Powering the Future: ICeGaN® ‘s role in redefining Power Supply Performance for Next Gen Data Centres

Farhan Beg, Director of Application Engineering, Cambridge GaN Devices

Bodo‘s Wide Bandgap Event 2024

Making WBG Designs Happen

GaN

Cambridge GaN Devices at a Glance

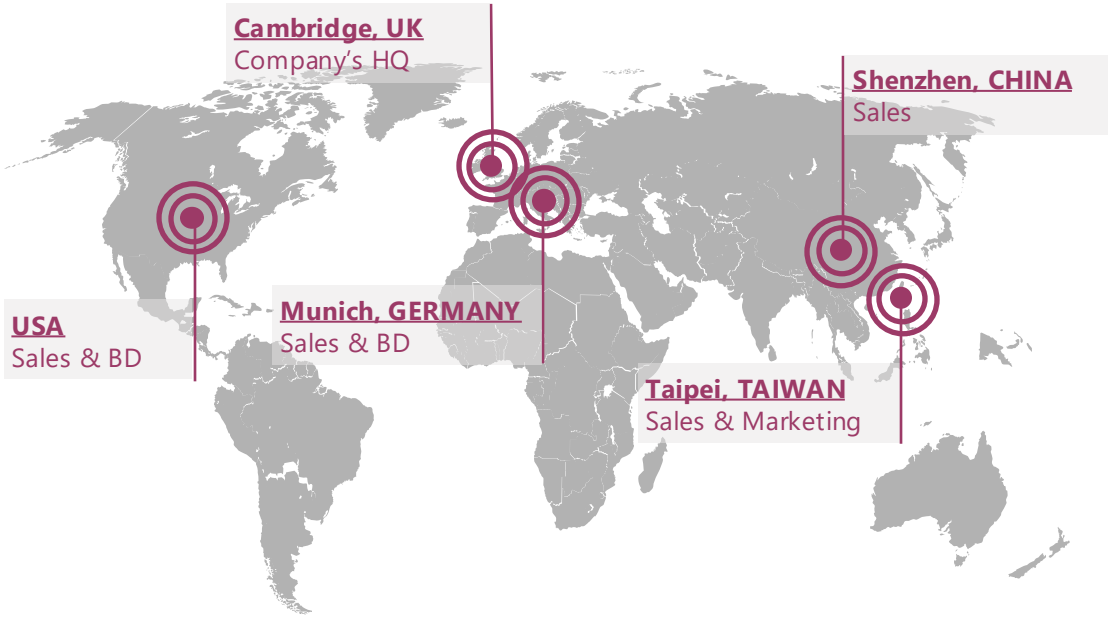
The Fast-paced Scaleup Making Green Electronics Possible

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

Operating from
5
Locations

Innovation
100+
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

Data Centre Industry Trends

Towards Enhanced Efficiency and Performance

Agile scalable infrastructure

- Demand for expanding server infrastructure
- Modular architecture for easy, quick integration and expansion

High-density computing

- Need for increased computing power
- Increase in power density demands
- More power per blade & rack

Advanced cooling technologies

- Convergence of air and liquid cooling
- Liquid cooling, particularly for high-density GPU & NPU applications

Sustainability and energy efficiency

- Strong focus on sustainability
- Clean energy adoption
- Efficiency improvement

Data Centre Design Trends

Be Ready for the Next-Gen Data Centre Power Demands

Power Trends

- Higher power per rack
- Higher peak load profile
- More demanding efficiency and current THD and PF specification
- Pushing for higher PSU power density
- Transition to liquid/hybrid cooling

