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Statut des technologies grand gap, stratégie ST et structuration de la filière française en GaN

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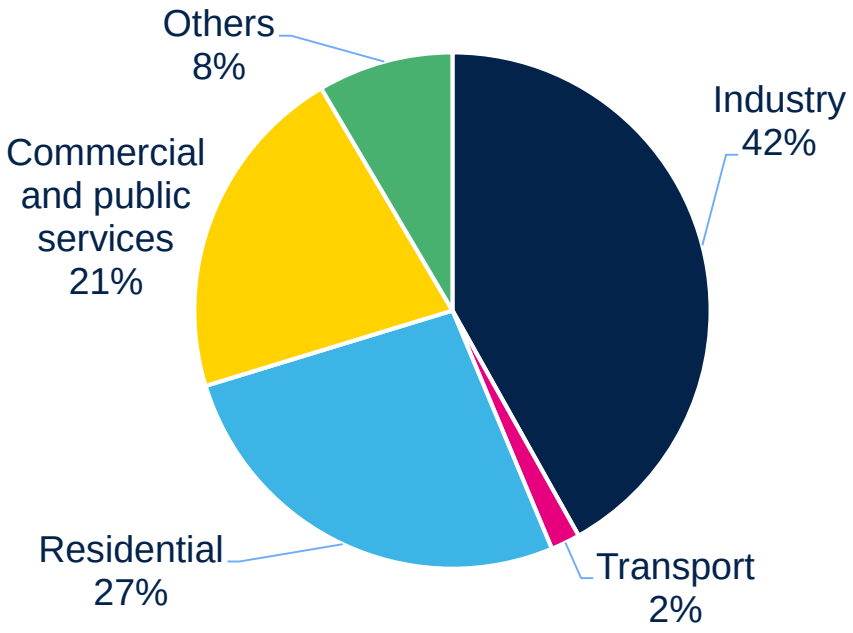
WBG Strategic Marketing Manager
STMicroelectronics Italie

STPOWER

Understanding the impact of global energy consumption

~23,000 TWh: total worldwide electricity consumption (2019)

Electricity Consumption by Sector



1% efficiency improvement in industrial electricity consumption

Would yield total energy saving of **95.6 TWh**

Corresponding to ~ **15 nuclear plants**

32 Million tons of CO2e

11 Million tons of coal equivalent

8 Million tons of oil equivalent

55 Million Barrels of Oil Equivalent

Source: IEA (International Energy Agency)

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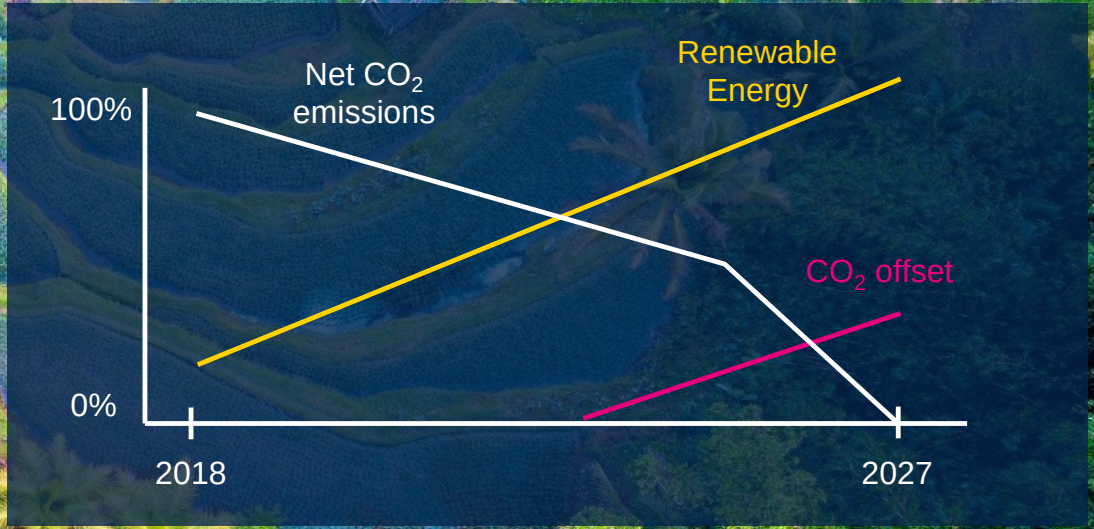
Commitment to Carbon Neutrality

ST will be Carbon Neutral by 2027

Milestones

- Compliance with the 1.5°C scenario (Paris COP21) by 2025
- Carbon neutral by 2027
- Sourcing 100% renewable energy by 2027
- Collaborative programs and partnerships for carbon neutrality throughout our ecosystems



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SiC and GaN target energy-efficient applications

