

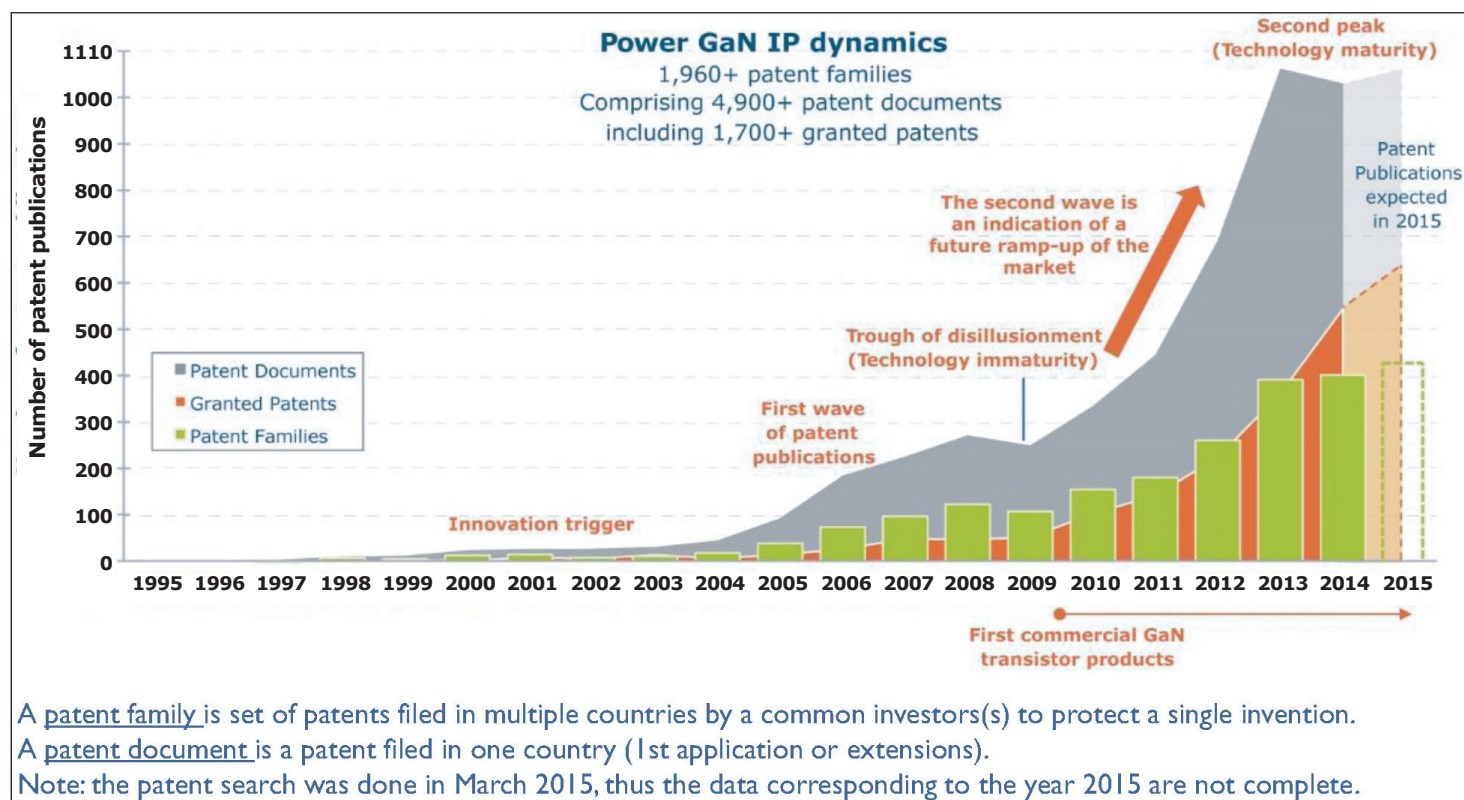
# Power GaN device IP dynamics heralds future ramp-up of market

Market forecasted to grow at a CAGR of 93% to \$300m in 2020.