New design challenges for PSU

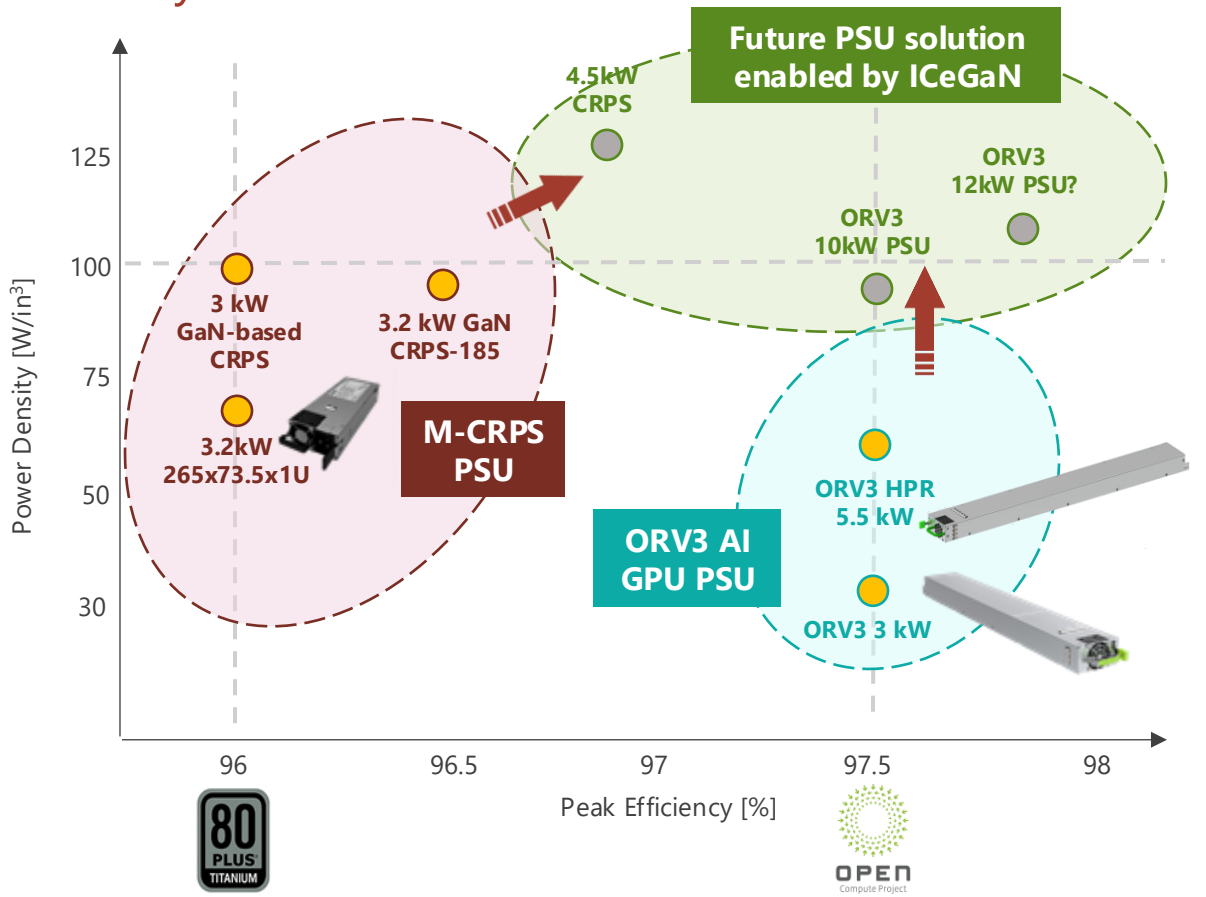
- Size reduction while meeting higher efficiency and holdup specification – **trade off between Power density vs Electrical Performance**
- AC Loss, Pulse load and PSU-BBU transition
- New control method and topology to improve light load current THD and PF
- Thermal management

ICeGaN® in Data Centres

Solution to the Challenge of Efficiency vs Power Density

- **AI demands higher efficiency and rack power density**
  - **15** kW/rack today, >**120** kW/rack by 2030
  - ORV3 HPR 5.5 kW spec has reached **50 W/in³** and **97.5%** peak efficiency
  - CRPS PSU has already reached 100 W/in³
  - Next generation OCP target 98% efficiency and 8-10 kW per PSU

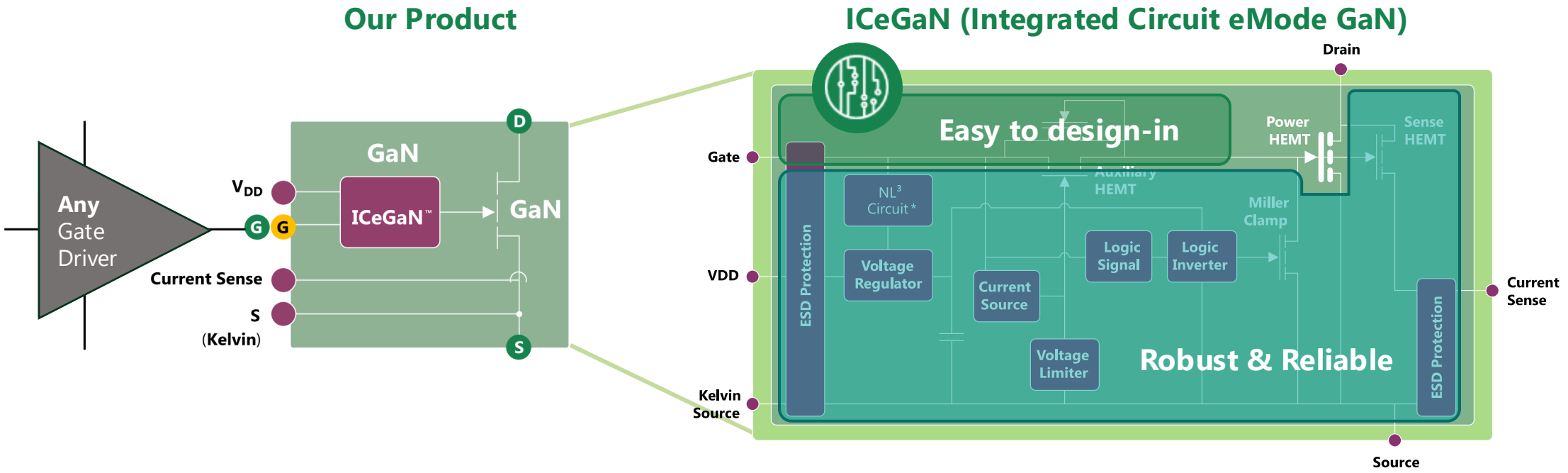
- **However, current solution has reached its limit!**
  - Design trade-off
  - Higher density or efficiency, but not both



ICeGaN can push the design boundary to the next level and **enable** future OCP solutions - 98% efficiency & >100 W/in³