Wide bandgap semiconductors offer superior benefits and characteristics vs. conventional silicon MOSFETs and IGBTs for the power transistor market

Advantages of GaN and SiC	Differences between GaN and SiC
• High−voltage capability • Faster switching speed • Higher operating temperature • Lower conduction resistance (less heat / power dissipation, greater efficiency)	• GaN switches faster than SiC • SiC operates at higher voltages than (lateral) GaN • SiC requires high gate drive voltage

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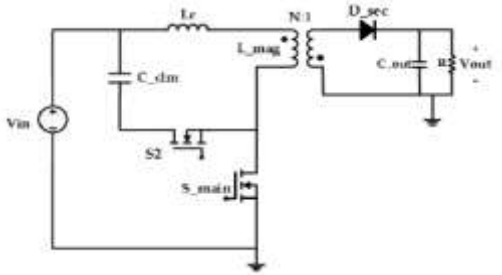
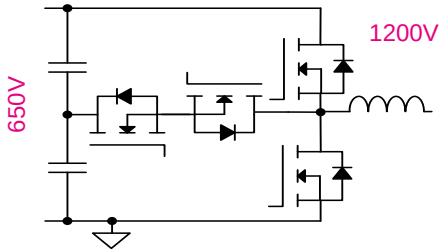
SiC and GaN enable simpler and more efficient topologies

LLC and Active Clamp Flyback in Si and GaN



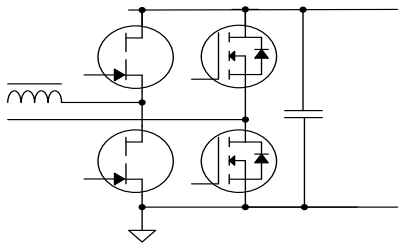
- **Higher frequencies** allowed, less Coss, better time management in ZVS with **GaN**
- **Higher Power density**
- **Higher efficiency** with **same BOM**

3-Level / HB (SiC) like Vienna topologies



- 3-Level becomes **bidirectional** with **SiC**
- **Higher frequencies** allowed (48 kHz+ vs. Typ. < 20 kHz))
- **Higher efficiency** with **same** or **lower BOM**

Totem Pole PFC (SiC and GaN)



- CCM Totem Pole **can only be** done with **SiC** and **GaN**
- **Higher power density**
- **Higher efficiency** with **lower BOM**

Efficiency improvement and BOM reduction

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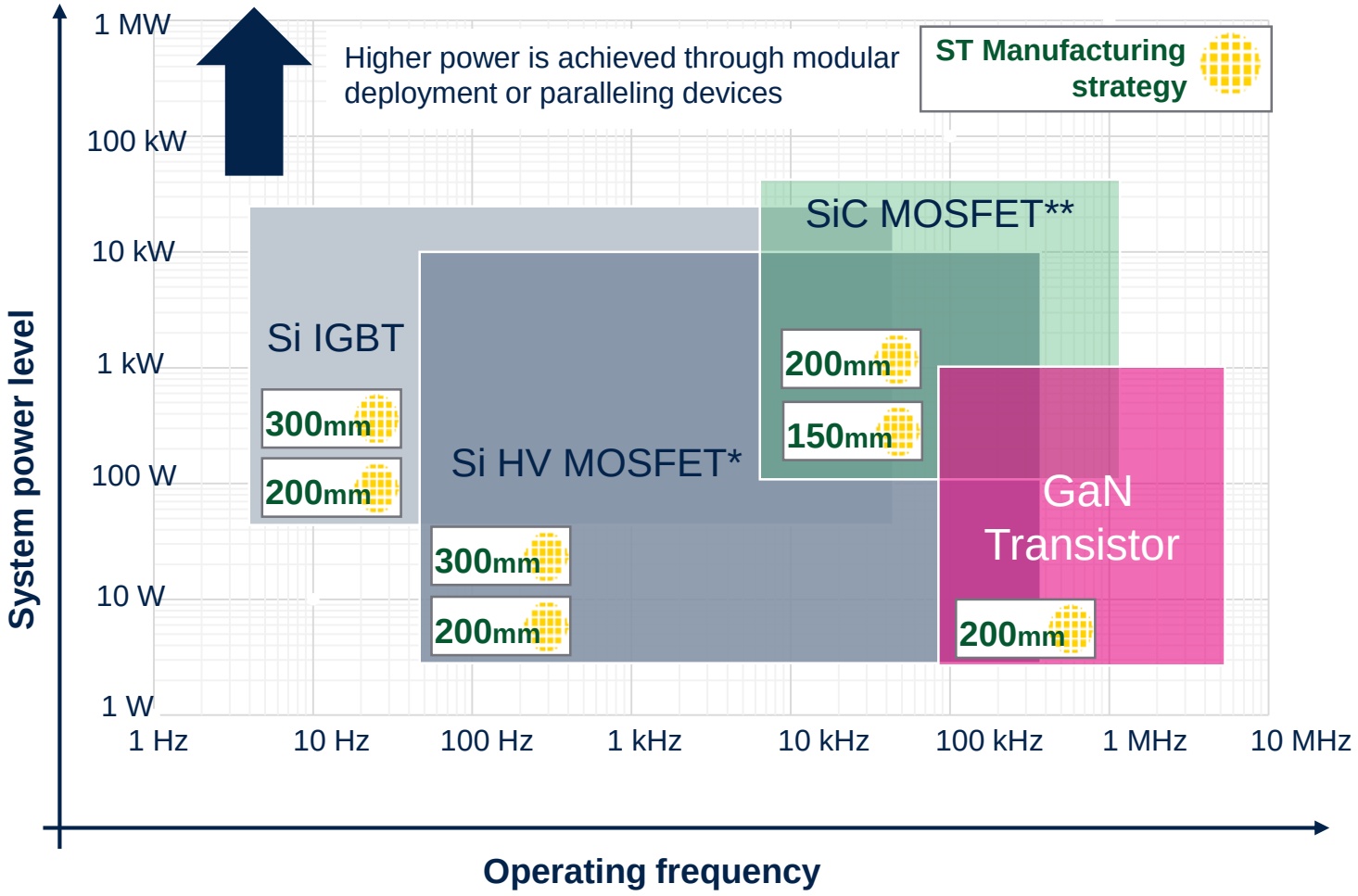
Technologies and manufacturing strategy overview



