

Silicon MOSFET
Market and
Technology Trends
2021

Market and Technology
Report 2021



AC: Alternative Current
ADC: Analog to Digital Converter
ADAS: Advanced Driver Assistance System
ASP: Average Selling Price
BEV: Battery Electric Vehicle
BGA: Ball Grid Array
BJT: Bipolar Junction Transistor
CAGR: Compound Annual Growth Rate
CCFL: Cold Cathode Fluorescent Lamp
CTE: Coefficient of Thermal Expansion
DBC: Direct Bonded Copper (=DCB)
DC: Direct Current
EEFL: External Electrode Fluorescent Lamp
EPS: Electric Power Steering
EV: Electric Vehicle
FOM: Figure of Merit
GaN: Gallium Nitride
HEV: Hybrid Electric Vehicle
IC: Integrated Circuit
IGBT: Insulated Gate Bipolar Transistor
IGCT: Integrated Gate-Commutated Thyristor
LEV: Light Electric Vehicle
LV-HV: Low Voltage – High Voltage

MLF: Micro Lead Frame
MOSFET: Metal Oxide Semiconductor Field Effect Transistor
NPT: Non-Punch-Through
OEM: Original Equipment Manufacturer
PCU: Power Control Unit
PDA: Personal Digital Assistant
PFC: Power Factor Correction
PHEV: Plug-in Hybrid Electric Vehicle
PT: Punch-Through
PWN: Pulse Width Modulation
QFN: Quad Flat No leads
Si: Silicon
SiC: Silicon Carbide
SMD: Surface Mounted Devices
SMPS: Switch Mode Power Supply
TIM: Thermal Interface Material
Tj: Junction Temperature
VRM: Voltage Regulator Module
WBG: Wide Band-Gap materials
WLCSP: Wafer Level Chip Scale Packaging
WLP: Wafer Level Packaging

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SCOPE OF THE REPORT

The main purpose of Yole's MOSFET report is to provide a broad and exhaustive overview of the MOSFET devices, applications and supply chain and associated trends.

This report fulfils the following objectives:

- Assess the market for MOSFET components, discrete and module packaged
- Explain the market dynamics for different MOSFET applications
- Identify the key drivers that will shape the market's future
- Provide an overview of the different MOSFET components used in power electronics
- Deliver a concise overview of the different applications driving the MOSFET business and related system topologies
- Present data rankings for the MOSFET industry leaders, describing supply chain consolidation, the latest M&A activity, and future trends across the player landscape

This report covers all MOSFET types and related markets. This includes:

- MOSFET
 - From -40V up to 4700V (including high voltage niche markets)
- Applications such as:
 - Automotive, including electric and hybrid electric vehicles
 - Consumer applications, including smartphones, audio & image and home appliances
 - Telecom and datacom
 - Industrial (motor drives, UPS...)

This report is both application and technology oriented:

- Each important application is targeted, with specific needs and evolutions analyzed, in order to determine challenges to be faced for MOSFET technologies and their impact on the overall market
- Technology evolution is provided

Special focuses are also included in this report, based on current trends both for technology and supply chain organization:

- Chinese supply chain and market, manufacturers and technology
- Focus on EV/HEV and Telecom
- Packaging trends and challenges to face, especially for power modules
- Competition understanding with WBG and Silicon IGBTs

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OBJECTIVES OF THIS REPORT

- Provide an overview of the entire power MOSFET market.
- Analyze the main drivers for MOSFET device applications.
- Provide market metrics and forecasts for MOSFET discrete devices.
- Analyze the silicon MOSFET competition: SiC MOSFET and GaN HEMT and IGBT.
- Provide the overview of the MOSFET supply chain, with the main players and their market shares as well as their product portfolio, with an additional focus on Chinese market.
- Analyze how business models and supply-chains evolve.
- Present main technological trends and ongoing development of MOSFET devices, dice and package levels.



Main drivers, applications and markets



Value proposition of MOSFET power devices

ABOUT THE AUTHORS

Biographies & contacts



Dr. Ana VILLAMOR

Dr. Ana Villamor is a Technology and Market Analyst for power electronics and compound semiconductors within the Power and Wireless division at Yole Développement (Yole). She participates in many custom studies and reports focused on emerging power electronics technologies, including device technology, and reliability analyses on MOSFETs, IGBTs, HEMTs, Power ICs, etc. She is also involved in various aspects of EV/HEV, and she has acquired in-depth knowledge of the power electronics industry. Dr. Villamor previously worked for Onsemi as a Device Development Engineer, where she obtained her Ph.D. in a collaboration with CNM-IMB-CSIC. Moreover, she holds an Electronics Engineering degree and a master's degree in Micro and Nano Electronics from Universitat Autònoma de Barcelona (SP). She has authored and co-authored several papers, as well as a patent.

E-mail: ana.villamor@yole.fr



Dr. Milan ROSINA

Dr. Milan Rosina is Principal Analyst, Power Electronics & Batteries, at Yole Développement (Yole), within the Power & Wireless division. Milan has 20 years of scientific, industrial, and managerial experience in equipment and process development. He also has experience in due diligence, technology, and market surveys in the fields of renewable energy, EV/HEV, energy storage, batteries, power electronics, thermal management, and innovative materials and devices. Dr. Rosina received his Ph.D. degree from the National Polytechnic Institute (Grenoble, France). He previously worked for the Institute of Electrical Engineering in Slovakia; Centrotherm in Germany; Fraunhofer IWS in Germany; CEA LETI in France; and at Direction of Research and Innovation, ENGIE.

E-mail: milan.rosina@yole.fr



Abdoulaye LY

Abdoulaye LY is a Technology & Market Analyst specializing in Power Electronic Systems at Yole Développement. As part of the Power Electronics & Wireless division at Yole, Abdoulaye's expertise is focused on power electronics system design.

