

POWER GaN

Patent Landscape Analysis

April 2023

PE International

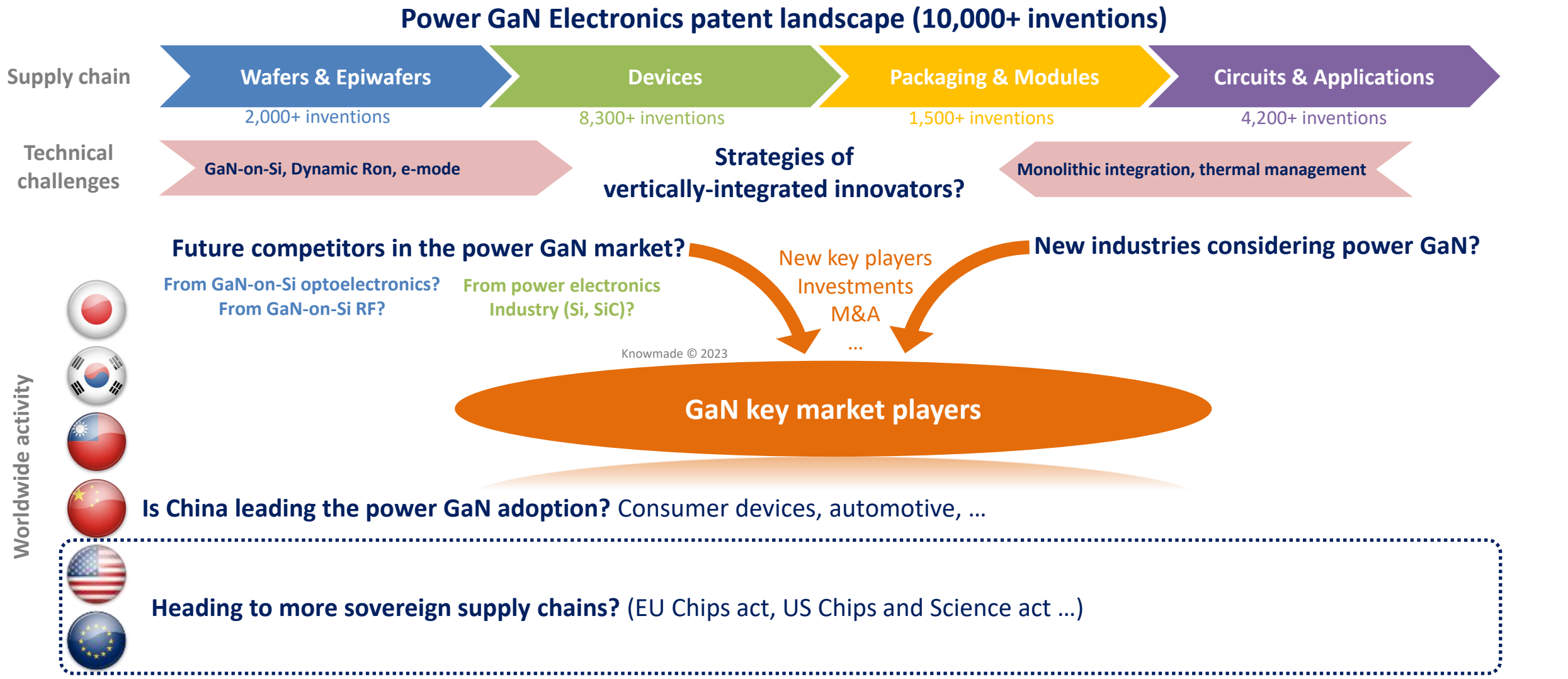
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POWER GaN PATENT LANDSCAPE

Patent investigation of the power GaN ecosystem

Use the patent information to anticipate and understand new competitions in the GaN industry (business, technology and IP)



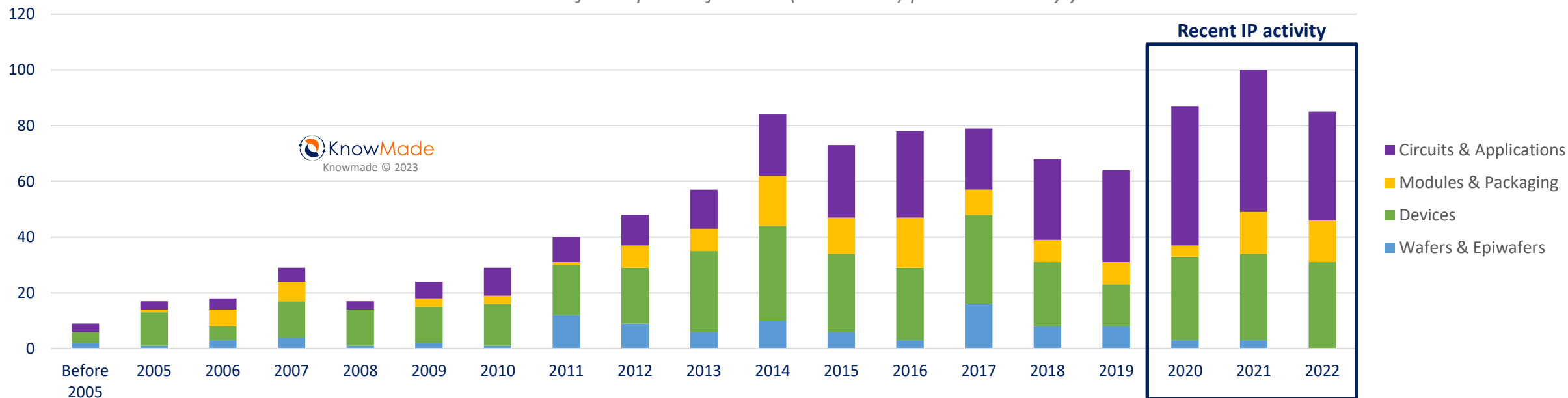
THE IP ACTIVITY OF EUROPEAN PLAYERS

Europe heading to a more sovereign supply chain?