Existing plants

- SiC 150mm fabs Catania and Singapore
- RF GaN 200mm fab in Catania
- HV Si MOSFET 150mm and 200mm fabs in Catania and Singapore
- IGBT 150mm and 200mm fabs in Catania and Singapore
- Assembly plants in Shenzhen, Muar, Calamba and Bouskoura
- High power module assembly line in Shenzhen

New / Planned plants

- Full integrated SiC facility in Italy
- Power GaN 200mm pilot line in Tours

Outsourcing

- Exploring foundries opportunity for HV Si MOSFET, IGBT and GaN
- Balancing back-end subcontracting

* 300mm: studying future technology expansion for Silicon High Voltage Power MOSFET
** Vertical integrated company through NORSTEL AB acquisition

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Silicon Carbide – latest press releases

7 Jan. 2019
Cree and STMicroelectronics Announce Multi-Year Silicon Carbide Wafer Supply Agreement

19 Nov. 2019
Cree and ST Expand and Extend Existing Silicon Carbide Wafer Supply Agreement

2 Dec. 2019
ST closes acquisition of silicon carbide wafer specialist Norstel AB

15 Jan. 2020
ROHM Group Company SiCrystal and ST Announce Multi-Year Silicon Carbide Wafer Supply Agreement

27 Jul. 2021
STMicroelectronics Manufactures First 200mm Silicon Carbide Wafers

17 Aug. 2021
Cree | Wolfspeed and STMicroelectronics Expand 150mm Existing Silicon Carbide Wafer Supply Agreement

25 Nov. 2021
A*STAR's Institute of Microelectronics and STMicroelectronics Team Up on Silicon Carbide R&D for the EV Market and Industrial Applications

9 Dec. 2021
STMicroelectronics Drives the Future of EVs and Industrial Applications with New Silicon-Carbide Devices


A*STAR's Institute of Microelectronics and STMicroelectronics Team Up on Silicon Carbide R&D for the EV Market and Industrial Applications


STMicroelectronics Drives the Future of EVs and Industrial Applications with New Silicon-Carbide Devices

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ST is the market leader in SiC MOSFETs

