



2022中国电力电子与能量转换大会  
暨中国电源学会第二十五届学术年会及展览会  
2022 China Power Electronics and Energy Conversion Congress  
& The 25th China Power Supply Society Conference and Exhibition

**“Pure-Play,  
Next-Generation  
Power Semiconductors**

**Electrify Our World™”**

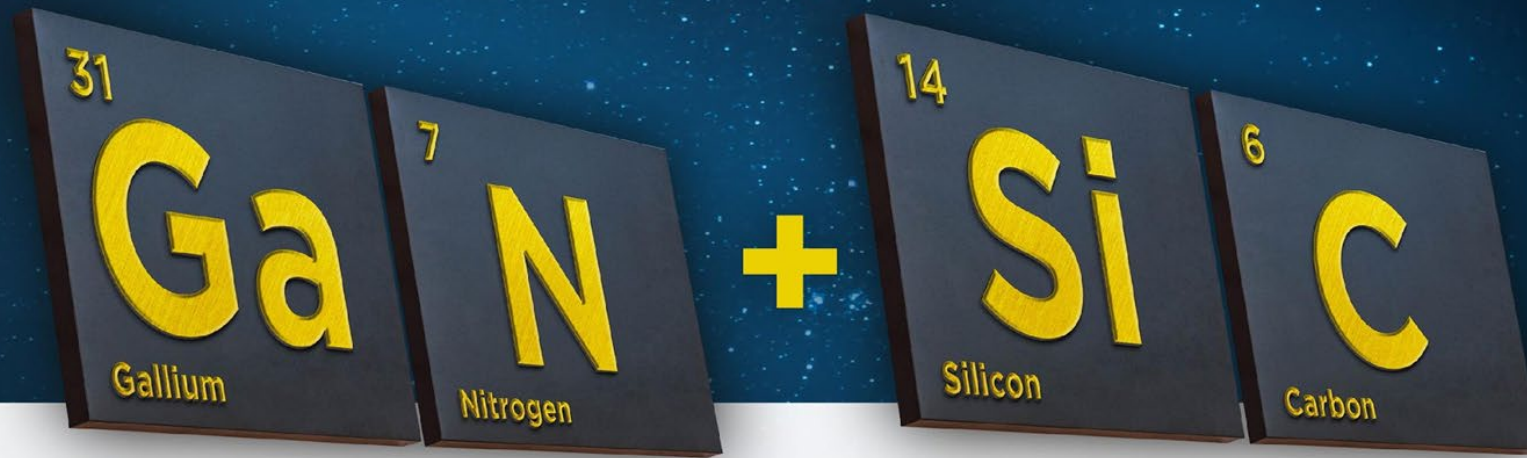
**Charles (Yinjie) Zha 查莹杰**  
**VP, GM Navitas Semiconductor China**



# Navitas

**Energy • Efficiency • Sustainability**

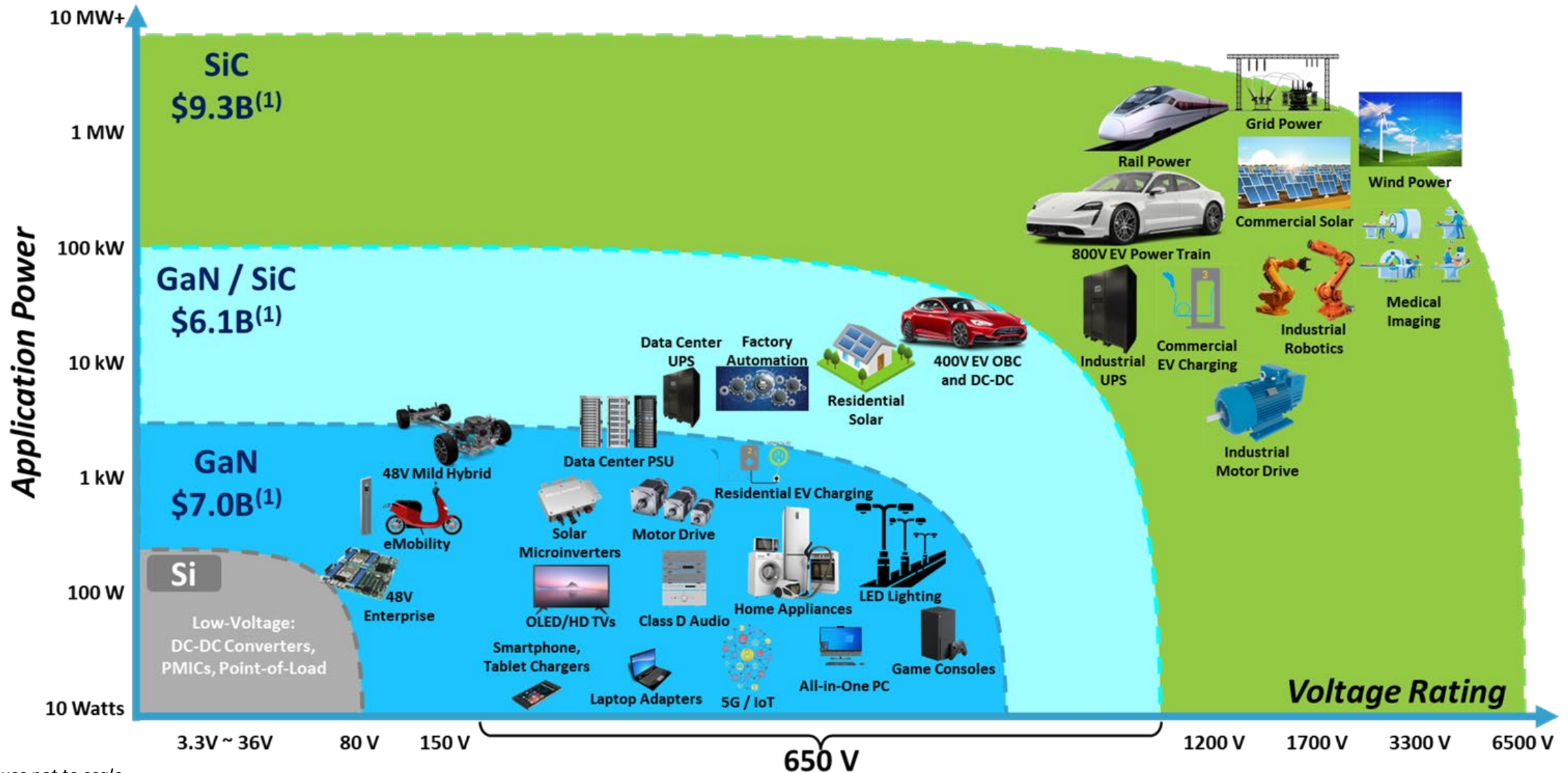




## *Pure-Play Next-Gen Power Semiconductors*

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.

# Industry's First Next-Gen Power Semi Player



Up To <b>20x</b> Faster Switching	Up To <b>3x</b> Smaller & Lighter	Up To <b>40%</b> Energy Saving	Up To <b>3x</b> Higher Power Density	Up To <b>3x</b> Faster Charging	Up To <b>20%</b> Lower System Cost
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Note: Navitas estimate of GaN- & SiC-based power systems compared to silicon in the 2024-2025 timeframe.

