



**Pure-Play, High-Speed  
GaNFast and GeneSiC:  
The Leading Edge of Next-Gen Power Semiconductors**



**Stephen Oliver**  
**VP Corp. Mktg. & IR**

**Navitas**  
*Energy • Efficiency • Sustainability*

Navitas  
GaNFast™  
Power IC

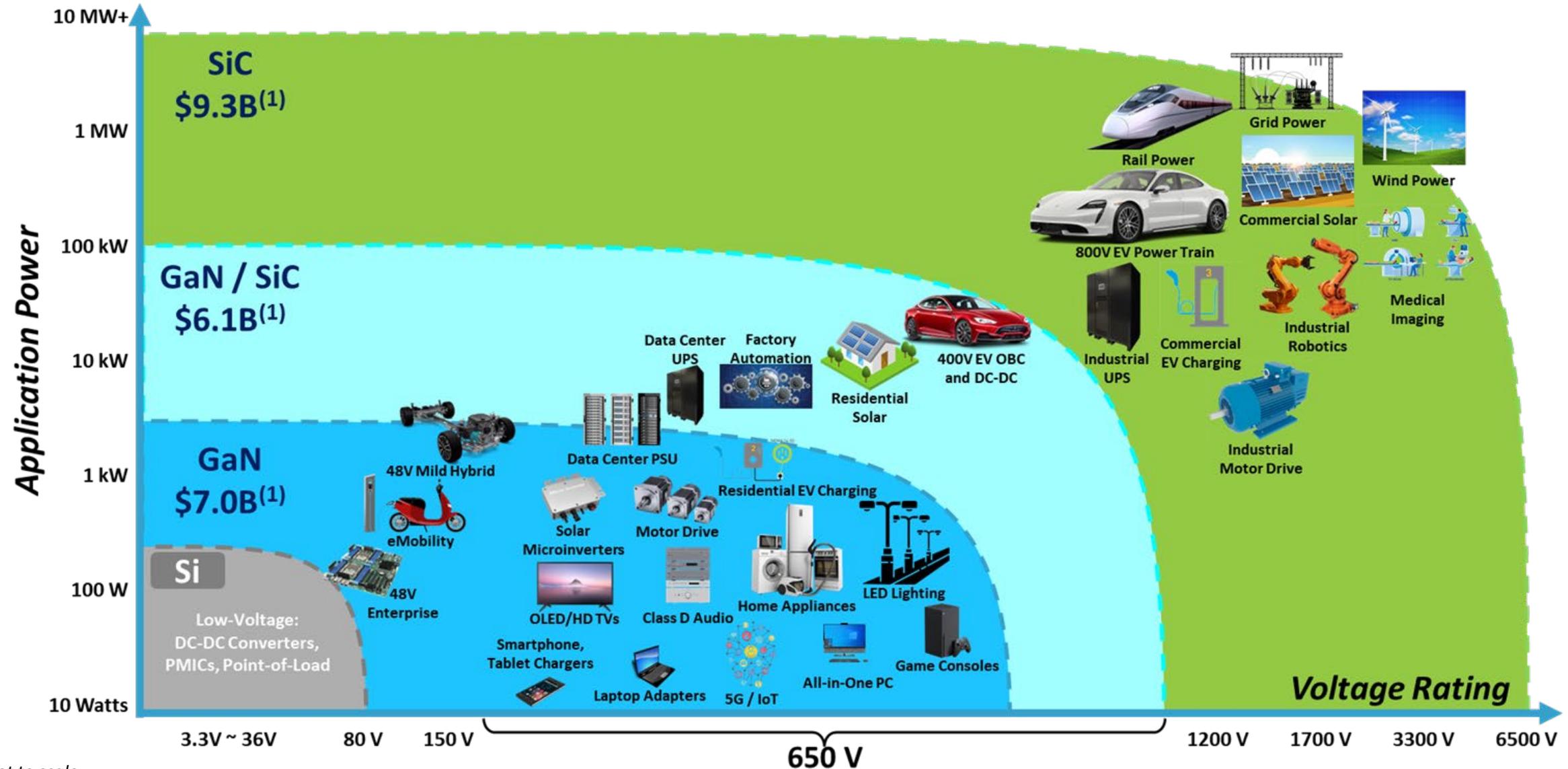
Navitas  
GeneSiC™  
Power



## *Pure-Play Next-Gen Power Semiconductors*

August 15th, 2022: Navitas Semiconductor, industry-leader in gallium nitride power ICs, acquired GeneSiC Semiconductor, silicon carbide pioneer and industry leader

# \$22B 'Pure-Play' Market Opportunity <sup>(1)</sup>

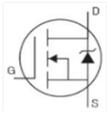


Axes not to scale

1) 2026E potential, Source: Yole, DNV, IRENA, Fraunhofer ISE, IHS, Cisco, Hyperscale, Peer annual reports, Wall Street research.  
© Navitas Semiconductor 2023

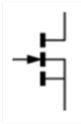
# The GaN Revolution: Critical Integration

Silicon FET



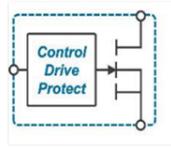
- Old, slow
- High  $Q_g$
- High  $C_{OSS}$
- $F_{SW} < 100$  kHz

Discrete GaN



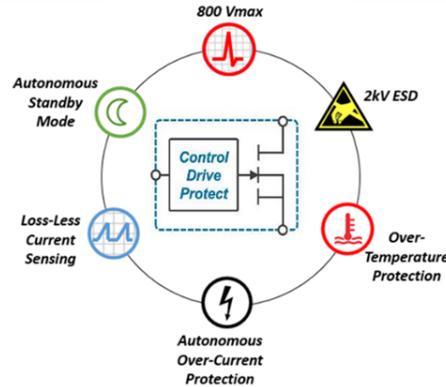
- External gate drive
- $dV/dt$  sensitivity
- Layout sensitivity
- ESD sensitivity
- Unknown reliability
- Unknown robustness

**GaNFast™**  
200-300 kHz



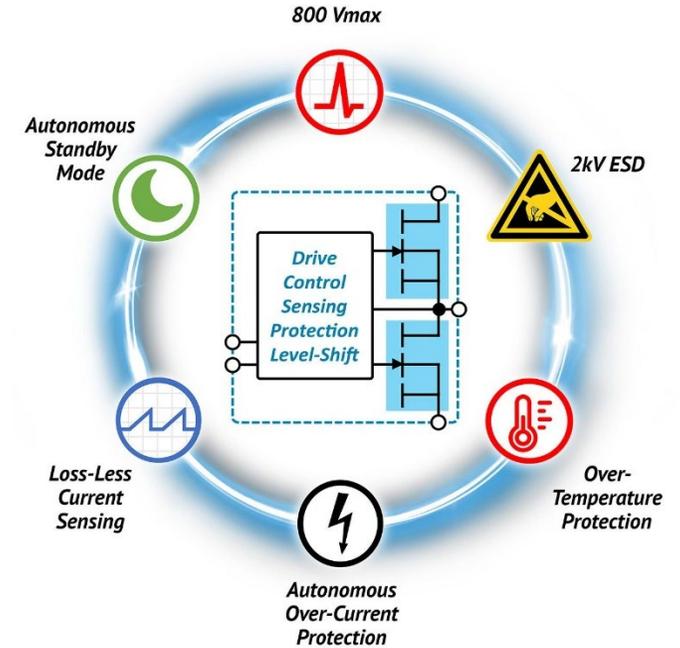
- ✓ Internal Gate
- ✓ Integrated Gate Drive
- ✓  $dV/dt$  Immunity
- ✓ Layout Insensitive
- ✓ 2 kV ESD rating
- ✓ Proven Reliability
- ✓ Proven Robustness