Real solutions in production for key global customers and markets

>50%
Today market share

>$1B
SiC revenues in 2024

>90
projects in development

Focus applications and key benefits

50% lower losses

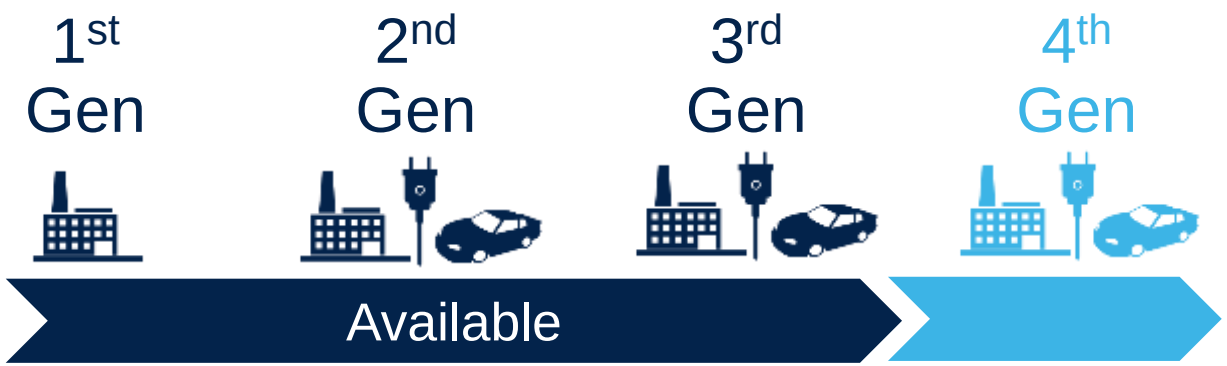
5x Frequency

Increased Power Efficiency

20% Reduced Total Cost of ownership

70-80% reduced/smaller size with an average weight reduction of **50%**

Technology roadmap

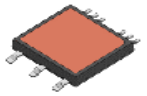


Advanced packaging offer

HiP247-4 leads

HU3PAK

STPAK



ACEPACK SMIT

Bare die

ACEPACK 1 - 2

ACEPACK DRIVE

Source OMDIA - Power Semiconductors Market Share Database – 2021

SiC power industry and supply chain challenges

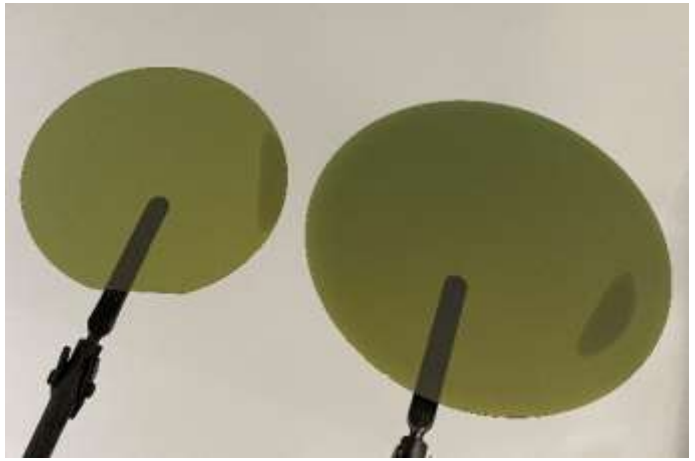
Wafer cost improvement

Quality improvement and reduction of defects

Bulk wafer and epitaxy compatibility

Speed-up migration to 8-inch diameter

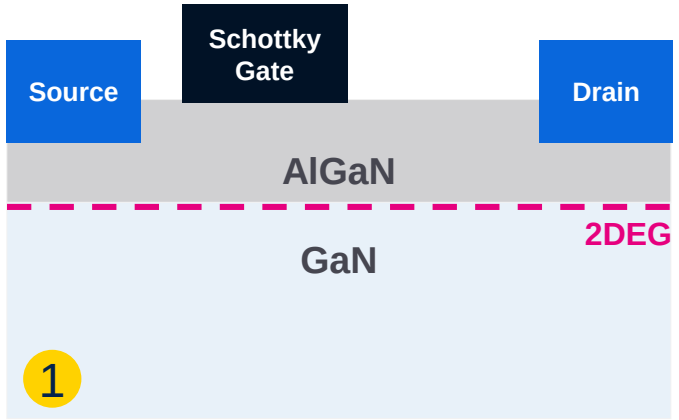
Process-step optimization, automation, and repeatability



