PE INTERNATIONAL CONFERENCE

ANGELTECH

Innoscience

Price competitive GaN power devices to enhance performances, shrinking size and lowering cost of power conversion solutions

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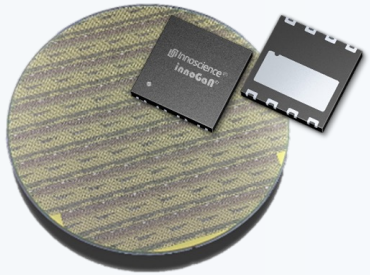
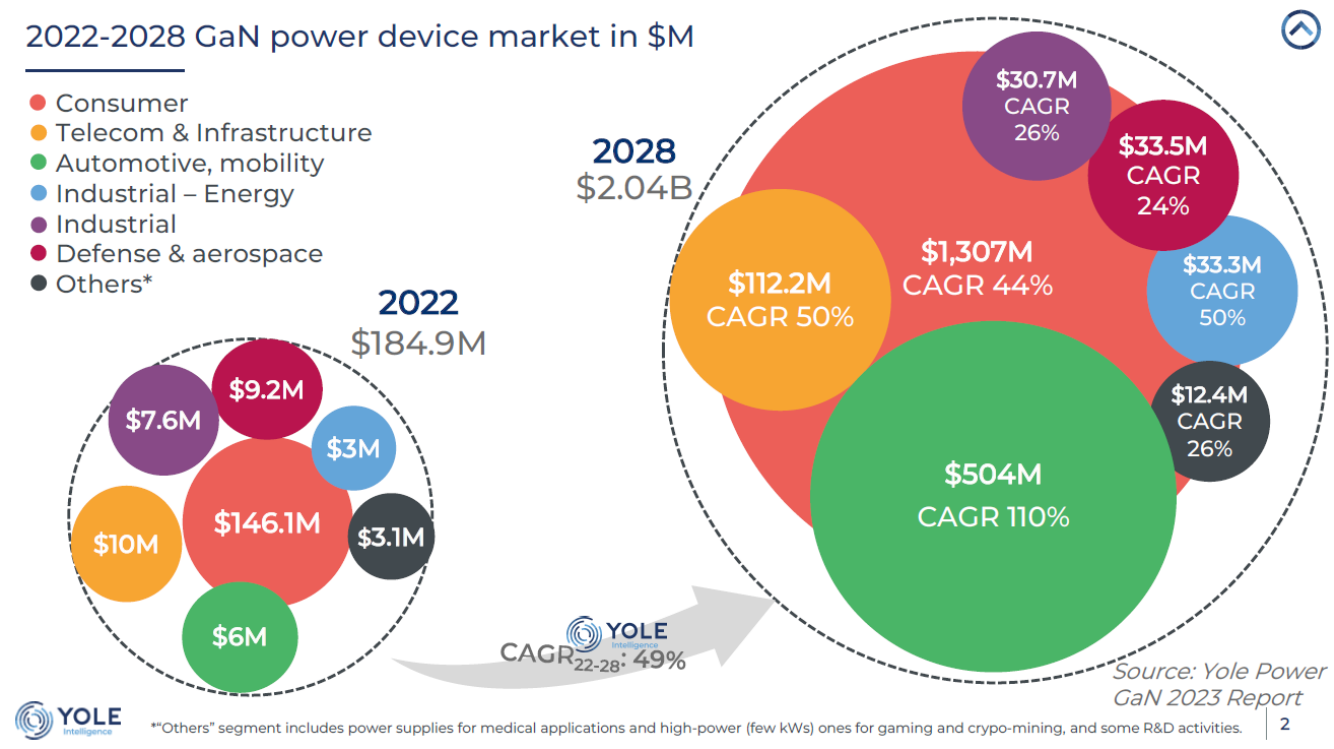


Power Electronics International

16th and 17th April

Brussel – Belgium

GaN power market is booming!



Courtesy of Yole

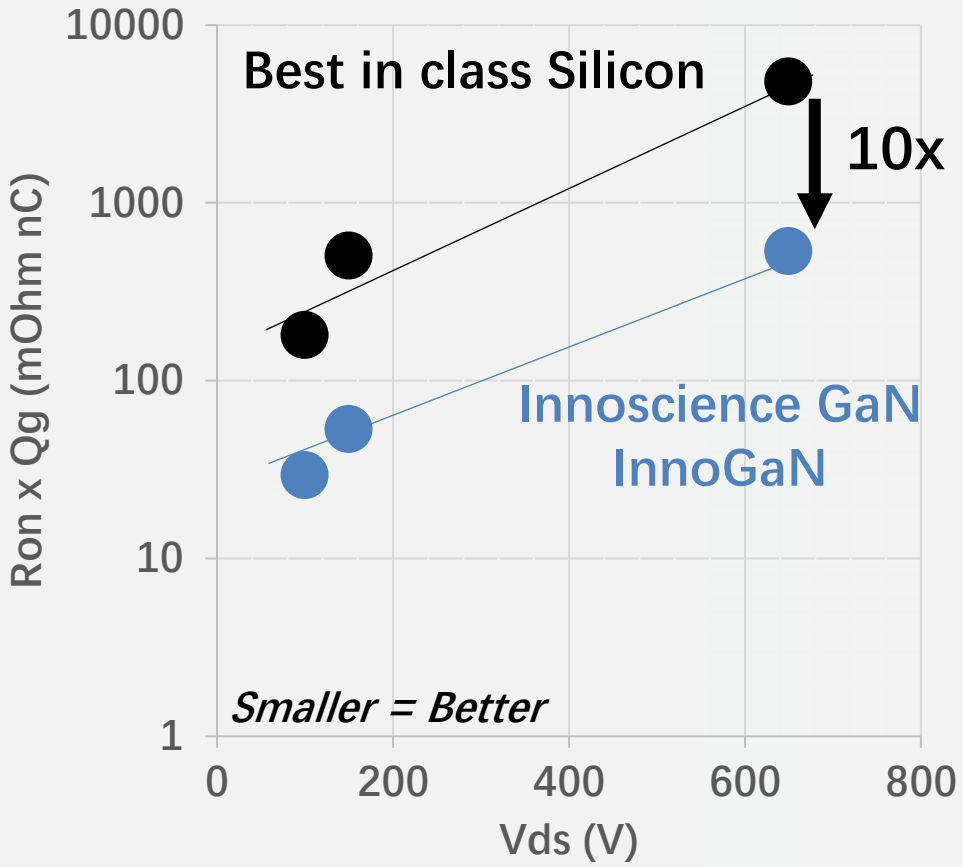
- **Many companies understand the benefits of using GaN power devices, as they enable:**
  - Smaller system size.
  - Higher power density.
  - Higher efficiency.
  - Cheaper solutions.

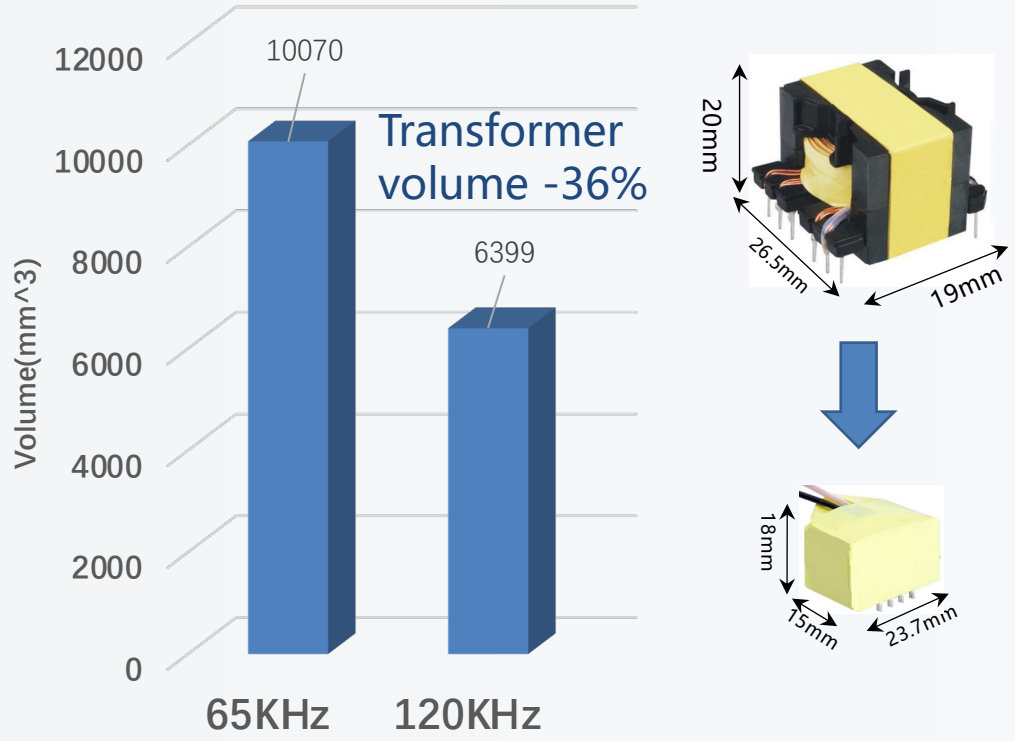
- **GaN is now being used in marketing for greener and powerful solutions!**

Source: https://www.yolegroup.com/product/report/power-gan-2023/
https://www.amazon.com/Charger-Sacrack-Charging-Station-Portable/dp/B09GJXVHVK/ref=sr_1_13?crid=2L65IYLP53UVN&keywords=anker%2Bpower%2Badapter%2Busb-c%2B100w&qid=1693385810&sprefix=anker%2Bpower%2Badapter%2Busb-c%2B100w%2Caps%2C152&sr=8-13&th=1
https://www.macrumors.com/2021/10/19/apple-140w-power-adapter-usb-pd-3-1/
https://www.amazon.com/Charger-Sacrack-Charging-Station-Portable/dp/B09GJXVHVK/ref=sr_1_13?crid=2L65IYLP53UVN&keywords=anker%2Bpower%2Badapter%2Busb-c%2B100w&qid=1693385810&sprefix=anker%2Bpower%2Badapter%2Busb-c%2B100w%2Caps%2C152&sr=8-13&th=1

Innoscience has shipped 600 Million InnoGaN!