**GaNSense™**  
500 kHz



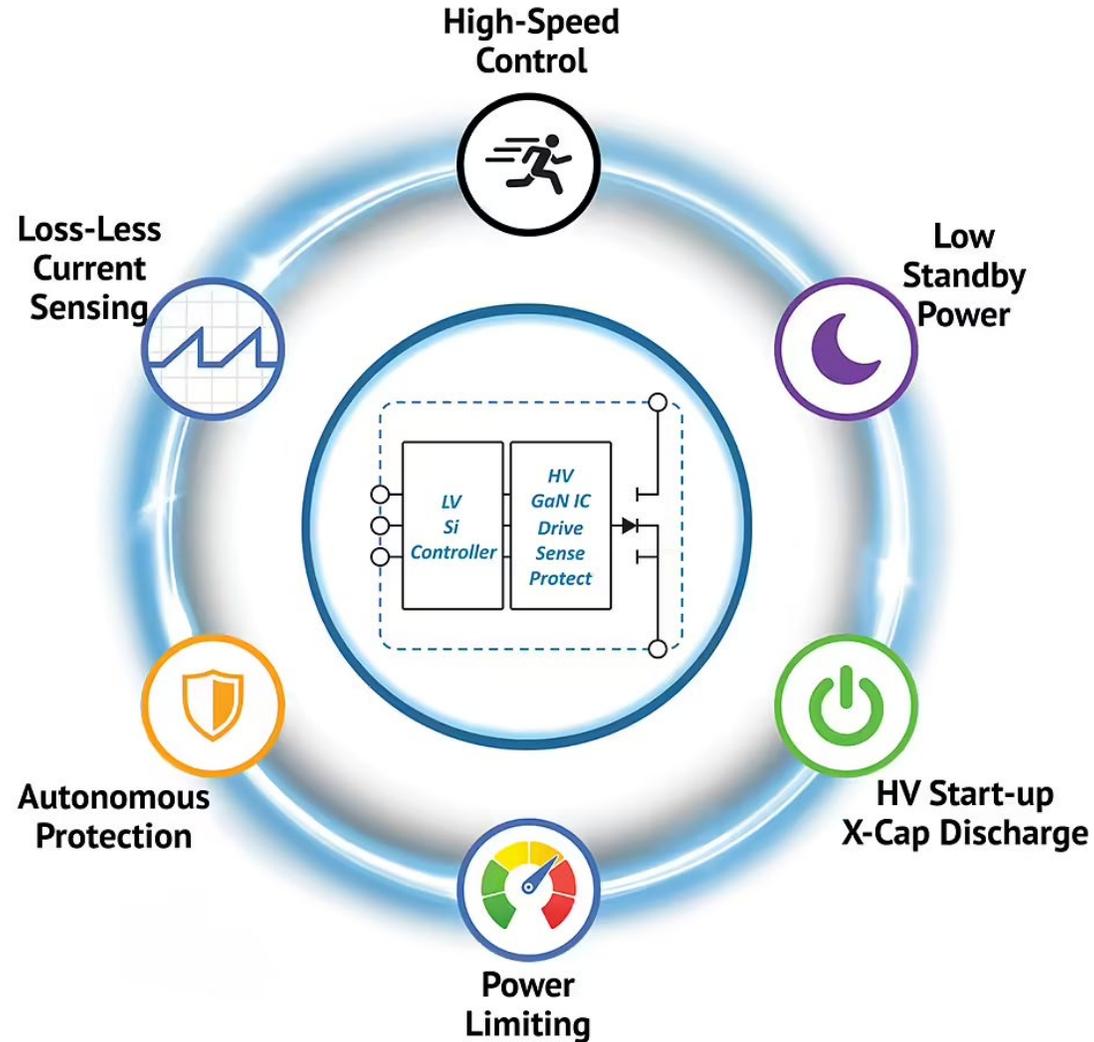
- GaNFast plus:**
- ✓ Autonomous Standby
  - ✓ Autonomous Protection
  - ✓ Loss-less Current Sensing
  - ✓ High Precision
  - ✓ High Efficiency

**GaNSense Half-Bridge**  
1 MHz

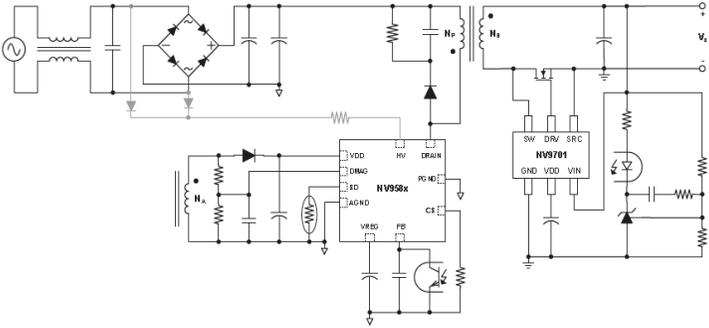


- GaNSense plus:**
- ✓ Highest integration
  - ✓ integrated HS and LS FETs
  - ✓ Integrated level-shift isolation
  - ✓ integrated boot-strap
  - ✓ Shoot-through protection
  - ✓ Enlarged cooling pads
  - ✓ Fastest switching
  - ✓ Highest efficiency



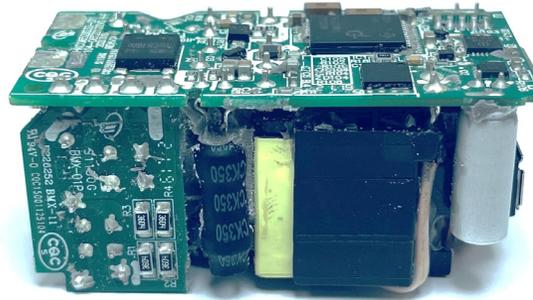


# 1.5x Power Density than Discrete GaN

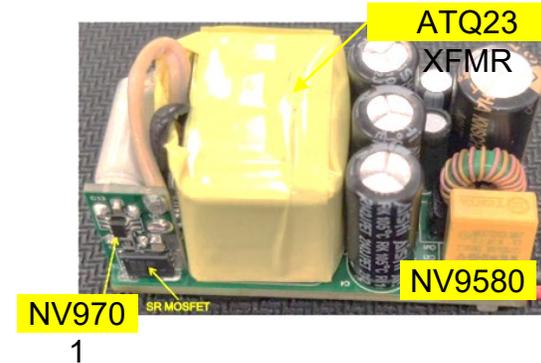


Typical 65W Application Circuit

## Discrete GaN



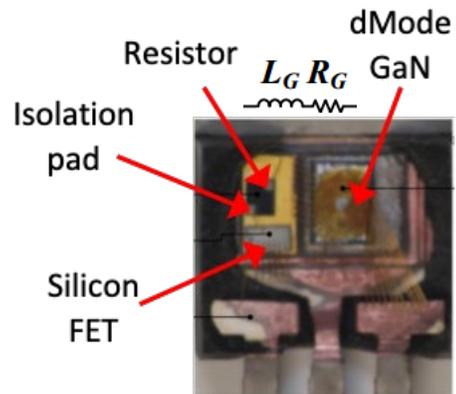
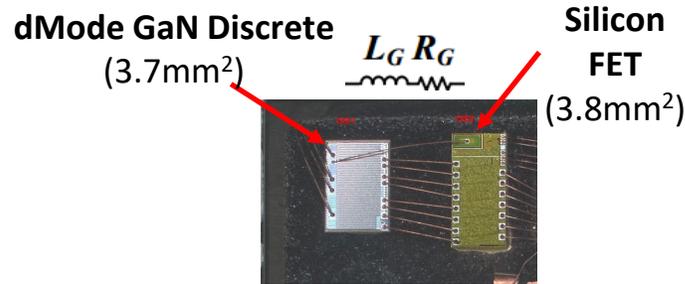
## GaN Sense Control



