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GaNFast Power ICs: Beyond Chargers

Shenzhen, Oct.28 2021

Navitas

Energy • Efficiency • Sustainability

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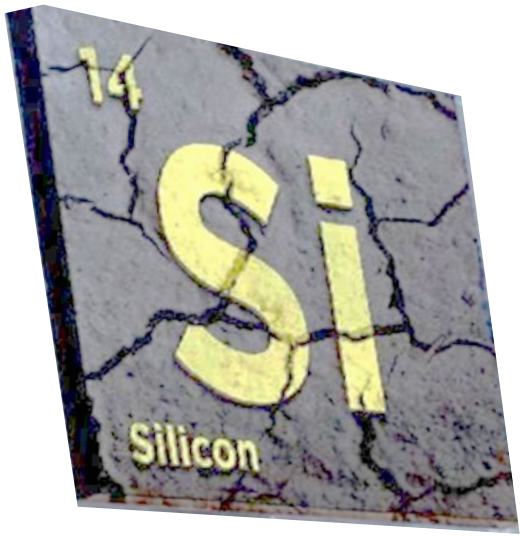
GaN Expected To Replace Silicon In Power Applications

Navitas



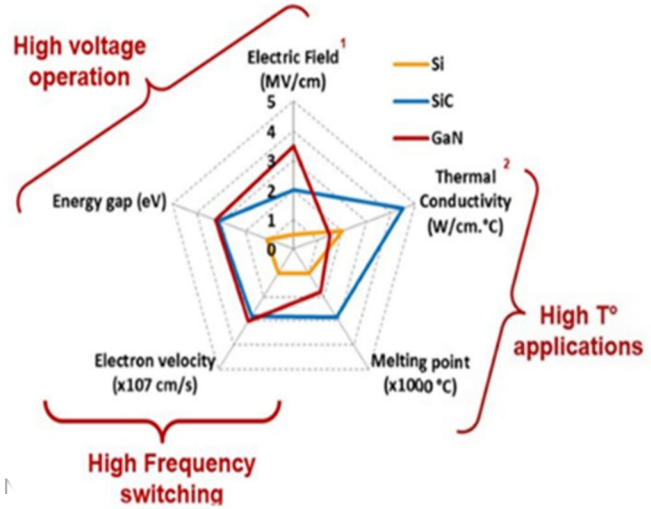
20x	3x	Up To 40%	Up To 3x	3x	20%
Faster Switching	Smaller & Lighter	Energy Savings	Higher Power Density	Faster Charging	Lower System Cost

Navitas GaN Is Empowering Efficiency In Industries Where Power Is Key(1)

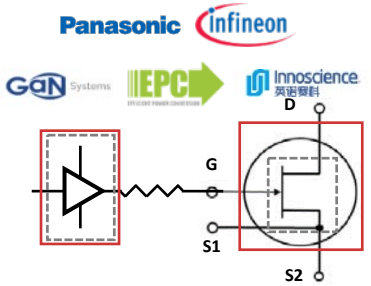
Note: Statistical data is based on Navitas estimate of GaN-based systems compared to Si-based in the 2024-2025 timeframe. Based on Navitas measurements of select GaN-based mobile wall chargers compared to Si-based chargers with similar output power.
(1) Relative to silicon, GaN has 10x stronger electrical fields and 2x greater electron mobility, enabling high voltages in fast chips and fast switching with high energy savings.

Power GaN Technologies

High Performance Semiconductor



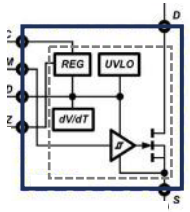
eMode FET
(normally off)



GaN Discrete
Complex gate drive

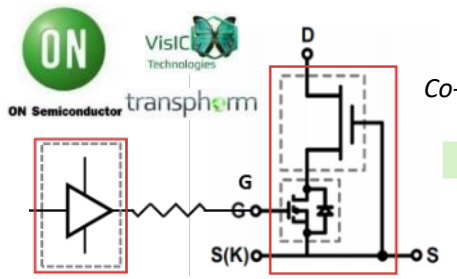
Integration

Navitas



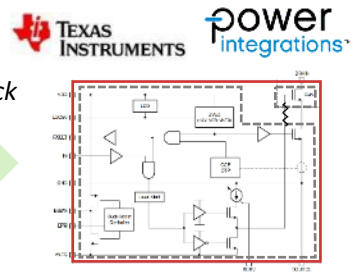
GaN Power IC
GaN Power (FET),
Drive, Control, Protection
120+ Patents

dMode FET
(normally on)



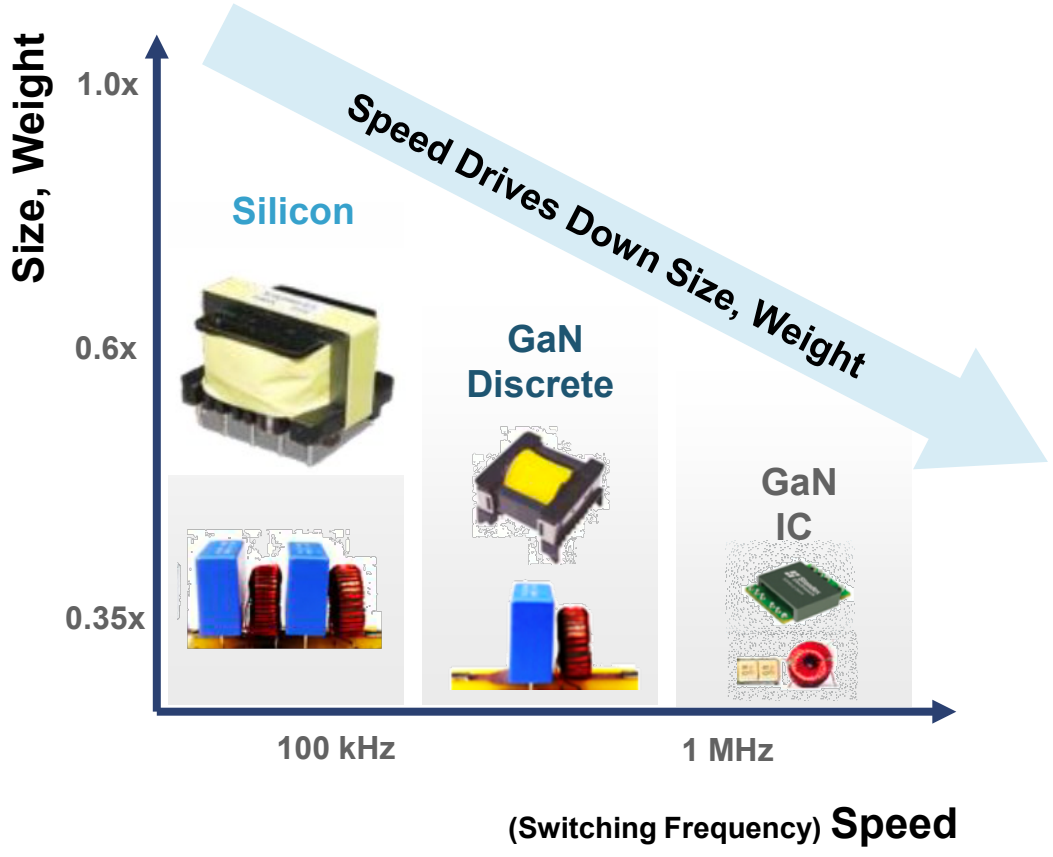
Extra Si FET in
'cascode' configuration

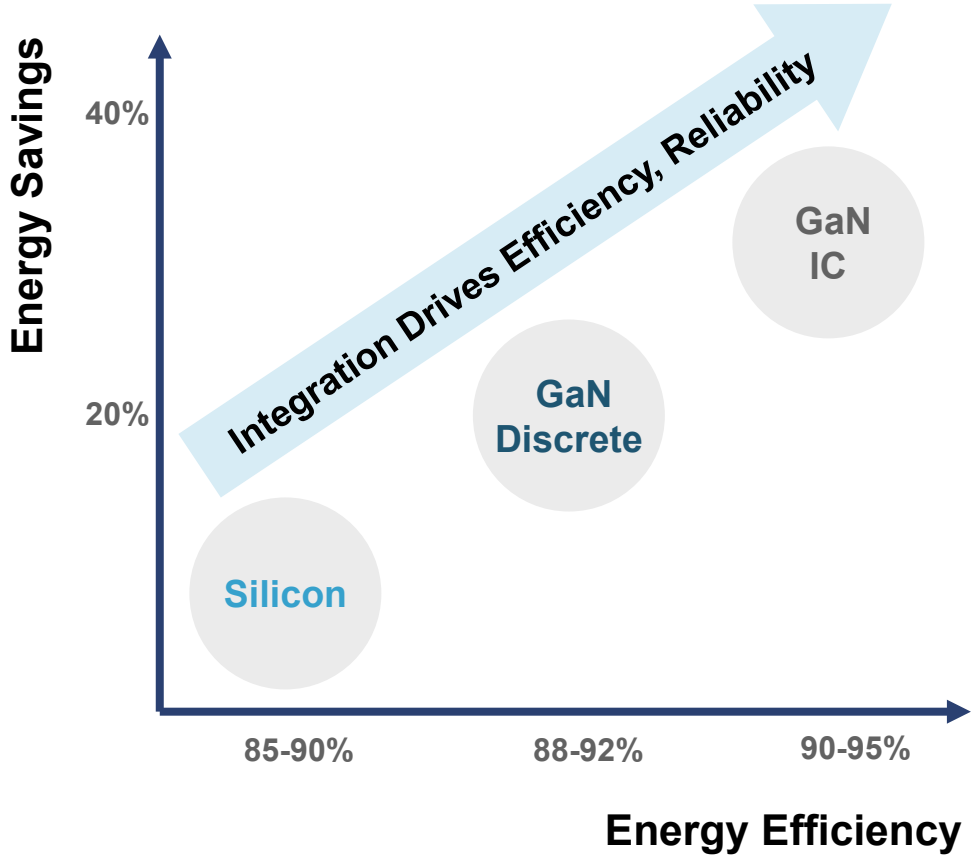
Co-pack



Si controller/driver
+ Si FET cascode
+ GaN dMode FET

Speed and Efficiency Drive Value





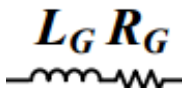
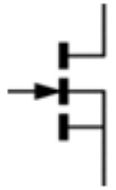
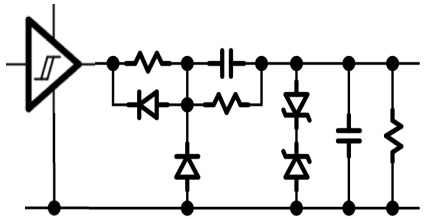
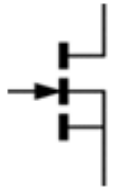
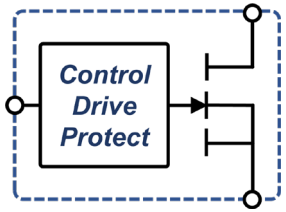
GaN power ICs enable up to 3x smaller, lighter (1)