System solution is smaller and cheaper with InnoGaN

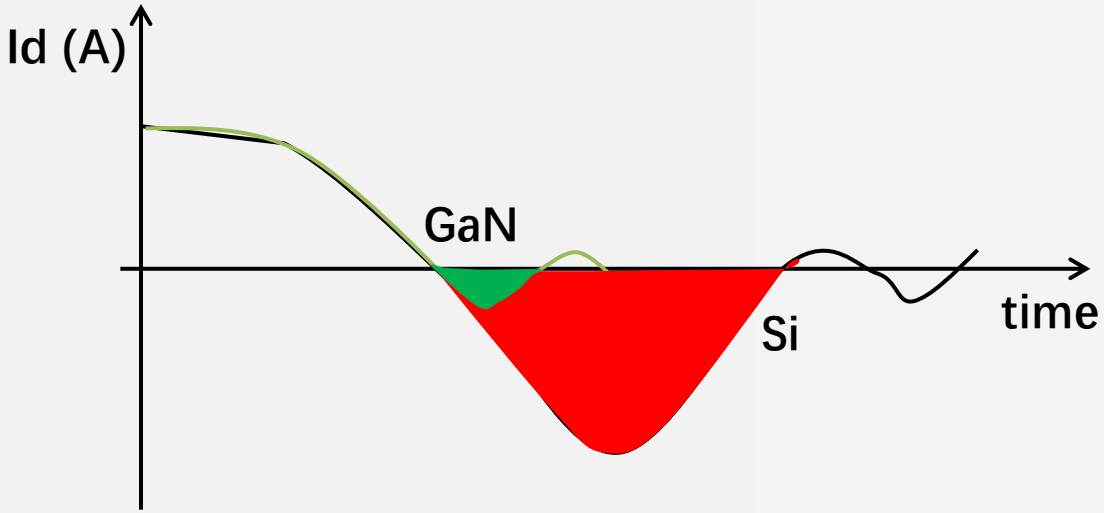




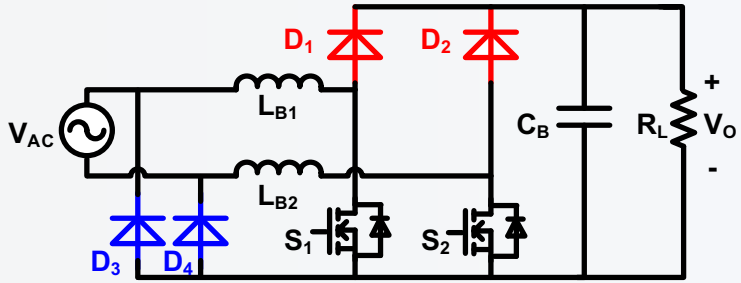
Ron Qg is 10x better than Silicon.
You can switch at higher frequency while keeping high efficiency.

High frequency means shrinking of the passives, making power systems smaller and often cheaper.

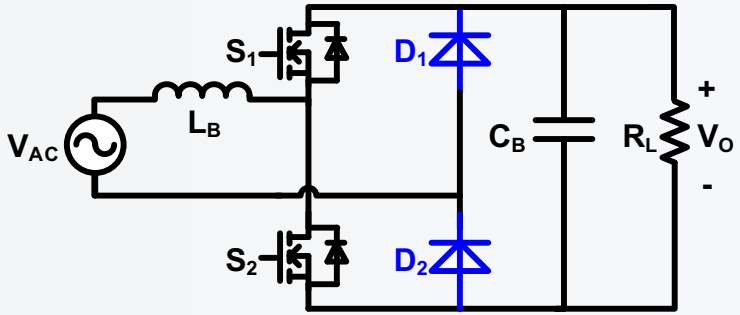
System solution is smaller and cheaper with InnoGaN



Dual Boost Bridgeless PFC



Totem-pole Bridgeless PFC



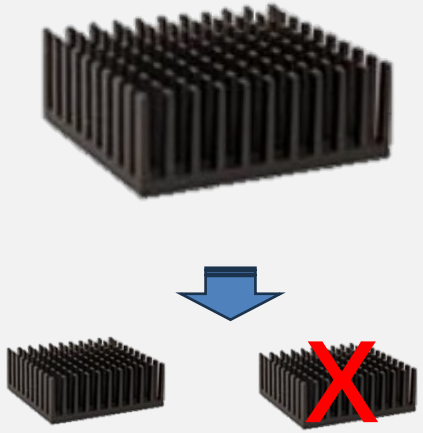
Simpler & with less components

GaN power devices do not have a body diode that means Qrr = 0 and no reverse recovery current.

No reverse recovery means simpler and cheaper system topology while keeping or increasing performance.

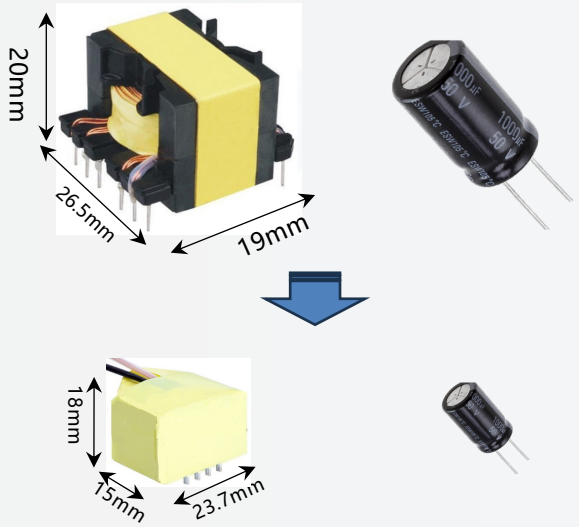
With GaN power conversion systems are Lighter, Smaller, Simpler and Cheaper

