

GaN discrete devices for portable and computing applications

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- LV GaN: Markets, requirements and value proposition
- Innoscience introduction
- Our LV technology and differentiators
- Manufacturing data
- Application examples and benefits
- Concluding remarks

GaN in Power supply – dominated by fast chargers today

650V GaN devices inside

with Innoscience

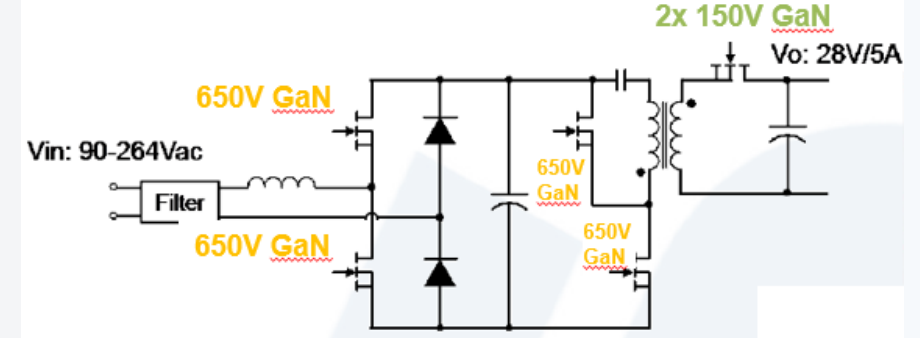
650V and 150V GaN devices inside

July'22

semiconductorTODAY
COMPOUNDS & ADVANCED SILICON

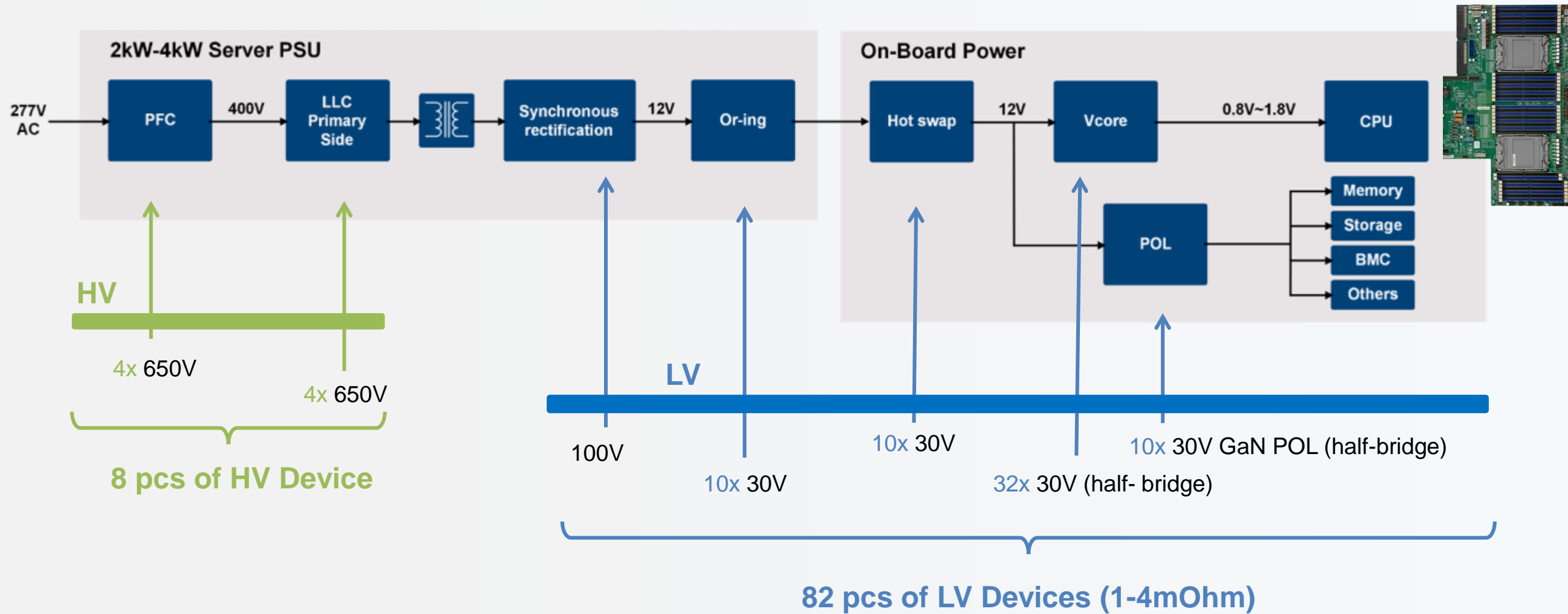
“By using all GaN FET technology, each charger in **Anker’s** new series is powered by two **Innoscience GaN** power chips on both the **AC** side and **DC** side (an all-GaN solution)”

