

# Silicon Carbide

From materials to devices,  
modules & circuits

Patent Landscape Analysis

December 2024

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# INTRODUCTION

## Context of the report

In the [Silicon Carbide \(SiC\) patent landscape 2022](#), KnowMade found out that the **intellectual property (IP) activities were ramping up for SiC devices**. Many historical IP players aimed to increase the perimeter of protection for their SiC inventions at this time. Electric vehicles (EV) had been driving the emergence of the power SiC market, prompting SiC companies to file **more patents in strategic regions for this industry**, such as **Europe** and **China**. In parallel, early leaders in the young SiC market have maintained or even accelerated their IP activities to prepare for a **stronger competition in the next few years**, since the EV boom led many new players to speed up the development of SiC technology. In this context, patents may be leveraged by leading SiC companies to **protect their market share** and thereby **secure the large investments** that have been required to enter the SiC industry. **The growing competition in the market is already conspicuous in the IP landscape.**

Furthermore, Chinese research organizations and companies have progressively ramped up their inventive activity since 2015. In 2023, Chinese entities have produced more than 70% of all power SiC patent publications. Even though the quality of such patents may be questioned, this situation brings about new challenges for global competitors in the semiconductor market looking to develop their manufacturing and business activities in China. In 2022, **KnowMade** released an [analysis](#) of the emerging Chinese SiC ecosystem based on the patenting activities of Chinese players across the SiC supply chain. An impressive number of newcomers were identified in the Chinese SiC patent landscape lately, of which many companies involved in the SiC wafer industry. With such a high number of companies involved in SiC wafer developments, China has already succeeded in stopping the shortage situation but opened a period of economic instability for many suppliers due to a fierce price competition. **This new context may favor patent litigations between SiC wafer suppliers.**

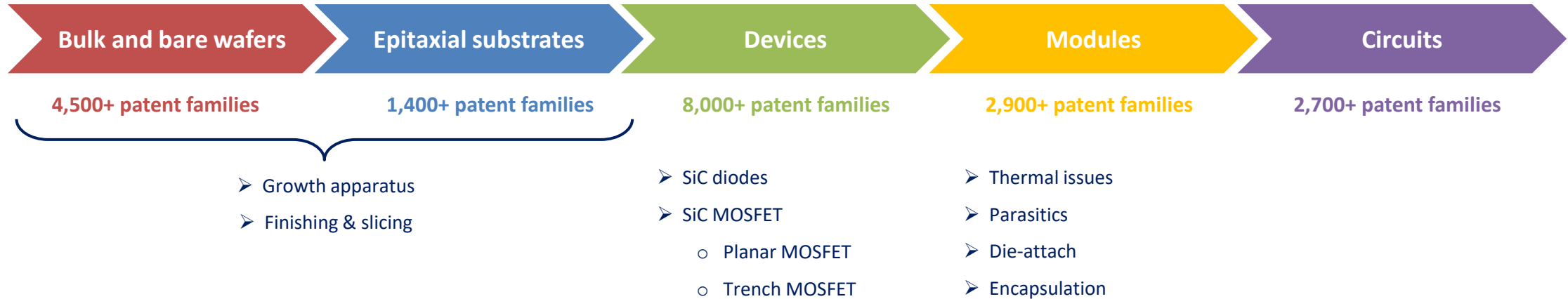
In 2021, two of the main early players in the power SiC market (ST, Wolfspeed) were sued by a US academic player (Purdue University), leveraging two fundamental patents related to **planar MOSFET technology**, to seek damages and get potential royalties from its IP. In the next few years, more litigations cases are expected between SiC players, as most of the main players in the SiC power device landscape have significantly improved their IP position since 2022, in terms of enforceable patents. The acceleration of IP activities is even more sensitive for **trench MOSFET technology**. It highlights the fact that most companies in the SiC device patent landscape have integrated trench MOSFET in their technological roadmap, leading to an acceleration in patent filings in this area. As a result, trench MOSFET has become an increasingly competitive IP space in recent years.

Eventually, most of the main companies pioneering the SiC market (incl. **Wolfspeed, STMicroelectronics, onsemi, Infineon, Rohm**) are developing themselves as integrated device manufacturers (IDM), making plans for a vertical integration of the SiC supply chain. Despite this general trend, the IP activities of these players are very contrasted across the SiC supply chain, highlighting quite differentiated IP strategies. While certain companies heavily rely on patents to assert their position in the market, other companies have not significantly developed their patent portfolio across the SiC supply chain. Although leading SiC companies may rapidly adjust their IP strategy to adapt to the fast evolution of the SiC industry, additional moves such as IP/manufacturing partnerships or M&A are expected to significantly reshape the SiC patent landscape. ,

# INTRODUCTION

## Objectives of the report

The report aims to provide a comprehensive view of the **power SiC patent landscape** along the whole supply chain / value chain, which has been split in the following 5 main categories and 10 main sub-categories:



More in details, the patent landscape analysis provides an overview of **power SiC patent landscape**:

