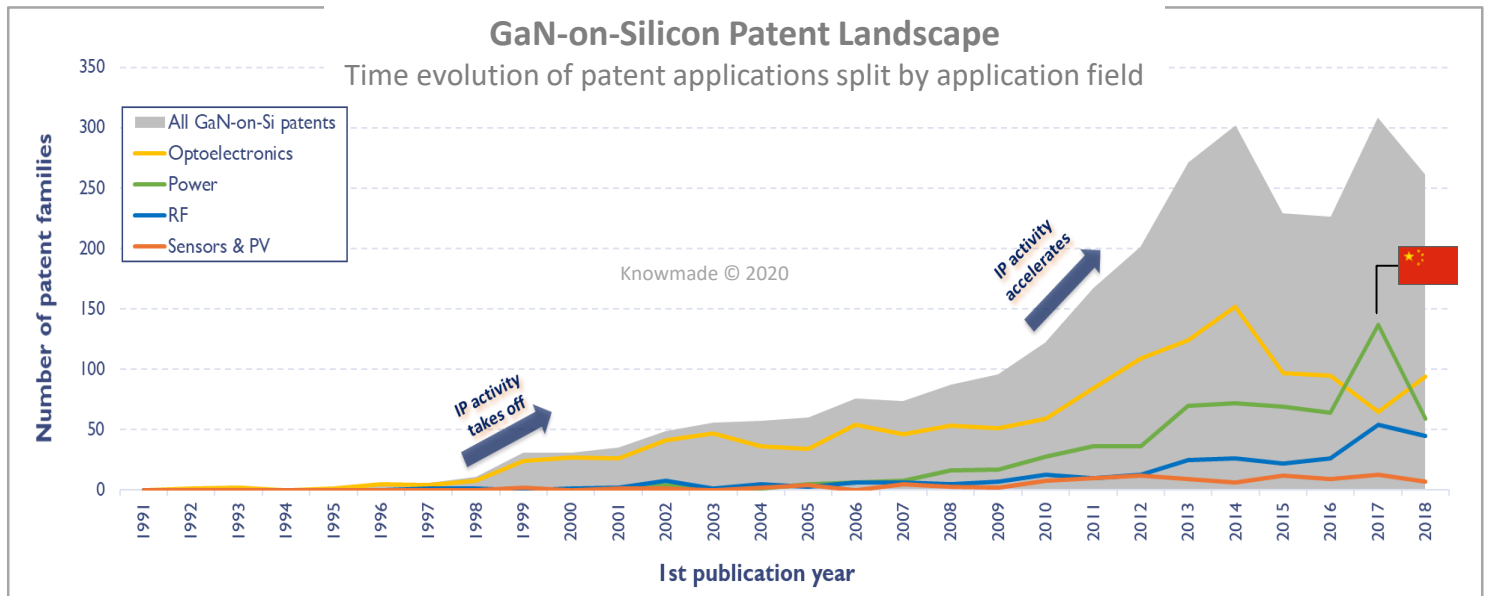
GaN-on-Silicon Patent Landscape

Key IP players for Optoelectronics, Power and RF applications

	Optoelectronics & Photonics	Power Electronics	RF Electronics
Key IP players with lower patenting activity			
Key IP players still active			
IP new entrants			

Optoelectronics and Photonics: Emerging applications driving IP activity

Starting in the late 1990s, GaN-on-Si patenting activity was driven by **LED applications**. The competition for GaN-on-Si LED intellectual property used to be a very Japanese affair, until the late 2000s when US players like **Bridgelux** and **Micron Technology** and Chinese players like **Lattice Power** emerged. At the same time, Japanese IP leaders sharply decreased their IP activity in the field, even shrinking the size of their portfolios, except for **Toshiba**, who remarkably accelerated patent filings in 2010-2015, while acquiring **Bridgelux**-related assets in 2013. Since **Toshiba** eventually stepped back from LEDs in 2015, the main IP players remaining active in the field are **Samsung**, **Osram** and a new entrant, **Zhongtuo Optoelectronics**. However, patenting activity is now powered by a new range of applications, related to displays, which involves micro-LEDs, including nanowire-based technologies, and smart lighting, moving towards a More than Moore market.



Power Electronics: US and European IP leaders backed by patent portfolios of Japanese historical players