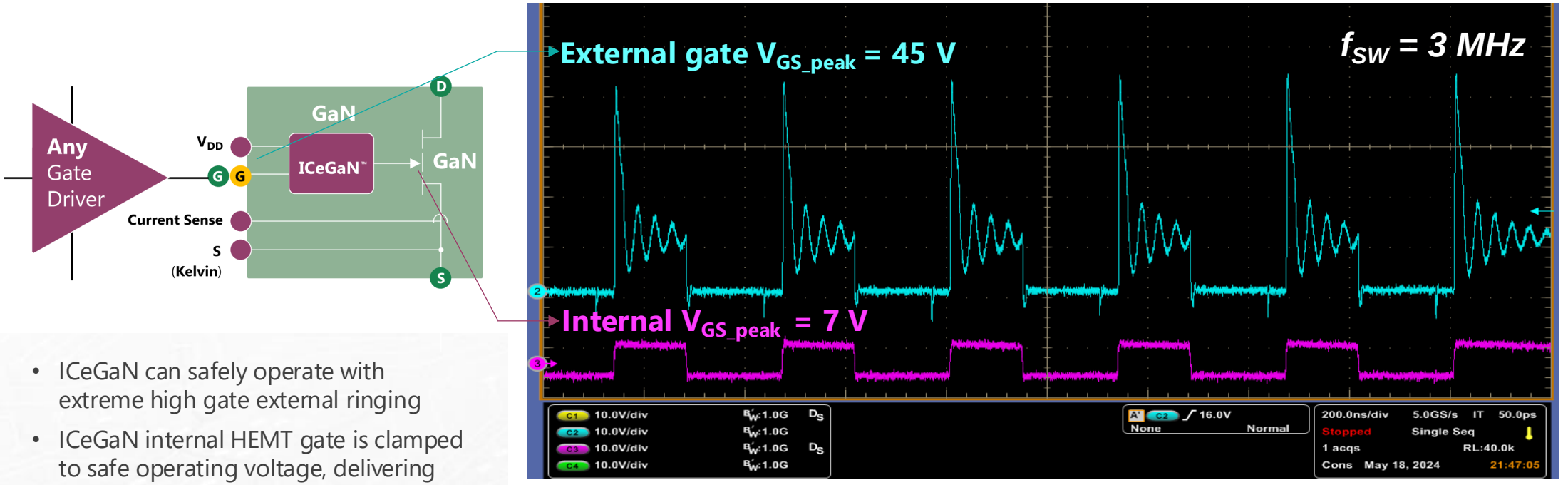
ICeGaN® Power IC

All-In-One Monolithic GaN Chip



- Increased V_{th} and maximum gate voltage – compatible with MOSFET and IGBT Drivers (12 & 15 V)
- Miller Clamp enables very high dv/dt and 0 V turn-off
- Improved robustness – 2 kV ESD all pins, high transient rating on the gate
- Withstands >80 V dynamic voltage overshoots at the Gate

ICeGaN®: Robustness ➡ Reliability



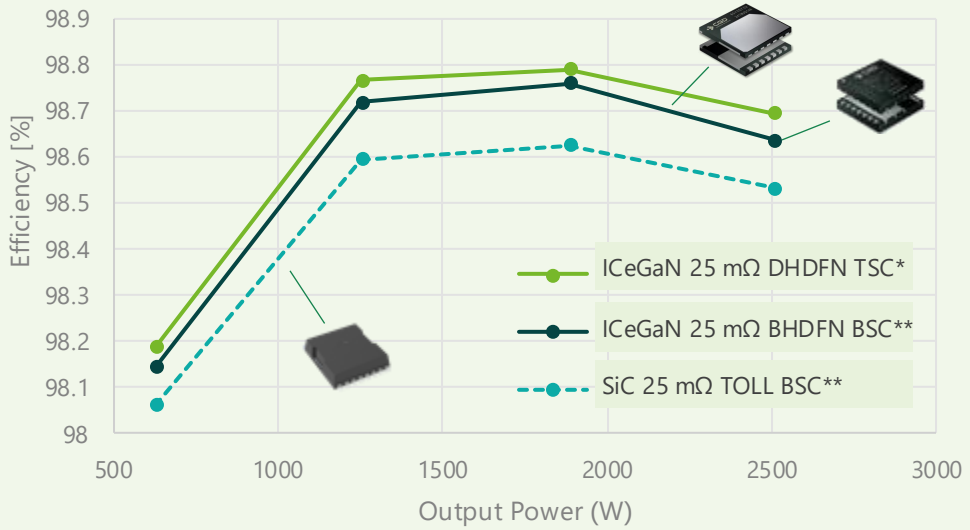
- ICeGaN can safely operate with extreme high gate external ringing
- ICeGaN internal HEMT gate is clamped to safe operating voltage, delivering very smooth and stable operation
- ICeGaN can kill induced oscillations even at 3 MHz

External circuit designed, built and tested by VIRGINIA TECH

ICeGaN takes GaN to the next level of reliability and performance

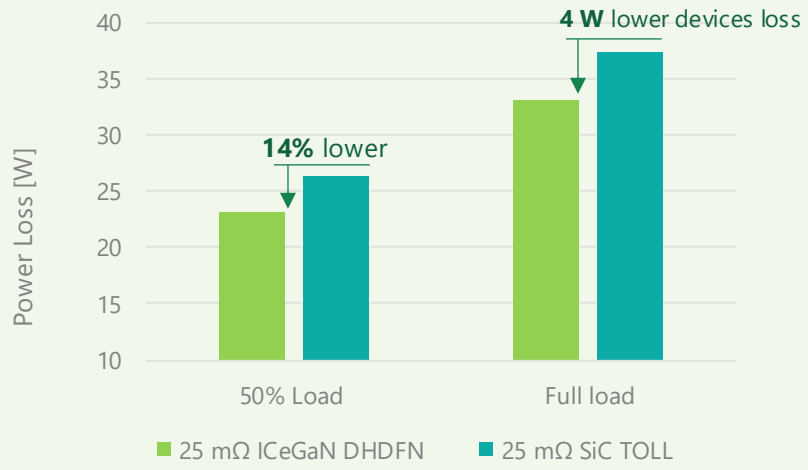
ICeGaN® Efficiency Advantage

ICeGaN P2 Series vs SiC in High-power Packages



Test Conditions: V_{IN} = 230 V_{AC}, V_{OUT} = 400 V_{DC}, f_{SW} = 65 kHz, P_{OUT} = 2.5 kW

*TSC = Top-Side Cooled configuration. **BSC = Bottom-Side Cooled configuration.