Prior to Yole, Abdoulaye served as an electrical engineer and power electronics system engineer at Centum Adetel Transportation Solution for 3 years, where he was in charge of converter design. He also performed simulations for catenary free tramways, tested qualifying auxiliary power supplies (APS) for railway applications and managed a team developing a new battery cooling system.

Abdoulaye graduated with a 2 years technical degree in 2014 from Bethune University Institute of Technology and in 2017 and received an electrical engineering degree from Grenoble Institute of Technology.

E-mail: abdoulaye.ly@yole.fr

COMPANIES CITED IN THIS REPORT

Alpha & Omega Semiconductor, Amkor, ASMC, Bosch, Central Semiconductor, Comchip, CR Micro, Daco Semiconductor, Diodes Incorporated, Episil, Global Wafers, HHGrace, Infineon, Littelfuse, Magnachip, Microchip, Macmic, NewPort Wafer Fab, Nexperia, Nuvoton, NXP, Onsemi, Panasonic, Powerchip, Renesas, Rohm, Sanken, Semipower, Shidengen, ShinEtsu, Sicamore, SiEn, Silan Microelectronics, Silterra, SMIC, ST Microelectronics, Sumco, Texas Instruments, Toshiba, Tower Semiconductor, Trinno, UTAC, Vanguard, Vincotech, Vishay, Vitelic and more.

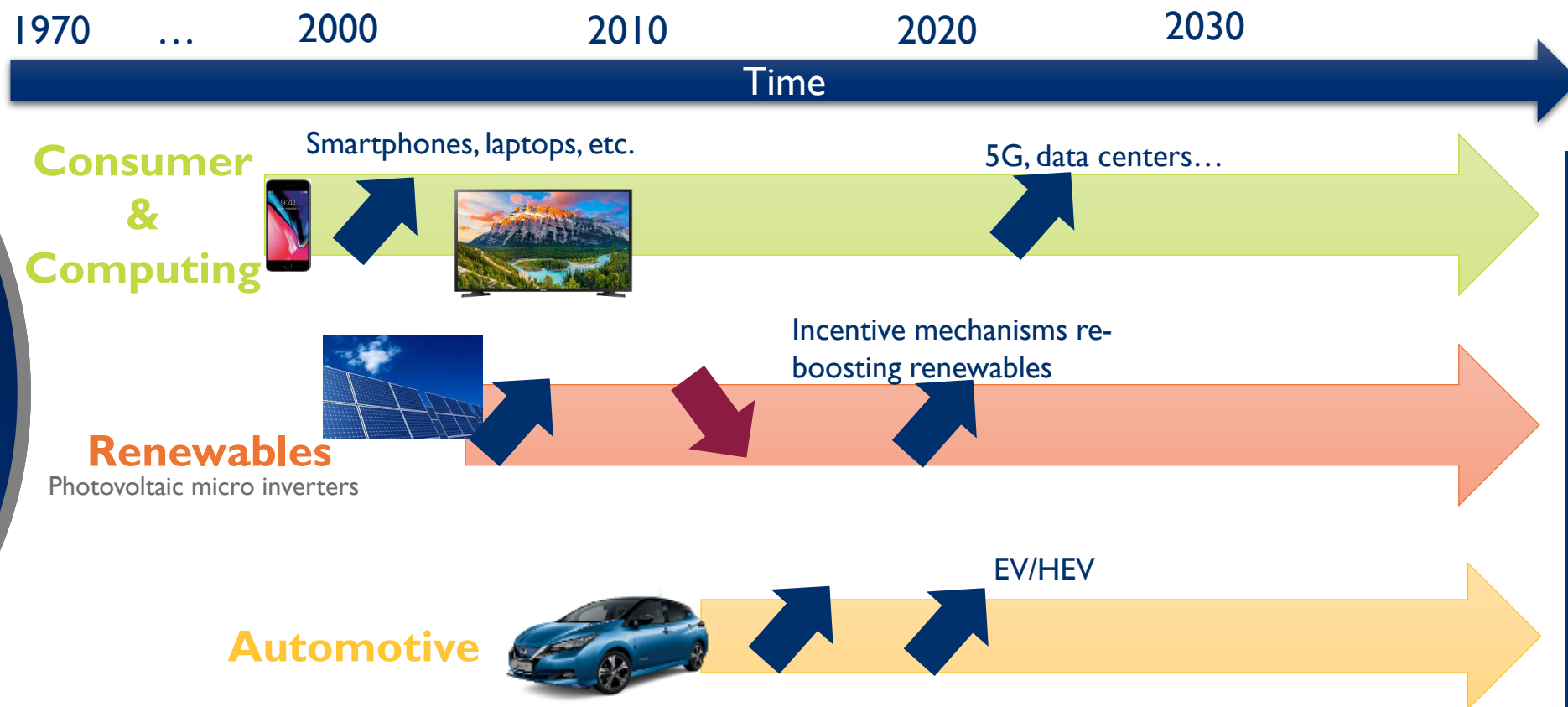
WHO SHOULD BE INTERESTED IN THIS REPORT

- MOSFET device suppliers wishing to identify the most promising markets, new and old growing MOSFET applications and business strategy approaches to adopt in face of growing adoption of SiC-MOSFET and GaN devices.
- Device integrators looking for technology trends and MOSFET suppliers.
- Investors and big companies evaluating investment into increasing MOSFET manufacturing capacities.
- Wafer and equipment manufacturers seeking for understanding the quantitative evolution of the future demand for MOSFET industry.
- R&D teams involved in developing new MOSFET device designs and device packaging solutions.

DRIVING APPLICATIONS - HISTORICAL PERSPECTIVE



Today, the automotive segment, especially EVs/HEVs, drives both technological development and market demand.



Historical MOSFET applications are still demanding high volumes MOSFETs.

