Enabling superior system cost and reliability in Consumer and Industrial markets

PE INTERNATIONAL CONFERENCE
ANGELTECH

Navitas
Energy • Efficiency • Sustainability

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Navitas

- Navitas Semiconductor
- Performance implications of GaN power ICs
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- Application example: High density mobile phone charger
- Application example: High performance motor drive
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- Conclusion

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

Navitas Fundamentals[(1)]

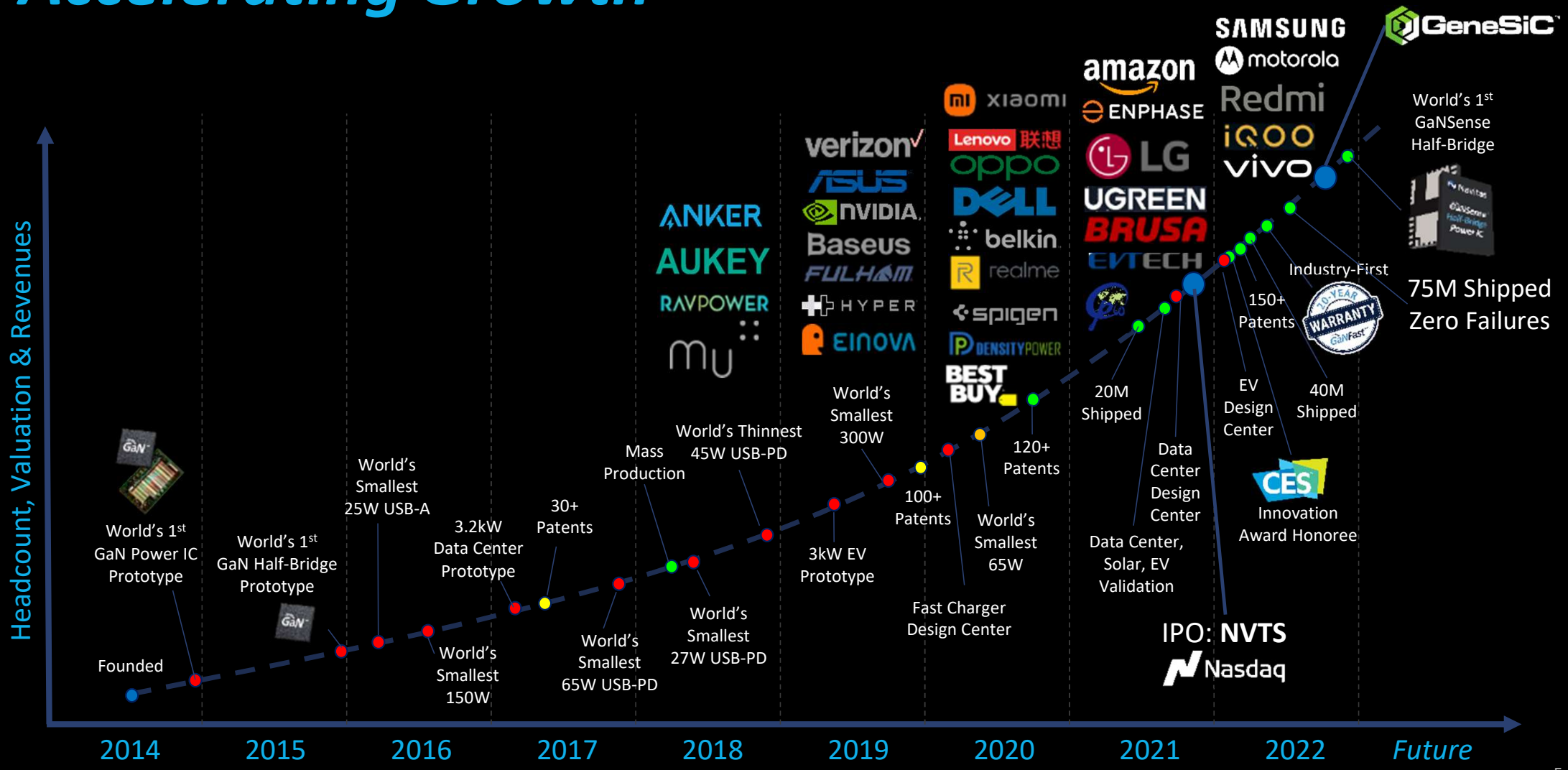
- Industry's only pure-play next-gen power semi company, $23B/yr market
  - Founded 2014, 220+ employees
  - Nasdaq: NVTS (IPO October 2021)
- Leading power GaN IC and power SiC technology, 185+ patents
  - >75M GaN, >9M SiC Shipped
  - 3x (GaN), 5x (SiC) capacity expansion starting in 2023
  - Major diversification in markets, regions
- Mission to Electrify Our World™
  - Industry leader in mobile fast, ultra-fast chargers
  - Market expansion on track / accelerated into data center, solar, EV

CERTIFIED CARBON NEUTRAL company
CarbonNeutral.com

20-YEAR WARRANTY GaNFast™

(1) See Navitas New York Investor Meeting September 13th, 2022, and Navitas' Q3'22 earnings November 9th, 2022, for details

Accelerating Growth



Benefits of Integration – what is a GaN power IC?

