Tutorial Series

# Powering up the future with GaN


**Thursday 9th February**
**5pm-5:50pm GMT**

CGD™
CAMBRIDGE GaN DEVICES

Presenter: Andrea Bricconi, CCO
Moderator: Nare Gabrielyan, Product Marketing Manager

# Ground Rules and Instructions

Please make sure you are muted

Use the chat for comments and questions

# Tutorial Webinar Series Schedule

CAMBRIDGE GaN DEVICES

| Topic | Presenter | Live Date |
| --- | --- | --- |
| **Powering up the future with GaN** | Andrea Bricconi, CCO | February 9th |
| **GaN devices in power electronics** | Florin Udrea, CTO | March |
| **Quality and ICeGaN reliability** | | April |
| **ICeGaN™ vs GaN** | | May |

# About the Host

- Master's degree in Physics, Academic research on III/V compound semiconductors.
- Spent more than 25 years in the semiconductor industry, covering different roles in Manufacturing, R&D, Marketing, Business development and Sales in major Semiconductor manufacturers.
- Working on LV and HV GaN power technologies, applications and marketing for the last 12 years, leading WW teams
- Joined Cambridge GaN Devices in 2020 as VP Business Development and Application Engineering. He is now the company's CCO, in charge of Sales & Marketing organization

# Cambridge GaN Devices at a Glance

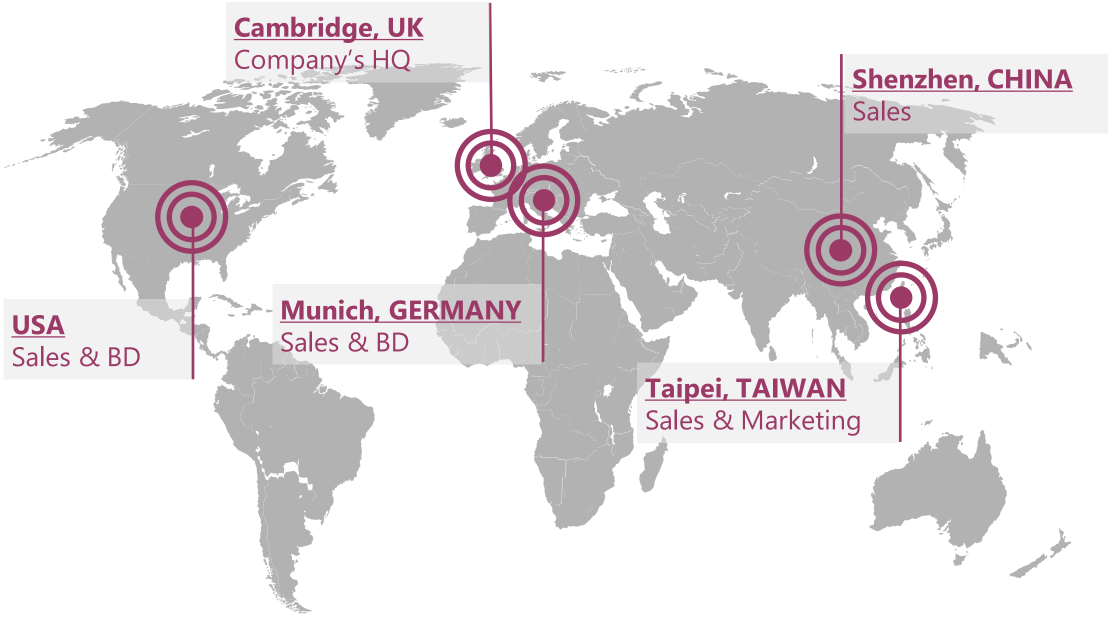
## A Fast-growing CleanTech Pioneer spun-out from the Cambridge University

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

**Operating from**
5
Locations

**Supporting**
20+
Leading customers

**Employees**
40+
> 300% growth (2019– 2022)




**Knowledge**

Academic excellence and industry expertise combined

**Innovation**

Innovative power solutions that help protect the environment

**Sustainability**

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

**Responsability**

Energy savings for reliable and sustainable electronics

# Outline

- The context
- The GaN promise
- ICeGaN™ for smart integration
- CGD's solutions
- Conclusions