	Discrete GaN	GaN Sense Control IC	
Power (W)	65	65	
Frequency (kHz)	100	125	25% faster
Peak Efficiency (%)	90.3	94.3	4% higher
Dimension: x,y, z (mm)	33 x 33 x 60	50 x 30 x 20	2x smaller
Power Density (W/CC) cased	1.03	1.50	1.5x higher

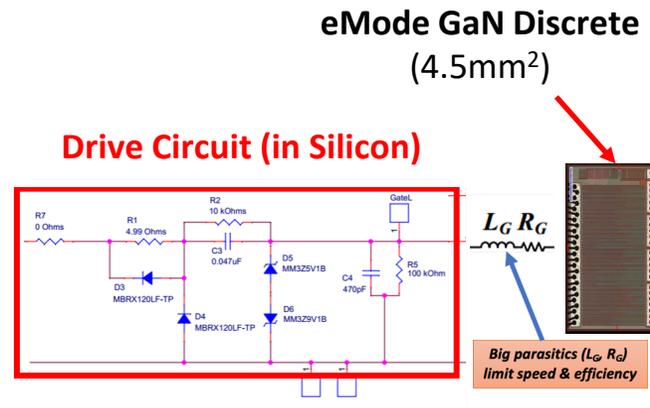
Feature	Competitor A	Competitor B	Navitas	Navitas Benefit
Max Frequency (kHz)	175	150	225	Higher Efficiency, Power Density
Package	PQFN 6x8	InSOP 10x14	PQFN 5x6	
HV Startup	Internal	Internal	Internal	
Lossless Current Sensing	No	Yes	Yes	
V <sub>DD</sub> Range (V)	7.9 - 40	4 - 6	6.2 - 80	
External V <sub>DD</sub> Regulator	Boost	Linear	Not Required	
External Components	+11	+18	+9	
PCB Footprint (mm <sup>2</sup> )	85	90	50	
Thermal Pad	Yes	No	Yes	
Standby Loss (mW)	50	<30	<20	
Hotspot	Yes	No	No	Higher Reliability
V <sub>DS</sub> (cont./trans.)	650 / 750	650 / 750	700 / 800	

## Discrete dMode GaN



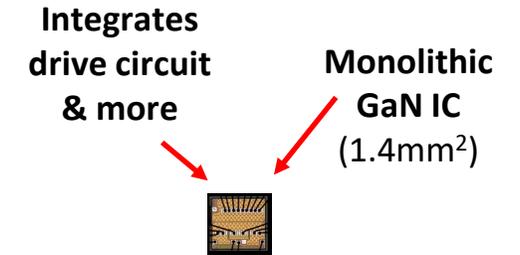
- **Extra Si FET + other**
  - **Cost & complexity**
  - **Adds parasitics & delay**
  - **Limits speed & efficiency**

## Discrete eMode GaN



- **Extra Si driver circuit**

## Navitas eMode GaN IC



- **No extra circuits**
- **No parasitics & delay**
- **Drive & power matched in GaN**
- **Integrated features, functions**
- **Highest speed & efficiency**
- **Highest robustness and reliability**
- **Simple customer design**
- **50-80% smaller chip**

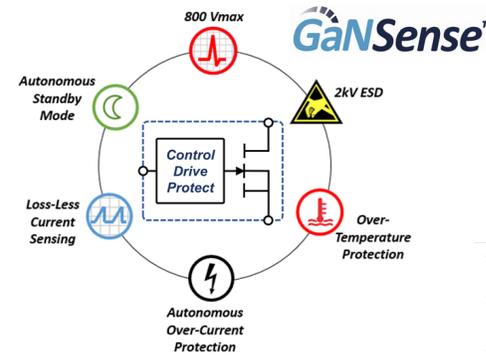
(1) 'dMode' = depletion mode = 'normally on' transistor, causes short circuit unless additional transistor added.

(2) 'eMode' = enhancement mode = 'normally off' transistor.

# Foundational Reliability

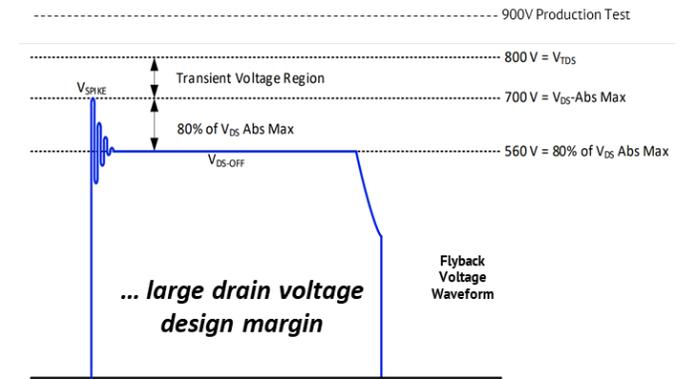
- **Design** for Reliability

- Integrated drive, sensing and protection
- Component reliability, and **system** reliability



- **Testing** for Reliability:

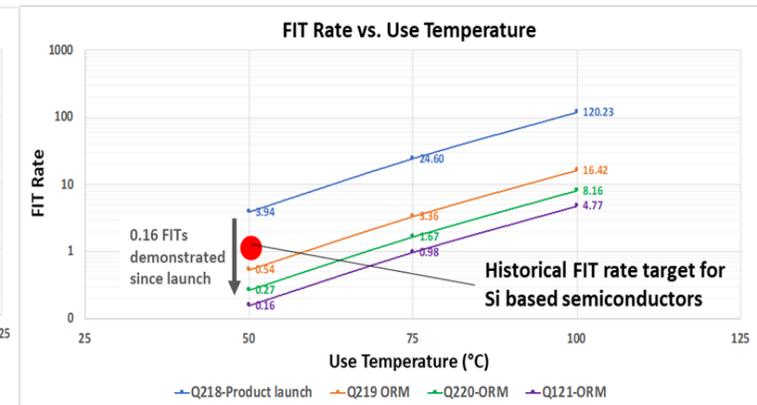
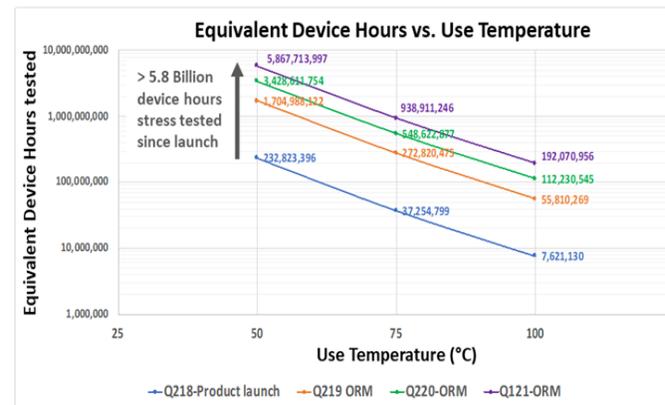
- Proprietary production test methods
- GaN ICs tested 400% (multi-temp, high-frequency)



