Strengths of IC enhancement-mode GaN

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Cambridge GaN Devices at a Glance

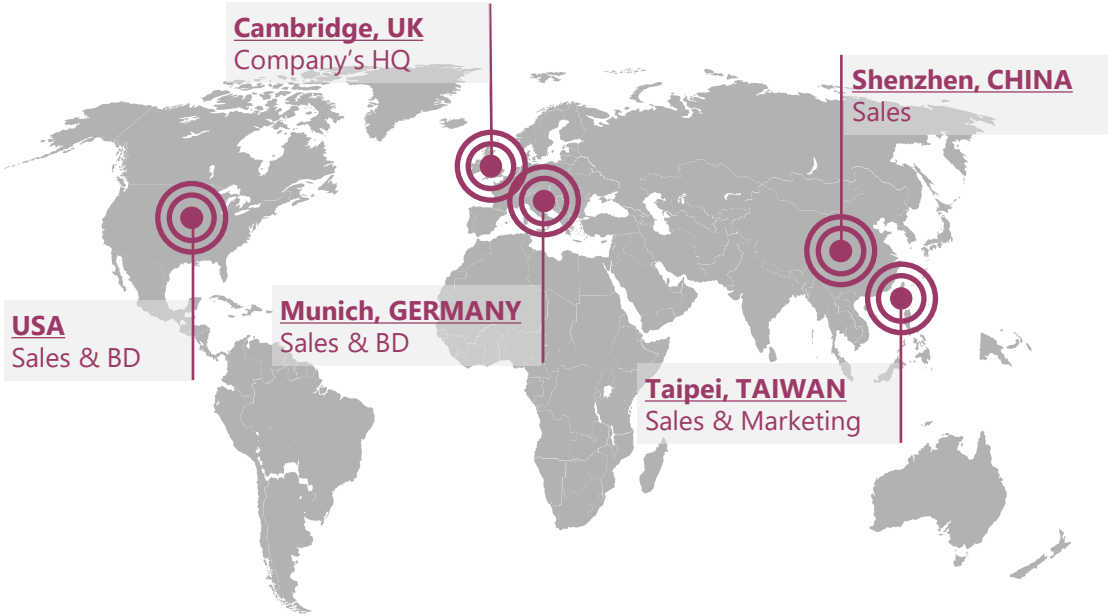
The fast-paced scaleup making green electronics possible

A fabless semiconductor company designing, developing and commercialising **energy-efficient GaN-based power devices and ICs**

Operating from
5
Locations

Innovation
91+
Patent applications

Employees
~60
> 300% growth (2020– 2023)



Knowledge

Academic excellence and industry expertise combined

Innovation

Innovative power solutions that help protect the environment

Sustainability

Eco-compatible business measures (**ESG**)

Collaboration

Cooperation, empowerment, respect, listening to customers, employees and partners

Figures of Merit, Key 600-650 V Power Technologies

Figure of Merit	Si Superjunction *	SiC *	GaN (vs incumbent)	Comments
$R_{DS(On)}$ x Area	100%	20%	30%	Density, Weight, Cost
$R_{DS(On)}$ x Q_{rr}	100%	10%	0	Half Bridge, hard commutation
$R_{DS(On)}$ x E_{oss}	100%	123%	80%	Switching losses, efficiency in e.g. classic PFC
$R_{DS(On)}$ x Q_g	100%	90%	8%	Driving losses, light load efficiency
$R_{DS(On)}$ x Q_{OSS}	100%	17%	10%	Efficiency at high frequency, soft switching
Ease of Use	High	High	Low/Medium	Si and SiC well established and understood
Robustness	High	High	Low/Medium	
Technology	Vertical	Vertical	Lateral	GaN enables integration