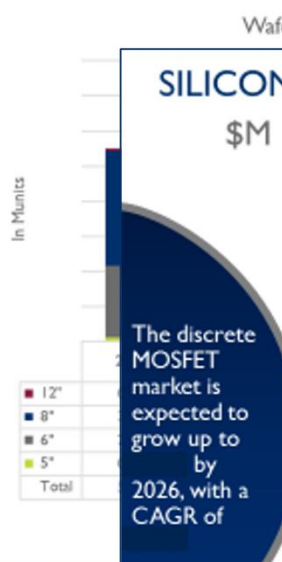
EV/HEV boom and growing number of electrical systems in the vehicles boost even further the need of MOSFETs in automotive.



WAFER STARTS MARKET FORECAST 2019-2026, IN MUNITS

Diameter evolution

The demand for MOSFET has decreased, thus the demand of wafer starts has also been impacted.



The discrete MOSFET market is expected to grow up to by 2026, with a CAGR of



Wafer starts per year forecast for Silicon MOSFET

SILICON MOSFET DISCRETE MARKET - METRICS AND FORECASTS

\$M

Discrete Power MOSFET market 2020-2026 (\$M)

COVID-19 impact Fast market recovery in 2021

Toit Développement - August 2021

SILICON MOSFET MODULE MARKET - METRICS AND FORECASTS

\$M

- BESS
- Autom
- Medica
- EV
- EV_DC
- PV
- UPS
- Industr
- Home
- Consu
- Teleco
- Others
- Total





ESTIMATE OF GLOBAL POWER MOSFET MARKET

Market size, split by voltage

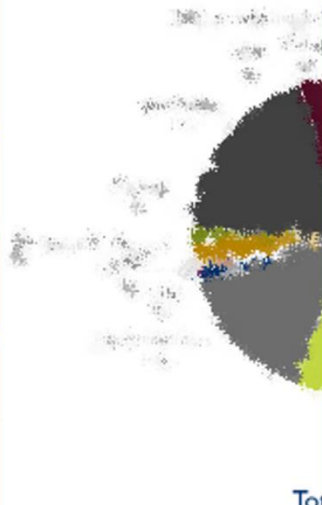
MOSFET market



Total

ESTIMATE OF GLOBAL POWER MOSFET MARKET

Comparison between 2020 and 2026 (discrete + module), split by application

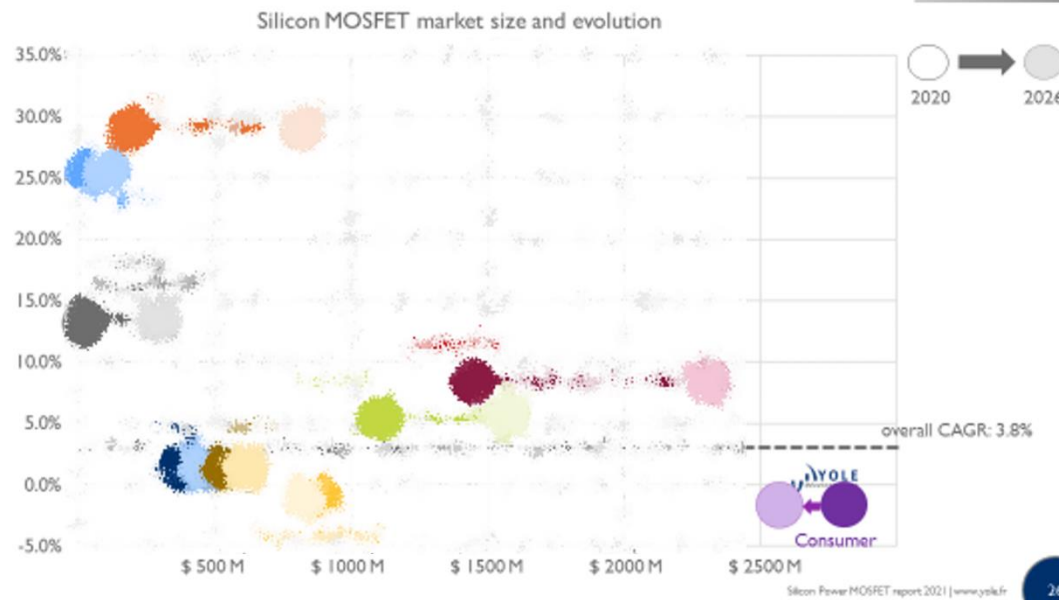


Even if consumer CAGR is expected to be negative due to a decrease of demand in the near future, it continues to be the largest segment for Silicon MOSFET