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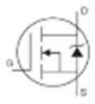
Silicon FET

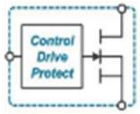


- Old, slow
- High Q_g
- High C_{OSS}
- F_{SW} < 100 kHz

Discrete GaN

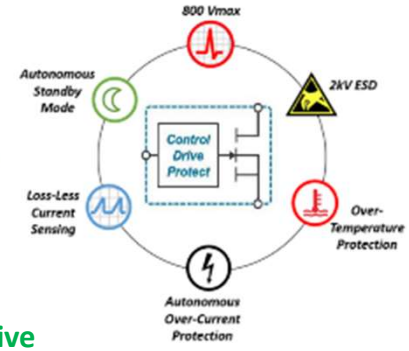
- Exposed gate
- External gate drive
- dV/dt sensitivity
- Layout sensitivity
- ESD sensitivity
- Unknown reliability
- Unknown robustness

GaNFast™



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

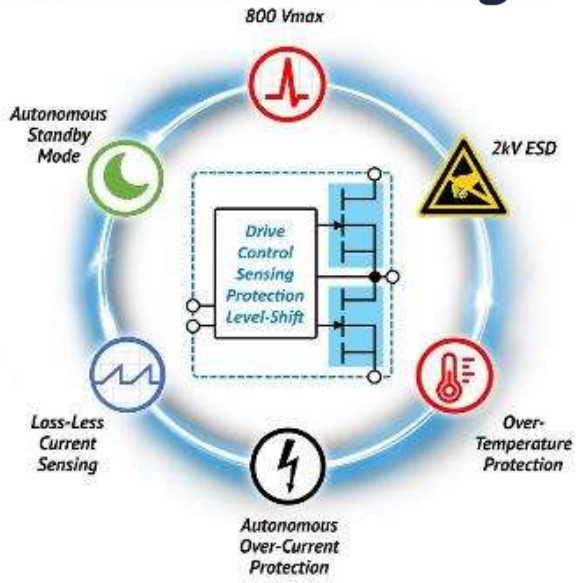
GaNSense™



GaNFast plus:

- ✓ Autonomous Standby
- ✓ Autonomous Protection
- ✓ Loss-less Current Sensing
- ✓ High Precision
- ✓ High Efficiency

GaNSense Half-Bridge



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

6

Leader in Sustainability

Navitas

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

Every GaNFast™ IC saves(3)

4 kg CO_2

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

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

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

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

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

August '22 First 100,000 tons CO_2 saved

October '22 Recognized for industry-leading sustainability reporting

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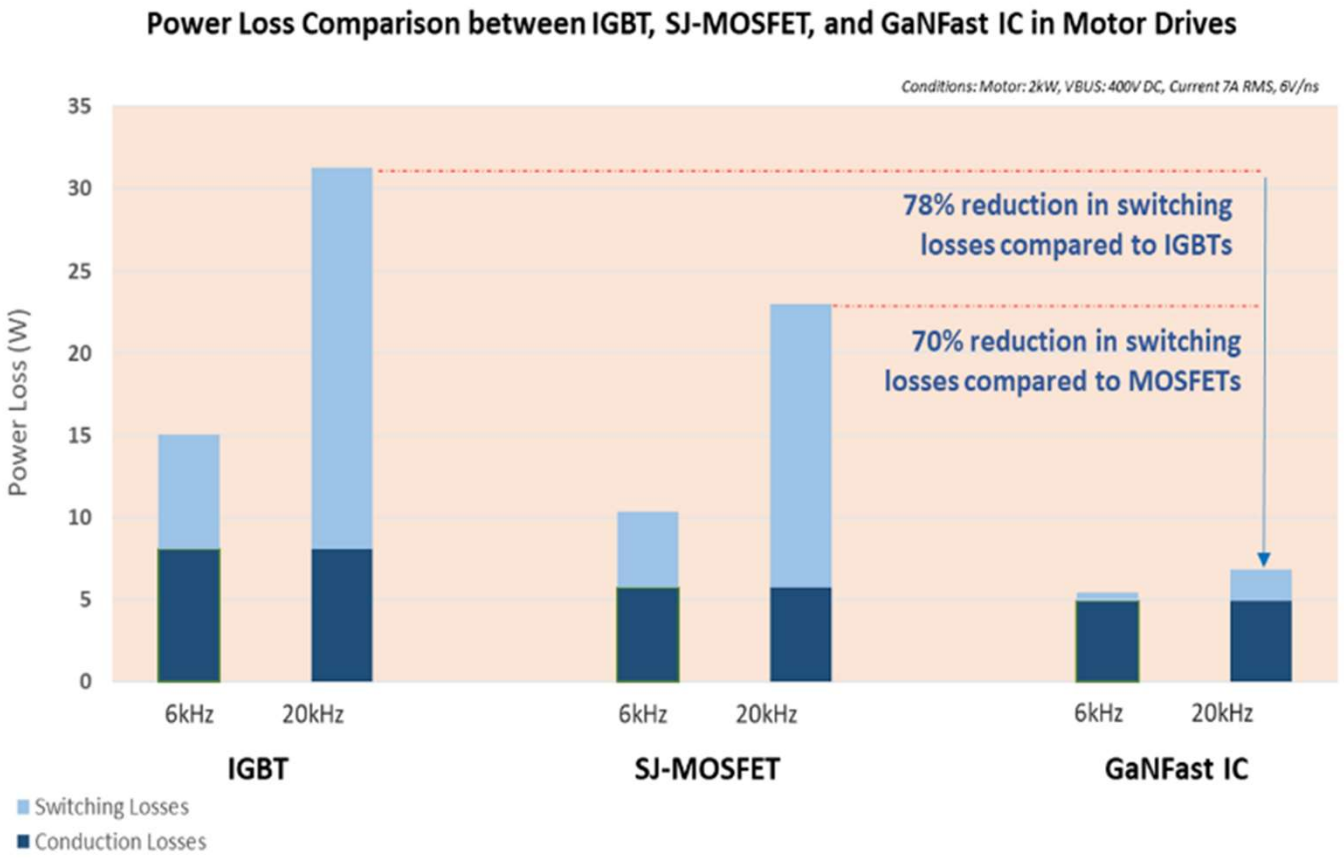
Total loss comparison of Silicon IGBT, silicon MOSFET and GaN power IC in a motor drive applicatoin