ICeGaN Benefits

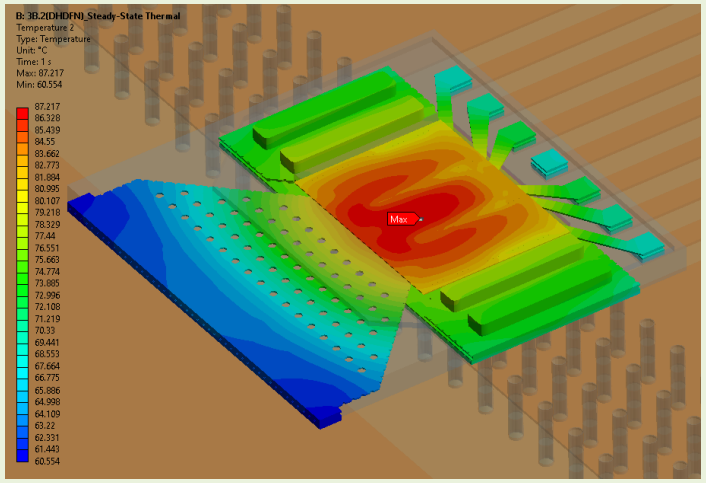
- **Lower switching loss (>3x better input FOM and Zero Q_{RR})**
- **Lower reverse conduction loss (0-V turn off)**
- **Superior thermal performance with DHDFN package**

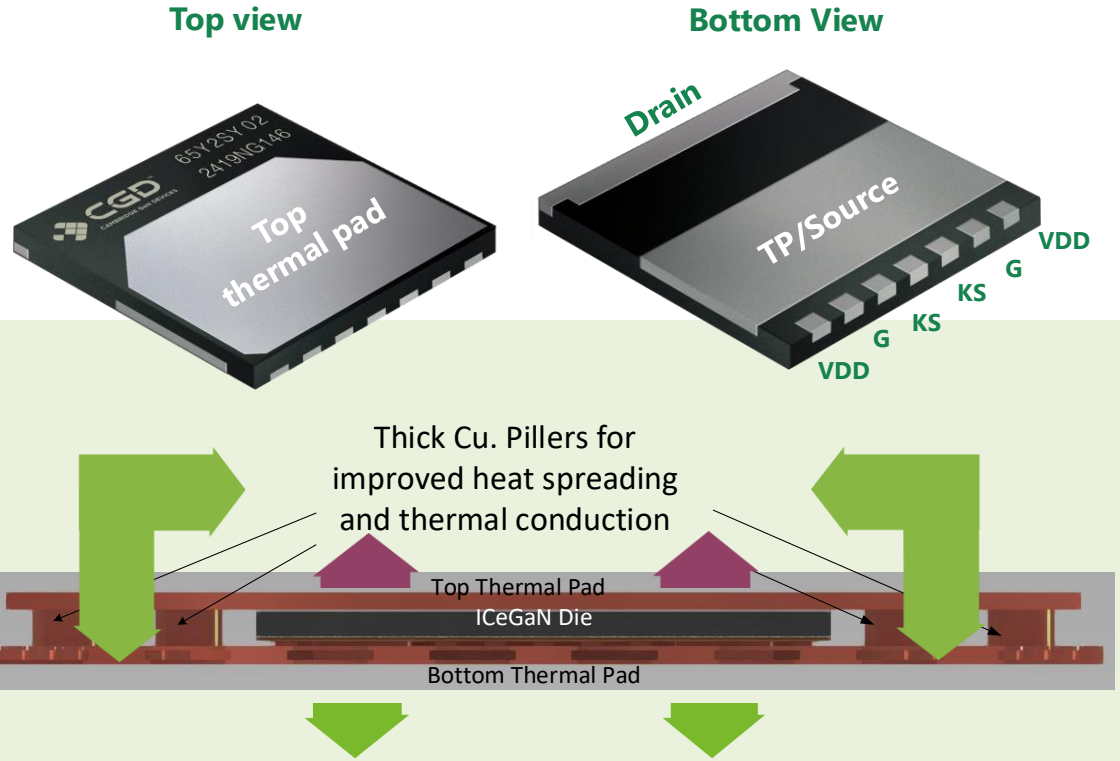
ICeGaN demonstrates higher efficiency even at low switching frequency

ICeGaN® Thermal Benefits

Dual-side Cooled DHDFN Package

- Compact size 10 x 10 mm with low thermal resistance
- True dual-side cooling capability with added Cu pillars for improved heat spreading and thermal conduction
- Low inductance with no wirebond for high-speed switching
- Wettable flank for automatic optical inspection
- Dual gate for flexible layout and easy paralleling