# **4 Megatrends** Driving The Growth of Energy Consumption

## Unprecedented Levels of $CO_2$ Emissions Caused by Human Activity

**Climate Change**

**Population Growth**

**Urbanisation**

**Digital Transformation**

**36,7Gt of $CO_2$ emissions**

**~23,000 TWh consumed electricity**


**Sources:** Global Energy Review 2021, World Energy Supply and Consumption, Statista; Data refer to 2019 w/ to $CO_2$ emissions and Twh consumed energy

# **3 Areas** Driving the Growth of Energy-Efficient Solutions

## 1. ELECTRIFICATION

**The e-mobility** disruption, energy efficiency regulations and $CO_2$ reduction emissions targets will drive change

## 2. RENEWABLE ENERGIES

**Wind** and **Solar** power expected to account for 50% of the power mix by 2030 and 85% by 2050

## 3. CONNECTIVITY

**Big data, Cloud Computing** and **5G** full deployment will continue a 3-digit growth (and **6G** is coming)


## Power Semiconductors are the Core of Energy Conversion and Control

**Sources:** Yole Développement - Forecast for eBike, eScooters and EV/HEV for GaN and a subset of Wide Band Gap, McKinsey Center for Future Mobility, McKinsey Global Energy Perspective 2022 Executive Summary

# An Ecosystem Geared up for the GaN Revolution

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## Governments and Policies

More global economies establish reduction policies to achieve **0-net $CO_2$ emission by 2050.**

Governments around the world announce a **national semiconductor strategy.**

## Markets and Trends

**Energy-efficient, power dense** and **miniatured devices** push the growth of GaN-based solutions.

Socio-economic factors and advances in technology are driving **energy use and electricity spending.**

## Investments and Landscape

The **semiconductor industry** has invested >>**$10bn** in WBG.

**New foundries** arise to fulfill the global demand for energy-efficient power devices.

# Technology Characteristics Comparison

## Intrinsic properties which are relevant for power conversion favour GaN on many aspects

| | Silicon Super-junction | GaN Cascode | p-GaN gate Schottky HEMT | ICeGaN™ |
|---|---|---|---|---|
| Specific on-resistance Ron x Area [mΩ x cm$^2$] | 8 | 2.8 | 3.2 | **3.2** |
| Typ. Threshold voltage [V] | 3.5 | 4.0 | 1.7 | **3.0** |
| Maximum gate Voltage [V] | 20 | 20 | 7 | **20** |
| Ron x Qg [mΩ x µC] | 3.5 | 0.8 | 0.3 | **0.3** |
| Ron x Qoss [mΩ x µC] | 21 | 6 | 3.3 | **3.6** |
| Ron x Qrr [mΩ x µC] | 312 | 6 | 0 | **0** |
| Negative voltage drive requirement | no | no | Desirable | **no** |
| Integrated Current Sensing | no | no | no | **yes** |
| Typical Packaging | TO220/TO-247 | TO-247 | SMD | **SMD** |

# Technology Characteristics Comparison

## Intrinsic properties which are relevant for power conversion favour GaN on many aspects

The lower the value the lower the driving loss. Key for **light load efficiency** but also enable **higher efficiency at high frequency.** High frequency enables **power density → GaN for light load or power density**

| | Silicon Super-junction | GaN Cascode | p-GaN gate Schottky HEMT | ICeGaN™ |
|---|---|---|---|---|
| | 8 | 2.8 | 3.2 | **3.2** |
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# Technology Characteristics Comparison

## Intrinsic properties which are relevant for power conversion favour GaN on many aspects

Less charges to dissipate at each commutation. Enables better soft switching.
GaN can provide **higher efficiency combined with high frequencies → HalfBridge LLC topologies → GaN or SiC based on needs**

| | Silicon Super-junction | GaN Cascode | p-GaN gate Schottky HEMT | ICeGaN™ |
|---|---|---|---|---|
| | 8 | 2.8 | 3.2 | **3.2** |
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# Technology Characteristics Comparison

## Intrinsic properties which are relevant for power conversion favour GaN on many aspects

The lower the better **for repetitive hard commutation** using a simple half-bridge-based circuit (e.g. totem-pole CCM-PFC) → **BOM savings for highest efficiency will use GaN (or SiC)**

| | Silicon Super-junction | GaN Cascode | p-GaN gate Schottky HEMT | ICeGaN™ |
|---|---|---|---|---|
| | 8 | 2.8 | 3.2 | **3.2** |
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# Efficient Power Electronics for a cleaner Environment