Application case:

- Bus voltage 400V
- Current 7A RMS
- Motor power 2kW
- Switching 6V/ns
- GaN and MOSFET same conduction losses

Using GaN FETs, the inverter efficiency increases by 2.5% (96%→98,5%) and total losses are halved (15W→6,8W)

→Significant reduction in cost, weight and size of thermal mgmt (like heatsink, fans, other thermal components)

→ Benefit even larger at higher switching frequency

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Foundational Reliability – driver integration is key

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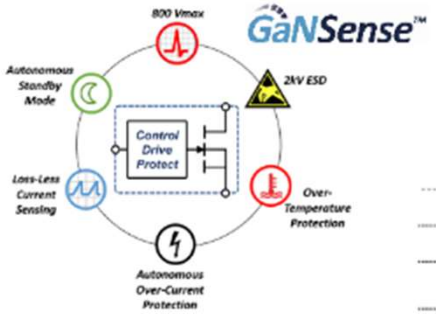
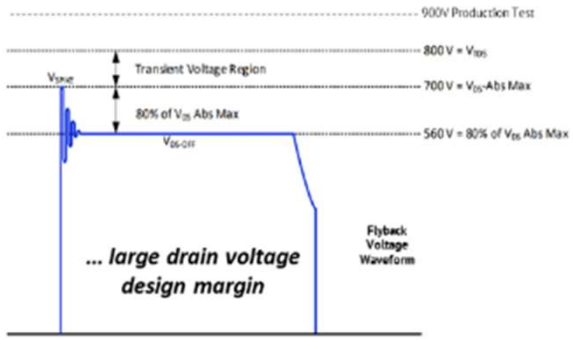
- ***Design*** for Reliability
  - Integrated drive, sensing and protection
  - Component reliability, and ***system*** reliability



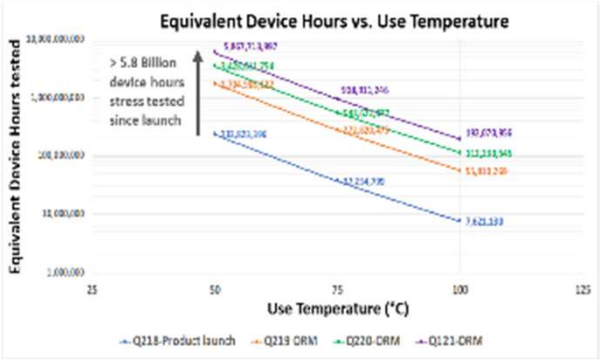
- ***Testing*** for Reliability:
  - Proprietary production test methods
  - GaN ICs tested 400% (multi-temp, high-frequency)

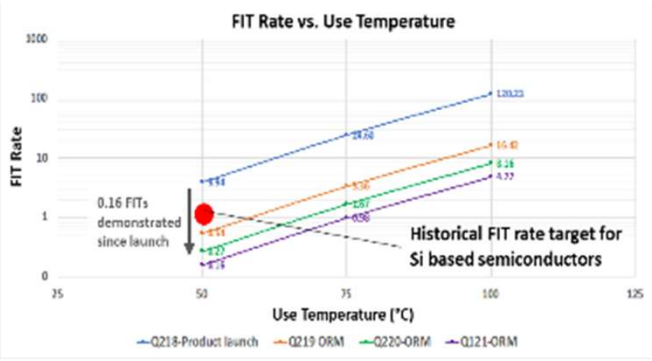


- ***Characterization*** for Reliability
  - Exhaustive, proactive, and unique Navitas reliability program
  - 5.8 B equivalent device hours tested(1)
  - Proprietary, highly-accelerated Op-Life, plus JEDEC, plus ELFR monitoring
  - Founder member of JEDEC JC70.1

Reliability Statistics

Calculated for High Line condition using HTOL (ZVS) results





(1) As of September 2022

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100% Tier 1 Mobile OEMs Adopting Navitas

Tier 1 OEMs

Aftermarket Examples

225+	290+	100%	75M+	Zero
GaN Chargers Mass Production(1)	GaN Chargers In Development(1)	Mobile OEMs Designing With Navitas GaN ICs	GaN ICs Shipped(2)	GaN Field Failures(2)

As of March 2023. Based on Navitas shipment data and no customer-reported consumer failures for production shipments.