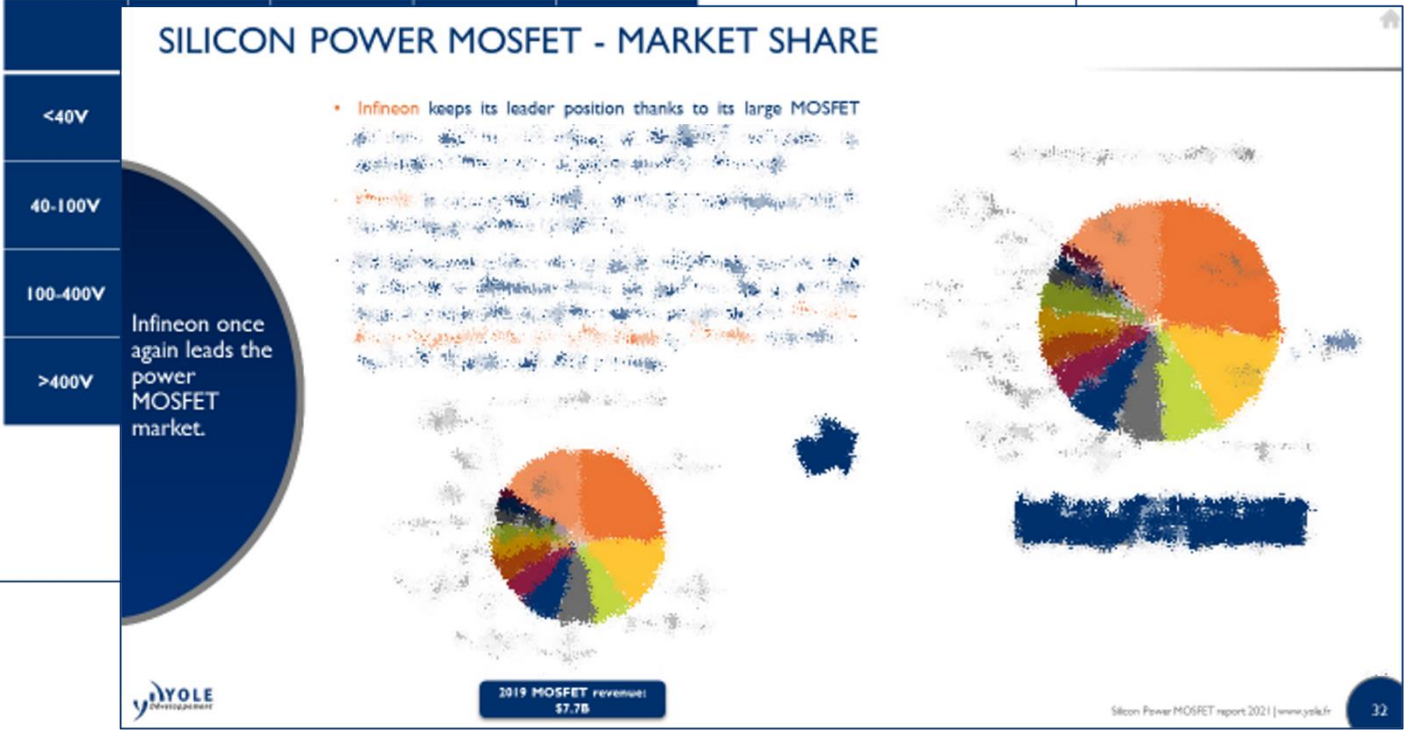
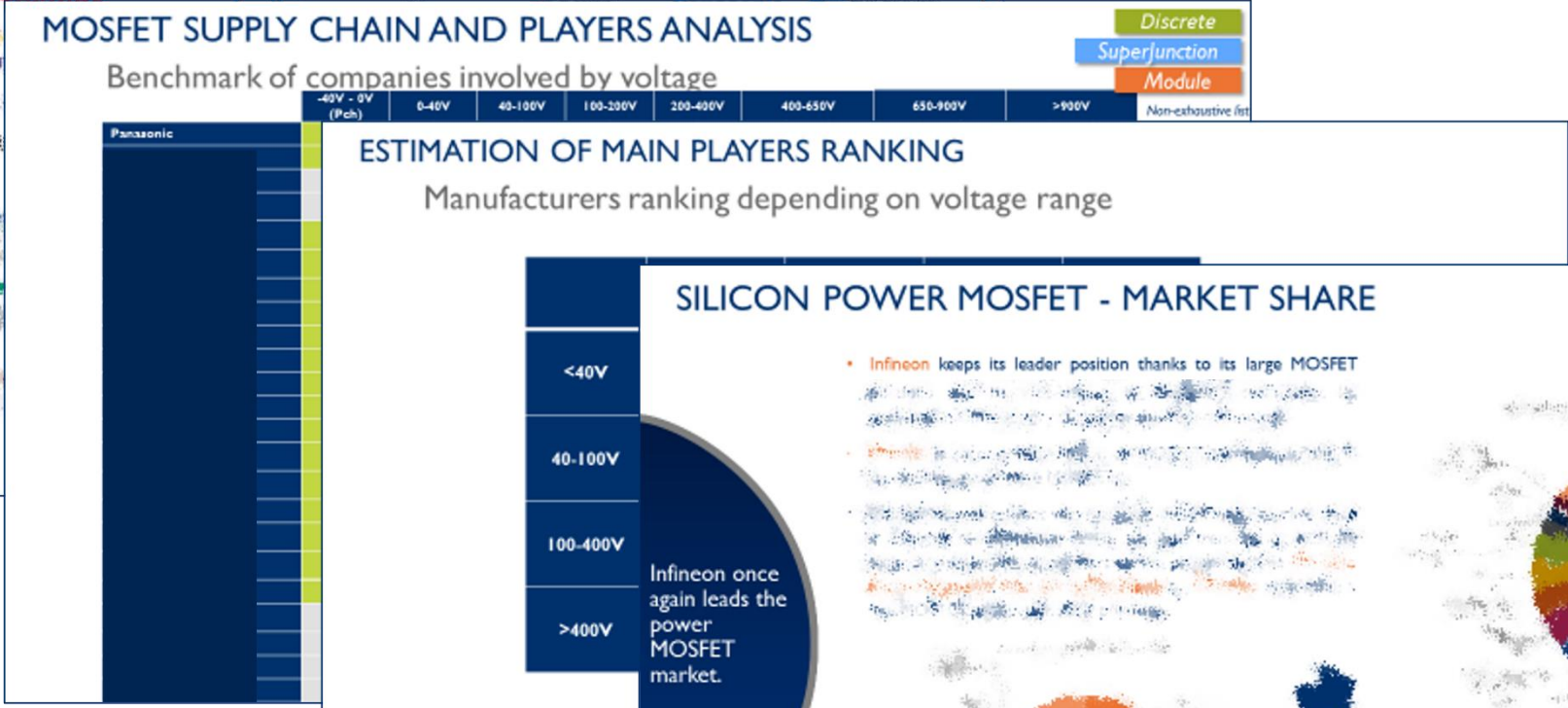