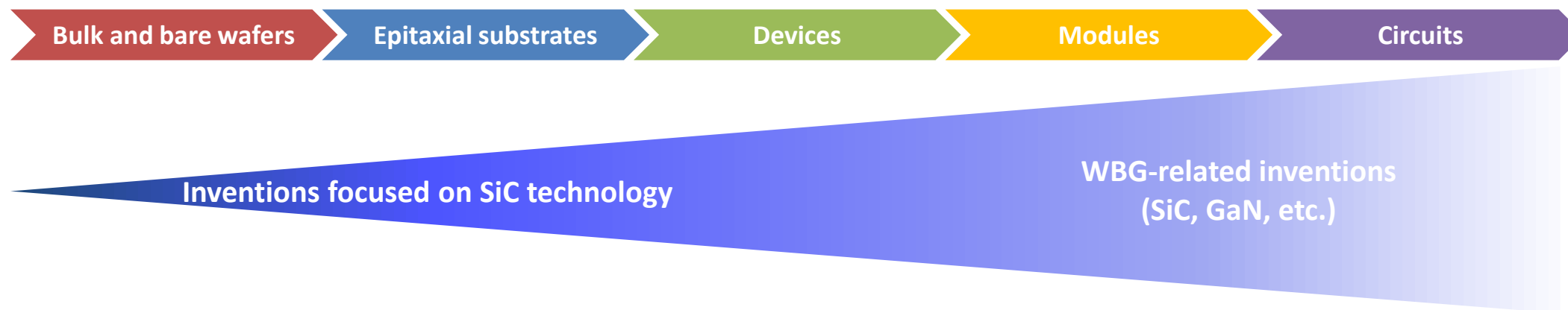
- To describe **global patenting trends** (time evolution of patent filings, geographical evolution of patent filings);
- To identify the **main IP players** and the **newcomers** in the different segments of the supply chain;
- To determine the status of their **patenting activity** (active / inactive) and their **dynamics** (ramping up, slowing down, steady);
- To identify the **IP collaborations** (patent co-filings) and **IP transfers** (changes of patent ownership) in the power SiC patent landscape;
- To provide a detailed picture of the **Chinese SiC ecosystem** focusing on the patenting activity of Chinese entities.

In addition, the report includes **IP profiles**, which provide a comparison and an overview of the patent portfolios and the recent patenting activity of **Wolfspeed, STMicroelectronics, onsemi, Infineon, Rohm, SK, Coherent, General Electric** and **San'an**.

# INTRODUCTION

## Research strategy and scope of the report

The patent selection is performed by KnowMade's analysts. Due to different strategies of patent filings across the supply chain, the scope of the patent selection must be tuned according to the position in the supply chain, as illustrated below:



### Included

- SiC substrate patents describing growth apparatus for **crystal growth (bulk)** and **epitaxial growth (thin films)**.
- SiC substrate patents related to **wafering (slicing, finishing)**.
- SiC substrate patents describing **SiC-on-SiC epitaxial structures**.
- SiC device patents describing **electronic devices** (MOSFET, IGBT, JFET, diodes, etc.).
- Power module patents describing **based on WBG devices**.
- WBG circuit patents describing **circuits and operating methods specific to SiC devices**.
- WBG circuit patents describing **driver and protection circuits for Wide bandgap (WBG) devices**.

### Excluded

- Substrate patents claiming different materials in addition to SiC (i.e., generic patents)
- SiC substrate patents describing **heterostructures (SiC-on-X, X is not SiC)**
- SiC device patents describing **other devices (optoelectronic devices, sensors, MEMS, etc.)**
- WBG power module patents including specifically **GaN devices**.
- WBG circuit patent describing **circuits and operating methods not specific to SiC devices**.
- WBG circuit patent describing **driver and protection circuits for GaN specifically**.

SAMPLE

# INTRODUCTION

Reading guide: find the right information in the report

SAMPLE

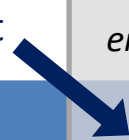
Report sections



Your concern



Information you get



## TECHNOLOGY

*For R&D teams,  
engineers, scientists*

## IP

*For IP teams,  
patent attorneys*

## MARKET

*For executives,  
business developers*

## PLAYER

*Zoom in a  
competitor / partner*

### PATENT LANDSCAPE OVERVIEW

- **Ranking of players** (enforceability, current activity, geo/tech coverage, prior-art contribution, etc.)
- **Patent filings dynamics per player**
- **IP collaborations** (co-filings, IPR transfers)
- **Patent litigation/oppositions**

Innovators

Main patent owners  
IP risks/opportunities

Ecosystem  
(competitors, newcomers,  
partners, clients)  
Main trends  
IP vs Market

IP position vs Market  
position  
Player relationships  
(collaborations/  
dependencies)

### SEGMENTS ANALYSIS

- **Patent filings dynamics per segment**
- **IP leaders per segment** (enforceability, current activity, blocking potential)
- **Key patents per segment**
- **Recent patenting activity per segment**

Technology trends  
Technology mapping

Blocking players  
IP risks/opportunities  
in each segment  
(FTO, litigation, licensing)

Benchmarking  
Markets of interest  
Future developments

IP position and level  
of investment in each  
segment  
Key IP developments

### IP PROFILE OF KEY PLAYERS

- **Patent portfolio summary** (portfolio size, IP activity evolution, patents legal status, geo/tech coverage, strengths/weaknesses, etc.)
- **Key patents**
- **Recent patenting activity**