* Specific technologies selected

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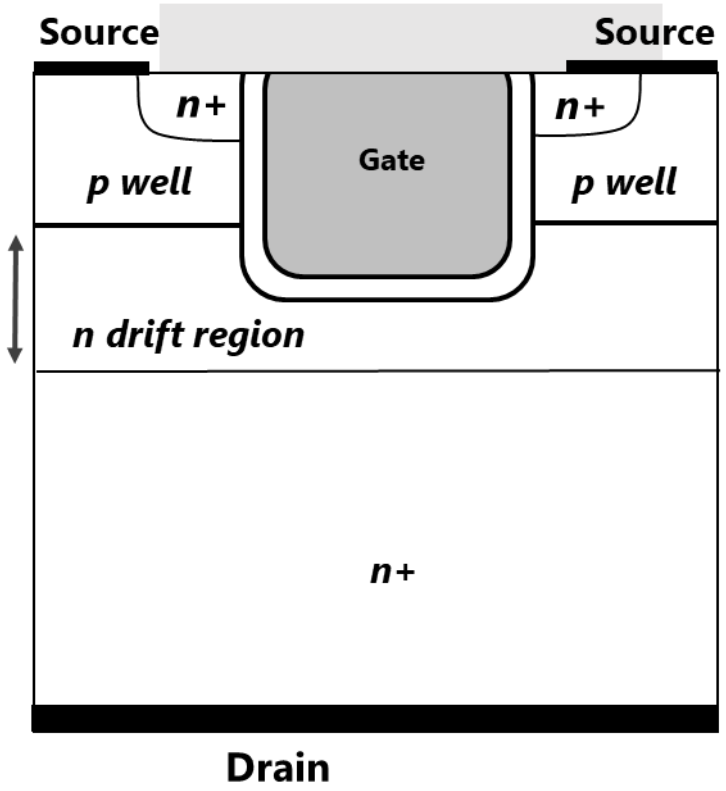
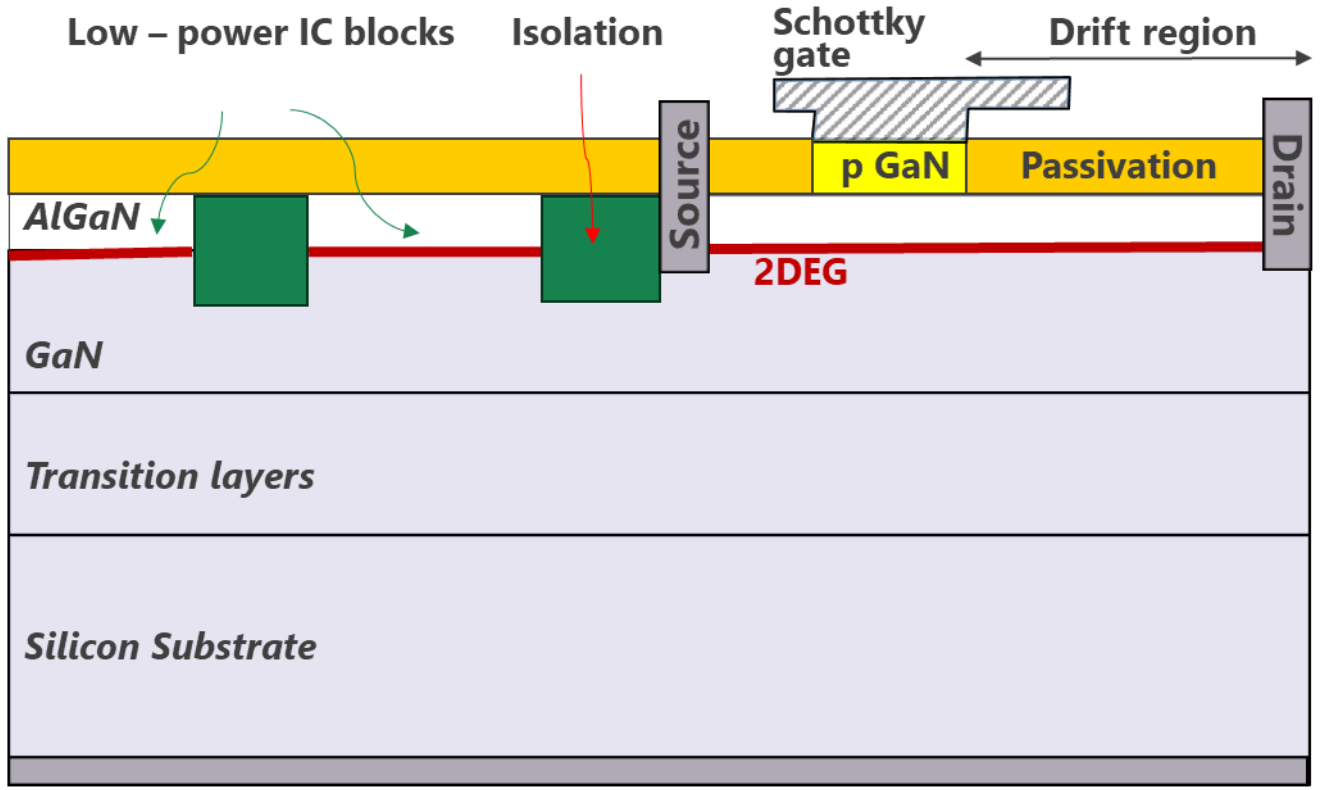
Vertical vs Lateral: Basics and Consequences

