



CPEEC · CPSSC
2023

2023中国电力电子与能量转换大会
暨中国电源学会第二十六届学术年会及展览会
2023 China Power Electronics and Energy Conversion Congress
& The 26th China Power Supply Society Conference and Exhibition

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

Michael.Xu
资深应用总监

广州, 2023.11.13

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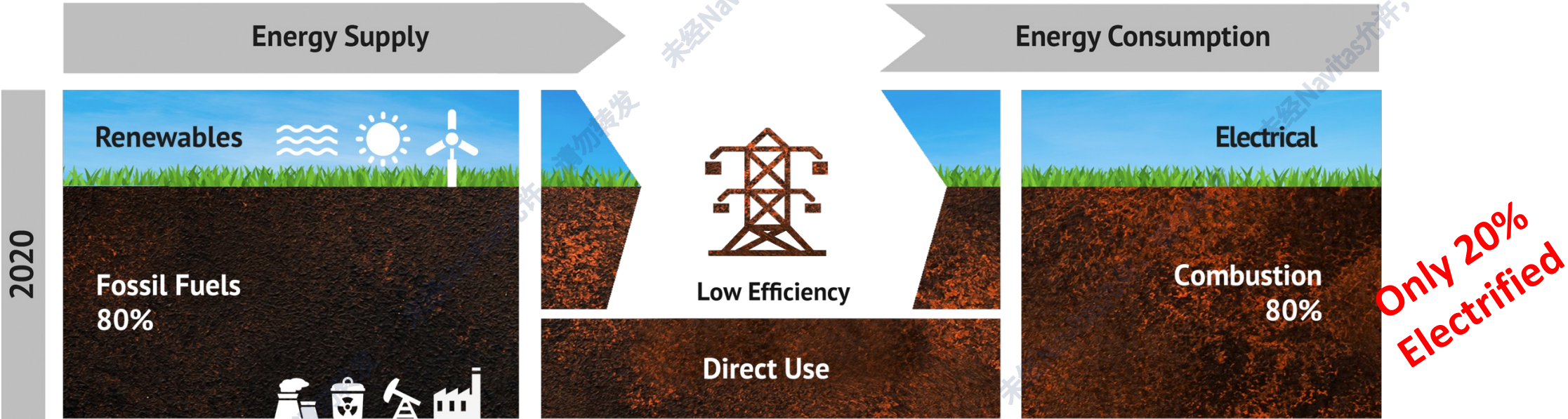


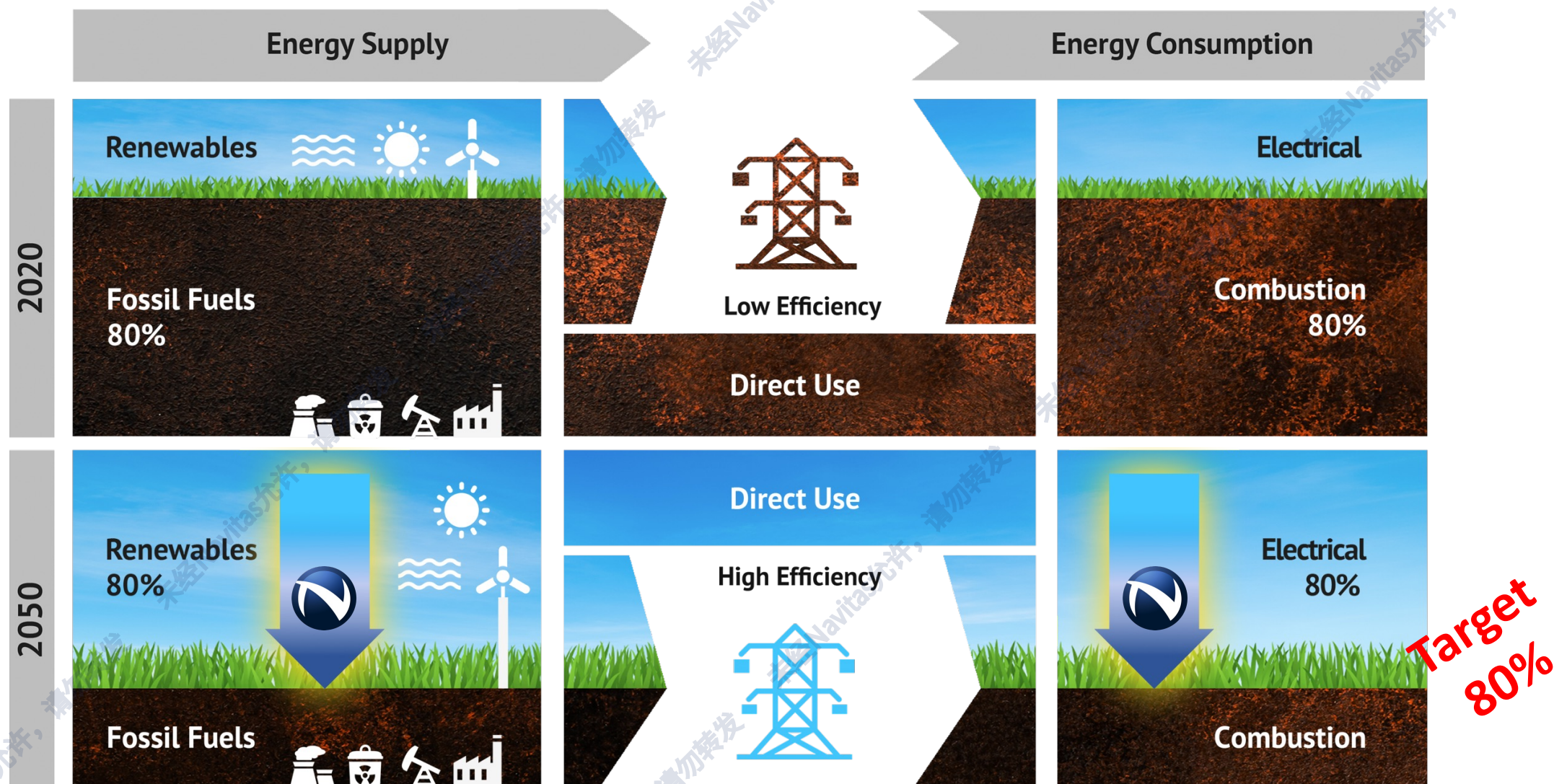
➤ The Introduction of Navitas

- Navitas is Pure-Play, Next-Gen Power Semiconductors

➤ GaNsafe™ Launch

- GaNsafe™ features
- Typical applications of GaNsafe™







GaNFast™



GeneSiC™



Up to
20x

Faster
Switching⁽¹⁾

Up to
3x

Smaller &
Lighter⁽¹⁾

Up to
40%

Energy
Savings⁽¹⁾

Up to
3x

Higher
Power Density⁽¹⁾

Up to
3x

Faster
Charging⁽¹⁾

Up to
25%

Lower
System Cost⁽²⁾



GaN and SiC replacing Si in next-generation power applications

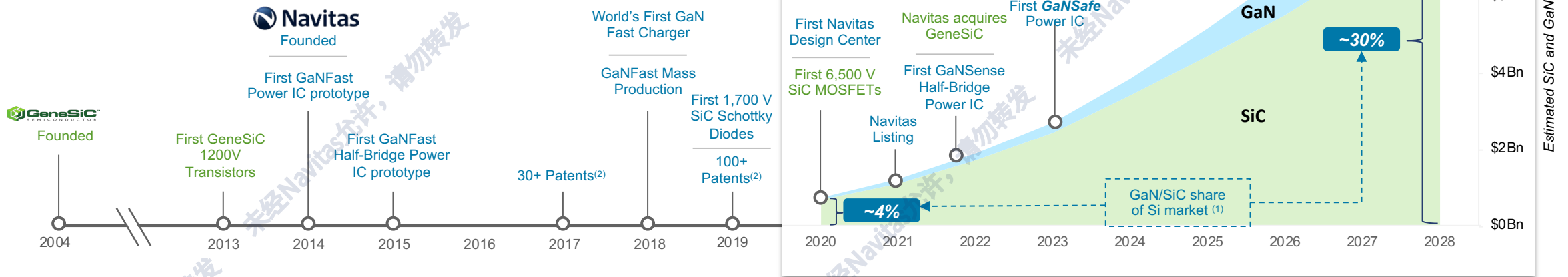
1. Statistical data is based on Navitas estimates of GaN-based systems compared to Si-based estimates in the 2024-2025 timeframe. Based on Navitas measurements of select GaN-based mobile wall chargers compared to Si-based chargers with similar output power, incl. 2019 study of 65W fast chargers, 2022 customer statement re 2.7 kW data center AC-DC
2. Navitas estimates based on customer feedback as the expected system cost saving overtime as of April 2023