GaN ICs save 40% energy (2)**, 100x more reliable** (3)

(1) Based on Navitas measurements of GaN-based chargers compared to Si-based chargers with the same output power.
(2) Navitas estimate of GaN-based power systems compared to Si-based systems in the 2024-2025 timeframe, Navitas measurements of select GaN-based chargers vs. Si-based chargers with similar power.
(3) V_{GS} failure distribution based on Navitas internal characterization of Discrete GaN Transistors compared to GaN power ICs.

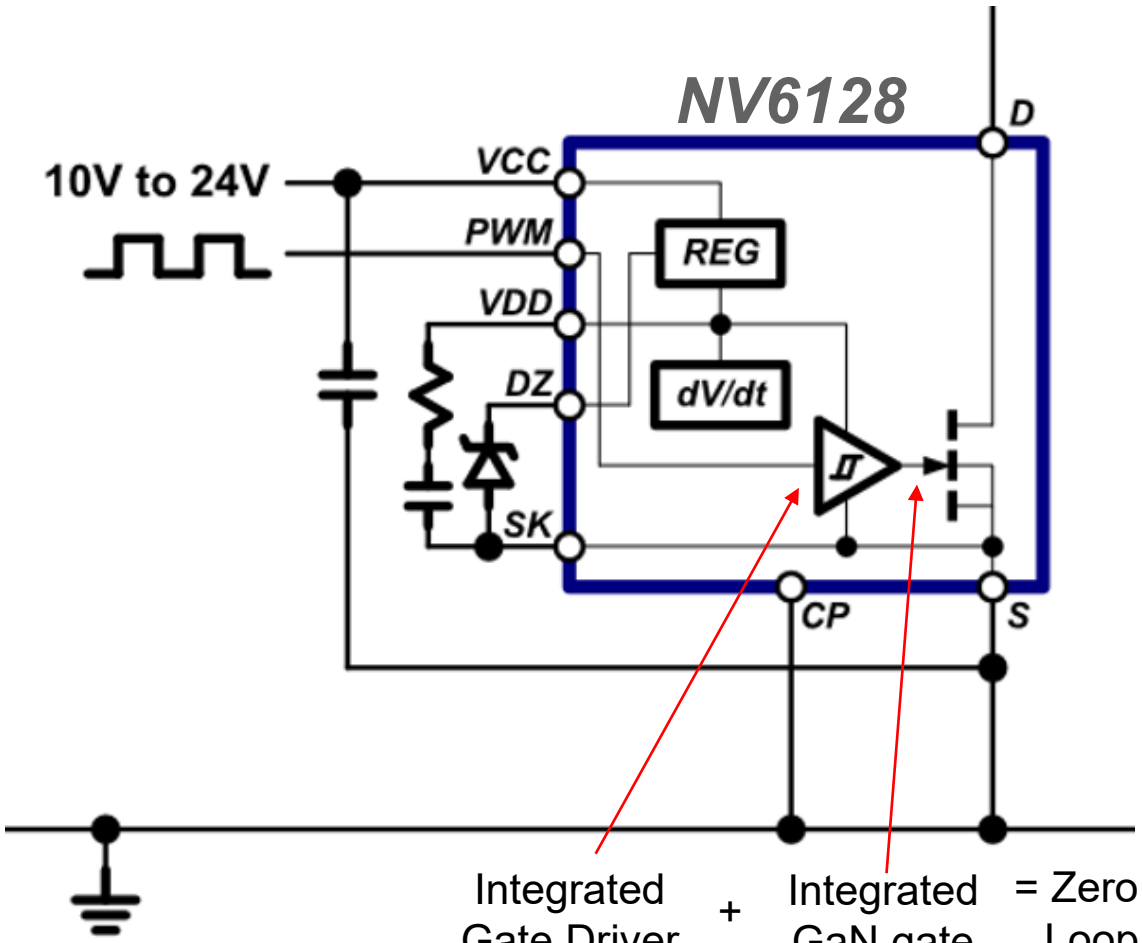
GaN Integration is Critical

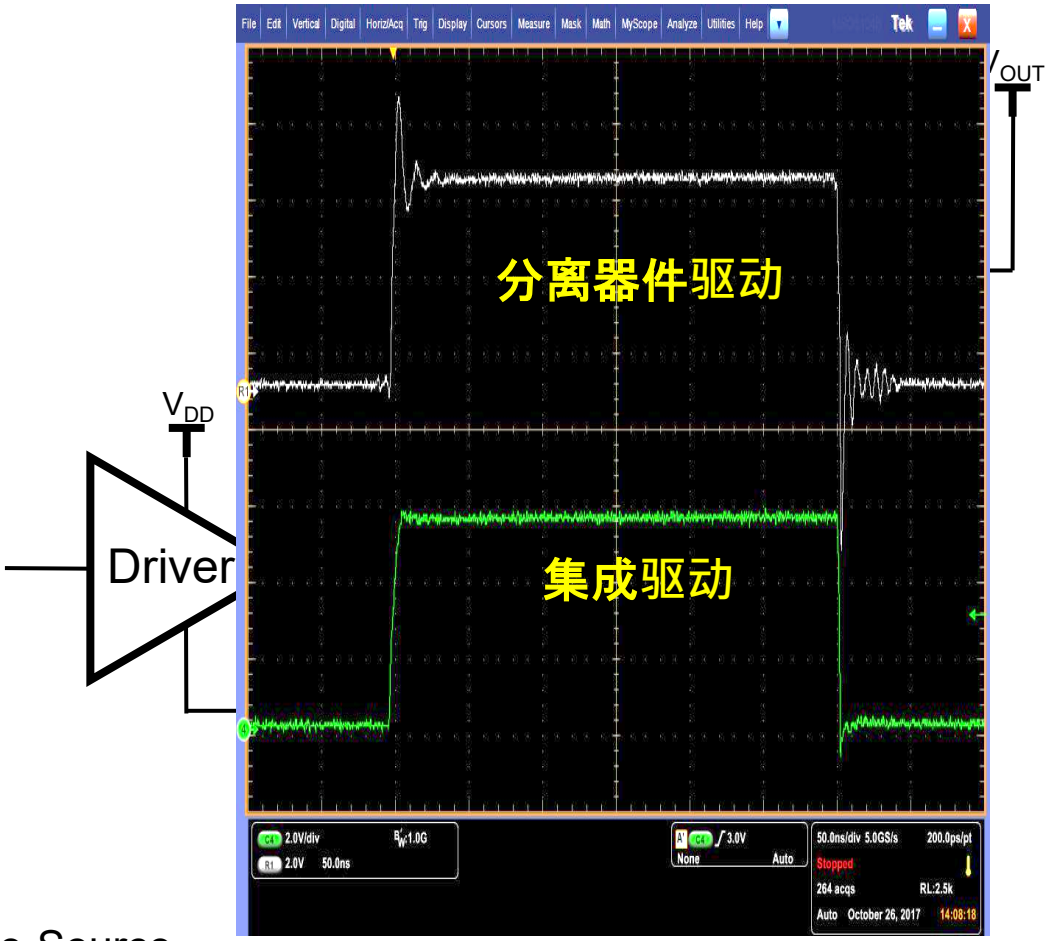
Navitas

	Driver Drive, control & protection	Parasitics Limit speed & efficiency	Power Device Si or GaN	Speed Switching Frequency	Power Density Faster Charging, Smaller Size	
Silicon Discrete	 *(in system controller)*			**< 100 kHz**		**<0.5 W/cc**
GaN Discrete, MCM	 *(complex circuit)*			**< 200 kHz**		**<1 W/cc**
Navitas GaN IC				**Up to 2 MHz** ***(3-10x faster)***		**>>1 W/cc**