Now Ultra-Fast Chargers

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

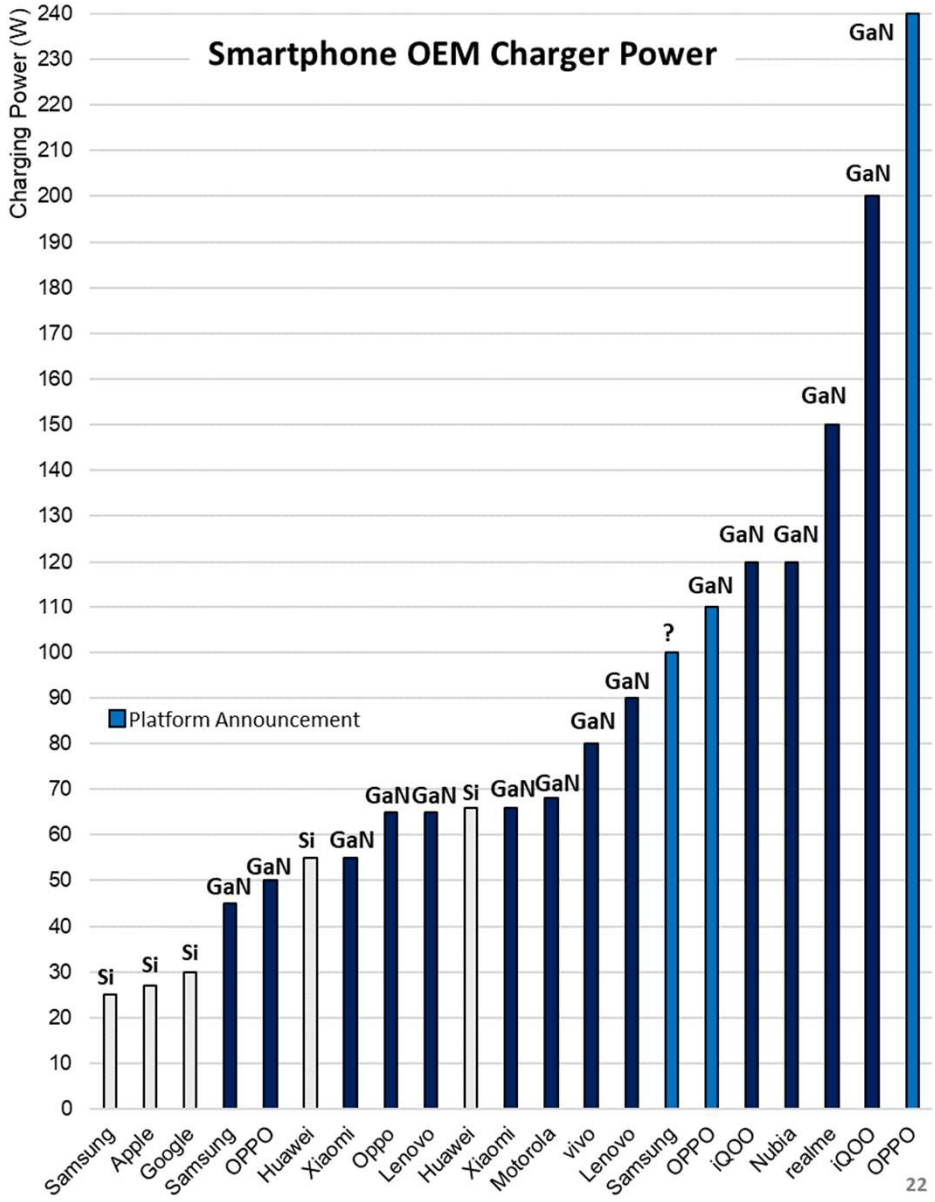
Key value drivers:

- **Lowest losses → High power density**
- **No big penalty for high switching frequency → Smaller components**

RedMi (Xiaomi) F1 Mercedes 120W

Realme (OPPO) GT Neo 3 150W

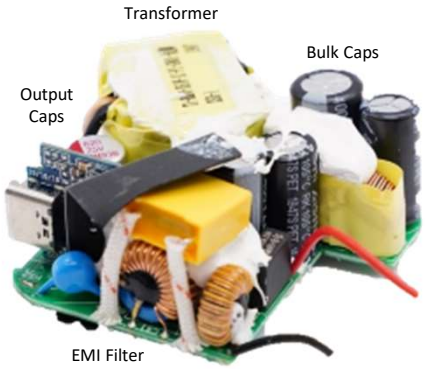
iQOO (vivo) 10 Pro, 200W



High Speed Shrinks Passive Components

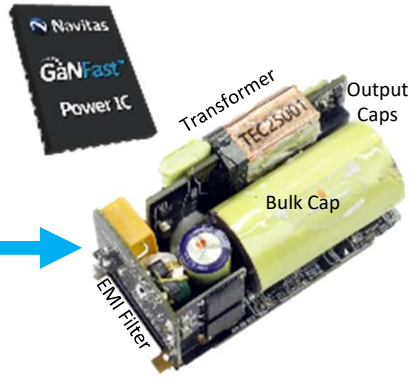
Typically, slow-speed designs have ~70% of volume used by transformer, capacitors, EMI filter, etc.

~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%**(1)



~400 kHz GaN IC
65 W, 31 cc

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

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

~2x faster charging!