SiC MOSFET– Schematic cross section



GaN HEMT – Schematic cross section



Vertical vs Lateral: Basics and Consequences

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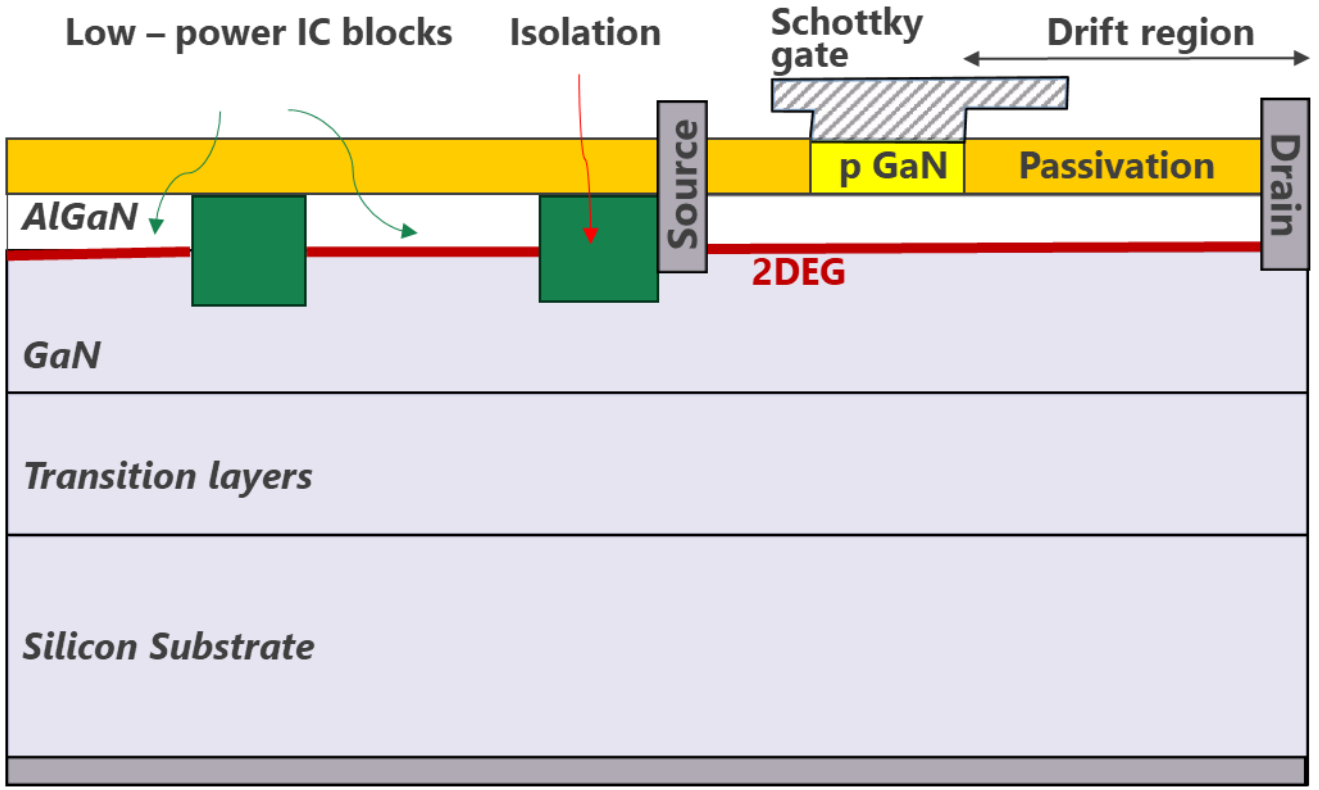
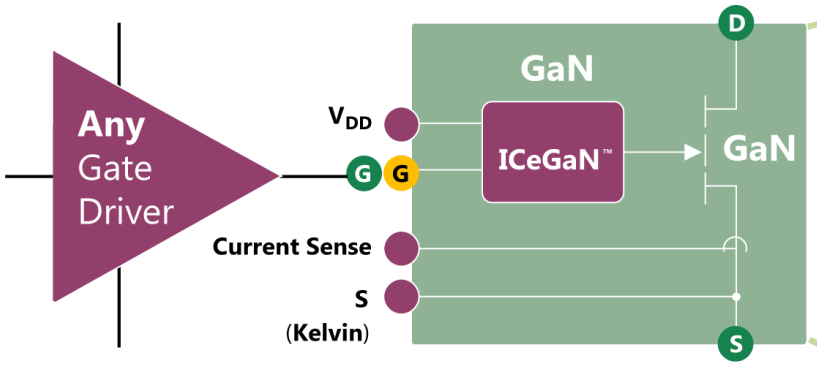