High efficiency



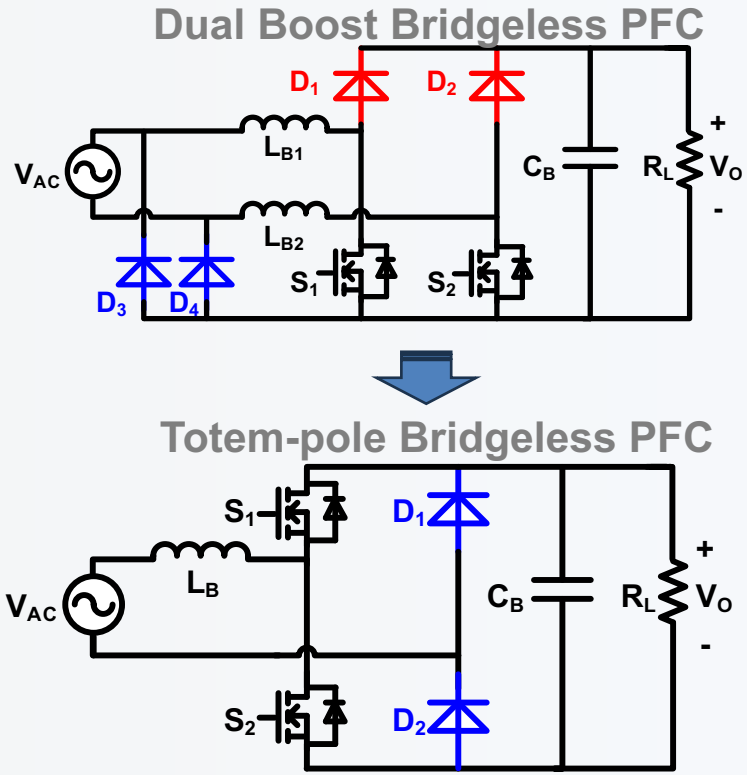
Heat sink elimination or smaller

High frequency



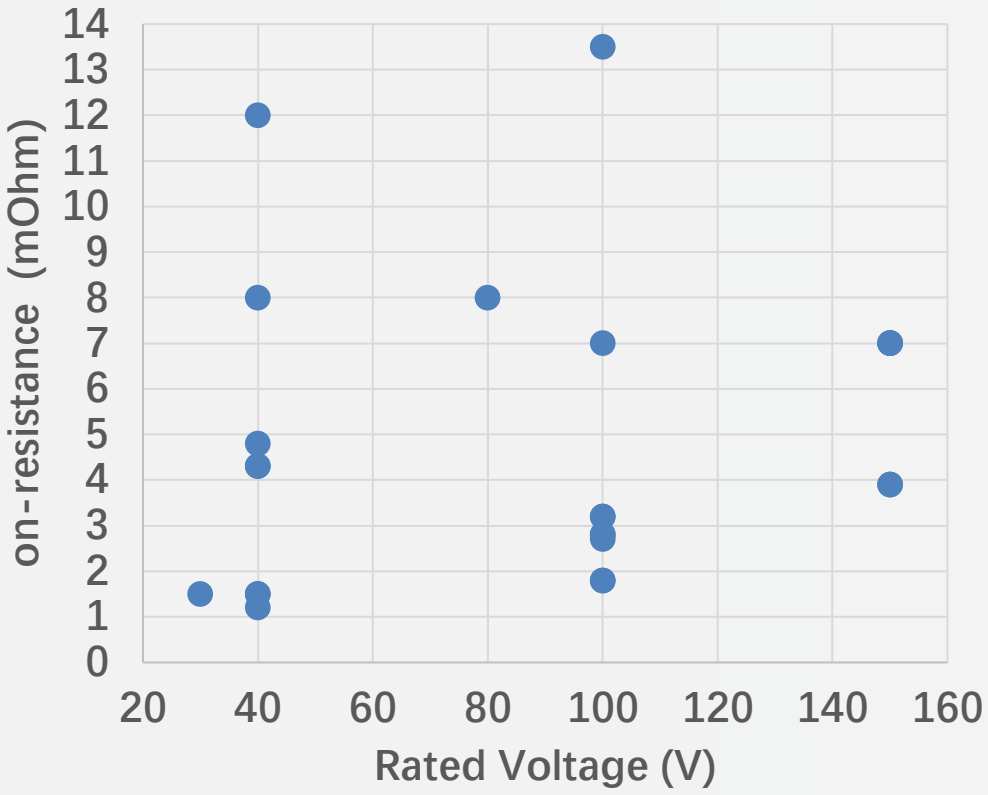
Size and cost reduction of the passives

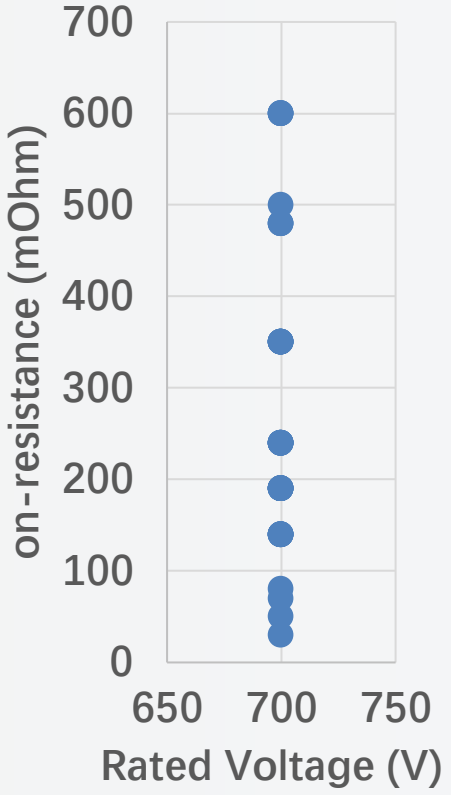
No body diode/no Reverse recovery



Simpler with less components (BOM)

Innoscience: one stop shop for e-mode GaN devices
LV, MV and HV devices





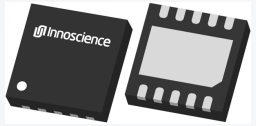
LV/MV:

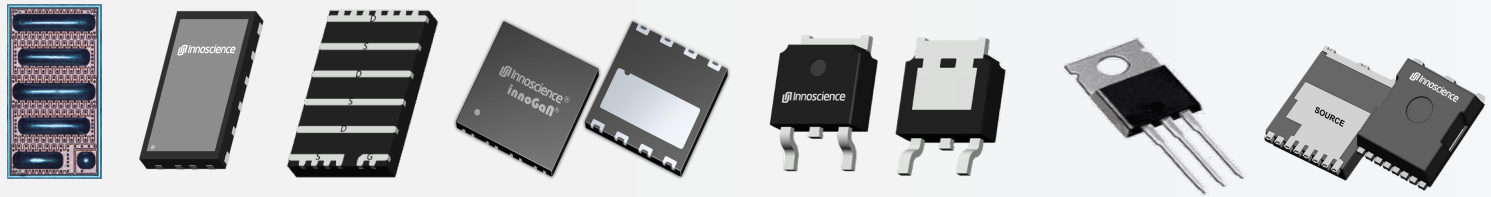
- 30V-150V
- Ron: 1.8mOhm – 14mOhm
- WLCSP, FCQFN, EN-FCQFN, LGA

HV:

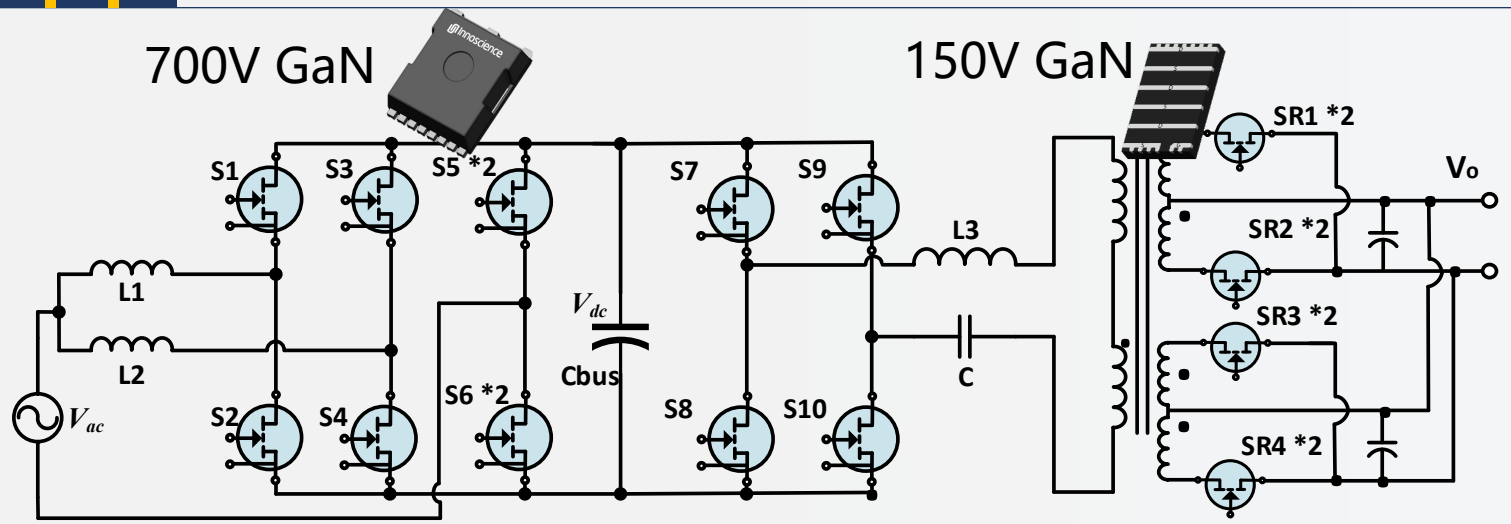
- 650V/700V
- Ron: 30mOhm - 600mOhm
- DFN, TO252, TO220, TOLL, TOLT

Single Channel Gate driver





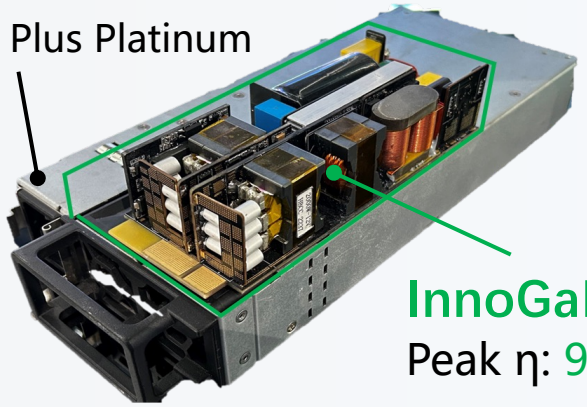
An example: 4.2kW PSU with GaN at primary and secondary side



