

SEMICON® TAIWAN

Sep. 6-8, 2023, TaiNEX 1&2, Taipei

**GaNSafe™ Power ICs Create
Highest Density and Efficiency in
Data Center & EV Power Systems**

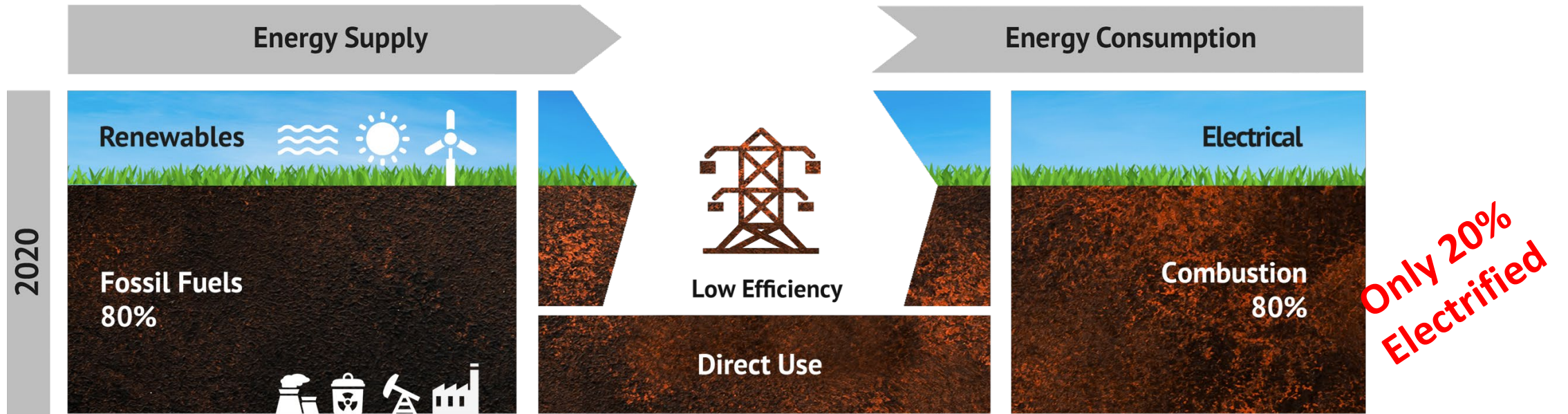
Charles Bailey
Sr. Director Navitas Semiconductor

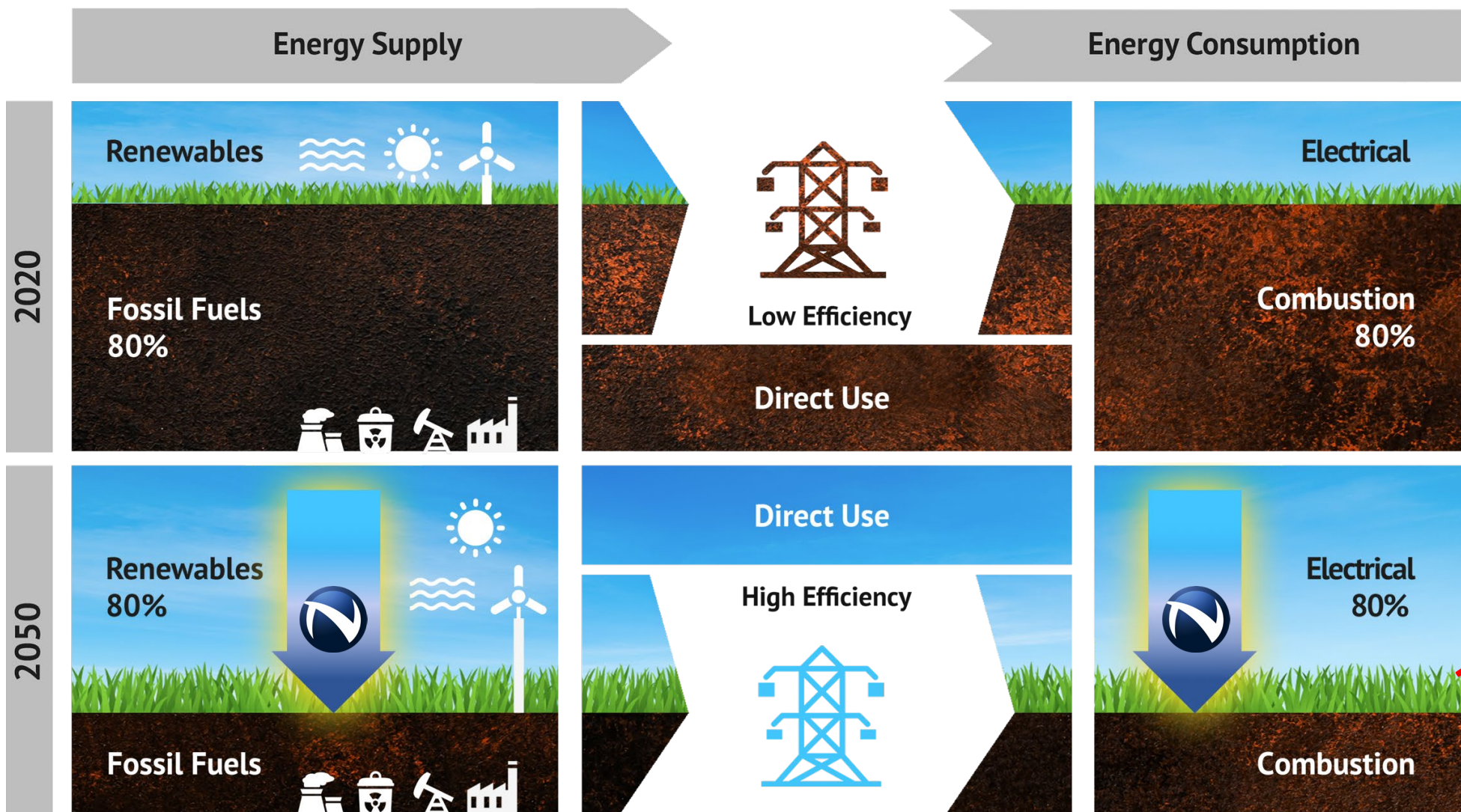
Taipei, September 2023

ir@navitassemi.com



The Fossil Fuel Challenge





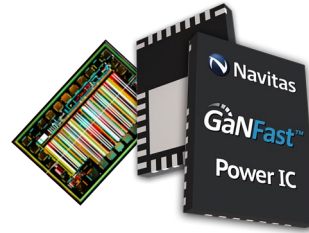
Target 80%

Accelerating Sustainability



February '22 First GaN sustainability report based on global standards.

Every **GaNFast™ IC**
saves
4 kg CO₂



4x-10x lower component CO₂ footprint than silicon

28% lower lifetime CO₂ footprint for chargers / adapters

Accelerates transition from ICE to EV by **3 years**, saving **20%/yr** of road-sector emissions by 2050

GaN + SiC save up to **6 Gton / year** by 2050



May '22 World's first semiconductor company CarbonNeutral® certified



August '22 First 100,000 tons CO₂ saved (Over 170,000 as of August 2023)



October '22 Recognized for industry-leading sustainability reporting

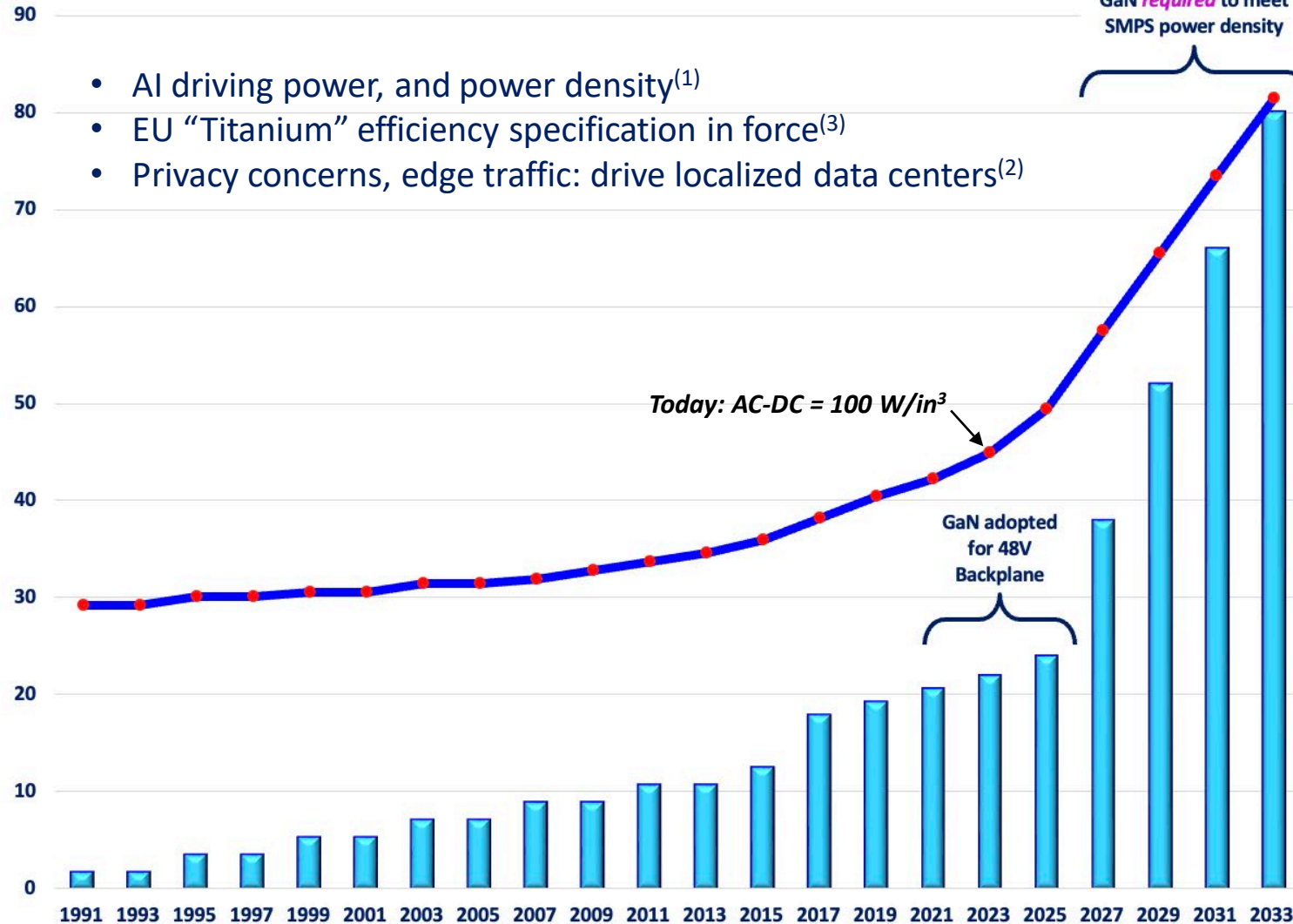
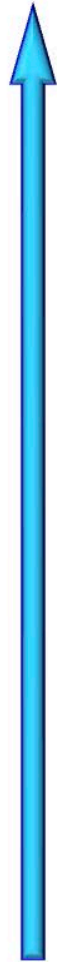
Accelerating Data Center Power, Efficiency



