

POWER SiC

Focus on Chinese ecosystem

Patent Landscape Analysis

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CS International

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SiC PATENT LANDSCAPE

Introduction

Context: The EV market drives the adoption of SiC technology, European, US and Japanese players have taken the leadership in the SiC power device market.

Challenges:

- **Supply shortage of high-quality SiC wafers** → increase the number of suppliers and their production capacity
- **Cost competitiveness** → improve the yields, reduce manufacturing costs, cut supplier margins
- **Device reliability in EV applications** → improve the technology from material to modules

Questions addressed by the presentation:

- What are the strategies of well-established IP/market players to limit the risks related to the supply chain and secure the adoption of SiC technology in EV?
- What are the strategies of countries emerging in the power SiC market (China, South Korea, Taiwan) to develop locally their own supply chain?



Analyze the IP strategy of players all along the Power SiC supply / value chain



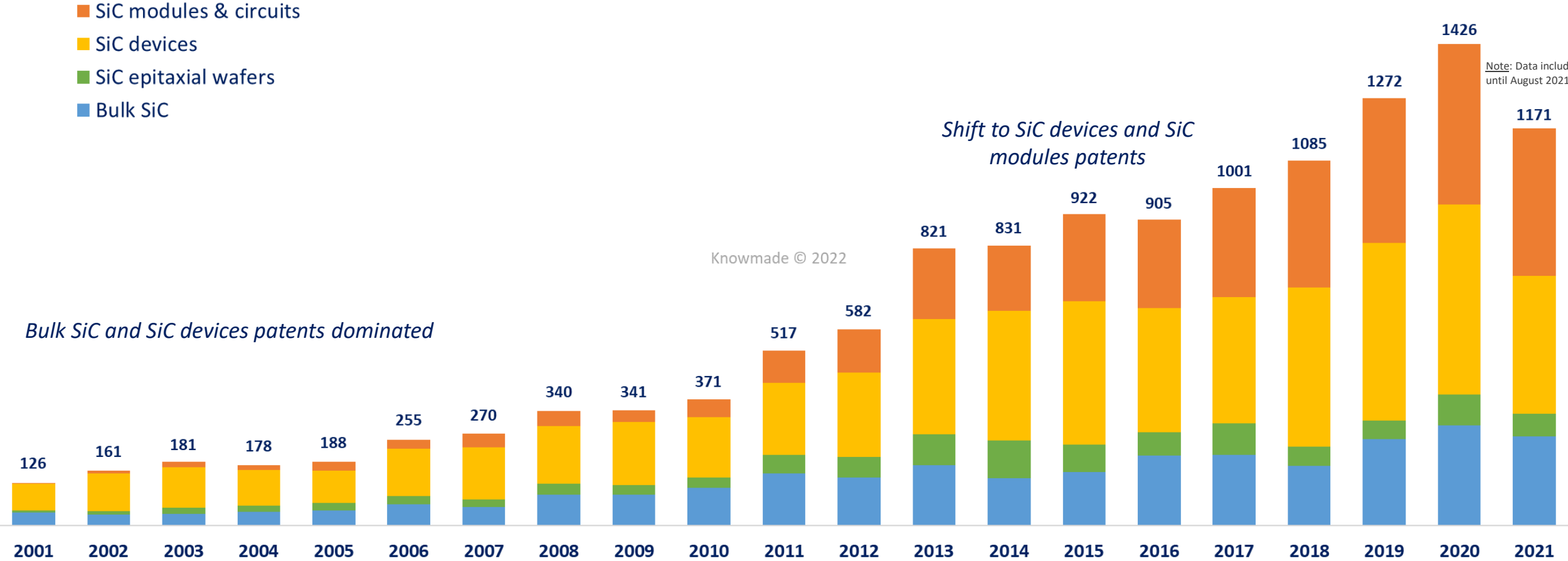
SiC PATENT LANDSCAPE

The patenting activity reflecting an increase in R&D investments

Timeline of power SiC patent publications

Number of new patent families (inventions) published per year

- Bulk SiC IP activity remained very active over the past decade
- SiC epiwafer IP activity has remained relatively limited



Note: Data included until August 2021

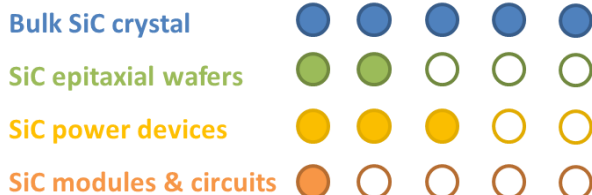
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SiC PATENT LANDSCAPE

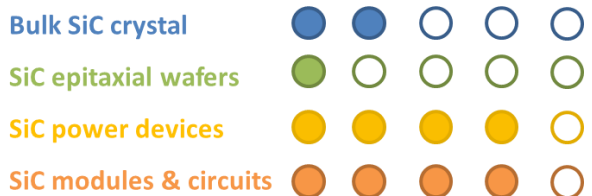
Who is driving the SiC patenting activity?