IP activity of European IP players across the Power GaN supply chain

Number of new patent families (inventions) published every year



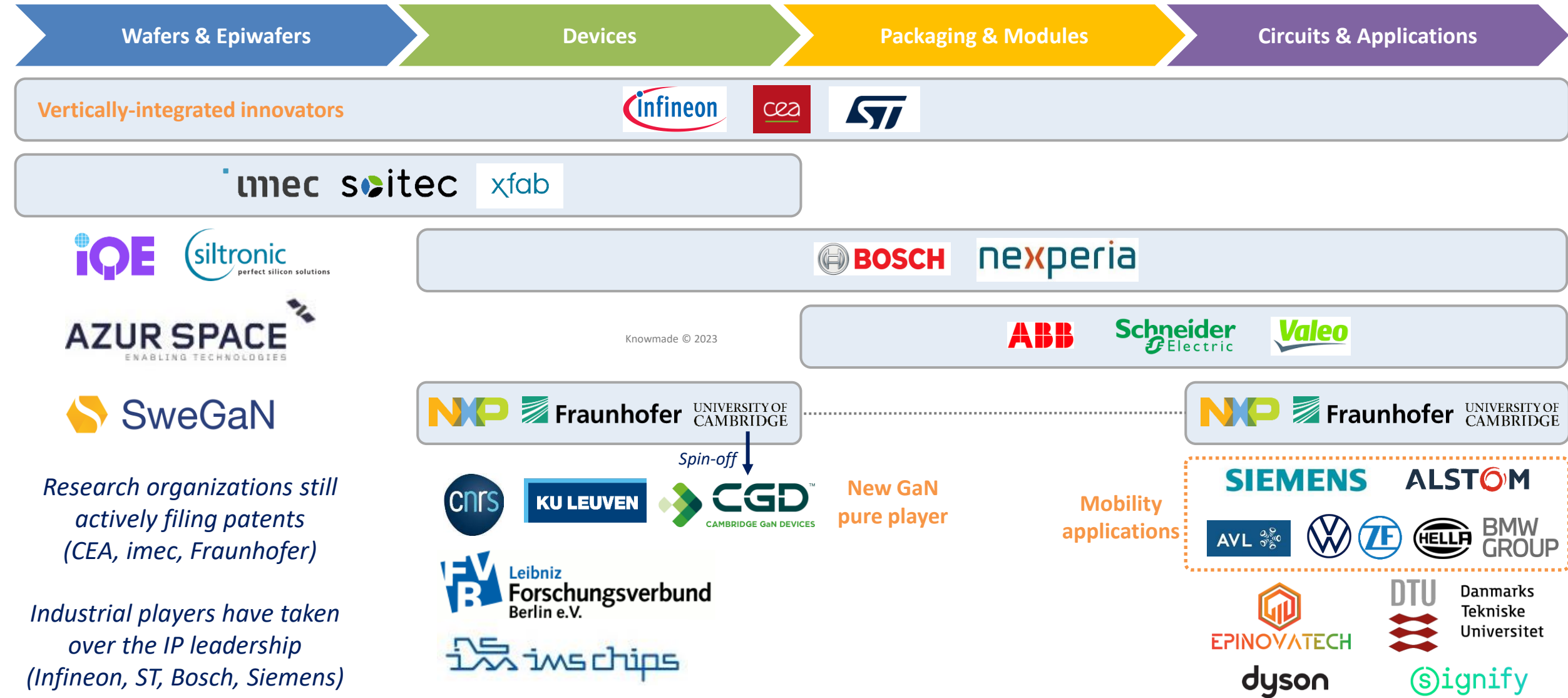
Overall, European players have been focusing their IP activities on the downstream supply chain

- European IP players have been focusing on Devices, Circuits & Applications
- The Circuits & Applications IP activity accelerated in 2019/2020
- The Wafers & Epiwafers IP activity is slowing down steadily
- The Modules & Packaging IP activity is strengthening

A PATENT PERSPECTIVE ON EUROPEAN POWER GAN SUPPLY CHAIN



Europe heading to a more sovereign supply chain?

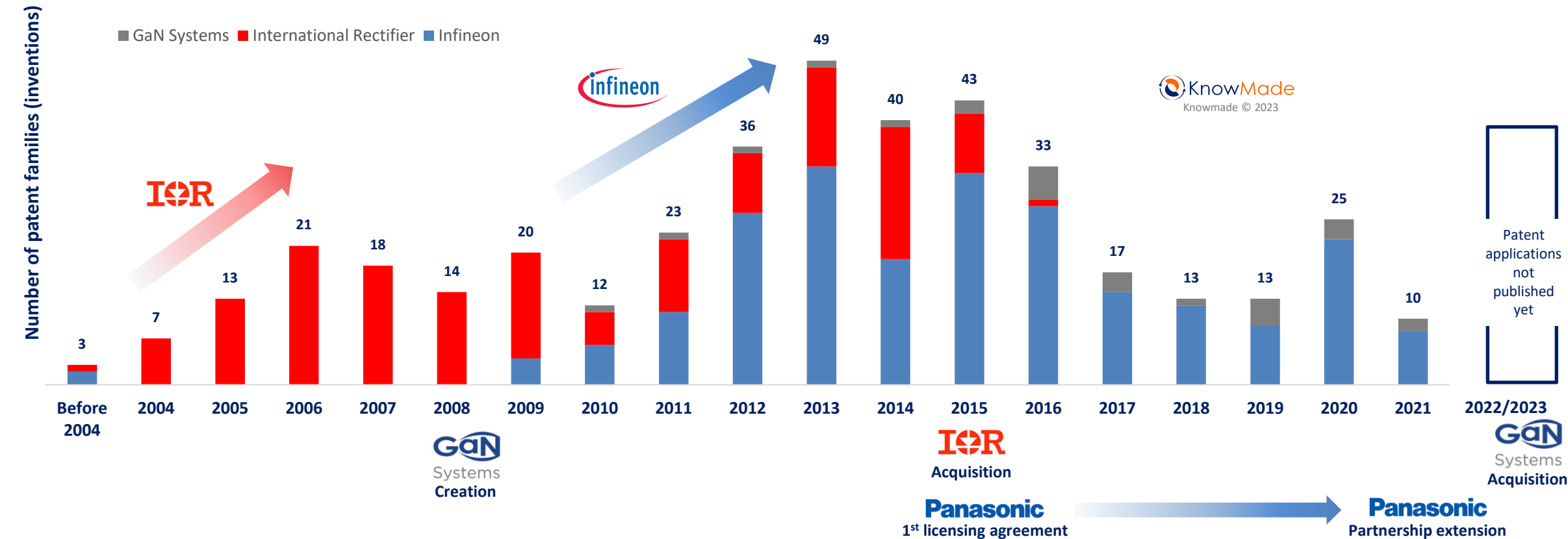


INFINEON INVESTMENTS IN POWER GAN SUPPLY CHAIN



A patent look at the acquisitions and partnerships

Timeline of new patent applications filed by Infineon, International Rectifier & GaN Systems



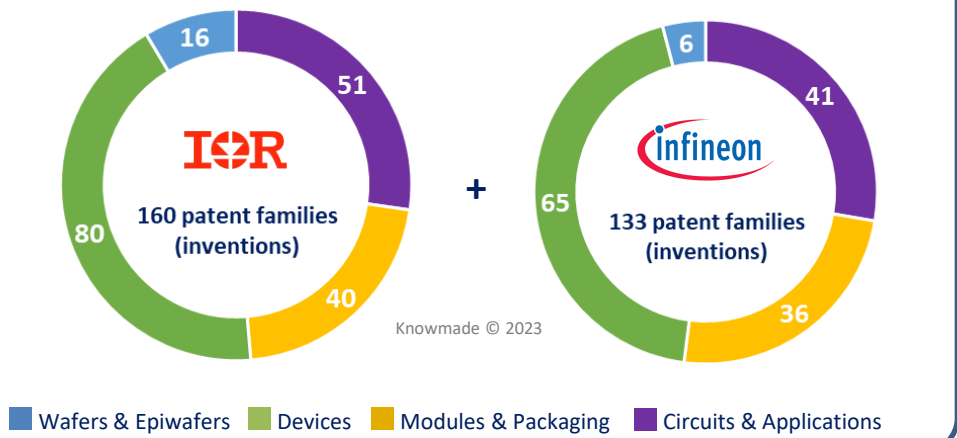
How does this strategy impact Infineon's patent portfolio?