● CRM Totem Pole PFC + AHB

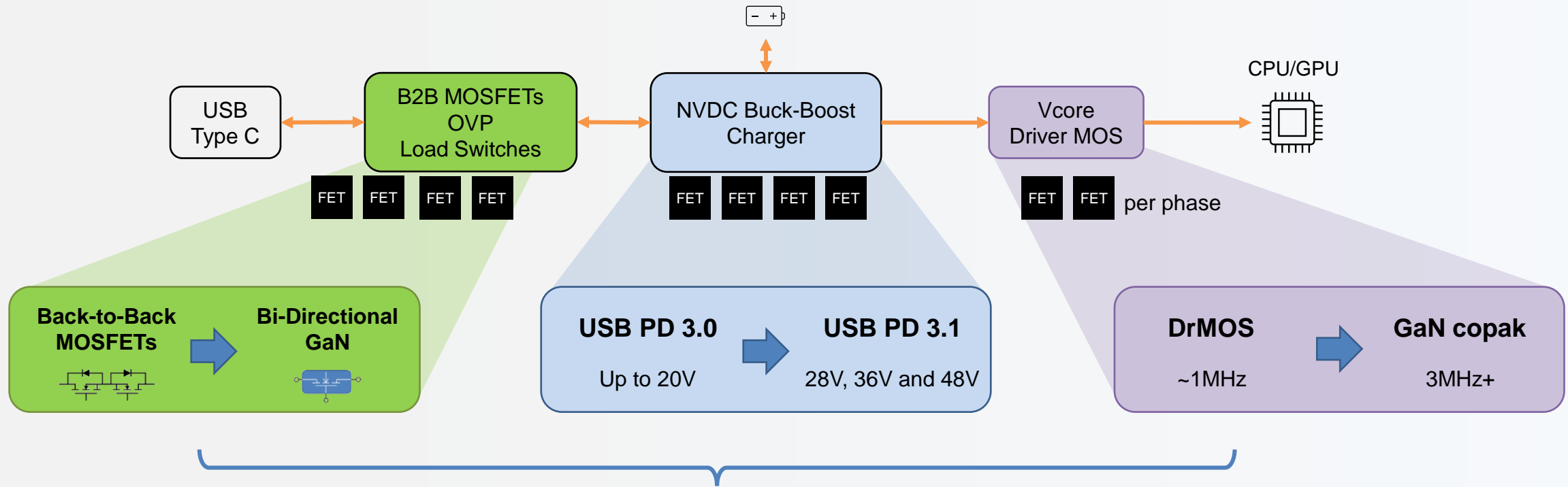


Source: Yole report, “GaN Power 2021: Epitaxy, Devices, Applications and Technology Trends”