AUTONOMOUS VEHICLES
4000GB

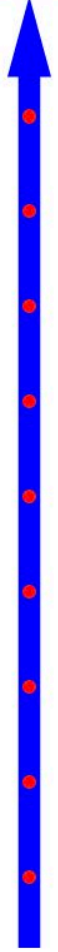


Rack Power
(kWatts)



- AI driving power, and power density⁽¹⁾
- EU “Titanium” efficiency specification in force⁽³⁾
- Privacy concerns, edge traffic: drive localized data centers⁽²⁾

AC-DC Power
Density
(Watts/Inch³)

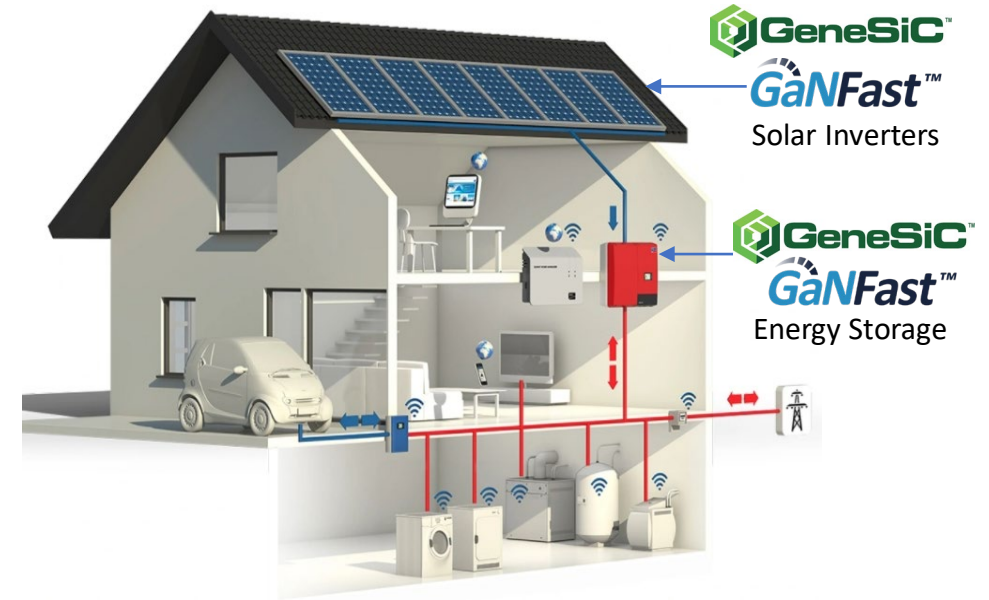
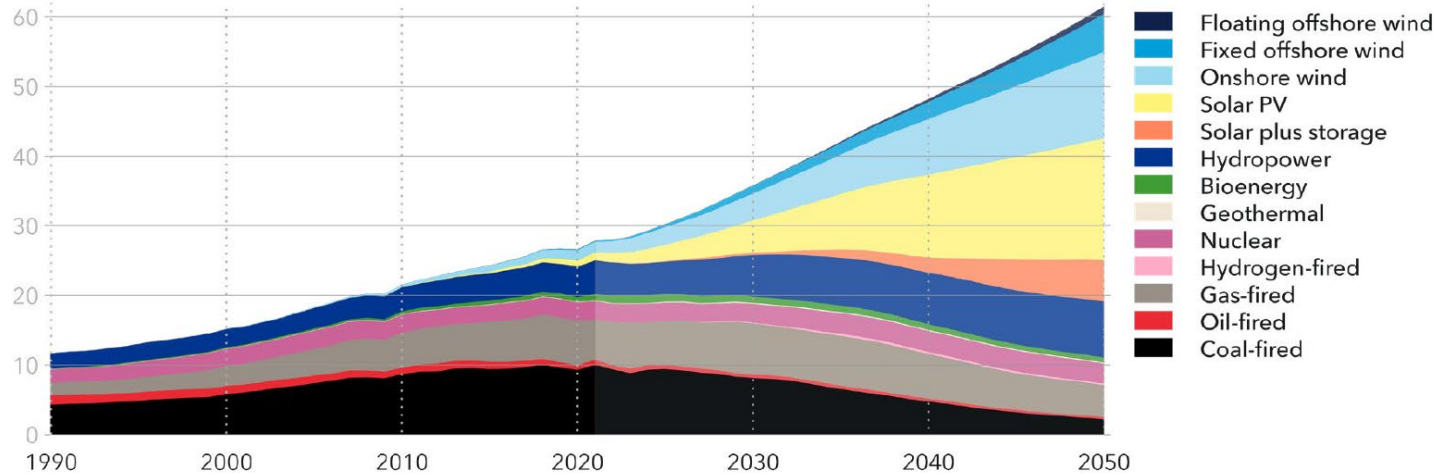


1. Cerebras white paper / website
 2. TD Cowen, per “AI to drive data center investments”, LightReading.com, 4-26-23
 3. European Union ‘Directive 2009/125/EC, 2019 Annex’, power supplies must be >96% efficiency peak, as of 1-1-23

Accelerating Energy Demand: Solar/ESS

World grid-connected electricity generation by power station type⁽¹⁾

Units: PWhr/year



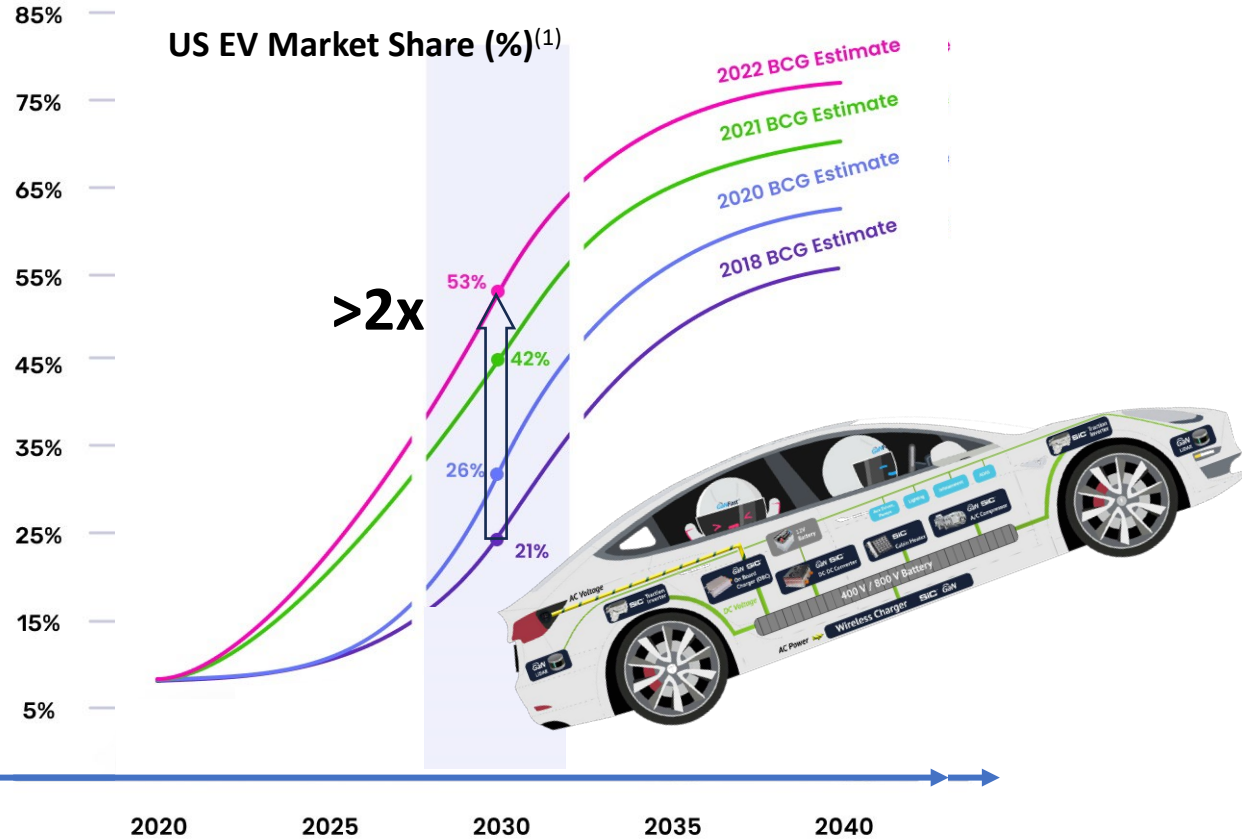
- Global electricity supply +2.3x by 2050⁽¹⁾
- Solar / energy-storage systems (ESS) up from ~2% to 38%⁽²⁾
- Energy storage critical to balance supply / demand



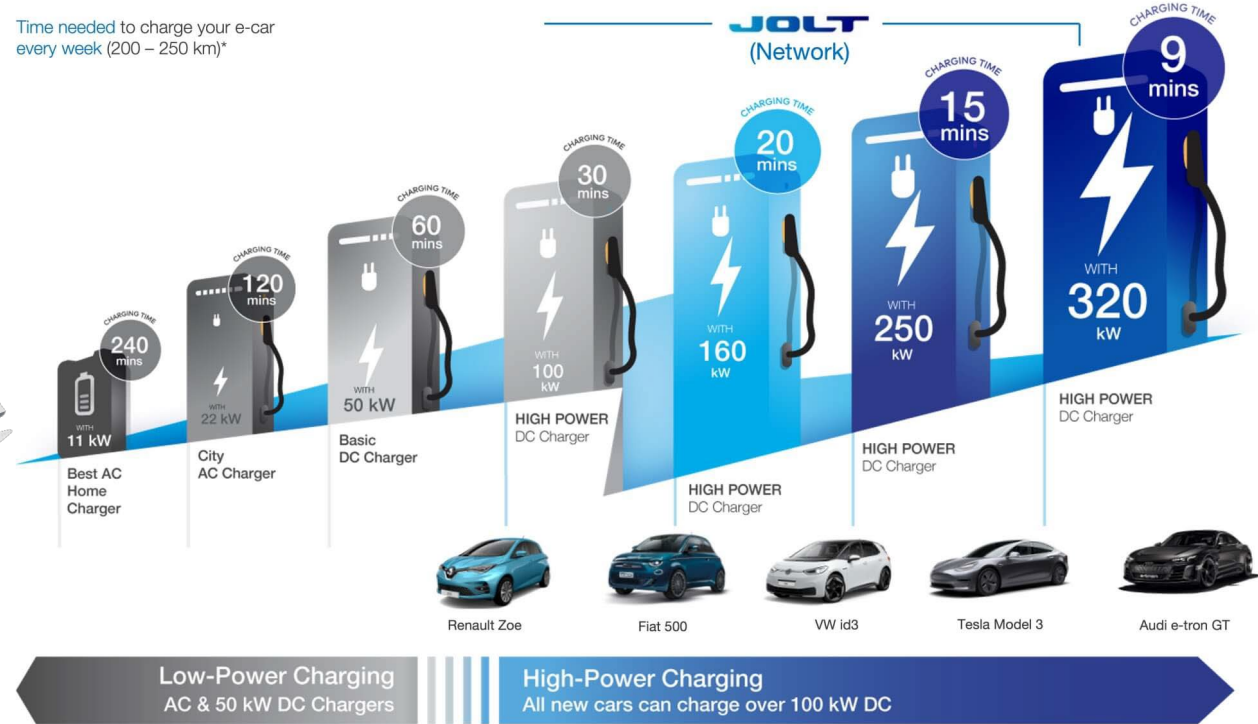
1. DNV Energy Transition Outlook 2022, updated January 2023. Grid-connected energy supply estimated to increase from 27 to 62 PWhr/year.