(1) Sep'22 Navitas survey of 20 publicly-available Navitas and MCM example chargers and reference designs 65W - 200W. Nominal 100 cc charger size selected, power capability determines charging speed

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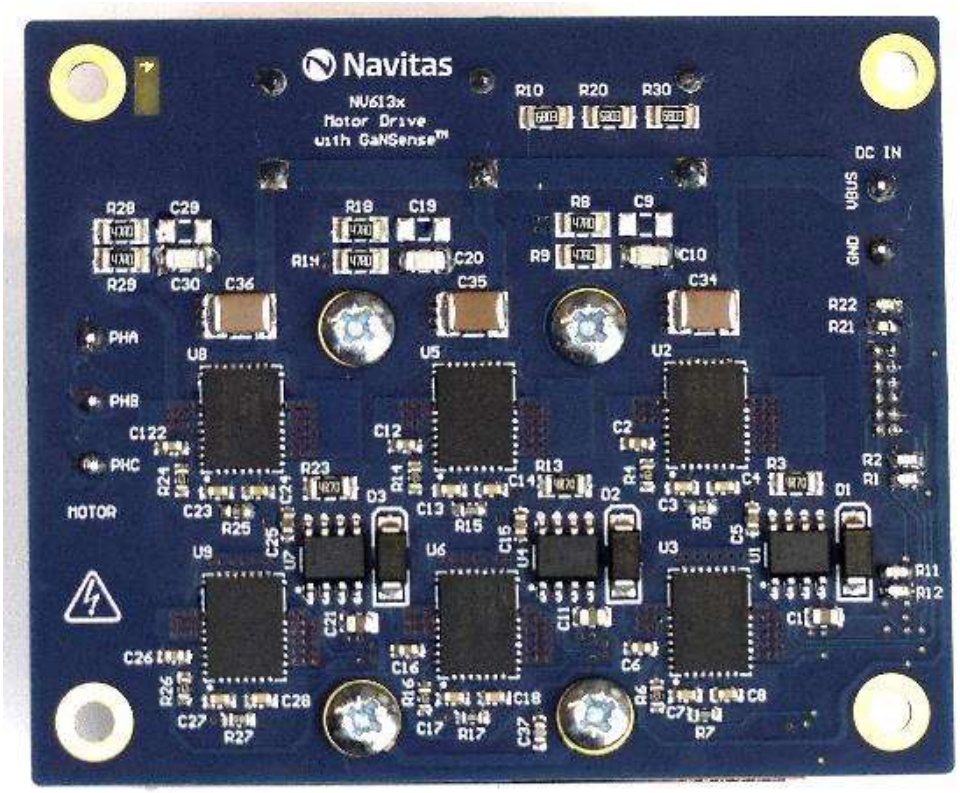
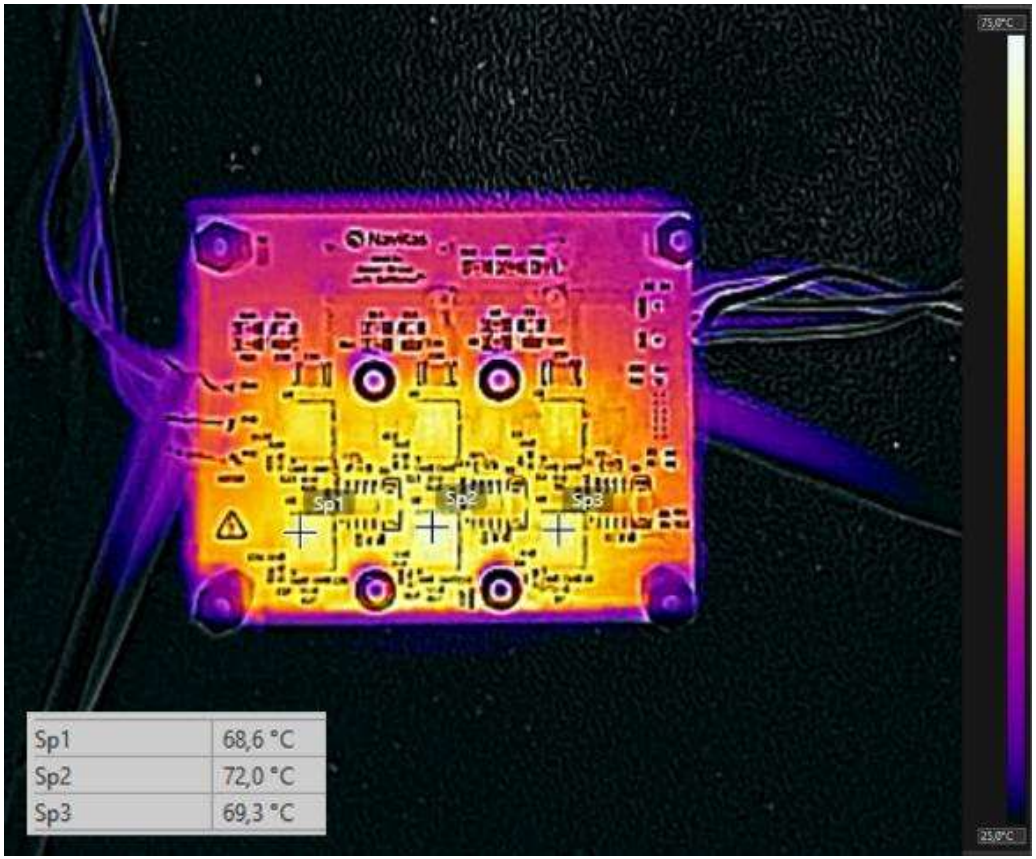
Reference design high power 6-in-1 inverter
Efficiency >99% at 500W, using NV6138