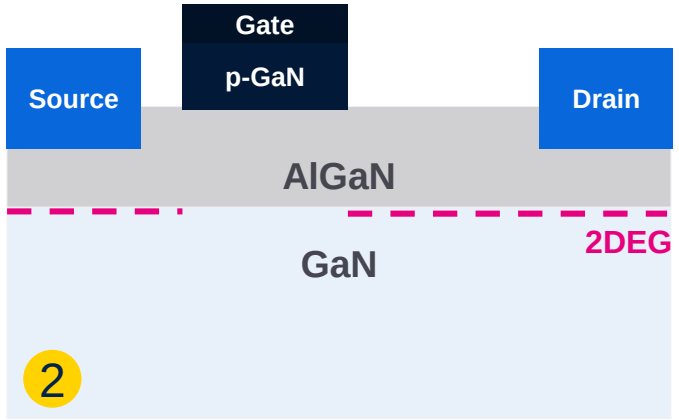
1st Gen DIODE using 8” Demonstrator

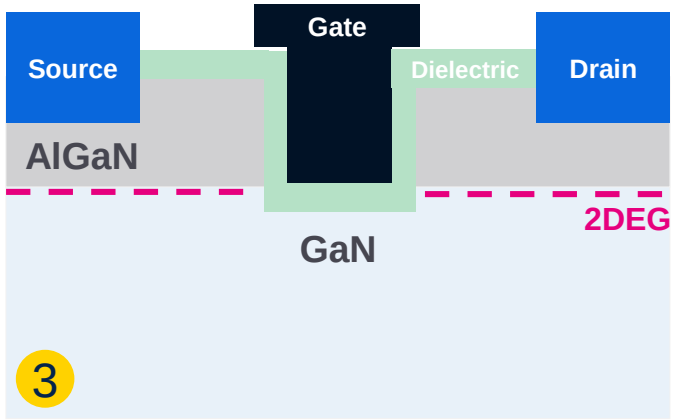
Different GaN HEMT alternatives

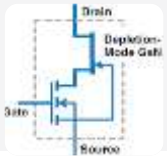
d-mode GaN



e-mode GaN





Normally-off operation		Advantages	Drawbacks
Cascode 	1	▪ Use of standard MOSFET gate driver ▪ Stable Vth>0 of the Si MOSFET	▪ Use of e-mode Si MOSFET in series to d-mode GaN HEMT to create a global e-mode HEMT ▪ Assembly process complexity ▪ Optimized Si MOSFET needed in each application ▪ Not suitable for low voltage (<200V) and high frequency (>500kHz)
p-GaN gate	2	▪ Low resistance under the gate ▪ No dielectric issue	▪ Limited positive gate voltage swing ▪ Trapping effect due to the p-GaN dopant
Recessed gate	3	▪ Minimization of gate leakage ▪ Vth higher than 1V	▪ Not suitable for low voltage channel resistance ▪ Threshold voltage instability due to the traps in insulator ▪ Dielectric impact on device performance (Ron and reliability)

2DEG=bidimensional electron gas

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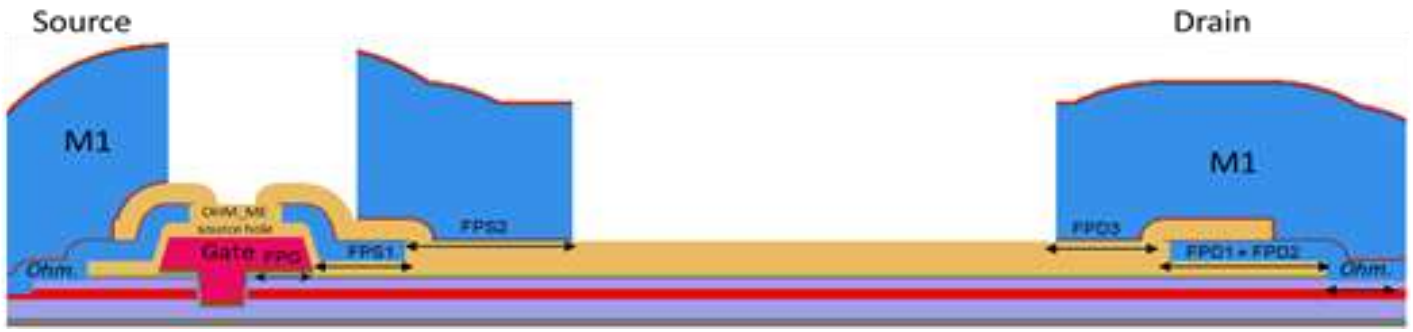
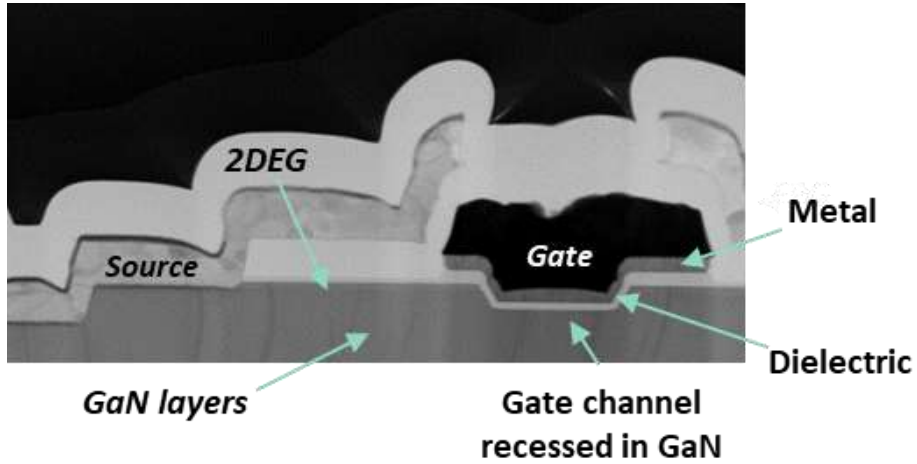
IRT POWERGAN transistor