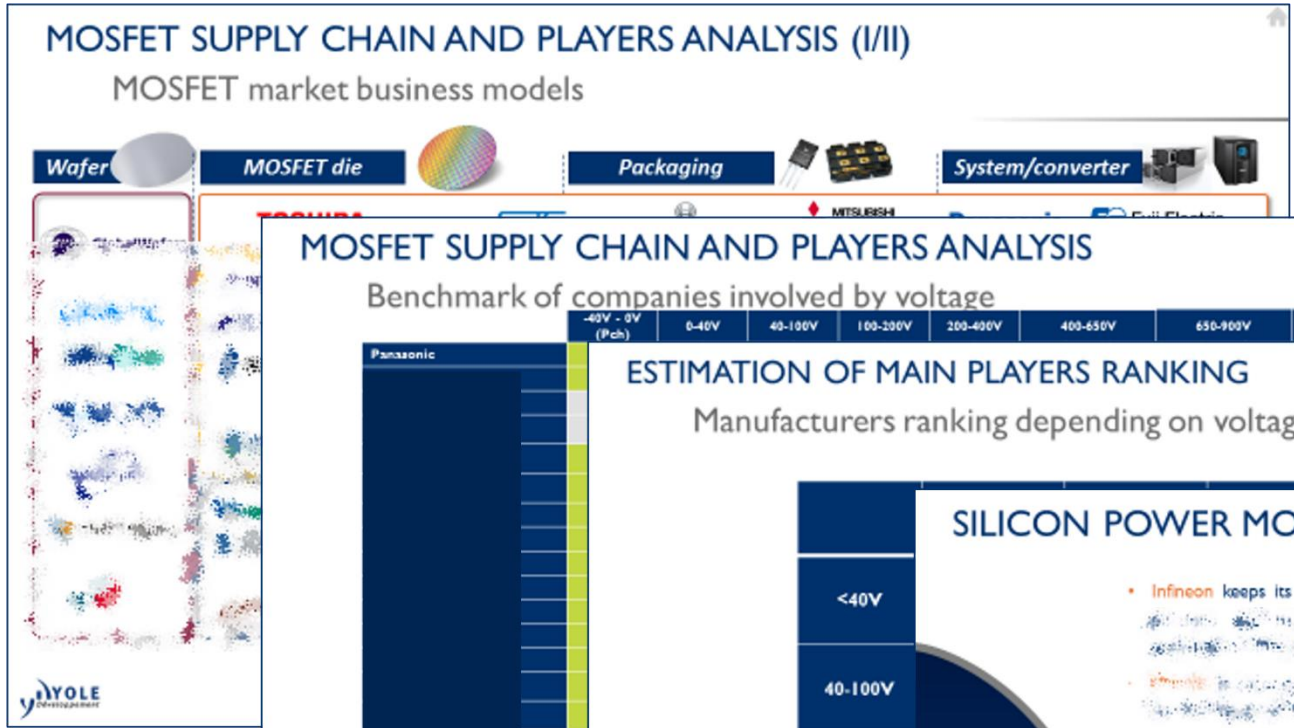
Total