2. DNV: Solar/ESS grows to 38% of supply by 2050. Historical data per IEA WEB (2022), GlobalData (2022)

Accelerating EV: Fast Charging (OBC, Roadside) Navitas

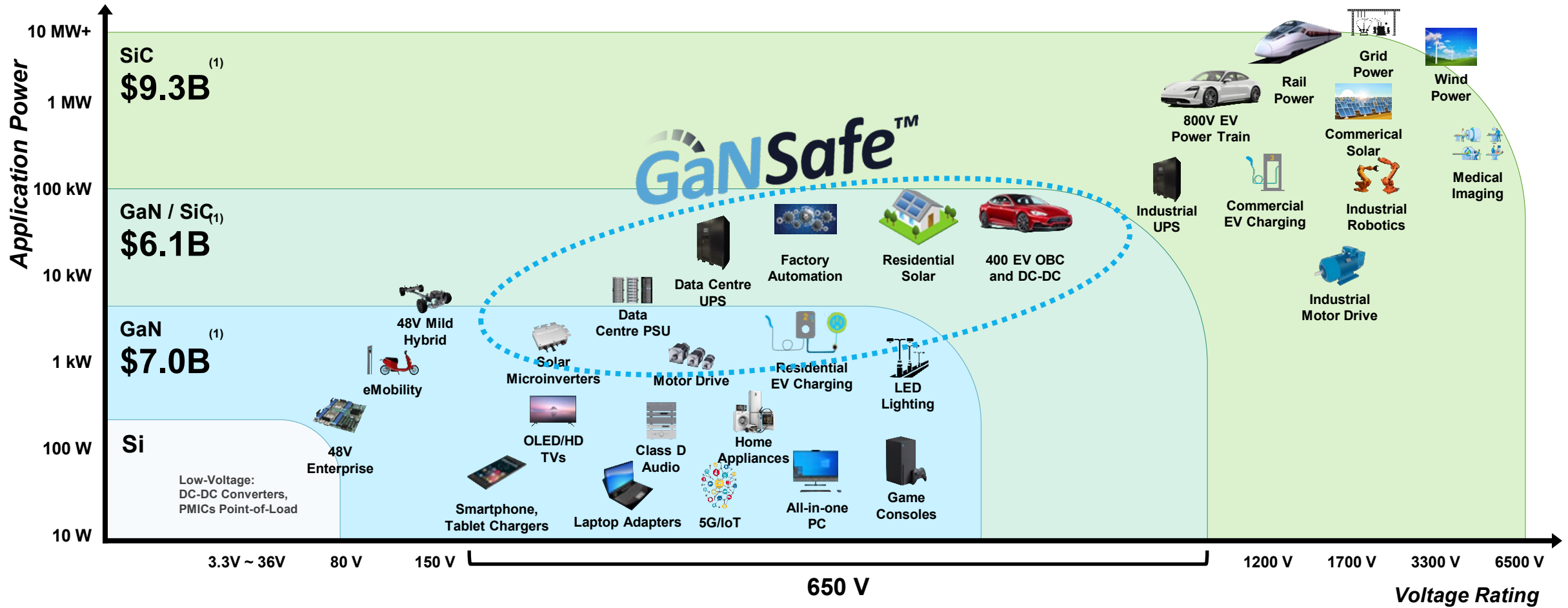


Time needed to charge your e-car every week (200 – 250 km)*



1. Chart BCG, via <https://www.recurrentauto.com/research/ev-adoption-us>
 2. <https://jolt.energy/whats-the-difference-between-ac-dc-and-ultra-fast-charging/>

GaNSafe™: Accelerating GaN into High Power

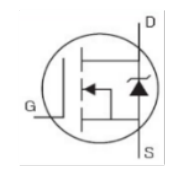


1. Navitas company estimates, potential market opportunity in 2026 is \$22B+ for GaN and SiC, replacing certain of the silicon market share. Axes not to scale

GaNSafe™: Ultimate Performance, Reliability

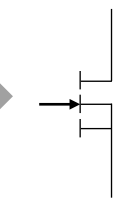


Discrete Silicon



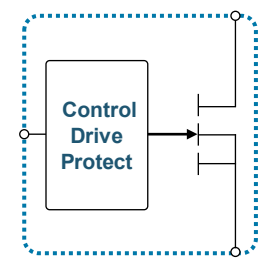
- Old
- Slow
- Low efficiency

Discrete GaN



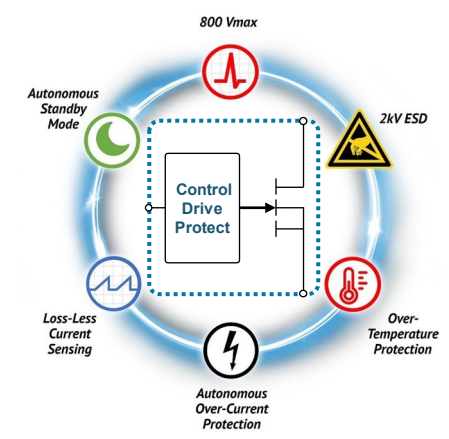
- Vulnerable
- Difficult to use
- Unknown reliability

GaNFast™



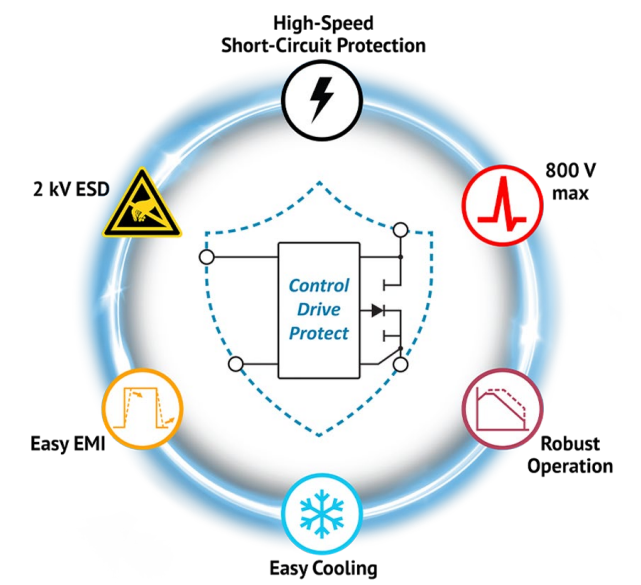
- ✓ Robust
- ✓ Easy to use
- ✓ Proven reliability

GaNSense™



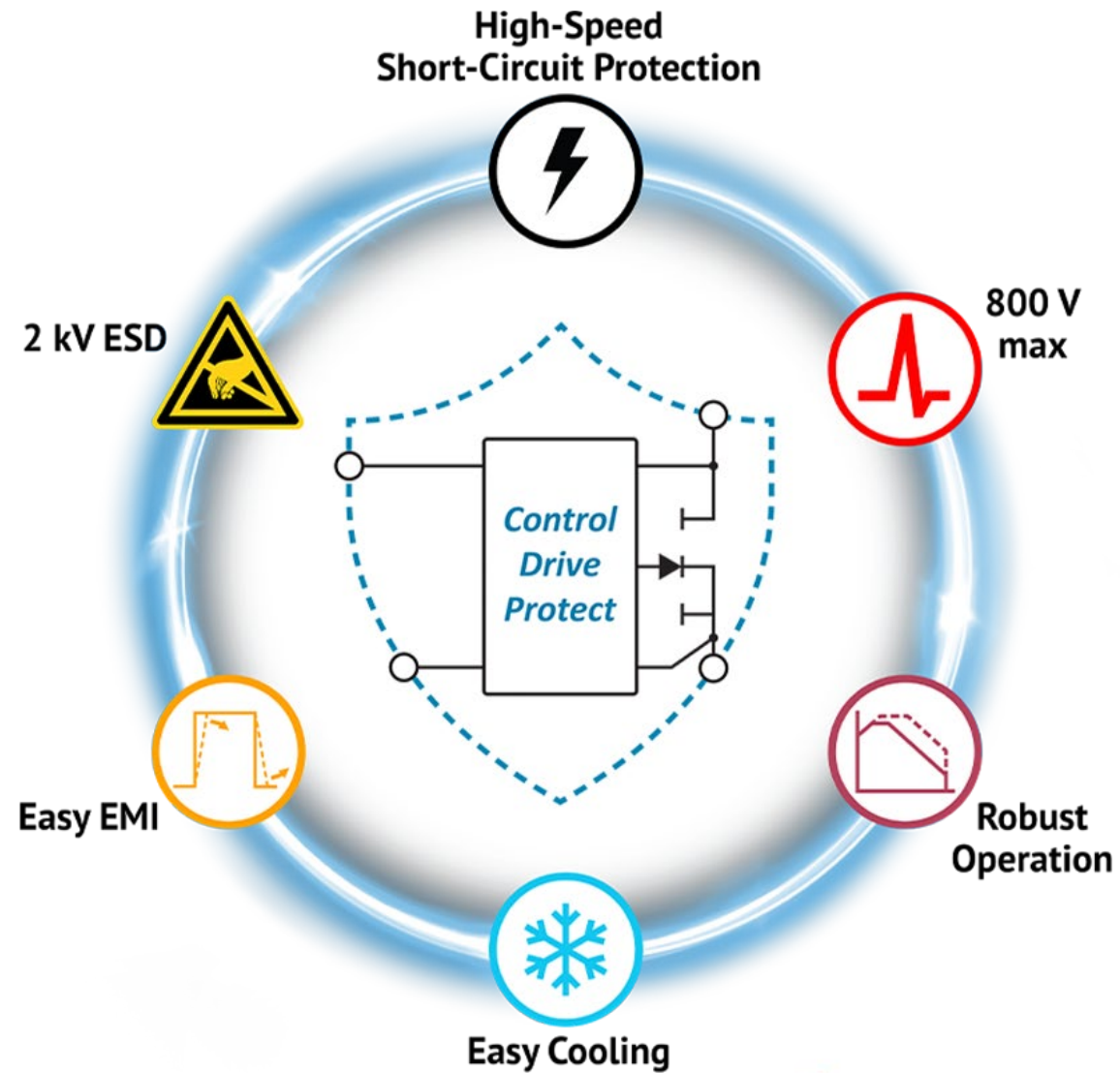
- GaNFast plus:
- ✓ Autonomous protection
 - ✓ Loss-less current sensing