Note: Based on Navitas lab evaluations of 65W chargers

Integration Drives Performance



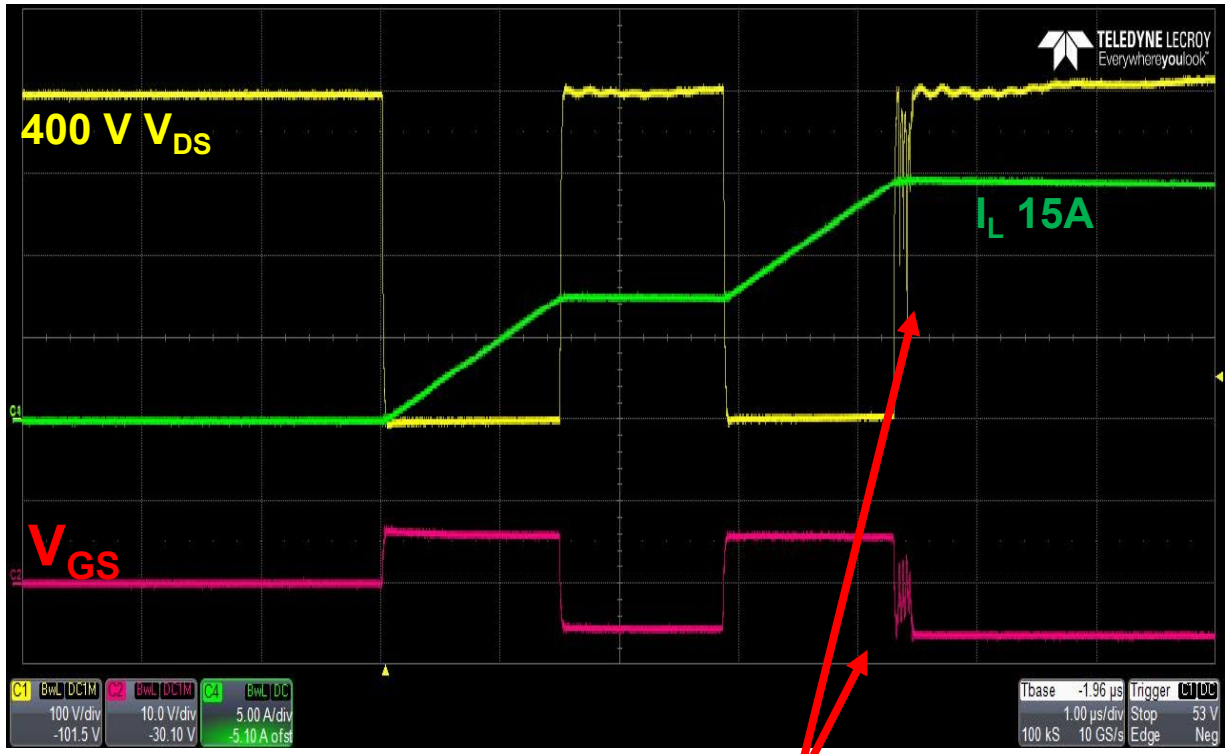


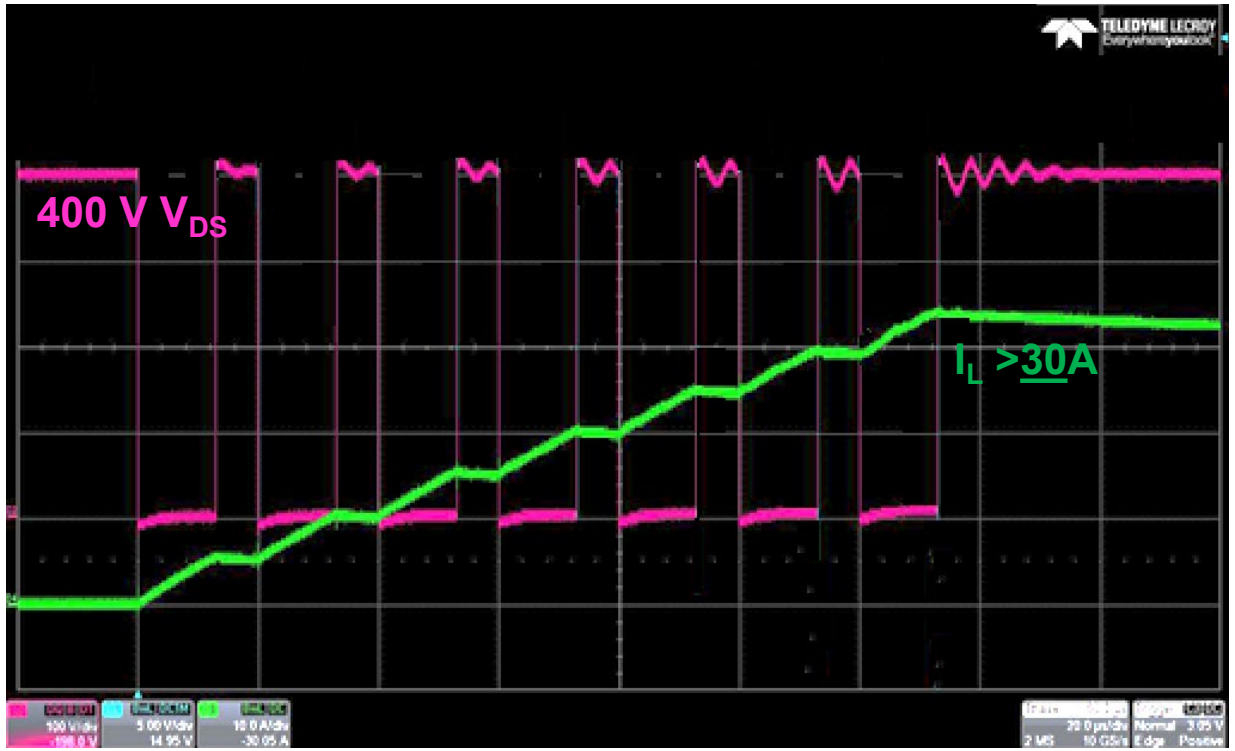
Integrated Gate Driver + Integrated GaN gate = Zero Gate-Source Loop Impedance

Only GaNFast is Fast… and Safe

Navitas

Discrete GaN → GaN Power IC





- Exposed gate
- Faulty switching
- Dangerous ringing & glitching!

- Integrated gate
- Clean switching
- Safe, smooth performance

Industry-Leading IP Position

Navitas

130+ Patents

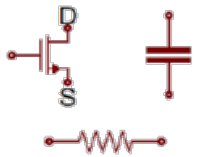
Issued / Pending

Applications across mobile, consumer, EV, enterprise and renewables

Mature and Comprehensive GaN Integrated Circuit Process Design Kit (PDK)

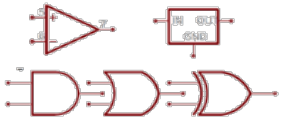
Device Development / Library

- 650 eMode power FET
- 12-40V eMode power FET
- 650V dMode power FET
- 12-40V dMode power FET
- 2-DEG & SiCr resistors
- Gate capacitors
- MIM / hybrid capacitors
- Over 20 devices developed



Circuit Development / Library

- Logic gates and latch
- Linear regulators
- Comparators
- Voltage sensors
- Charge pump
- Bootstrap circuits
- Level-shifters
- Protection circuits
- Over 200 circuits developed

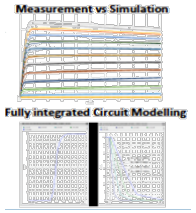


Characterization and Verification

- Dedicated and automated characterization stations (wafer level, package)
- Safe Operating Area (SOA)
- Layout Design Rule Checker (DRC)
- Layout Versus Schematic (LVS)
- Layout Parasitic Extraction and simulation tool (LPE)
- Over 1Mu characterized

Models and Simulation

- Device and circuit models with <5% accuracy
- Ultra-fast system simulations (Simplis)
- Accurate and fast device, circuit and system models cut design time from weeks to days and reduce design cycles by 50-75%



High-Volume, Low-Cost, High-Reliability Manufacturing

Navitas

Navitas' 20+ years of GaN experience

Solved complex issues with:

- Manufacturing
- Reliability
- Materials
- Capacity
- Cost

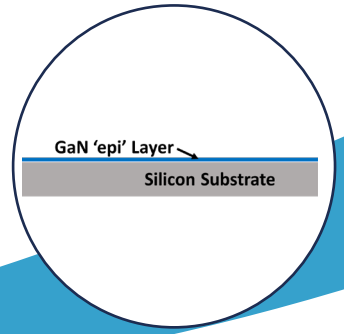
GaNFast Power ICs

Tier-1, Low-Cost Packaging
Standard, high-capacity
Low-cost, available

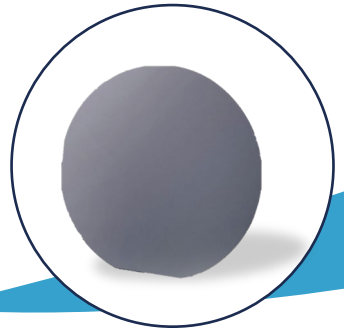
Finished Wafer

Tier-1, Low-Cost Foundry
TSMC Fab 2 (6", 0.35µm CMOS)
Old, available, under-utilized, low-cost fabs available

GaN Epi Layer
Multi-sourced reactors, scalable, low CapEx



Low-cost, Si wafer
"GaN-on-Si" technology



- ✓ 90%+ yields
- ✓ 24M+ shipped(1)
- ✓ 0 GaN field-failures(2)
- ✓ Committed capacity, with significant upside
- ✓ Only 12-week lead-times

(1) Based on Navitas cumulative production shipments through July 1st, 2021.