INFINEON INVESTMENTS IN POWER GAN SUPPLY CHAIN

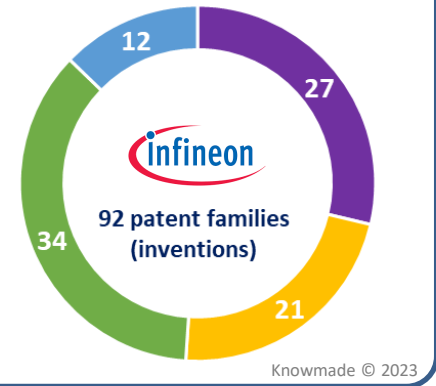


How does this strategy impact Infineon's IP position?

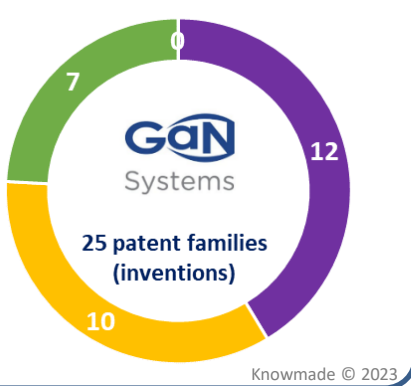
Infineon's and IR's power GaN patent portfolios *before the acquisition*



Reinforcement of Infineon's power GaN patent portfolio *after the acquisition*

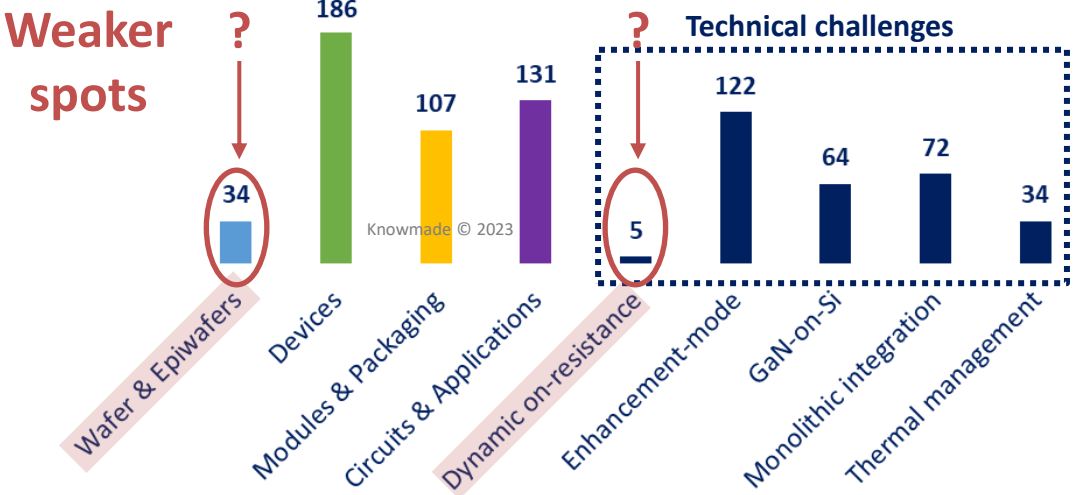


GaN Systems' power GaN patent portfolio



Technology breakdown of the patent portfolio

Number of patent families per category



Geographical breakdown of the patent portfolio

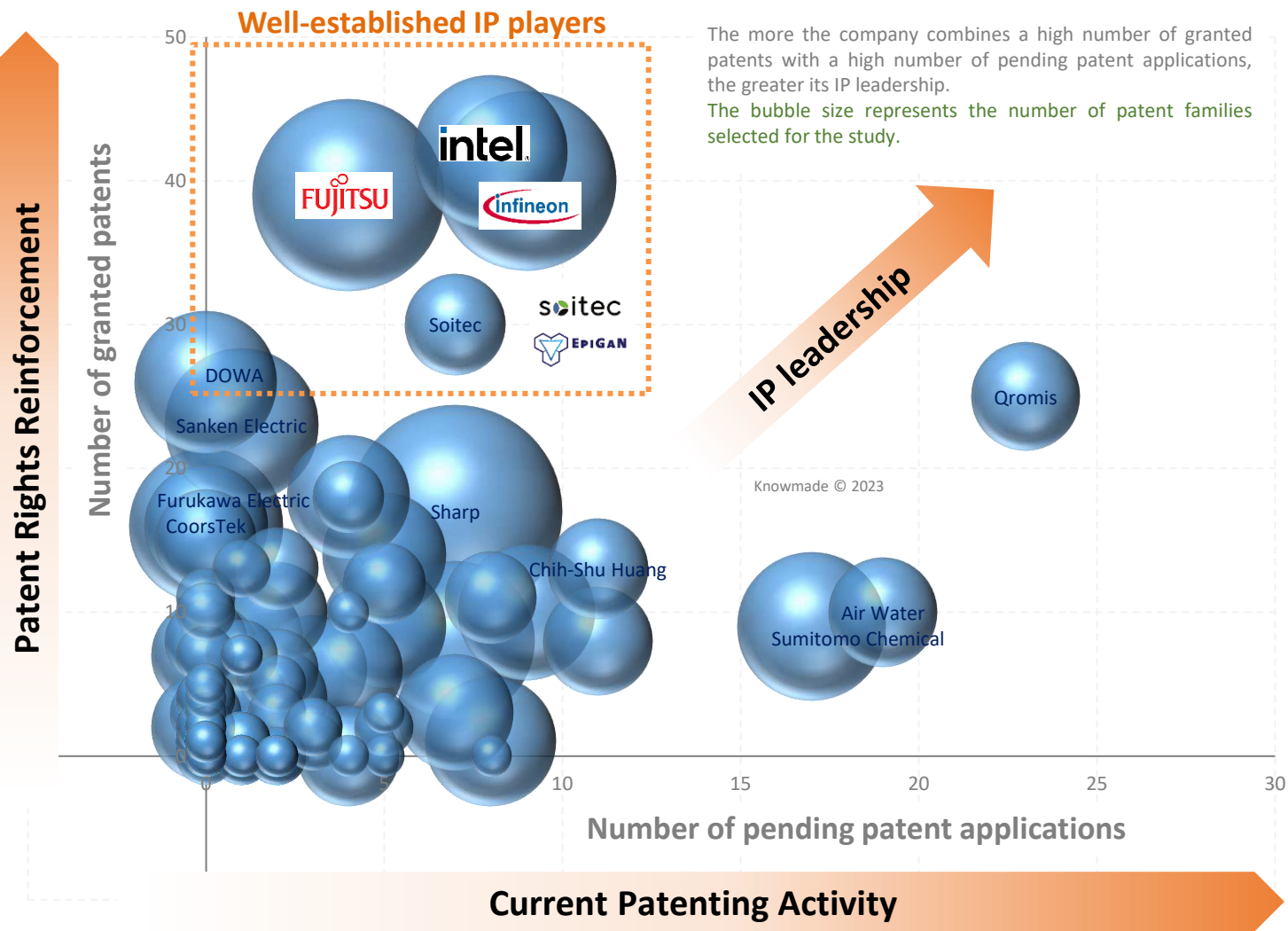
Number of patents and pending applications per country



