Optimized for Performance and Price: Here Come the GaN Chargers!

Munich Airport Hilton, December 3rd 2019
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Navitas Semiconductor Inc.

- World’s first & only GaN power IC company
  - Production released with fast revenue ramp
  - Qualified ‘Beyond JEDEC’, zero ppm field returns
  - 1M+ shipped, 6-12 weeks leadtime

- Navitas: Latin for Energy
  - *Energy* savings
  - *Bringing a new Energy to power electronics*

- Founded January 2014, HQ El Segundo, CA
- Proven management team, 75 employees
- Tier 1 manufacturing partners
- Strong financial investors ($1B+ managed capital)
Today’s Power Revolution

- Linear Regulators
- Switching Regulators
- Switching Regulators
- HF Switching Regulators

Power Density (W/in³)

- Si BJTs → Si FETs
- New Magnetics
- New Controllers
- New Topologies

- 2x Lower Loss
- 3x Lower $/W

- 5x Increase in 10 years

- <10%/yr improvement over 30 years

- 40% efficiency

- 1977
- 1987

- 50 Hz
- 30 kHz
- 65 kHz
- 1 MHz

- 90%
- 95-98%

- 2x Lower Loss
- 3x Lower $/W

- New GaN Power ICs
- New Magnetics
- New Controllers
- New Topologies

- 2017
- 2027
More Screen, More Battery... & 5G?

Source: gsmarena.com, Navitas

2007
Apple
iPhone 1
36.5 cm^2
1,400 mAh

2013
Samsung
Galaxy S4
68.9 cm^2
2,600 mAh

2019
Huawei
Mate X
205 cm^2
4,500 mAh

Smartphone Screen Size (cm^2) and Battery Capacity (mAh) 2007-2019
Incl. Apple, Google, Huawei, OnePlus, Oppo, Samsung, Vivo, Xiaomi

Images to scale
Source: gsmarena.com, Navitas
More Battery, More Charge Time

Source: gsmarena.com, Navitas

2007
iPhone 1
1,400 mAh
1.7 hrs

2013
Galaxy S4
2,600 mAh
3.1 hrs

2019
Mate X
4,500 mAh
5.4 hrs

Apple 5W
Cube
Vivo’s Super FlashCharge 120W technology, claims 100% charge of a 4,000 mAhr phone battery in just 13 minutes.

Source: Navitas
Enabling Technology: GaN

GaN replaces silicon, electrifies applications around the world.

GaN Speed
GaN Efficiency
GaN Density

High voltage operation
Electric Field (MV/cm)

Energy gap (eV)

Thermal Conductivity (W/cm°C)

Electron velocity (x10^7 cm/s)

Melting point (x1000 °C)

High T° applications
High Frequency switching
World’s First GaNFast™ Power ICs

Fastest, most efficient GaN Power FETs
- >20x faster than silicon
- >5x faster than cascoded GaN
- Proprietary design

First & Fastest Integrated GaN Gate Drivers
- >3x faster than any other gate driver
- Proprietary design
- 75+ patents granted/applied

Up to 40 MHz switching, 5x higher density & 20% lower system cost
Single GaNFast Power IC

- Monolithic integration, 650V
  - GaN FET
  - GaN Driver
  - GaN Logic
- “Digital In, Power Out”

5 x 6 mm QFN

Diagram showing circuit components and connections.
- Monolithic integration, 650V
  - 2x GaN FETs
  - 2x GaN drivers
  - GaN Logic (level-shift, bootstrap, UVLO, shoot-through, ESD)
  - “Digital In, Power Out”
Reliability → Qualification → Release