# The GaN Revolution: Ultimate Integration

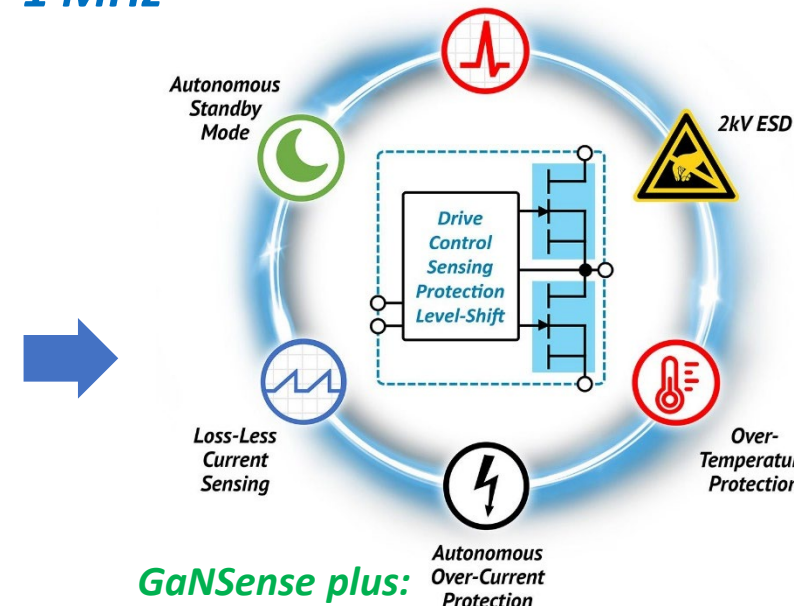
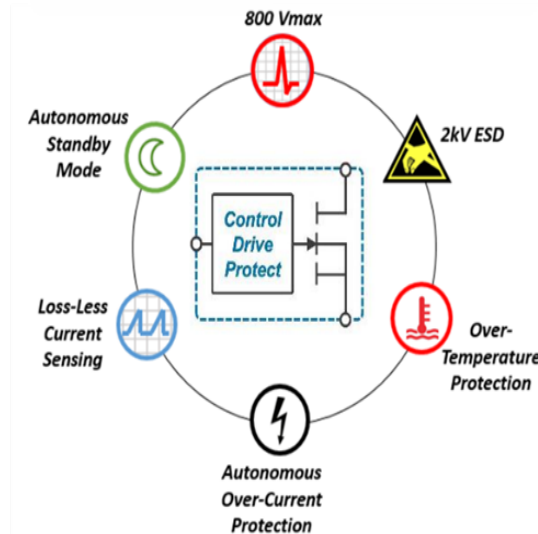
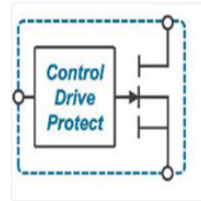
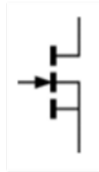
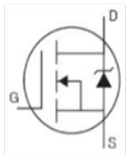
Si MOSFET

Discrete GaN

**GaNFast™**  
200-300 kHz

**GaNSense™**  
500 kHz

**GaNSense Half-Bridge**  
1 MHz



- Old, slow
- High  $Q_g$
- High  $C_{oss}$
- $F_{sw} < 100kHz$

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

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

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

- 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



# High Volume, High Quality



May 2022



March 2022

***October 2022: Over 60,000,000 GaNFast shipped:  
Zero reported GaN-related field failures<sup>(1)</sup>***

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)

## 100%-Tested Robust Avalanche

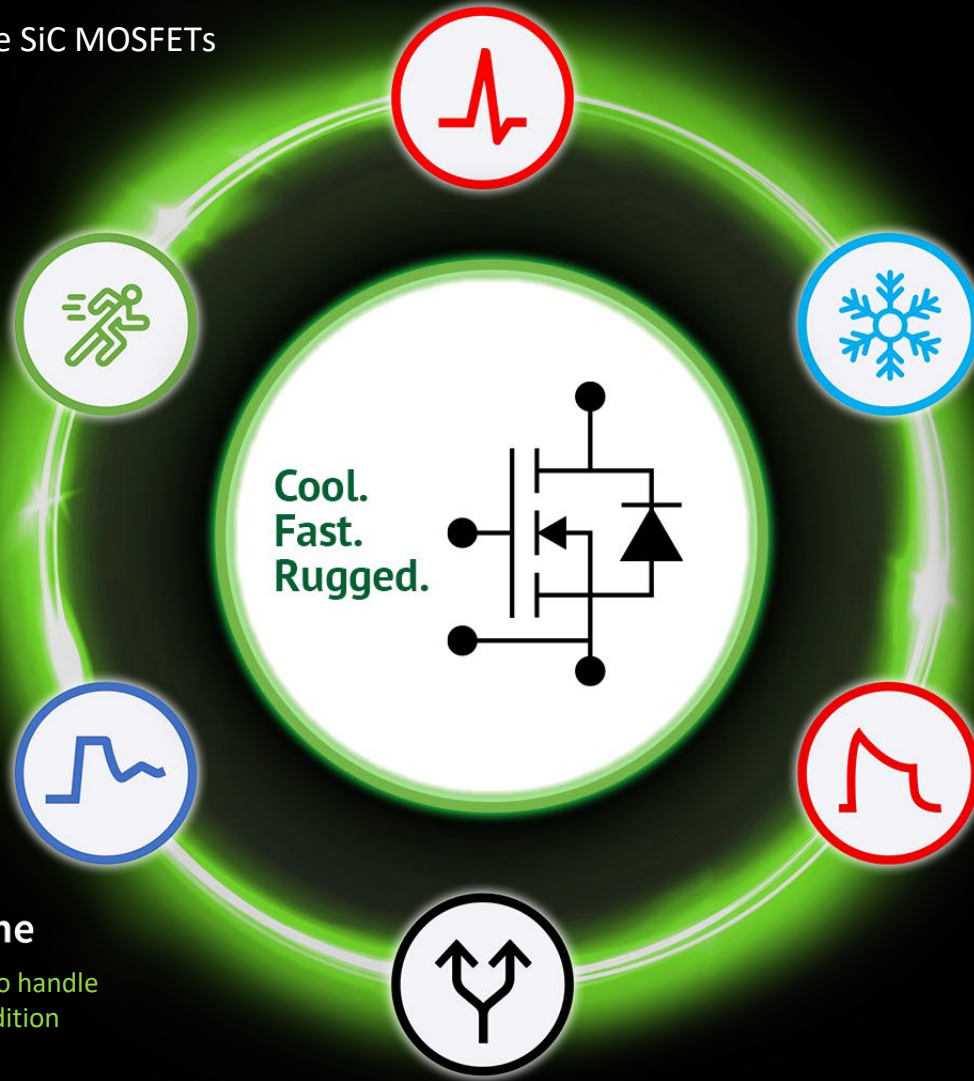
Highest published capability to handle excess energy in fault condition

## Long Short-Circuit Withstand Time

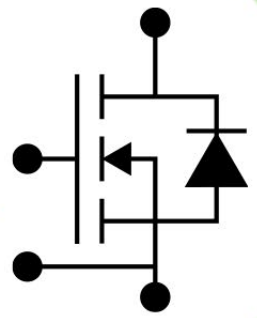
World-class survival duration in fault condition

## High-Power Paralleling

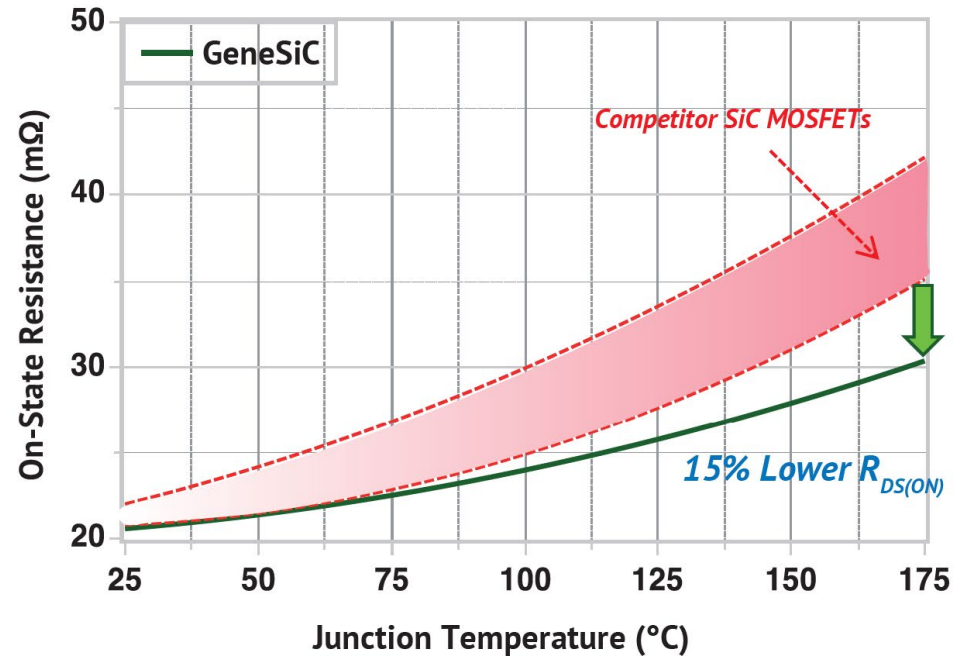
Matching currents  
(Stable  $V_{TH}$ )



Cool.  
Fast.  
Rugged.