Silicon

Peak η : 94%

80 Plus Platinum

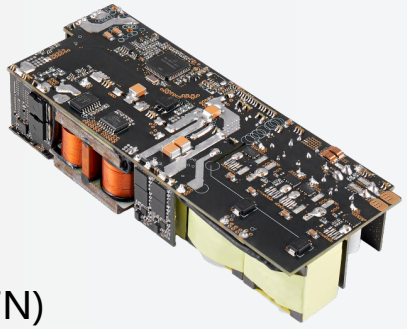


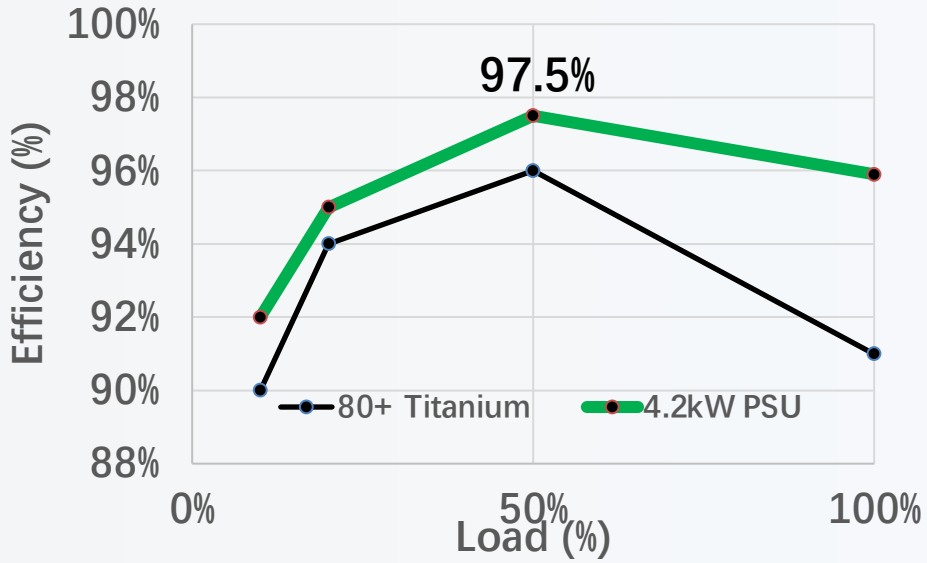
InnoGaN

Peak η: 97.5%

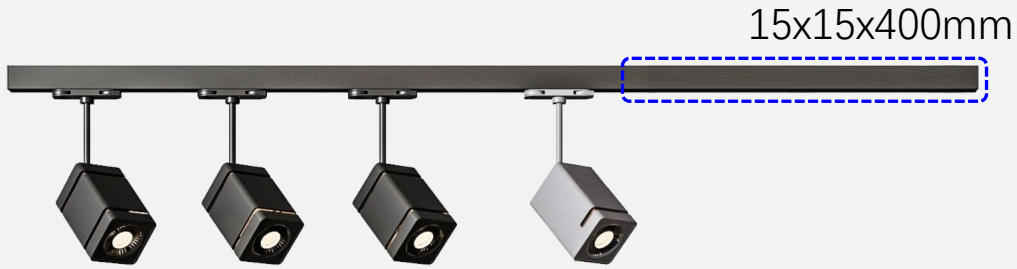
80 Plus Titanium

- **Topology: Totem pole PFC + LLC**
- InnoGaN FETs:
  - S1-S4: INN650TA050AH (650V/70mΩ, TOLL)
  - S5-S10: INN650TA030AH (650V/30mΩ, TOLL)
  - SR1-SR4: INN150FQ032A (150V/3.2mΩ, FCQFN)
- Output: 12V, 4.2kW
- **Size 37x69x185mm – 130 W/in³**
- **Meet 80 PLUS Titanium rating**





Another example: LED Track Light （150W）



Example Silicon driver #1: too long

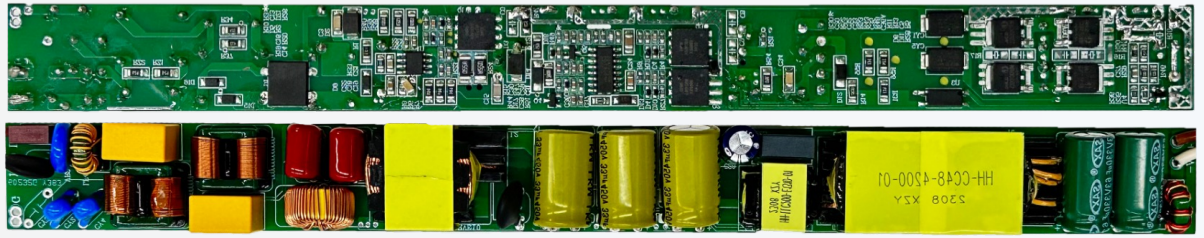
Driver occupies large part of the track

Example Silicon driver #2: too thick

Driver height doesn't match the track.

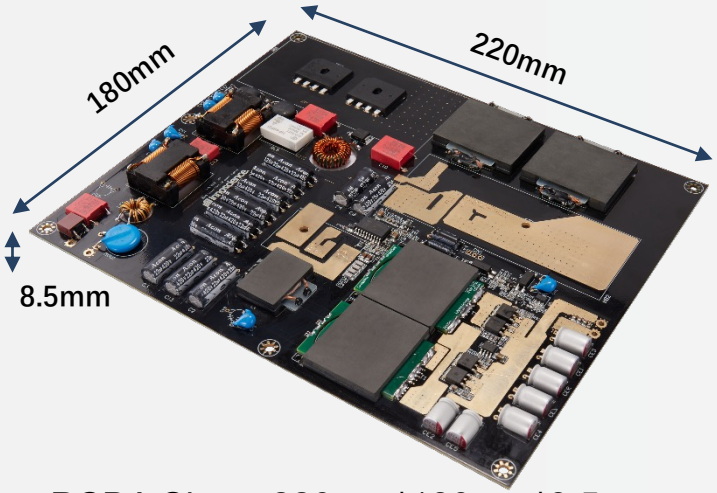
InnoGaN Solution（PFC+LLC, 200KHz) : perfect

Balance of size and shape and gain 4% in efficiency (6W saved/track)



InnoGaN makes anything smaller, thinner and more efficient

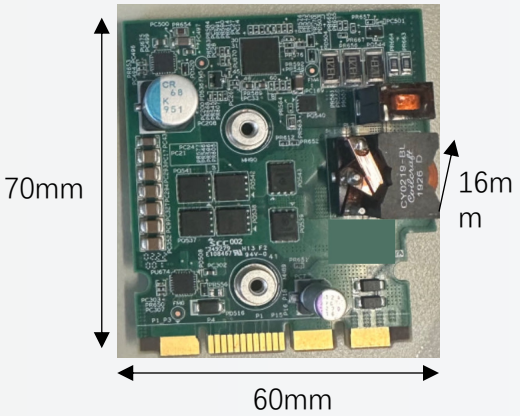
300W ultra-thin TV power supply



PCBA Size: 220mm*180mm*8.5mm

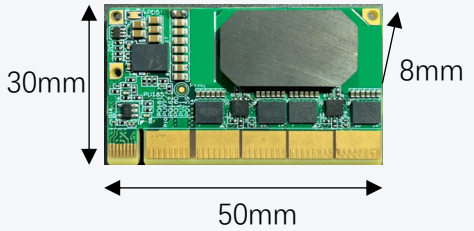
1000W 48V-12V DC-DC 1MHz Power Module

600W Silicon solution



70% side reduction

1kW SolidGaN Solution



Peak Efficiency: 97.9%

Peak Efficiency : 98.5%

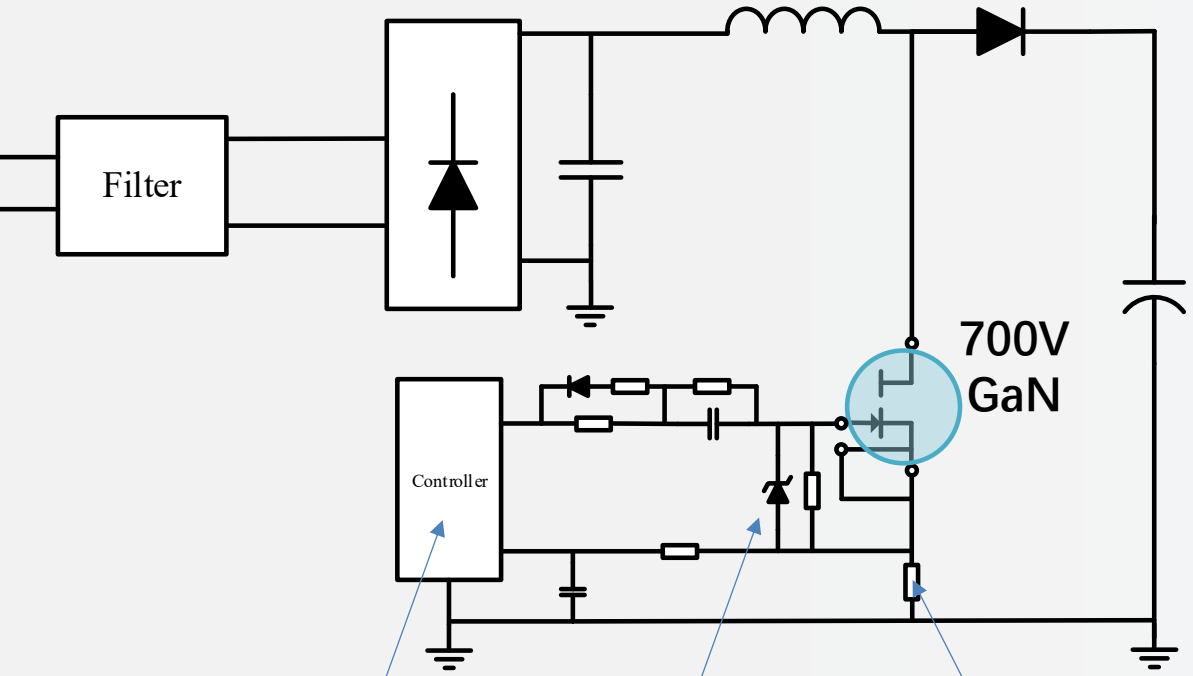
20W-240W PD Charges

…And many others (inverters, motor drivers, PV u-inverters etc..)