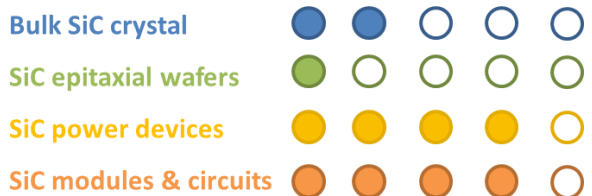
Focus of the patenting activity



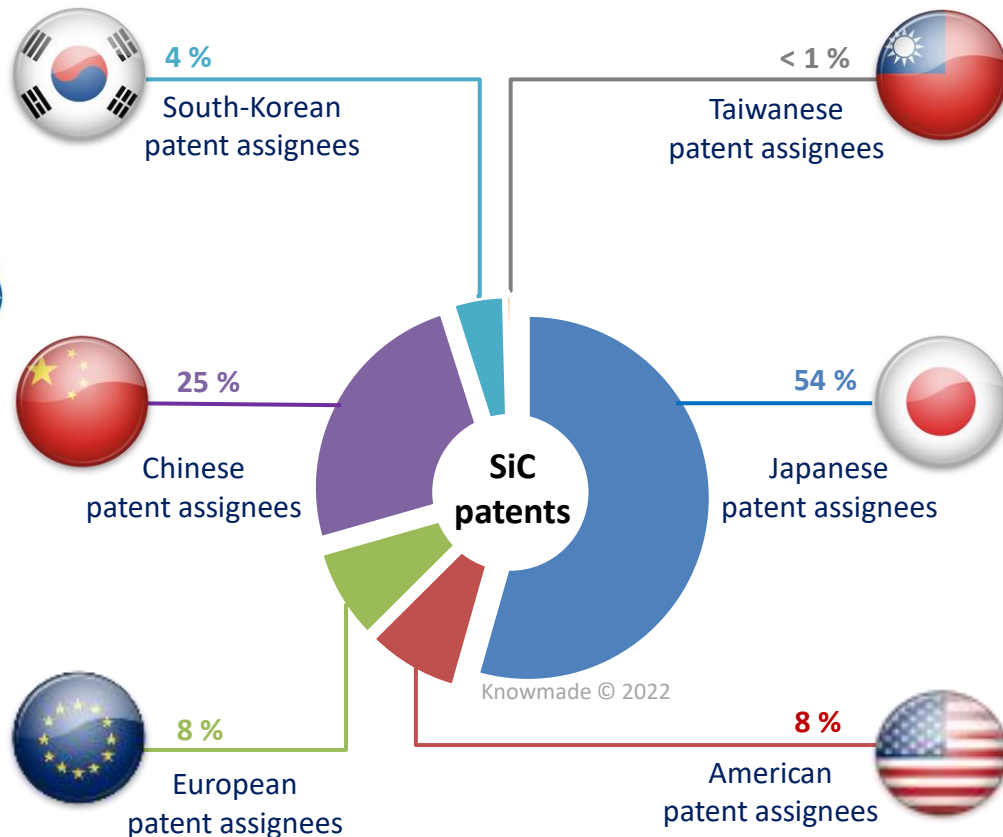
Focus of the patenting activity



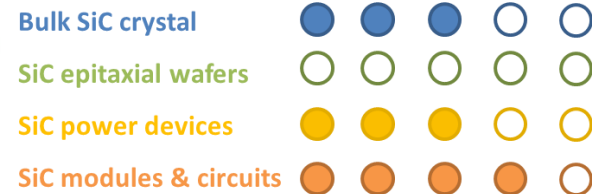
Focus of the patenting activity



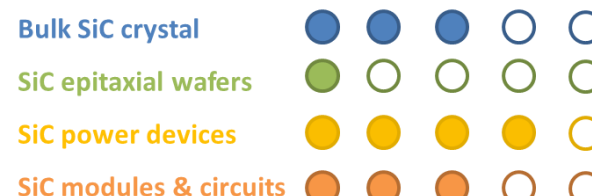
Geographical breakdown of main players driving the SiC patent activity