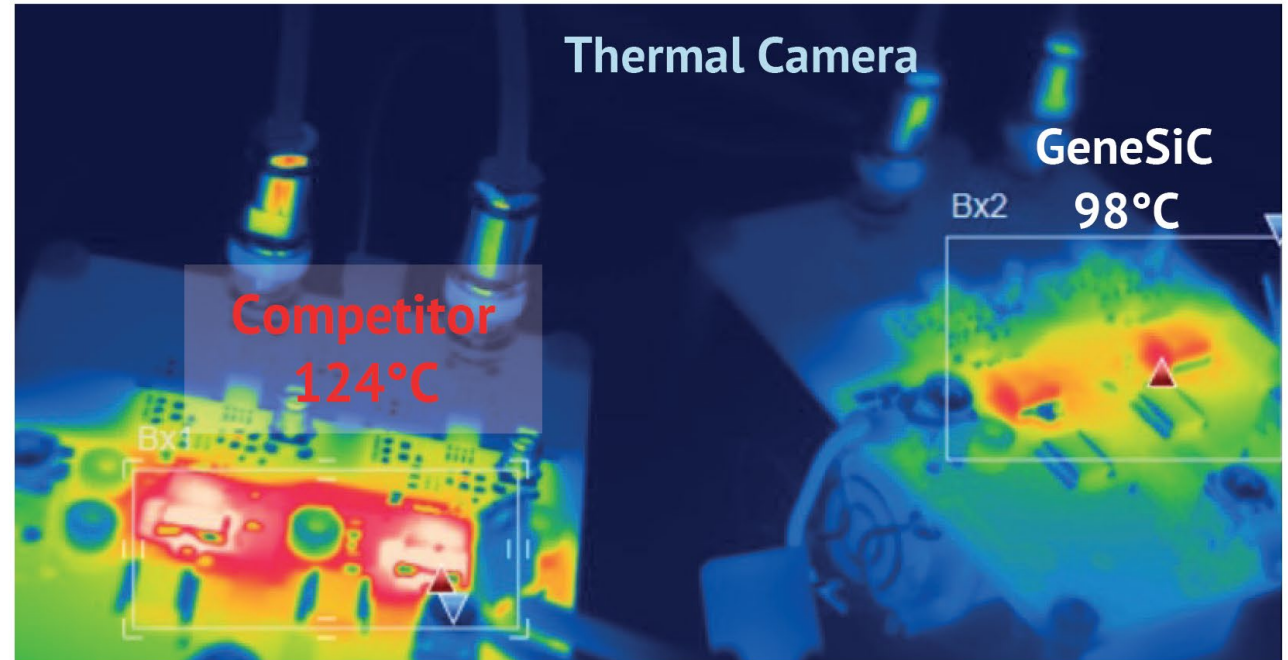


$$R_{DS(ON)} \text{ v/s } T_j$$



- **GeneSiC vs. competitor SiC FET**
  - » 1200 V, 20 mΩ, TO-247-4L
  - » Higher drain current
  - » Lower conduction losses
  - » Cooler operation

## In-Circuit, High-Speed Test



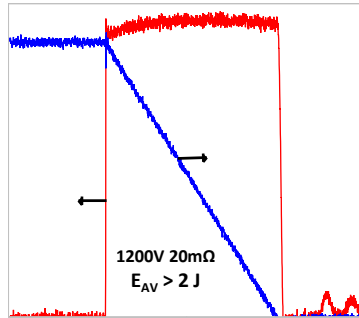
- **GeneSiC vs. competitor SiC FET**
  - » 1200 V, 40 mΩ, D2pak in half-bridge
  - » 150 kHz switching = ~10x faster than Si IGBT
  - » 30% lower FET loss vs. other SiC
  - » 25°C cooler operation = 3x longer lifetime



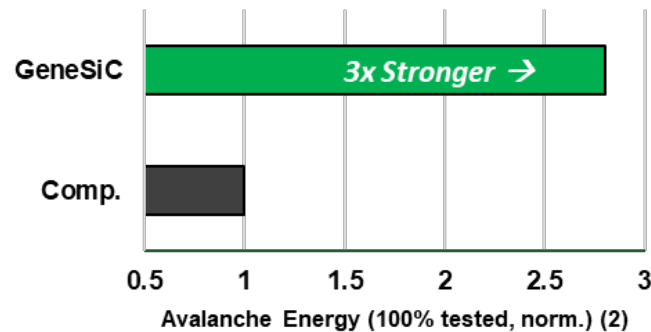
# High Quality, High Reliability

## 100%-Tested Avalanche

Highest published capability to handle excess energy in fault condition

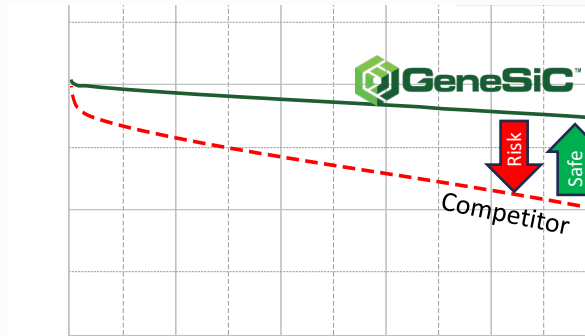


Critical in applications like motor drives to withstand unclamped inductive load (UIL) energy dump in situations like motor open-circuit (O.C.)



## High Power Paralleling

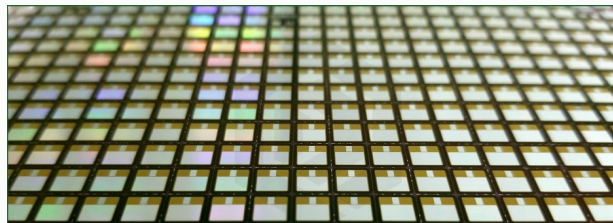
Matching currents  
(Stable  $V_{TH}$ )



@ 175°C

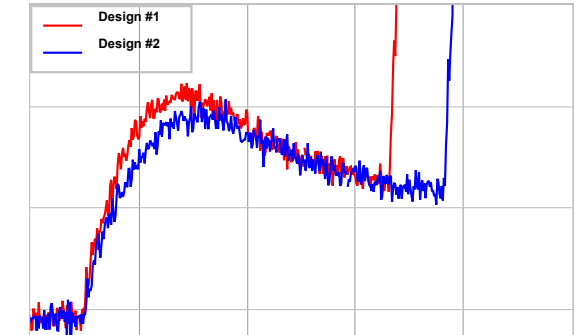
Competitor products allow threshold voltage to drop under high voltage, creating risk of turn-on error

GeneSiC packaged and bare-die FETs can be paralleled reliably for high-power applications

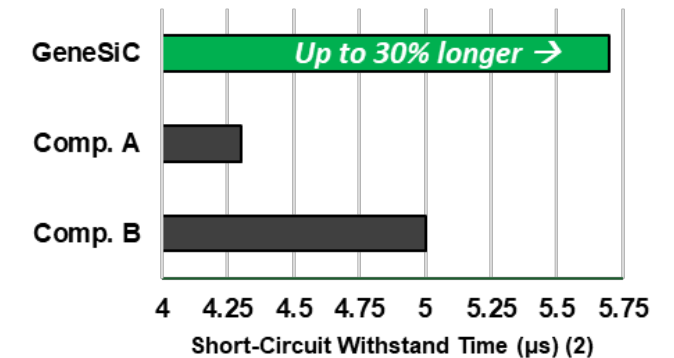


## Long Short-Circuit Withstand Time

World-class survival duration  
in fault condition



Critical to prevent failures like motor short circuit where the FET faces full voltage ( $V_{DD}$ ) in ON-state.