Discrete and integrated solution: PFC case study

Discrete solution

Flexible Precautions Several components



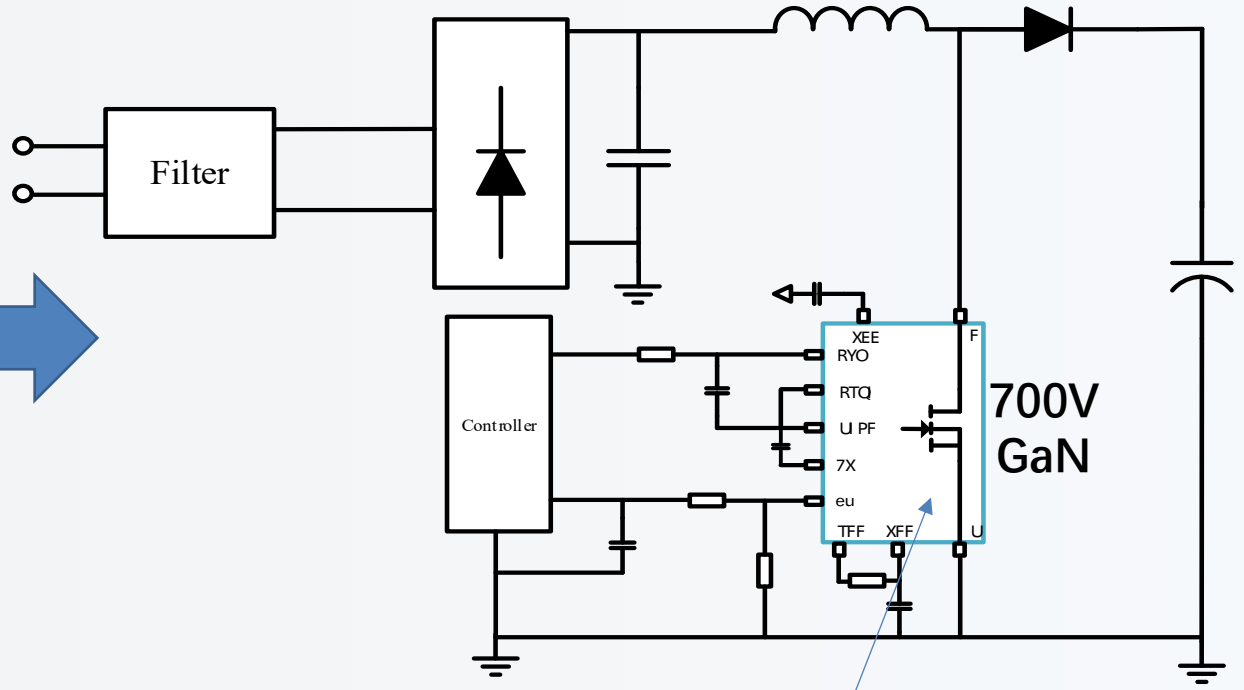
Needs to be optimized to drive GaN

Diode to protect the gate

Rsense (to read-out current)

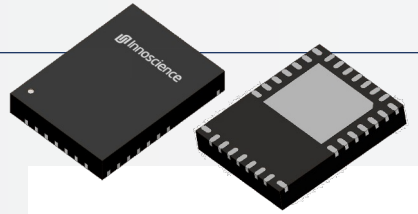
Integrated Solution

Easy Protected Everything Integrated



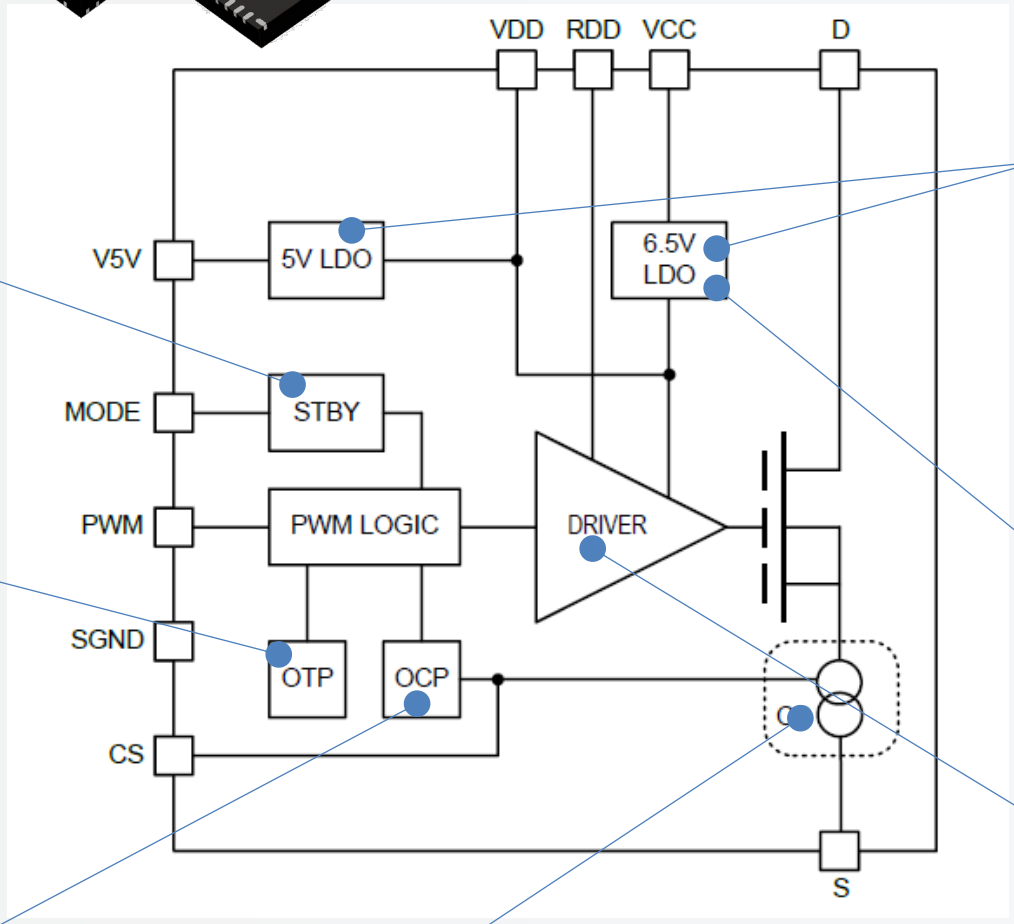
All the functions integrated and optimized: just solder it

ISG610x – 700V SolidGaN with Current Sense



Ron: 140 – 460 mOhm

Autonomous standby (STBY) mode to improve system efficiency.
The internal circuitry is turned off when no PWM signal → supply current is drastically reduced to 115uA (typical)



VCC and VDD Under Voltage lockout (UVLO) protection: turn-off the GaN FET and ignore PVM when needed

Internal Voltage Linear Regulator: to assure 6.5V to maximize power efficiency while ensuring the reliability of the GaN FET

Optimized Gate driver: design to effectively drive the GaN HEMT for high frequency operations

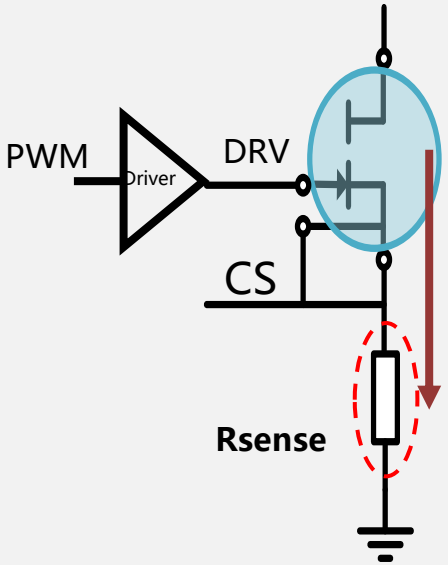
Over Temperature Protection (OTP): if the internal junction temperature Tj exceeds 165°C, the GaN FET is turned off.

Cycle-by-cycle **over current protection (OCP)** based on the current-sense signal to protect the GaN FET

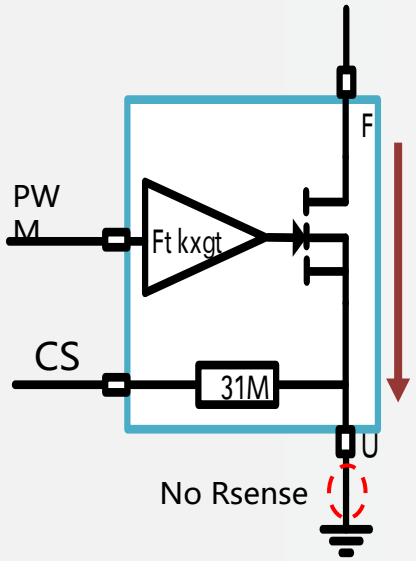
Loss-less Current Sensing with 7% Accuracy