GaNSafe™

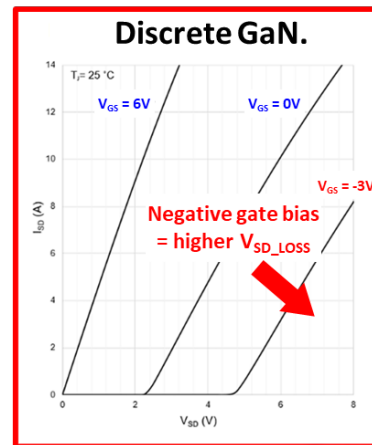
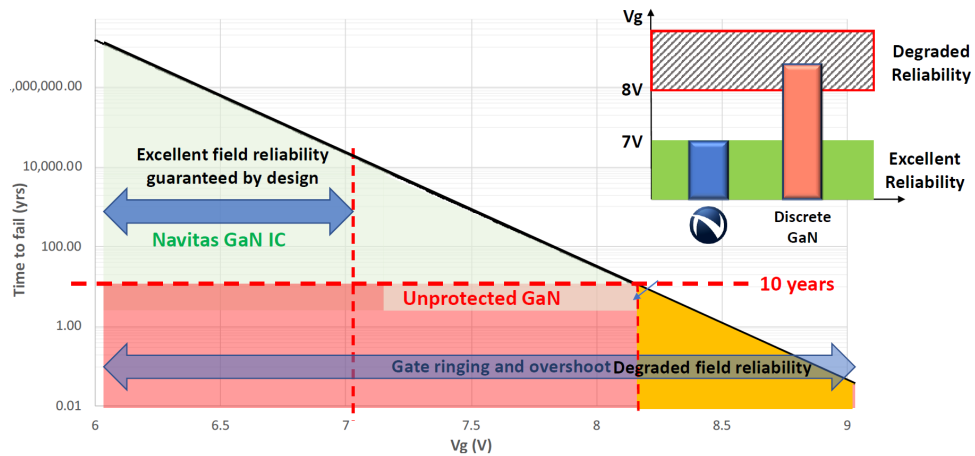
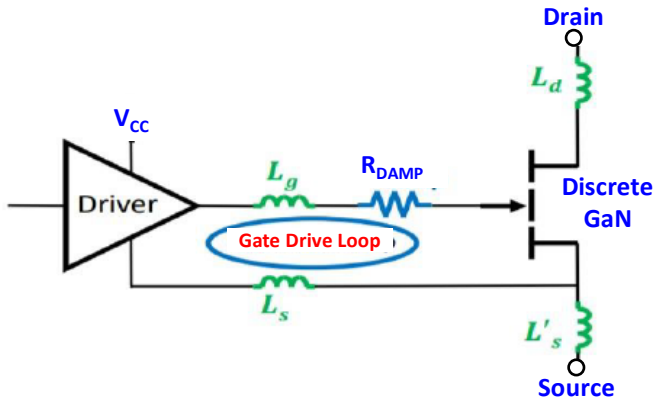


- GaNSense plus:
- ✓ Short-Circuit Detection
 - ✓ Ultra-fast autonomous protection
 - ✓ Robust, cool packaging
 - ✓ Programmable dV/dt turn-ON and OFF

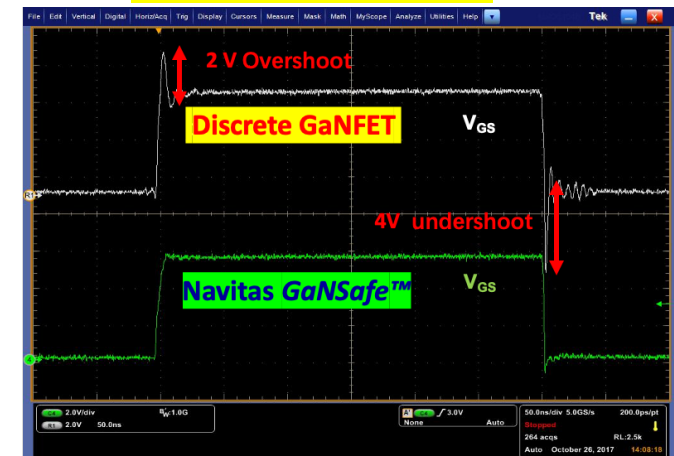




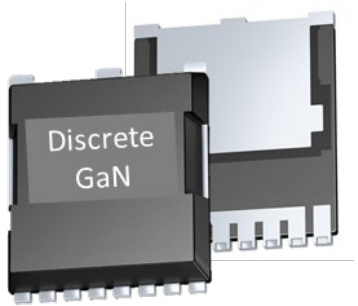
- **Discrete GaN = high risk**
 - Weak gate, high loop inductance
 - Shoot-thru risk multiplied by increased di/dt in high-power applications
- **GaNFast™** integrated, regulated gate drive, zero loop inductance
- Fewer components, smaller PCB,
- Higher efficiency, lower system cost
- **GaNSafe™** optimized for high power
 - More protection (300 ns Desat SCP, OTP, UVLO, ESD, etc.)
 - More control (dV/dt ON & OFF, etc.)
 - Industry-standard, robust, cool packaging



Discrete GaNFET

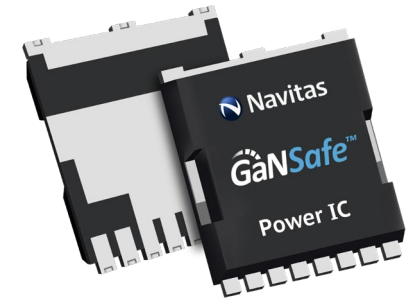
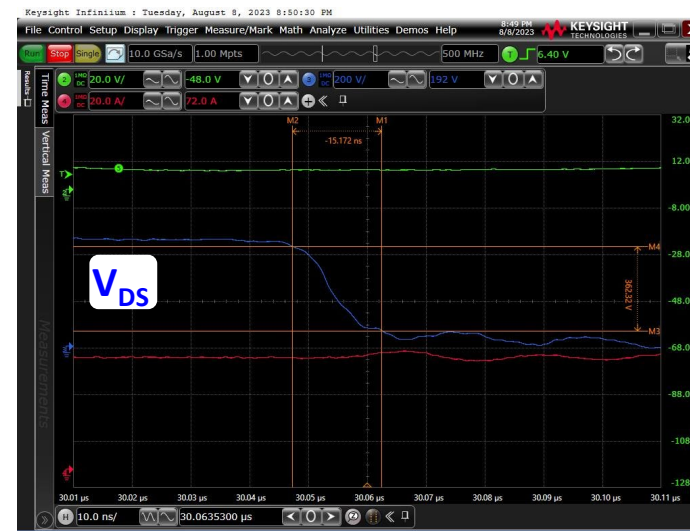
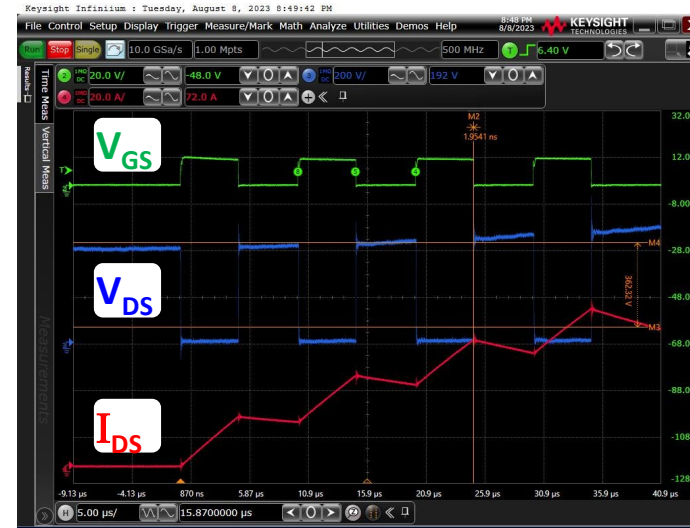


- Double-pulse test:
400 V, 30 A, $R_{SERIES} = 11\text{ m}\Omega$



Discrete GaN
42 mΩ max

Significant spikes
Excessive turn-ON ringing
250 V undershoot



GaNSafe™

45 mΩ max
(NV6513)

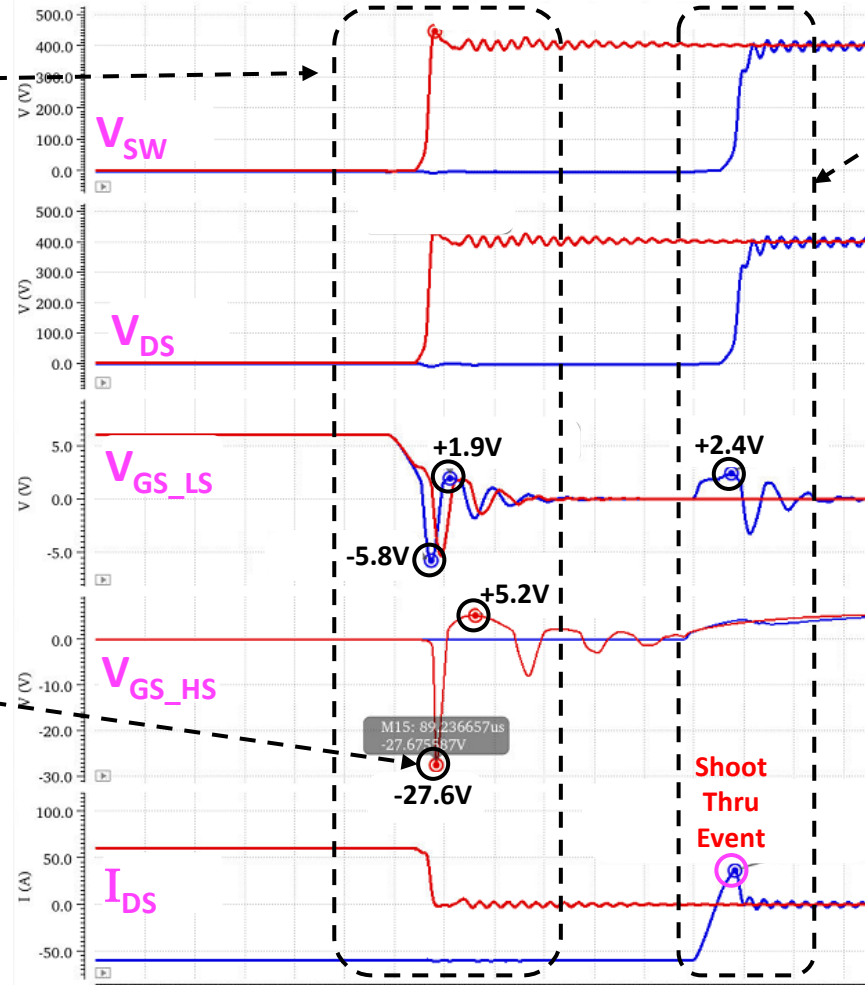
No voltage spikes
No ringing
No undershoot

Discrete GaN: Major Challenge in High Power Navitas

Boost Mode:

LS Turn-OFF causes severe HS & LS V_{GS} ringing due to gate loop inductance coupled with higher di/dt when operating in high power applications