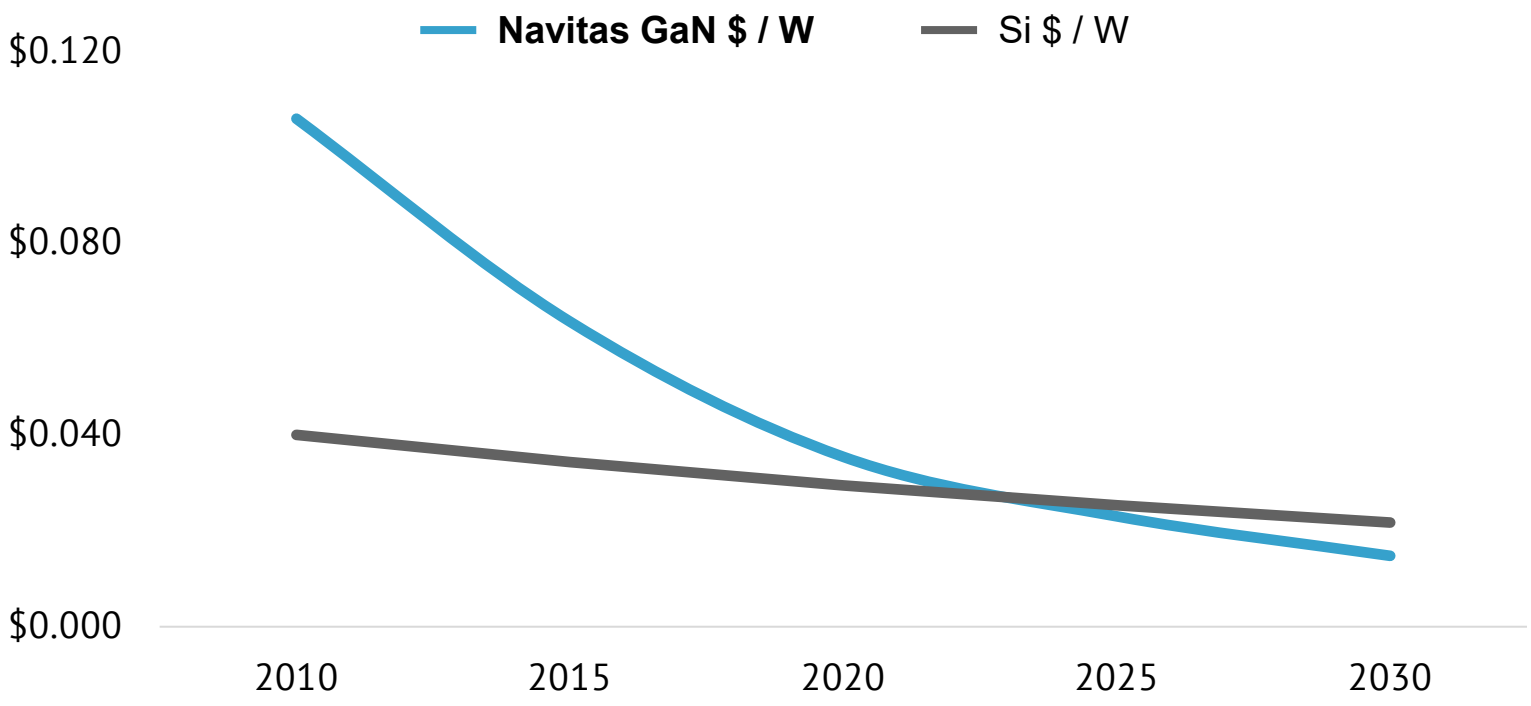
(2) Based on no customer-reported consumer failures for production shipments through July 22nd, 2021.

System-Cost Tipping Point

Navitas

Mobile served as a pioneer and other markets are expected to reap the benefits at lower cost points

Navitas GaN vs Silicon – $ Dollar Per Watt(1)



How Navitas Enables Lower Cost

Early Mover Advantage
High yields and
low manufacturing cost(2)

New GaN Generations Every Year
Cost and performance improvements
each generation

Increasing Levels of GaN Integration Every Year
Lower customer implementation costs

Faster GaN Performance Every Year
Smaller and lower cost external
components every year

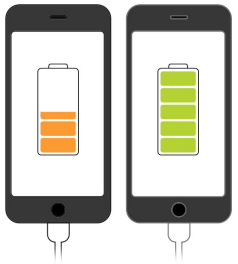
Navitas is Positioned to Drive Mainstream Adoption

(1) Navitas estimate comparing cost of GaN-based vs Si-based wall charger bill-of-materials cost (high-voltage power device, driver/controller, magnetics, PCB and case) for typical 65W mobile charger.
(2) Based on Navitas production release of 650V GaN power IC in Q3 '18.

GaN is the Future of Mobile Charging

Navitas

Fast
Up to 3x more power
Up to 3x faster charging

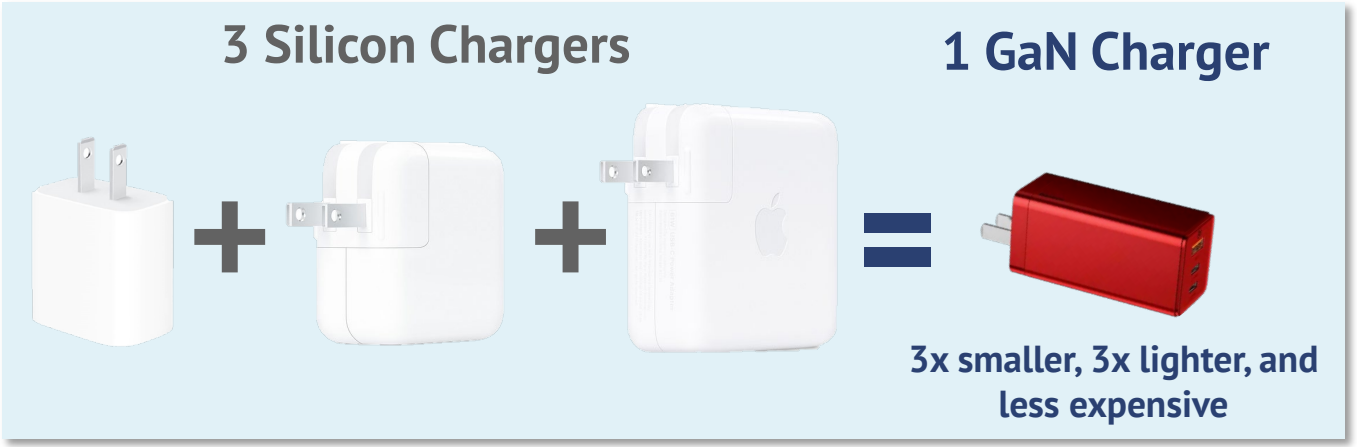


Mobile
Half the size and weight
of traditional chargers

Universal
One charger for ***ALL*** your devices
One and Done!!

$2.5B/yr
GaN IC
Opportunity(2)

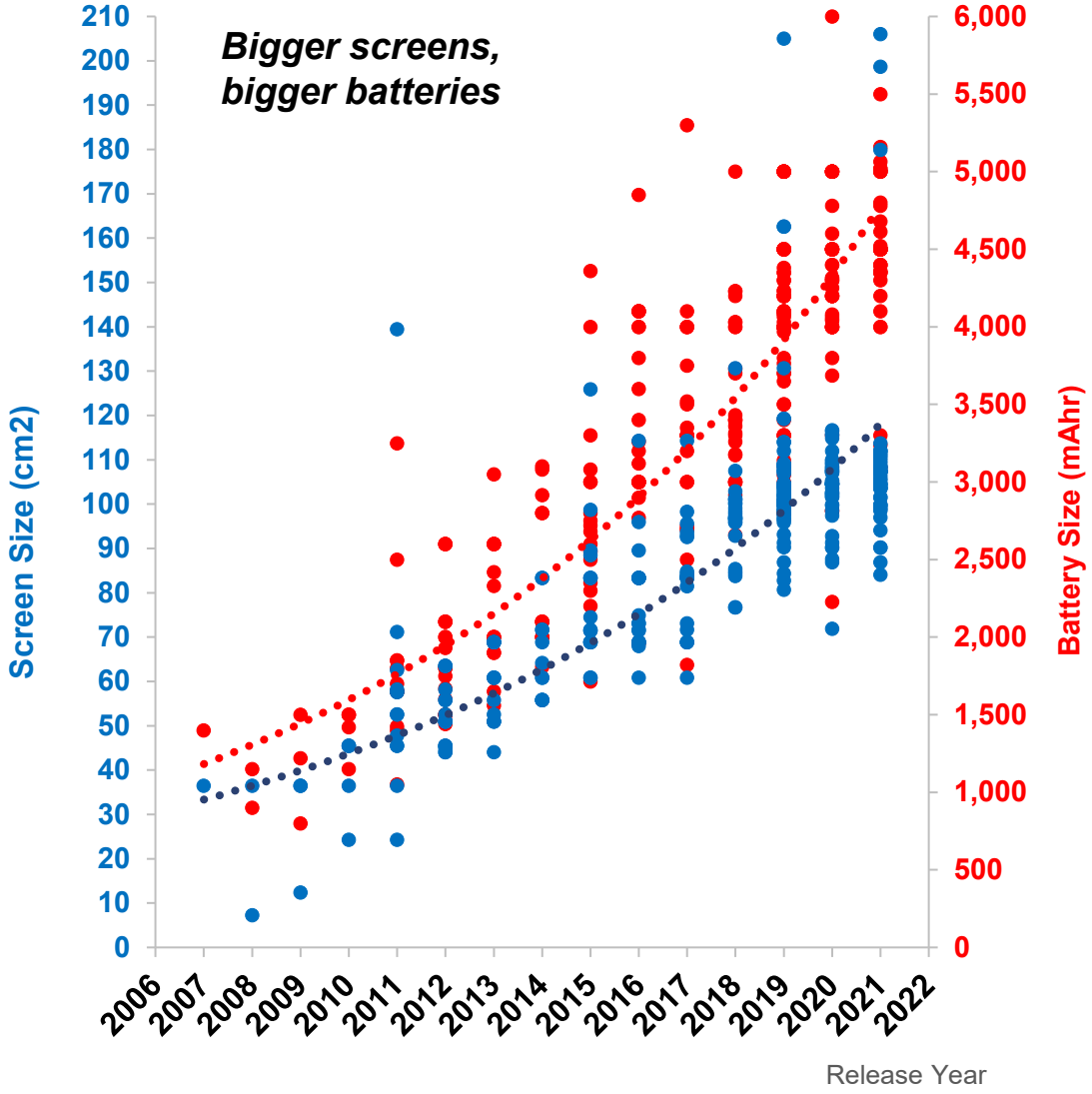
- 2.5B mobile chargers / year
- ~$1 GaN per charger