Reliability models on IC building blocks = Robust design

Mission profile driven reliability = Protected Customer

Comprehensive reliability monitoring

<table>
<thead>
<tr>
<th>Reference</th>
<th>Test Conditions</th>
<th>Duration</th>
<th>Lots</th>
<th>S.S.</th>
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</thead>
<tbody>
<tr>
<td>JESD22-A113</td>
<td>Preconditioning (MEIL): Moisture Preconditioning + 3x reflow: HAST, UHAST, TC &amp; PC</td>
<td>N/A</td>
<td>3</td>
<td>308</td>
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<tr>
<td>JESD22-A104</td>
<td>Temperature Cycle: -55°C / 150°C</td>
<td>1,000cy</td>
<td>3</td>
<td>77</td>
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<tr>
<td>JESD22-A122</td>
<td>Power Cycle: Delta Tj = 100°C</td>
<td>10,000cy</td>
<td>3</td>
<td>77</td>
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<td>JESD22-A110</td>
<td>Highly Accelerated Stress Test: 130°C / 85%RH / 100V V(3)</td>
<td>98hrs</td>
<td>3</td>
<td>77</td>
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<tr>
<td>JESD22-A108</td>
<td>High Temperature Reverse Bias: 150°C / 520V V(20)</td>
<td>1,000hrs</td>
<td>3</td>
<td>77</td>
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<tr>
<td>JESD22-A108</td>
<td>High Temperature Gate Bias: 150°C / 5V V(20)</td>
<td>1,000hrs</td>
<td>3</td>
<td>77</td>
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<tr>
<td>JESD22-A108</td>
<td>High Temperature Operating Life</td>
<td>1,000hrs</td>
<td>3</td>
<td>77</td>
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<tr>
<td>JESD22-A108</td>
<td>Early Life Failure Rate</td>
<td>24 hrs</td>
<td>3</td>
<td>1,000</td>
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<tr>
<td>JS-001: 2014</td>
<td>Human Body Model ESD</td>
<td>N/A</td>
<td>1</td>
<td>3</td>
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<tr>
<td>JS-002: 2014</td>
<td>Charged Device Model ESD</td>
<td>N/A</td>
<td>1</td>
<td>3</td>
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</table>

Metric | Results
--- | ---
Equivalent device hours tested* | 1.7 billion hours
FIT* | 0.54

*Calculated from HTOL tests

Power ICs

Quality

Speed

Efficiency

Now in high volume production!
GaNFast Chargers Are Here!

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

**Mobile**
- Half the size & weight of traditional chargers

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

**Flexible**
- Charger and battery pack,
  - and multiple outputs

Design = Apple + Anker + Navitas

**AUKEY**

- 27W
- 24W
- 30W
- 45W

**RAVPower**

- 45W

42W (30W-C + 18W-A) + 5,000 mAhr
More Power, Higher Power Density

Images to scale

Apple Si 18W
42 x 41 x 27 mm
= 47 cc, 60 g
(fixed AC pins)

AUKEY 27W
36 x 36 x 32 mm
= 41.5 cc, 45 g

70% more Power for Size
(1.7x W/cc)

Apple Si 61W
73 x 73 x 28 mm
= 149 cc, 193 g

Eggtronic GaN 65W
68 x 50 x 19 mm
= 65 cc, 90 g

140% more Power for Size
(2.4x W/cc)
Ultra Portability
3-in-1, 3x Smaller, Lighter, Cheaper

Baseus GaN 65W
75 x 35 x 32 mm
= 84 cc, 125 g

Apple Si 18W
42 x 41 x 27 mm
= 47 cc, 60 g
(fixed AC pins)

Apple Si 30W
55.9 x 55.9 x 32 mm
= 87 cc, 158 g

Apple Si 61W
73 x 73 x 28 mm
= 149 cc, 193 g

Retail $29

$49

$69

283 cc, 411 g, $147

84 cc, 125 g, $35

USB-C #1 up to 65W
USB-C #2 up to 30W
USB-A up to 30W
World’s Smallest 300W

World’s Fastest Laptop:
Asus ProArt StudioBook One
NVIDIA Quadro RTXTM 6000

300W in 92 x 92 x 28 mm
= 237 cc
= 1.3 W/cc
More Power, Faster Charge

Vivo’s Super FlashCharge 120W technology, claims 100% charge of a 4,000 mAh phone battery in just 13 minutes.

Source: Navitas
Si: Size and Price (60-65W USB-PD)

Source: Navitas research
Survey of universal AC-input, USB-PD chargers Nov 13th 2019. Folding pins unless otherwise stated. 6 Si chargers with >20% 1-star (negative) reviews excluded.
GaN: Smaller **and** Cheaper

Source: Navitas research
Survey of universal AC-input, USB-PD chargers Nov 13th 2019. Folding pins unless otherwise stated. 6 Si chargers with >20% 1-star (negative) reviews excluded
Here come the GaN chargers

Visit www.GaNFast.com for more!