V_{GS} rating violated:
Negative spike on LS Turn-OFF goes beyond -20V limit

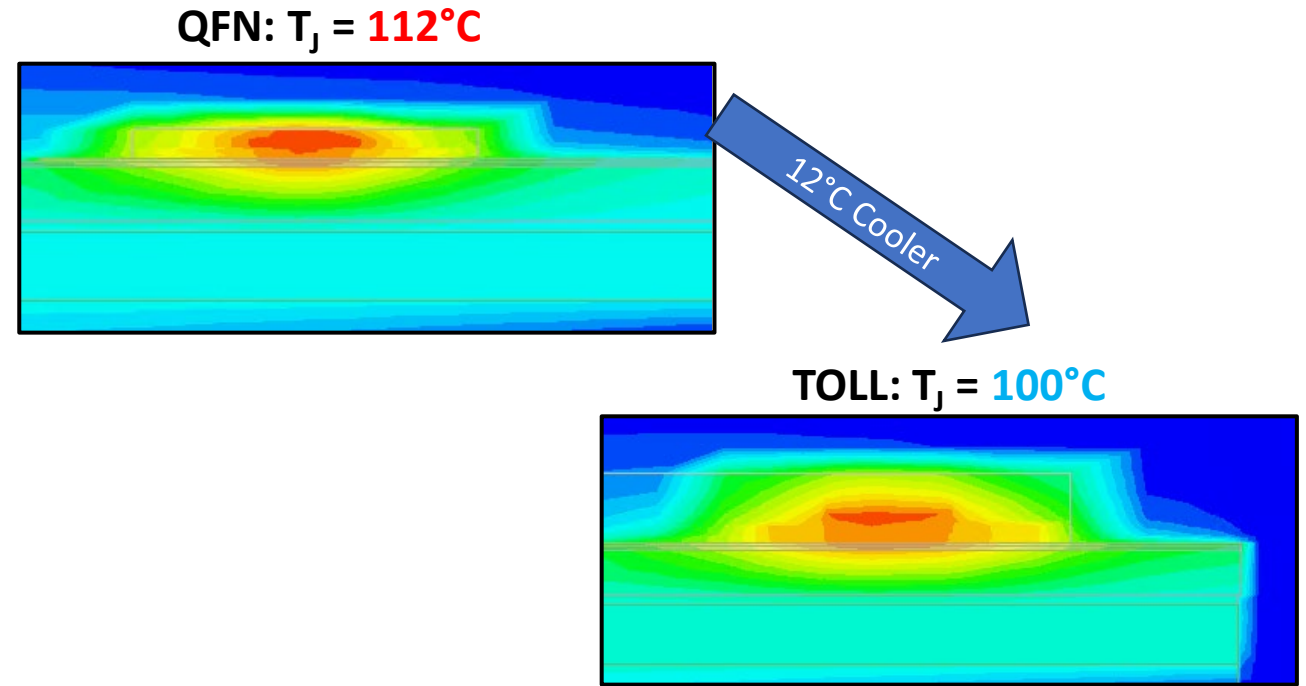
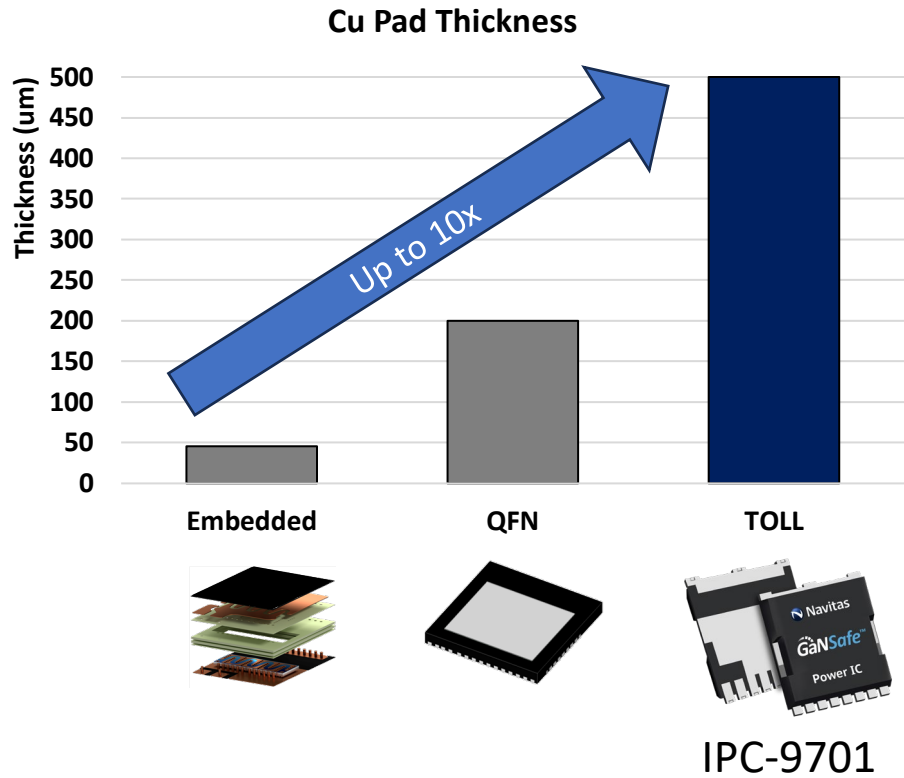


Buck Mode:

LS gate is pulled-up as Switch Node rises, with simultaneous surge in I_{DS}

400V 60A Simulation:

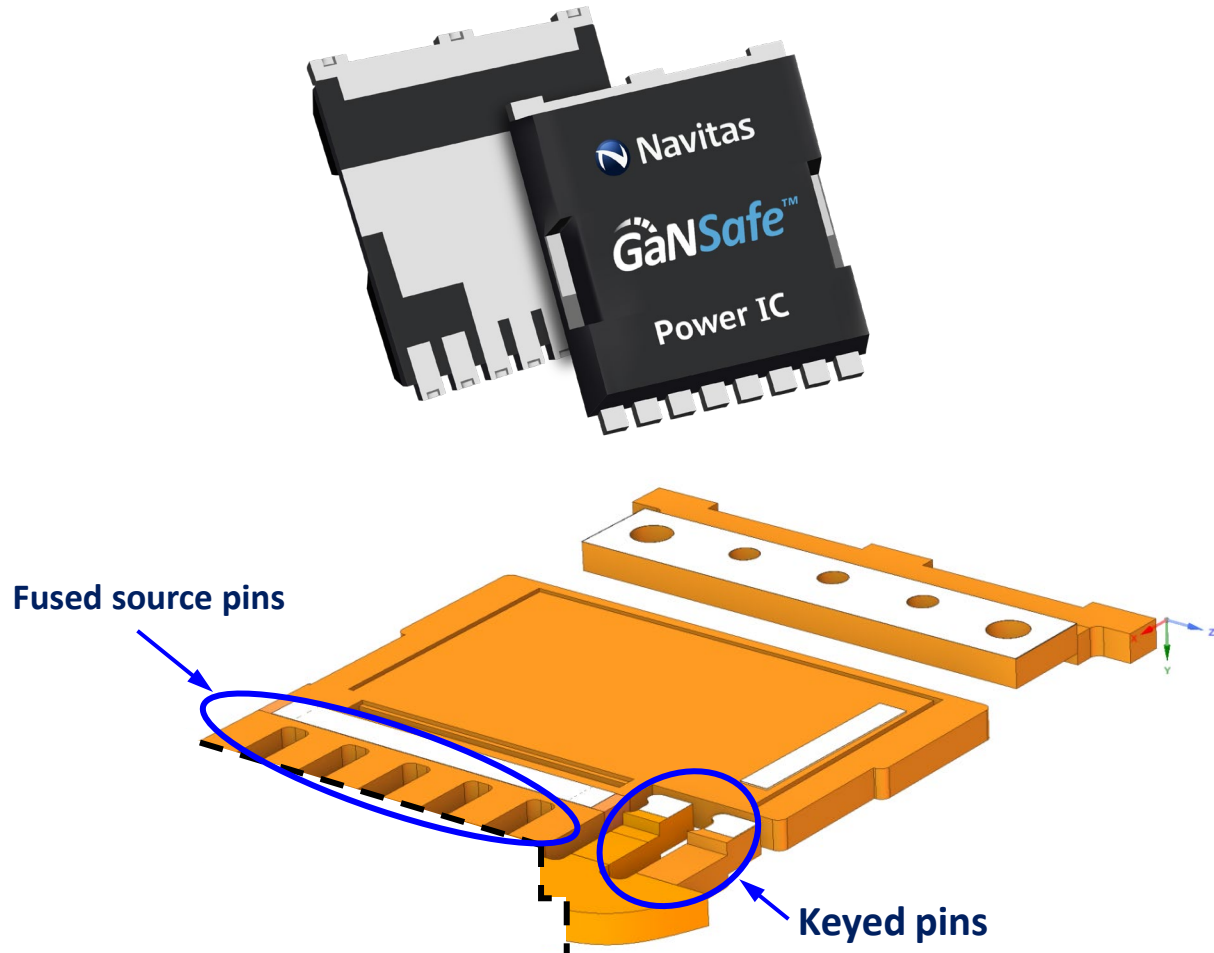
- Discrete GaN
- 25m Ω
- TOLL



GaNSafe™

- Optimized, system-level cooling ($R_{\theta_{J-A}}$)
 - Larger, thicker Cu pad
 - High-conductivity die attach