Power supply Servers – big opportunity for LV GaN



Power supply computing/mobile – LV GaN opportunity



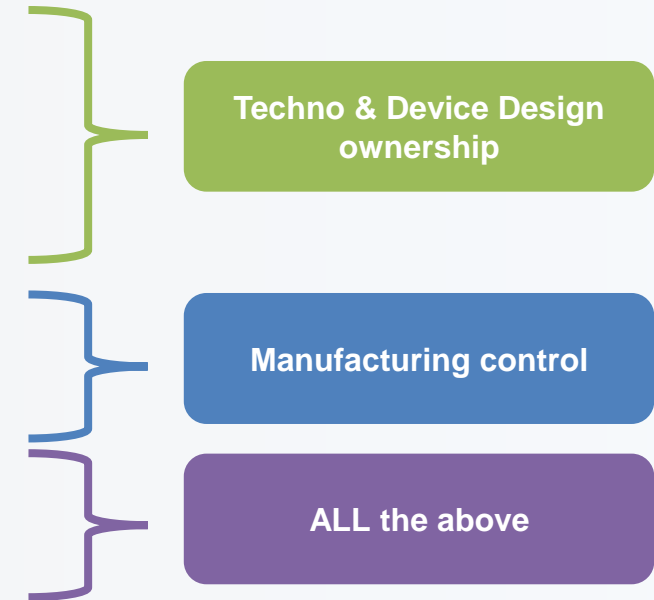
10+ pcs of LV Devices (<4mOhm)

Key differentiators:

- Footprint
- Lower Ron
- Less self-heating
- Footprint
- Efficiency at higher freq.
- Less self-heating
- Footprint
- Higher efficiency
- Higher power density

How to capitalize on the big opportunity in LV GaN?

- Power supply market is a great business opportunity for low voltage GaN
- The key enablers for GaN to enter and replace Si-MOS in low voltage
 - Performance optimized 30V, 40V and up to 100V devices
 - Breakthrough in reducing of IGSS and IDSS leakage
 - Innovative device concepts (bi-directional switches)
 - Cost effective manufacturing
 - High volume capacity and fast ramp-up support
 - High yield and low PPM
 - Reliability and application support