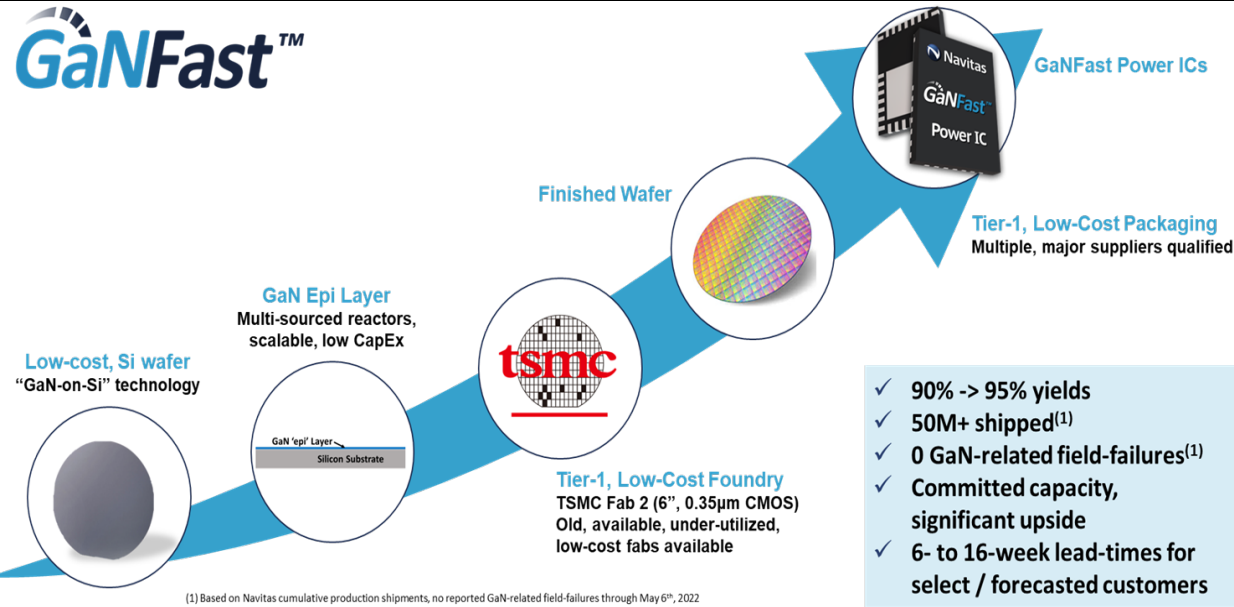


# Zero reported GeneSiC-related field failures!

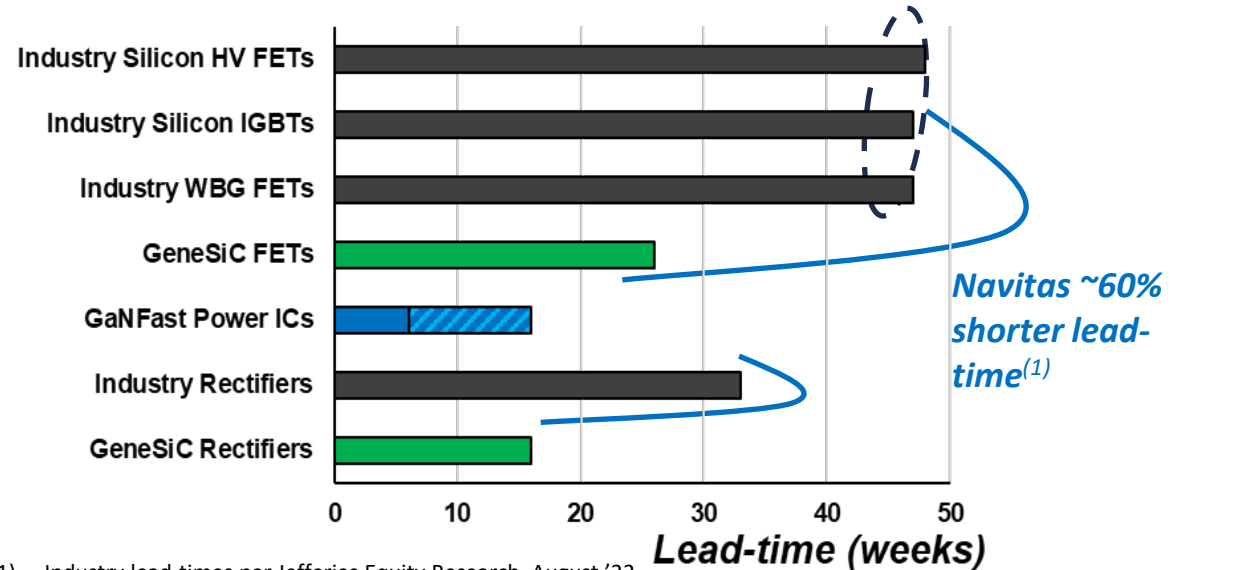
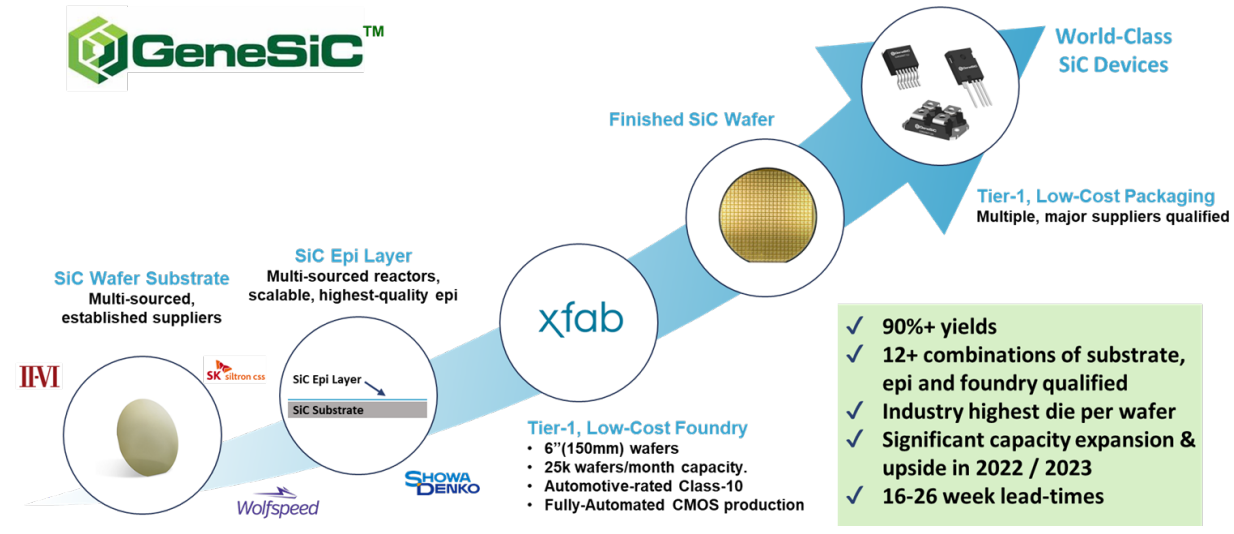
1) As of September '23, per GeneSiC records  
2) 1,200 V, 20 mΩ FET  
© Navitas Semiconductor