Right Time, Right Technology, Right Company

Technology Development

Validation

Mass Adoption



1. Estimated based on Power SiC/GaN Compound Semiconductor Market Monitor, Q1 2023, Yole Intelligence

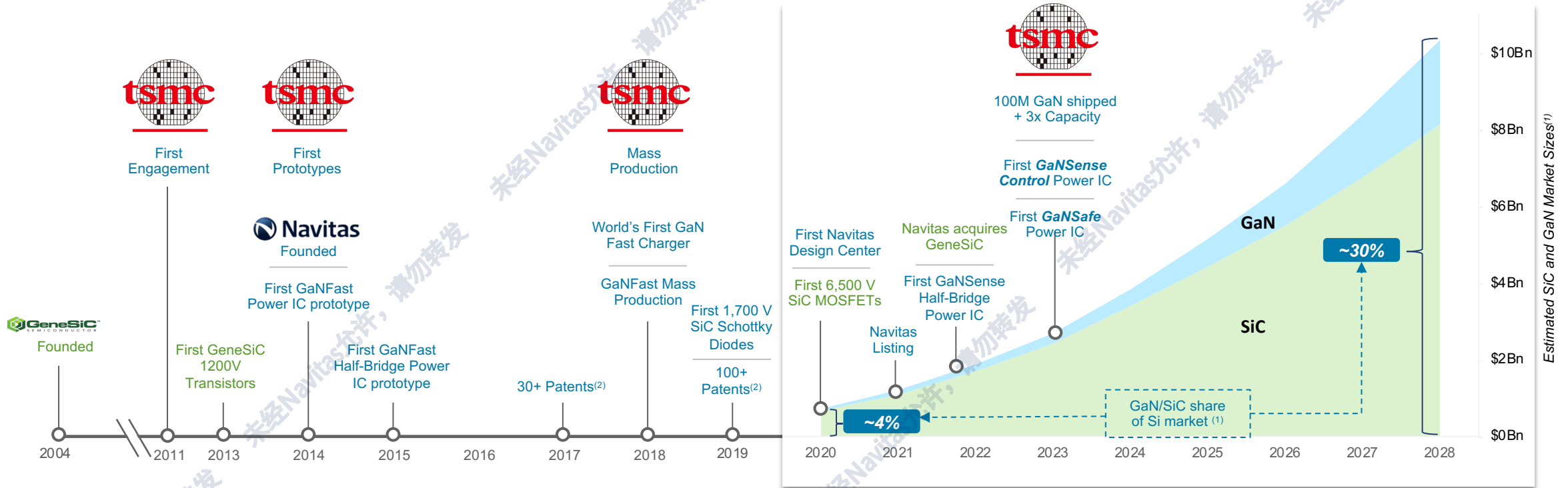
2. Granted or pending

Right Partnership: Navitas + TSMC

Technology Development

Validation

Mass Adoption



1. Estimated based on Power SiC/GaN Compound Semiconductor Market Monitor, Q1 2023, Yole Intelligence

2. Granted or pending

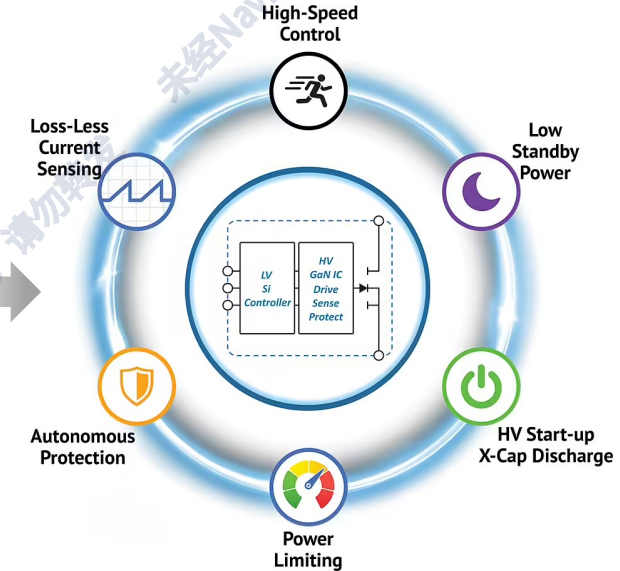
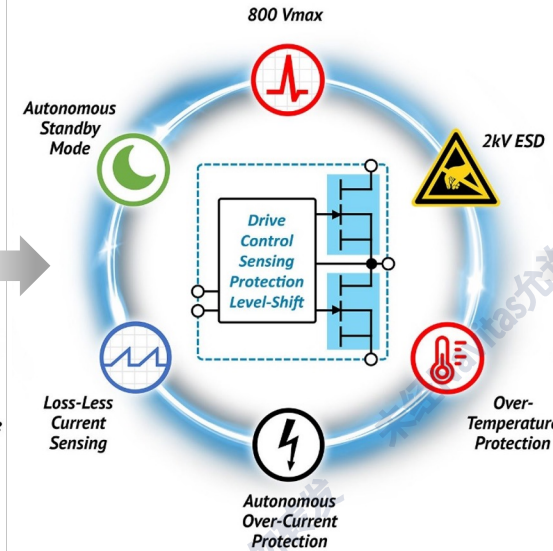
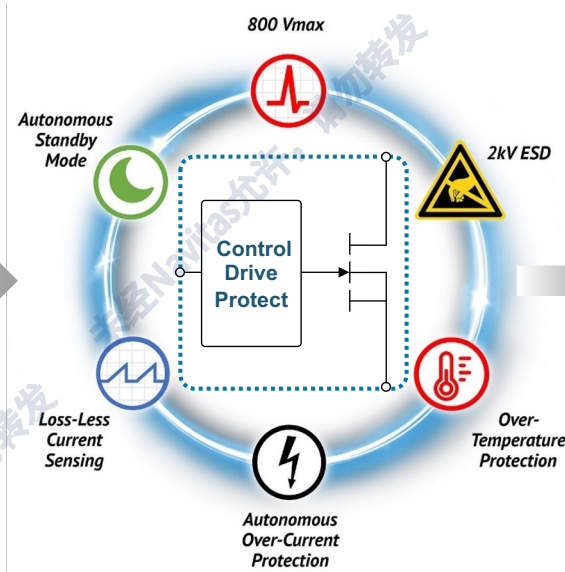
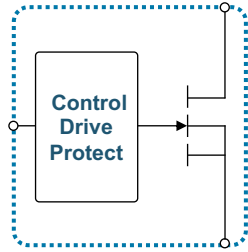
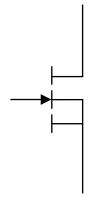
Discrete
GaN

GaNFast™

GaNSense™

GaNSense
Half-Bridge

GaNSense
Control



- Vulnerable
- Difficult to use
- Unknown reliability

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

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

- GaNSense plus:
- ✓ Integrated HS, LS, level-shift isolation
 - ✓ Complete protection

- GaNSense plus:
- ✓ LV silicon system controller
 - ✓ Fewest components

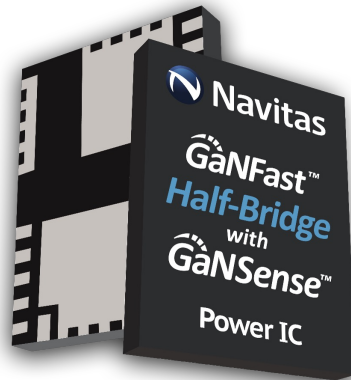
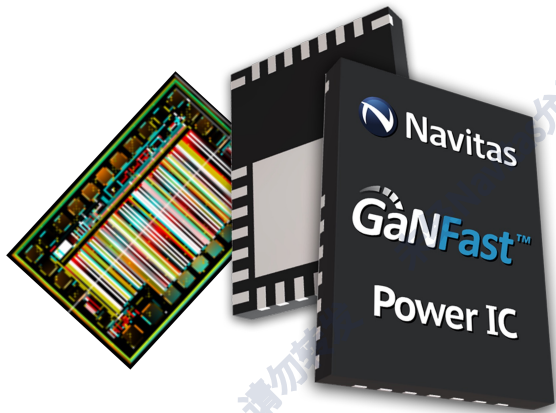
Efficiency

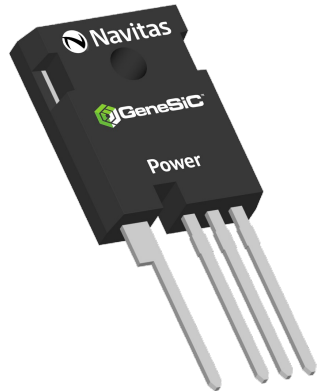
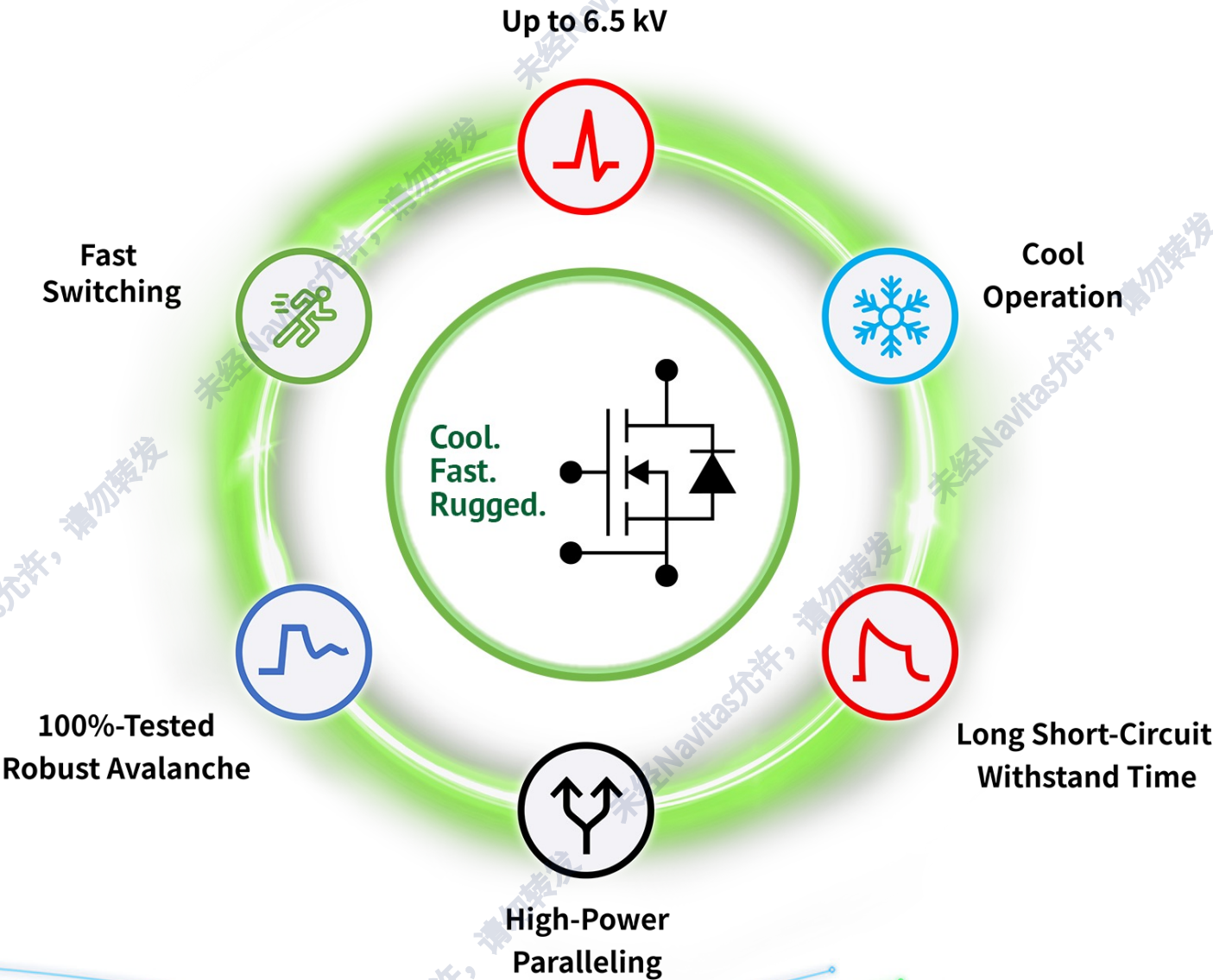
Reliability

Speed

Integration

***100,000,000+
Shipped***





Comparison Results of 1200V 40mR SiC FET

	GeneSiC	Wolfspeed	ROHM	Infineon	Onsemi	ST
	G3R40MT12K	C3M0040120K	SCT3040KRHR	IMZA120R040M1H	NTH4L040N120M3S	SCT025W120G3-4AG
Vds	1200V	1200V	1200V	1200V	1200V	1200V
Id @25C	66A	66A	55A	55A	54A	52A
Id @100C	47A	48A	39A	39A	38A	39A
Vgs_max	-10V/+22V	-8/+19V	-4/+22V	-7/+20V	-10V/+22V	-10V/+22V
Rdson typ. @25C, ID = 35A	40mΩ@Vgs=15V 34mΩ@Vgs=18V	40mΩ@Vgs=15V	40mΩ@Vgs=18V, ID = 20 A	39mΩ@Vgs=18V, ID = 20 A	40mΩ@Vgs=18V, ID = 20 A	45mΩ@Vgs=18V, ID = 30 A
Rdson max. @25C, ID = 35 A	45mΩ@Vgs=18V	53.5mΩ@Vgs=15V	52mΩ@Vgs=18V, ID = 20 A	54.4mΩ@Vgs=18V, ID = 20 A	54mΩ@Vgs=18V, ID = 20 A	54mΩ@Vgs=18V, ID = 30 A
Rdson typ. @175C	57mΩ@Vgs=15V 50mΩ@Vgs=18V	68mΩ @Vgs=15V	72mΩ@Vgs=18V	77mΩ@Vgs=18V	80mΩ@Vgs=18V	99mΩ@Vgs=18V
Rg_int	1.2Ω	3.5Ω	7Ω	2.5Ω	3.8Ω	1Ω
Qg	88nC	99nC	91nC	46nC	106nC	101nC
Ciss @800V	2897pF	2900pF	1337pF	1620pF	1700pF	2086pF
Crss @800V	7.1pF	5pF	27pF	11pF	7pF	18pF
Coss @800V	88pF	103pF	76pF	75pF	80pF	90pF
Eoss@800V	34uJ	40uJ	35uJ	30uJ	/	/
Vsd @-5V, 17A, 25C	4.8V	5.5V	4V	3.8V	4.5V	3.5V