GAN-ON-SI EPIWAFERS

Is the IP competition over?

GaN-on-Si epiwafers technical challenge



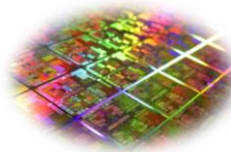
Infineon stands out as an IP leader for GaN-on-Si epiwafers (high number of granted patents)

The IP competition related to GaN-on-Si is slowing down:

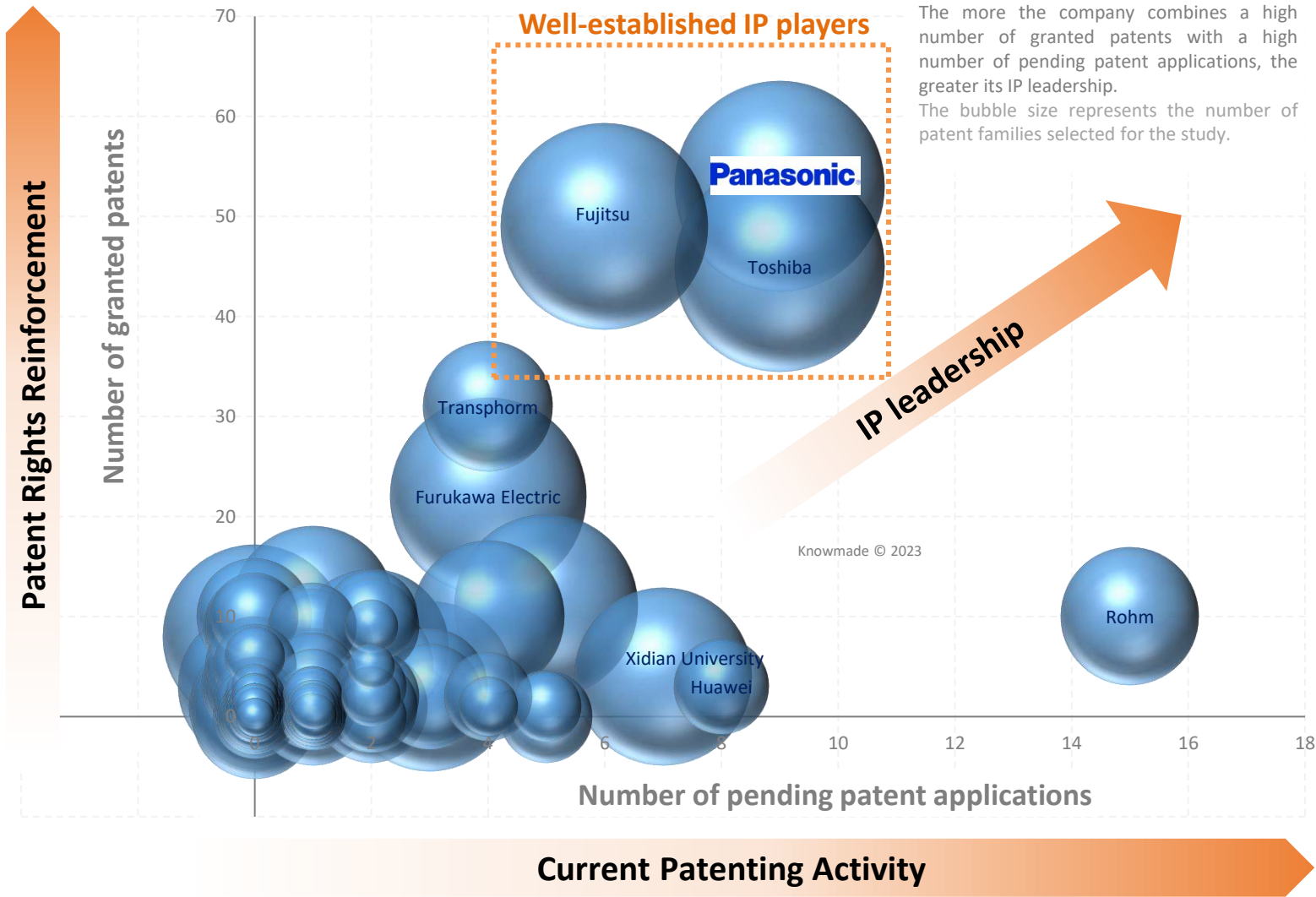
- Few stand-out well-established IP leaders
- No IP leader on conventional GaN-on-Si epiwafers
- Few IP challengers

DYNAMIC ON-RESISTANCE

Panasonic's leadership to benefit to Infineon's IP strategy?



Dynamic on-resistance technical challenge

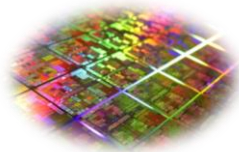


Panasonic leads the IP activity related to dynamic on-resistance of Power GaN devices