1. Navitas' simulated temperature gradients for TOLL and QFN under identical system thermal design and 200 LFM airflow

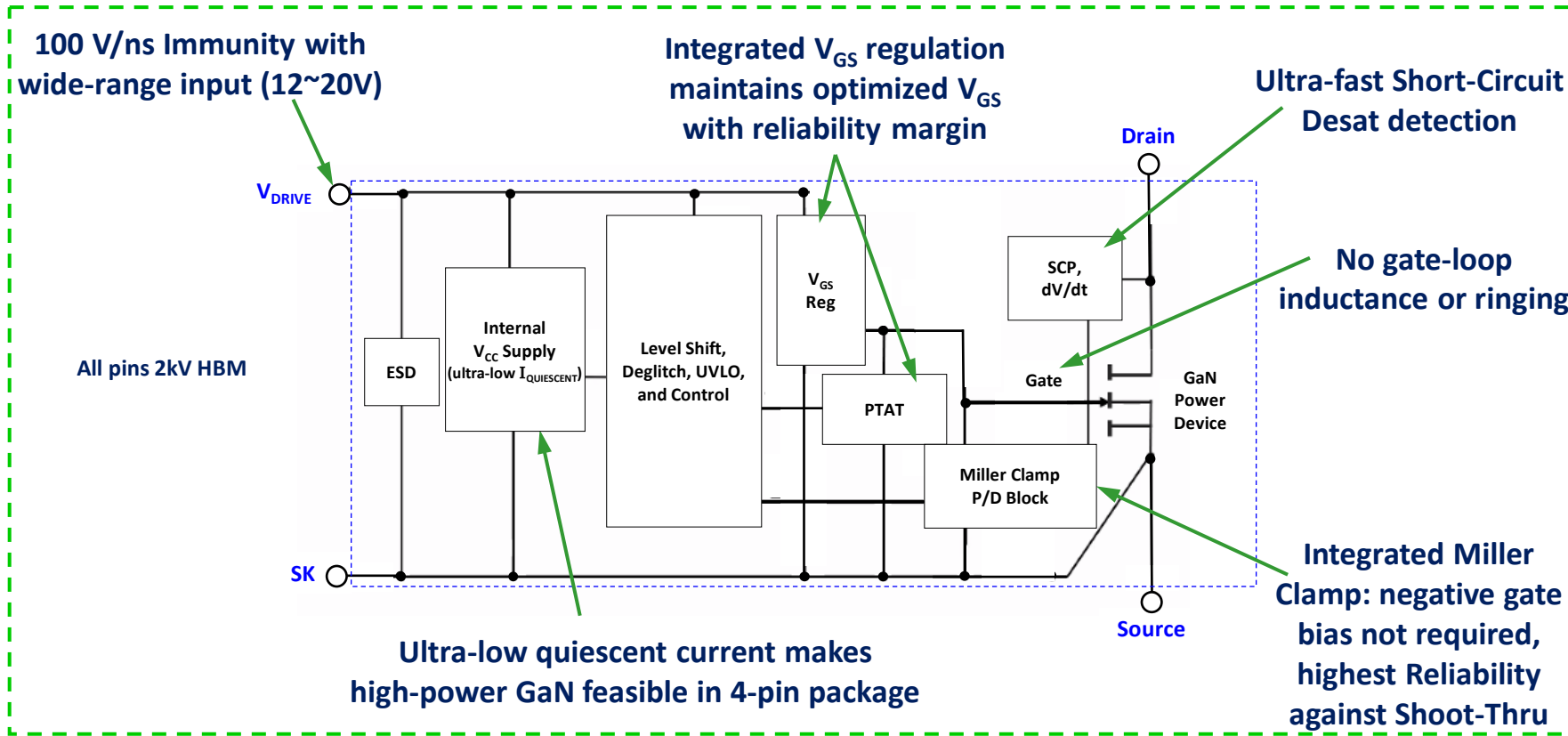


- TOLL = “Transistor Outline Lead-Less”
- 10 x 10 mm
- Mechanically robust, novel leadframe
 - Keyed V_{DRIVE} and SK pins
 - Improved mechanical performance
 - Fused source pins
 - Improved thermals)
- Passed IPC-9701 for long mechanical lifetime

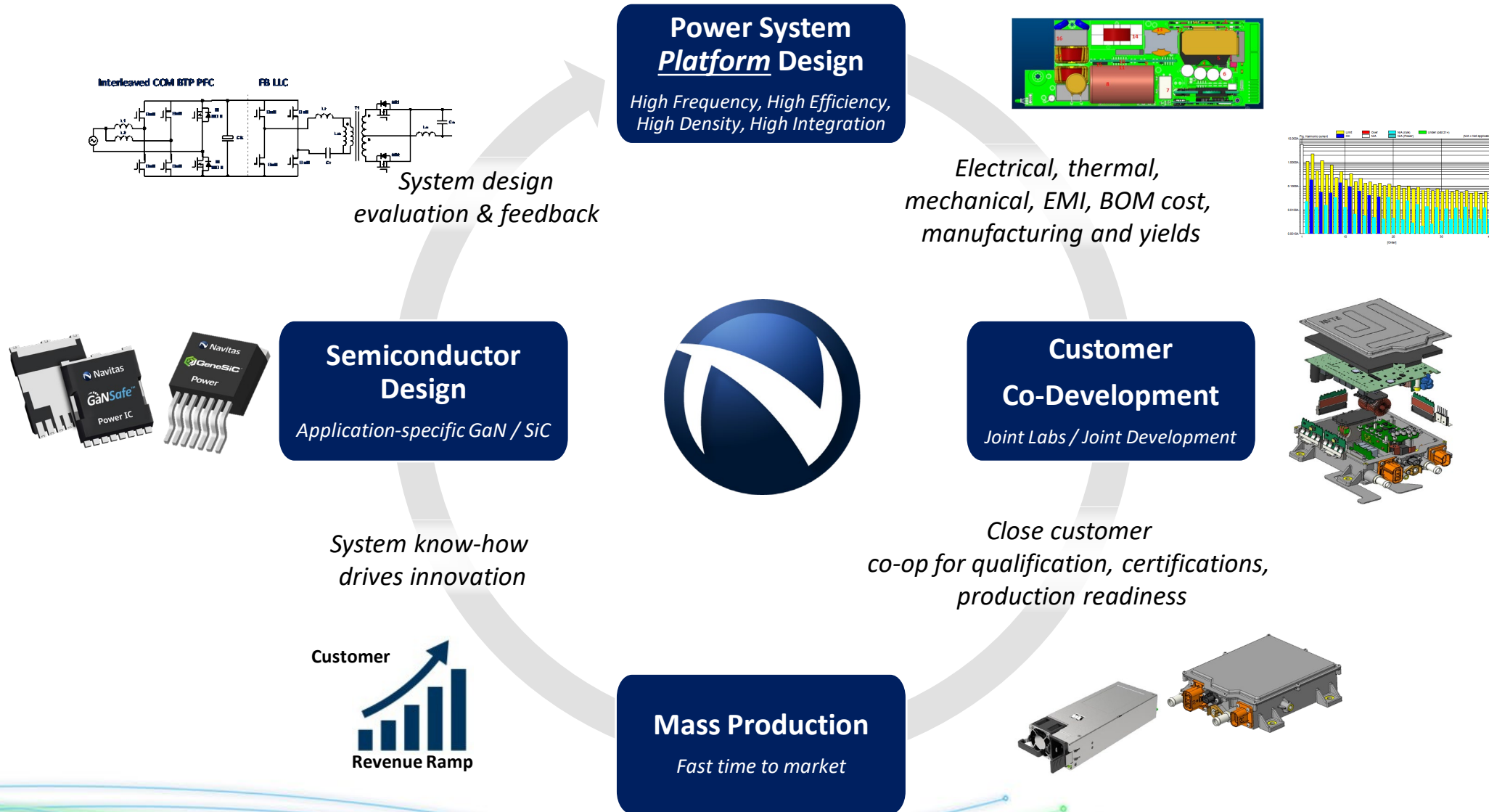


GaNSafe™
Integrated GaN gate drive, protection
and features, in 4-pin industry-standard
thermally-enhanced package...

1. IPC-9701 “Thermal Cycling Test Method for Fatigue Life Characterization of Surface Mount Attachments”



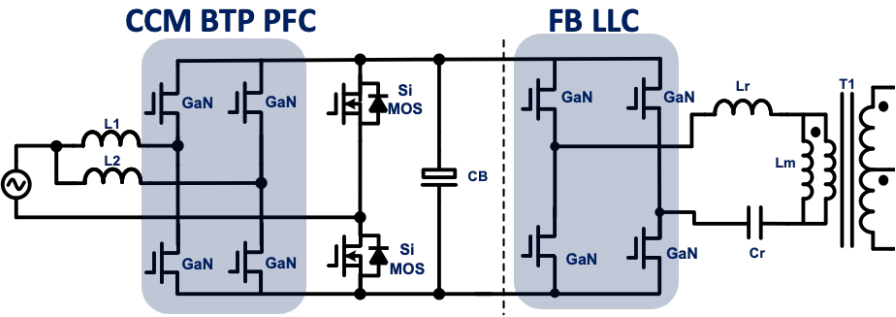
Accelerating TTM Requires Platform Focus

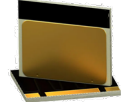



GaNSafe™: Max Performance for Data Center



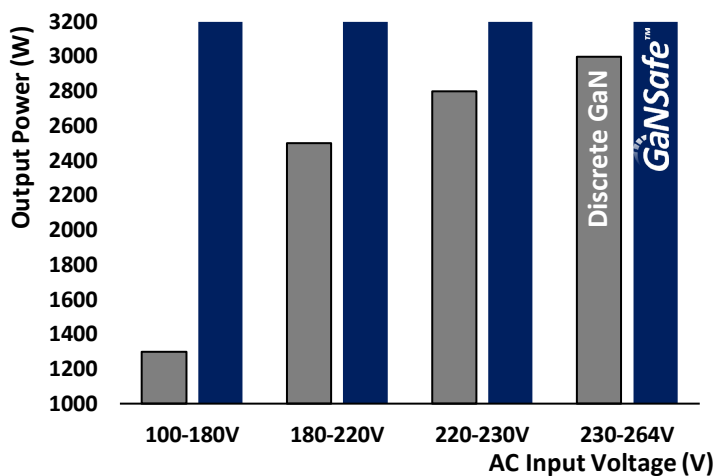
- Data center AC-DC 'silver box' (12V)
- CRPS185 form factor



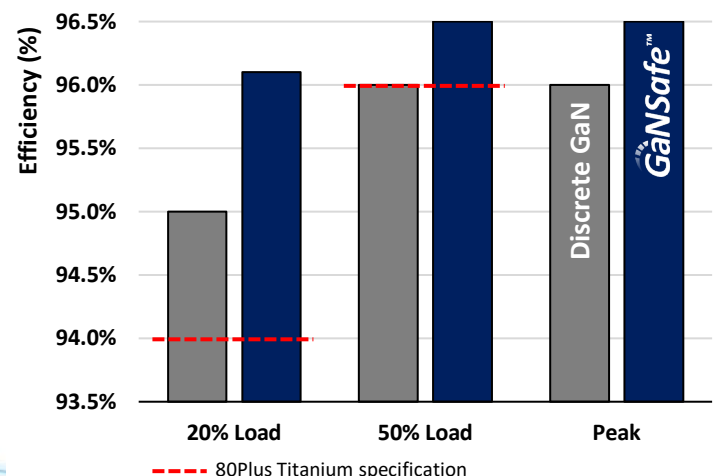
Power	2,800 W	3,200 W
PFC	8 x 32 mΩ	4 x 45 mΩ
DC-DC	4 x 32 mΩ	4 x 55 mΩ
Total	12 x Embedded 	8 x TOLL 