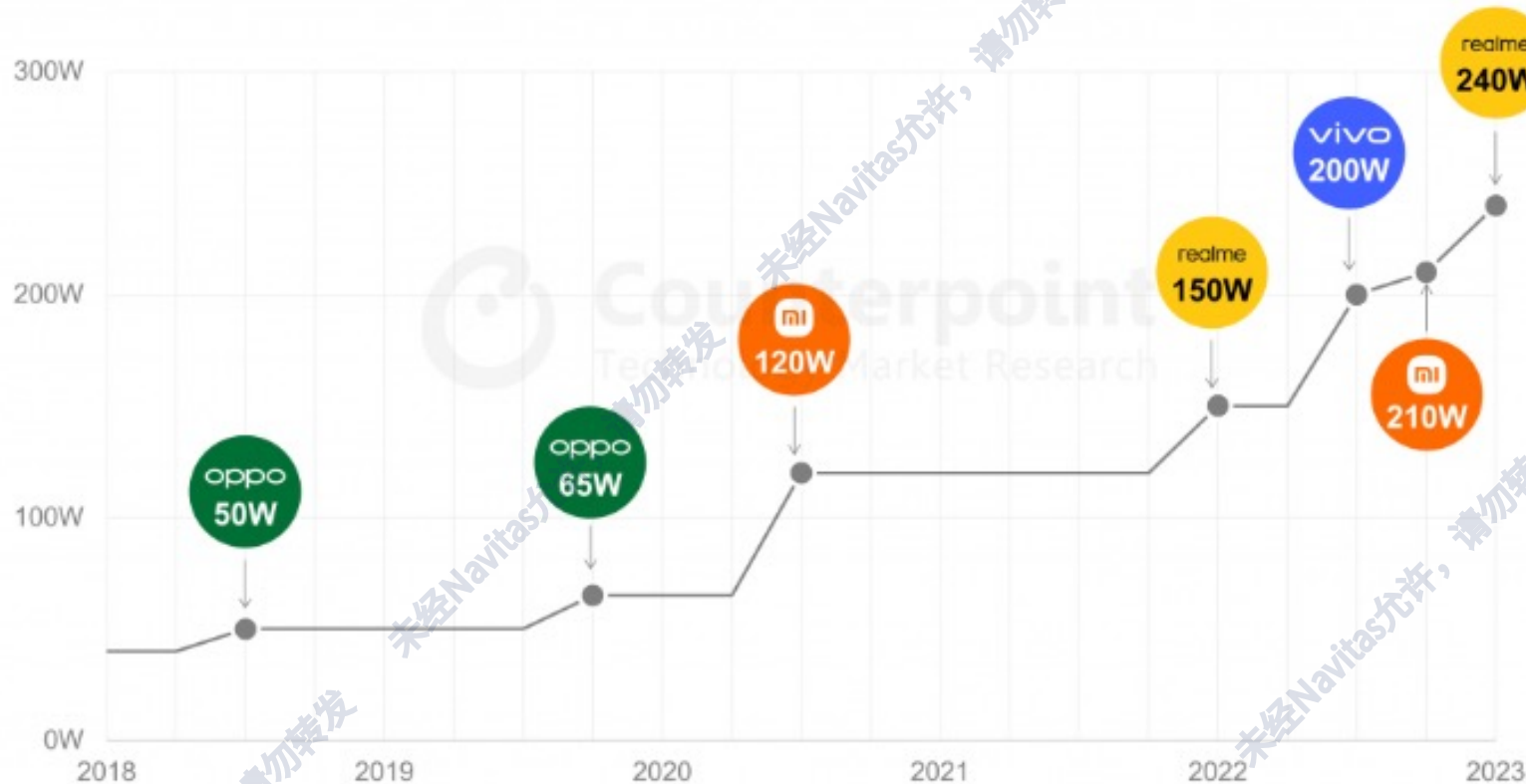
Comparison Results of 1200V 40mR SiC FET

	Navitas-GeneSiC	W Comany	R Comany	I Company	O Comany	S Comany
	G3R40MT12K	Cxxxx	Sxxxx	Ixxxx	Nxxxx	Sxxxx
Vds	1200V	1200V	1200V	1200V	1200V	1200V
Id @25C	69A	66A	55A	55A	54A	40A
Id @100C	49A	48A	39A	39A	38A	40A
Vgs_max	-10V/+22V	-8/+19V	-4/+22V	-7/+20V	-10V/+22V	-10V/+22V
Rdson typ. @25C, ID = 35A	40mΩ@Vgs=15V 34mΩ@Vgs=18V	40mΩ@Vgs=15V	40mΩ@Vgs=18V, ID = 20 A	39mΩ@Vgs=18V, ID = 20 A	40mΩ@Vgs=18V, ID = 20 A	49mΩ@Vgs=15V 40mΩ@Vgs=18V
Rdson max. @25C, ID = 35 A	45mΩ@Vgs=18V	53.5mΩ@Vgs=15V	52mΩ@Vgs=18V, ID = 20 A	54.4mΩ@Vgs=18V, ID = 20 A	54mΩ@Vgs=18V, ID = 20 A	54mΩ@Vgs=18V
Rdson typ. @175C	57mΩ@Vgs=15V 53mΩ@Vgs=18V	68mΩ @Vgs=15V	72mΩ@Vgs=18V	77mΩ@Vgs=18V	80mΩ@Vgs=18V	71mΩ@Vgs=18V
Rg_int	1.2Ω	3.5Ω	7Ω	2.5Ω	3.8Ω	1Ω
Qg	88nC	99nC	91nC	46nC	106nC	56nC
Ciss @800V	2897pF	2900pF	1337pF	1620pF	1700pF	1329pF
Crss @800V	7.1pF	5pF	27pF	11pF	7pF	10pF
Coss @800V	88pF	103pF	76pF	75pF	80pF	78pF
Eoss@800V	34uJ	40uJ	35uJ	30uJ	/	/
Vsd @-5V, 17A, 25C	4.5V	5.5V	4V	3.8V	4.5V	2.6V

Accelerating Mobile: Navitas wins 100% Milestones⁽¹⁾



Fast Charger Milestones in Terms of Wattage



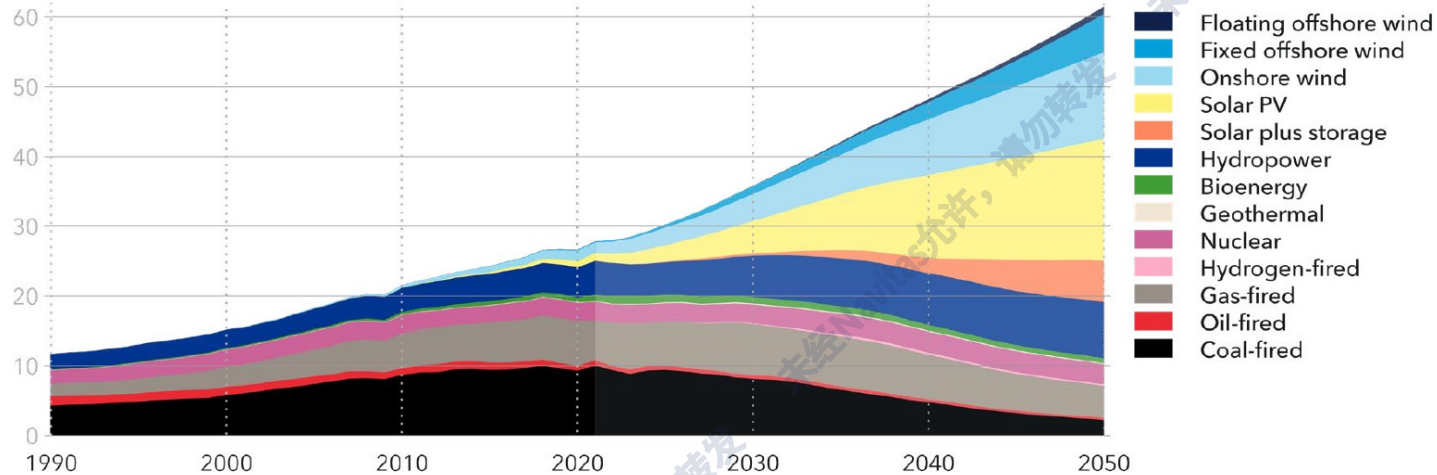
Source: Counterpoint Research



1. Chart from Counterpoint Technology Market Research, published July 2023 (<https://www.counterpointresearch.com/insights/fast-charging-global-smartphone-sales-q1-2023/>). Design wins claim per Navitas press releases.

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 Data Center Power, Efficiency



AUTONOMOUS VEHICLES
4000GB



Rack Power
(kWatts)

90
80
70
60
50
40
30
20
10
0

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

Today: AC-DC = 100 W/in³

GaN adopted for 48V Backplane

GaN required to meet SMPS power density

AC-DC Power Density
(Watts/Inch³)

200
180
160
140
120
100
80
60
40
20
0

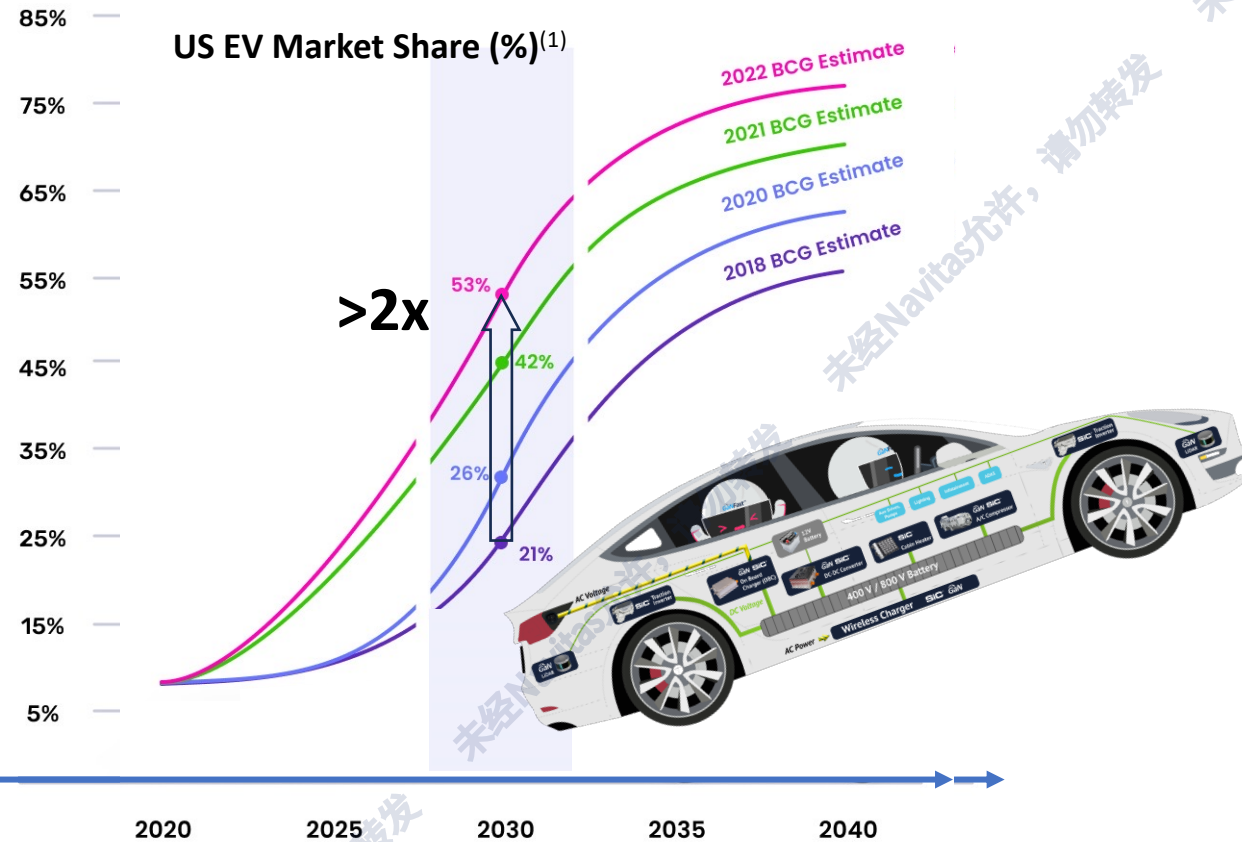
1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019 2021 2023 2025 2027 2029 2031 2033

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 EV: Faster Charging (OBC and Roadside)