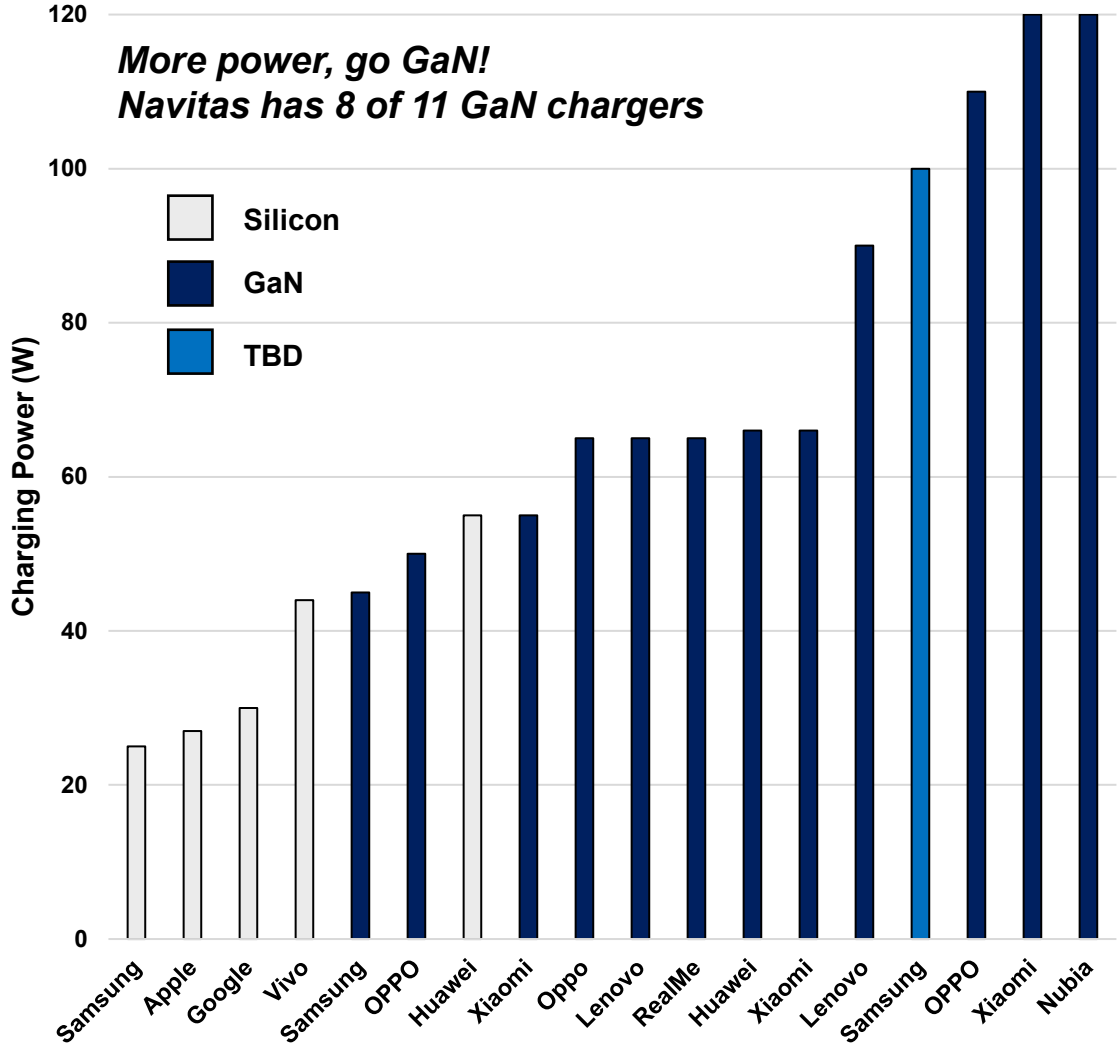


65W
Multi-Port
GaNFast
Charger(1)

(1) Based on Navitas measurements of select GaN-based mobile wall chargers compared to Si-based chargers with similar output power.
(2) Based on estimates from IDC PC Tracker, USB-C research, Yole Research and Navitas estimates.

Power-Hungry Smartphones Use GaN

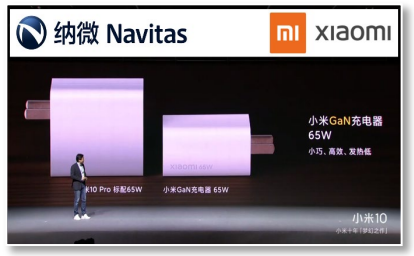




(1) Navitas survey of public information, including gsmareana.com, Nov 2nd 2021

Leading Customers Adopting Navitas GaN

Tier 1 OEMs



Aftermarket Examples

140+
GaN Chargers In Mass Production

150+
GaN Chargers In Development (MP 2021-2022)

90%+
Mobile OEMs Designing With Navitas GaN ICs

30M+
GaN ICs Shipped

Zero
GaN Field-Failures(1)

Note: #chargers as of July 7th 2021. #shipped as of October 31st, 2021.
(1) Based on no customer-reported consumer failures for production shipments through July 22nd 2021.

Navitas GaN Chargers from 20W to 300W

Navitas

chargeasap

200W 2C+2A
203 cc, 220 g

Baseus

120W 2C+A
154 cc, 216 g

SHARGE

100W 3C+A
149 cc, 220 g

AUKEY

Omnia 90W
2C+A
131 cc. 190 g

Lenovo 联想
thinkplus

Pro 65W C+A
76 cc, 106 g

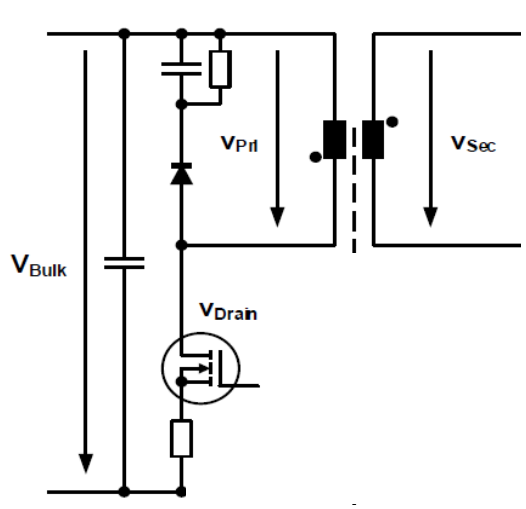
UIBI 柚比

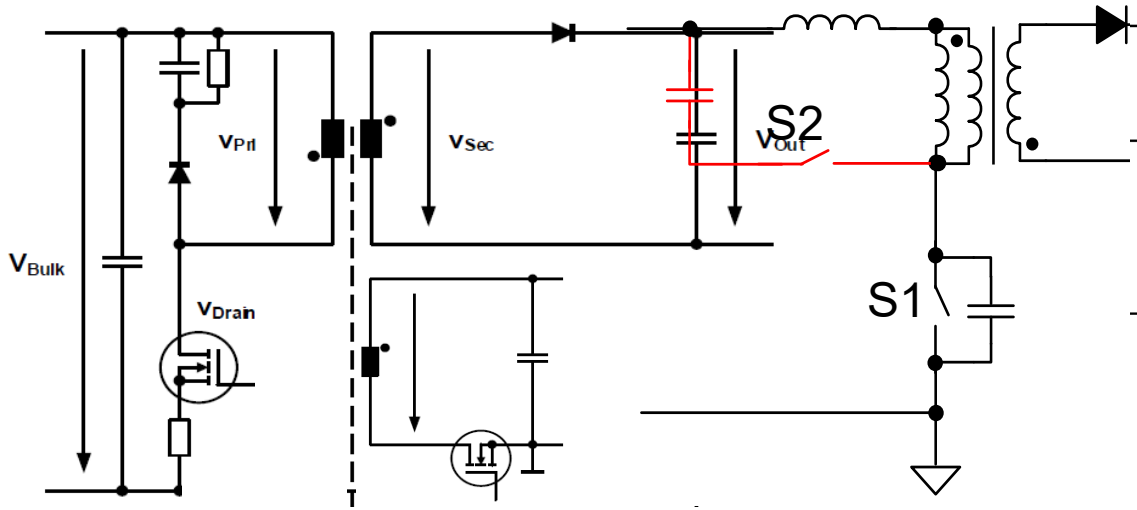
30W C+A
67 cc, 82 g

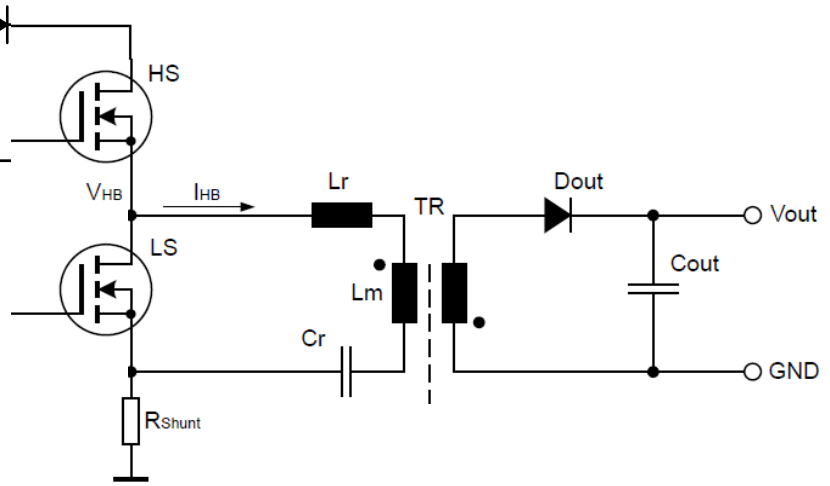
spigen

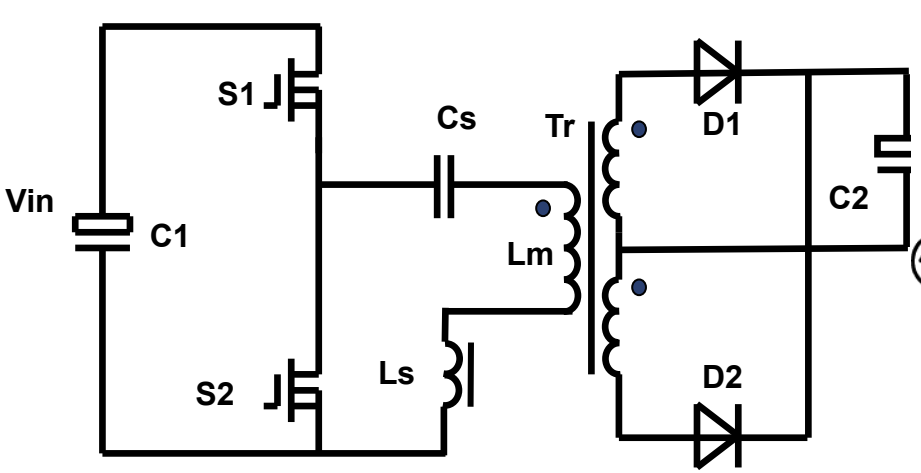
20W C

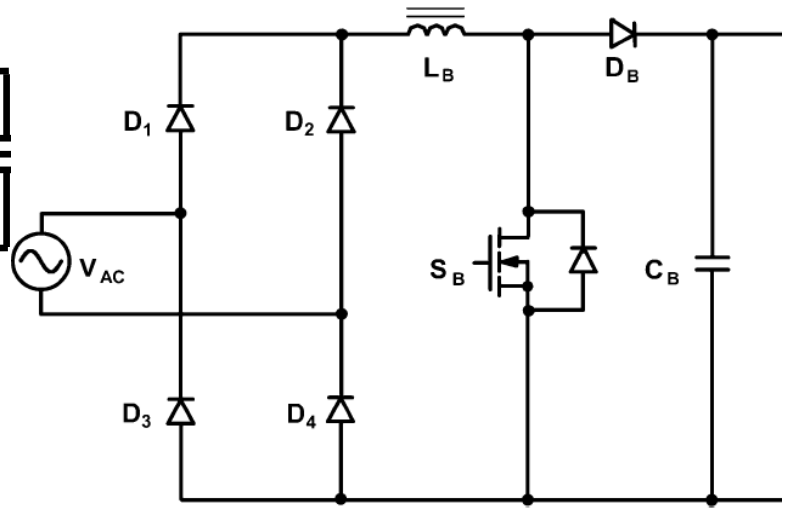
Navitas GaN Applied in High-Speed Topologies