# High Capacity, 60% Shorter Lead-times

**GaNFast™**



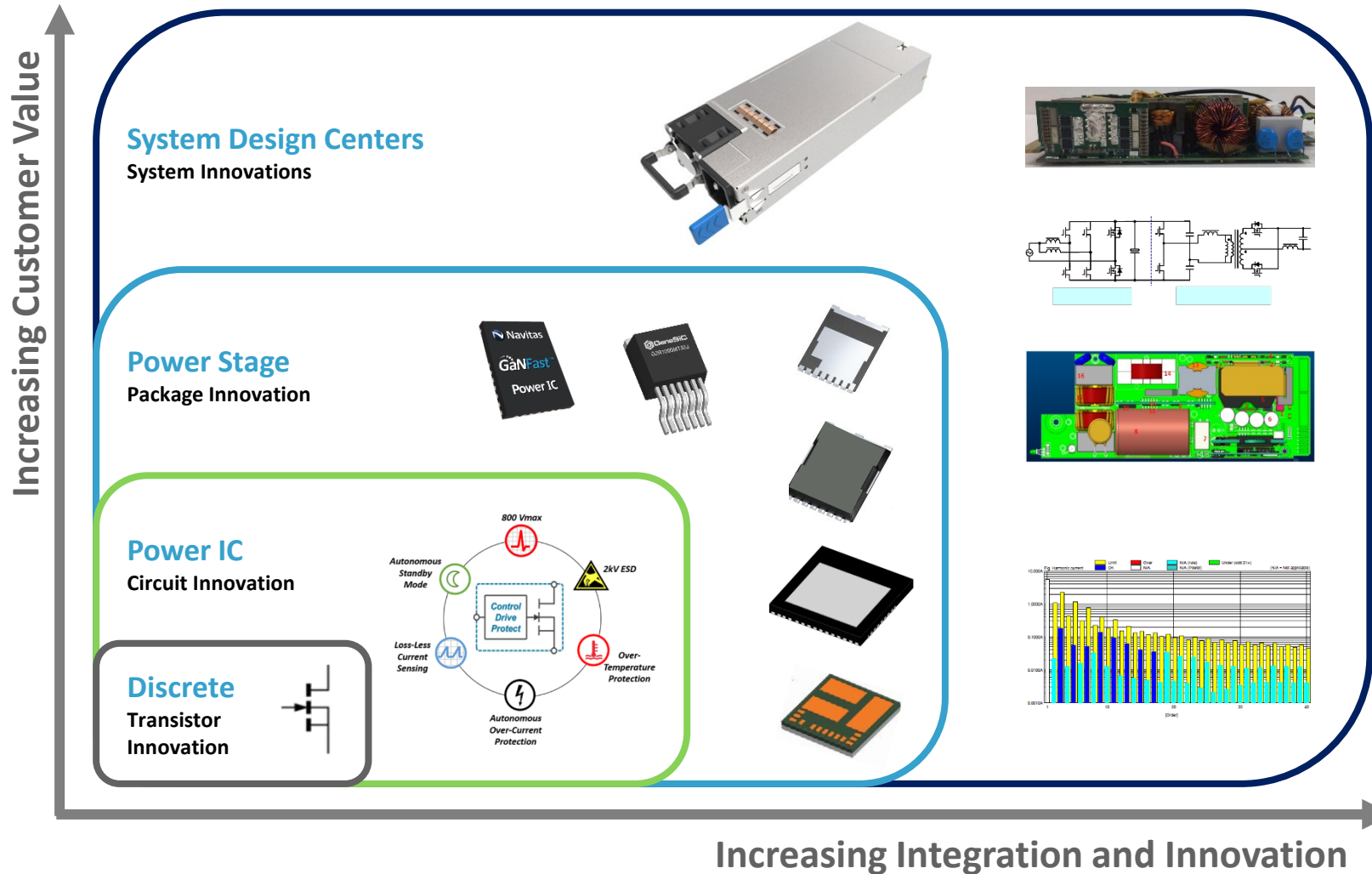
**GeneSiC™**



- Immediate availability for 1k prototyping
- GaNFast: Power ICs at 6-16 weeks today  
Committed 3x capacity in 2023
- GeneSiC: Rectifiers at 16 weeks  
FETs at 26 weeks  
Committed 5x capacity in 2023

1) Industry lead-times per Jefferies Equity Research, August '22  
2) Majority of parts available immediately from stock. Production lead-times, capacity as of September 2022 © Navitas Semiconductor 2022

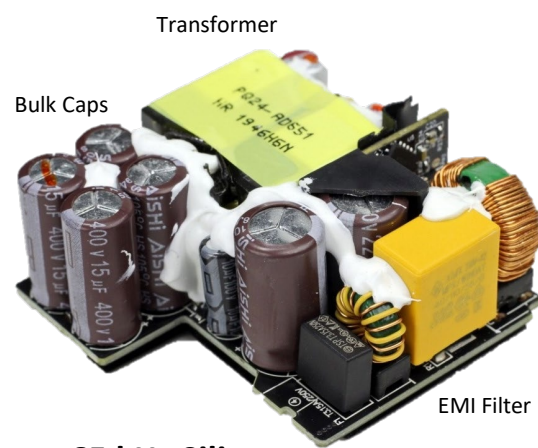
# Unique System Design Center Strategy



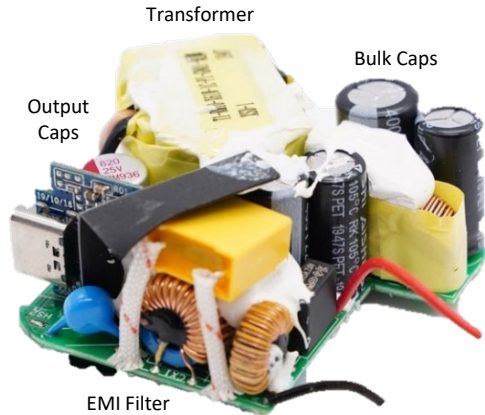
- Assist customers to adopt next-gen GaN and SiC
  - Circuit design
  - High-frequency magnetics
  - Thermal design
  - Advanced packaging / modules
- Advanced performance
  - Higher power density
  - Higher efficiency
  - Lower system cost
- Business advantages
  - Faster time-to-market
  - Maximum 'first-time-right' designs

# Shenzhen: Mobile Fast Charging

Typically, slow-speed designs have ~70% of volume used by transformer, capacitors, EMI filter, etc.

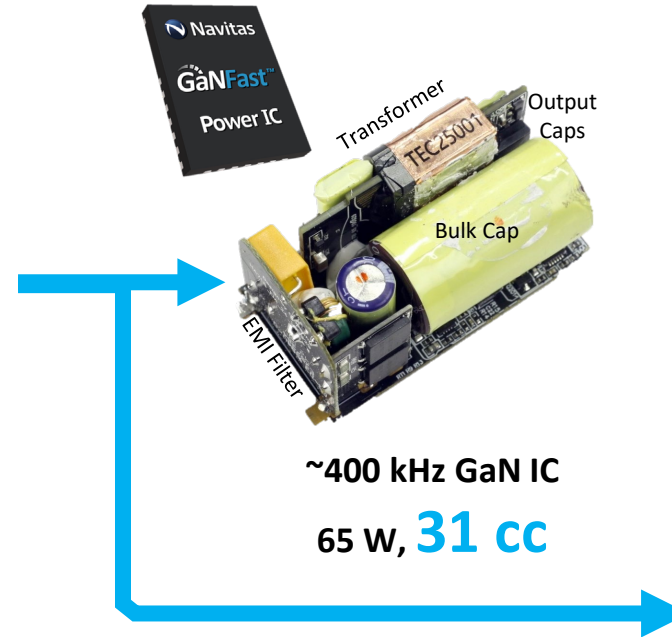


~65 kHz Silicon  
65 W 43 cc



~75 kHz GaN Discrete / MCM  
65 W, 46 cc

High-speed GaN IC designs **shrink** 'passive' components by ~50%<sup>(1)</sup>



~400 kHz GaN IC  
65 W, **31 cc**

Half-Bridge IC delivers ~2x the power, or ~2x faster charging in the **same size**<sup>(1)</sup>



~750 kHz peak Half-Bridge GaN IC  
**120 W, 44 cc**

**~2x faster charging!**



# 100% Tier 1 Mobile OEMs Adopting Navitas



## Tier 1 OEMs



## Aftermarket Examples



225+

GaN Chargers  
Mass Production<sup>(1)</sup>

290+

GaN Chargers  
In Development<sup>(1)</sup>

100%

Mobile OEMs Designing With  
Navitas GaN ICs

60M+

GaN ICs Shipped<sup>(2)</sup>

Zero

GaN Field Failures<sup>(2)</sup>

(1) As of June 30<sup>th</sup>, 2022. (2) Based on Navitas shipment data and no customer-reported consumer failures for production shipments through October 2022.