Silicon
14
**Si**
28.086

## Traditional Si-based Devices

SLOW SWITCHING / HIGHER ENERGY LOSSES

BULKY FOR THE REQUIRED POWER

NOT SPACE OPTIMISED

COST OPTIMISED

Less Efficient,
Less Sustainable

Gallium
31
**Ga**
69.72

Nitrogen
7
**N**
14.01


## GaN-based Devices

**20x**
FASTER SWITCHING / LOW ENERGY LOSSES

**Up to 3x**
HIGHER POWER DENSITY & FASTER CHARGING

**3x**
SMALLER AND LIGHTER

$/W

**20%**
LOWER SYSTEM COST

Up to **40%** Energy Savings

# What if All Data Centres Were to Adopt GaN

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## Green house emissions from

**20,345,297**
Barrels of oil consumed

**1,709,856**
Homes' electricity use for one year

## Carbon sequestered by

**10,399,631**
Acres of U.S. forests in one year

## Green house emissions avoided by

**1,893,471**
Gasoline-powered passenger vehicles driven for one year

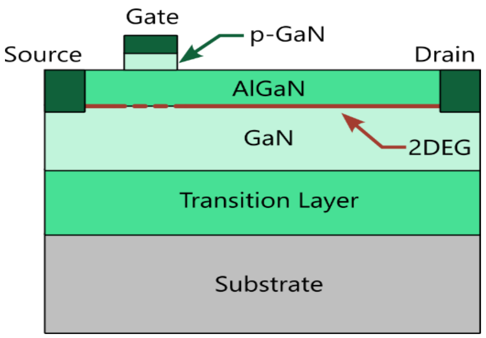
**3,040,714**
Tons of waste recycled instead of landfilled

**12.4TWh saved in a year - 9,000,000 tons of $CO_2$ - 1.6b$ electricity bill saving**

**CGD estimations based on 8% higher efficiency per server PSU**
**Sources:** Eaton, Statkraft - Data Centers and Decarbonization – Oct. 21

# From Discrete to Hybrid and Monolithically Integrated

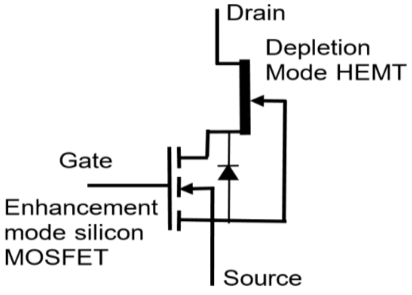
## Discrete HEMT




### Discrete

P-GaN Enhancement HEMT

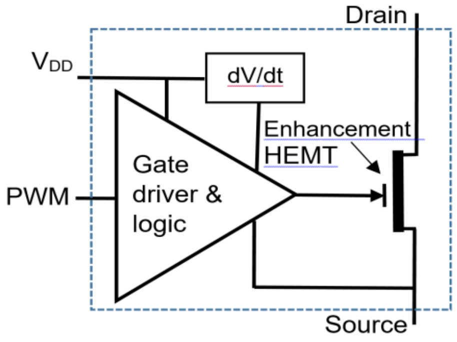
## Cascode Si MOSFET + HEMT




### Hybrid

Schottky gate depletion mode HEMT in series with a silicon low-voltage MOSFET

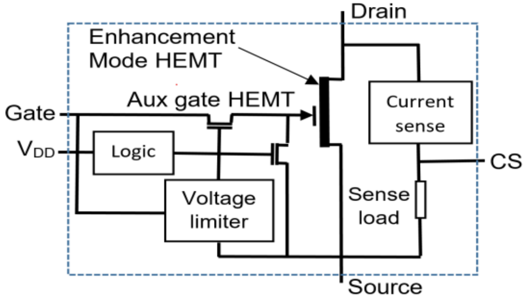
## Power IC with HEMT and integrated drive