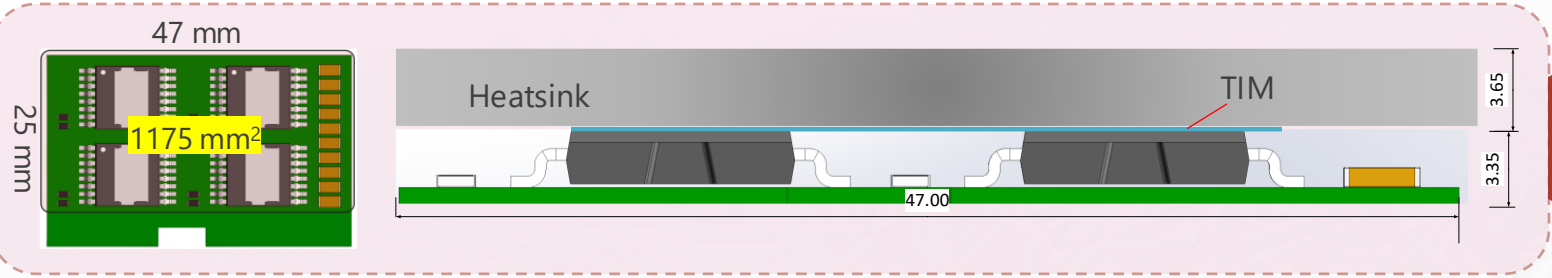




Cross section showing the dual thermal conduction path

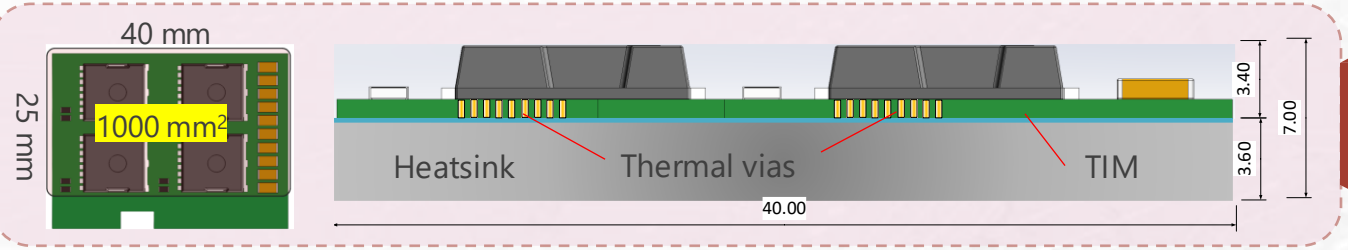
Smaller size with ICeGaN® in DHDFN

TOLT FB Power Stage
(Top side cooled)
- **47 x 25 x 7** mm



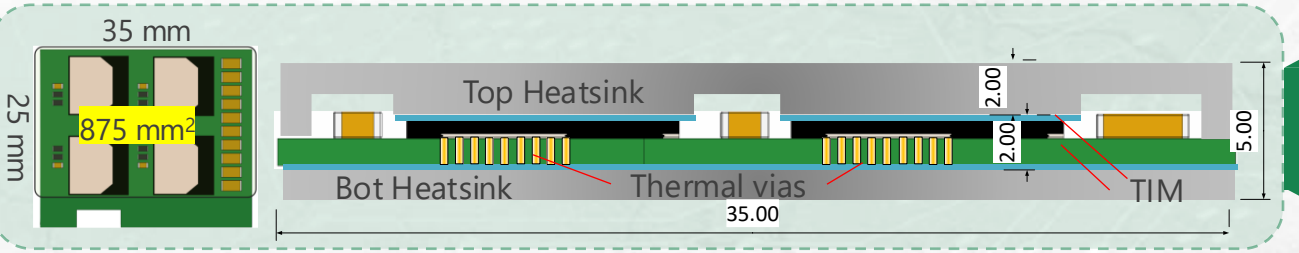
8225 mm³

TOLL FB Power Stage
(bot side cooled)
- **40 x 25 x 7** mm



7000 mm³

DHDFN FB Power Stage
(dual side cooled)
- **35 x 25 x 5** mm



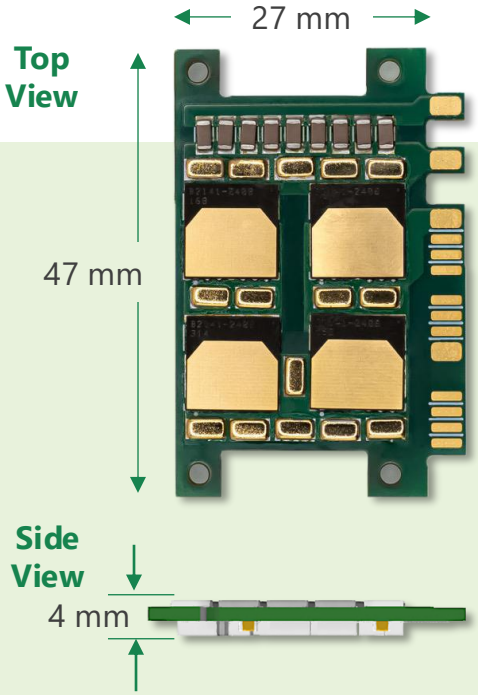
4375 mm³

CGD's DHDFN achieves **~2x** smaller power stage vs TOLT

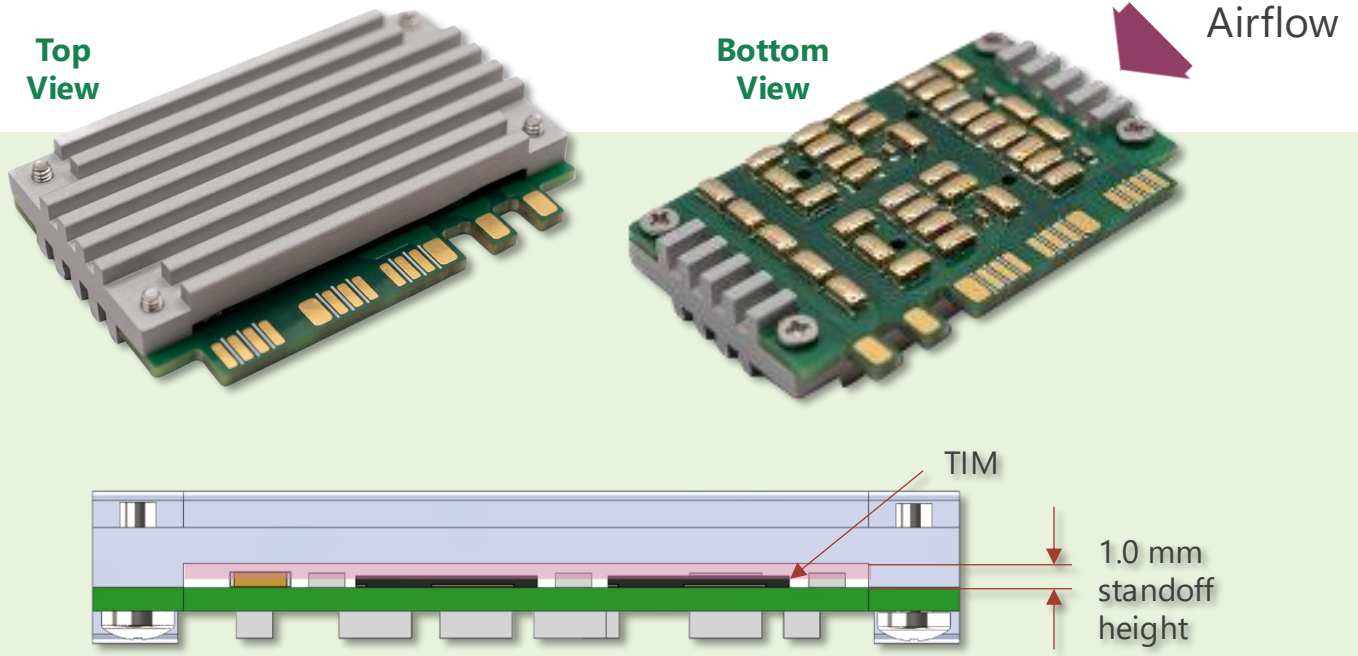