GaNSafe™
33% fewer power components

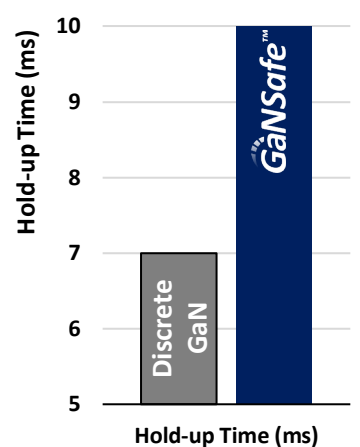
GaNSafe™ True 3,200W CRPS185



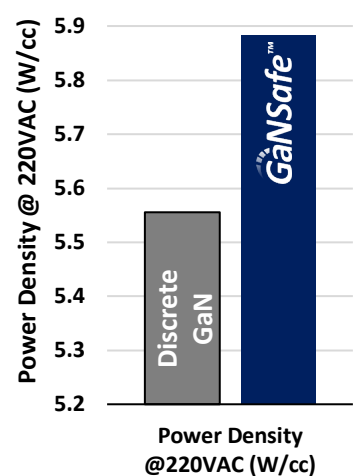
GaNSafe™ Titanium Plus, with margin



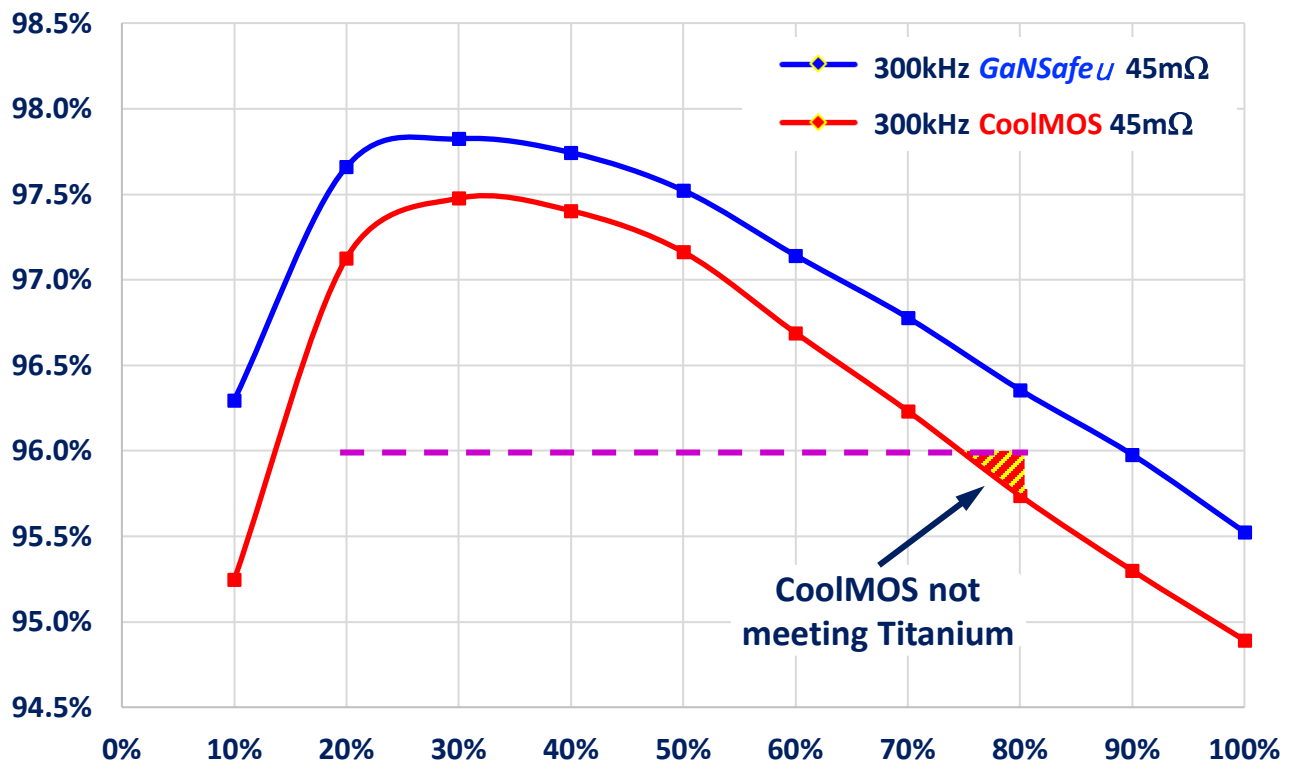
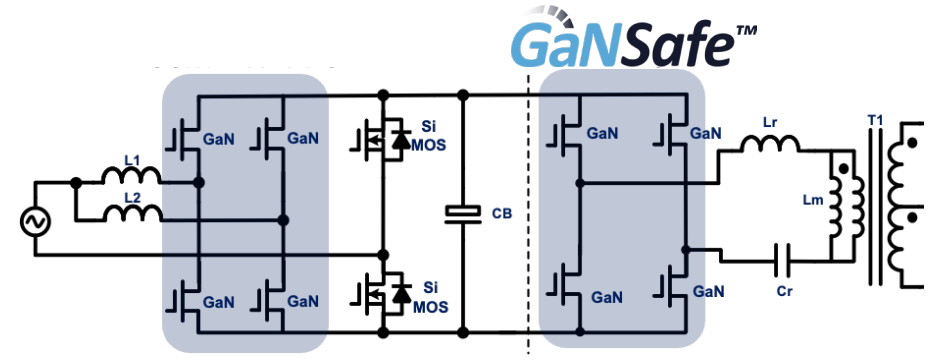
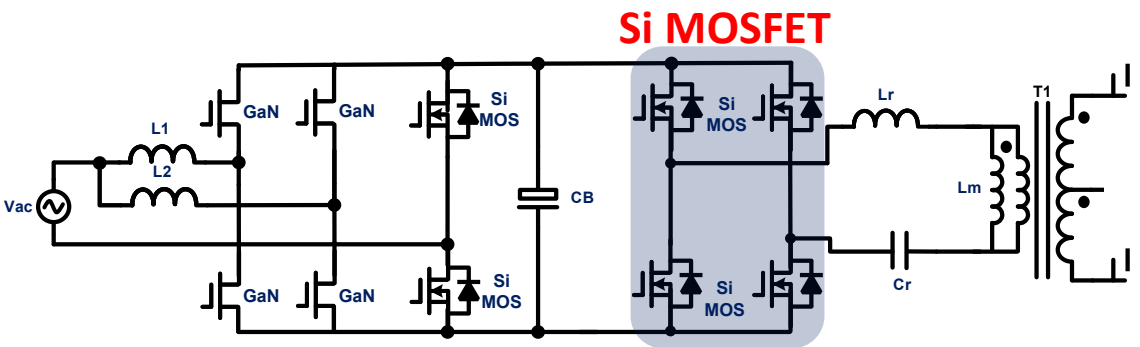
GaNSafe™ +40% Hold-up



GaNSafe™ ~100W/in³



GaNSafe™: Higher Efficiency than Si in LLC



- GaNSafe™ meets Titanium with higher power density at 300kHz
- CoolMOS does not meet Titanium at 300kHz F_{sw} in LLC stage
- GaNSafe™ meets EN55022 / CISPR22 Class A (CE and RE)

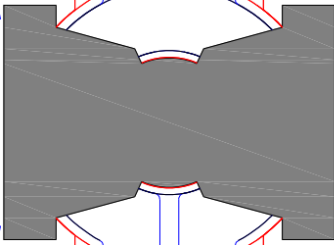

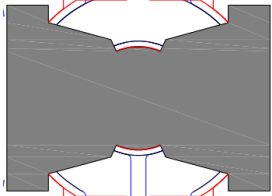
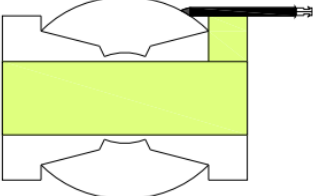

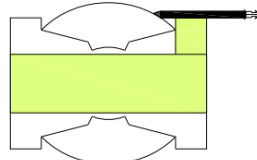









GaNSafe™ Yields Higher Density, Lower BOM



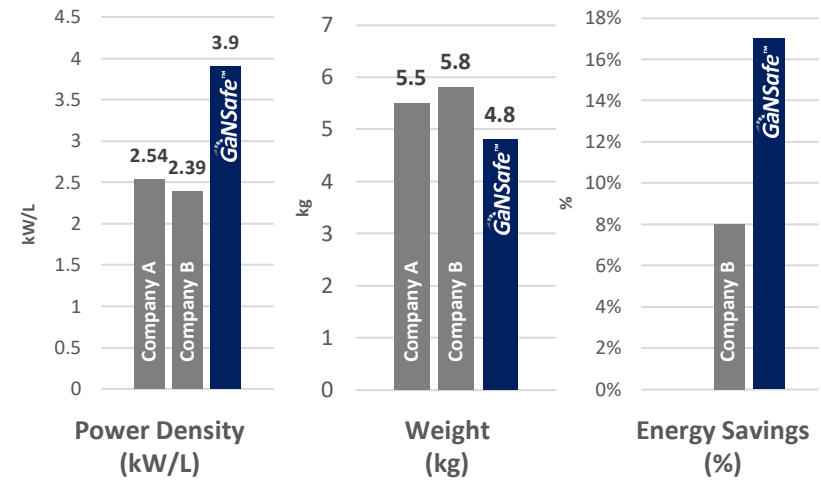
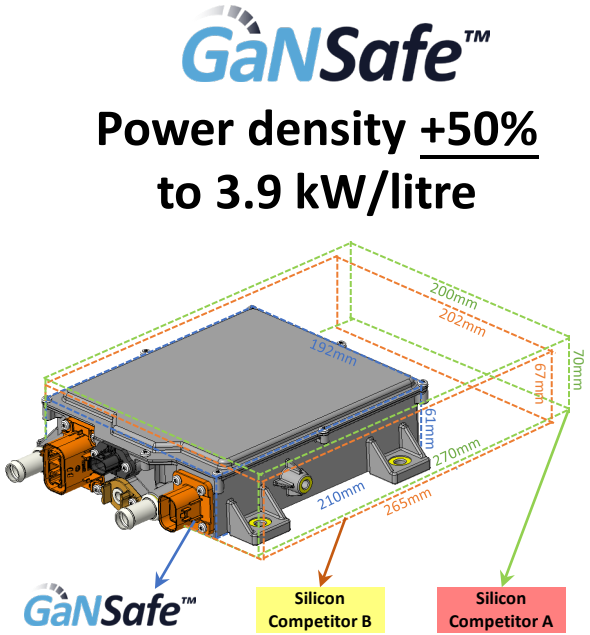
Si 150 kHz LLC

GaNSafe™

300 kHz LLC

<p>Main Transformer</p>	 <p>PQ3628 Size: 36 x 28 x 24 mm</p>		 <p>PQ3033 = 14% smaller Size: 30 x 33 x 21 mm</p>
<p>Resonant Choke</p>	 <p>PQ2618: Size: 26 x 18 x 19 mm</p>		 <p>PQ2018 = 43% smaller Size: 20 x 18 x 14 mm</p>
<p>Resonant Capacitor & Output MLCC</p>	 <p>630 V, 10 nF 1206 *40pcs 16 V, 10 uF 1206 *64pcs</p>		 <p>630 V, 10 nF 1206 *12pcs 16 V, 10 uF 1206 *50pcs = 40% fewer</p>
<p>Primary Switch</p>	 <p>IPT60R055CFD7 *4pcs</p>		 <p>NV6512C *4pcs</p>
<p>Protections & Features</p>	 <p>1 kV ESD</p>		 <p>SCP, 2 kV ESD, dV/dt Control</p>