MOSFET MARKET EVOLUTION, PER APPLICATION

Market segment size and evolution - comparison



SUPPLY CHAIN ANALYSIS, BENCHMARKING, MARKET SHARES...



COVID-19 IMPACT IN MOSFET MARKET: AUTOMOTIVE FOCUS

Yole Développement, May 2021

Conversation type with semiconductor manufacturer in Q2 2020

What did semiconductor manufacturer do to not loose cash?

Conversation with semiconductor manufacturer in end Q3 2020

Several OEMs

« Tomorrow I don't use more chips and I don't know when I will need them »

« I need more chips! is increasing so rapidly home-office and lockdown (computers, gaming, etc) »

KEY GLOBAL NEWS: PARTNERSHIPS, M&A, KEY INVESTMENTS

Fujitsu Semiconductor and Onsemi announce strategic partnership

IXYS acquires RadloPulse

ROHM semiconductor acquires PowerView

NXP sells its standard nexperia

nuvoTon

KEY GLOBAL NEWS: MANUFACTURING CAPABILITIES

There are many investments from major MOSFET players to enlarge power semiconductor manufacturing

Infinion stopped production for 6 weeks in Texas's fab due to severe winter storm

nexperia

Q2-2020

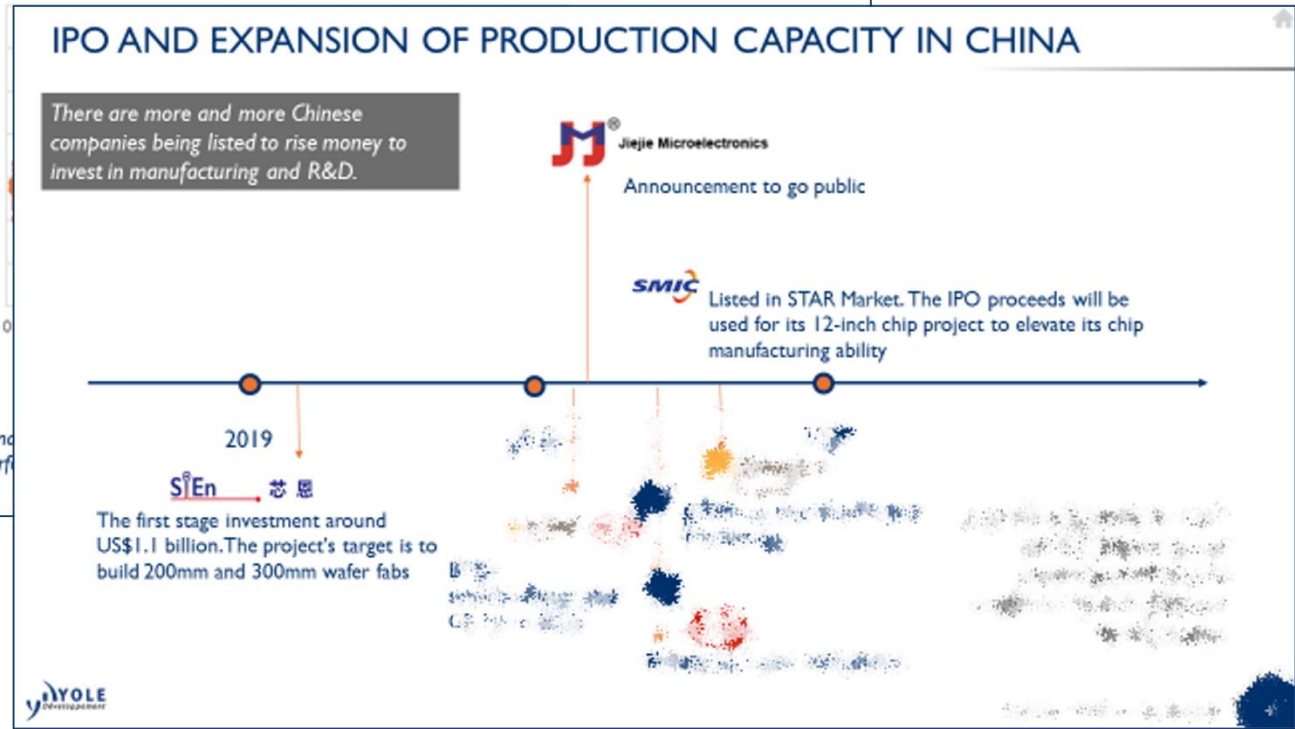
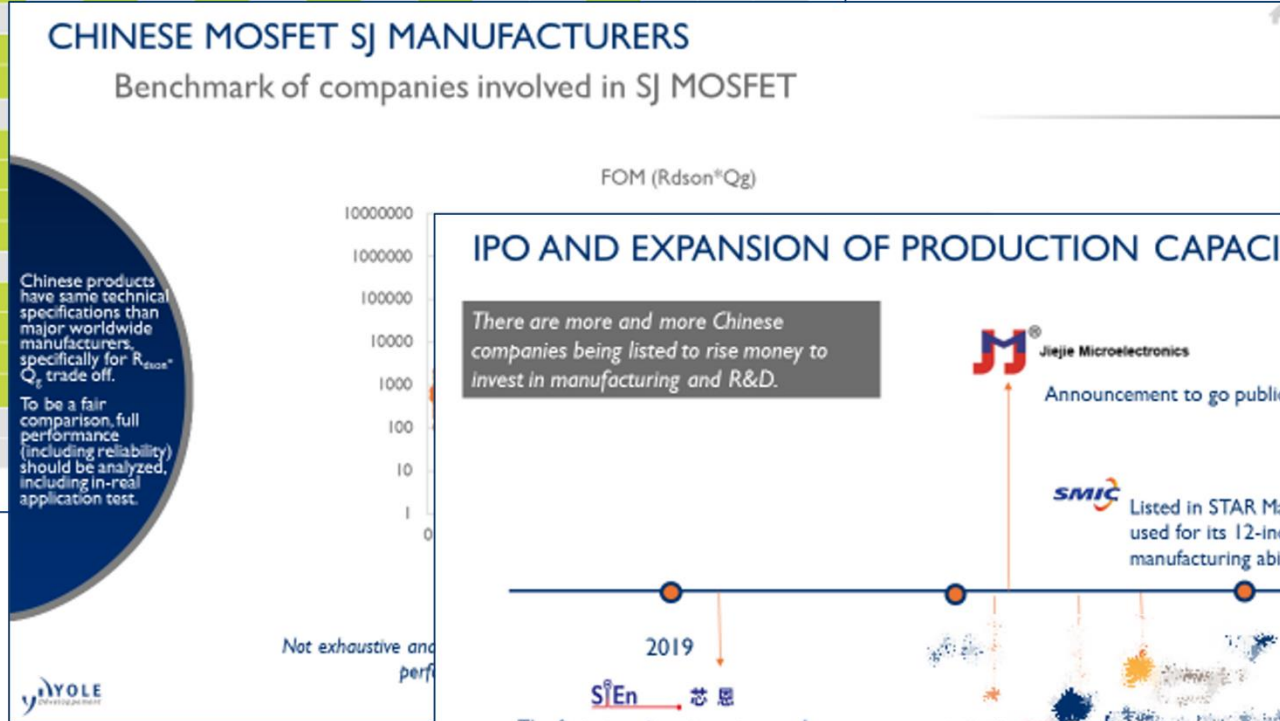
COVID crisis started

2014

2015

Infinion Technologies AG to acquire International Rectifier

Infineon's in market appliances outstanding manufacturer LS Industr



TECHNOLOGY ANALYSIS AND TRENDS

DIFFERENT POWER MOSFET STRUCTURES - SUMMARY

Comparison

	Planar gate	Trench gate VDMOS	Super Junction	Super Junction
--	-------------	-------------------	----------------	----------------

Rdson
Qg
Cell pitch
Die cost*
Voltage range

BV	30V
Rch	
Repi	
Rsub	

Resistive Component

Different technologies have been developed for different voltage ranges to provide better performance