# Hangzhou: Data Center

European Data Center power supplies must meet **'Titanium'** efficiency (>96% peak) from Jan 1<sup>st</sup>, 2023<sup>(1)</sup>

Design Center: 4 platforms, 8 customer projects: 1.3 kW, 1.6 kW, 2.7 kW, 3.2 kW CRPS

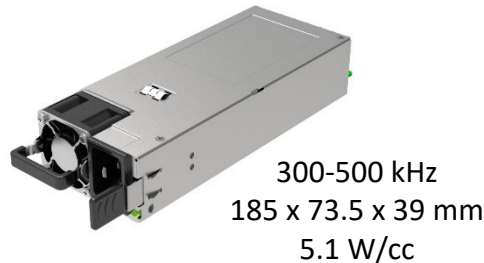
GaN ICs can reduce electricity use by up to 10%, save >15 TWh or \$1.9B in annual electricity costs<sup>(2)</sup>

## Silicon AC-DC 3,200W



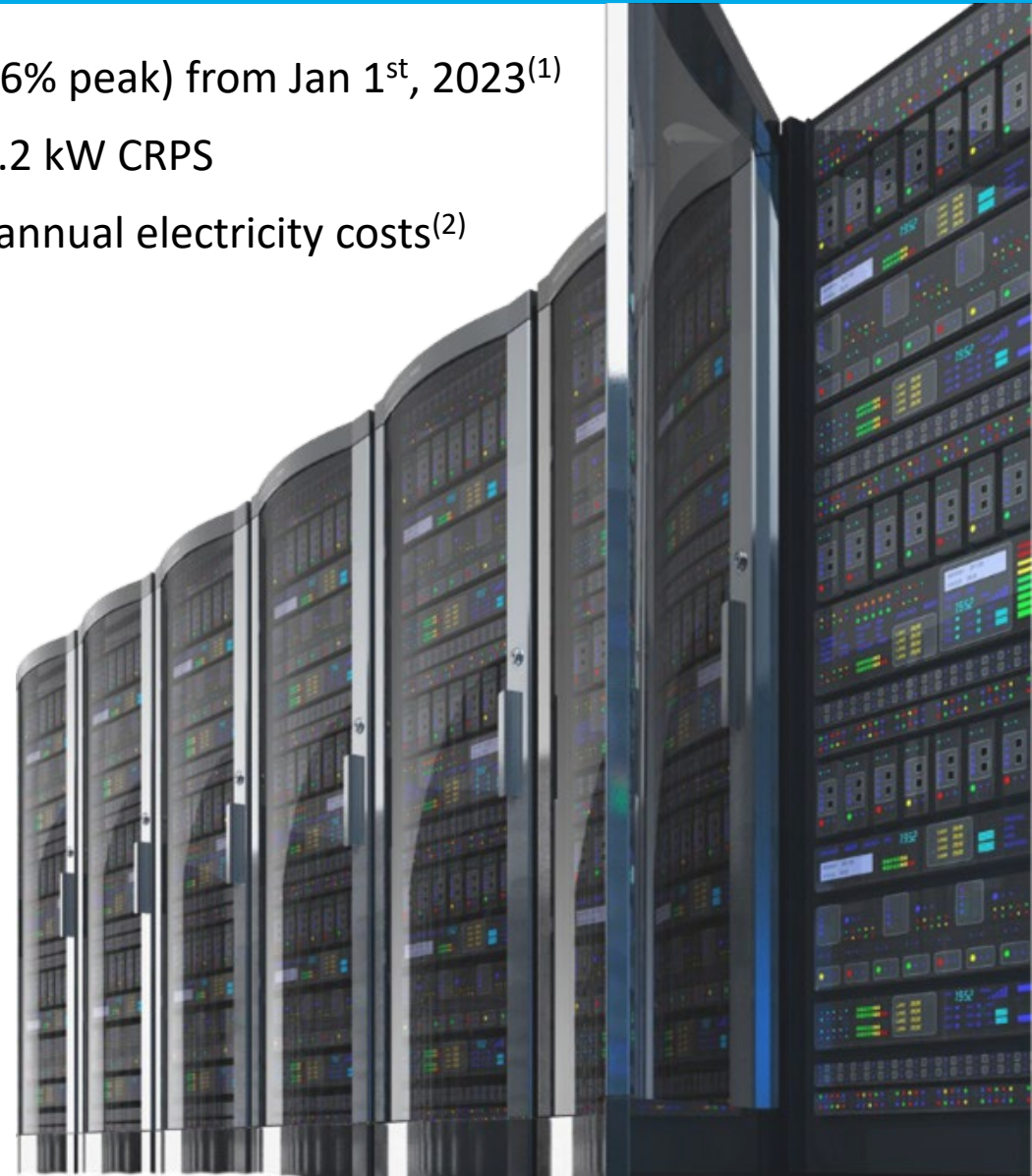
## GaNFast AC-DC 2,700W

- >2x higher power density
- >30% reduction in energy loss

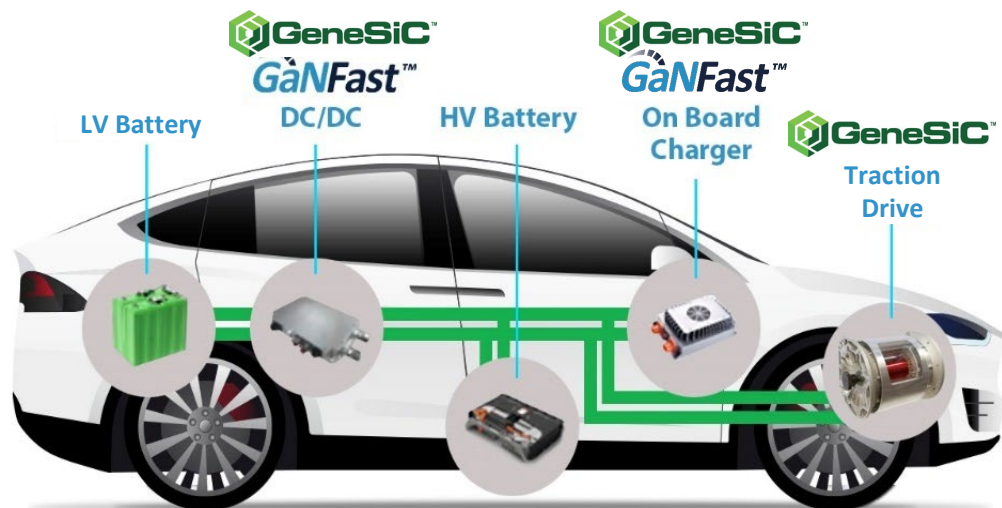


***"GaN is a breakthrough new technology that is enabling dramatic reductions in size, energy savings and power density"***  
***"Navitas is an excellent partner with industry-leading GaN ICs"***

Robin Cheng, VP R&D



(1) European Union 'Directive 2009/125/EC, 2019 Annex', power supplies must be >96% efficiency peak.  
(2) 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



## Dedicated EV System Design Center

- 3 platforms
  - 400V 6.6 kW W bi-directional charger (2-in-1)
  - 800V 6.6 kW bi-directional charger and DC-DC (3-in-1)
  - 22 kW wall charger to 400V, 800V