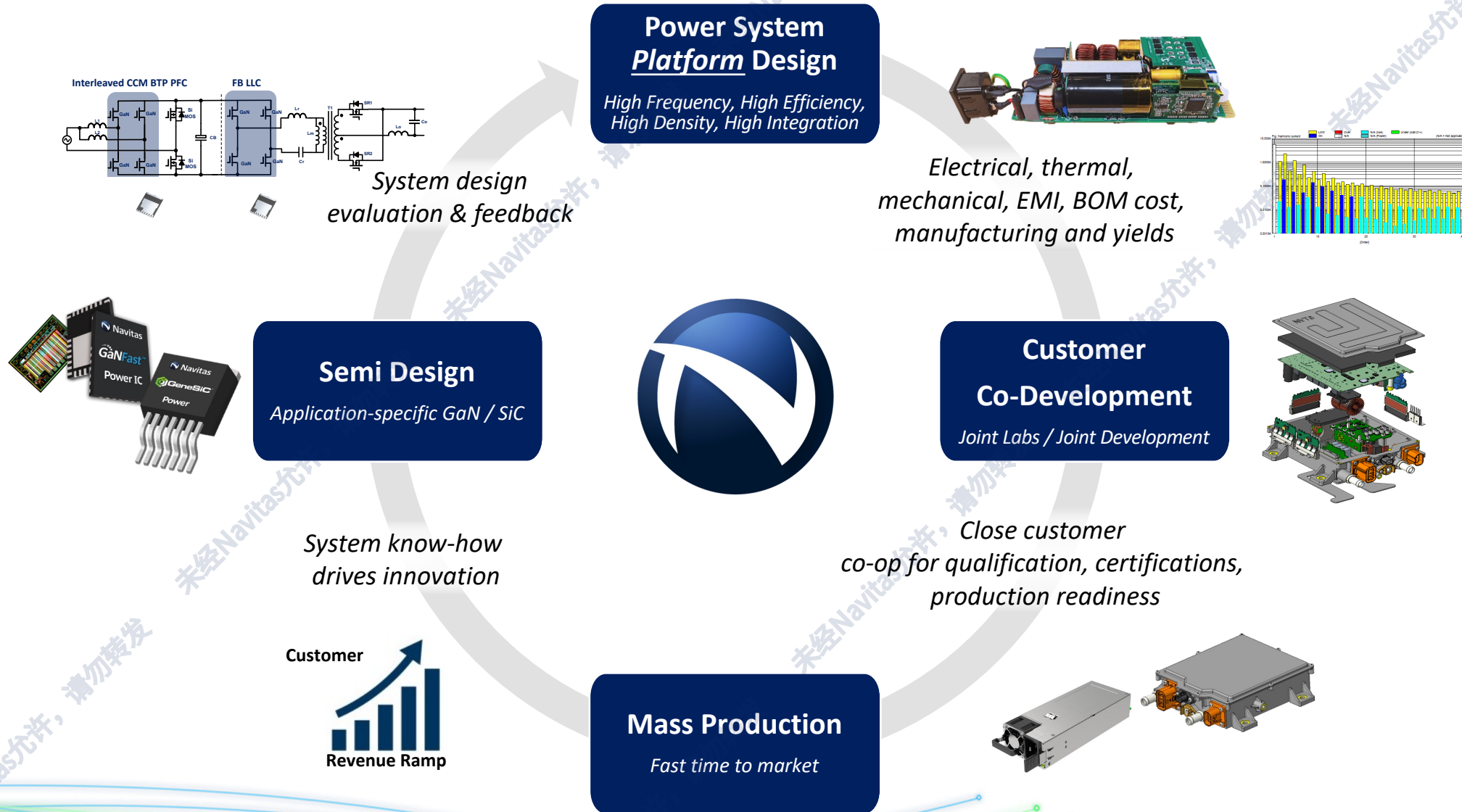


Time needed to charge your e-car every week (200 – 250 km)*



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/>



Accelerating \$1B⁽²⁾ Customer Pipeline, Diverse markets



- Q2 2023: Pipeline up 30% to \$1 billion, with more projects, more \$ potential in all markets

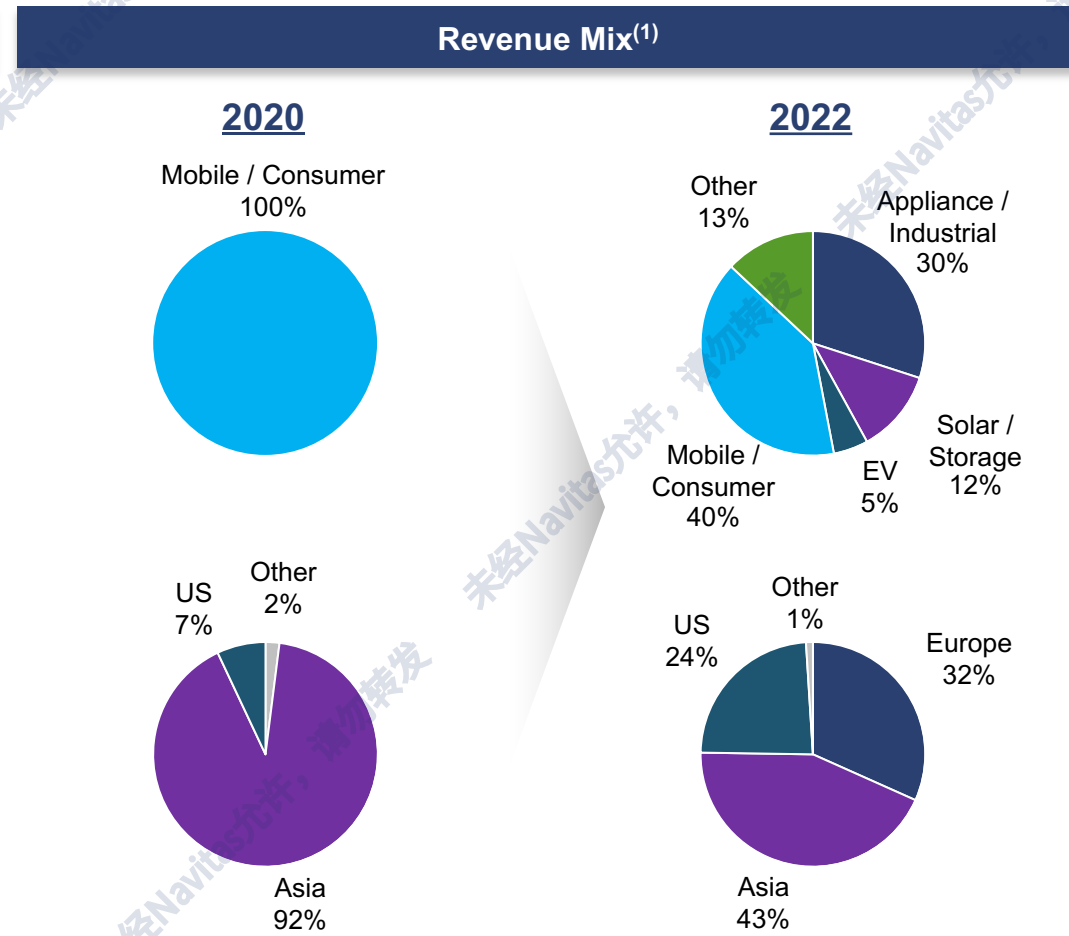
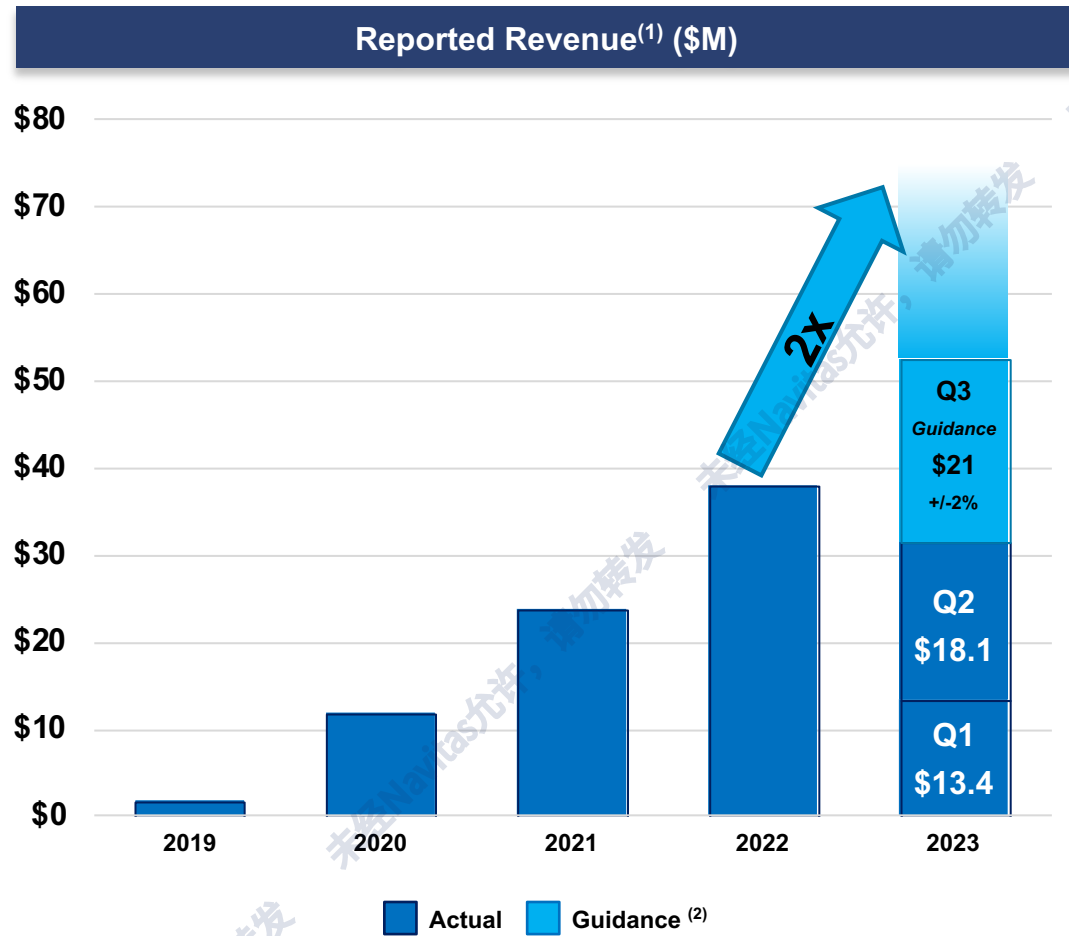
1. Navitas estimates of top OEMs in each respective market and their existing customer engagements. Appliance/Industrial 'top 10' based on Navitas estimate

2. "Pipeline opportunity" reflects estimated potential future business based on interest expressed by potential customers for qualified programs, stated in terms of estimated revenue that may be realized in one or more future periods. Pipeline opportunity is not a proxy for backlog or future revenue or other measure or indicator of financial performance. Rather, Navitas uses customer pipeline as a statistical metric to indicate relative changes in future potential business across various product markets. Time horizons vary accordingly, based on product type and application. Actual business realized depends on ultimate customer selection, program share and other factors

3. Navitas estimates for potential customer revenue across GaN or SiC in the market stated

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Accelerating Growth & Diversity



- Q2 '23 revenue +110% from Q2 '22
+35% from Q1 '23
- Gross Margin: 41.5%
- Cash: \$177.7M (no debt)
- Shares: 175M

- Significant diversification in markets, geography

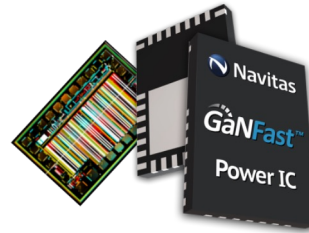
1. Reported revenue not pro forma for GeneSiC financials for the period prior to the close of the acquisition of GeneSiC on 8/15/2022. Only includes GeneSiC revenue for the period post transaction close (8/15/2022 – 12/31/2022)

2. Q3'23 and CY2023 guidance as of 8-14-23 only. Not updated



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

Next step...