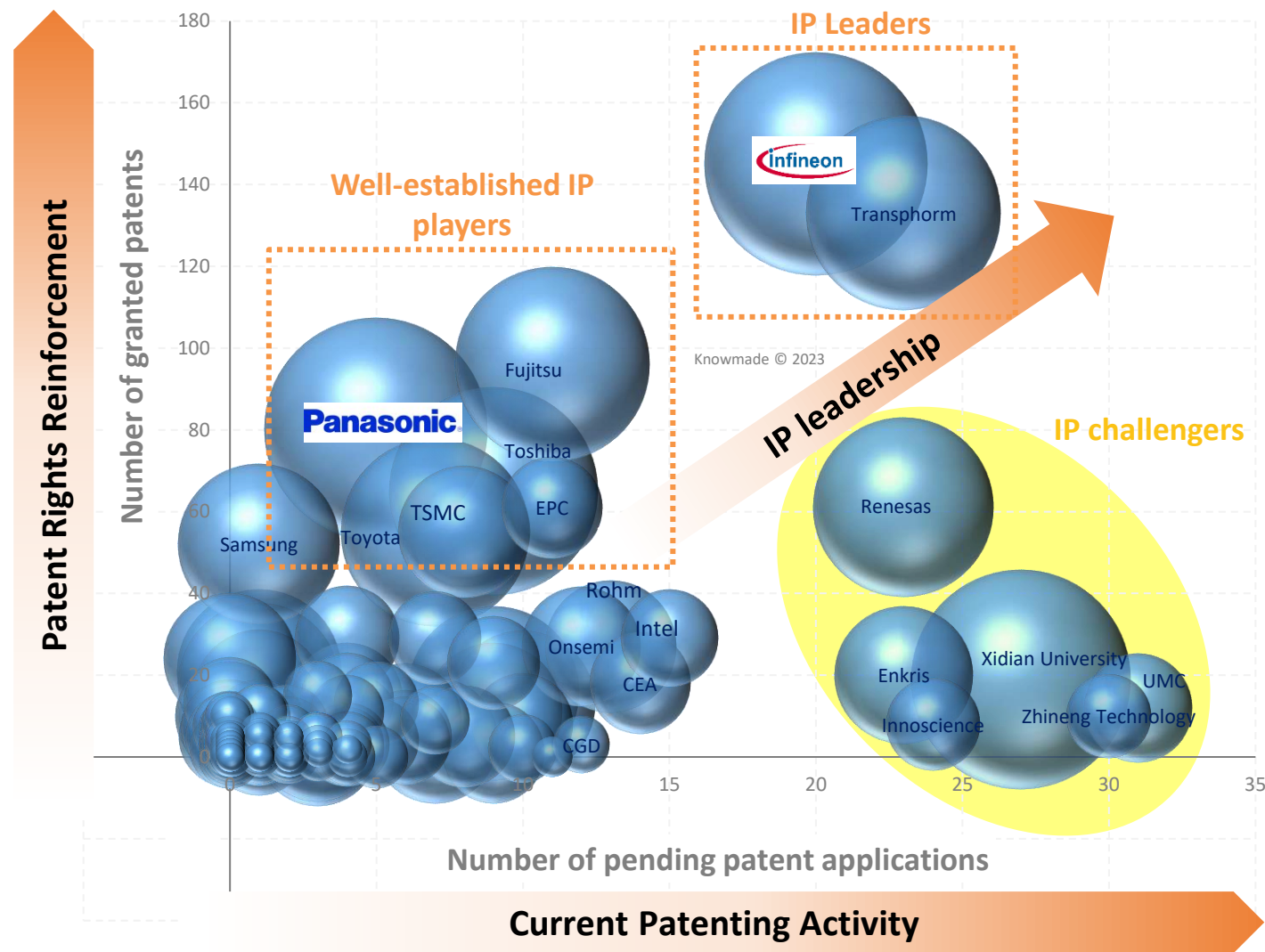
From a patent perspective, the deal with Panasonic also strengthens Infineon's IP position related to dynamic Ron solutions

E-MODE DEVICES

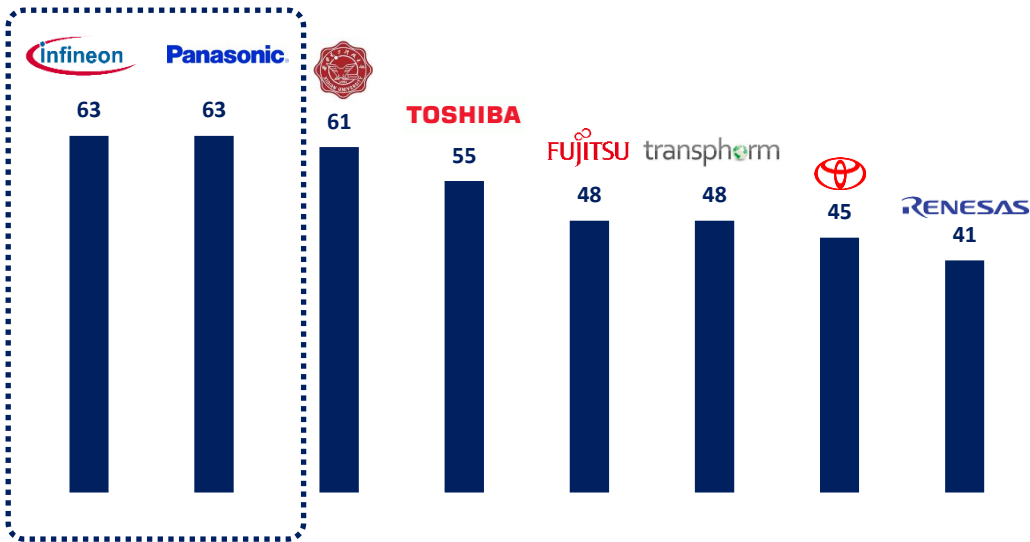
Where is the current competition for Power GaN IP?