### Power IC – Level 2 monolithic integration

- Enhancement mode HEMT
- Gate driver integrated
- dV/dt slew rate adjustment

## Smart HEMT - ICeGaN™ HEMT

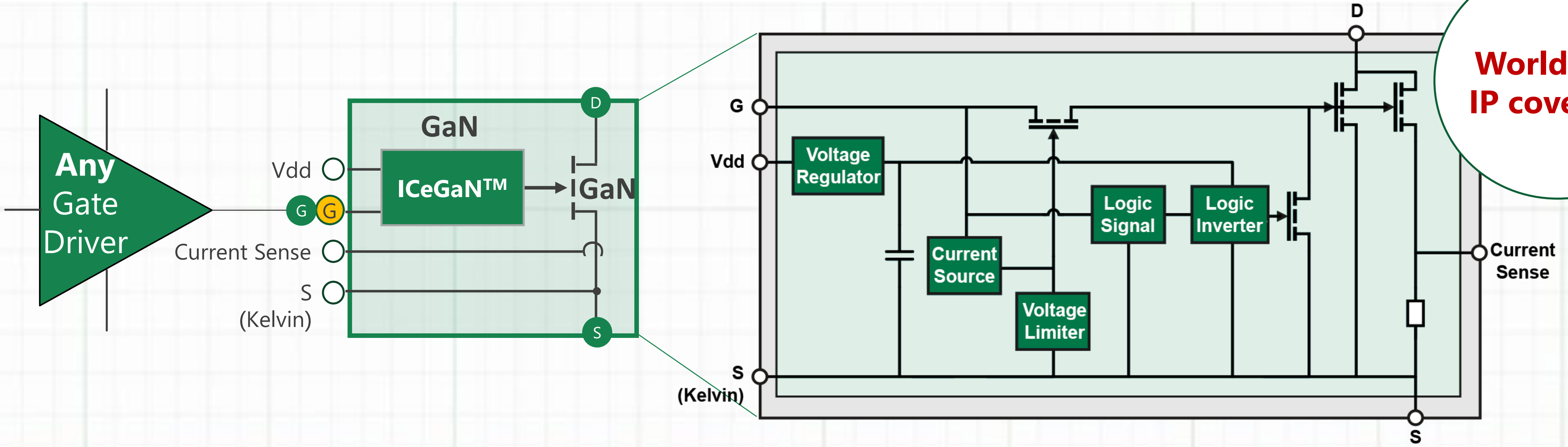



### Power IC – Level 1 monolithic integration

- Enhancement mode HEMT
- Smart interface for higher threshold voltage and higher reliability of the gate
- Gate voltage protection
- Current sensing

# Decades of Research Led to ICeGaN™ All-In-One GaN Chip

## Combined System Performance and Ease-of-Use to Meet the Customers´ Requirements




**Worldwide IP coverage**

Ease-of-use ✓

System cost ✓

Scalability ✓

Gate robustness ✓

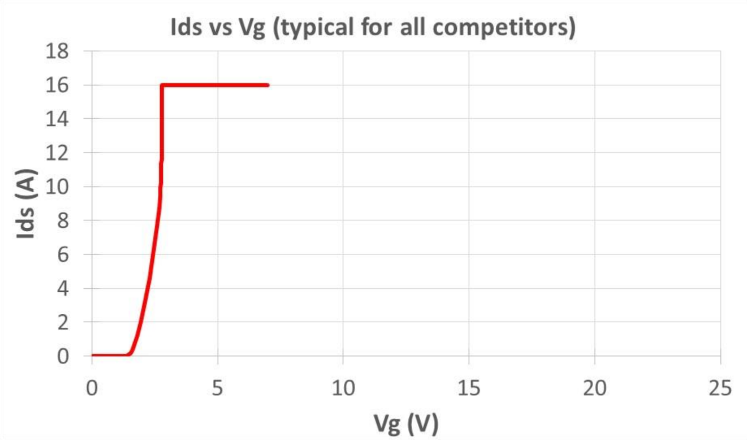
System performance ✓

*"CGD's GaN can work on our 65W system and support high gate drive voltage (like Silicon) –*
**Lead Consumer customer #1**

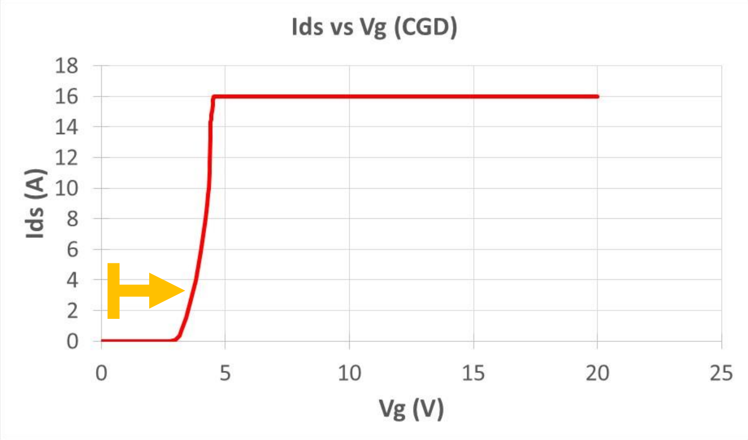
*On next multi-port PD charger, we achieve 1% higher efficiency than with previous GaN source –*
**Lead Consumer customer #2**