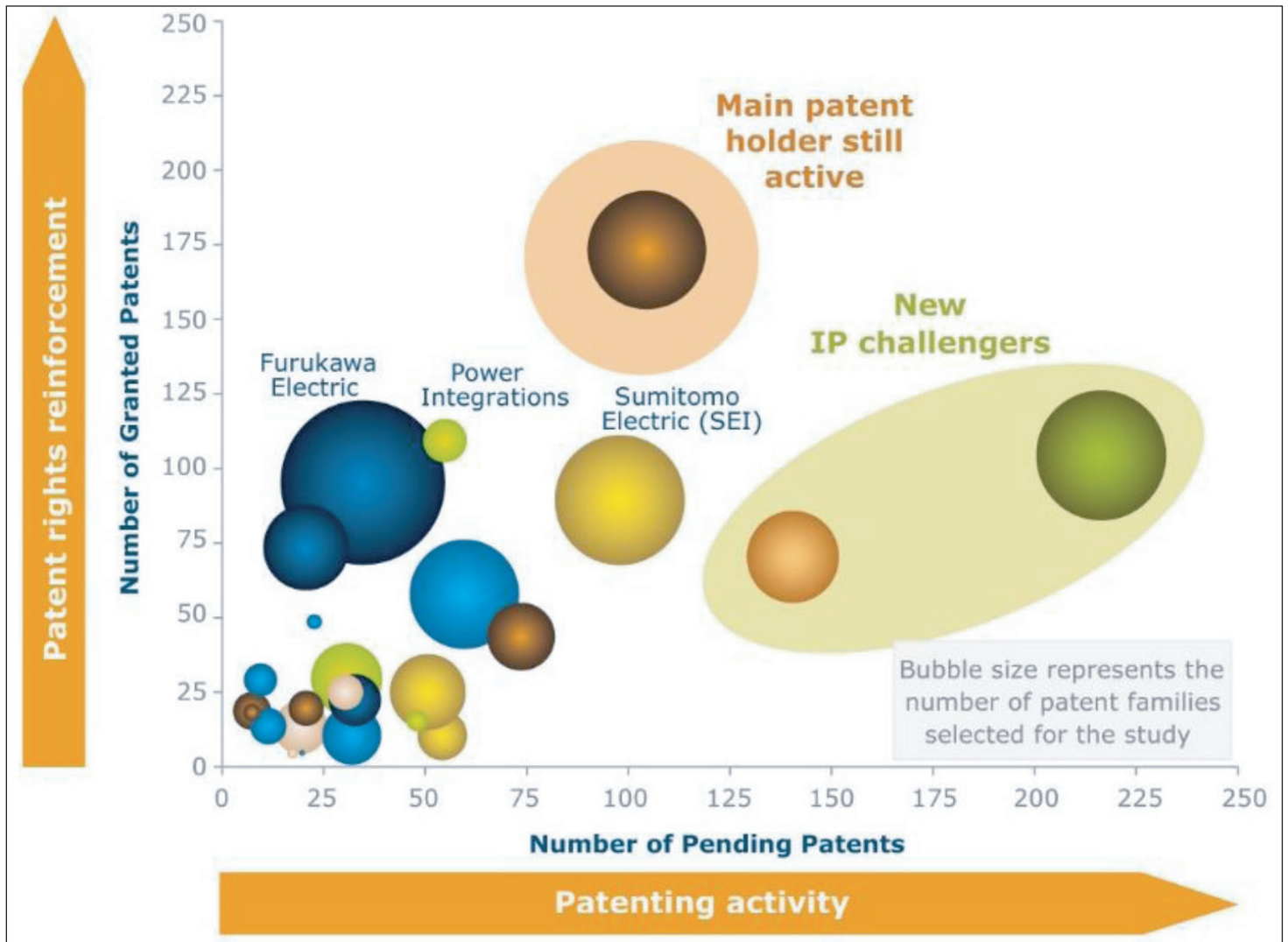
There are currently only a few players selling power GaN products (e.g. Infineon/IR, EPC, GaN Systems, Transphorm) and the market is still small, estimated to be \$10m in 2015 in the report 'GaN and SiC devices for power electronics applications' from Yole Développement. However, the potential energy efficiency savings from the adoption of GaN power semiconductor devices has led to significant research and development that is now beginning to be realized in commercially available devices, and the device market will ramp up from 2016 at a compound annual growth rate (CAGR) of 93% to more than \$300m in 2020 in the baseline 'nominal' scenario, forecasts the market research firm.

In preparation for this significant growth, the gallium nitride power industry is consolidating, and GaN technology is spreading across the value chain. This can be seen in recent mergers and acquisitions (e.g. Infineon/International Rectifier, Transphorm/Fujitsu's GaN Power Conversion business), license agreements (Infineon/Panasonic, Transphorm/Furukawa) and the will of several firms to move onto the mass-production stage (Transphorm/Fujitsu).

As GaN power devices are now poised for rapid market adoption, a strong intellectual property (IP) position is essential for companies to grow their GaN business, says KnowMade, partner of Yole Développement. In today's power GaN market, it is crucial to



Power GaN IP dynamics. (Source: 'GaN Devices for Power Electronics Patent Investigation, KnowMade, September 2015.)



**IP leadership of patent assignees for GaN devices. (Source: 'GaN Devices for Power Electronics Patent Investigation, KnowMade, September 2015.)**

understand the global patent landscape, enabling firms to anticipate changes, harvest business opportunities, mitigate risks and make strategic decisions to strengthen their market position and maximize the return on their IP portfolio, KnowMade adds.

Up to April 2015, more than 1960 patented inventions related to GaN power electronics have been published worldwide. The first patents were published in the mid-1990s by silicon power companies (Furukawa Electric, International Rectifier, Infineon etc). But the take-off of patenting activity was really observed ten years later with a first wave of patent publications over the 2005–2009 period, due mainly to US-based companies (International Rectifier, Power Integrations) and Japanese companies (Panasonic, Rohm, Furukawa Electric, Sumitomo Electric, Toshiba, Toyota). A second wave of patent publications began in 2010, originating mainly from Mitsubishi Electric, Fujitsu, Transphorm, Avogy and Infineon, while the first commercial products, collaborations, mergers and acquisitions emerged. Recently, LED pure-players like Seoul Semiconductor have entered the power GaN IP arena.