DHDFN Full-Bridge Design Example

Compact Dual-side Cooled Power Stage for 1U High-density PSU Design

Dimensions



With heatsink

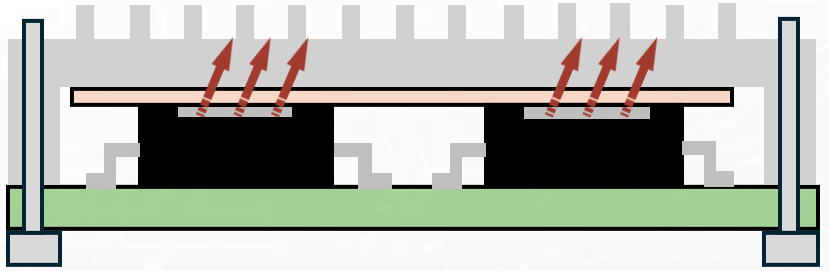


ICeGaN® in DHDFN enables compact design to aim for high power densities

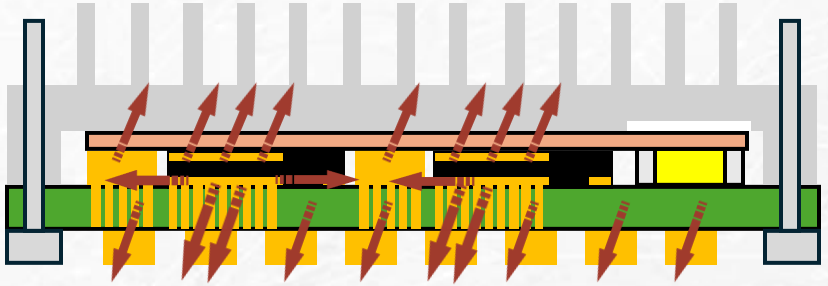
Advantages of DHDFN Package Over TOLT

More Surface Area Under the Same Volume

Typical cooling design using TOLT



Recommended cooling design using DHDFN



Advantages of DHDFN over TOLT:

Double-sided cooling:
Allows efficient heat dissipation from both the top and bottom sides.