# Enhancement mode GaN can be operated like MOSFETs

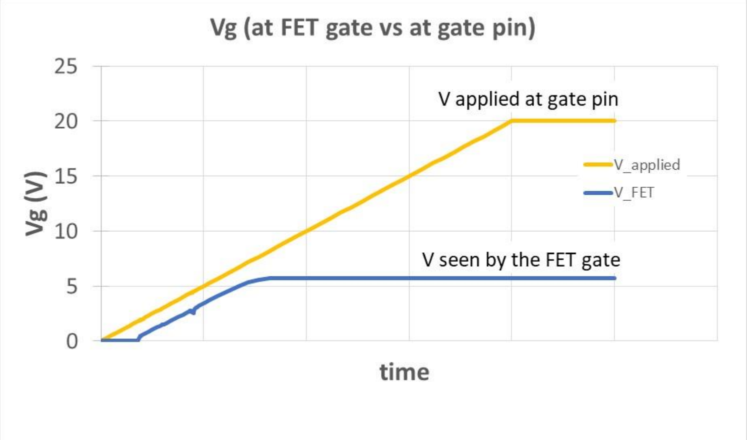
## Threshold voltage is pushed to 3 V and max Gate Voltage to 20 V




Typical transfer characteristics for eMode GaN HEMTs



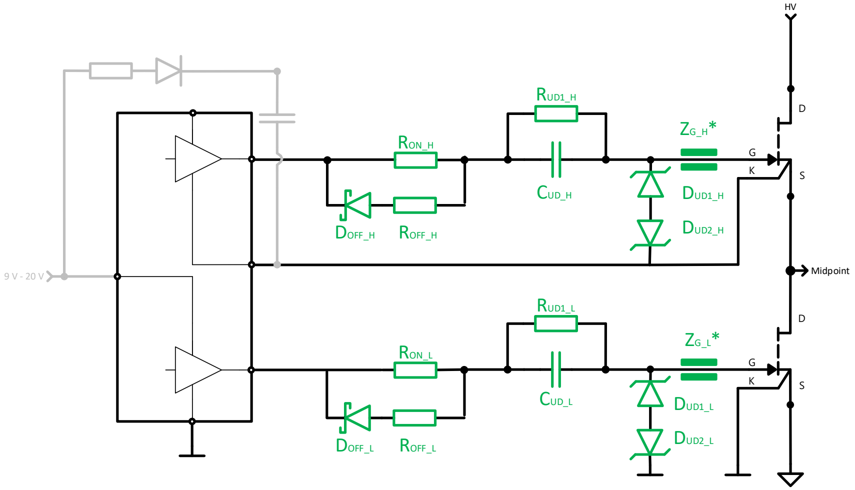

CGD's transfer characteristics

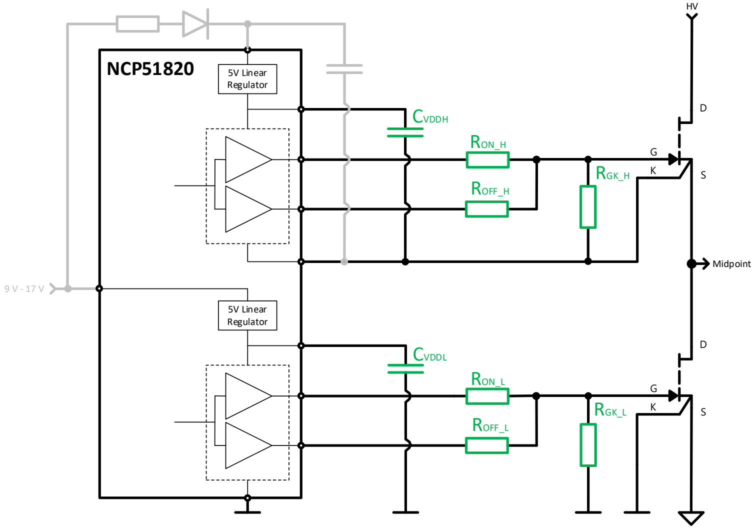


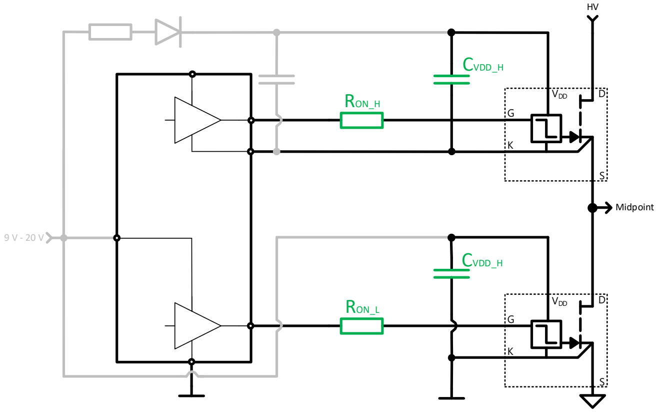

Internal gate signal is optimized for safe operation while external signal goes up 20 V