MOSFET TECHNOLOGY EVOLUTION

General scheme

High voltage
Medium voltage
Low voltage

SJ TECHNOLOGY DEVELOPMENT

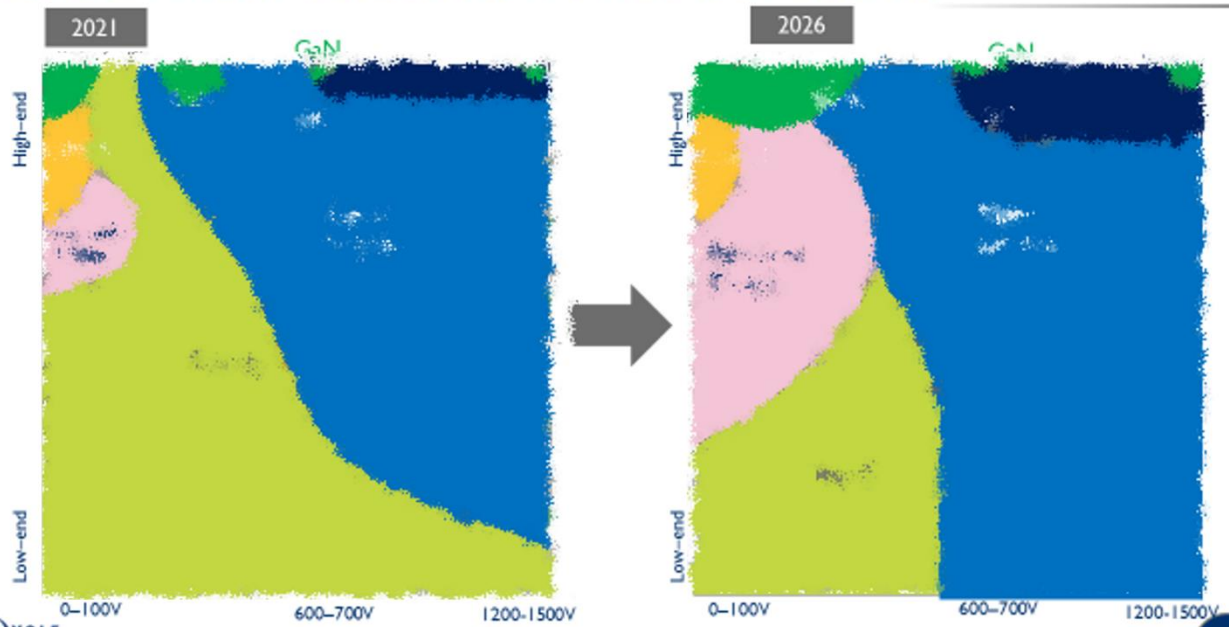
First SJ structures in the market: CoolMOS. Infineon could gain many customers with its early entry, which are still fidel to the company



*Date of technology may differ between companies

Today, both

FUTURE MARKET DEVELOPMENT IN TERMS OF VOLTAGE



*non-exhaustive list

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SILICON MOSFET AVAILABLE COMMERCIAL PRODUCTS

Driven by 12V and 48V battery applications, and

There is a cost-performance trade off and different technologies are chosen to get different performances.

*R_{ds(on)} in mOhm and Q_g in nC
 ** Compiled results include a

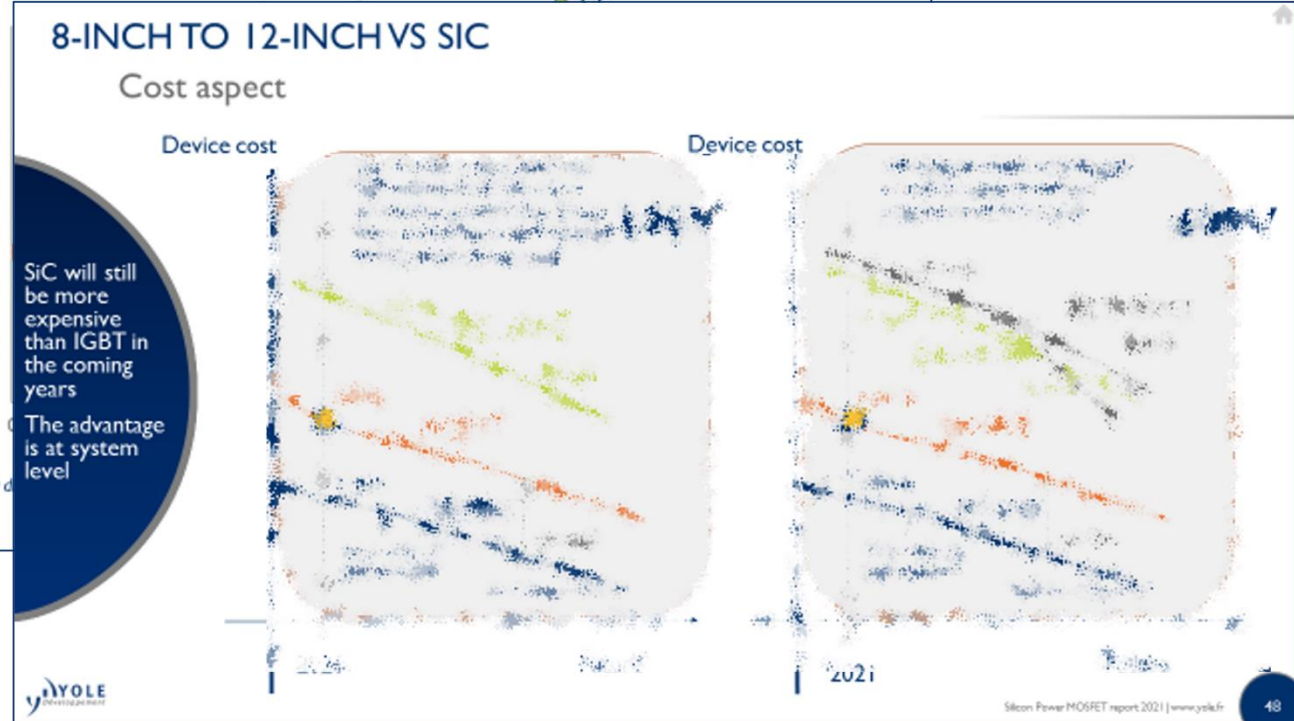
AVAILABLE COMMERCIAL PRODUCTS OVERVIEW

FOM (R_{ds(on)}*Q_g)