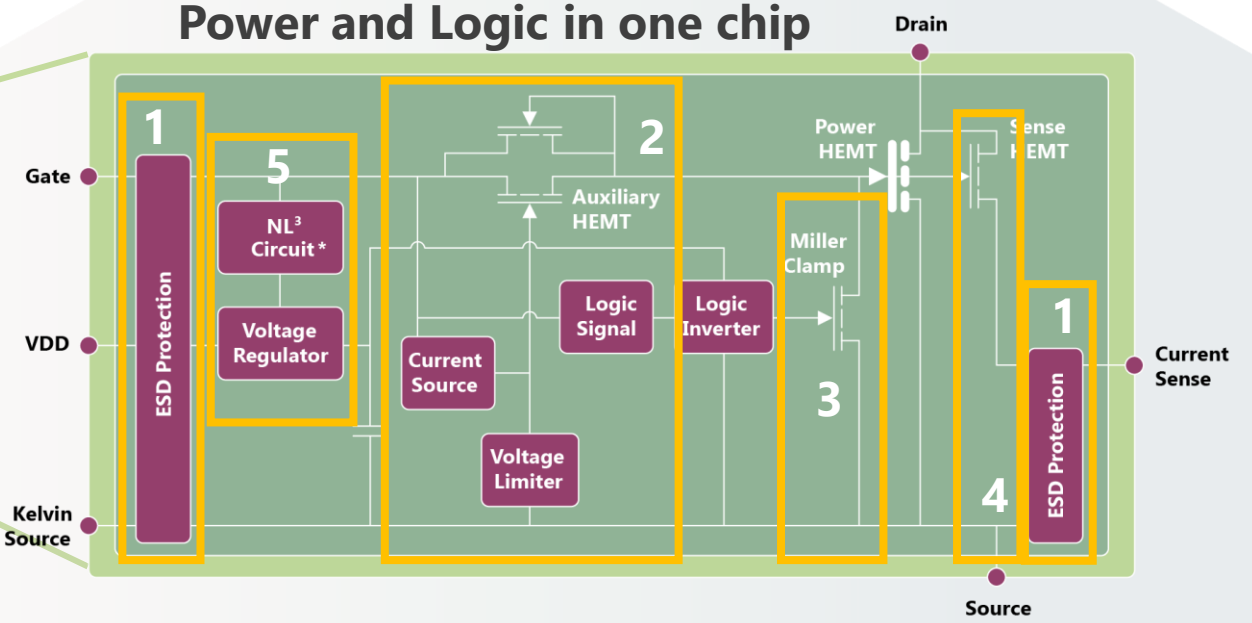
- Due to lateral technology, GaN can incorporate a power HEMT and adjacent, isolated circuit blocks.
- Unlike in vertical switching devices, the substrate does not switch and this offers safer vertical isolation.
- Lateral isolation is provided through isolation regions which remove the 2DEG underneath.
- Integration of multiple structures require the availability of HV and LV cells in the same chip.
- CGD partner with TSMC, all processes are available.