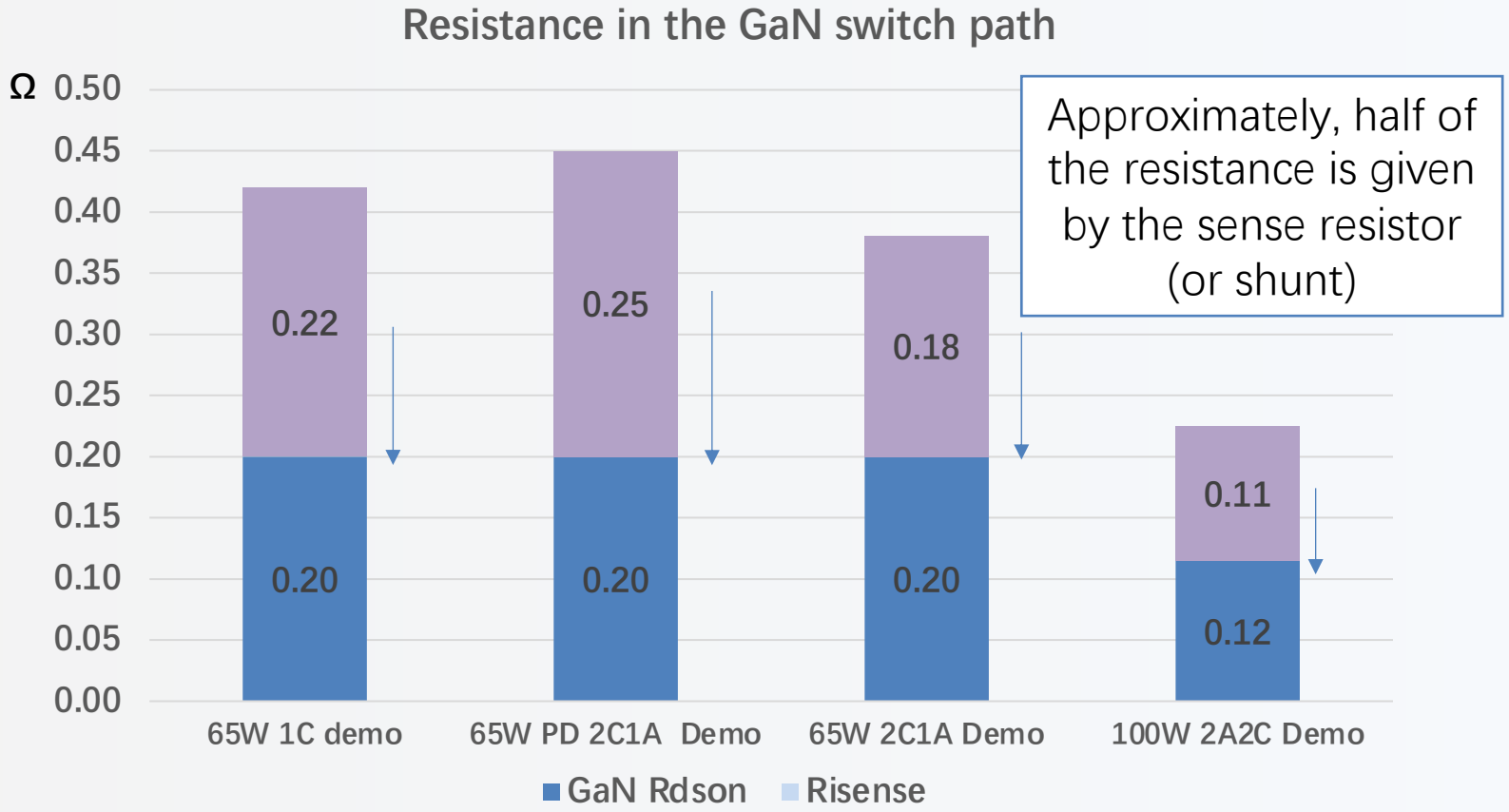
Benefit of Lossless Current sensing

Typical discrete



With lossless current sensing





Approximately, half of the resistance is given by the sense resistor (or shunt)

- Current sensing resistor loss is eliminated (save in cost, efficiency etc..)
- Larger GaN R_{dson} can be used. → Cost reduction

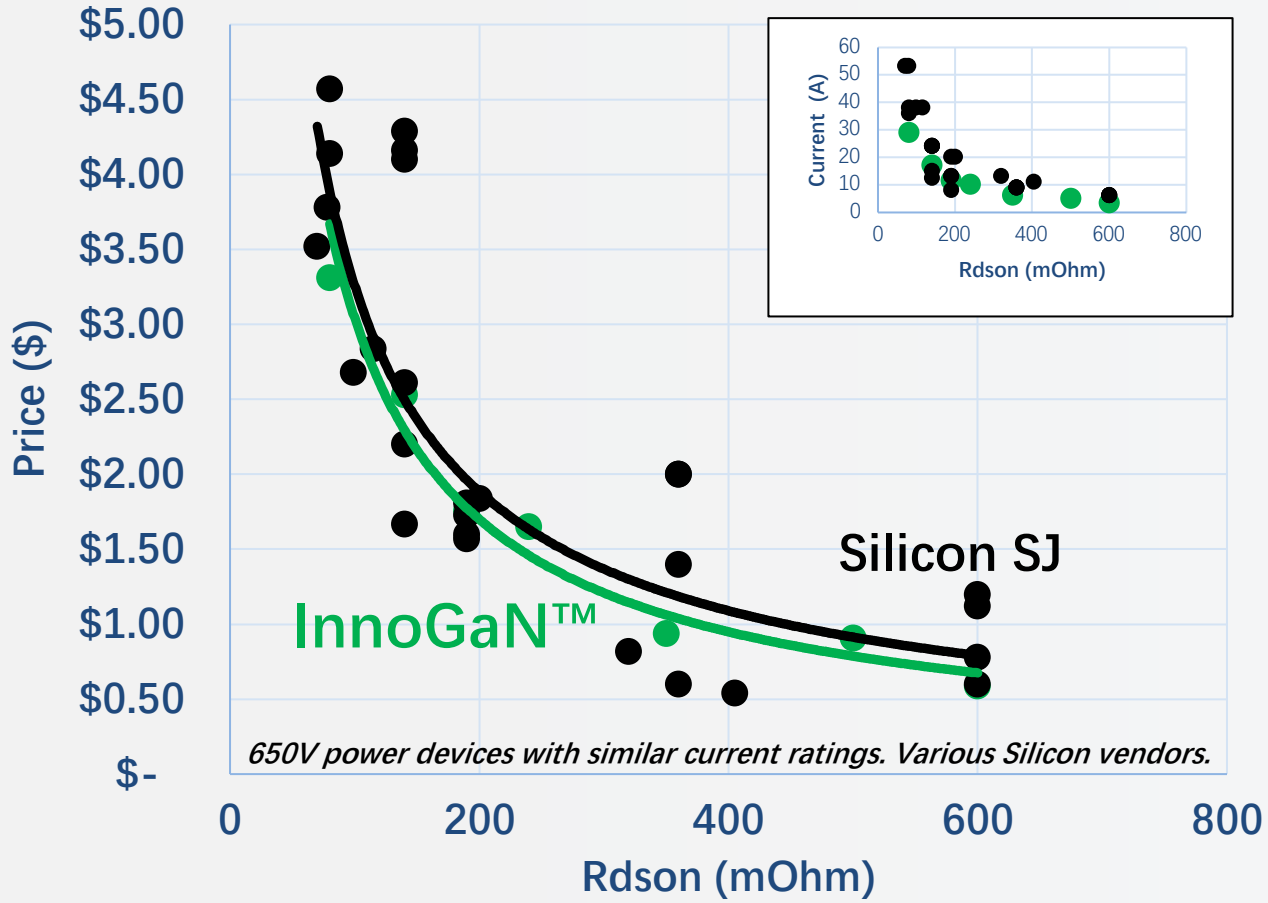
Why are some companies holding back from moving into GaN?

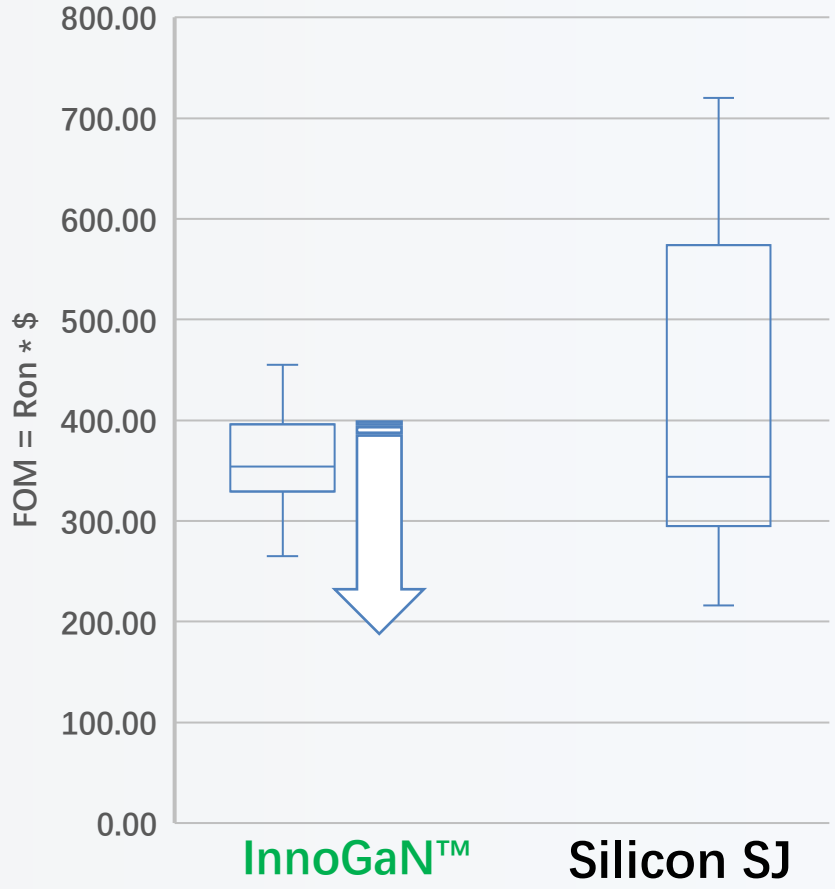
- **Price perception:** GaN power devices are 2x or 3x more expensive than a Si power device.