Innoscience introduction

World's Leading GaN Manufacturer and Solution Provider



Founded

Dec. 2015



Employees

1600+



Global Patents

700+



Products

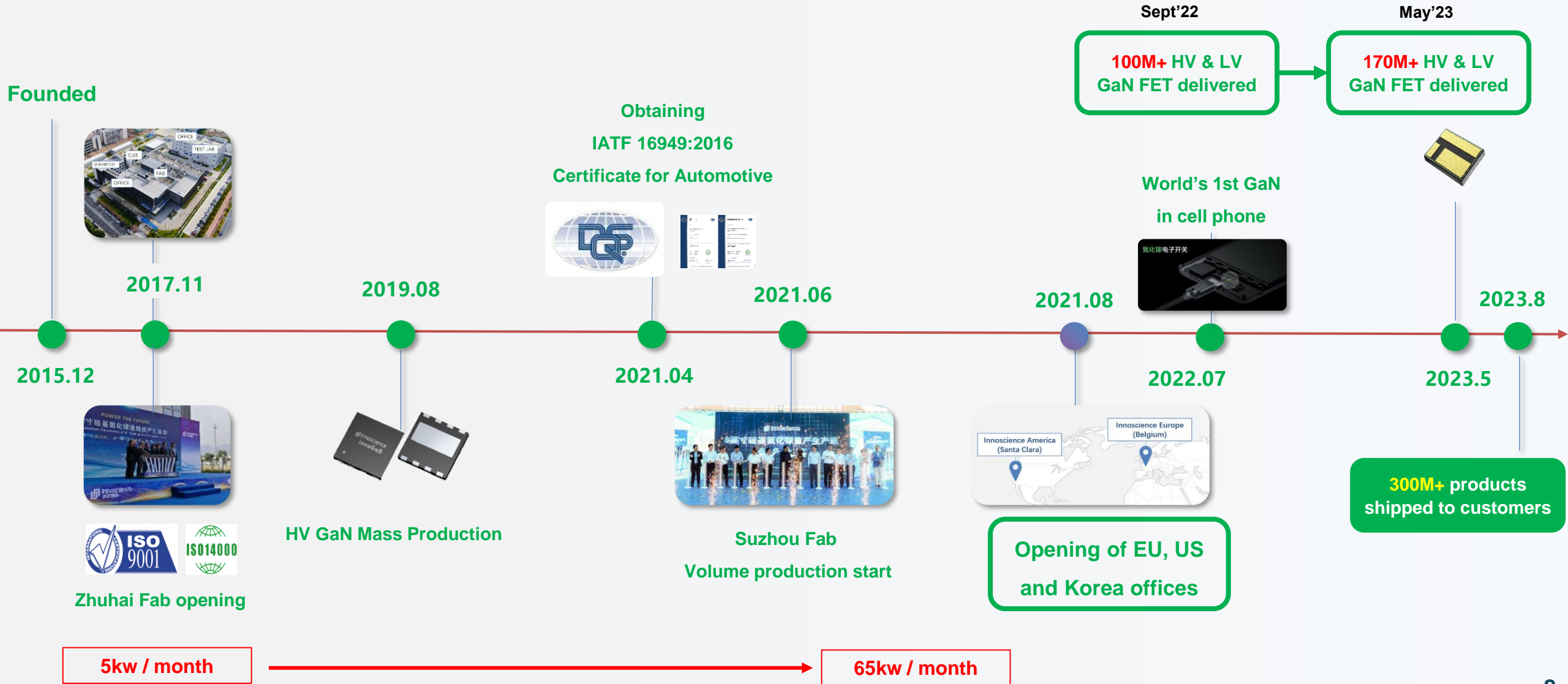
30V-700V GaN Devices

Wafer

Drivers



Innoscience – Major Milestones

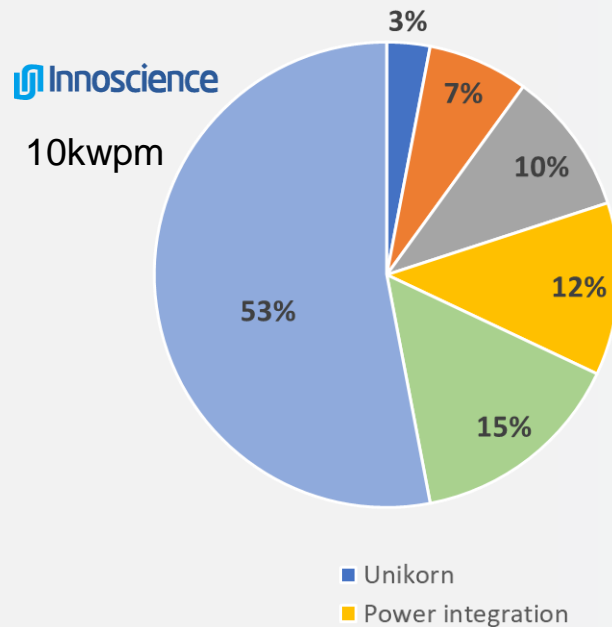


Innoscience manufacturing prowess

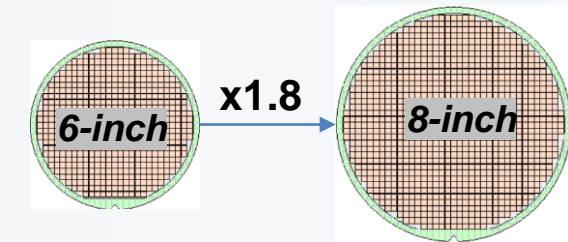
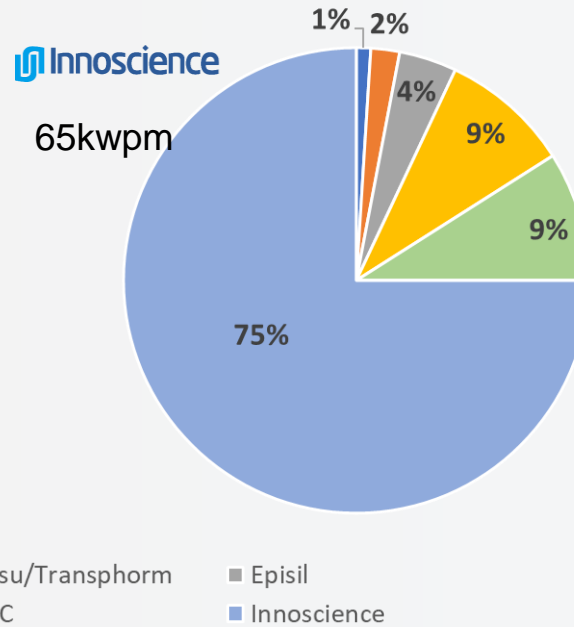
- 8-inch production fabs with high-throughput modern manufacturing tools
- Our GaN wafer capacity exceeds the rest of the world combined supply