Decades of Research Led to ICeGaN™

Combined system performance and ease of use



High level view



- ✓ Ease of use
- ✓ System performance
- ✓ Scalability
- ✓ System cost
- ✓ Reliability
- ✓ Gate robustness

1. ESD protection on all terminals
2. Gate voltage clamping, higher threshold voltage and extended static (0-20 V) and dynamic (0-70 V) voltage range
3. Miller Clamp and logic to ensure high dV/dt, fast switching and achieve true 0 V turn off
4. High efficiency current source solution
5. No Load Light Load (NL^3) circuit to enable ultra-low power losses when the device is in stand-by mode (H2 series)
6. Slew rate can be adjusted with external Rg

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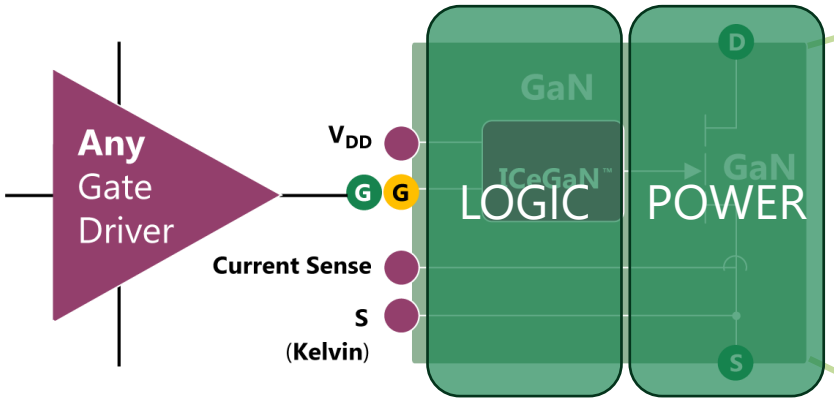