## Synergistic & Engaged Customers

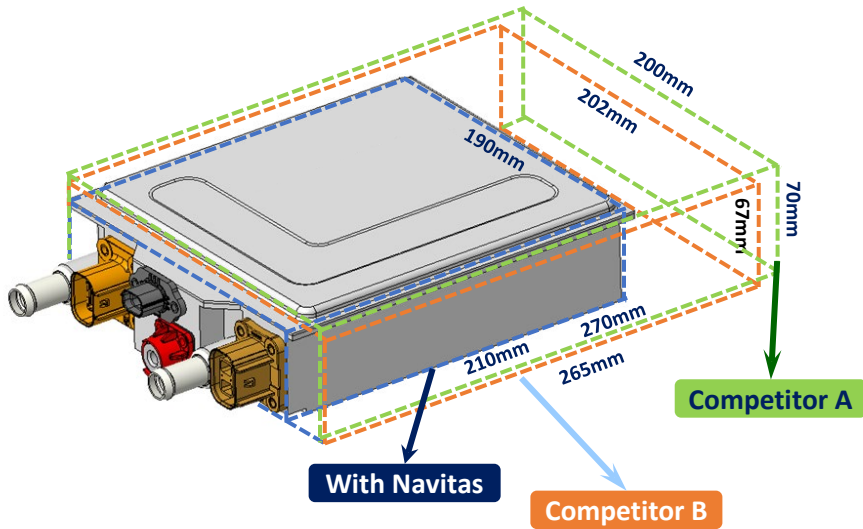


## \$12B/yr Potential for GaN/SiC by 2030<sup>(1)</sup>

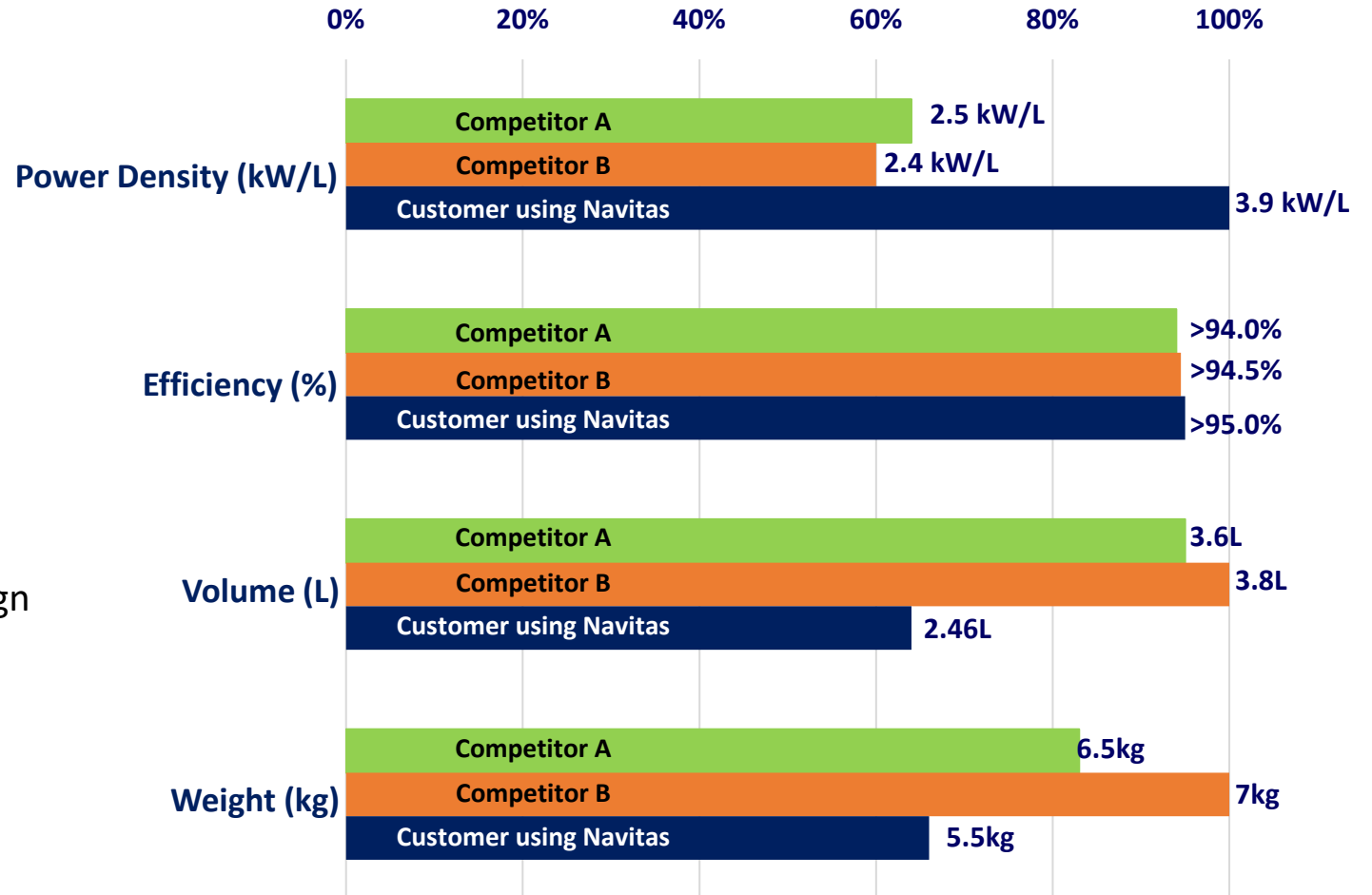
- ✓ OBC > \$38
- ✓ DC-DC > \$12
- ✓ Traction drive > \$286
- **Total:** > \$330 per EV = \$10.1B
- ...and > \$1.9B in road-side chargers

Note: Assumes 150 kW traction inverter, 100 kWh battery, \$100/kWh battery cost and typical 230 mile range. (1) Estimate 2030, 30M EV/yr, based on DNV and Navitas analysis (2) Based on BCG Research, Yole Research and Navitas analysis.

# System Design Center Accelerates Customer Revenue

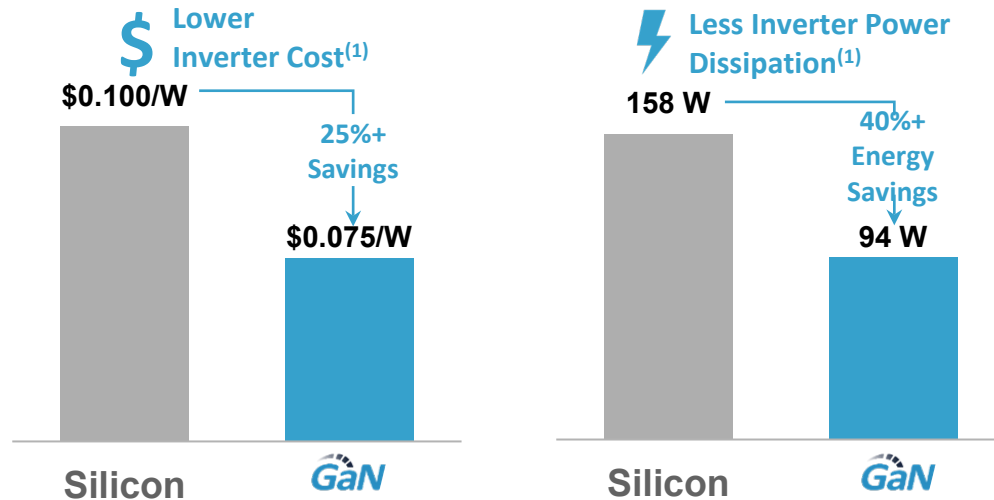


- Navitas' Shanghai EV System Design Center:
  - Optimized Magnetic designs, higher  $F_{SW}$
  - Optimized system and component thermal design
- Achieves:
  - Higher efficiency -
  - Higher power density
  - Lower weight
  - ***Faster time-to-market***





# GaN + SiC for Solar & Energy Storage



(1) EnergySage Solar Marketplace, 2020.