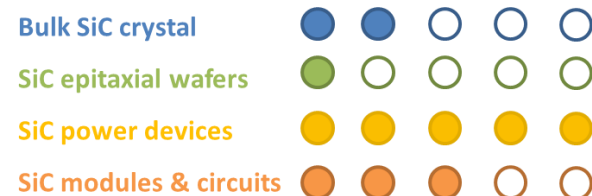
Focus of the patenting activity



Focus of the patenting activity

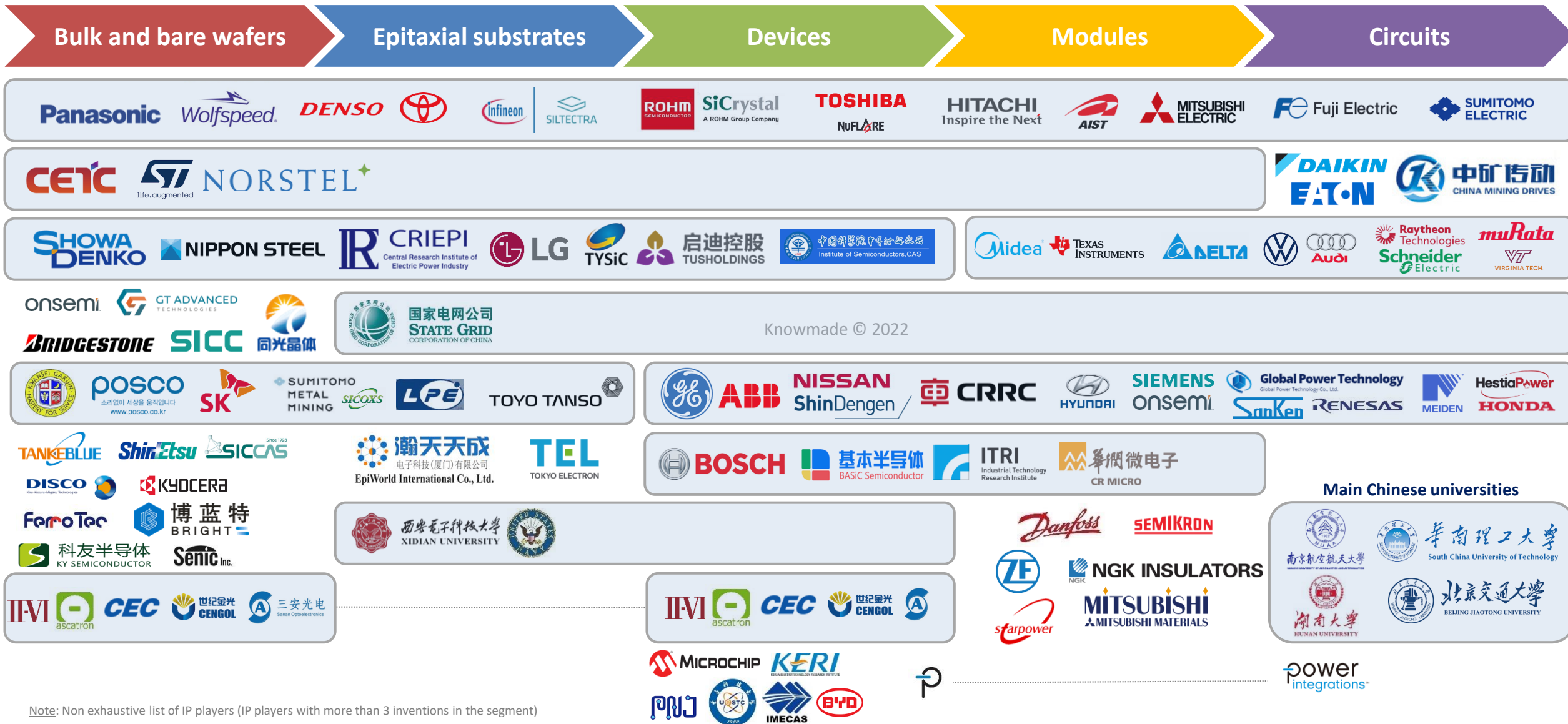


Focus of the patenting activity



SiC PATENT LANDSCAPE

The power SiC supply chain from a patent perspective



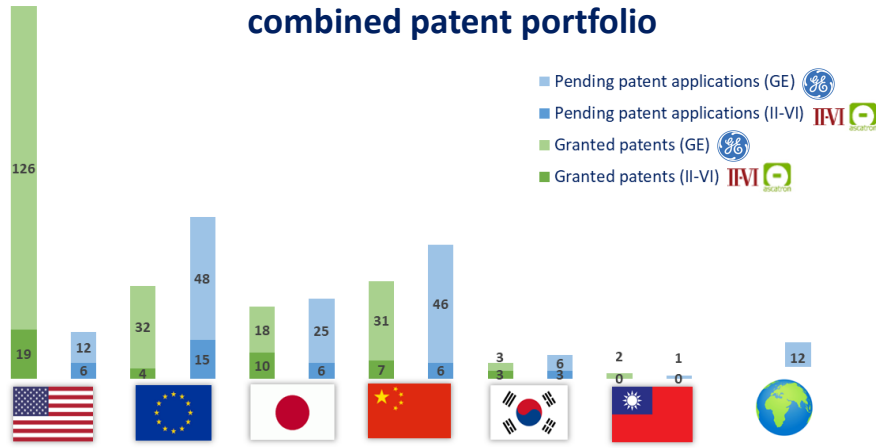