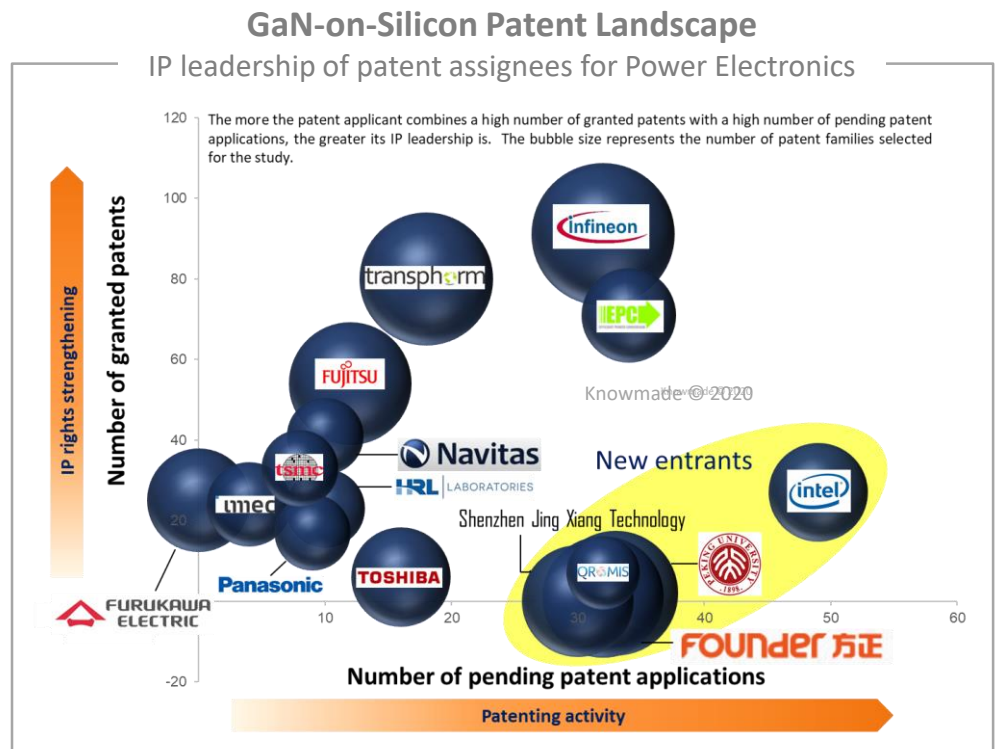
Infineon made a giant step in the GaN-on-Si landscape by acquiring **IR** in 2015 but had to consolidate the move by licensing **Panasonic’s** patented HD-GIT technology and by further strengthening its own portfolio as attested by significant IP activity since then. The next IP leader behind **Infineon** is **Transphorm**, which has taken several shortcuts as well, by establishing strong partnerships, including IP transfers, with **Fujitsu** and **Furukawa Electric** in 2010-2015. Likewise, multiple startups were established to develop GaN power technology based on GaN-on-Si, backed by academic and established industrial IP players in the patent landscape, such as **Qromis**, **Navitas**, **EpiGaN** and **ExaGaN**.

Patenting activity in the field of power electronics remarkably peaked in 2017, due to the entry of several Chinese new entrants in the patent landscape, including **FMIC**, **Innoscence**, **Peking University**, **Shenzhen Jing Xiang Technologies** and **South China University of Technology**, focusing on different aspects of GaN-on-Si technology, and filing patents in China mainly.

RF electronics: Macom and Intel have taken the lead on GaN-on-Si RF technology

There is a large discrepancy between the RF GaN-on-Si patent landscape and the overall RF GaN patent landscape, described in our report [“RF GaN Patent Landscape Analysis 2019”](#). **Macom**, which managed to keep IP rights on part of **IR’s** GaN-on-Si portfolio after its acquisition by **Infineon**, is the main player continuing the development of RF GaN-on-Si technology. **Fujitsu**, an historical GaN-on-Si IP player, has strongly reduced its related IP activity.

The next leading patent applicant in the field is **Intel**, which is particularly interested in novel approaches towards monolithic integration with Si CMOS for RF electronics for More-than-Moore systems-on-chips.



Useful Excel patent database

This report also includes an **Excel database with the over 2,800 patents and patent applications** 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, patent assignees, patent’s current legal status, and technological and application segments.

Companies mentioned in the report (non-exhaustive)

Toshiba, Sharp, Panasonic, Sanken Electric, Infineon/International Rectifier, Intel, Samsung, University Beijing, Transphorm, Fujitsu, Lattice Power, FMIC - Founder Microelectronics, imec, South China University of Technology, Toyoda Gosei, cea - French Alternatives Energies And Atomic Energy Commission, Furukawa Electric, Macom/Nitronex, IQE, 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, Fuji Electric, LG Innotek, Coorstek, Qromis, glo, Institute of Semiconductors (CAS), Corning, Sumitomo Electric, HRL Laboratories, EPC - Efficient Power Conversion, MIT - Massachusetts Institute of Technology, Allos Semiconductors, Nagoya Institute of Technology, Navitas Semiconductor, NGK Insulators, NTT - Nippon Telegraph & Telephone, Micron Technology, Hitachi, Toyota Central R&D Labs, STmicroelectronics, SK Siltron, Enkris Semiconductor, Shin-Etsu, Bridgelux, Rohm, Epistar, Oki Electric Industry, Tsing Hua University, ITRI - Industrial Technology Research Institute, Samsung Electro Mechanics, CNRS - French National Research Center, Exagan, IBM, ETRI - Electronics & Telecommunications Research Institute, VisIC Technologies, Mitsubishi Electric, Renesas Electronics, Texas Instruments, Nanchang University, HiWafer, Sino Nitride Semiconductor, National Sun Yat Sen University, Soitec/EpiGaN.

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