- **Reliability perception**: GaN is a new technology, and its reliability is questionable.

GaN vs Silicon Super Junction (SJ) price

Source: www.richardsonrfpd.com and www.digikey.com



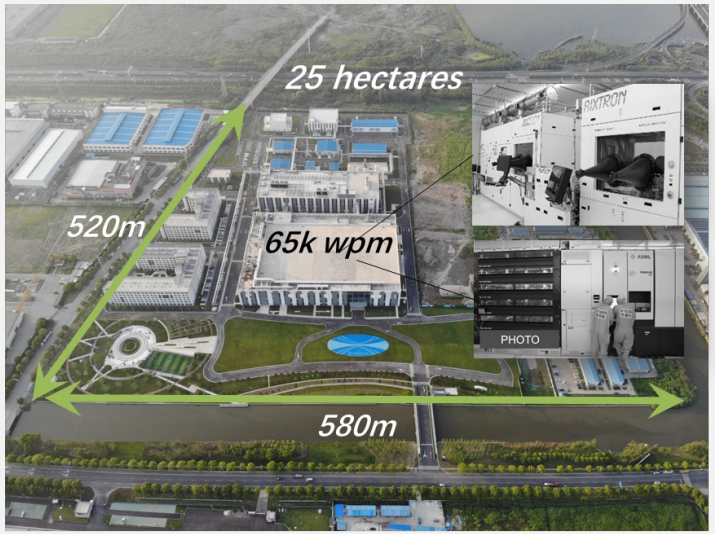


Price of InnoGaN is comparable to Si Super Junction (SJ) devices

and we still have room to reduce device cost (epitaxy, processing, die size etc..)

How did we reduce the cost of GaN?

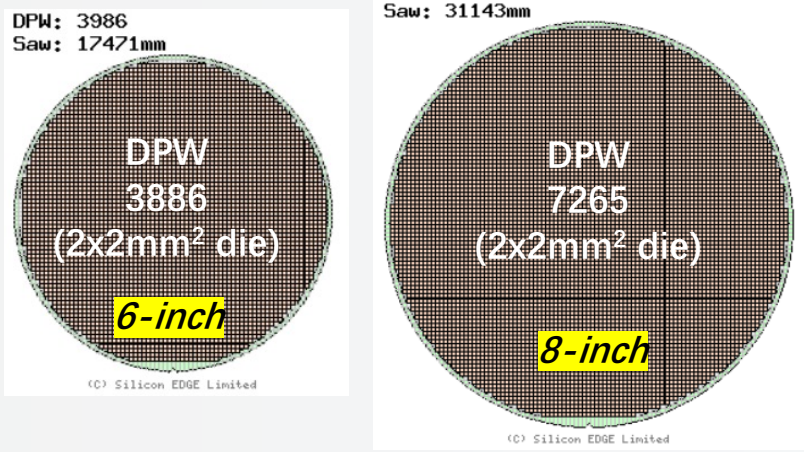
Economy of scale & Integrated Device Manufacture (IDM) model



~35 soccer fields

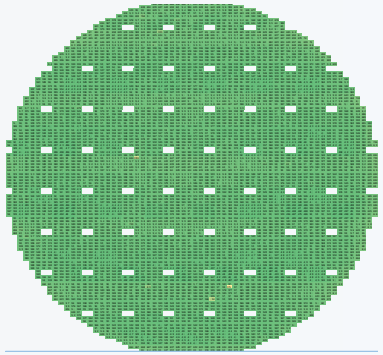
1600 engineers (300 R&D)
700+ patents

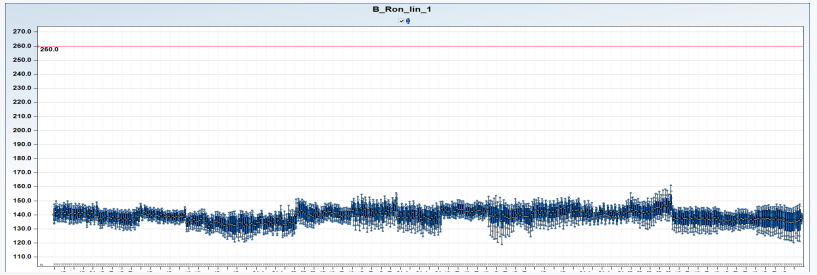
8-inch GaN-on-Si wafers
(~2x more dies than 6-inch)



~1.8x more dies per wafer (DPW)

High yield





Why are some companies holding back from moving into GaN?

- ~~**Price perception:** GaN power devices are 2x or 3x more expensive than a Si power device~~

InnoGaN is price competitive with Silicon
(plus with GaN you save cost on the system solution that is also smaller and more efficient than with silicon.)

- **Reliability perception**: GaN is a new technology, and its reliability is questionable

Reliability of GaN power devices

GaN tech is not new: they have been developed and studied for the past for 15-20 years.

Qualification standards:

- Must do: JEDEC tests for power devices.
- **JEDEC JEP180: specific for GaN**
  - Devices are stressed under switching stress (mimic real application usage)

We also do some extras:

- Test to failure and lifetime extrapolation
  - **HTGB**: beyond max gate specs
  - **HTRB**: beyond max off-state drain voltage specs

JEDEC for GaN

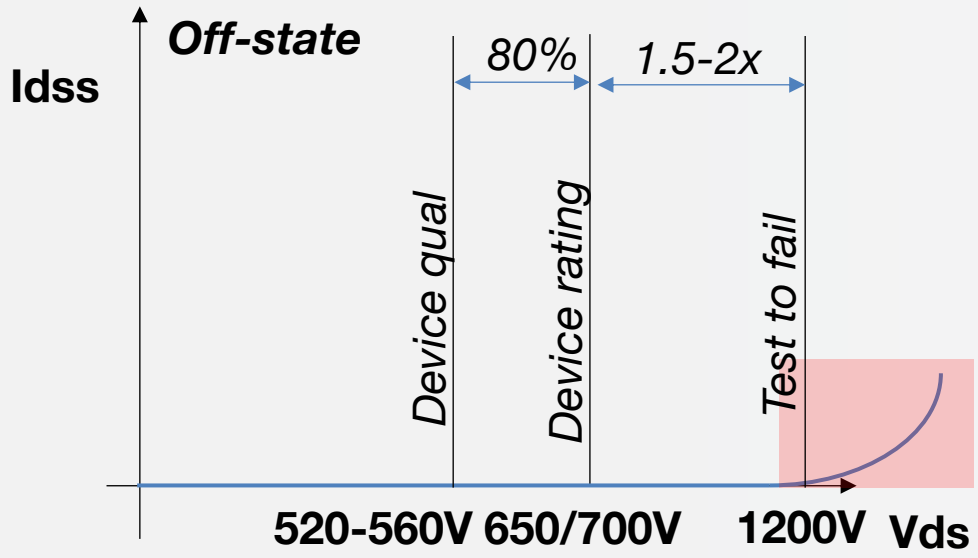
Component level	Established framework for Si qualification and reliability	**JESD47, AEC-Q100, JEP122**
	GaN Failure mechanisms, lifetime extrapolation	**JEP122, JEP180**, literature
Power-supply level	Switching reliability for power management usage of GaN	**JEP180:** Switching Reliability Evaluation for GaN Power Devices
	GaN-specific test methods	**JEP173:** Dynamic ON-Resistance Test Method **JEP182:** : Continuous Switching Test Method
	Extreme operation (Lightning surge, short circuit)	**IEC 61000-4-5, VDE0884-11**

Innoscience's qualification

Qualification Items		
Category	**Test**	**Reference**
Chip Related Items	HTRB	JESD22-A108
	HTGB	JESD22-A108
	HBM	ESDA/JEDEC JS-001
	CDM	ESDA/JEDEC JS-002
Package Related Items	PC	J-STD-020
	H³TRB	JESD22-A101
	HAST	JESD22-A110
	TC	JESD22-A104
	MSL3	J-STD-020
System Related Items	DHTOL	JEP180

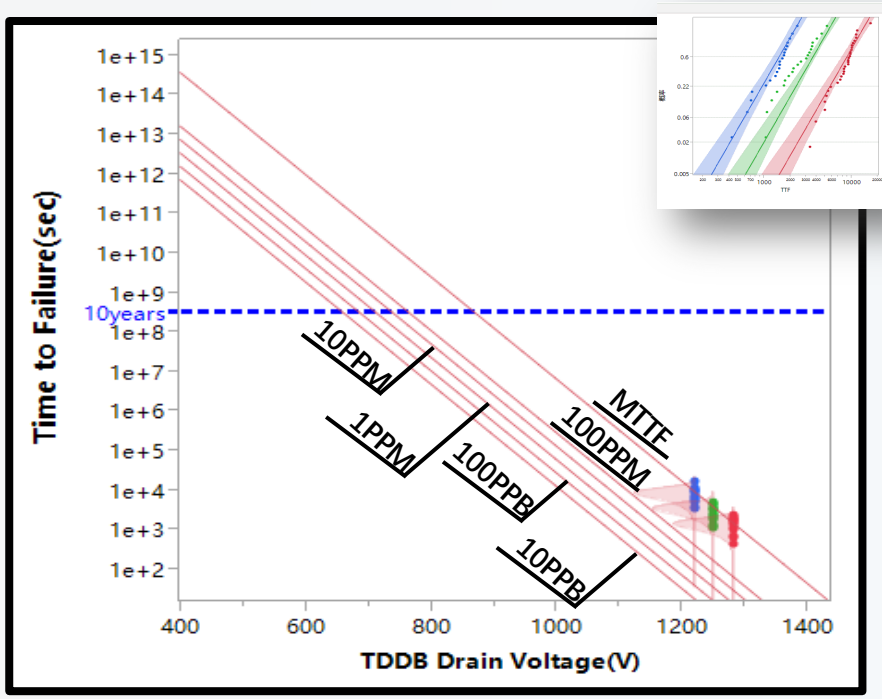
source: JEDEC, JEDEC JEP 180 and S. Bahl, white paper, https://www.ti.com/lit/wp/snoaa68/snoaa68.pdf