Current R&D activities  
Technology roadmap

Blocking patents  
Geo/Tech coverage  
Link between patents  
and products

Future products  
Potential partners  
Potential targets

R&D investment level  
Key inventions  
Current IP activities  
Strengths / Weaknesses



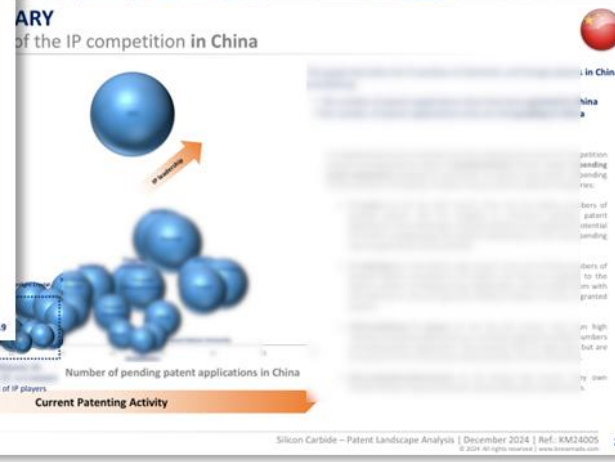
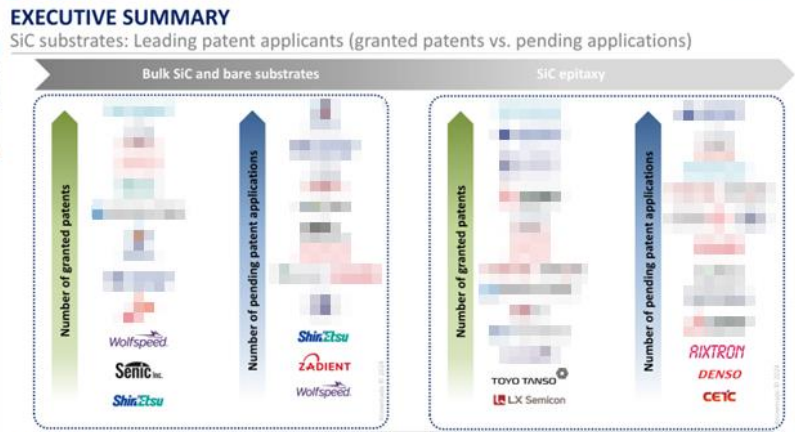
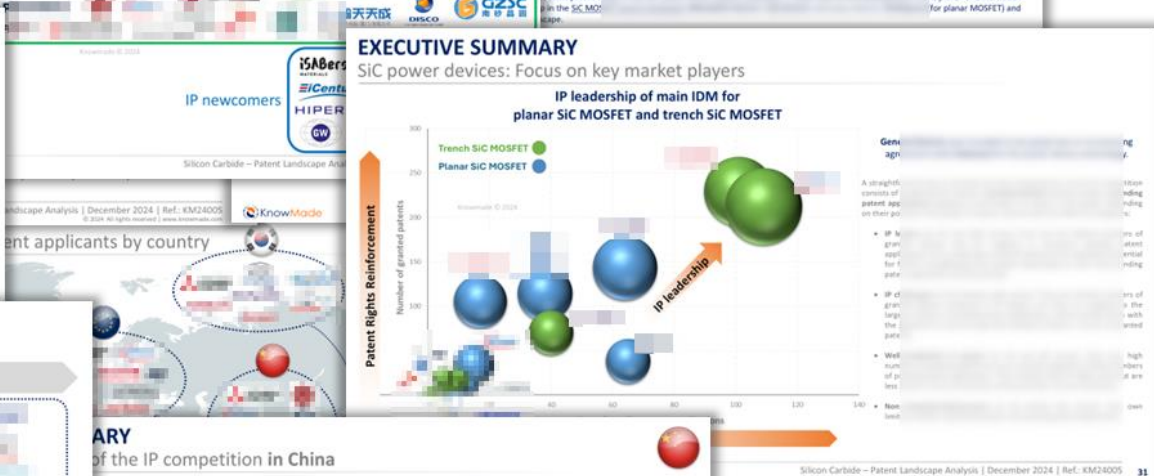