CPEEC · CPSSC
2023

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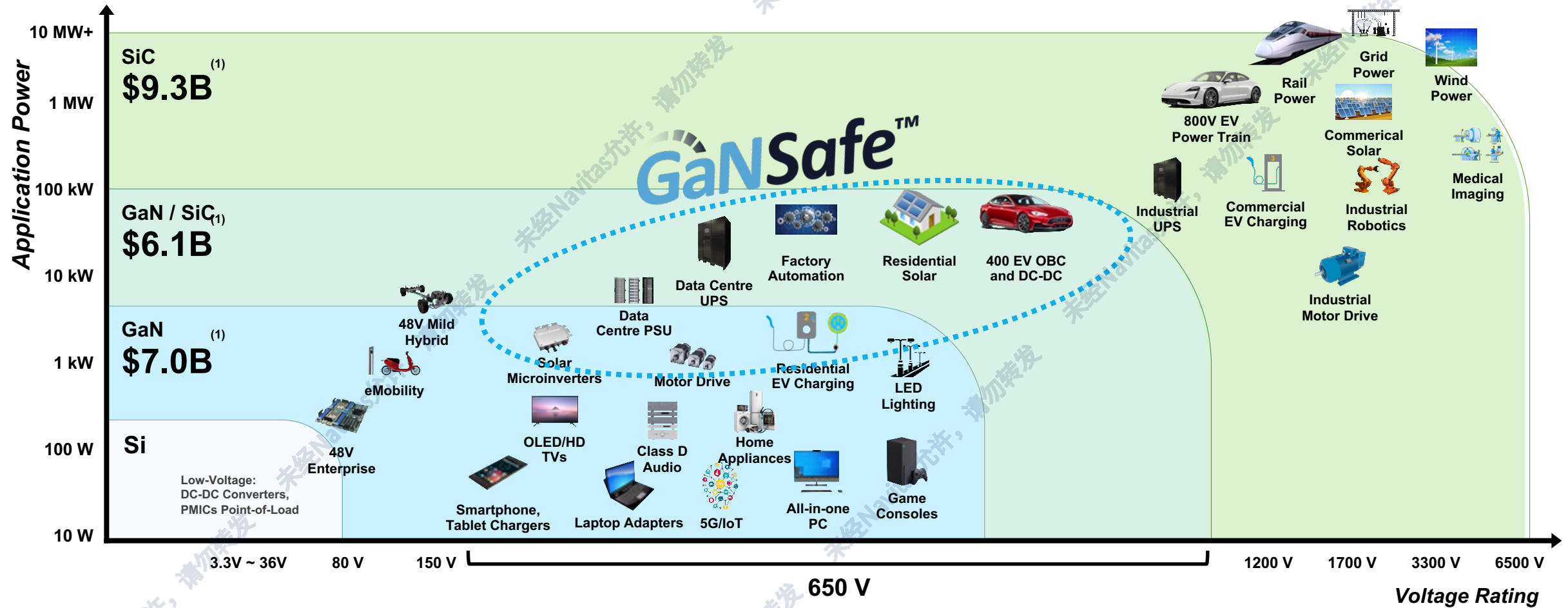
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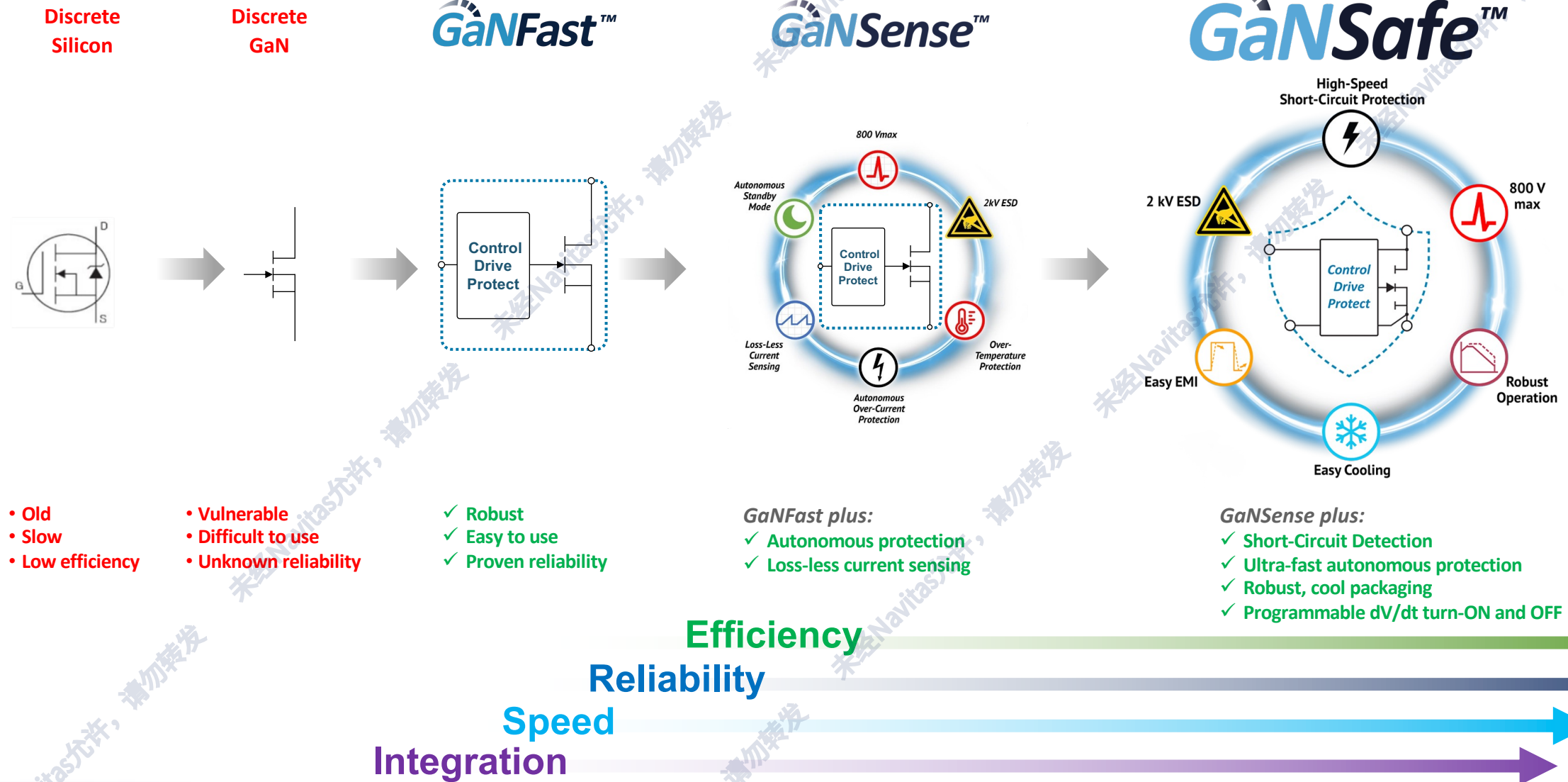
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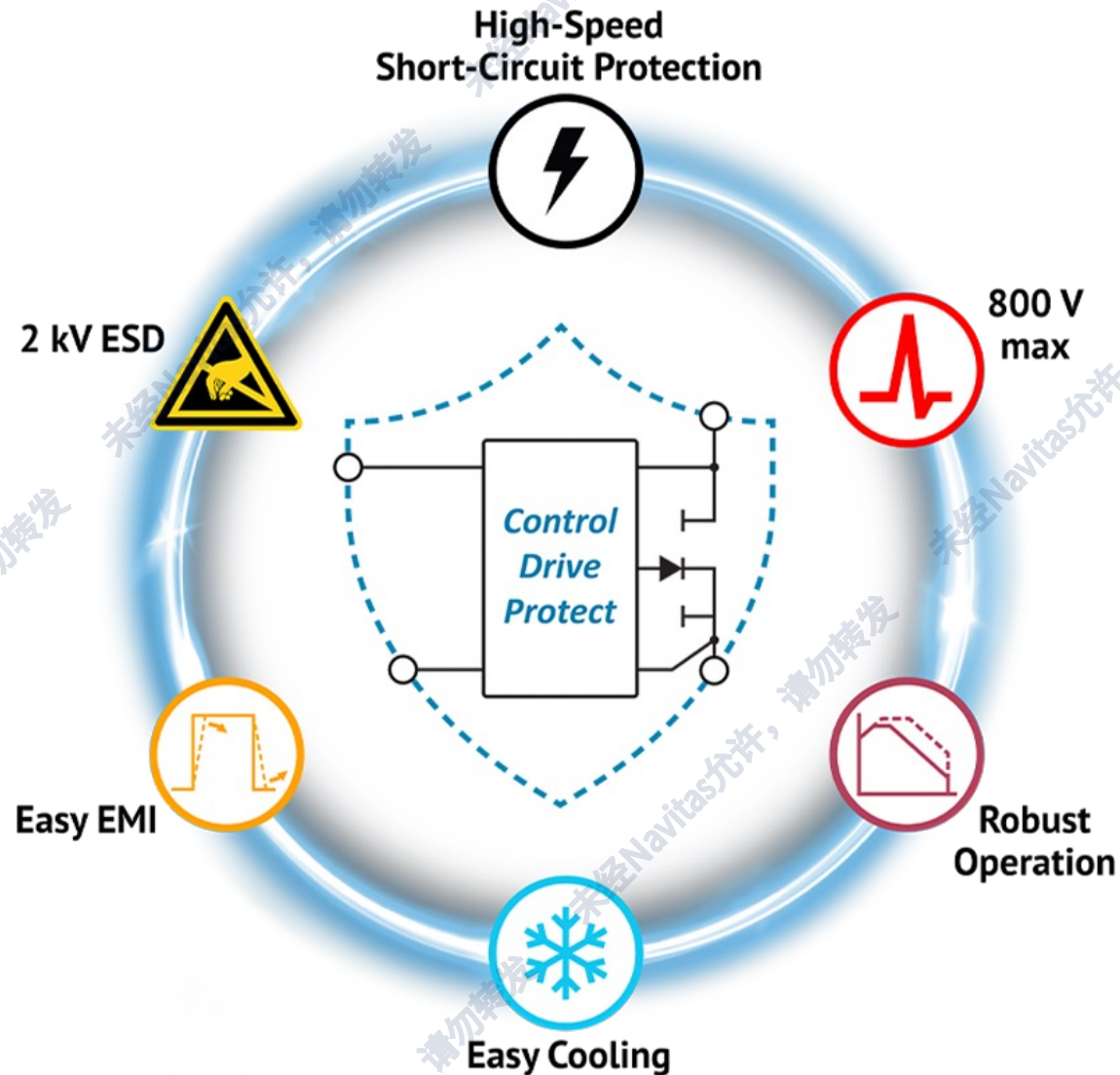


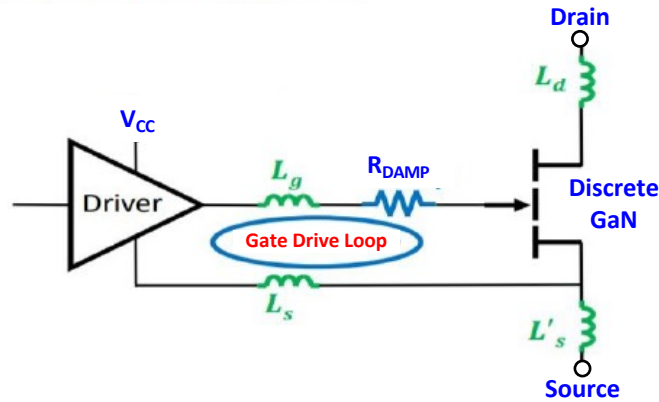
GaNSafe™: Accelerating GaN to High Power



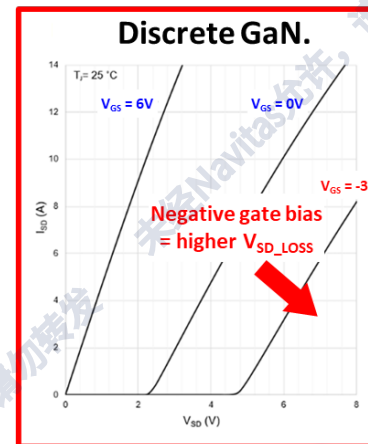
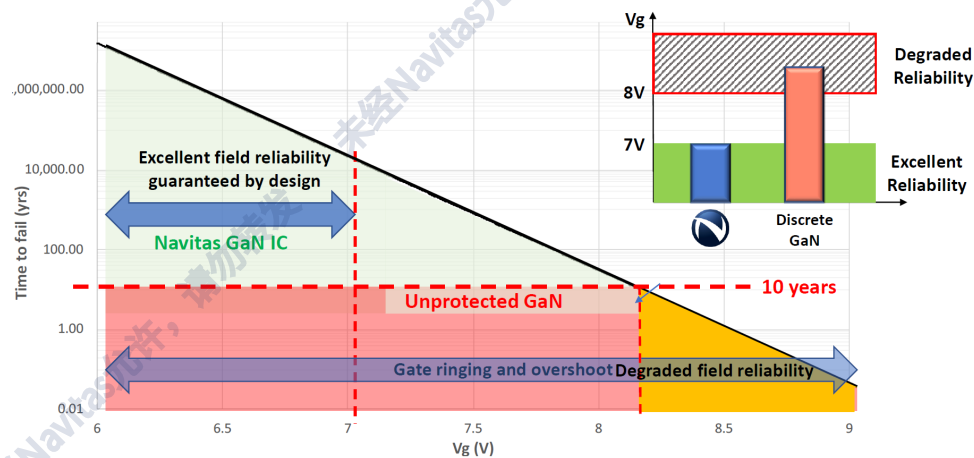
1. Navitas company estimates, potential market opportunity in 2026 is \$22B+ for GaN and SiC, replacing certain of the silicon market share. Axes not to scale