- **Characterization** for Reliability

- Exhaustive, proactive, and unique Navitas reliability program
- 5.8 B equivalent device hours tested<sup>(1)</sup>
- Proprietary, highly-accelerated Op-Life, plus JEDEC, plus ELFR monitoring
- Founder member of JEDEC JC70.1

Reliability Statistics  
Calculated for High Line condition using HTOL (ZVS) results



(1) As of September 2022  
© Navitas Semiconductor 2023

# GaN Integration Drives Speed, Efficiency, Stability Navitas

## Discrete GaN Half-Bridge



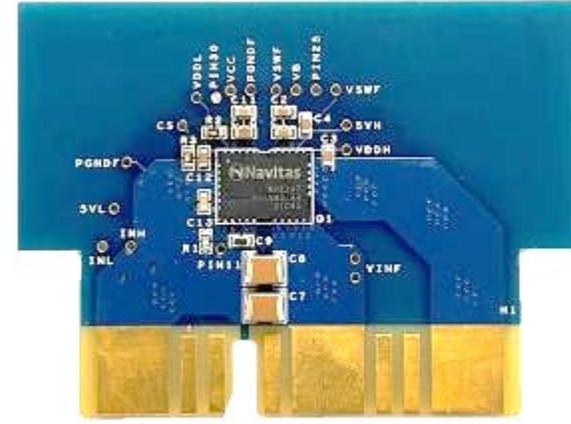
- 33 components
- 250 mm<sup>2</sup> footprint
- External HB driver HVIC
- External HV bootstrap
- 2x HV bypass diodes
- 2x external gate drives
- Exposed gates

61% fewer components

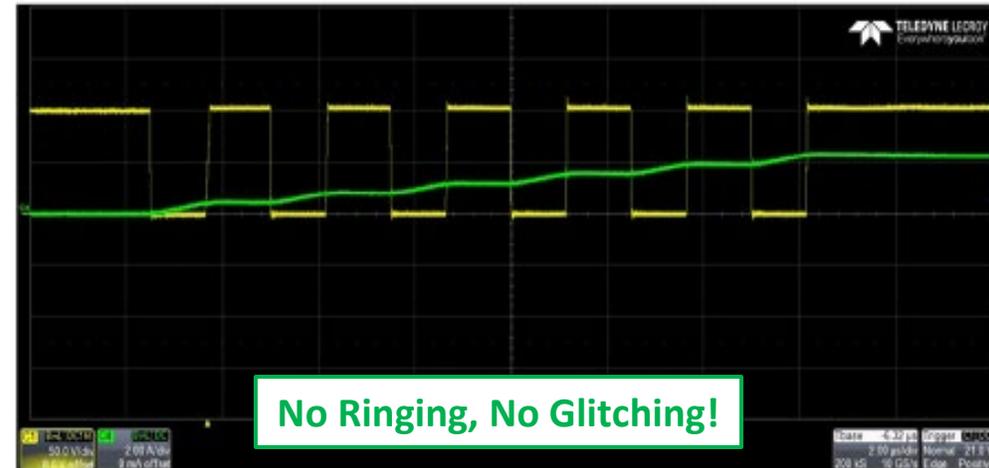
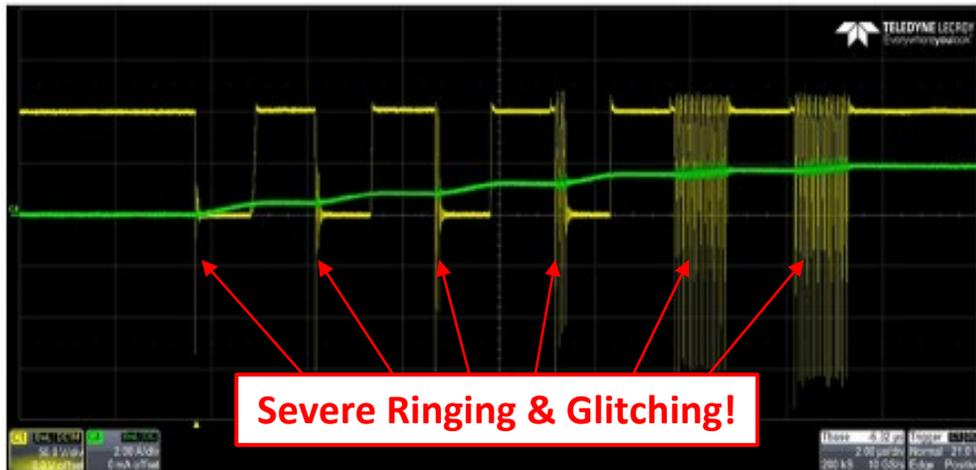
64% smaller footprint

Complete integration

## GaNSense Half-Bridge IC



- ✓ 13 components
- ✓ 90 mm<sup>2</sup> footprint
- ✓ Level shifters
- ✓ Bootstrap
- ✓ Gate drivers
- ✓ No exposed gates





# 100% Tier 1 Mobile OEMs Adopting Navitas

## Tier 1 OEMs



## Aftermarket Examples



**240+**  
GaN Chargers  
Mass Production<sup>(1)</sup>

**250+**  
GaN Chargers  
In Development<sup>(1)</sup>

**100%**  
Mobile OEMs Designing With Navitas  
GaN ICs

**70M+**  
GaN ICs Shipped<sup>(2)</sup>

(1) as of Q4'22 report  
© Navitas Semiconductor 2023

# Now Ultra-Fast Chargers

- Major trend
- New, fast-growth market: \$1B opportunity by 2025<sup>(1)</sup>
- Full charge in <10 mins (200W)
- Increased GaN\$ per charger
- World's highest power density 120W, 150W, 200W, 240W