# Patent landscape overview

## Executive summary

SAMPLE



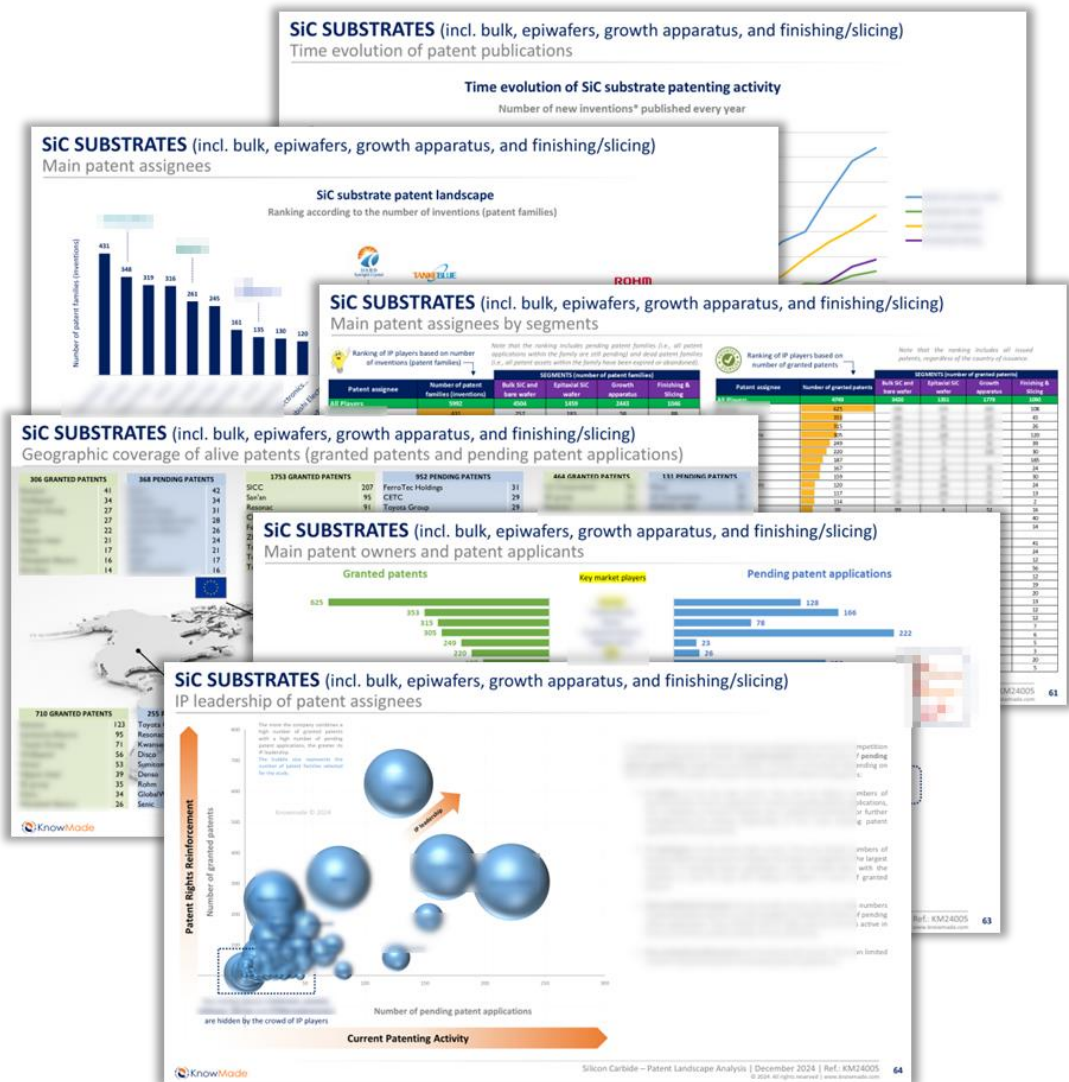


# SiC substrates (incl. bulk, epiwafers, growth apparatus, and finishing/slicing)

General trends, Key patent assignees, Newcomers, Patent legal status, Geo coverage

SAMPLE

## Focus on bulk SiC and SiC epiwafers

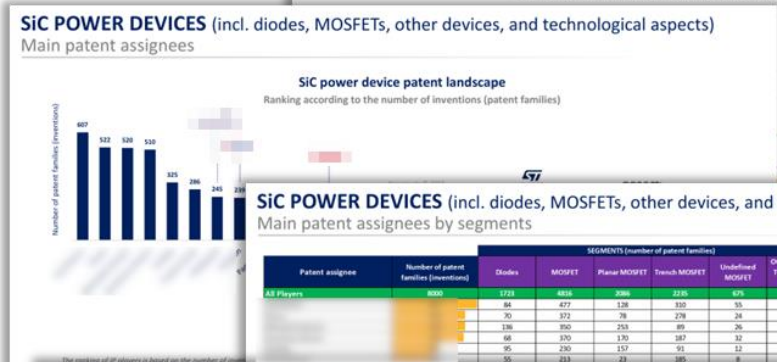




# SiC power devices (incl. diodes, MOSFETs, other devices, and technological aspects)

General trends, Key patent assignees, Newcomers, Patent legal status, Geo coverage