Note: Non exhaustive list of IP players (IP players with more than 3 inventions in the segment)

SiC PATENT LANDSCAPE

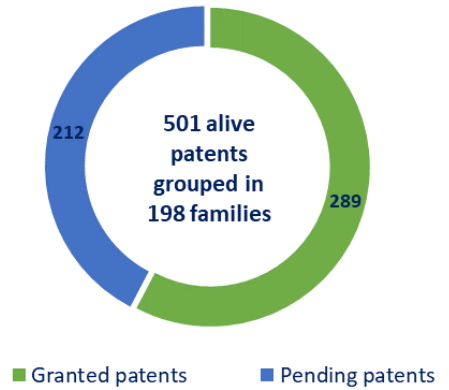
II-VI & General Electric: covering the whole supply chain via patent licensing



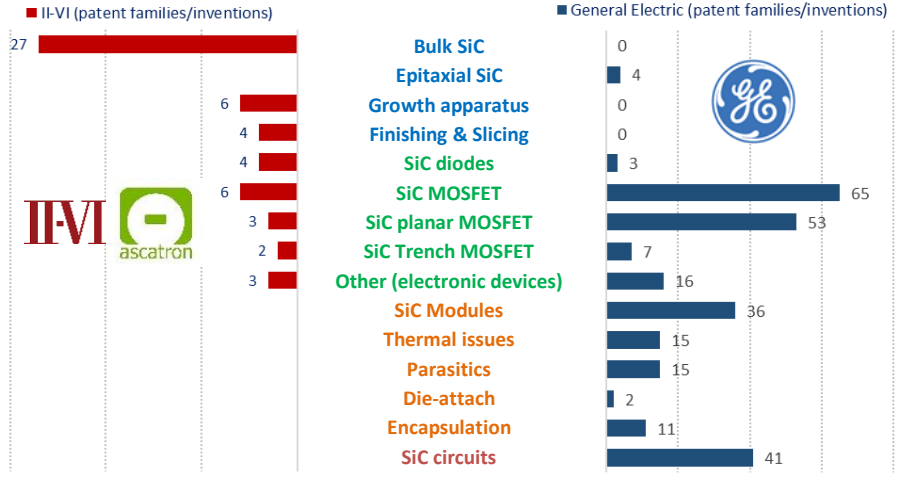
Geographical coverage of the combined patent portfolio