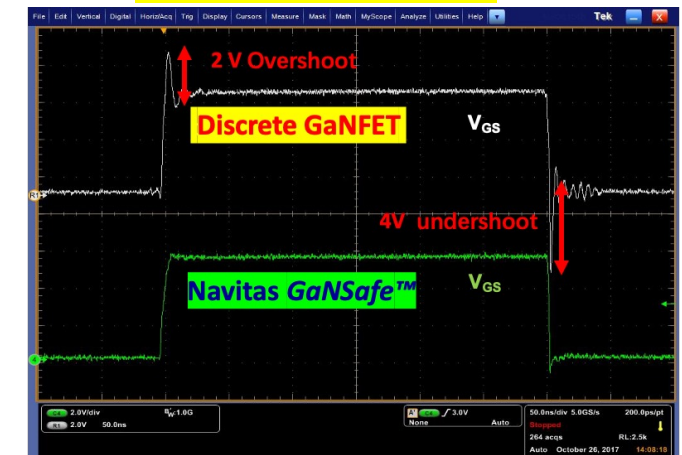




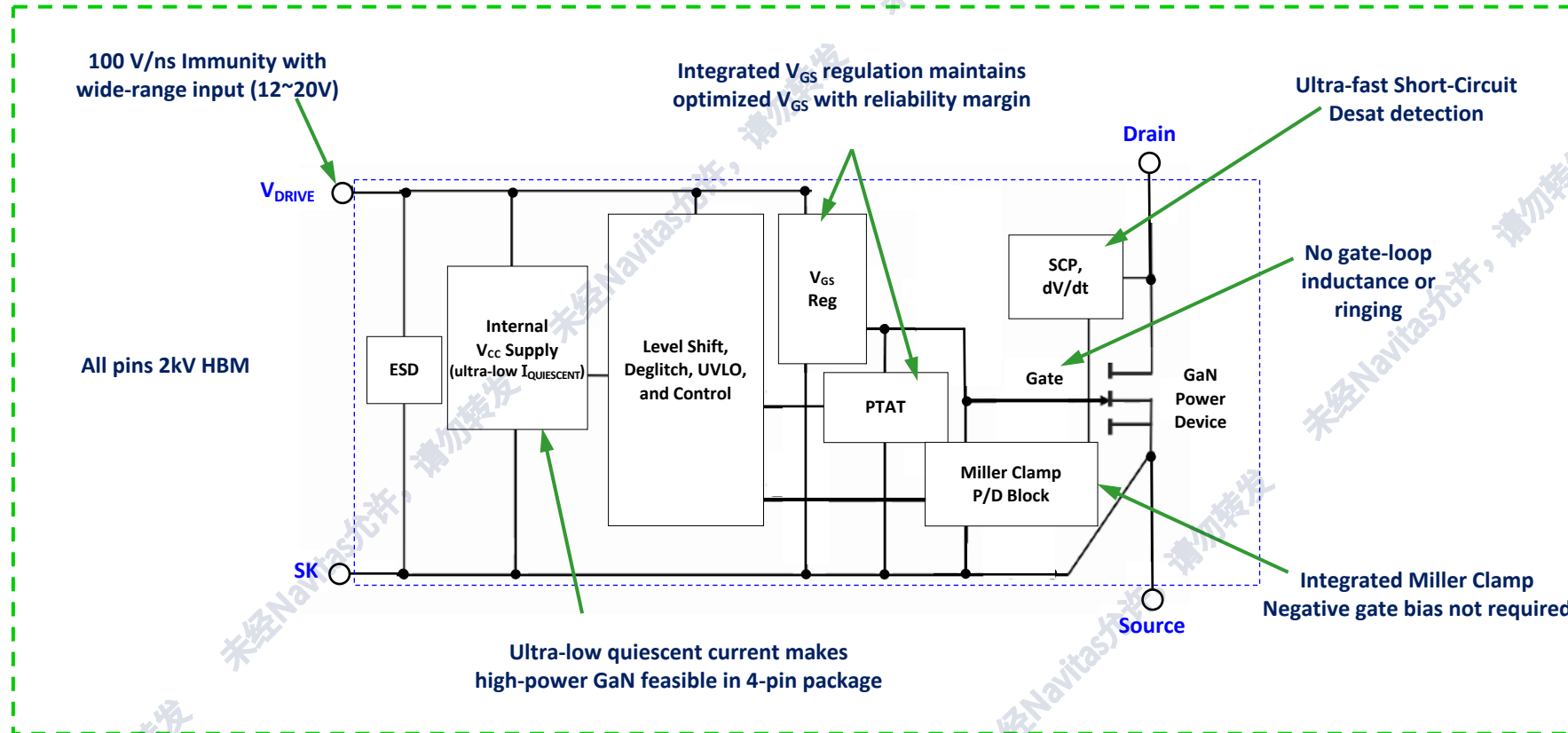
- **Discrete GaN = high risk**
 - Weak gate, high loop inductance
 - Shoot-thru risk multiplied by increased di/dt in high-power applications
- **GaNFast™** integrated, regulated gate drive, zero loop inductance
 - Fewer components, smaller PCB,
 - Higher efficiency, lower system cost
- **GaNSafe™**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

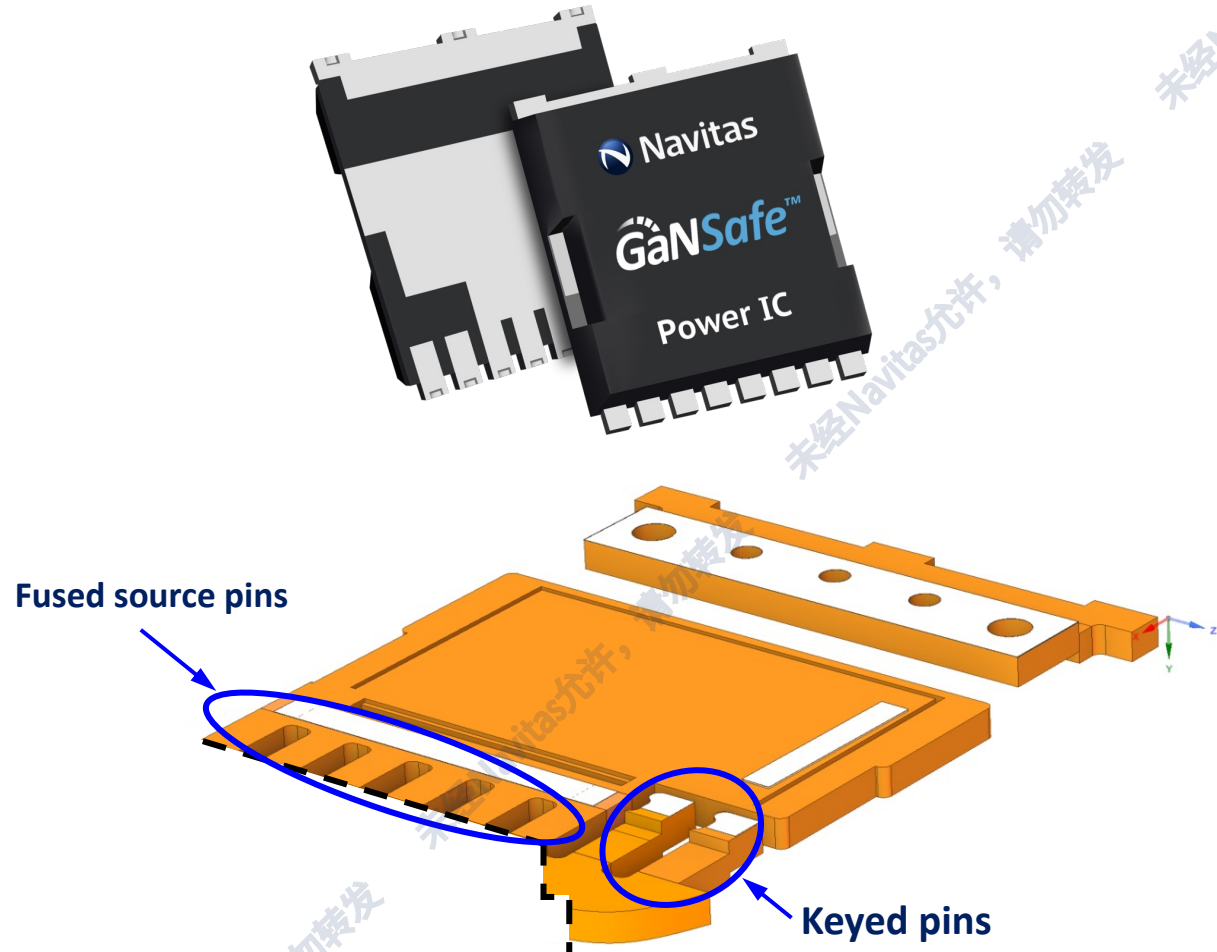


Discrete GaNFET



GaNSafe™: Reliable high-power in only 4 pins





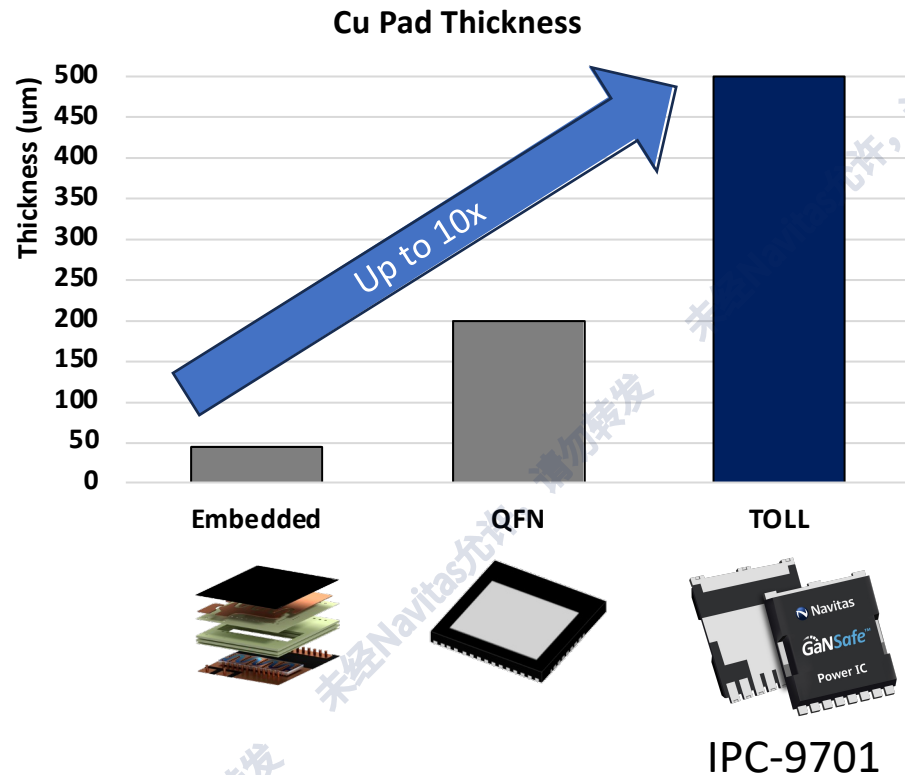
- TOLL = “Transistor Outline Lead-Less”
- 10 x 10 mm
- Mechanically robust, novel leadframe
 - Keyed V_{DRIVE} and SK pins
 - Improved mechanical performance
 - Fused source pins
 - Improved thermals)
- Passed IPC-9701 for long mechanical lifetime



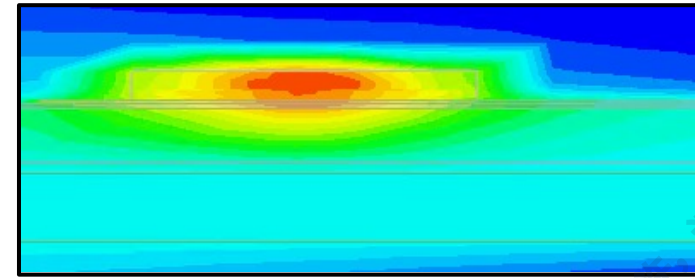
GaNSafe™

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”