e-mode GaN technical challenge



Main innovators for e-mode GaN devices
Number of patent families



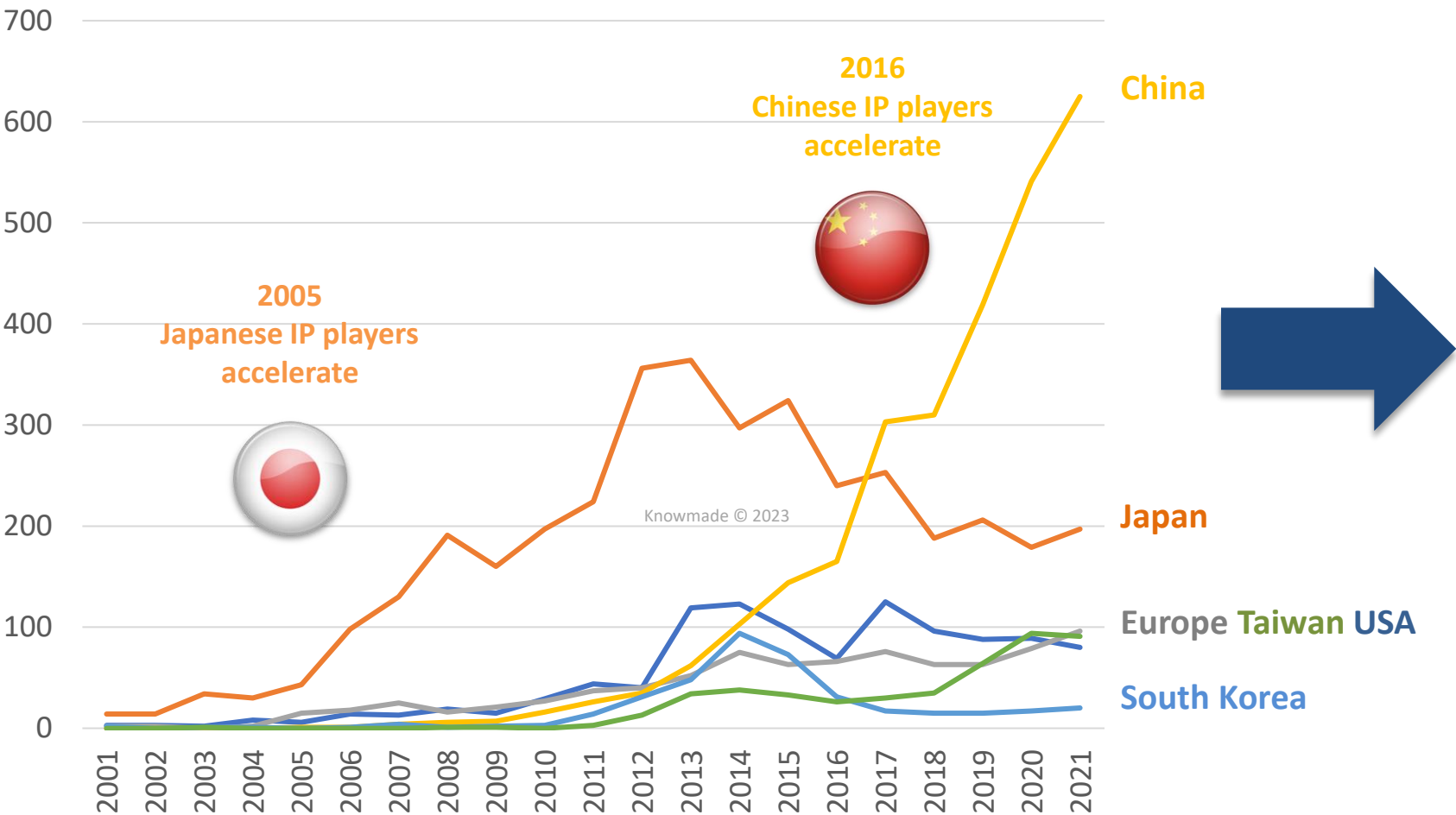
Infineon and Panasonic stand out as top innovators for e-mode GaN devices
(number of inventions)

CHINA IN THE POWER GAN IP LANDSCAPE

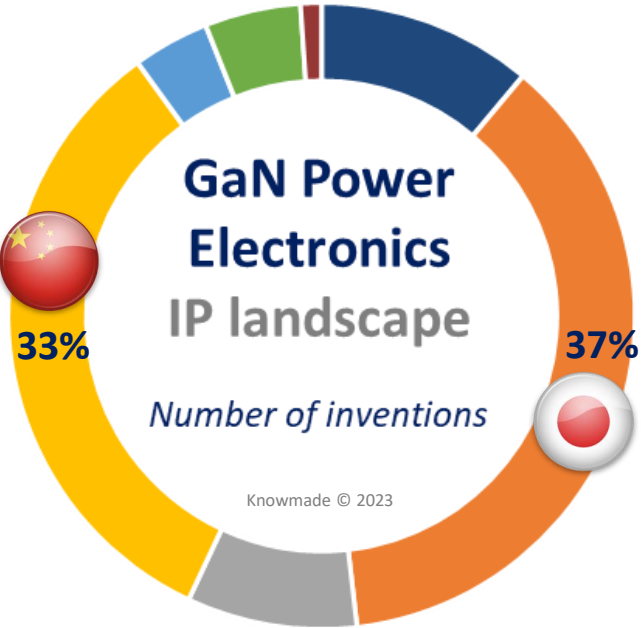
Is China leading the power GaN adoption?



GaN Power Electronics: Time evolution of the patenting activity by company headquarters



Chinese IP players are catching up in terms of patenting activity



But how close is China to close the gap with the well-established countries?

A PATENT PERSPECTIVE ON THE POWER GAN SUPPLY CHAIN IN CHINA



Who are the main players driving the emergence of a domestic supply chain?



CHINESE IP ACTIVITY OVERSEAS

Chinese players with international ambitions



Chinese players focus on the US territory



The main Chinese players active abroad are Innoscience, Huawei and Enkris Semiconductor



How does Innoscence’s IP activities support its strategy in the Power GaN competition?

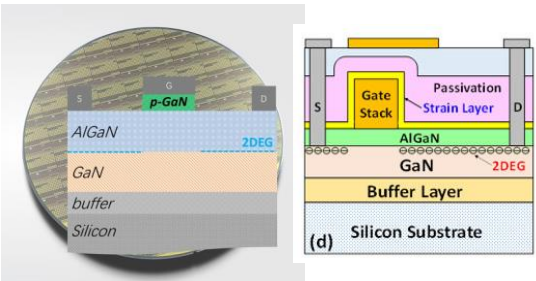
PRODUCTS

IP ACTIVITY

Wafers & Epiwafers

2015-2020

Innoscence R&D activities covering 8-inch GaN-on-Si epitaxy and e-mode GaN HEMT processing



Devices

2021-2023

Innoscence released and extended its InnoGaN series products (discrete devices)

30V-150V - Low & Medium Voltage InnoGaN™



650V - High Voltage InnoGaN™

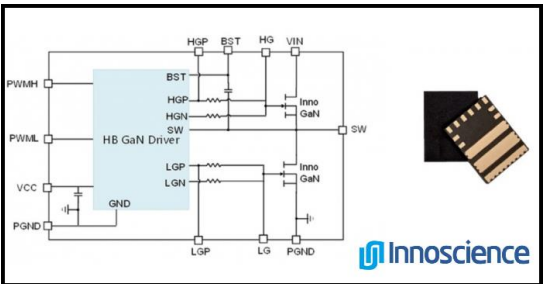


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Circuits & Applications

2023

Innoscence SolidGaN chip (half-bridge circuit + driver circuitry)



Innoscence published its **first patent** applications in **2017**, focusing on **wafers and epiwafers**

Limited number of inventions related to **devices** until **2019**

The IP activity related to **devices** took off in **2020** and accelerated in 2021/2022