A combined patent portfolio including 190+ SiC inventions



Technology coverage of the combined patent portfolio



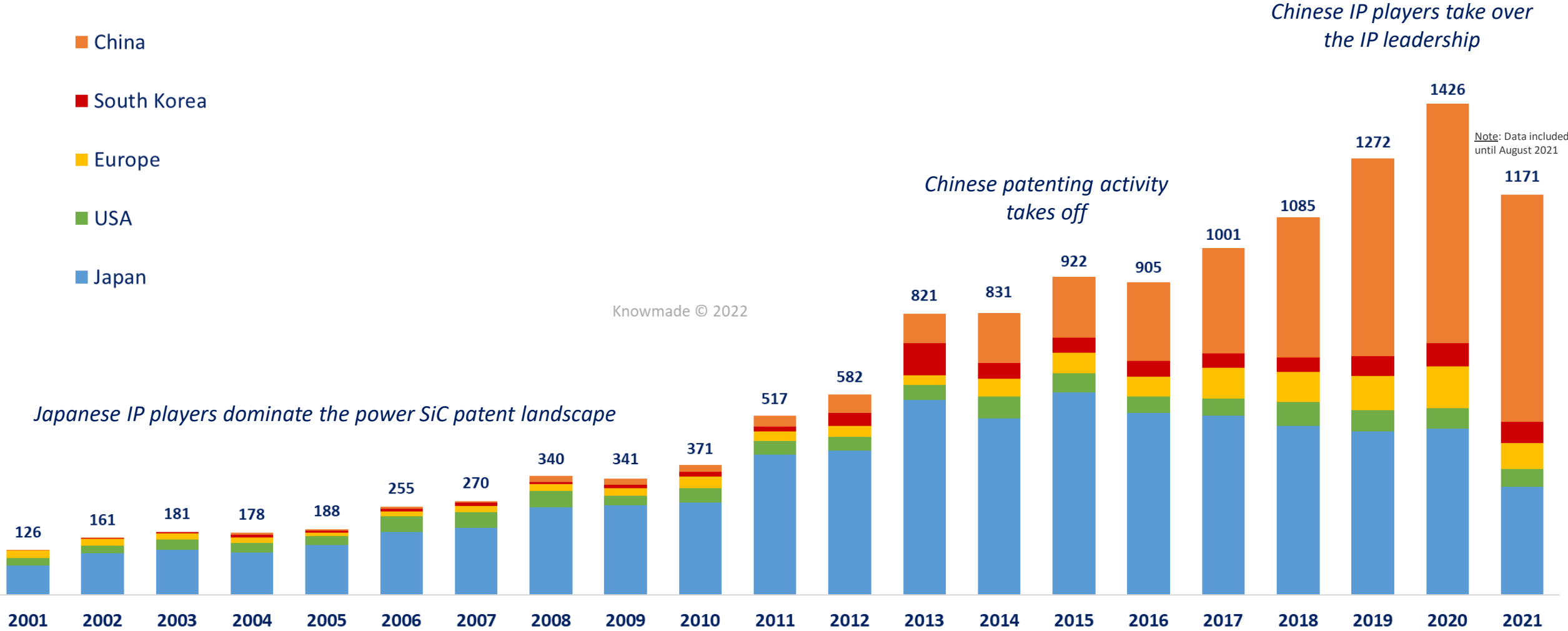
Note: A patent family can belong to multiple segments

SiC PATENT LANDSCAPE

What is happening in China?

Timeline of power SiC patent publications

Number of new patent families (inventions) published per year



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SiC PATENT LANDSCAPE

Focus on China: Main Chinese IP players along the power SiC supply chain



Bulk and bare wafers: CETC Shanxi Shuoke Crystal, Poshing, THET, #2 institute

Epitaxial substrates: CETC Poshing, #13 #55 research institutes

Devices: CETC THET, #13 #55 research institutes

Modules: CETC THET, Yangzhou Guoyang Electronics

Circuits: 中矿传动 CHINA MINING DRIVES, AUX 奥克斯

Sanan Optoelectronics (三安光电), Institute of Semiconductors, CAS (中国科学院半导体研究所), TUSHOLDINGS (启迪控股), TYSIC, CEC CHINA ELECTRONICS CORPORATION (中国电子信息产业集团有限公司)

Midea, YuanShan Electr. (元山电子)

JSG

CR MICRO (华润微电子), BASIC Semiconductor (基本半导体), SEMILAND Power Modules, Huaxinwei Semiconductor Technology (Beijing) (华夏微电子)

南京航空航天大学 Nanjing University of Aeronautics and Astronautics (NAAU)

SICC, SICCAS (Since 1928)

国家电网公司 STATE GRID CORPORATION OF CHINA

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TANKEBLUE, 博蓝特 BRIGHT

XIDIAN UNIVERSITY (西安电子科技大学), WINS, SASTC (陕西半导体技术研究所)

MAGMIC, starpower, 常州瑞华 CHANGZHOU RUIHUA

华南理工大学 South China University of Technology

同光晶体, 山东大学 SHANDONG UNIVERSITY

NASO TECH 纳设智能

CRRC, Global Power Technology Co., Ltd.