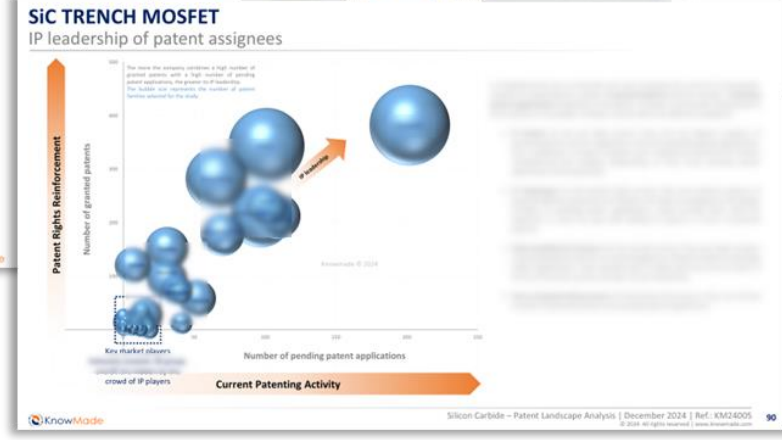
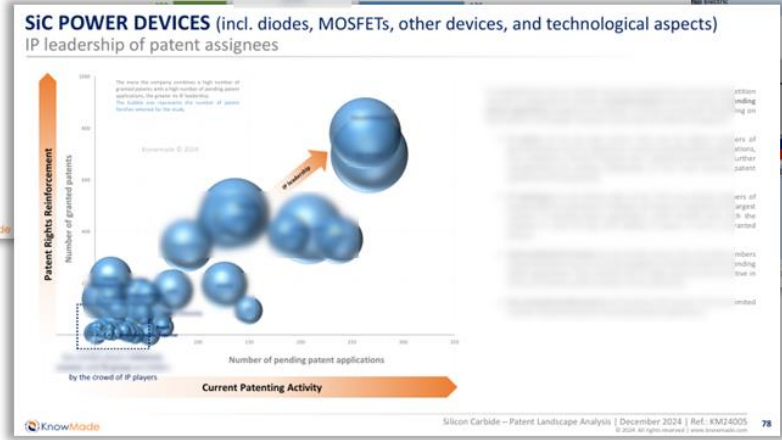
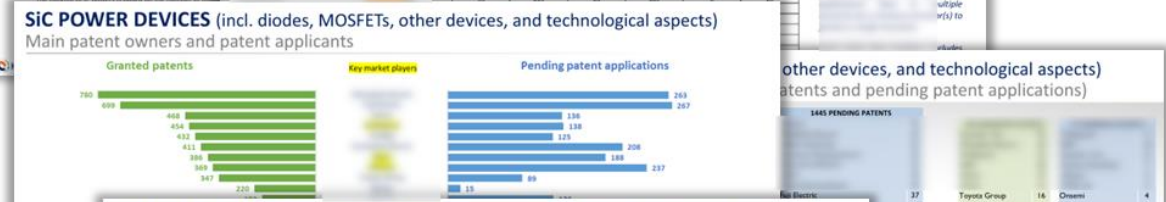
SAMPLE



**SiC POWER DEVICES** (incl. diodes, MOSFETs, other devices, and technological aspects)  
Main patent assignees by segments

Patent assignee	Number of patent families (inventions)	SEGMENTS (number of patent families)					
		Diodes	MOSFET	Planar MOSFET	Trench MOSFET	Undefined MOSFET	Other Devices/Technological Aspects
All Players	8000	1723	4816	3366	2285	1275	1668
1	86	477	128	102	55	40	40
2	70	312	78	178	28	32	32
3	138	300	253	89	26	50	50
4	68	370	170	187	32	88	88
5	95	230	157	91	33	73	73
6	50	213	22	185	8	25	25

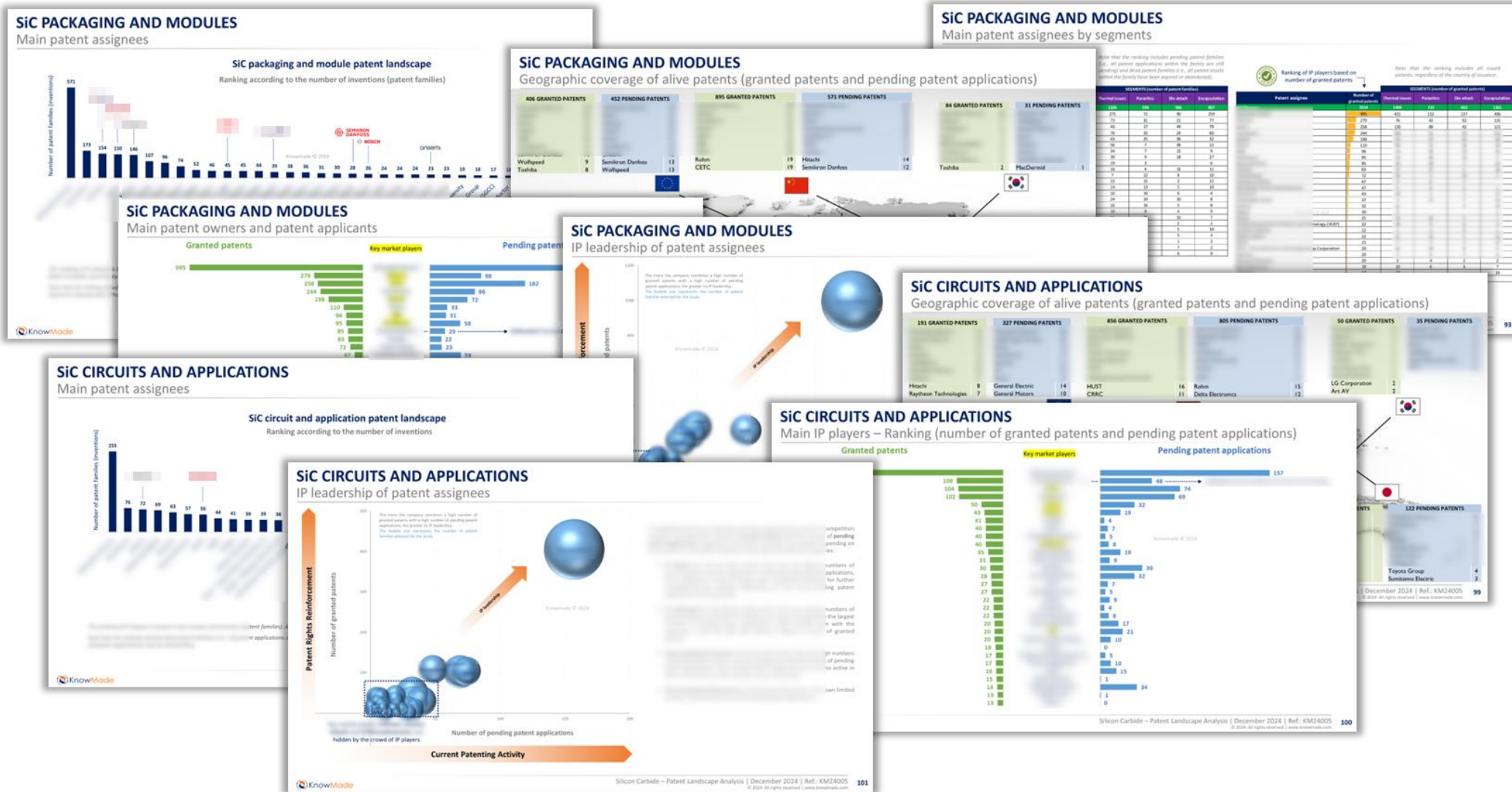
## Focus on SiC diodes, planar SiC MOSFETs and trench SiC MOSFETs