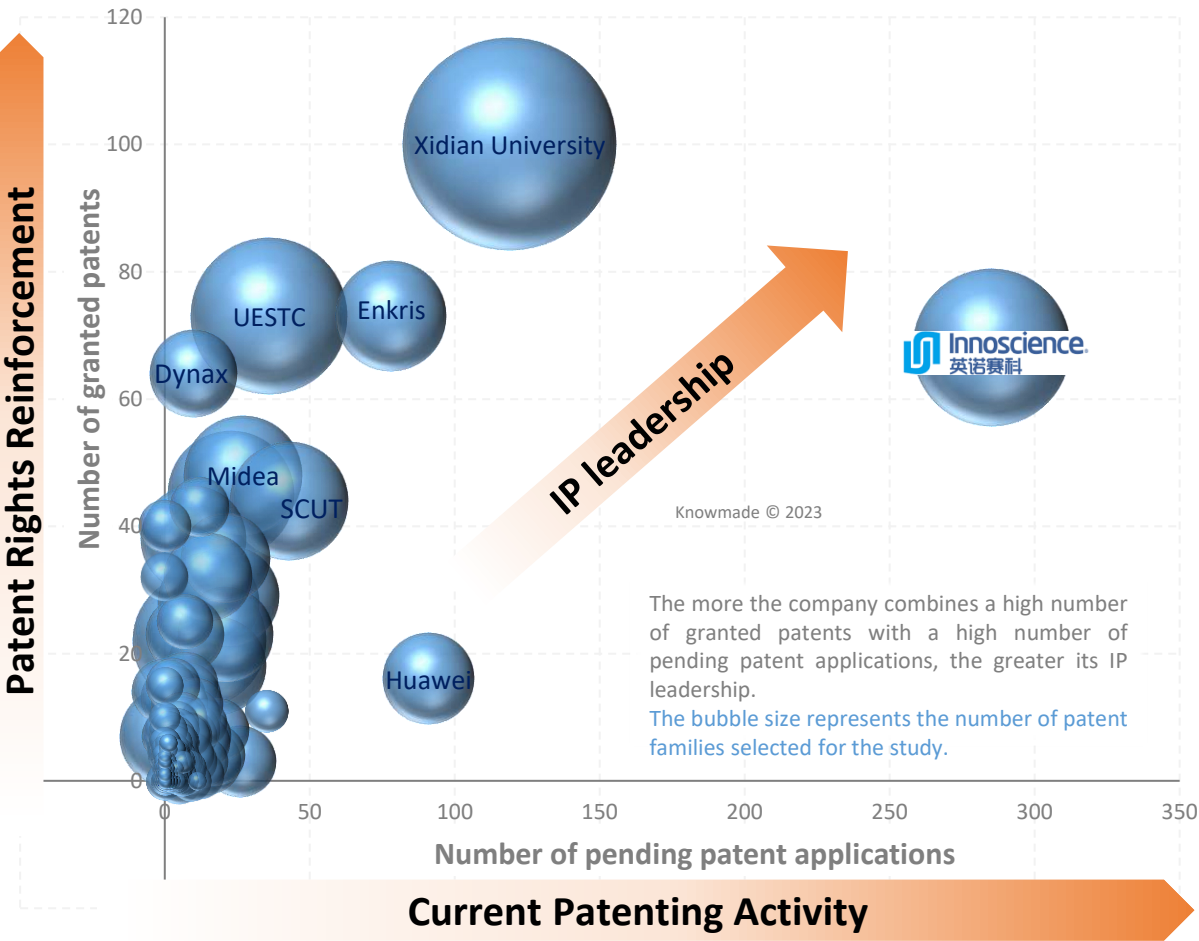
Since **2020**, Innoscence has been expanding its IP activities to the **downstream supply chain**

INNOSCIENCE IP LEADERSHIP

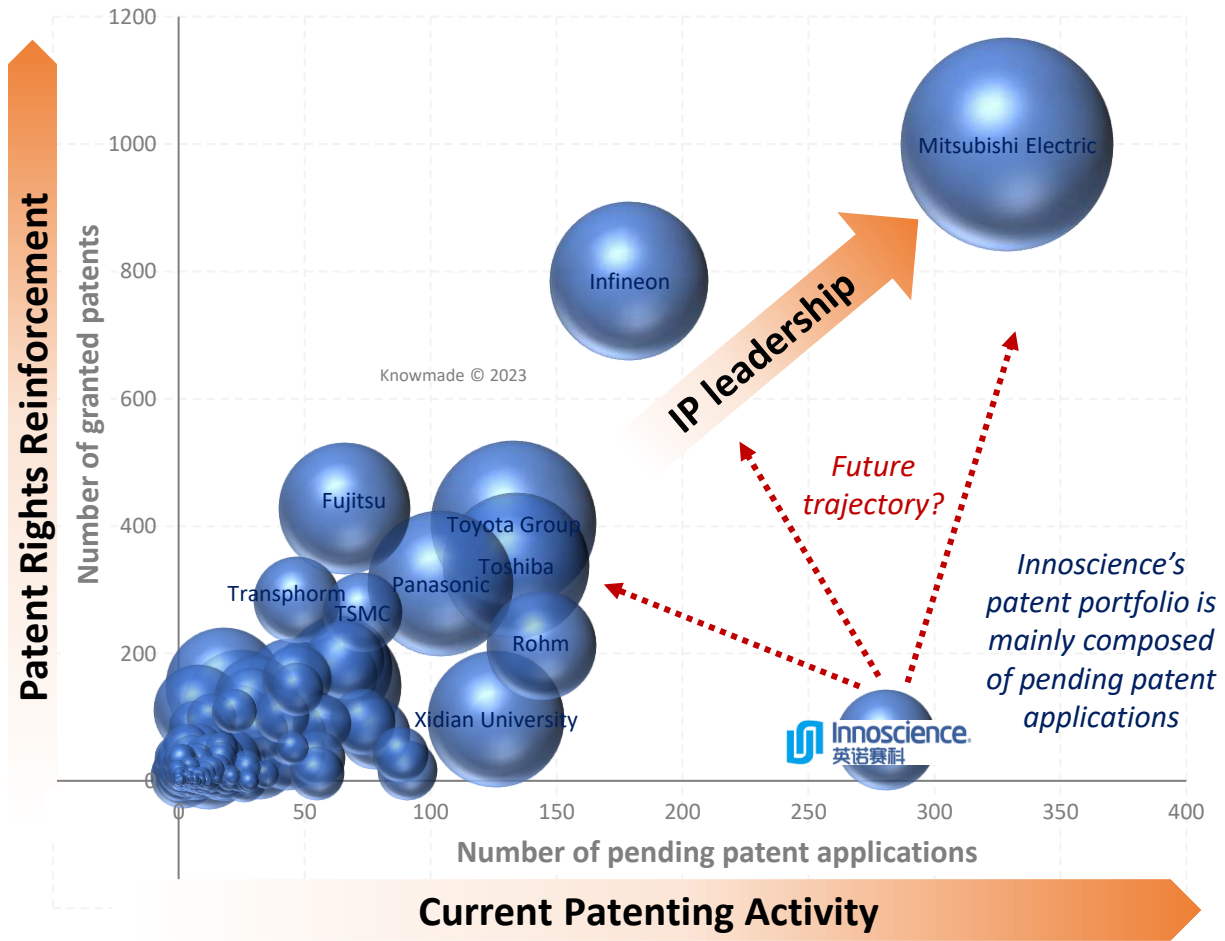
A leading Chinese IP player and the main global IP challenger