- New power device based on GaN HEMT with a recessed-MOS gate
- Principle of operation
  - The recess in GaN cut the 2DEG ensuring a Normally-off operation
  - The dielectric inserted between GaN and gate-metal ensure a low gate leakage and a higher endurance with respect to maximum allowed gate voltage

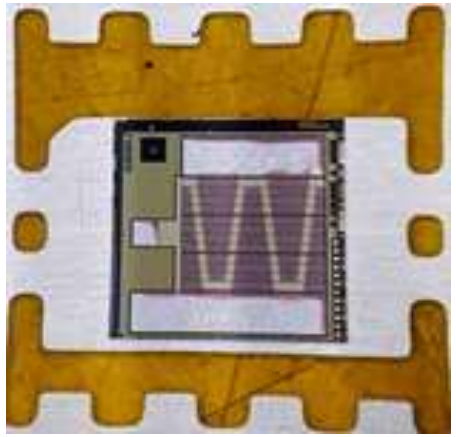


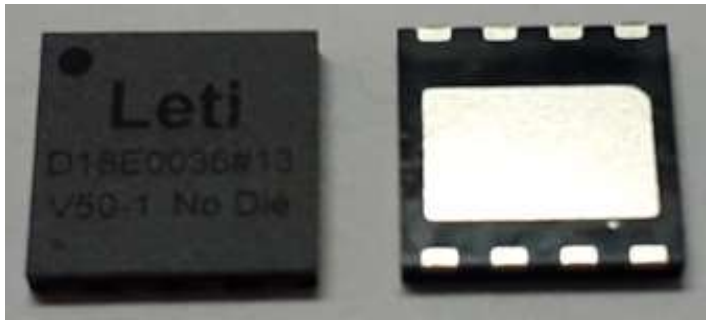


Source: Leti ceatech

IRT POWERGAN transistor

- Main results
  - Normally-off operation obtained thanks to the recessed-gate architecture, with very low level of gate current, and good electrostatic control of the channel
  - A 30nm oxide-based dielectric allows to sustain a 10 years lifetime in terms of dielectric breakdown at a maximum gate voltage of 8V & 150°C (12V@25°C)



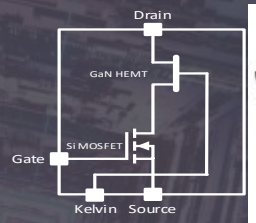
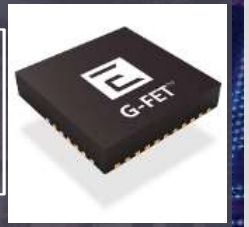
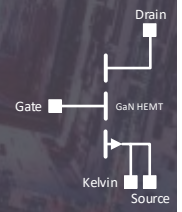
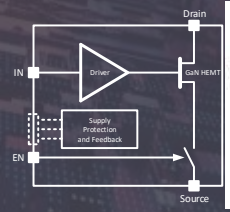
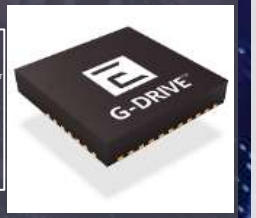


- Process manufacturing fully compatible with ST pilot line

Source: Leti ceatech

PowerGaN* product family

A serious alternative to silicon in power conversion applications

G-FET	**650V** **D-MODE**	 	Very fast, ultra-low Qrr, **robust GaN cascode FET** with **silicon gate drive** for power applications
G-HEMT	**650V and 100V** **E-MODE**	 	Ultra-fast, zero Qrr e-mode HEMT, easily parallelable, for very high frequency and power applications
G-DRIVE**	**650V** **D-MODE**	 	Ultra-fast GaN switch with embedded gate drive to simplify board design and minimize parasitic inductance

(*) The enhanced product portfolio includes devices from Exagan, a subsidiary of ST
(**) For industrial market only

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PowerGaN market segmentation by product family

Performance
Time-to-Market

	Applications	PowerGaN family
Consumer (1)	**Personal Electronics** • Chargers • Adapters • USB PD • Consumer Electronics Power Supply	**G-FET / G-DRIVE, G-HEMT** • Low to mid frequency • Low to mid Power • SiP solutions • Legacy package
Industrial and Telecom (2)	**Smart Industry** • PSU for Telecom • PSU for Datacenter and Servers • Solar • PSU for Industrial Drives	**G-FET / G-DRIVE, G-HEMT** • Mid to very high frequency • Mid to high Power • 100V GaN availability • Legacy and new package
Automotive (3)	**Car Electrification** • On-board Chargers • 400V-12V DC/DC converter • 48V-12V DC/DC converter • LiDAR • Traction Inverter	**G-FET / G-HEMT** ▪ Very high frequency ▪ High Power ▪ 100V GaN availability ▪ Assembly requirements (CSP and KGD) ▪ PCB embedding trends