# High Performance in HB and Low Side topologies

## BOM costs can be greatly reduced




### GaN #1 – Competitor's Application Note on HalfBridge driving

**Driven by: Standard Si Half-Bridge \Driver**

**Requires: 16 External Components**

- 6 resistors | 2 Capacitors | 6 diodes | 2 beads

### GaN #2 – Competitor's Application Note on HalfBridge driving

**Driven by: GaN specific Half-Bridge Driver**

**Requires: 8 External Components**

- 6 Resistors | 2 Capacitors

### CGD's ICeGaN™

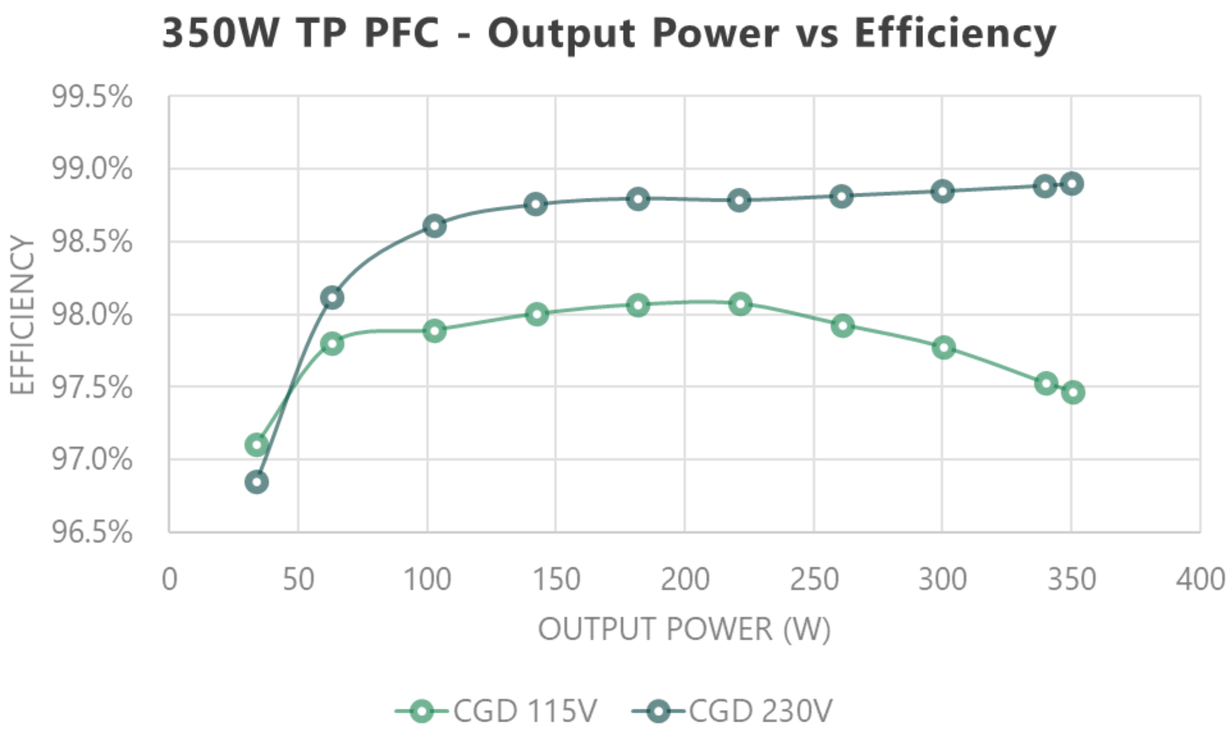
**Driven by: Standard Si Half Bridge Driver**