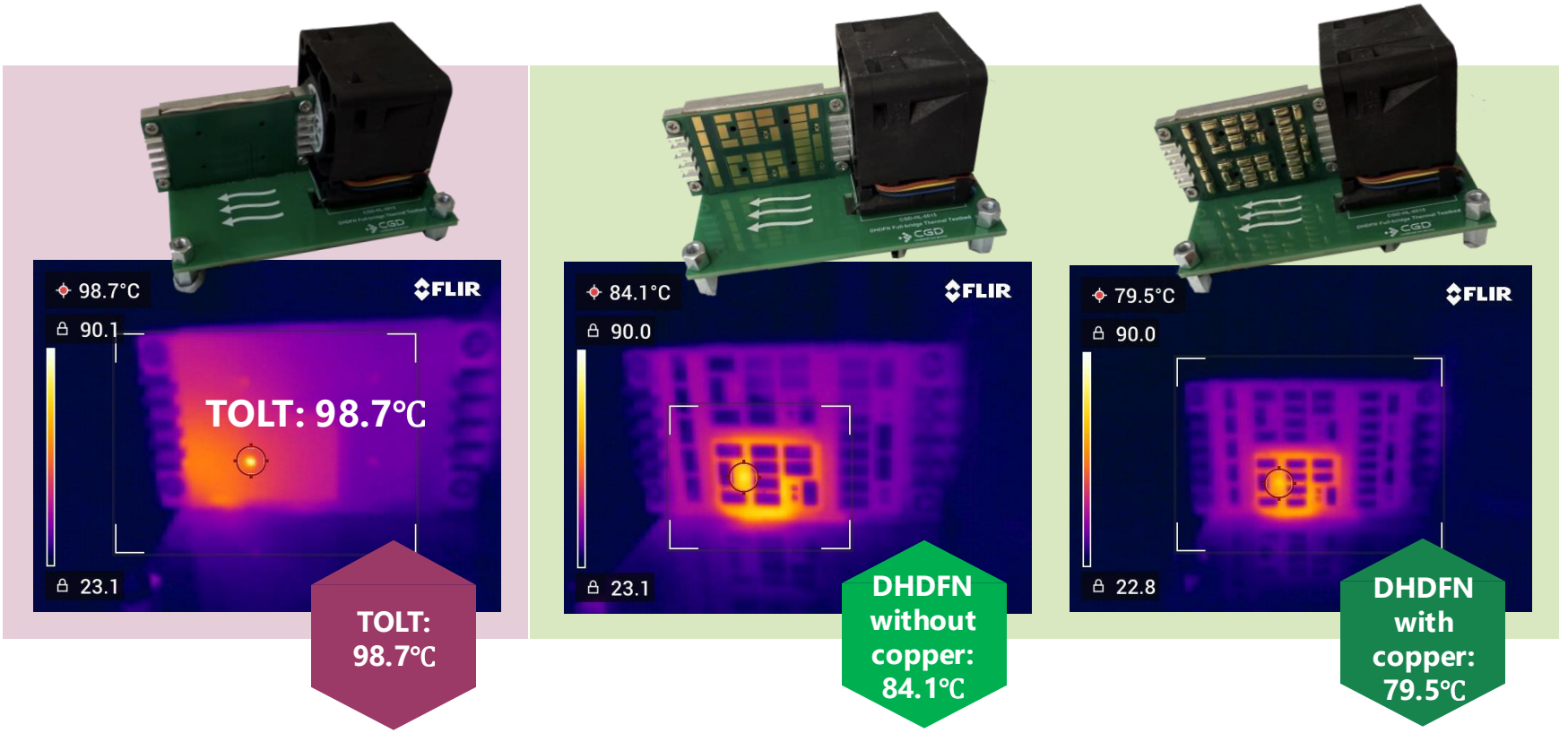
3.5x thinner package:
Enables the use of longer heatsink fins, resulting in lower thermal resistance.

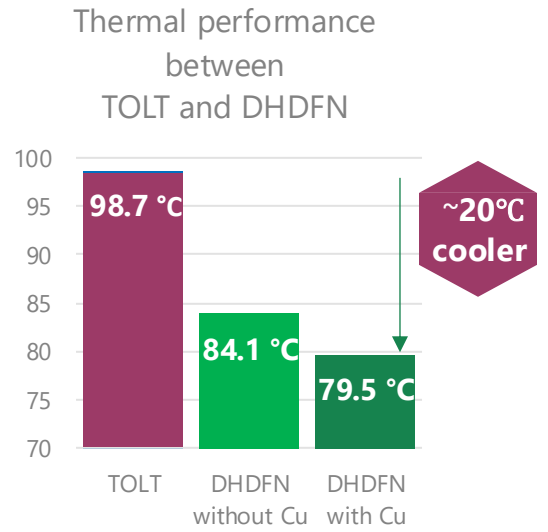
40% footprint reduction:
Provides extra space for decoupling capacitors, reduces the power loop, and improves EMI performance.

DHDFN outperforms TOLT in full-bridge topology both thermally and in EMI performance

Advantages of DHDFN Package Over TOLT

Test results – 15 W Loss At a Single Device





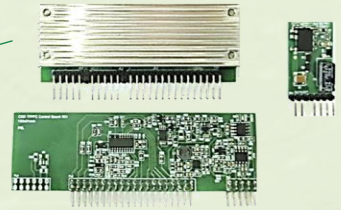
Test conditions: 15 W loss at a single device, 15,900 RPM fan speed, 23°C T_{amb}

DHDFN runs 20 °C cooler than TOLT under the same box volume

CGD's 3 kW Totem Pole PFC Evaluation Board

- 3 kW operation at 230 V_{AC} (1.5 kW at 115 V_{AC})
- V_{IN}: 90 -264 V_{AC}; V_{OUT}: 400 V_{DC}
- Switching frequency: 65 kHz
- 2x ICeGaN® (650 V, 25 mΩ, DHDFN package) in half-bridge
- Reduced external component count compared to discrete eMode GaN