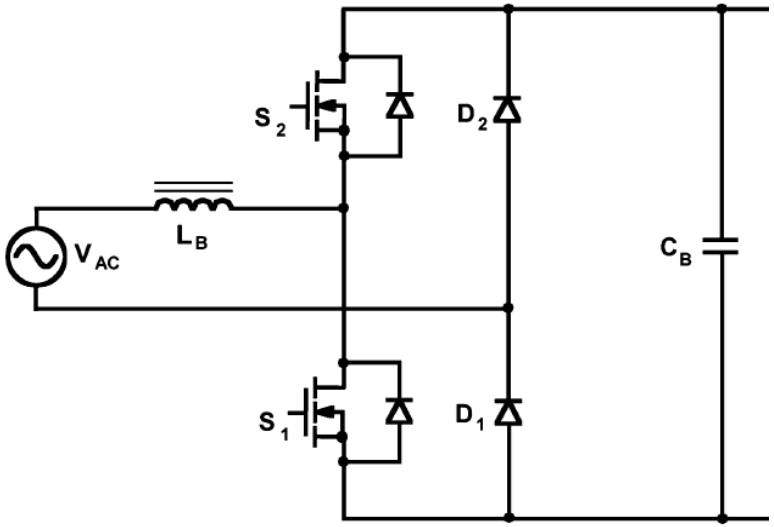






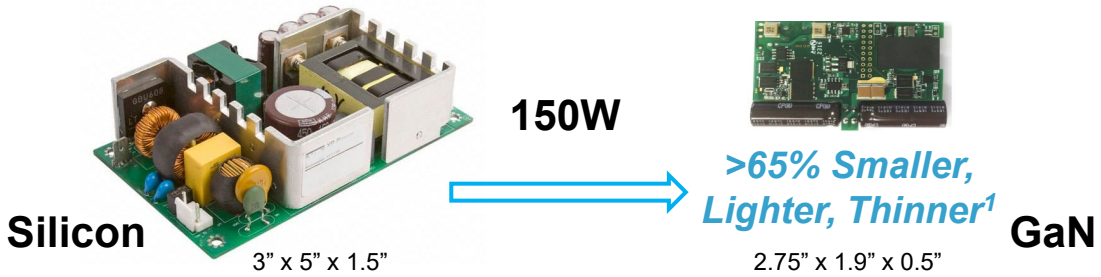






Consumer: More Power, Smaller Size, $2B/yr Opportunity

Navitas



- Need more power in smaller, slimmer sizes
  - Ultra-thin TVs, gaming, all-in-one PCs, smart home = 600M/yr
  - TV screens upgrade from UHD to 8K = **4x** more power
  - $3/unit potential GaN
  - *= $2B+ /yr opportunity(3)*
- GaN ICs make it possible
  - Up to 3x smaller and lighter, low-profile form factors
  - Up to 40% energy savings

GaN Is The Answer As Consumers Demand More Power And Smaller Form Factors

(1) Based on Navitas measurements comparing typical 150W 65 kHz Si-based AC/DC power adapter to 150W 1MHz GaN-based power adapter prototype.
(2) Based on information provided to management by potential customers.
(3) Based on estimates from Gartner, Pulsenews, WitsView, Statista and Navitas estimates.

Data Centers: Save $1.9B/yr [1]

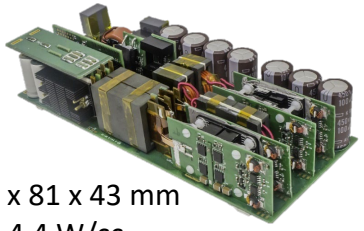
- **44% of Data Center costs related to power (electricity, power & cooling)[3]**
- Estimate GaN ICs can reduce electricity use by up to 10%[2]
- Worldwide, could save >15 TWh or $1.9B in annual electricity costs (1-year ROI of 6x)[1]

Silicon AC-DC 3,200W

325 x 107 x 41 mm
2.2 W/cc

GaN AC-DC 3,200W[4]

- 2x higher power density
- 38% reduction in energy loss

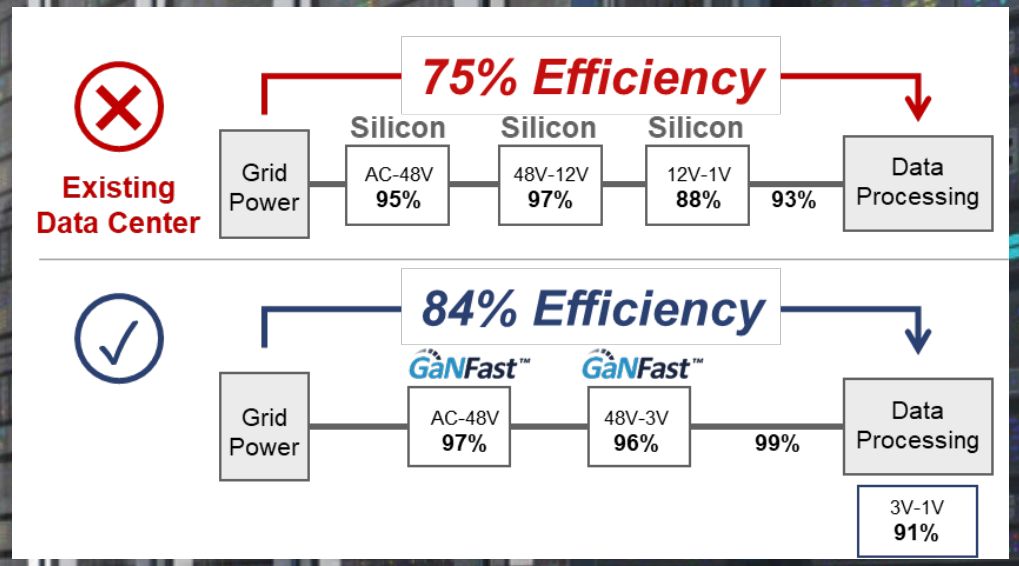


210 x 81 x 43 mm
4.4 W/cc

*"**GaN** is a **breakthrough new technology** that is enabling dramatic reductions in size, energy savings and power density"*
*"Navitas is an excellent partner with **industry-leading GaN ICs**"*

Robin Cheng, VP R&D

肯微科技股份有限公司
Compuware Technology Inc.