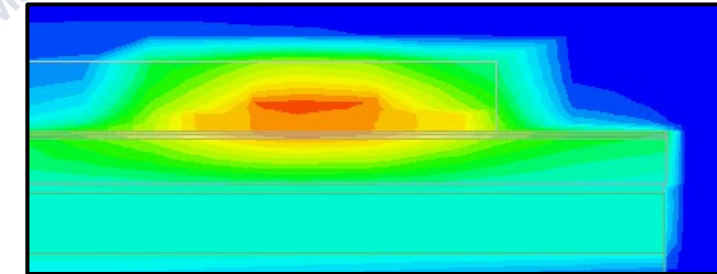


QFN: $T_j = 112^\circ\text{C}$



12°C Cooler

TOLL: $T_j = 100^\circ\text{C}$



GaNSafe™

- Optimized, system-level cooling ($R_{\theta_{JA}}$)
 - 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

GaNSafe™ Yields Higher Density, Lower System Cost

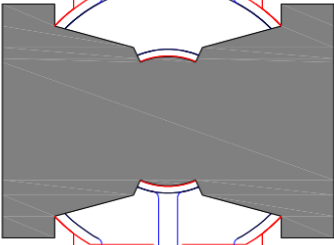
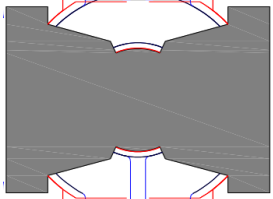
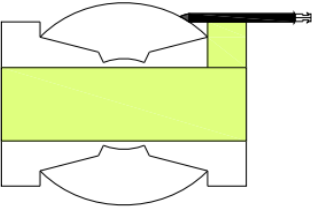
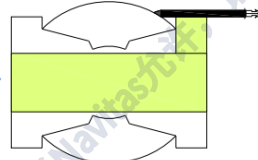


Si 150 kHz LLC

3.2kW

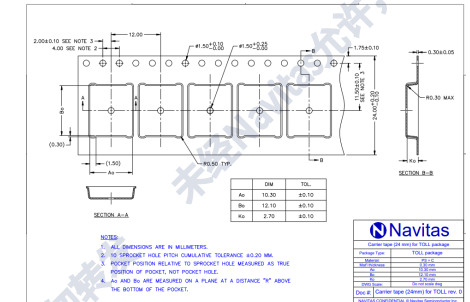
GaNSafe™

300 kHz LLC

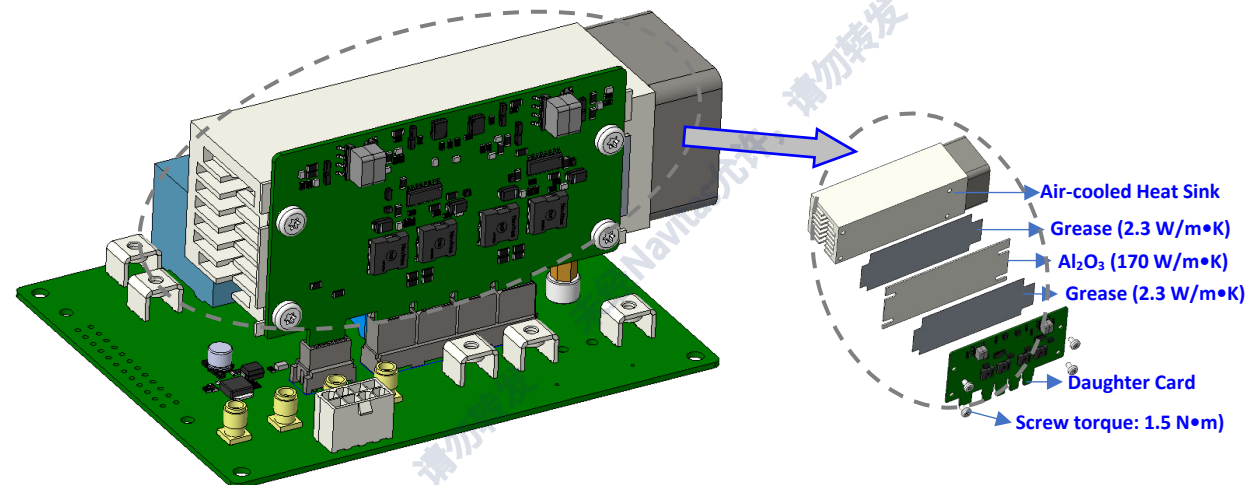
Main Transformer	 PQ3628 Size: 36 x 28 x 24 mm	→	 PQ3033 = 14% smaller Size: 30 x 33 x 21 mm
Resonant Choke	 PQ2618: Size: 26 x 18 x 19 mm	→	 PQ2018 = 20% smaller Size: 20 x 18 x 14 mm
Resonant Capacitor & Output MLCC	 630 V, 10 nF 1206 *40pcs 16 V, 10 uF 1206 *64pcs	→	 630 V, 10 nF 1206 *12pcs 16 V,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

20% size reduction, >5% cost reduction

Part#	V _{DS} (Cont, Max) (V)	V _{DS} (Dyn, Max) (V)	R _{DS(ON)} (Max 25°C) (mΩ)	I _D (Max) (A)	Package	Evaluation Kit
NV6515	650	800	35	57	TOLL 10x10 Bottom-cool 	Power Board, Full Bridge Daughter Card, and FanSink/TIM ~ configurable for DPT or Half-Bridge testing
NV6513			45	48		
NV6512			55	34		
NV6511			98	22		

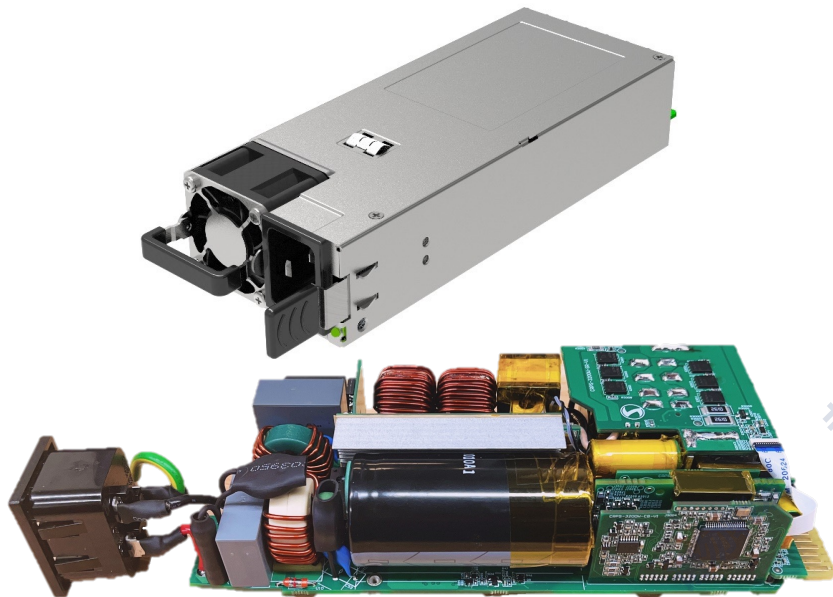


TnR Ordering	
Mini-Reel (7" dia)	Qty500 Pcs "-MR" suffix
Standard (13" dia)	Qty2,000 Pcs



1. Samples and collateral available immediately to qualified customers

NVTS CRPS185 3200W 12V

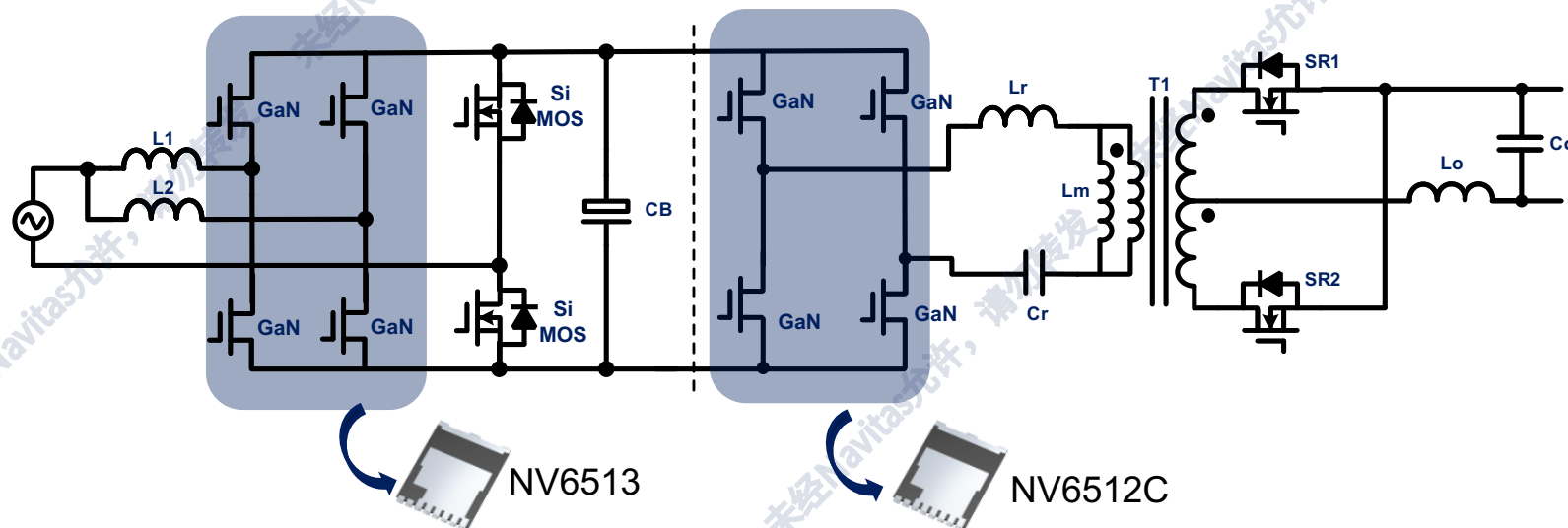


纳微 CRPS185 3200W 平台

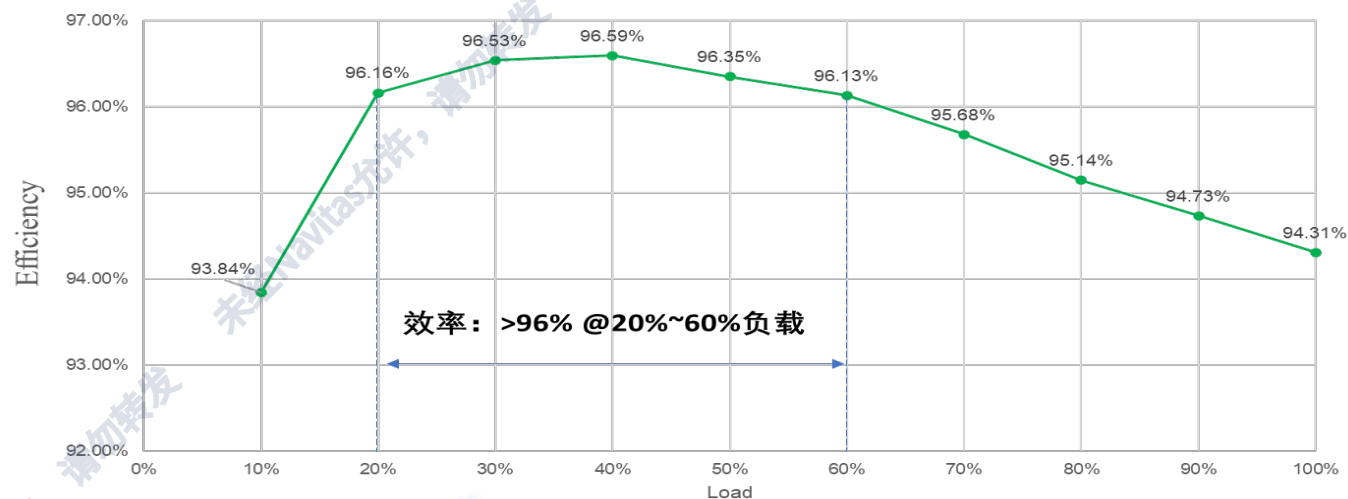
- 兼容 2.7kW, 3kW, 3.2kW
- 功率密度高达**98W/inch³**
- Titanium+ Efficiency: 峰值效率**96.6%**,
>96% @20%~60% load
- Hold up time: 12ms@2700W, 10ms@3200W

Interleaved CCM TP PFC(65kHz)