**Requires: 4 External Components**

- 2 Resistors | 2 Capacitors

# High Performance in HB and Low Side topologies

## BOM costs can be greatly reduced



# CGD Product Portfolio

## A Targeted Offering Entering the Market with 2 SMD Packages, 3 $R_{DS(on)}$ Classes

**CGD's H1 series are SINGLE CHIP** eMode HEMT, with 3V threshold voltage, with real 0V turnOFF and with a revolutionary gate concept that can be operated up to 20V.

*No cascode, no complex multi-chip configurations or no thermally complex integrated solutions, but a single chip with embedded proprietary logic which enables the coupling with std gate drivers or controllers.*


| PN | Type | $R_{DS(on)}$ | Voltage Rating | DC Current rating | Peak Gate Voltage | Package | Features | Preferred gate driver |
|---|---|---|---|---|---|---|---|---|
| CGD65A055S2 | Single eMode | 55 mOhm | 650 V (750 V*) | 27 A | 20 V | DFN 8x8 | ICeGaN™**, Current Sense *** | Any MOSFET driver |
| CGD65A130S2 | | 130 mOhm | | 12 A | | | | |
| CGD65B130S2 | | | | | | DFN 5x6 | | |
| CGD65B200S2 | | 200 mOhm | | 8.5 A | | | | |

*,**,*** see product datasheets

**APPLICATIONS**

# DesignIn support with Reference Designs and Eval Boards

## Support Material  available in English, Simplified and Traditional Chinese


02 ICeGaN™ IN LLC
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ICeGaN™ IN LLC
CGD-AN2201

MARCH 2022

CONTRIBUTORS
JOHN FINDLAY

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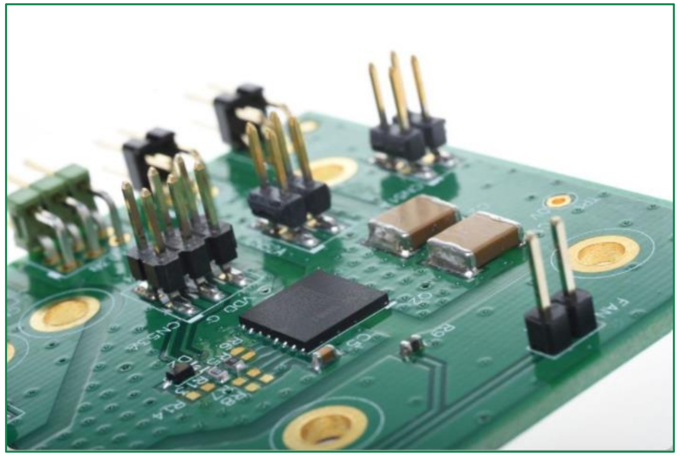
CGD

| TECHNICAL CONTENT |
|---|
| • Application Notes<br>• User Guides<br>• White Papers |

| MARKETING CONTENT |
|---|
| • Product Brief<br>• Podcast and Videos<br>• Technical Articles |

| BOARDS |
|---|
| • Evaluation Boards & Userguides<br>• Interface Boards<br>• Reference Design Boards |

Visit: www.camgandevices.com

# Conclusions

- The world must make a better use of energy and reduce carbon footprint. This requires new technologies to replace silicon.
- GaN, among others, show incredible potential and is rapidly gain market traction in consumer and industrial applications. Automotive will come.
- 600 V+ GaN HEMTs shall be made as ease to use as possible and deliver on promises, to broaden market adoption and further improve on efficiency and power density.
- There's only one technology which requires **no negative** voltage for gate driving, **extended gate voltage to 20 V** and true **3 V threshold voltage**, all integrated into **1 enhancement mode 650 V GaN HEMT** and this is **ICeGaN™ by Cambridge GaN Devices**.
- CGD is in mass production and will broaden their sales channels shortly. Stay tuned!


GaN
CGD™
CAMBRIDGE GaN DEVICES
Stay tuned with us!