High level view

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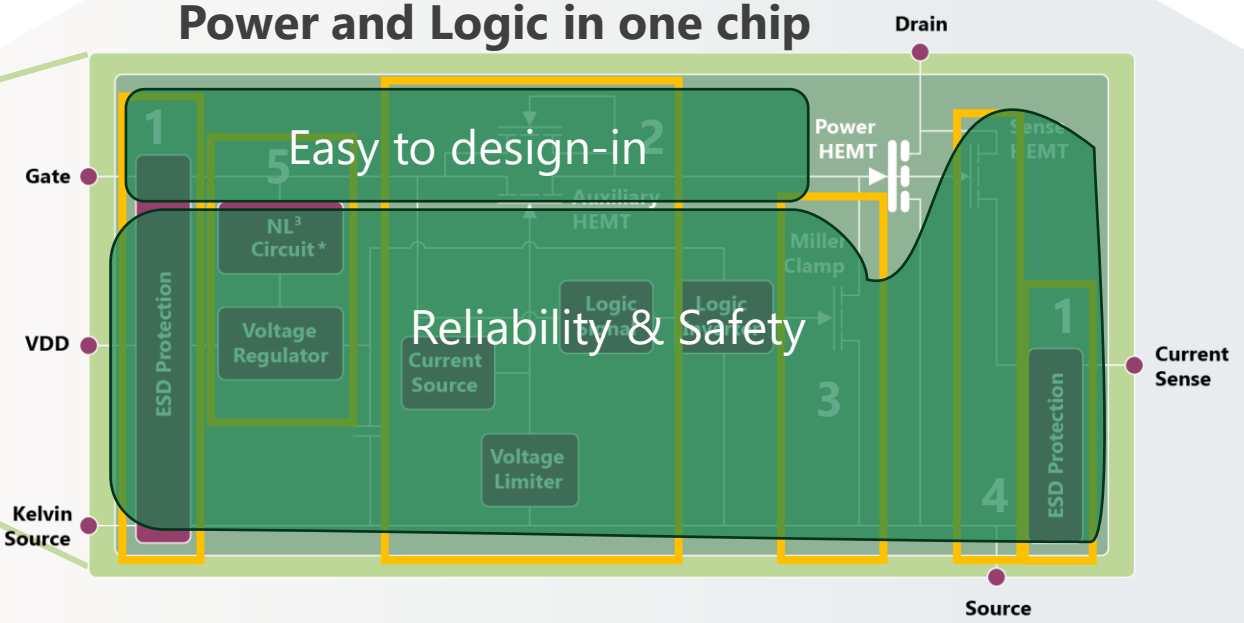
Power and Logic in one chip



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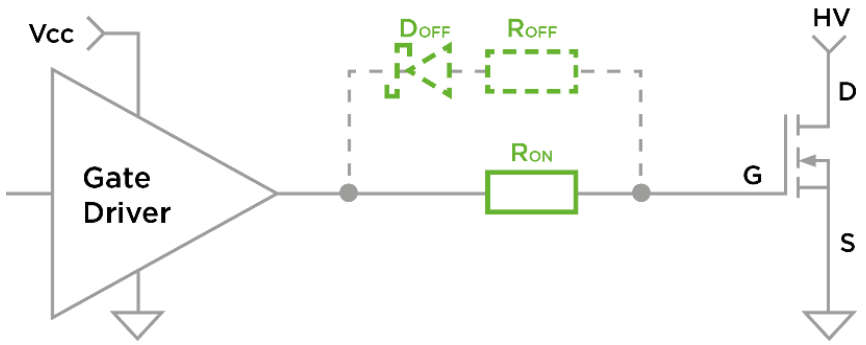
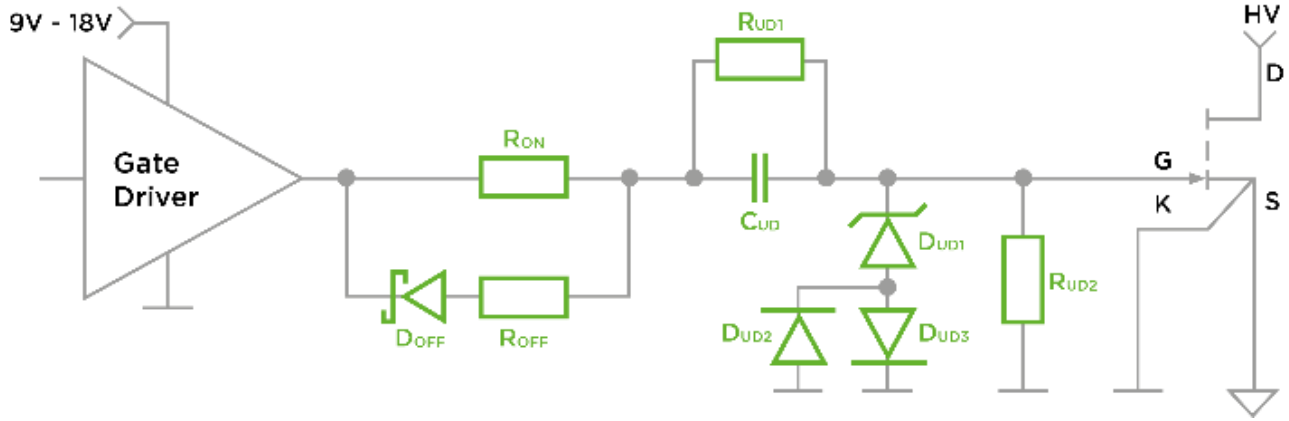
eMode GaN HEMT Is Very Different from MOSFET