# SiC power modules, packaging, and circuits

General trends, Key patent assignees, Newcomers, Patent legal status, Geo coverage

SAMPLE

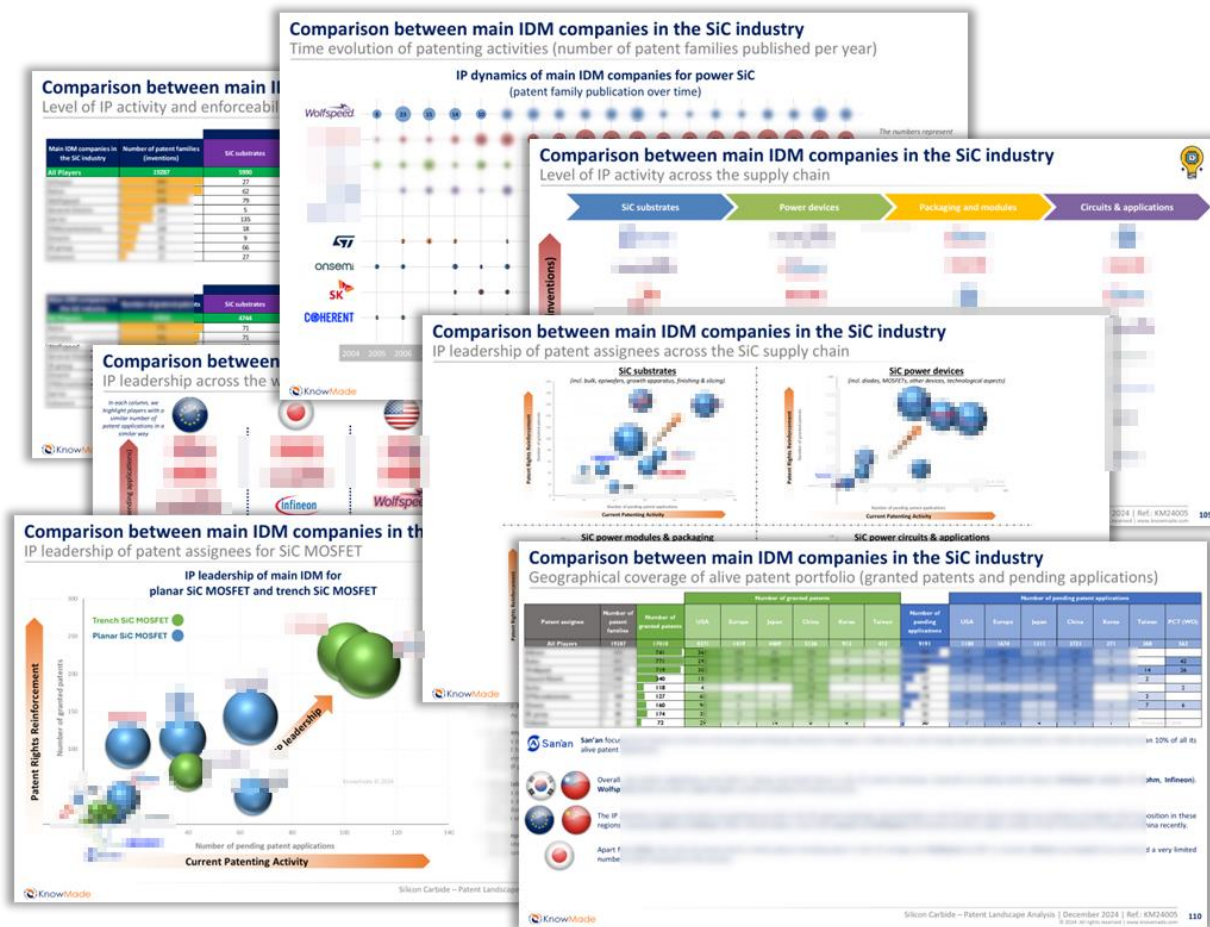


# Benchmark of key players

IP dynamics, IP position across the supply chain, IP leadership, Geographic coverage

SAMPLE

A focus on main SiC device market players and/or companies investing significantly into building a vertically-integrated infrastructure for SiC is provided in a dedicated section. Such companies have adopted an IDM business model and look to integrate within the company every step of SiC manufacturing, from material growth, to device manufacturing and packaging. Interestingly, the comparison of their IP activities highlights quite differentiated IP strategies.