NAURA 北方华创, 超芯星 HYPERSiCS

JHL 季华实验室 JI HUA LABORATORY

FOUNDER 方正, UESTC (电子科技大学)

HUAZHONG UNIVERSITY OF SCIENCE & TECHNOLOGY

科友半导体 KY SEMICONDUCTOR, GZSC 南砂晶圆

瀚天天成 EpiWorld International Co., Ltd. (电子科技有限公司(厦门)有限公司)

BYD, IMECAS, 新功率 CEPOWER

Chongqing Wattscience Electronic Technology, Xiamen Xinguang Runze Technology (China SiC Power)

西安交通大学 XI'AN JIAOTONG UNIVERSITY

Xingteliang Group (CISRI 中国钢研)

Note: Non exhaustive list of Chinese IP players

世纪金光 CENGOL, GREE

SiC PATENT LANDSCAPE

Vertically-integrated innovation: CETC internal resources



CETC #13 research institute / CETC #55 research institute



Yangzhou Guoyang Electronics

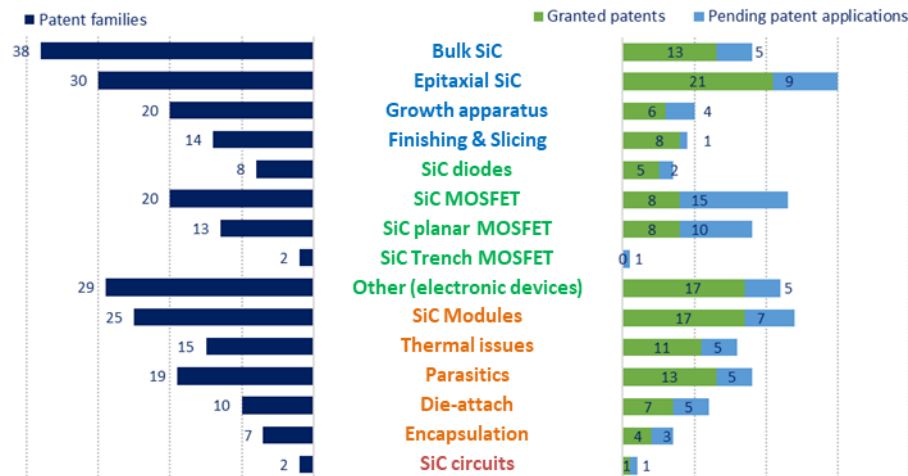


Tonghui Electronic Technology (THET)



CETC #2 research institute

Shanxi Shuoke Crystal



Note: A patent family can belong to multiple segments

SiC PATENT LANDSCAPE

Vertically-integrated innovation: Internal & external sources

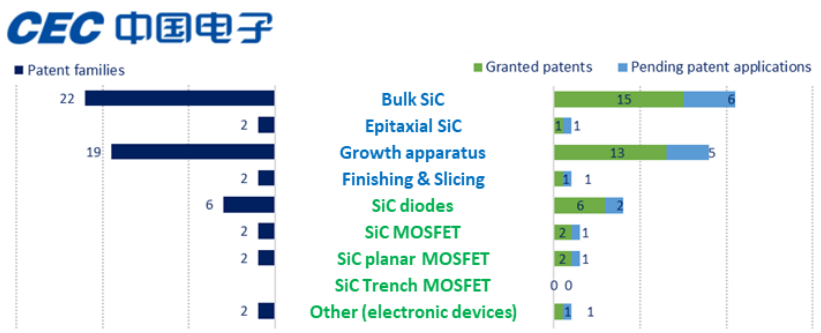


CECS 中电化合物半导体有限公司
CEC Compound Semiconductor Co. Ltd.