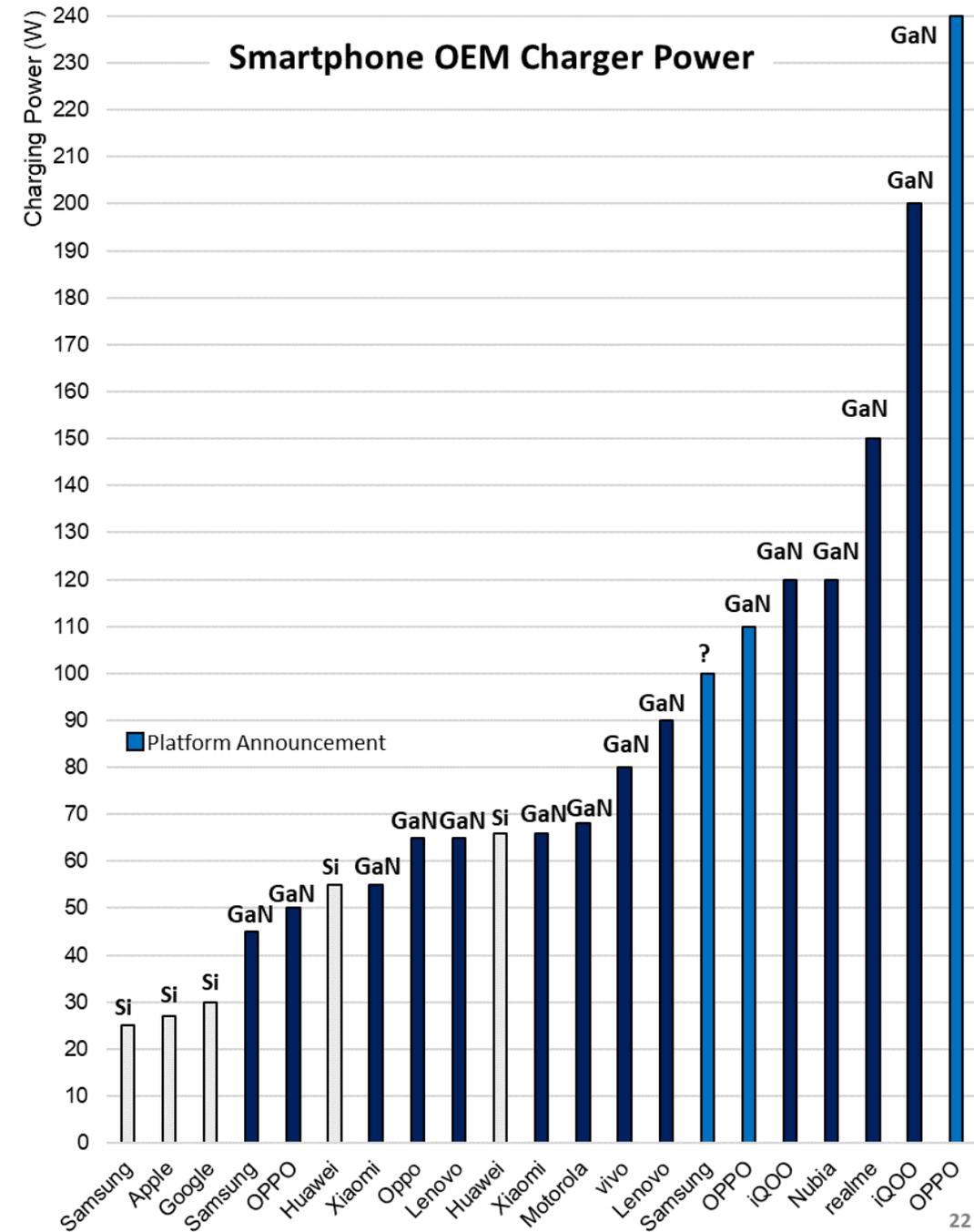
RedMi (Xiaomi) F1 Mercedes 120W



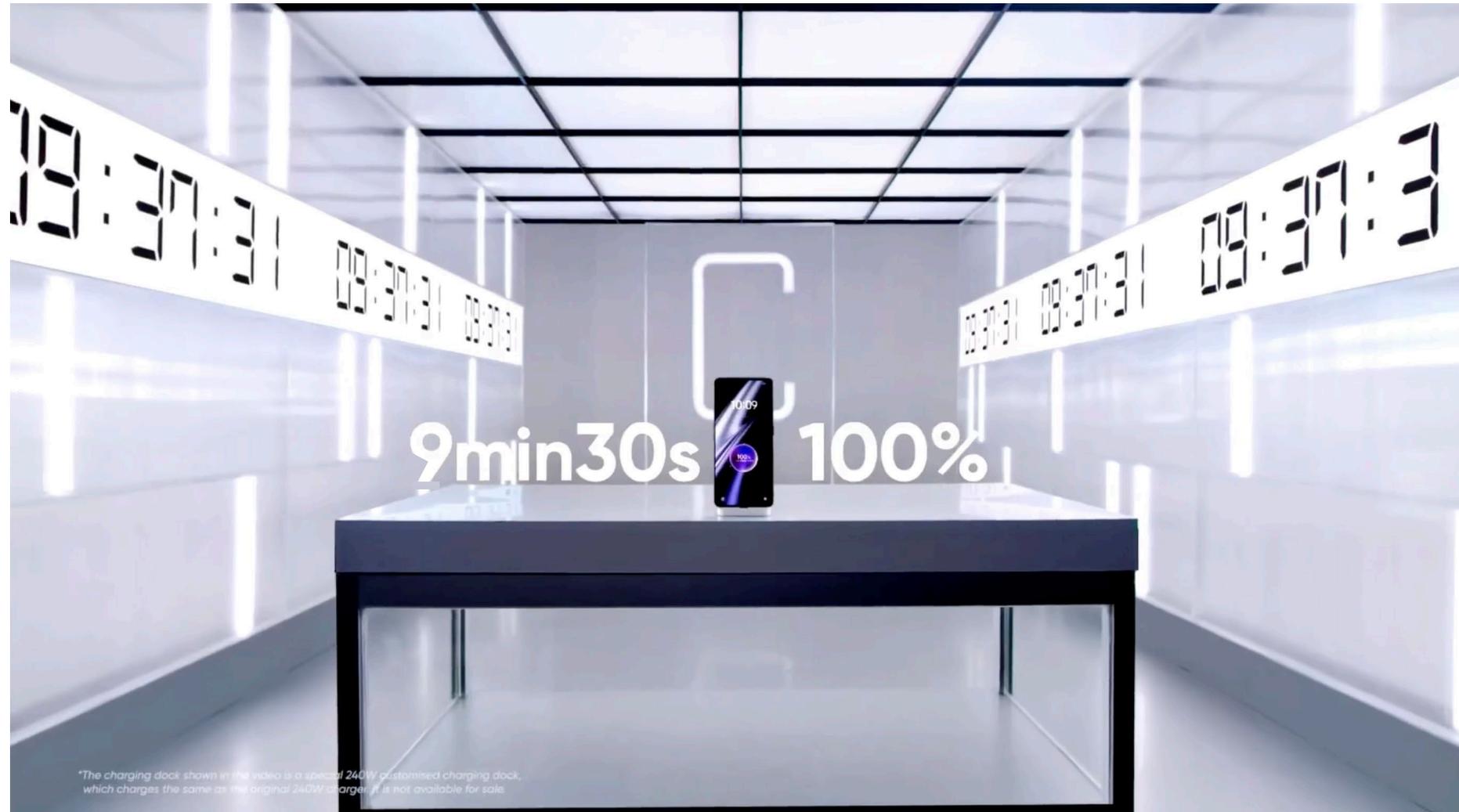
Realme (OPPO) GT Neo 3 150W



iQOO (vivo) 10 Pro, 200W



# Powering the World's Fastest-Charging Smartphone



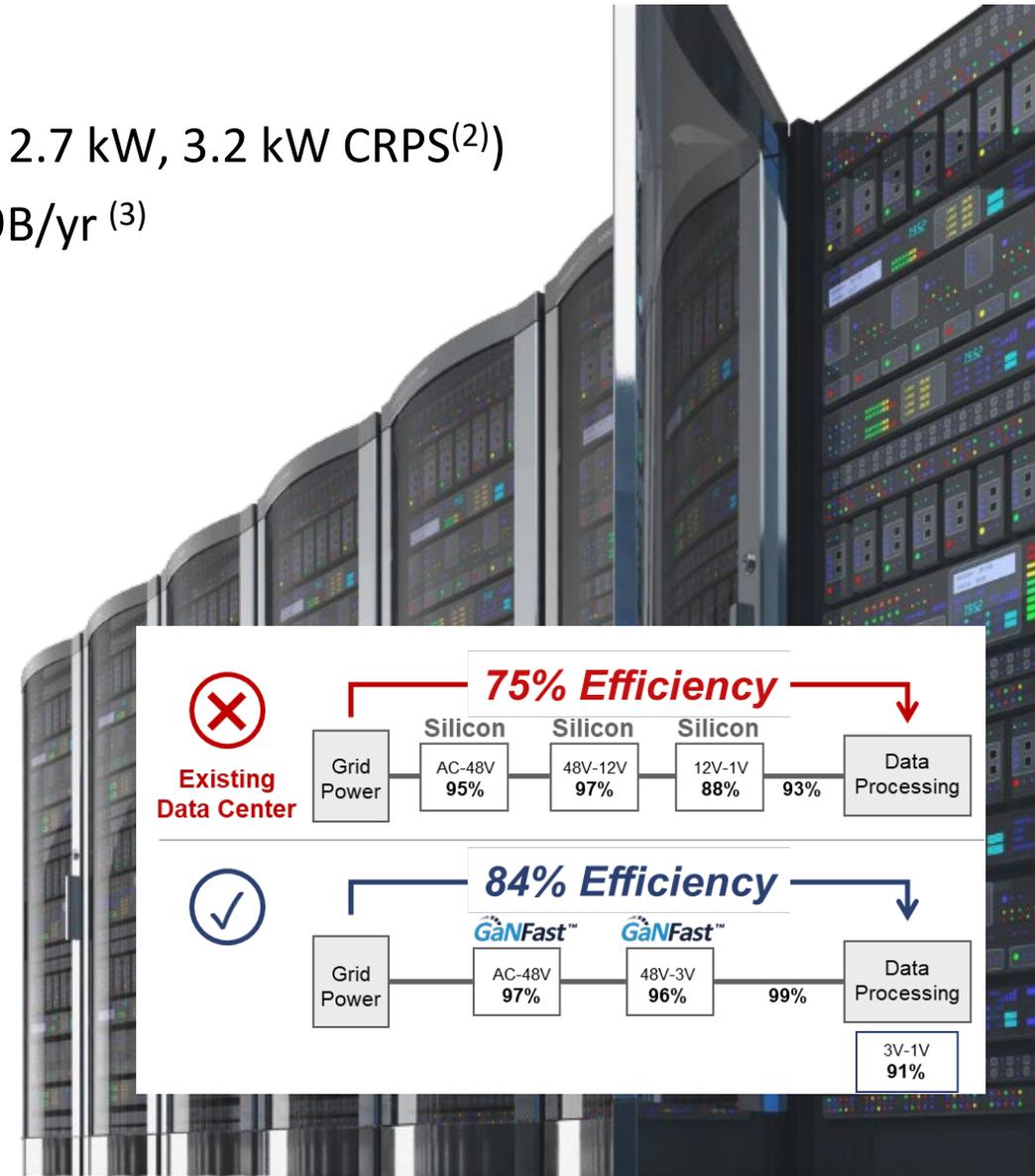
# GaNFast Exceeds “Titanium”, >2x Power Density

- Euro ‘Titanium plus’ standard from January 1<sup>st</sup>, 2023<sup>(1)</sup>
- Design Center: 4 platforms, 10 customer projects (1.3 kW, 1.6 kW, 2.7 kW, 3.2 kW CRPS<sup>(2)</sup>)
- GaN can reduce electricity use by up to 10%, save >15 TWh or \$1.9B/yr <sup>(3)</sup>

Slow Silicon AC-DC 3,200W	GaNFast AC-DC 2,700W
<p>47 kHz 325 x 107 x 41 mm 2.2 W/cc</p>	<p>300-500 kHz 185 x 73.5 x 39 mm 5.1 W/cc</p> <ul style="list-style-type: none"> <li>• &gt;2x higher power density</li> <li>• &gt;30% reduction in energy loss</li> </ul>