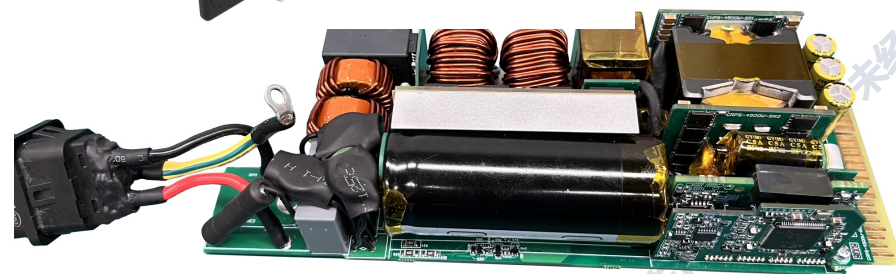
130kHz FB LLC+SR



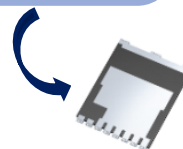
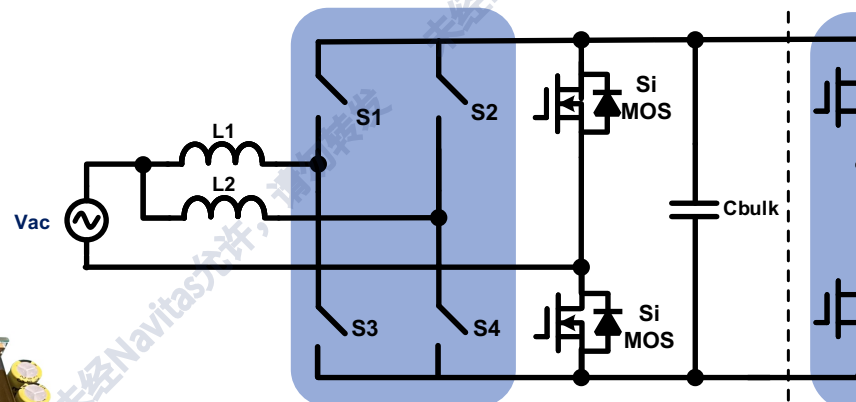
CRPS185 3.2kW 12V Efficiency @230Vac/25C, with Vsb loss



NVTS CRPS185 4500W 54V

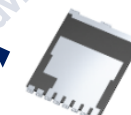
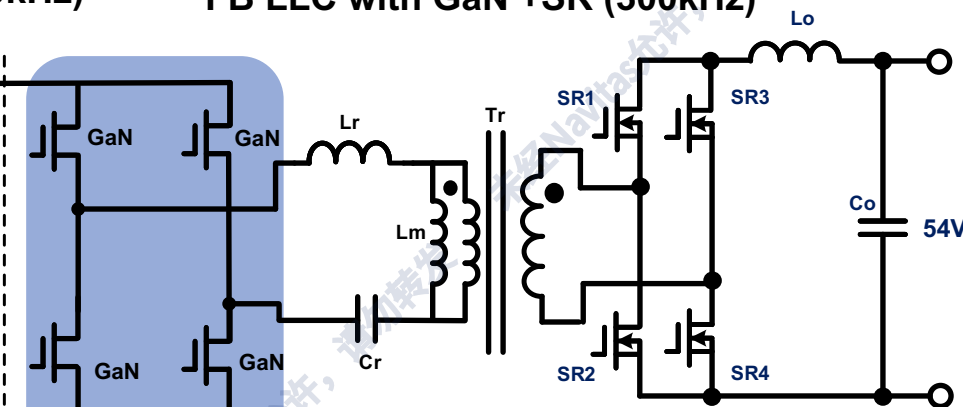


Interleaved CCM TP PFC with SiC/GaN(80kHz)



GaN: NV6515 or
SiC: G3F25MT06L

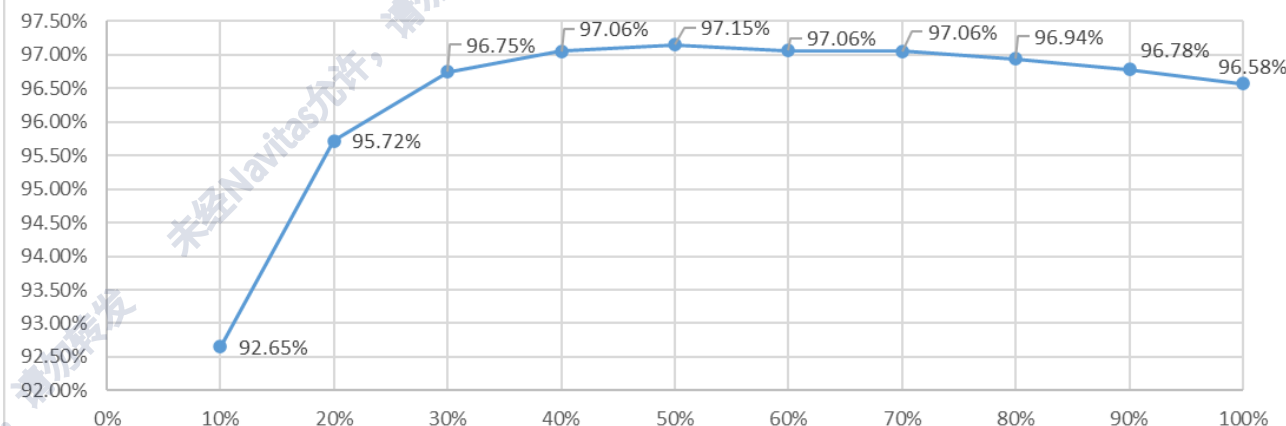
FB LLC with GaN +SR (300kHz)



NV6515

- 功率密度高达 **138W/inch³**，得益于高频LLC设计 (**300kHz**谐振频率)
- 在此功率密度(开关频率)下整机效率还能 **>97%** @50% load，得益于GaN的使用
- 如果LLC SR替换为GaN，驱动损耗大幅降低，整机效率将进一步提高

CRPS-4.5kW PSU Efficiency@230Vac, 25C and exclude Fan loss





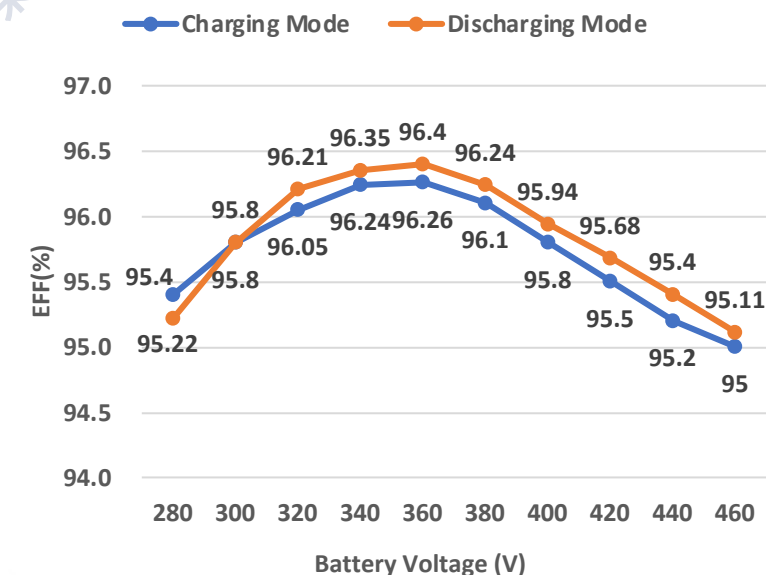
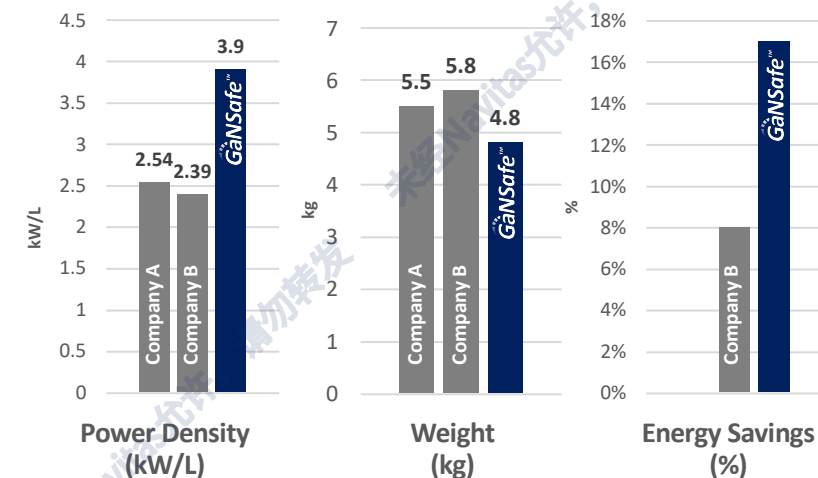
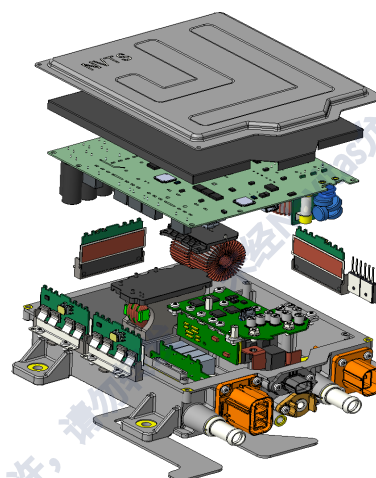
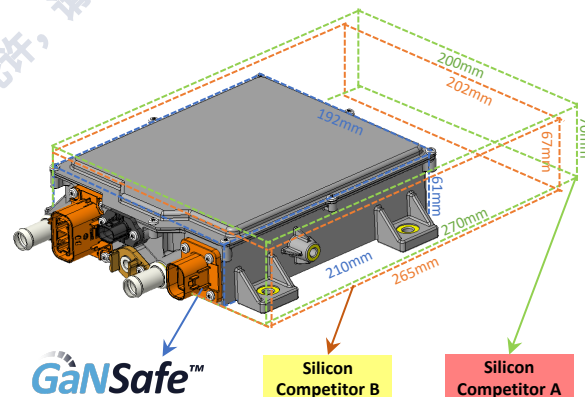
Combination 6.6 kW OBC + 3 kW DC-DC:

- **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

GaNSafe™
Power density +50%
to 3.9 kW/litre





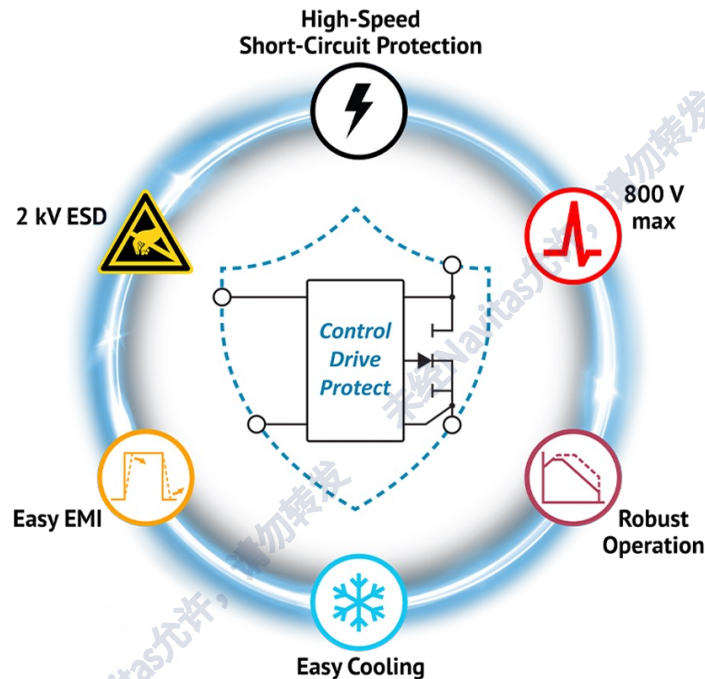
- Navitas is the industry leader in GaN

- **GaNFast™:**

- 100M+ shipped, 20-year warranty

- **GaNSafe™:**

- Most protected, most reliable, safest GaN power semi
- Benchmark efficiency, power density, reliability
- Robust, 4-pin TOLL
- Easy to use, fast time-to-market
- Demonstrated performance for AI, EV, Solar and more
- Strong customer pipeline
- ***Driving GaN into high power***



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