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Accelerating our GaN execution strategy

Partnerships and acquisitions today → Optimized manufacturing strategy tomorrow

TSMC partnership

Leveraging ST's market expertise and TSMC foundry know-how to bring Power GaN & GaN ICs to market

EXAGAN majority stake acquisition

A step forward in product development and epitaxy expertise for our long-term GaN roadmap, ecosystem and business

External

Complement roadmap by partnering with foundries to improve time-to-market and enable multi-site high volume

Internal

Targeting internal 200mm manufacturing in **Tours** leveraging proprietary technology (100V…650V)

2020 2021 2022 2023 2024 2025

GaN 200 mm line in Tours
New Building, clean room & full production line…

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GaN 200 mm line in Tours
… mastering Epitaxy step

ST GaN ecosystem

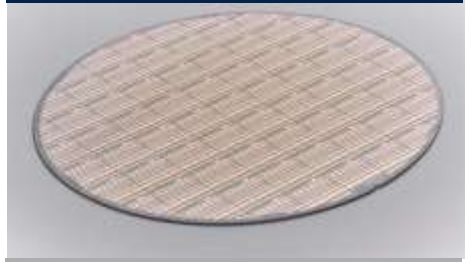
People

Dedicated R&D experts in new WBG materials and power solutions to replicate a new successful story on GaN as already done with SiC, Power and Smart Power Technologies

Application knowledge

ST can leverage on an unmatched knowledge of power systems to take the full benefits of GaN products in any applications

GaN Technology



ST is the sole supplier capable of offering a comprehensive PowerGaN product line-up covering main application domains

Package Technology

ST can offer a robust family of packages with enhanced thermal performances through the exposed top metal and reduced parasitic thanks to bond wire free technologies

Manufacturing

ST can leverage on in-house Si fabs with easy scaling up for high volume production and established supply chain.
In house epy-wafers manufacturing as key enabling factor for strategic supply chain independency