Chinese IP landscape



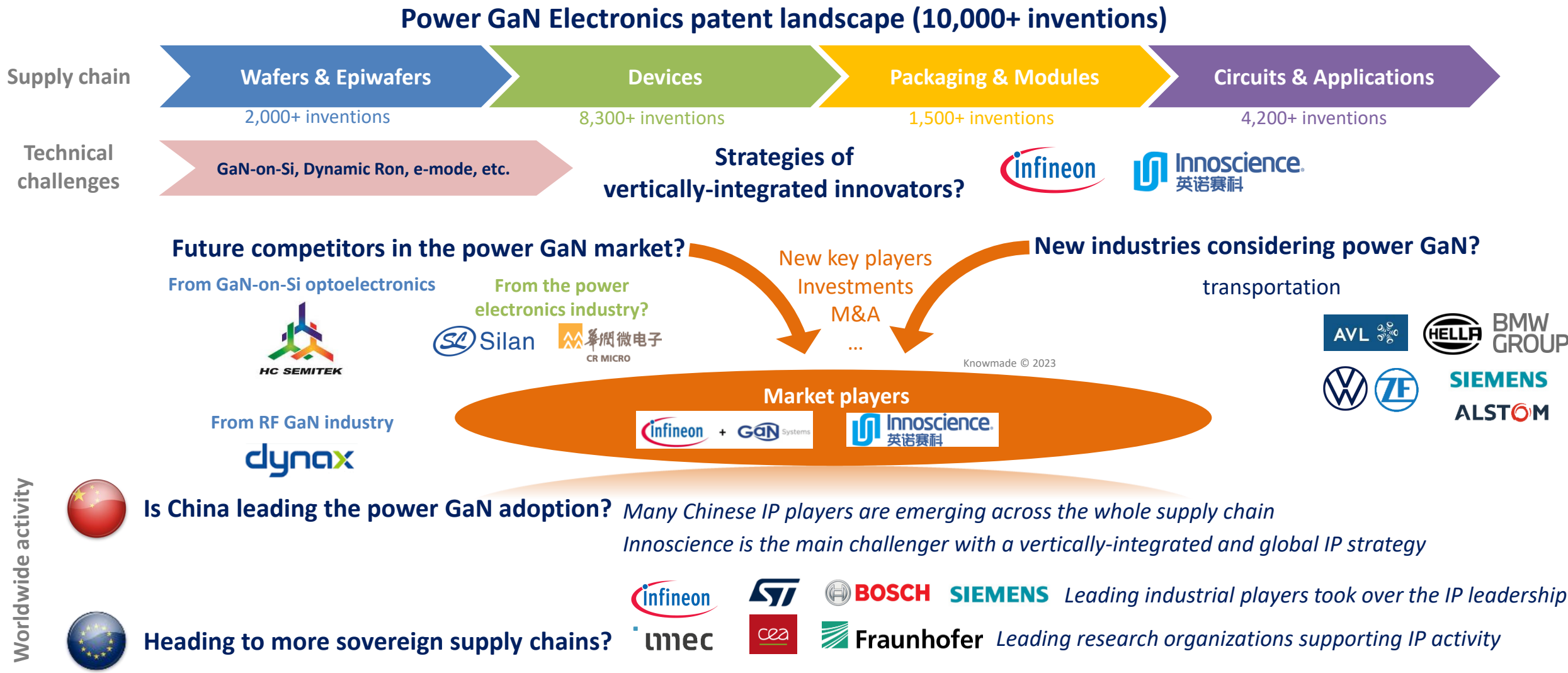
Global IP landscape



POWER GAN PATENT LANDSCAPE

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Use the patent information to anticipate and understand new competitions in the GaN industry (business, technology and IP)



POWER GAN ECOSYSTEM

Take-away messages



GaN Electronics for Power & RF applications



European IP landscape

SUPPLY CHAIN ESTABLISHMENT

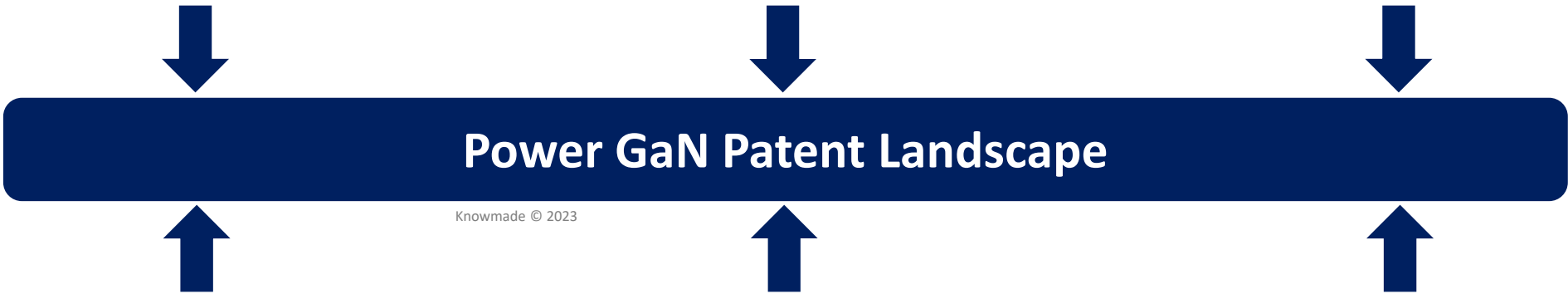
- Significant IP activity from leading research organizations (**CEA, imec, Fraunhofer**)
- Industrial players took over the IP leadership across the whole supply chain (**Infineon, ST, Bosch, Siemens**)

VERTICALLY-INTEGRATED INNOVATORS

- **Infineon** confirmed its IP leadership after **IR's** acquisition across the whole supply chain
- The partnership with **Panasonic** strengthens **Infineon's** IP position for e-mode GaN device and complete its patent portfolio for dynamic Ron
- GaN **systems'** patent portfolio will further enhance its position in the downstream supply chain

IP COMPETITION

- **Infineon's** and **ST's** patenting activity cover the largest markets for Power GaN technology (Asia, USA, Europe)
- The IP competition seems to be over for GaN-Si and slowing down for dynamic Ron
- Patent applicants currently focus on e-mode GaN devices including many Asian challengers and newcomers



Chinese IP landscape



- New players in the Power GaN IP landscape such as **Ingacom, YASC, Niway Semiconductor, and Zhineng Technology**
- Players coming from other industries such as **HC Semitek, Dynax/Gpower, Silan, and CR Micro**

- **Innoscience, Huawei, CETC** are the main Chinese vertically-integrated innovators
- **Innoscience** and **Huawei** have accelerated their patenting recently, expanding their activities across the supply chain in opposite directions
- Both players have been mainly assigned to pending patent applications so far (to be monitored)

- The main global IP competitors from China are **Innoscience, Huawei** and **Enkris Semiconductor**
- **Innoscience** and **Enkris Semiconductor** have focused their patenting activity on e-mode GaN devices so far



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