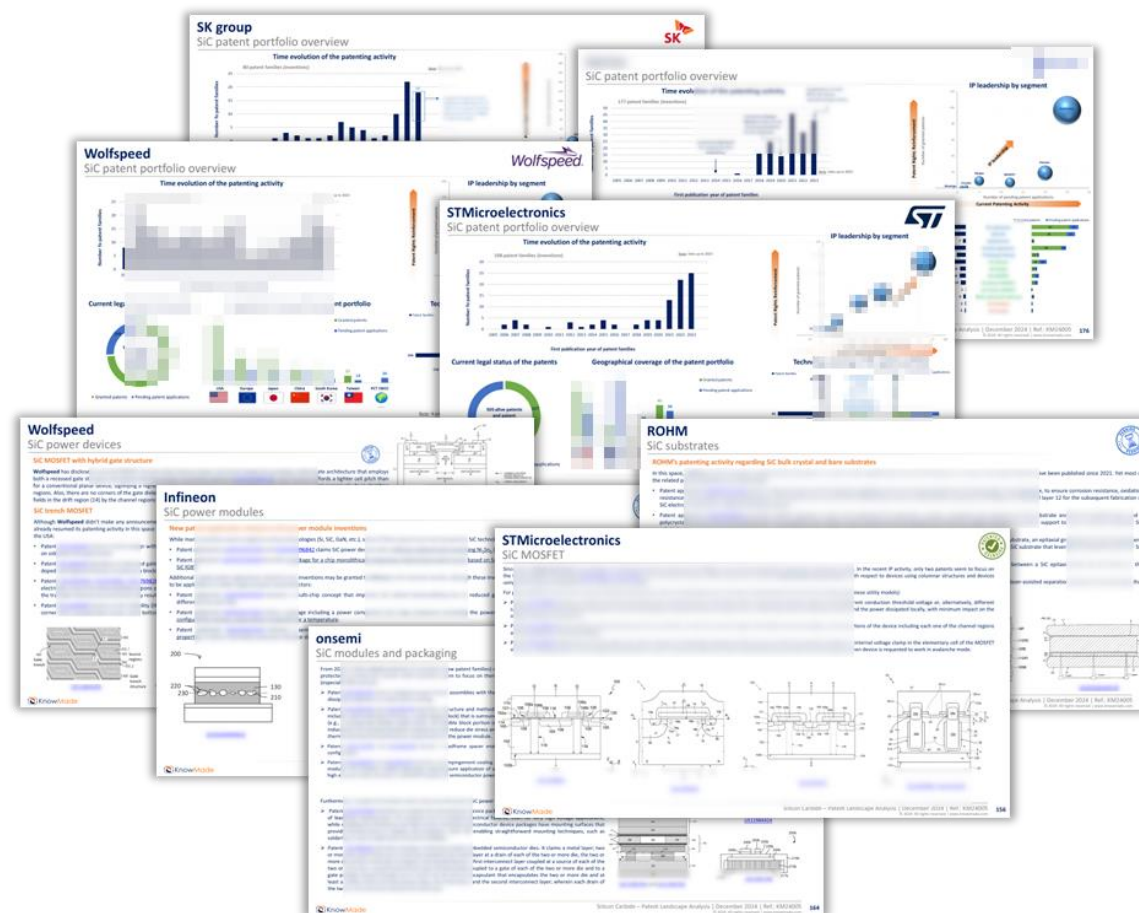


# IP profile of key players

## IP portfolio summary, IP strategy, key patents and recent IP activity

SAMPLE

A focus on main SiC device market players and/or companies investing significantly into building a vertically-integrated infrastructure for SiC is provided in a dedicated section. For each player, the SiC patent portfolio is statistically analyzed to provide an overview of its strengths, its potential for reinforcement and level of IP activity. The recent patenting activity of the player is then reviewed. It allows to detect small signals, such as involvement in new technological areas or a strong IP activity in new regions, and it may provide insights into the company's strategic plans and recent evolutions of SiC technology.



# ORDER FORM

## Silicon Carbide (SiC)

Patent Landscape Analysis – December 2024

Ref.:KM24005



### SHIP TO

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Job Title:

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State:

Postcode/Zip:

Country:

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Date:

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FRANCE

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Bank: Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var, France  
IBAN: FR76 1460 7003 6360 6214 5695 139  
BIC/SWIFT: CCBPFRPPMAR

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- within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.

2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including in cases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.

2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in article 3.

2.4 The mailing is operated through electronic means either by email via the sales department. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to

produce sufficient evidence of such defects.

2.6 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer’s risk.