*“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) European Union ‘Directive 2009/125/EC, 2019 Annex’, power supplies must be >96% efficiency peak.  
 (2) CRPS = Common Redundant Power Supply standard, defined by Intel for standardized mechanical form-factors, targets hyper-converged compute, storage and networking eqpt.  
 (3) Navitas est. based on a) Navitas server/datacom forecast & AAAS data, b) \$0.12/kWhr, c) Si vs. GaN \$/W and d) data-center loading profile. 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

Up to 6.5 kV

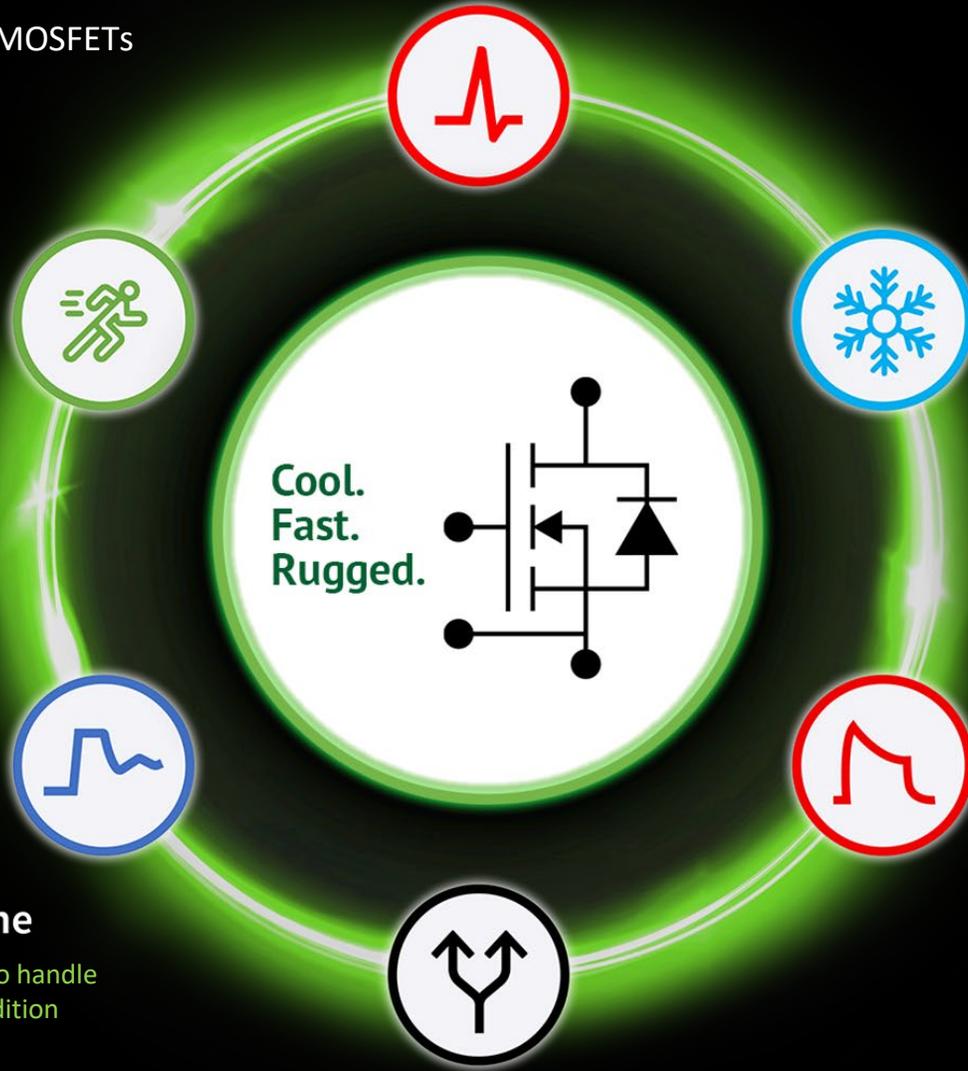
Largest range of SiC FETs & diodes  
(650 V to 6.5 kV)

## Fast Switching

Highest efficiency hard-switch, soft-switch  
(Lowest  $E_{ON}$ ,  $E_{OFF}$ ,  $E_{ZVS}$  losses)

## Cool Operation

Lowest  $R_{DS(ON)}$  at high temperature  
(25% lower than industry typical)



Cool.  
Fast.  
Rugged.