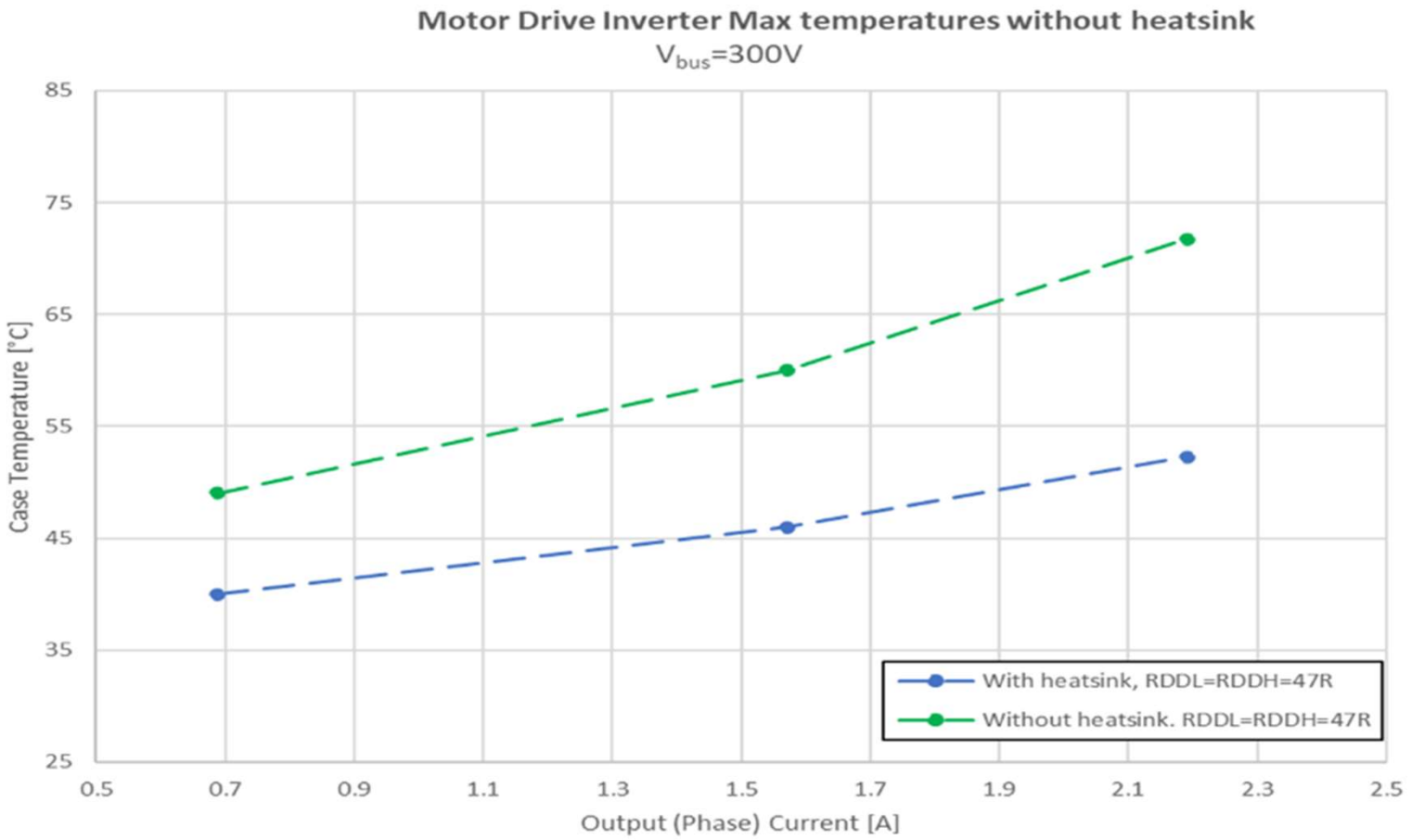


Board size 74mm x 62mm



Thermal scan @ 500W, 20kHz (R_{THCA} ~20K/W), T_{amb} = 25°C
No heatsink used

Reference design 1kW motor inverter
Max temperatures with / without heatsink



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GaNFast Exceeds "Titanium" with >2x Power Density