Discrete GaN, complex and costly driving circuits are needed

Today's technology: Si or SiC



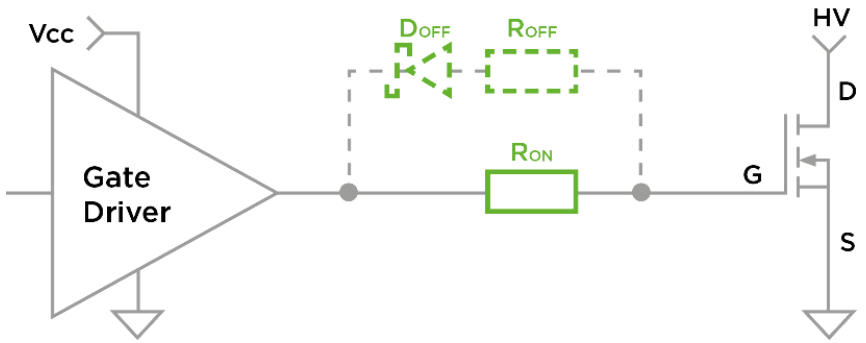
Enhancement Mode GaN technology: if only Power is included



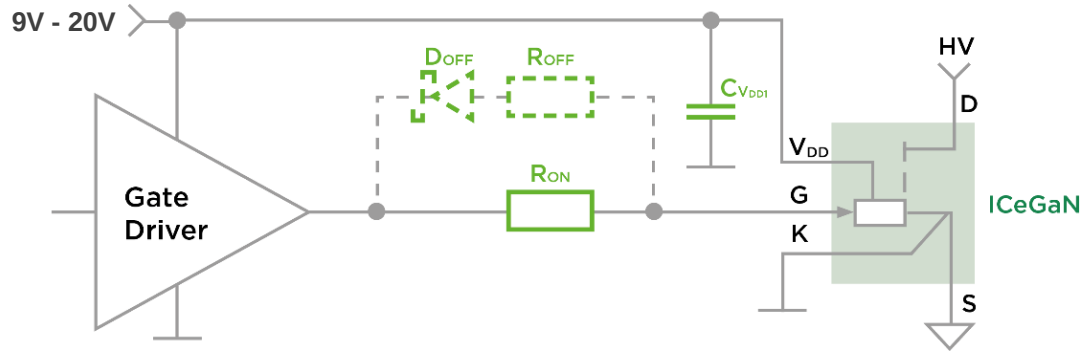
eMode GaN HEMT Is Very Different from MOSFET

If Logic and Power work together, simplicity and robustness are guaranteed

Today's technology: Si or SiC



ICeGaN: all driving complexity is removed



- Threshold Voltage shifted to 3 V
- Outer Gate Voltage up to 20 V
- Inner Gate Voltage is temperature dependent
- TurnOFF is ensured at 0 V, no negative Voltage needed
- dV/dt immunity, gate robustness
- Easy paralleling of multiple GaN HEMTs
- Significant BOM and $ savings

ICeGaN™: $ Advantage - High Power

If Logic and Power work together: advantage for Half Bridge topologies

Half Bridge BOM Costs*
(server, telecom)

with Standard Discrete GaN

38 components	2 ICs needed	BOM cost for 3kW ACDC: > $2

with ICeGaN

15 components	1 IC needed	BOM cost (average for 3kW) ACDC: $1.4

BOM SAVINGS: >30%

Inverter Stage BOM Costs*
(motor drives, home appliances)

with Standard Discrete GaN

3 ICs 3-phase needed	BOM cost for 3 phase motor drive: ~$2.5

with ICeGaN

1 low cost IC needed	BOM cost: < $1

BOM SAVINGS: ~60%

* All data and calculations and ASPs are available. Data above don't include the power transistors