## High-Power Paralleling

Matching currents  
(Stable  $V_{TH}$ )

## 100%-Tested Robust Avalanche

Highest published capability to handle excess energy in fault condition

## Long Short-Circuit Withstand Time

World-class survival duration in fault condition



# GaN + SiC for Solar & Energy Storage



25°C cooler with GeneSiC

## Customers in Development, Production



### Market Potential (2)

- Residential Micro >\$1.4B (GaN)
  - Residential String >\$1.0B (SiC)
  - Commercial String >\$1.0B (SiC)
  - Energy Storage >\$1.25B (SiC) (50% attach rate)
- Total = >\$4.65B**

### Navitas Strength & Opportunities

- Solar up 3x 2022-2027, more capacity than natural gas by 2026, coal by 2027
- Inflation Reduction Act: >\$50B to solar, storage and wind
- Bus voltages rising to 1,500V – matches GeneSiC 3,300V capability

# Pure-Play EV: The Largest Opportunity

**>\$11B/year Opportunity<sup>(1)</sup>**  
 (On-board >\$10B/yr + Roadside >\$1B/yr)

**Customers in Production,  
 Development**

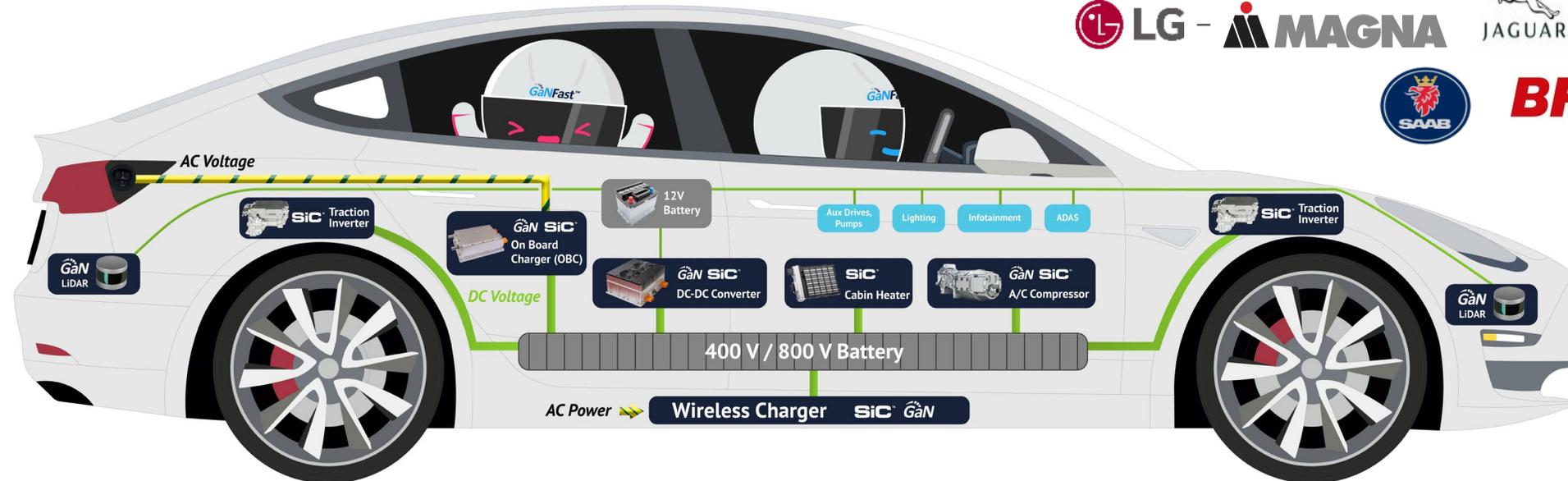
## Navitas EV System Design Center

- 5 platforms including 400V, 800V and 6.6-22 kW
- Bi-di charger (2-in-1), bi-di + DC-DC (3-in-1)
- Increasing bus voltages play to GeneSiC 3,300 V strength

## Navitas + Geely Joint EV Design Center



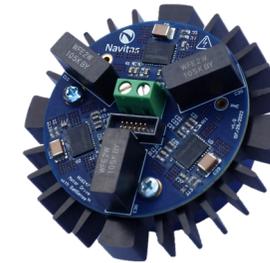
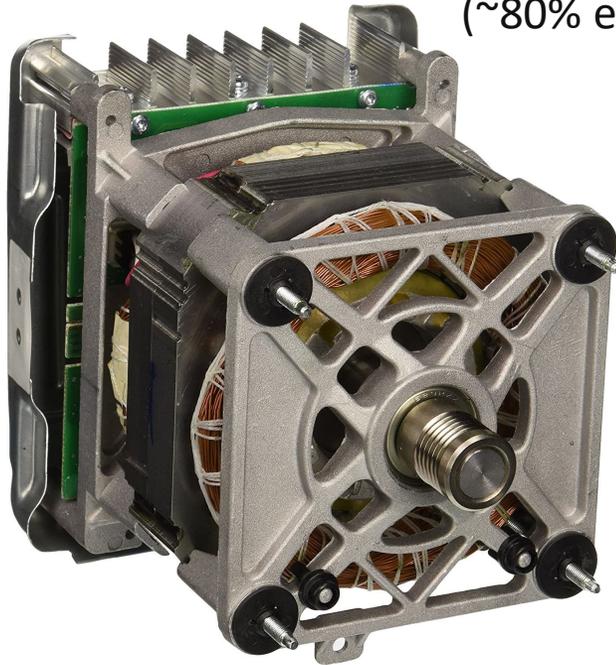
**"10-80% charge in only  
 18 minutes!"<sup>(2)</sup>**



(1) Estimate 2030, 30M EV/yr, based on DNV and Navitas analysis. Note: Assumes 150 kW traction inverter, 100 kWh battery, \$100/kWh battery cost and typical 230 mile range.

(2) Level 3 800V 350 kW DC charger 10-80% in 18 minutes for Genesis GV70 SUV

Legacy Si-Based Brush-less DC (BLDC)  
Motor & Inverter for Washing Machine  
(~80% efficiency)



Navitas 300W  
3-phase Platform  
for Inverter-Motor  
Integration

- 2x higher frequency
- >60% fewer components, PCB area
- 95-97% efficiency
- 80% energy savings vs Silicon BLDC
- 90% energy savings vs AC motors
- High reliability
- Fast time to market

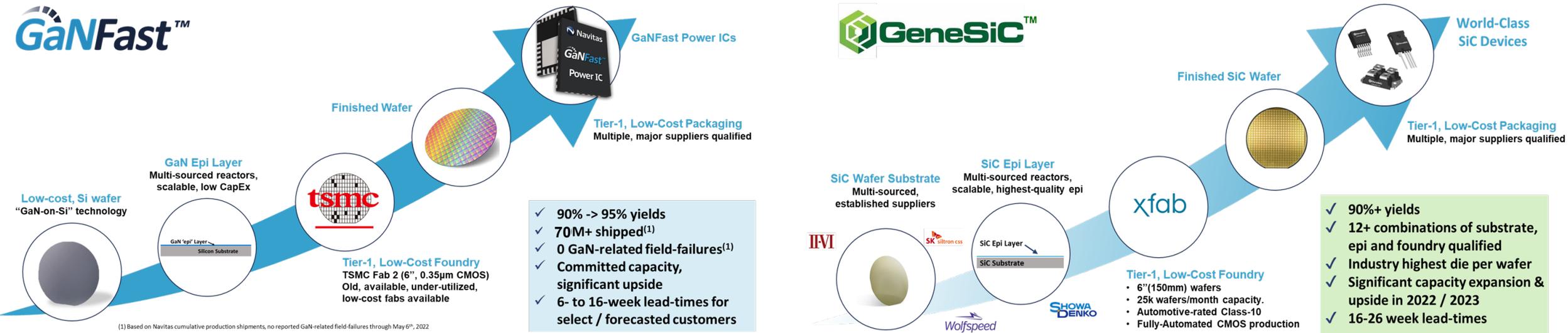
**>\$1.5B/year Opportunity for 50-300W Motors<sup>(1)</sup>**

***Inflation Reduction Act: \$9B to upgrade US home appliance efficiencies***

(1) Navitas estimate 50-300W motors, including circulators, hydronic pumps, aircon IDU/ODU fans, HVAC, air purifiers, hair dryers, refrigerator compressors, dishwashers, washing machines.