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

Slow Silicon AC-DC 3,200W

47 kHz
325 x 107 x 41 mm
2.2 W/cc

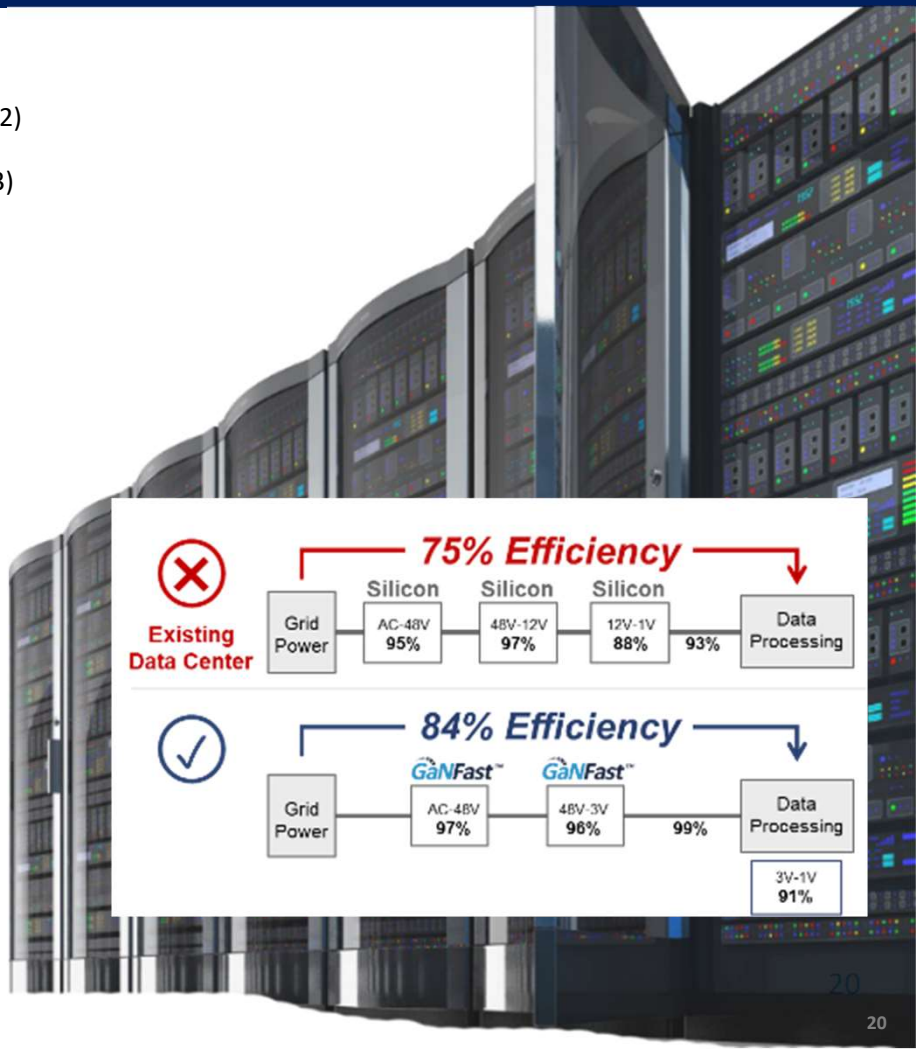
GaNFast AC-DC 2,700W

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

300-500 kHz
185 x 73.5 x 39 mm
5.1 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**"*

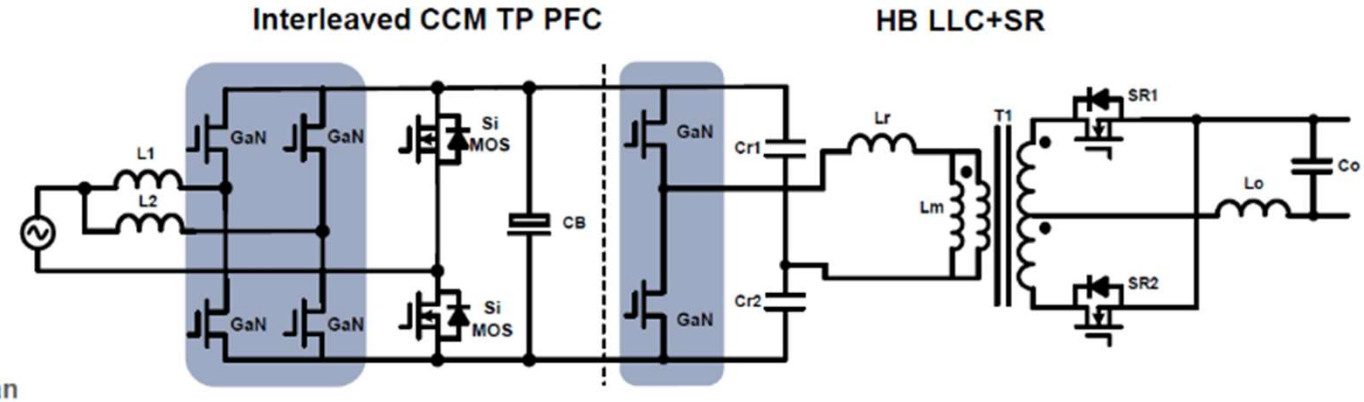
Robin Cheng, VP R&D 肯微科技股份有限公司 Compuware Technology Inc.