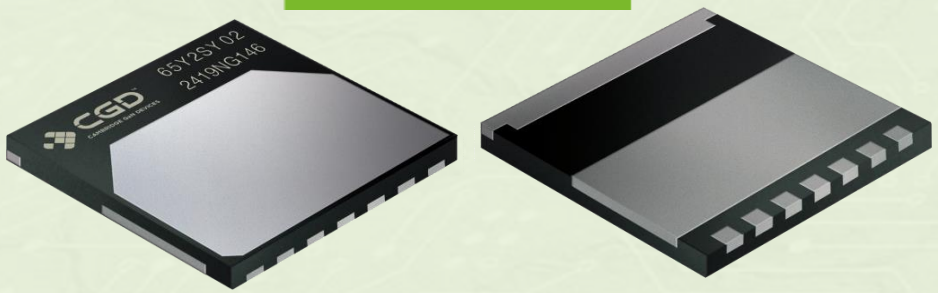
CGD65D025SP2 high frequency half-bridge daughterboard with heatsink



Auxiliary Supply daughterboard

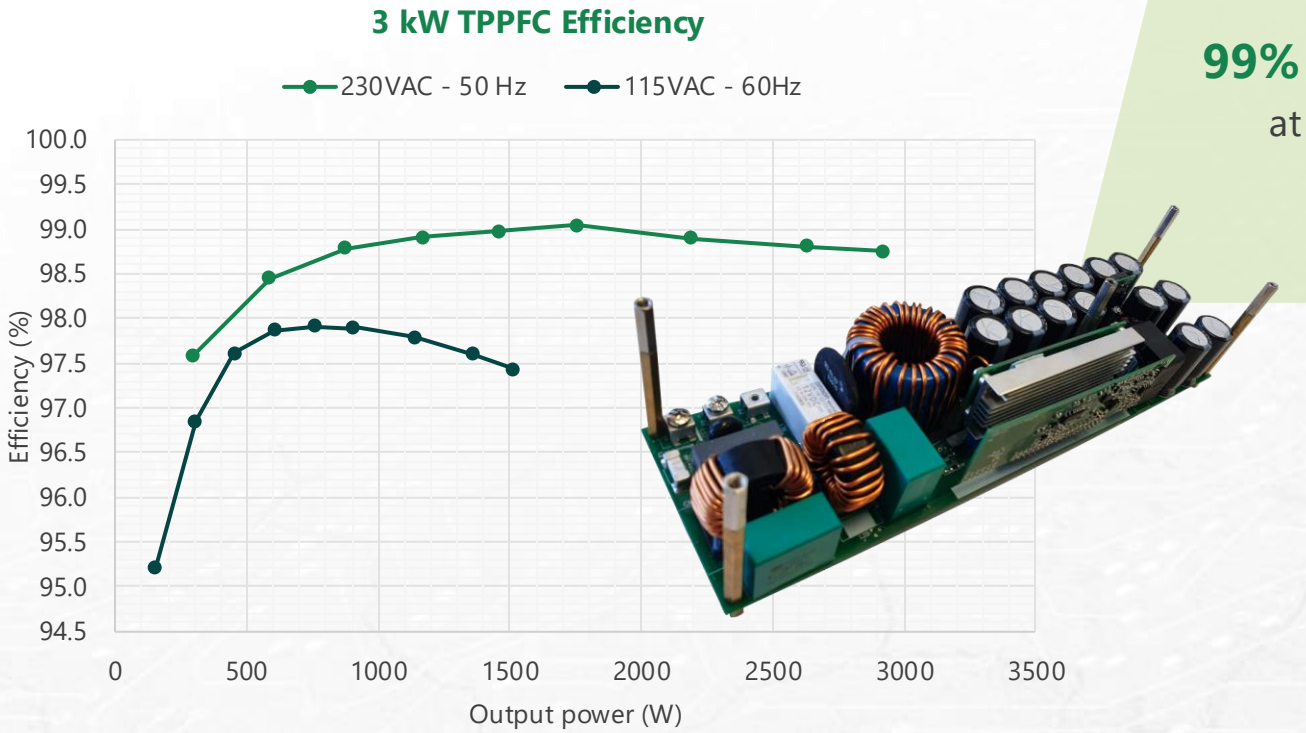
Control card

2x CGD65D025SP2



ICeGaN® Meeting Data Centre Demands

CGD's 3 kW Totem Pole PFC Design



99% efficiency
at 50% load

Exceeds
80 PLUS Titanium
efficiency specification

Suitable for high-efficiency applications like
ORV3 3KW PSU

ICeGaN can enable future OCP solutions with 98% efficiency & >100 W/in^3

ICeGaN® Product Portfolio for Data Centres

PN	$R_{DS(on)}$ typ (mΩ)	Current Rating (A)	Package	Features	Preferred Gate Driver	Status
CGD65C025SP2	25	60	BHDFN-9-1	ICeGaN	Any MOSFET and IGBT driver	Contact factory
CGD65D025SP2	25	60	DHDFN-9-1	ICeGaN Dual gate		
CGD65C055SP2	55	27	BHDFN-9-1	ICeGaN		
CGD65D055SP2	55	27	DHDFN-9-1	ICeGaN Dual gate		

BHDFN:
Bottom-Side Cooled

DHDFN:
Dual-Side Cooled

BH = Bottom heat-spreader **DH** = Dual heat-spreader

See product datasheet

Dare to innovate differently

Thank You

CAMBRIDGE GaN DEVICES