GTA 积塔半导体
GTA Semiconductor

Alpha power solutions acquired by HDSC 华大半导体
HUADA SEMICONDUCTOR

Example #1

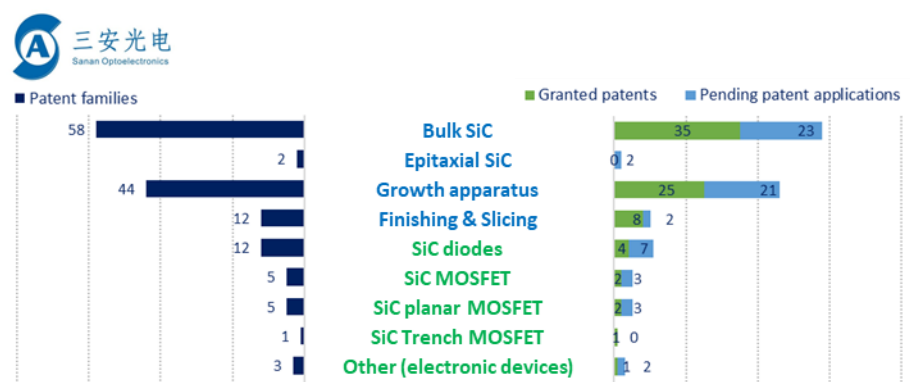


Note: A patent family can belong to multiple segments

厦门市三安集成电路有限公司
Xiamen San'an Integrated Circuit Co., Ltd.

Example #2

Nortel New Materials acquired by 三安光电
Sanan Optoelectronics



Note: A patent family can belong to multiple segments



SiC PATENT LANDSCAPE

The Chinese research system supported the emergence of industrial players

Main IP players

New IP players



CEIC Shanxi Shuoke Crystal, Poshing, THET, #2 institute

CEIC Poshing, #13 #55 research institutes

ISCI 中国科学院半导体研究所 Institute of Semiconductors, CAS

TYSiC

SICC 同光晶体

TANKEBLUE

STATE GRID 国家电网公司 CORPORATION OF CHINA

XIDIAN UNIVERSITY 西安电子科技大学

SICCAS Since 1928

SHANGHONG UNIVERSITY 山东大学

瀚天天成 电子科技(厦门)有限公司 EpiWorld International Co., Ltd.

KY SEMICONDUCTOR 科友半导体

CISRI 中国钢研

NAURA 北方华创

HYPERSiCS 超芯星

AURORA

GZSC 南砂晶圆

JHL 季华实验室 JI HUA LABORATORY

NASO TECH 纳设智能

BRIGHT 博蓝特

CENGOL 世纪金光

JSG

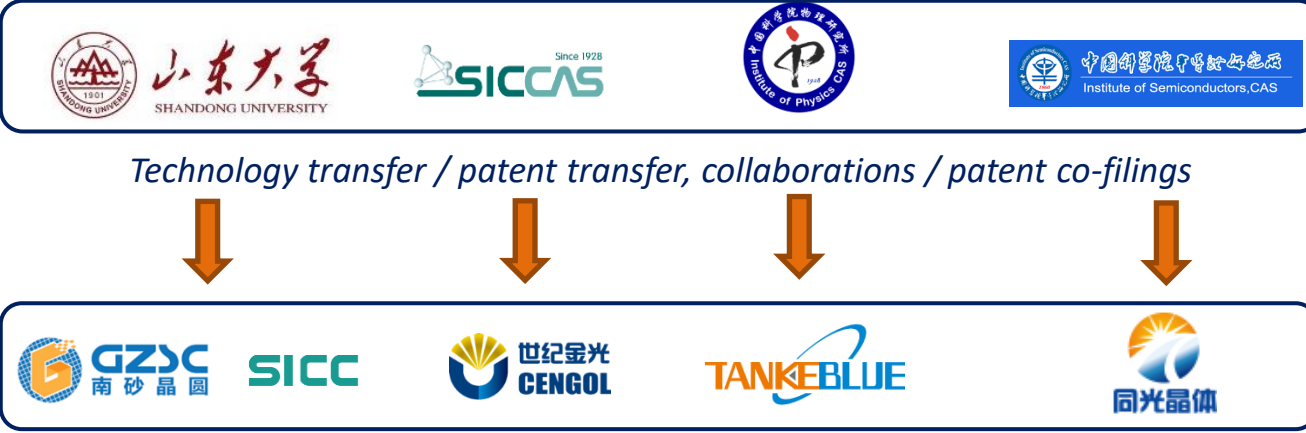
TUSHOLDINGS 启迪控股

CEC 中国电子信息产业集团有限公司 CHINA ELECTRONICS CORPORATION

SANAN OPTOELECTRONICS 三安光电

From sapphire material business to SiC wafer business

CHINESE RESEARCH ORGANIZATIONS DRIVING THE EMERGENCE OF DOMESTIC INDUSTRIAL LEADERS



PUBLIC INITIATIVES TO SPUR THE DEVELOPMENT OF SiC TECHNOLOGY IN THE CHINESE INDUSTRY



SiC PATENT LANDSCAPE



The rise of Chinese industrial players in the power SiC competitive landscape

SiC power device patent landscape

HISTORICAL IP PLAYERS



IP CHALLENGERS (NEWCOMERS)



FROM RESEARCH ORGANIZATIONS TO START-UP COMPANIES

TsinSiC, Xiamen Purple Silicon Semiconductor Technology, SiCChip...