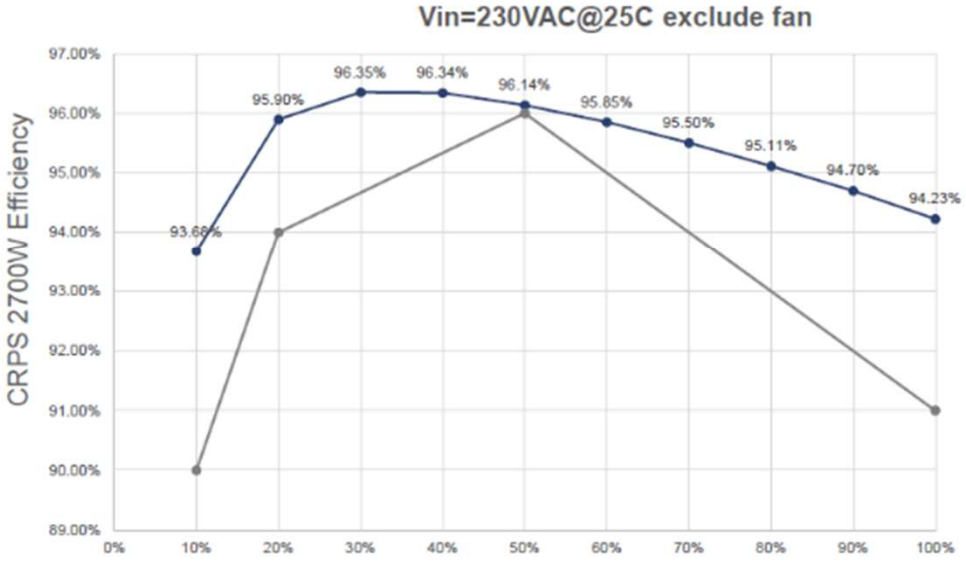


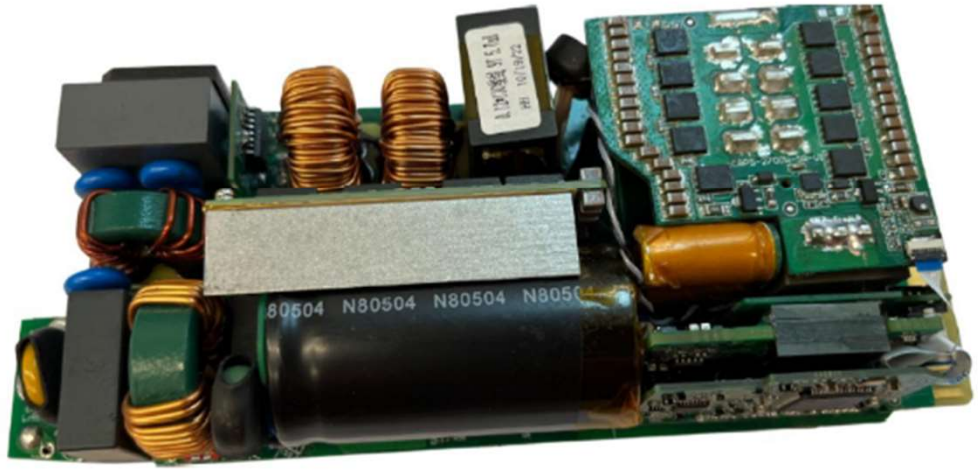
(1) European Union 'Directive 2009/125/EC, 2019 Annex', power supplies must be >96% efficiency peak.
(2) CRPS = Common Redundant Power Supply standard, defined by Intel for standardized mechanical form-factors, targets hyper-converged compute, storage and networking eqpt.
(3) Navitas est. based on a) 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

GaNFast™ Server power supply 2.7kW
Titanium+

- Output power 2.7kW
- Peak efficiency 96.34%
- Power density 5.1W/cc







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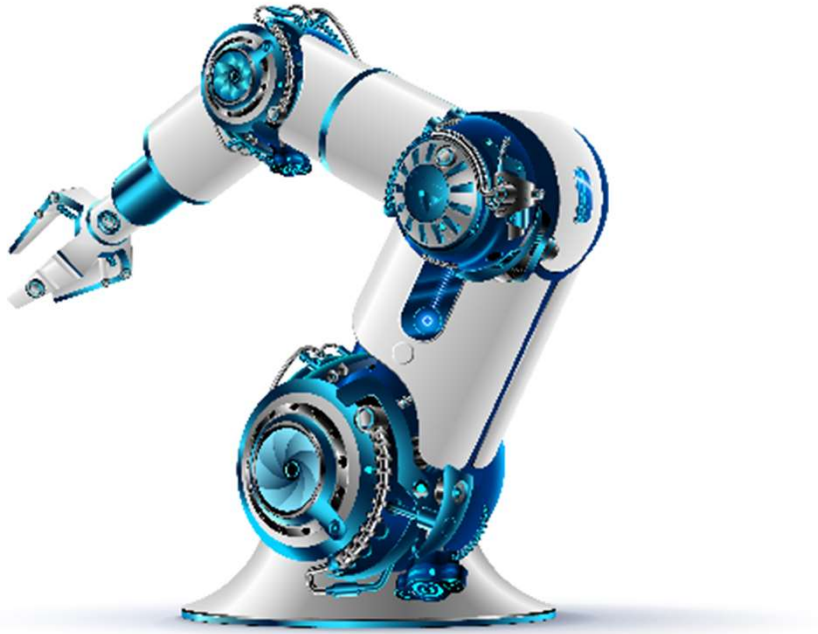
Conclusion – The time is now

- Through GaNFast™ / GaNSense™ integration, GaN power ICs are ready now
  - Reliable and repeatable performance of e-mode GaN power transistors
  - Smallest form factor and lowest losses
  - Easy to use digital power stage
- Massive performance improvement over silicon alternatives
- Very good availability and plentiful supply chain – re-using older silicon fabs with little additional expense and waste



GaN power ICs enable the next level of performance, reliability and robustness in power electronics applications

Thank you!

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