

# 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

### RELATED REPORTS 2019

#### FROM KNOWMADE

- [Power GaN - Patent Landscape 2019](#)
- [RF GaN - Patent Landscape 2019](#)
- [GaN Power & RF - Patent Monitor](#)

#### FROM YOLE DEVELOPPEMENT

- [Power GaN 2019: Epitaxy, Devices, Applications & Technology Trends](#)
- [RF GaN Market 2019: Applications, Players, Technology and Substrates](#)

#### FROM SYSTEM PLUS

- [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.

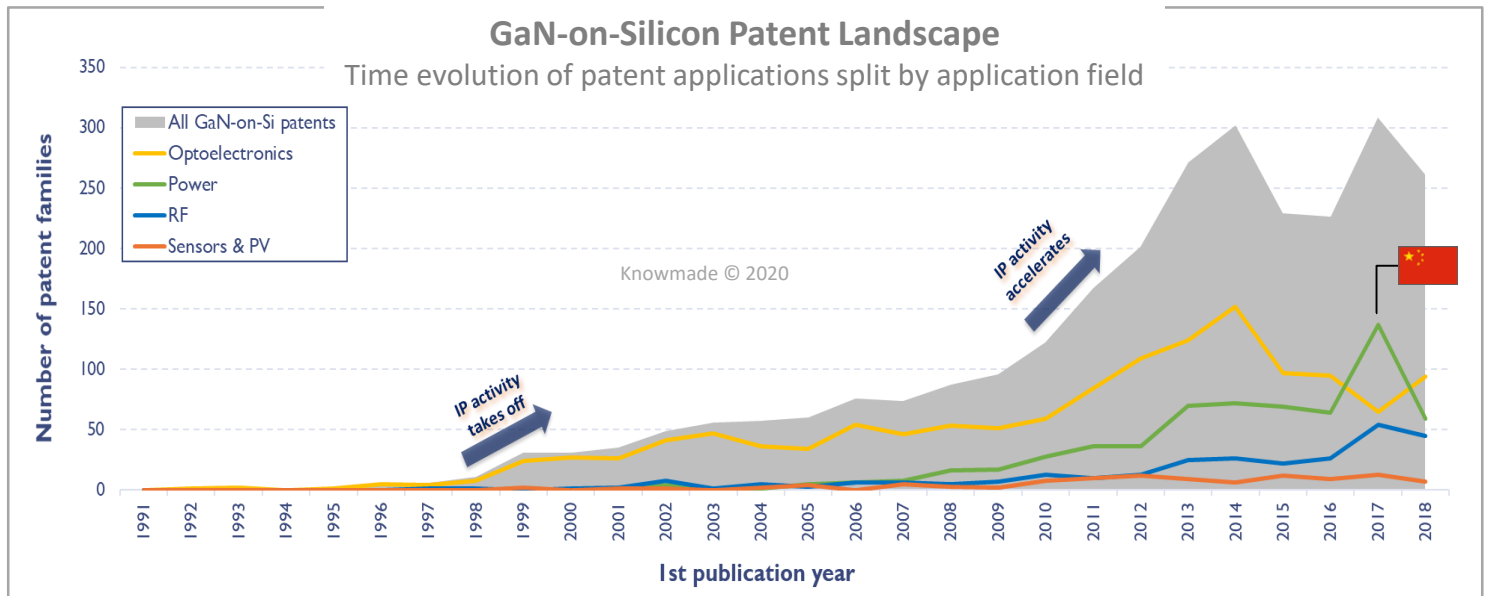
### GaN-on-Silicon Patent Landscape

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**

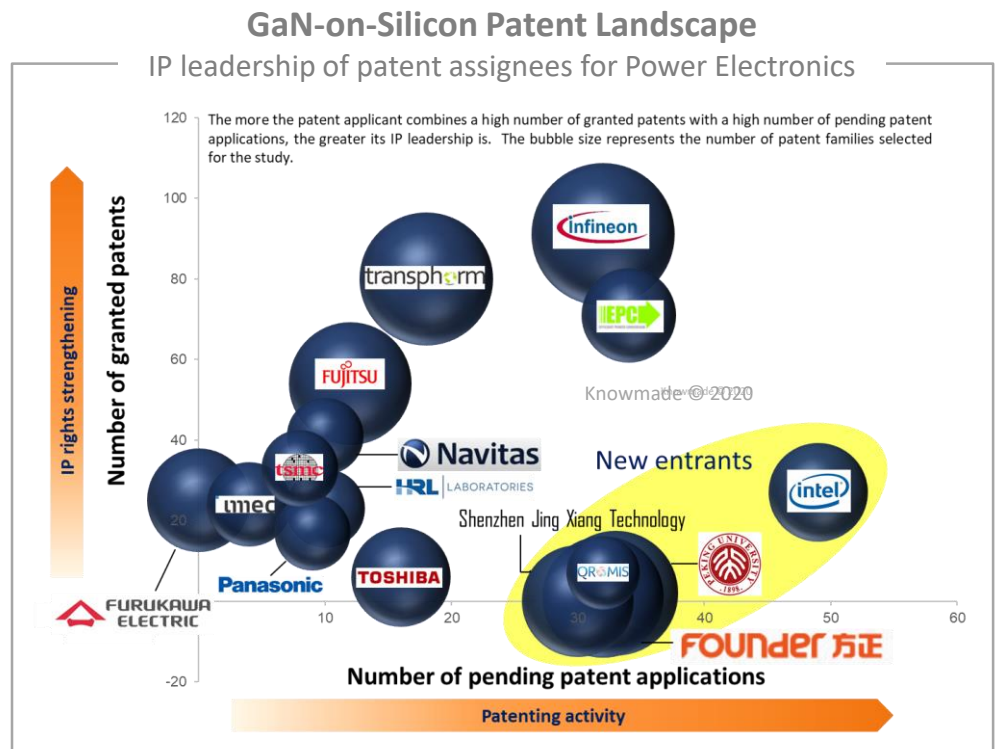
**Infineon** made a giant step in the GaN-on-Si landscape by acquiring **IR** in 2015 but had to consolidate the move by licensing **Panasonic’s** patented HD-GIT technology and by further strengthening its own portfolio as attested by significant IP activity since then. The next IP leader behind **Infineon** 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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**ABOUT KNOWMADE**

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**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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