● Silicon MOSFET
 ● GaN
 ● SiC

GaN and SiC presents an advantage in performance if compared with Silicon MOSFET

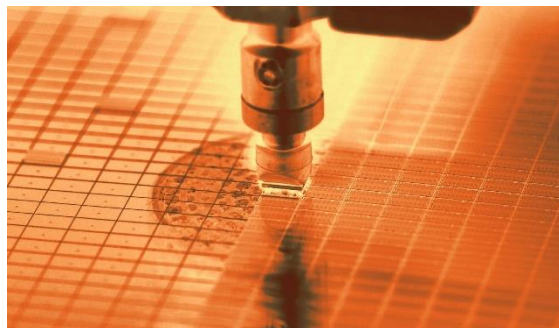
*R_{ds(on)} in mOhm and Q_g in nC
 ** Compiled results include about 3000 d



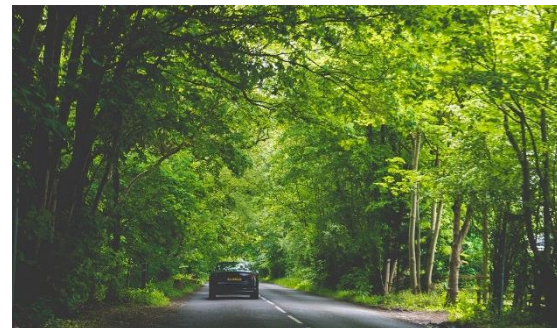
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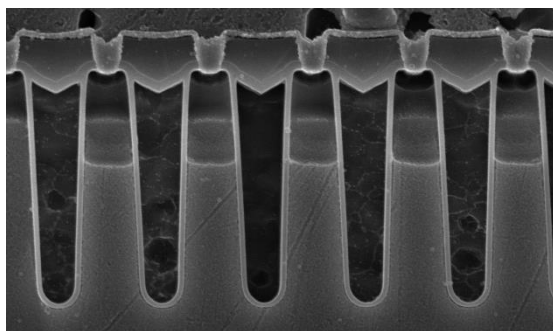
Status of the Power Electronics Industry 2020



Power Electronics for E-Mobility 2021



IGBT Market and Technology Trends 2021



DC Charging for Plug-In Electric Vehicles 2021



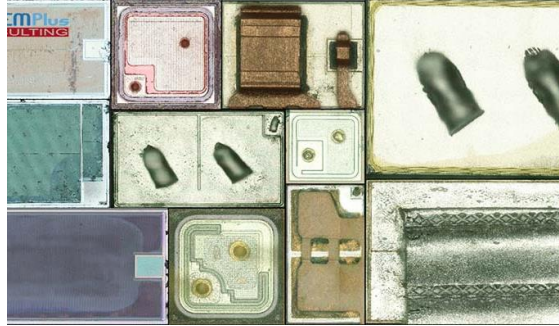
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YOLE GROUP OF COMPANIES RELATED ANALYSES

System Plus Consulting

Automotive Low-Voltage Si MOSFET Comparison 2021



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HOW TO USE OUR DATA?

Yole Group of Companies, including Yole Développement, System Plus Consulting and PISEO, are pleased to provide you a glimpse of our accumulated knowledge.

We invite you to share our data with your own network, within your presentations, press releases, dedicated articles and more, but you first need approval from Yole Public Relations department.

If you are interested, feel free to contact us right now!

We will also be more than happy to give you updated data and appropriate formats.

Your contact: Sandrine Leroy, Dir. Public Relations
Email: leroy@yole.fr





REPORTS, MONITORS & TRACKS

Western US & Canada

Steve Laferriere - steve.laferriere@yole.fr
+ 1 310 600 8267

Eastern US & Canada

Chris Youman - chris.youman@yole.fr
+1 919 607 9839

Europe and RoW

Lizzie Levenez - lizzie.levenez@yole.fr
+49 15 123 544 182

Benelux, UK & Spain

Marine Wybranietz - marine.wybranietz@yole.fr
+49 69 96 21 76 78

DACH (North Germany, Austria, Switzerland)

Neha CHAUDHURY - neha.chaudhury@yole.fr
+49 172 97 47 248

South Germany & France

Martine Komono - martine.komono@yole.fr
+49 173 69 43 31

India and RoA

Takashi Onozawa - takashi.onozawa@yole.fr
+81 80 4371 4887

Greater China

Mavis Wang - mavis.wang@yole.fr
+886 979 336 809 +86 136 6156 6824

Korea

Peter Ok - peter.ok@yole.fr
+82 10 4089 0233

Japan

Miho Ohtake - miho.ohtake@yole.fr
+81 34 4059 204

Japan and Singapore

Itsuyo Oshiba - itsuyo.oshiba@yole.fr
+81 80 3577 3042

Japan

Toru Hosaka - toru.hosaka@yole.fr
+81 90 1775 3866

FINANCIAL SERVICES

- › Jean-Christophe Eloy - eloy@yole.fr
+33 4 72 83 01 80
- › Ivan Donaldson - ivan.donaldson@yole.fr
+1 208 850 3914

CUSTOM PROJECT SERVICES

- › Jérôme Azémar, Yole Développement - jerome.azemar@yole.fr - +33 6 27 68 69 33
- › Julie Coulon, System Plus Consulting - jcoulon@systemplus.fr - +33 2 72 17 89 85

GENERAL

- › Jean-Christophe Eloy, Marketing & Communication
eloy@yole.fr - +33 472 83 01 01
- › Sandrine Leroy, Public Relations
sandrine.leroy@yole.fr - +33 4 72 83 01 89
- › General inquiries: info@yole.fr - +33 4 72 83 01 80

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