# High Capacity, 50% Shorter Lead-times<sup>(1)</sup>



- Tier-1 foundry partners, excellent manufacturing support
- High yields, low costs, flexible supply chains
- Long-term capacity agreements: GaN up 3x, SiC up 5x starting in 2023
- 50% shorter lead-times than industry typical

1) Industry lead-times per Jefferies Equity Research, August '22  
© Navitas Semiconductor 2023



**75,000,000  
Shipped**

*Electrify Our World™*



**Navitas**

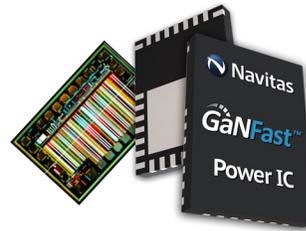
*Let's go GaNFast™*

# Leader in Sustainability: 150,000+ tons CO<sub>2</sub> Saved! <sup>(1)</sup>



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

Every **GaNFast™** IC  
saves  
**4 kg CO<sub>2</sub>**



**4x-10x** lower component CO<sub>2</sub> footprint than silicon

**28% lower** lifetime CO<sub>2</sub> 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

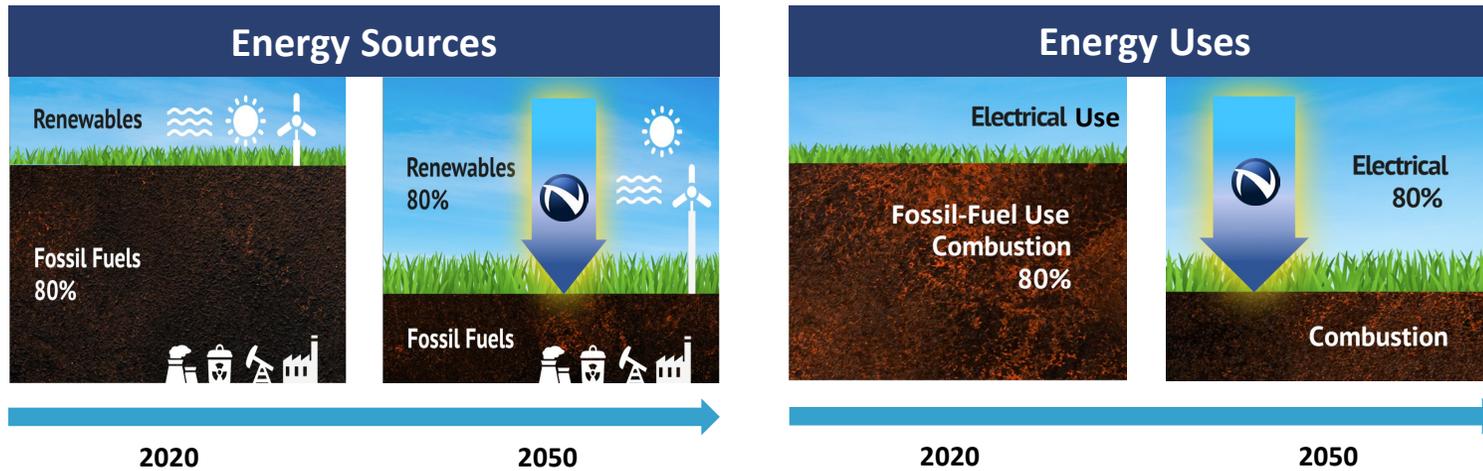


August '22 First 100,000 tons CO<sub>2</sub> saved

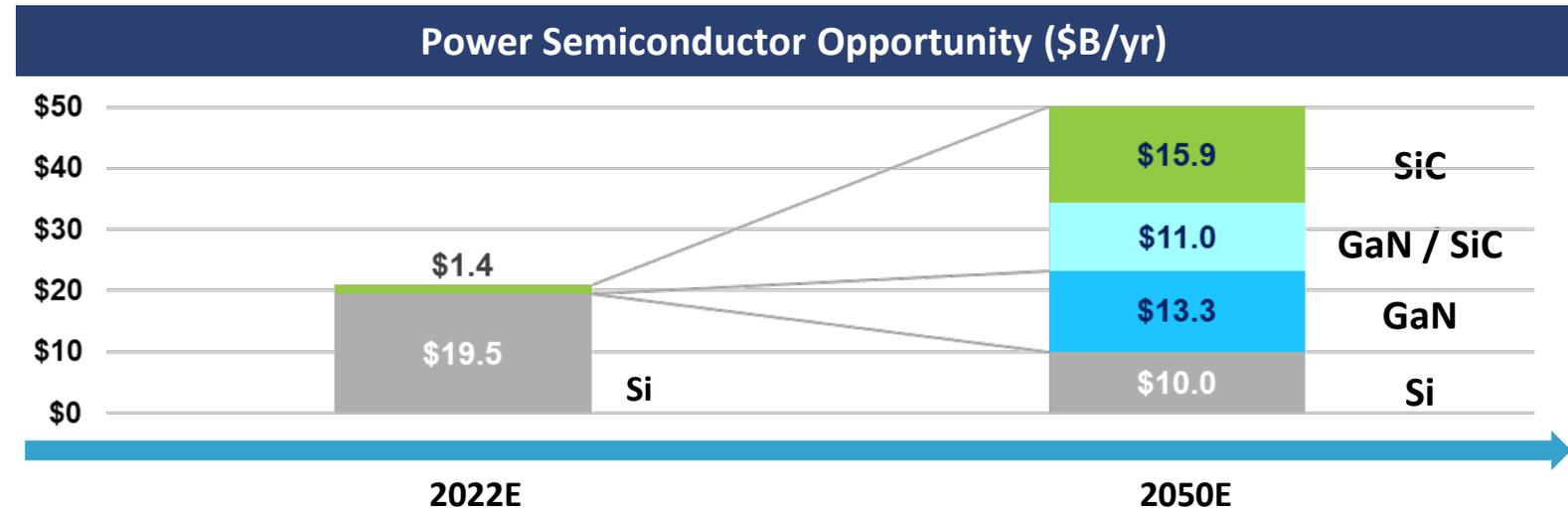


October '22 Recognized for industry-leading sustainability reporting

## Energy sources and uses are being electrified...



...creating a **\$40B GaN + SiC opportunity by 2050**



Fossil-fuel vs renewable ratios adapted from IRENA 2020 "Global Renewables Outlook".  
Shift required to meet "Transforming Energy Scenario, 9.5 Gton target in 2050", per Paris Agreement's 1.5°C rise.  
Market opportunity \$ from Yole Développement, 2020 and Navitas analysis.



**Pure-Play, High-Speed  
GaNFast and GeneSiC:  
The Leading Edge of Next-Gen Power Semiconductors**



**Stephen Oliver**  
**VP Corp. Mktg. & IR**

**Navitas**  
*Energy • Efficiency • Sustainability*

Navitas  
GaNFast™  
Power IC

Navitas  
GeneSiC™  
Power