## Synergistic & Engaged Customers



## Market Potential for GaN/SiC<sup>(2)</sup>

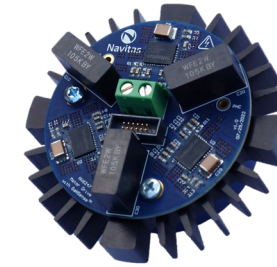
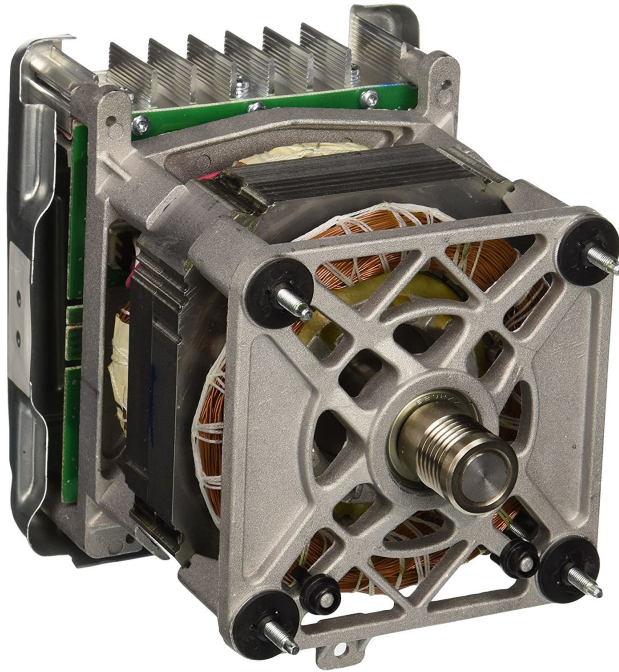
- 5-10kW Residential >\$1.40B
- 1kW residential (micro) >\$1.00B
- Energy Storage >\$1.25B (50% attach rate)
- Commercial (string) >\$1.00B
- >\$4.65B

(1) Navitas est. 6.2 kW residential installation with silicon inverter at 97.5%, GaN at 98.5% efficiency.  
 (2) Market estimates for 2030, based on DNV and Navitas analysis

# 50-300W Motors = \$1.5B/yr GaN Opportunity<sup>(1)</sup> Navitas



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



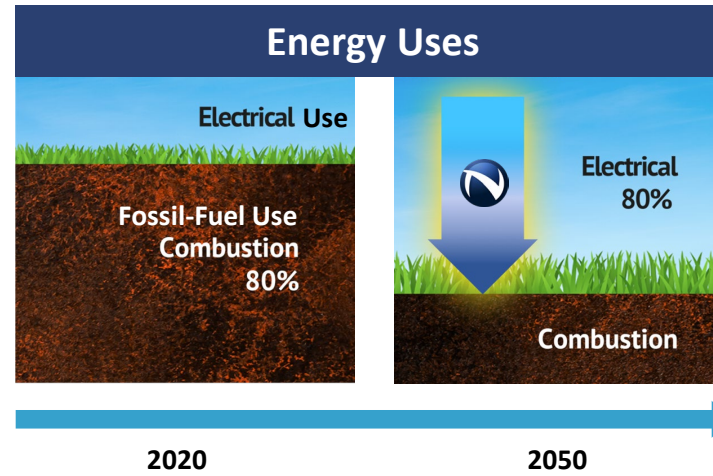
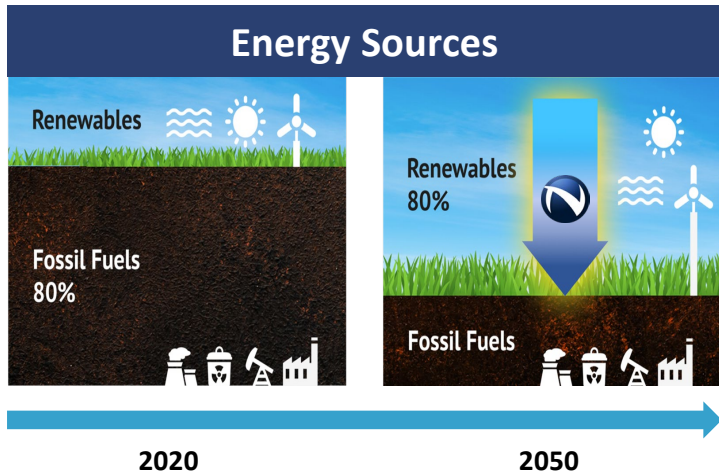
Navitas 300W 3-phase Platform  
for Inverter-Motor Integration

- **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**

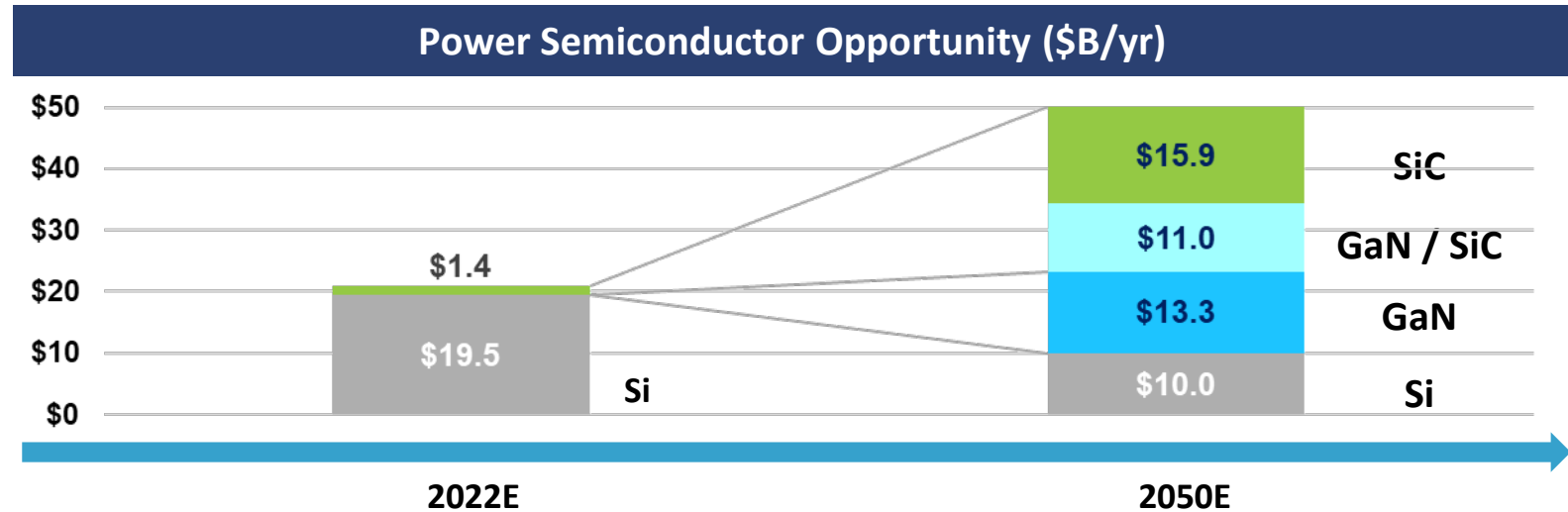
(1) Navitas estimate 50-300W motors, including circulators, hydronic pumps, aircon IDU/ODU fans, HVAC, air purifiers, hair dryers, refrigerator compressors, dishwashers, washing machines.

# Mission: Electrify Our World™

Energy sources and uses are being electrified...



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



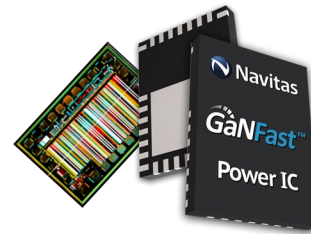
Fossil-fuel vs renewable ratios adapted from IRENA 2020 "Global Renewables Outlook".  
 Shift required to meet "Transforming Energy Scenario, 9.5 Gton target in 2050", per Paris Agreement's 1.5°C rise.  
 Market opportunity \$ from Yole Développement, 2020 and Navitas analysis.

# Leader in Sustainability



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

Every **GaNFast™ IC** saves<sup>(3)</sup>  
**4 kg CO<sub>2</sub>**



**4x-10x** lower component CO<sub>2</sub> footprint than silicon<sup>(1)</sup>

**28% lower** lifetime CO<sub>2</sub> footprint for chargers / adapters<sup>(2)</sup>

**Accelerates** transition from ICE to EV by **3 years**, saving **20%/yr** of road-sector emissions by 2050 <sup>(4)</sup>

GaN saves up to **2.6 Gton / year** by 2050<sup>(5)</sup>



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



CPEEC · CPSSC  
2022

2022中国电力电子与能量转换大会  
暨中国电源学会第二十五届学术年会及展览会  
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“全面专注下一代功率半导体，  
共同 Electrify Our World™”

欢迎扫码，关注纳微



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# Navitas

Energy • Efficiency • Sustainability