ICeGaN™: Performance Advantage

Improved device/system robustness and efficiency for low and high power applications

Robustness

Gate under Dynamic Voltage

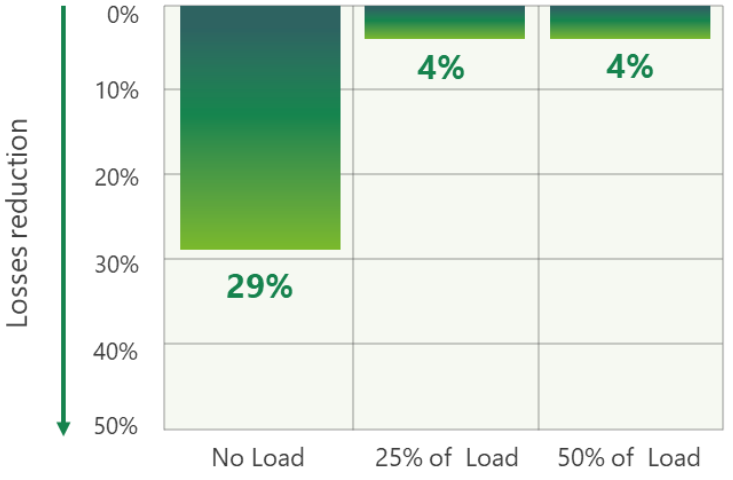
Technology	25°C	150°C
ICeGaN	84 V	92 V
Si IGBT	80 V	80 V
SiC MOSFET	70 V	70 V
Std eMode GaN	24 V	25 V

B. Wang et al "Exceptional Gate Overvoltage Robustness in P-Gate GaN HEMT with Integrated Circuit Interface", APEC 2024

Efficiency for Low Power

No Load / Light Load losses

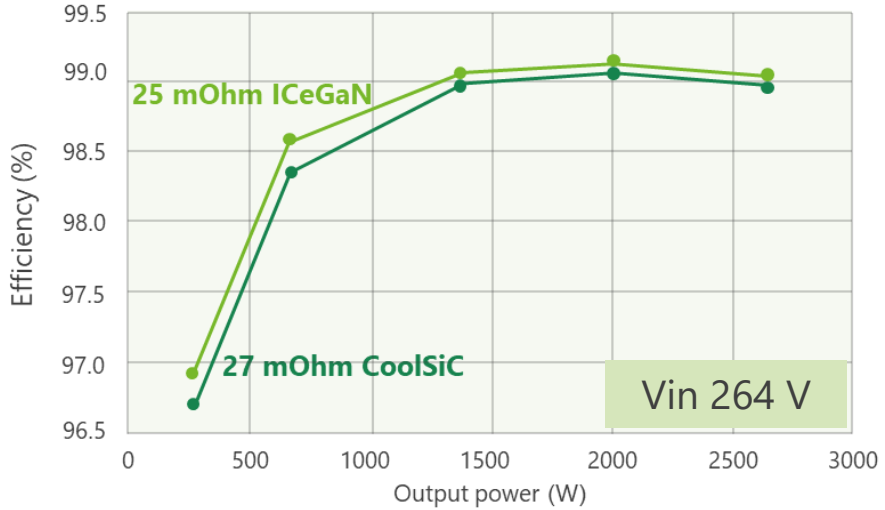
65 W – USB-PD QR flyback
CGD vs. top SoC 650 V GaN vendor



Efficiency for High Power

ICeGaN vs Si Carbide

3.2 kW – TotemPole PFC
CGD vs. top 650 V SiC vendor



Summary and Conclusions

- GaN HEMTs are the present and future of Power Conversion and are manufactured in high volumes.
- GaN potential can be better exploited by integrating Logic and Power, like in the ICeGaN.
- Robustness and Reliability are same or better than incumbent Si / SiC technologies.
- Economy of scale will make it the technology of choice, beyond what was initially envisioned…Automotive included.