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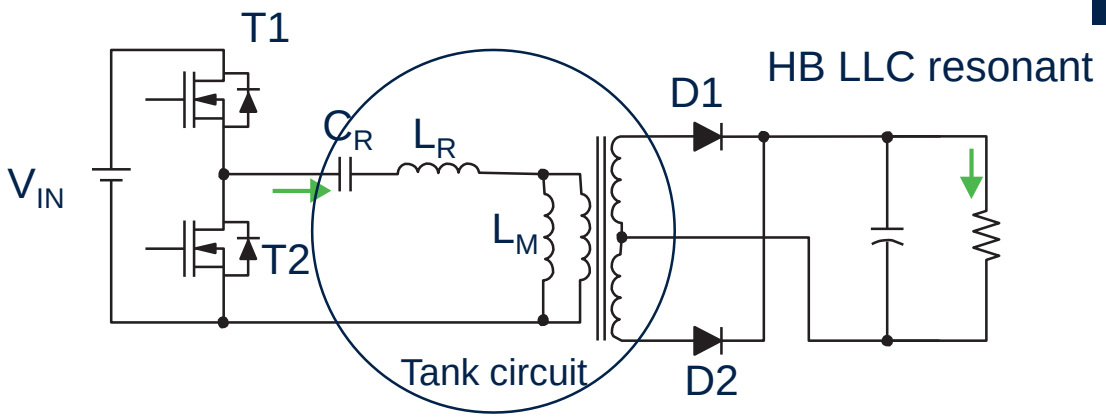
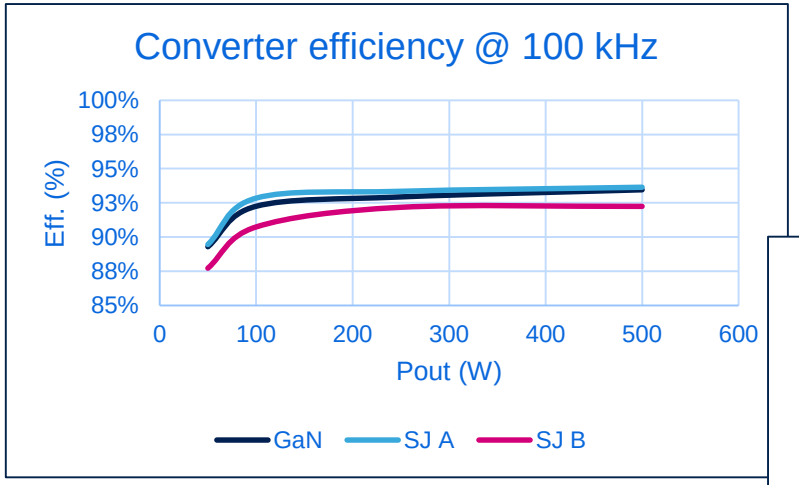
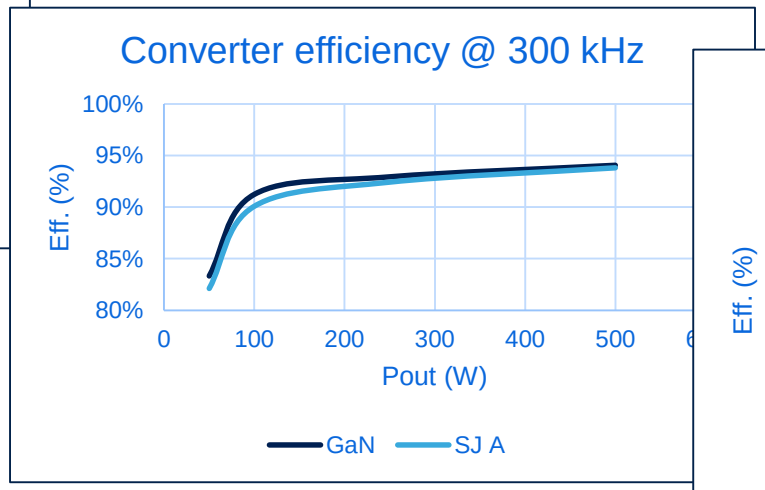
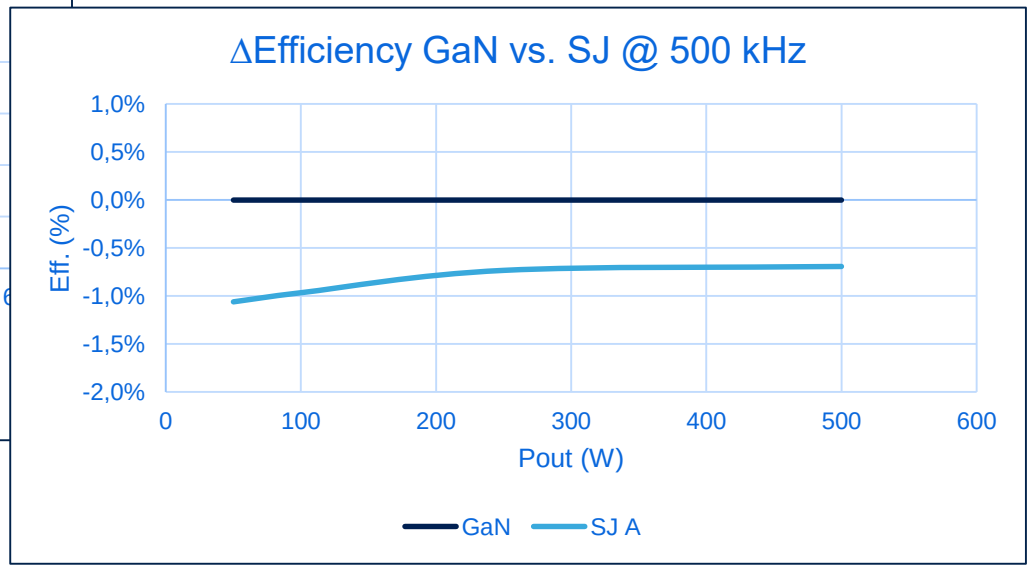
PowerGaN vs. Silicon MOSFET

Device	BV_{DSS} @ 1mA [V]	V_{GSth} @ 250 µA [V]	$R_{DS(on)}$ @ 5A [mΩ]	Chip size Normalized %
GaN	700	1.14	113	22.9
SJ A	645	4.38	114	90.5
SJ B	635	4.18	112	100









Points clés à retenir

- Les semiconducteurs à grand gap répondent aux exigences de l'économie décarbonée et à celles de la transition énergétique permettant d'améliorer l'efficacité de conversion systématiquement
- ST poursuit une stratégie globale sur les produits à grand gap
- Présence solide dans le marché des voitures électriques grâce aux composants (MOSFETs) en SiC
- Coopération en cours avec l'IRT Saint Exupéry: SiCRET. GaNRET prochainement. ECSEL: TRANSFORM et GaN4AP
- Feuille de route complète en GaN
- La filière du GaN s'appuie sur un écosystème de compétences industrielles et de recherche avancée

PowerGaN program has been supported by ANR under the convention ANR-10-AIRT-05

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Our technology starts with You

Find out more at www.st.com/stpower

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