Note: Non exhaustive list of Chinese IP players

Leading IP players in the SiC circuit patent landscape are academic organizations

CONCLUSION

Power SiC Patent Landscape



Global IP landscape

SiC SUBSTRATE TECHNOLOGY

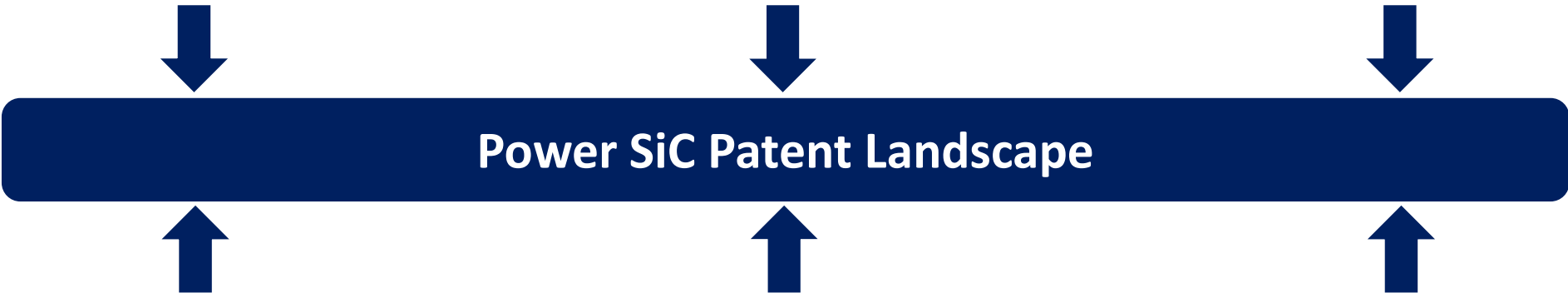
- US and Europe: few IP newcomers, established players → disruptive technologies
- Japanese IP leaders → markets
- Numerous IP newcomers in Asia and stand-out IP players showing up

VERTICALLY-INTEGRATED INNOVATION

- IP leaders: patent portfolios covering the whole supply/value chains
- Few companies have the capability to achieve vertically-integrated innovation → spurs M&A, cooperation & licensing
- Combined with a global patenting activity → secures the leadership in power SiC market

SiC POWER DEVICE TECHNOLOGY

- IP leaders extend the geographic coverage of their patent portfolios
- Notable differences in the IP strategy of main market players



Chinese IP landscape



- SiC wafer industry building on the strong academic background
- Numerous IP newcomers (bulk SiC / SiC epitaxy)

- Emergence of vertically-integrated players → Large state companies paving the way

- SiC industry building on the existing infrastructure in power electronics & compound semi (opto)electronics
- Power device makers extending their IP activity to downstream supply chain

LEADERSHIP BEING TRANSFERRED FROM RESEARCH ORGANIZATIONS / STATE-OWNED COMPANIES TO PRIVATE COMPANIES

THANK YOU!

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www.knowmade.com

Released and Upcoming Power Electronics Reports:

Next-Generation Power Modules (2021) Patent Landscape Analysis



Power SiC (2019) Patent Landscape Analysis



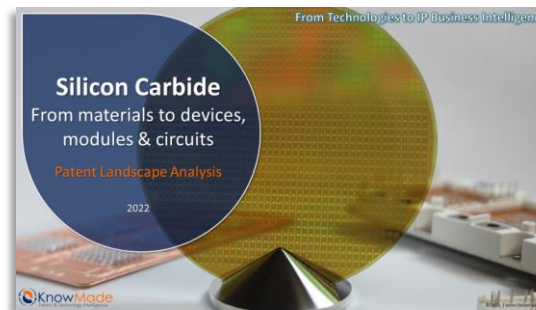
Power GaN (2019) Patent Landscape Analysis



GaN for Power & RF Patent Monitor



Power SiC (2022) Patent Landscape Analysis



GaN Electronics Patent Landscape Analysis (Q4 2022)



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