The time evolution of patent filings has reached a peak, and KnowMade expects a slowdown in new patent applications. Meanwhile, following successful prosecution of the many pending patent applications, granted patents worldwide should increase. KnowMade believes that the second peak of patent filings, combined with the significant ratio of patents in force and the large number of patent applications still in the pipeline worldwide, is an indication of the technology maturity heralding a future ramp-up of the GaN power market.

### Key players and new IP challenges

More than 200 patent applicants are involved in power GaN IP, estimates KnowMade. Most of the major silicon power players are present in the list of the top patent applicants, including International Rectifier/Infineon, Panasonic, Furukawa Electric, Sumitomo Electric, Fujitsu, Mitsubishi Electric, Toshiba, Sharp, Fuji Electric, Rohm and Power Integrations. This indicates strong interest from power players in the GaN business, KnowMade notes. So far, only IR/Infineon has commercialized GaN devices but, armed with strong IP,

	DEVICE				OPERATING			PACKAGING		
	D-mode (Normally-on)	E-mode (Normally-off)	Cascode (N-off circuit-based approach)	Vertical Device (CAVET)	Current Collapse	Dynamic R-on	Gate Charge (Miller effect)	Low Stray Inductance Package	Thermal Management (package, module)	Chip-Scale Package
GaN-on-XX	GaN-on-SiC	MITSUBISHI ELECTRIC power integrations	Panasonic transpherm	transpherm		transpherm			MITSUBISHI ELECTRIC	
	GaN-on-Si	MITSUBISHI ELECTRIC power integrations GaN Systems	FURUKAWA ELECTRIC IQR Infineon EPC FUJITSU Panasonic transpherm	IQR Infineon SHARP GaN Systems transpherm	IQR	FURUKAWA ELECTRIC Panasonic	IQR transpherm	IQR EPC Panasonic SHARP	IQR Infineon MITSUBISHI ELECTRIC	IQR GaN Systems
	GaN-on-Sapphire	power integrations ROHM								
	Bulk GaN			avogy SUMITOMO ELECTRIC						

Patent differentiation of key players for GaN power transistors. (Source: 'GaN Devices for Power Electronics Patent Investigation, KnowMade, September 2015.)

other traditional power players are able to disrupt and reshape the market, says the market research firm.

The report provides a ranking and analysis of the relative strength of the top patent holders derived from their portfolio size, patent citation networks, countries of patents filing and current legal status of patents. Yole reveals the IP strength of key power

GaN players and depict their competitive positioning.

It can be safely assumed that International Rectifier (IR) has the best patent portfolio in power GaN, and that the combined company IR/Infineon has the strongest IP, putting them in the position to lead GaN power market growth, reckons KnowMade. However, this IP leadership position could evolve in the future since newcomers like Transphorm, Fujitsu and Mitsubishi Electric are becoming major forces and may reshape the power GaN patent landscape, KnowMade adds.

Transphorm is the most important IP challenger in the power GaN arena (ahead of other GaN start-ups like EPC and GaN Systems). Its patent portfolio and partnerships with the likes of Furukawa, Fujitsu and On Semiconductor have put it in a strong position to take a leading role in the GaN device market, reckons KnowMade. Furukawa Electric has an ample IP portfolio with a significant 'blocking potential', but the company has not yet been able to commercialize the technology

**Power GaN IP is just beginning to be leveraged by companies to negotiate licensing and supply agreements such as those between Infineon and Panasonic and between Transphorm and Furukawa Electric**

on its own. By giving Transphorm exclusive licensing rights on its GaN patent portfolio, Furukawa Electric has found a strategic partner to bring its technology to market.

Fujitsu and Mitsubishi Electric have demonstrated an interest in power GaN technology since 2010 with a strong increase in their patenting activity these last three years, heralding substantial future IP portfolios.

### Patented technology and IP strategy

The 1960-plus patented inventions selected for KnowMade's study have been manually categorized by technology segment. The existing power GaN IP covers the whole of the value chain, from epitaxial wafers and power semiconductor devices to discrete components, power modules, packaging, circuits and systems. The dataset of patents has been organized into various technical challenges (E-mode, cascode, E/D-mode monolithic, vertical devices, current collapse, dynamic  $R_{on}$ , gate charge, breakdown voltage, stray inductance, thermal issues, chip-scale package) and type of substrate for GaN epitaxy (SiC, silicon, bulk, sapphire). A special focus is provided on power semiconductor devices (transistors and diodes at the semiconductor level) and power components (discrete components, power modules and packaging).

KnowMade says that power GaN IP is just beginning to be leveraged by companies to negotiate licensing and supply agreements such as those between Infineon and Panasonic and between Transphorm and Furukawa Electric. To date, no litigation cases related to the power GaN domain have been filed, but this should change as the market expands, expects KnowMade. ■

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