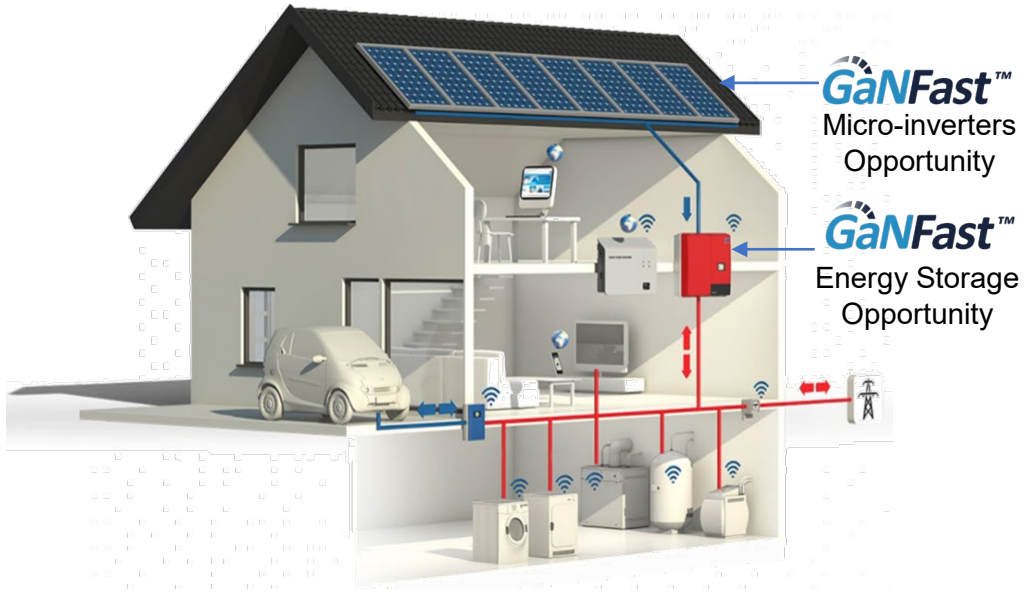


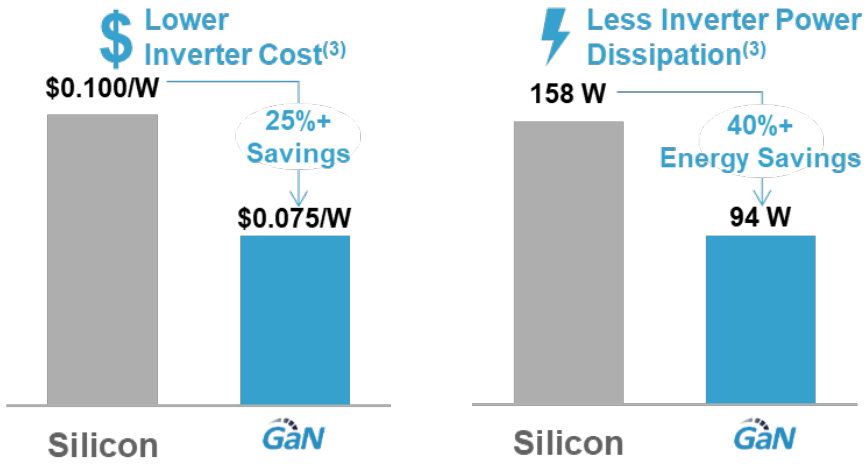
(1) Navitas estimate based on a) Navitas server/datacom forecast & AAAS data, b) $0.12/kWhr, c) Si vs. GaN $/W and d) data center loading profile.
(2) Navitas estimated based on known existing Si-based solutions to deliver >500A next-generation data processors to Navitas targets for new GaN-based AC/DC and DC/DC for these same next-generation data processors.
(3) Schneider Electric. White Paper – Determining Total Cost of Ownership for Data Center and Network Room Infrastructure.
(4) Navitas measurements based on existing Si-based 3.2kW AC/DC server power supply to a 1 MHz GaN-based 3.2kW AC/DC prototype.

Solar: Up to 40% Energy Savings[2]

Navitas

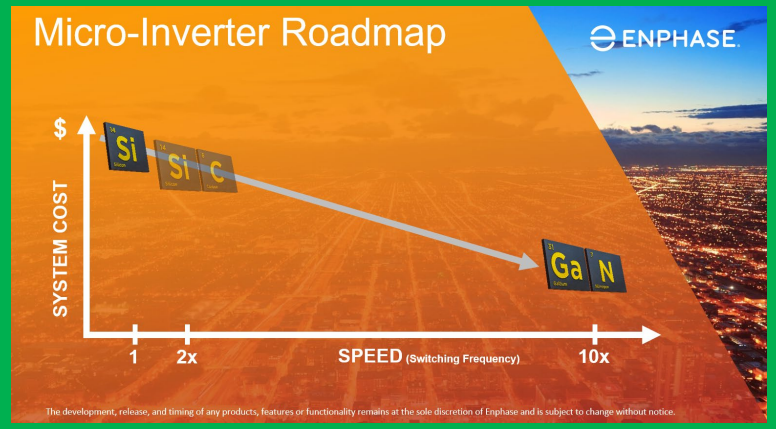
- Shrink microinverter size, weight & cost
  - 25% *cost reduction* of solar inverters[2]
  - Up to 40% energy savings
  - *Improve solar payback by 10%+* (vs. typical 8 years[1])
- Total residential solar GaN IC opportunity > $1B/yr[3]
  - $3M GaN IC sales potential per GW solar installation
- Leading player expected to adopt GaN IC in next-gen
  - >$500M GaN IC revenue opportunity between 2023-2030





(1) EnergySage Solar Marketplace, 2020.
(2) Navitas est. vs. Si-based 500W residential micro-inverters assuming GaN-based inverter enables 40% reduced power loss and 25% lower inverter costs
(3) Navitas est. average 2021-2030, residential installations, MarketsandMarkets, IHS, Fraunhofer ISE, customer input.

"It's the ***end of the road for silicon***."



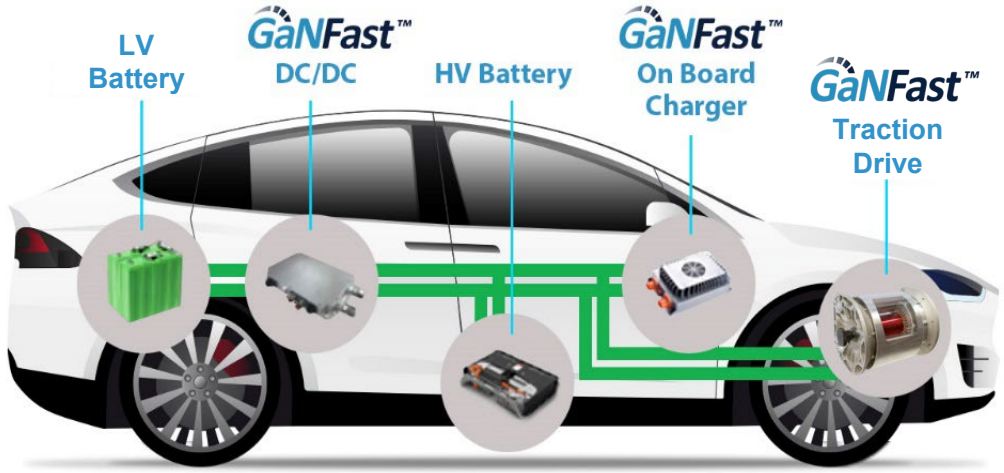
*"**GaN** offers **>10x** frequency and **significant** cost advantages."*

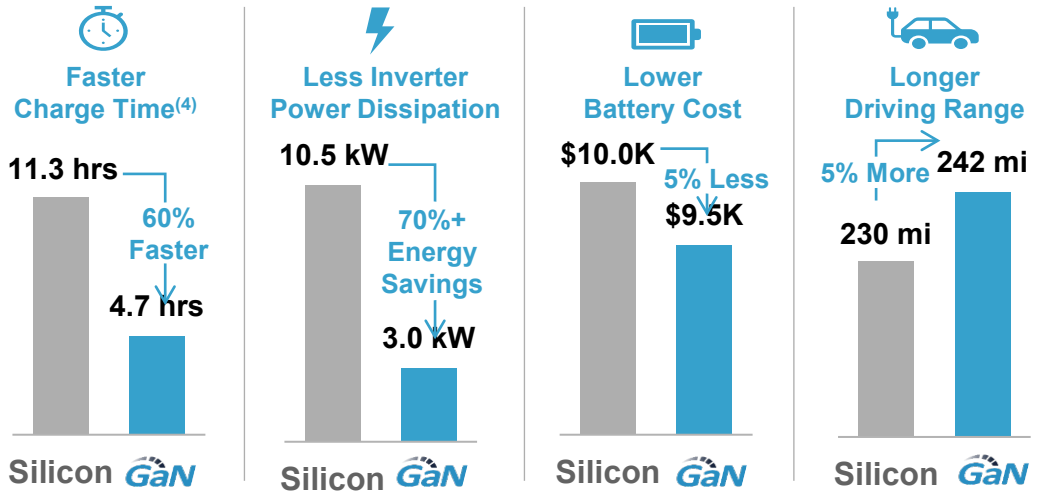
Power Electronics Architect
ENPHASE

(3) Navitas est. based on 6.2 kW residential installation. Si inverter at 97.5% efficiency, GaN at 98.5%.

EV / eMobility: Accelerating Adoption by 3 Years[1]
Longer Range, Lower Costs

Navitas





- 3x faster charging[4]
- Extended range
  - 70% energy savings enables 5% extended driving range, or 5% lower battery costs[3]
- >$2.5B/yr GaN opportunity in 2025[2]
  - ~$50 GaN in OBC, ~$15 DC-DC, ~$200 traction = ***$250+ GaN TAM per Pure-EV***
  - >50Mu/yr EVs projected by 2030
  - $400M opportunity with 1st EV customer (2025-30)

"Our current OBC product line up is Si & SiC. ***GaN*** will enable us to ***further improve***."

"Navitas advantages are ***simplicity of driving, high-speed, reliability & compact form factor***."

VP Power Products BRUSA

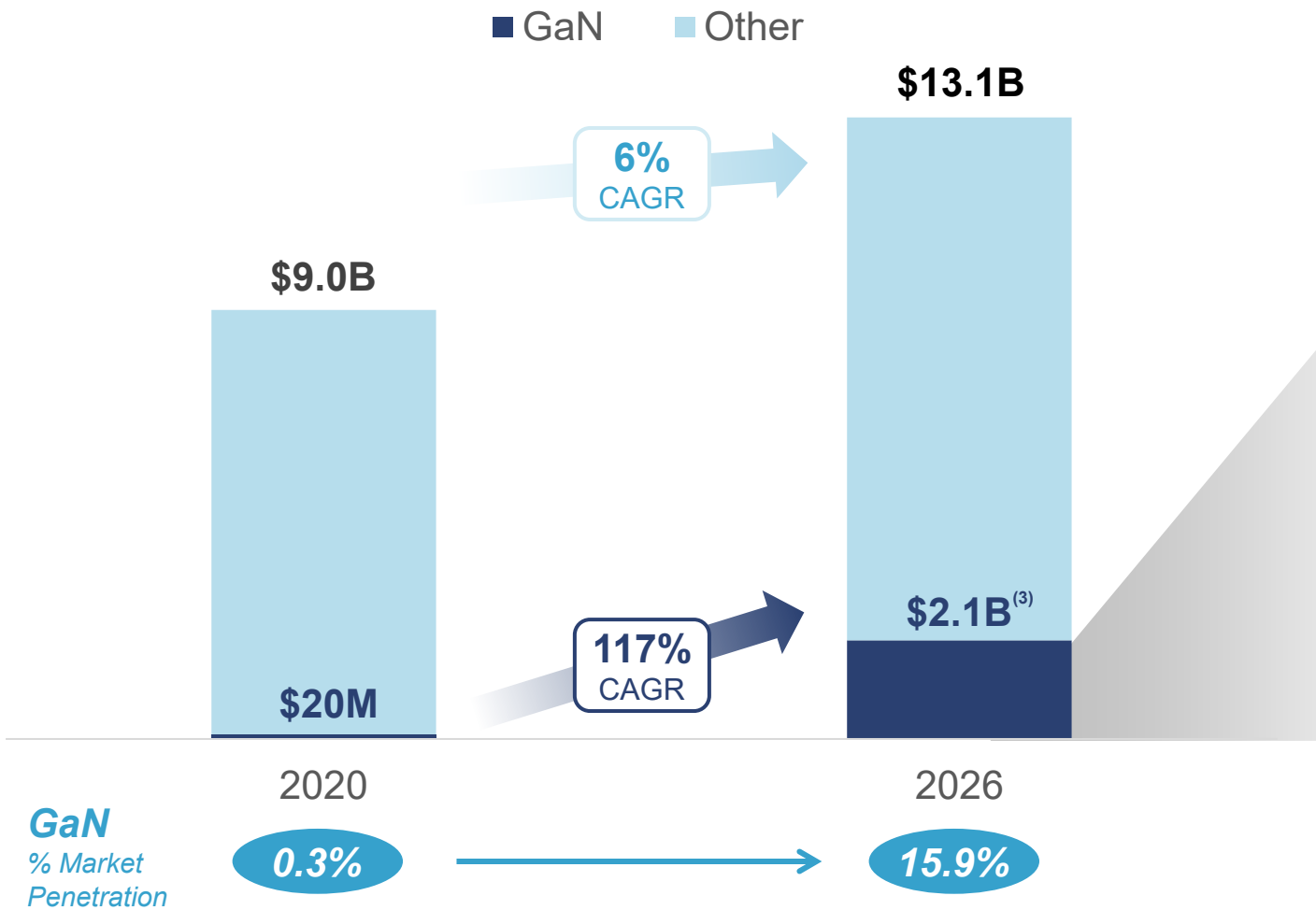
Note: Assumes 150 kW traction inverter, 100 kWh battery, $100/kWh battery cost and typical 230 mile range.