GaNSafe™ Delivers Highest OBC Power Density Navitas

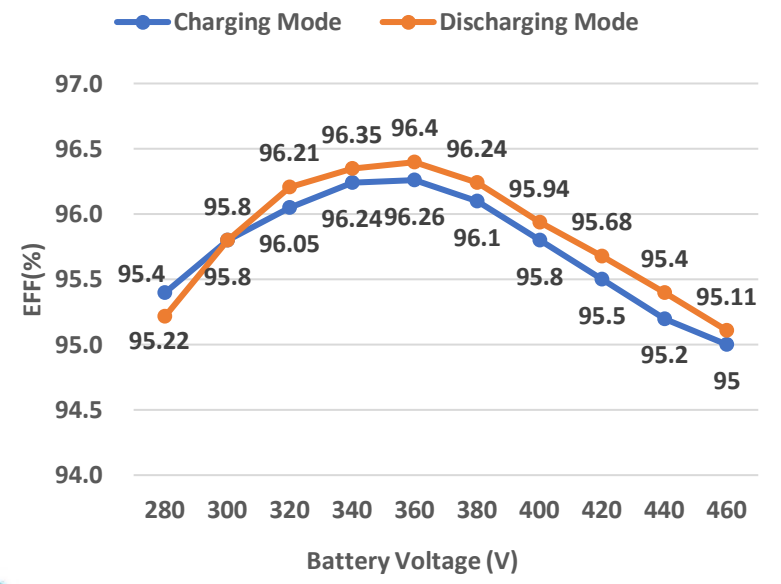
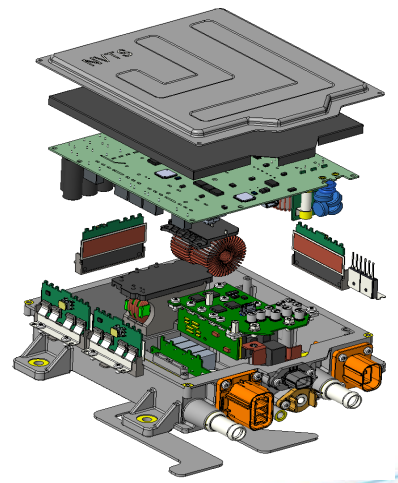


Combination 6.6 kW OBC + 3 kW DC-DC:

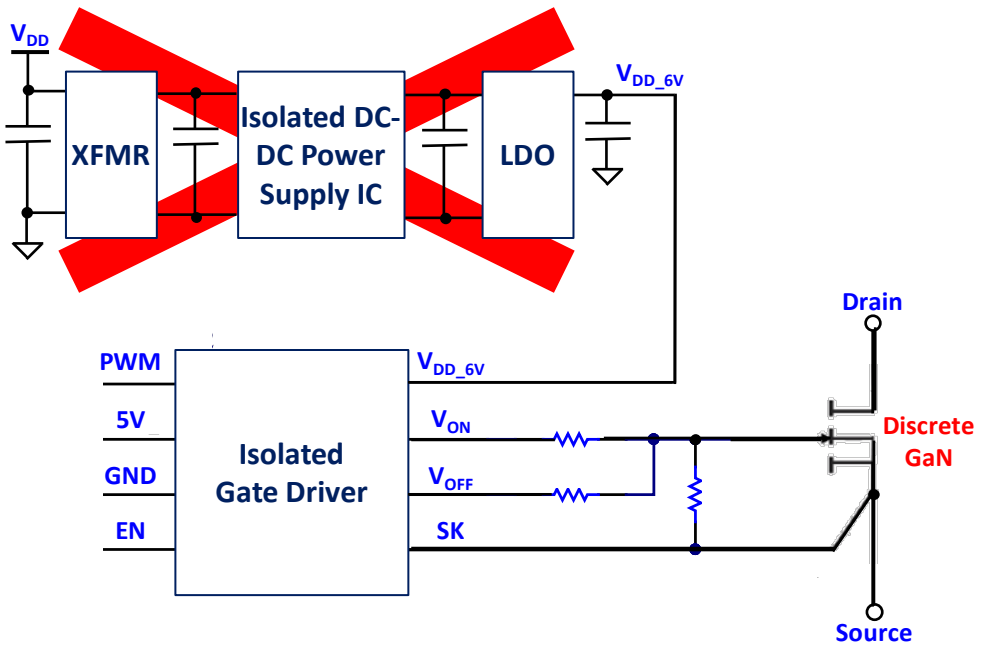
- AC Input: 90~265 V_{AC} up to 32 A
- DC Output: 470~860 V_{DC}, full load
- Power Output: 6.6 kW charging, 6.0 kVA discharging
- Efficiency: ≥ 95% @ Full Load
- DC-DC Output: 9~16 V_{DC}

Mechanical:

- Dimensions: 210 x 192 x 61mm (≤ 2.5 litre)
- Cooling: -40 to +65°C (Cold Plate)
- Communication: IP 67, CAN Bus interface



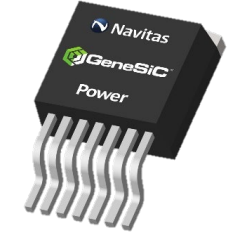
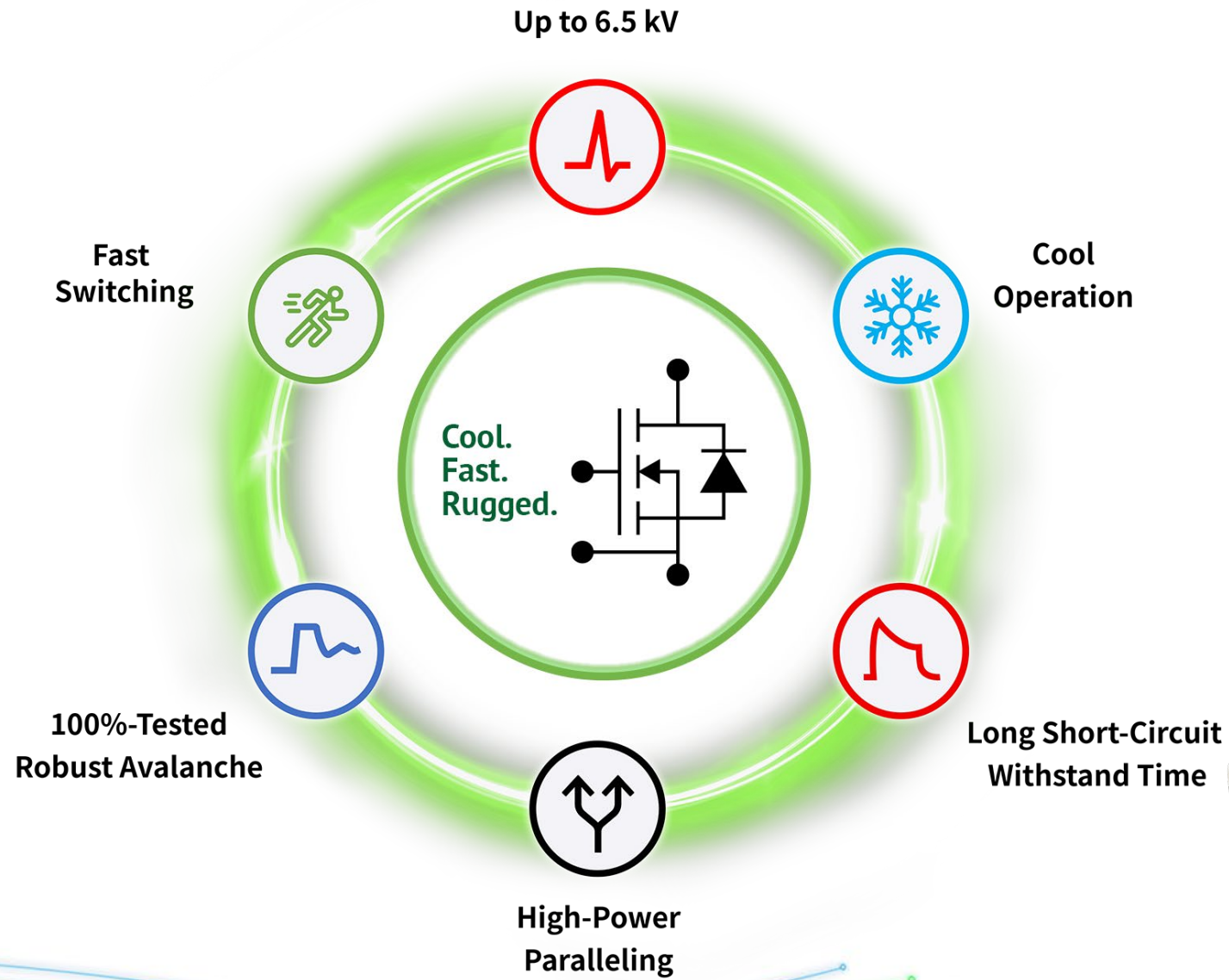
Typical GaN discrete high-side schematic for use in high-power applications:



Eliminate costly DC-DC supply

- **GaNSafe™**
 - Use Boot Strap for high power applications:
\$1 saved per half-bridge
 - Integrated UVLO and Miller Clamp: no power sequencing issue, no negative gate drive (V_{GS})
 - Includes SCP protection and 2 kV ESD

GeneSiC™ : Highest Performance & Ruggedness Navitas





- Navitas is the industry leader in GaN

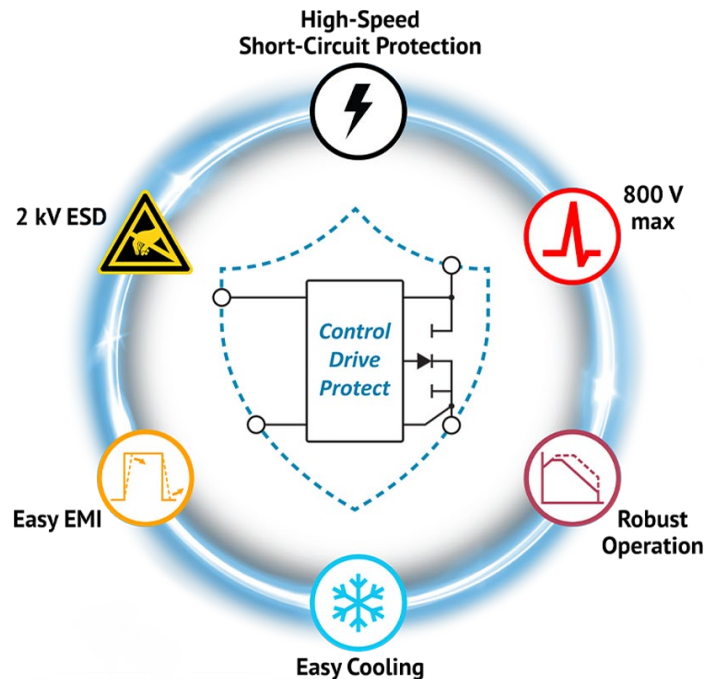
- **GaNFast™:**

- 100M+ shipped, 20-year warranty



- **GaNSafe™:**

- Overcomes challenges inherent to Discrete GaN
- Most protected, most reliable, safest GaN power semiconductor in 4-Pin TOLL
- Allows Benchmark efficiency, power density, reliability
- Demonstrated performance for AI, EV, Solar and more
- **Driving GaN into high power**



Discover more at
navitassemi.com