HTRB test to bring device to failure in off-state at high Vds

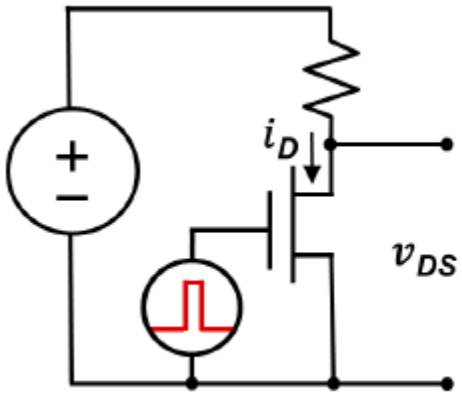


10ppb well above 10 years lifetime at typical max operating voltage.

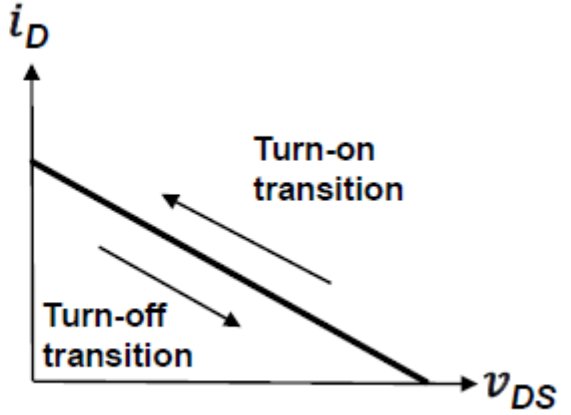
Lifetime evaluation			
Ppm/ppb	**Vop@520V,Tj150℃ (Years)**	**Vop@560V,Tj150℃ (Years)**	**Vop@700V, Tj150℃ (Years)**
10ppm	6500	1970	29
1ppm	2980	900	14
100ppb	1360	410	6
10ppb	**620**	**190**	**2.9**

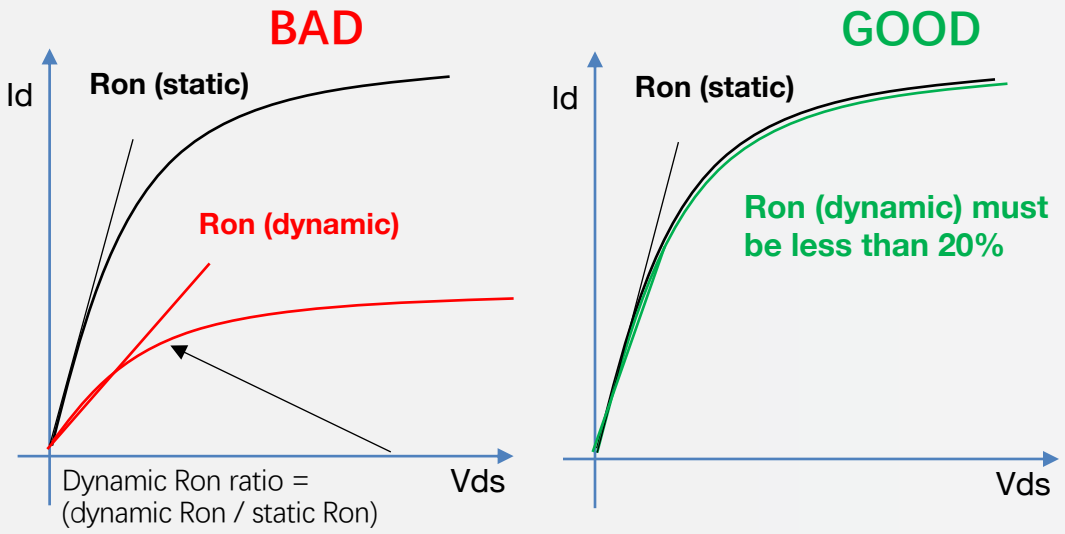


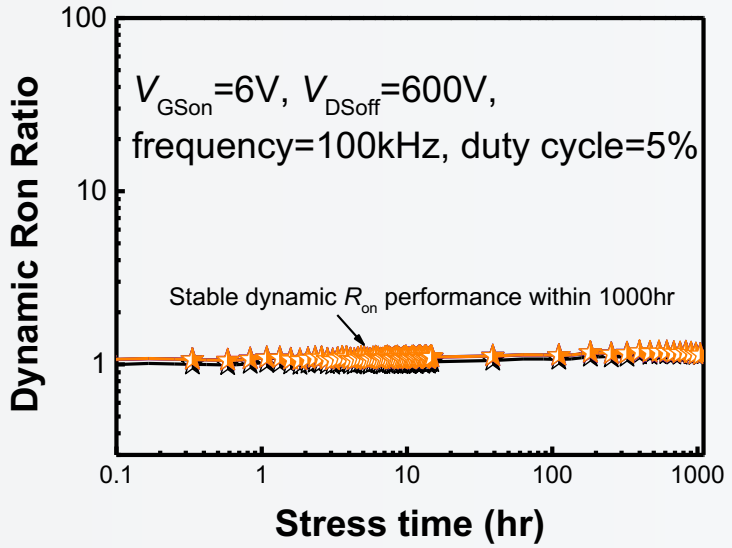
Following JEDEC JEP180: Switching tests specific for GaN



Switching locus curve for resistive switching







Stable Dynamic Ron during 1000 hrs resistive load switching test at 600V

Source:
JEDEC JEP180
S. Bahl, GaN power devices and applications reliability, Short courses Power America, Nov 2021.

Why are some companies holding back from moving into GaN?

- ~~**Price perception:** GaN power devices are 2x or 3x more expensive than a Si power device~~

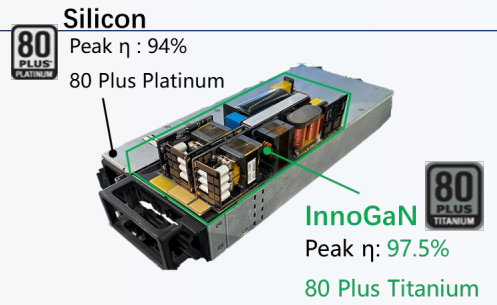
InnoGaN is price competitive with Silicon
(plus with GaN you save cost on the system solution that is also smaller and more efficient than with silicon)

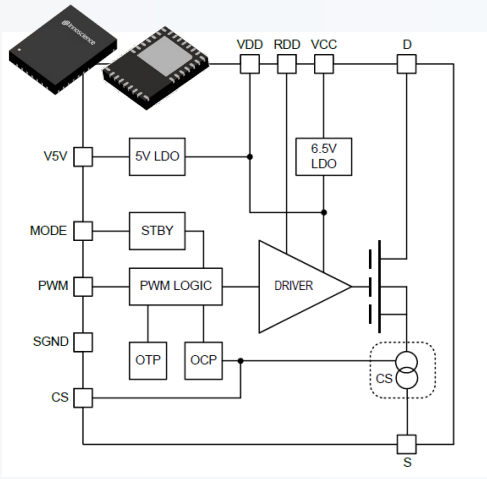
- ~~**Reliability perception**: GaN is a new technology, and its reliability is questionable~~

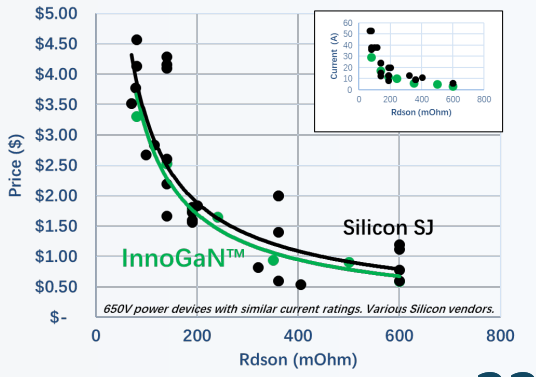
Innoscience GaN (InnoGaN) is reliable

Conclusion

- **InnoGaN makes any power converter system smaller, thinner and more efficient**
- **Innoscience is one-stop shop for e-mode GaN devices**
  - wide voltage range: LV (30V-40V), MV (80V-150V) and HV (650V/700V)
  - Discrete and Integrated solutions
  - GaN gate driver
  - Largest GaN power device manufacturing capacity
- **New Innoscience Integrated solution (SolidGaN™)**
  - Driver + GaN + protection and other features
  - Easy to use and solder
- **InnoGaN is price competitive with Silicon**
- **InnoGaN is reliable**







Thank you

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