(1) Based on DNV and Navitas analysis
(2) Based on BCG Research, Yole Research and Navitas analysis.
(3) Navitas estimate based on discussions with major suppliers of power electronics to the electric vehicle industry.
(4) 6.6 kW Si OBC vs. 21 kW GaN OBC assuming a 90 kWh battery and 80A wall charge limit.

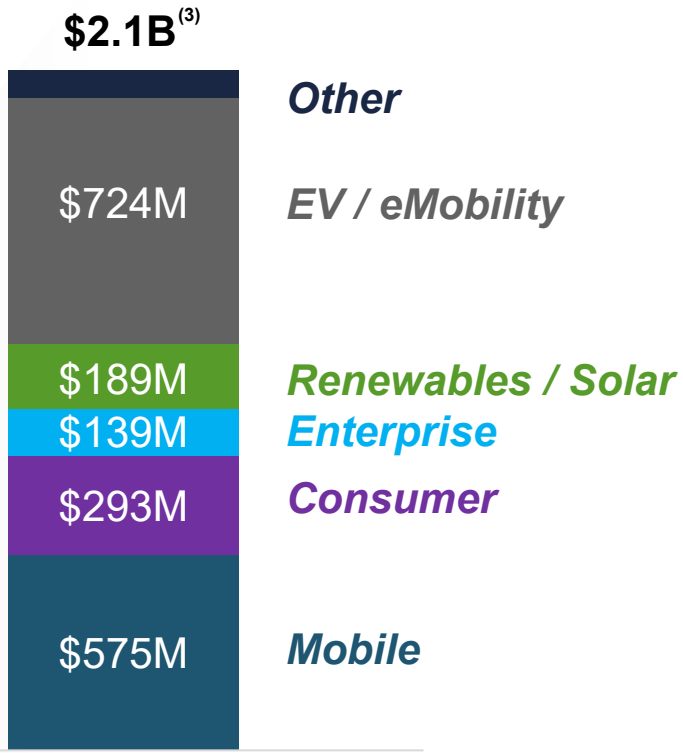
Power Market Grows, GaN Market Grows Faster!

Navitas

GaN Opportunity Within Total Power Semiconductor TAM[1,2]



GaN Power Semiconductor TAM[2]



(1) GaN IC potential market based on voltage rating of 80V – 1,000V derived from Yole Développement, Status of the Power Electronic Industry 2020.
(2) IHS SiC GaN Power Semiconductors Report 2020, Yole Power Devices Summary – 2019-25, expert interviews.
(3) Reflects midpoint of forecasted 2026 market size range of $1.6 billion to $2.6 billion.

GaNFast is 'Green'

Navitas

GaN Power ICs Reduce CO_2 Emissions

4x-10x lower component CO_2 footprint than silicon(1)

28% lower lifetime CO_2 footprint for chargers / adapters(2)

Accelerate transition from ICE to EV by **3 years**, saving **20%/yr** of road sector emissions by 2050 (4)

GaN addresses **2.6 Gton / year** by 2050(5)

Every GaNFast™ power IC shipped saves(3)

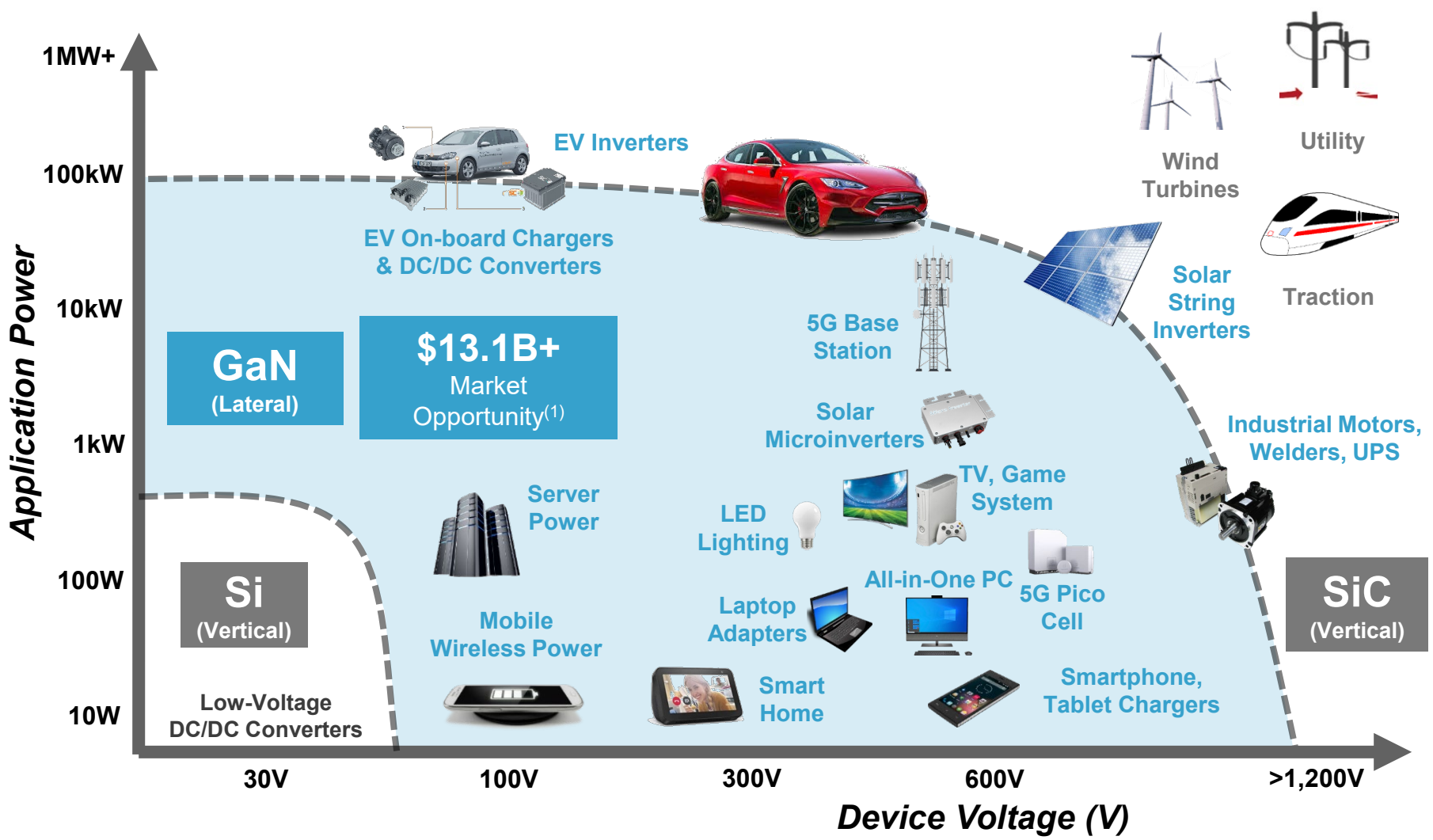
4 kg CO_2

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

(1) Navitas and Earth-Shift Global analysis. 4x lower for 2021, 10x lower by 2022 per life-cycle analysis
(2) Navitas and Earth-Shift Global estimated based on 65W charger per life-cycle analysis
(3) Navitas estimate based on GaN vs Si total life-cycle analysis.
(4) DNV estimate for 75%-adoption milestone pull-in, total road sector benefit

(5) Company information, DNV GL, EPA, IEA, International Renewable Energy Agency (IRENA). See 5-7-21 Investor presentation for details (filed with SEC)
Derived from demand and energy efficiency CO2 reduction of 1.4 Gt; assumes a $0.12 / kWh cost of electricity and a carbon to energy ratio of 0.00071 tons / kWh, aligned with the EPA's marginal emission rate.

GaN: A Big Opportunity



GaN vs. SiC Comparison

	GaN	SiC
Device Structure	Lateral	Vertical
Circuit Integration	Yes (Power + Analog)	No
Switching Frequency	Highest (200 kHz – 2 MHz)	Medium (100 – 300 kHz)
Cost	Si substrate (very low cost)	SiC substrate (10x cost vs Si)
Thermal performance	Same as Silicon (1.3 W/cmK)	Highest (3.8 W/cmK)

(1) GaN IC potential market based on voltage rating of 80V – 1,000V derived from Yole Développement. Status of the Power Electronic Industry 2020. Reflects estimated GaN market opportunity for power semiconductors by 2026.

Thank You


Navitas
Energy • Efficiency • Sustainability
Navitas
GaNFast™
Power IC