## 3. PRICE, INVOICING AND PAYMENT

3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmade, PayPal or by electronic transfer to the following account:

Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var, France

BIC or SWIFT code: CCBPFRPPMAR

IBAN: : FR76 1460 7003 6360 6214 5695 139

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

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4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

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b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take

reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

## 5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

## 6. PROTECTION OF THE SELLER’S IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;

- Recordings and re-transmittals over any network (including any local area network);

- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;

- Posting any Product to any other online service (including bulletin boards or the Internet);

- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

## 7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

## 8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

## 9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.



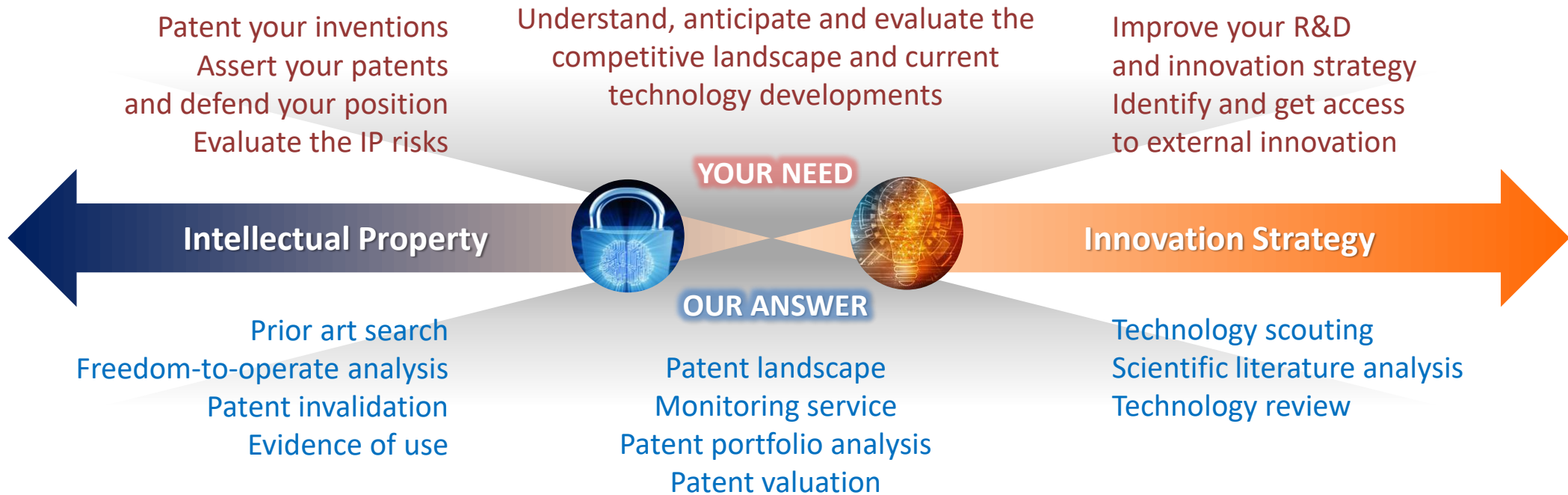
# KNOWMADE

## Patent and Technology Intelligence

# KNOWMADE PURPOSE

Turning **patent information** and **scientific literature** into actionable insights, providing high value-added reports for **decision-makers** working in **R&D, Intellectual Property, Innovation Strategy, and Marketing**

Competitive landscape | Technology trends | Opportunities / Risks | R&D and IP strategy



# KNOWMADE OFFER

## CUSTOM SERVICES

(Tailor-made analysis)

*To meet your needs and budget/lead time constraints*

- Specific and dedicated report.
- Prior-art search, literature review, patent landscape, freedom-to-operate, patent valuation, IP due diligence, technology scouting, monitoring service, etc.

Format

- PDF file with analyses.
- Excel file with data.
- Access to the analyst.

## REPORTS

(multi-client product)

*To understand the competitive landscape and explore the emerging ecosystems and new technologies*

- Stand alone report
- Patent landscape.
- Overview on IP dynamics, trends and players.
- Competitor, technology and strategy analysis.
- Benchmark of patent portfolios.
- Key IP players & key patents.

Format

- PDF file with analyses.
- Excel file with patent data.

## MONITORS

(multi-client product)

*To track the latest R&D developments and IP activities, and to be sensitive to weak signals*

- Annual subscription
- Patent monitoring service.
- Quarterly updated patent data and technology trends.
- Current R&D and IP activities.
- Early detect weak signals, opportunities and risks.
- Open discussion with analyst.

Format

- PDF file with analyses.
- Excel file with patent data.
- Direct access to the analyst.

## INSIGHTS

(free article & webinar)

*To get unique information about industry and technology*

- Analyst point of view about industry news (product release, M&A, start-up, fund-raising, etc.) from a patent perspective.

Format

- Knowmade website



# MAIN FIELDS OF EXPERTISE

## SEMICONDUCTORS

- Materials & Substrates
- Power electronics
- RF & Wireless datacom
- MEMS, Sensing & Imaging
- Photonics, Lighting & Display
- Memory
- Packaging

## ENERGY

- Batteries
- Fuel-cells
- Solar PV
- Power management



## HEALTHCARE

- New therapeutic tools
- Medical diagnostics
- Medical devices and imaging
- Drug discovery and delivery

## AGRI-FOOD

- Food processing & formulation
- Vegan food
- Next-gen packaging
- Microbiology





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