

Gallium Nitride Power Transistors in the EV World
June 2017

GaN Systems - Industry leading GaN transistor supplier





Agenda



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A high-level view – we'll go through it quickly

Why GaN? Where is GaN technology at today? Where is GaN technology being used today? Where is GaN being used in vehicle electrification? Conclusion

Agenda



Why GaN?

Where is GaN technology at today?

Why use GaN?



Better Transistors....

- Unrivalled switching performance
- 13X better than best silicon
- 6X better that best SiC

....Better Power Electronics

- More Efficient
- Smaller / Lighter
- Lower cost

- (cuts losses 50-90%)
- (1/4 the weight)
- (30% savings)

Same PSU with GaN





Power Supply with Silicon



How long has it been around?

A brief history of GaN

•	2004	Commercial introduction of first GaN RF transistors		
•	2008	First shipments of 100V GaN power transistors		
		 Enhancement mode – behave like better MOSFETs 		
		 Manufactured in silicon foundry in a low-cost process 		
•	2012	First shipments of 600/650V GaN power transistors		
•	2013	First GaN automotive projects start in Asia		
•	2014	First shipment of GaN Systems 100V and 650V GaNpx parts,		
		(available through distribution)		
		First GaN automotive projects start in EU/USA		
•	2015	Some GaN parts lower price than silicon parts for the first time		
•	2020	Job#1 for first volume production cars with GaN in electronics		
•	2015 2020	Some GaN parts lower price than silicon parts for the first tim Job#1 for first volume production cars with GaN in electronics		

How do Silicon and GaN and SiC compete?



(Source: GaN and SiC for power electronics applications report, Yole Développement, July 2015)



Silicon		Gallium Nitride		Silicon Carbide			
<100V	100V	650V 1	.2kV	1.7kV	3.3kV	6.5kV +	

Technologies are largely complementary and will continue to coexist

GaN vs SiC example?



1kW Synchronous buck DC/DC systems (400-200 V, 200 kHz, Tamb=25°C)





GaN is more efficient = higher density

GaN runs cooler = better reliability

Can you reduce cost with GaN?



GaN design results - example

- 50% reduction in losses
- 20-30% size decrease
- 5-15% solution cost decrease

 Most customers break even or save cost at the system level when switching to GaN Systems devices



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What will GaN parts cost in future?



- Smaller die, simpler manufacturing process than SJ MOSFET
- Price per amp converging with silicon
- Same cost as silicon, small premium on price for huge performance benefits
 - Price gap getting narrower, Performance gap getting wider









Where is GaN technology being used today?

Examples

SolPad Mobile

- Solar panel plus storage plus inverter
 - 600Wh storage, 1kW output
- Targeted at consumers
- Extremely compact power electronics
- No heatsink
- Tight cost constraints

Solbgo





Wireless Power

- Consumer and industrial applications
- High frequency: 6.78MHz and 13.54MHz
- Higher power: 30W to 3kW
- Longer range
- Lower cost amplifiers with GaN





G-Philos home battery energy storage system (ESS)

- Consumer product for Asian markets
- 25% reduction in power loss
- >30% size reduction
- 50% weight reduction
- Eliminated cooling fan

hilos





Yaskawa Industrial Servos

- Up to 3kW servo drives
- Higher switching frequency
- Higher efficiency
- Minimal heat no heatsink
- Smaller size 50% reduction











Tactical Power System

- 94-98% efficient
- IP67 sealed
- Passive cooling
- Used in extreme environments by military
 - Left in deserts
 - Dropped out of planes
- Commended for robustness by customers

Where else is GaN being used?











Power Adapters – 50% size/weight Motor Drives for appliances TVs – thinner power supplies

Enterprise





48V datacenters – DC-DC AC-DC PSUs UPS - Efficiency / power density

Industrial and Grid





Industrial Motor and Servo Drives Energy Storage Solar Inverters - Efficiency / power density / cost

... and Transportation

Why are these other markets important?



Consumer market gives production volume

- Economies of scale = lower cost
- Optimized manufacturing process with high Cpk
- Field hours for reliability data
- Statement from leading Tier 1
 - "the best thing you can do for us is make millions of parts in consumer applications"

Enterprise, Grid and Military proves reliability

- Extreme environmental stress
- High reliability/availability requirements
- Enterprise and Grid needs automotive spec (but won't pay for it)





Where is GaN being used in vehicle electrification?

Electrification – Optimization and Cost Down



EV / PHEV



48V Mild Hybrid



Typical Applications

- DC/DC Converter
- On-Board Charger
- Traction Inverter

Using GaN transistors reduces

• Size, Weight and BoM cost

Typical Applications

- BSG/ISG Inverter
- DC/DC Converter

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48V 12kW Mild Hybrid Inverter





Performance results

- 1/5th the size and 1/3rd the weight
- 12% reduction in power losses
- Air-cooled form factor
- 20% lower BOM cost
- OEM/Tier 1s are asking for 48V GaN solutions
 - Packaging pressure



	GaN Systems	Legacy
Transistor	GS61008P	Silicon MOSFET
FOM (nC*mΩ)	84	263
Power Density	3.03 kW/L	0.57 kW/L
Efficiency	92%	91%

On-Board EV Chargers





Traction Inverters







Why GaN?

- Where is GaN technology at today?
- Where is GaN technology being used today?
- Where is GaN being used in vehicle electrification?

Conclusion

Conclusion – good news



- GaN's benefits enable BOM savings and significant size/weight savings
- Don't plan for drop-in replacement of Silicon transistors – you'll miss out on the advantages

System design is key to GaN's performance

- There are now well established tools and techniques to take *full* advantage of GaN
- Happy to help you learn how...

5x smaller 3x lighter 20% lower cost

Silicon

Tomorrow's power today[™]