GaN fab capacity: 2022



2025

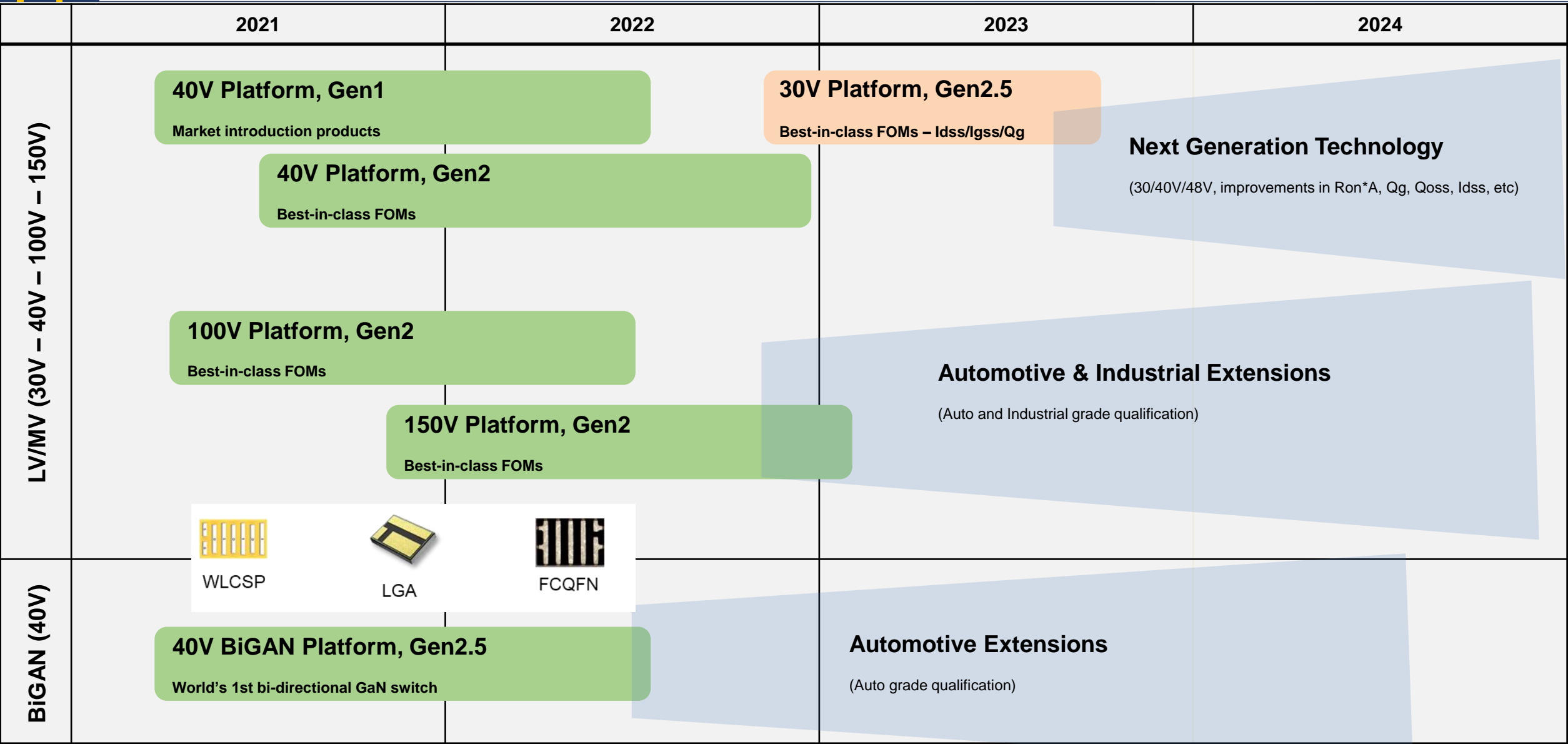


Superior cost productivity due to 8-inch vs. competition using 6-inch wafers

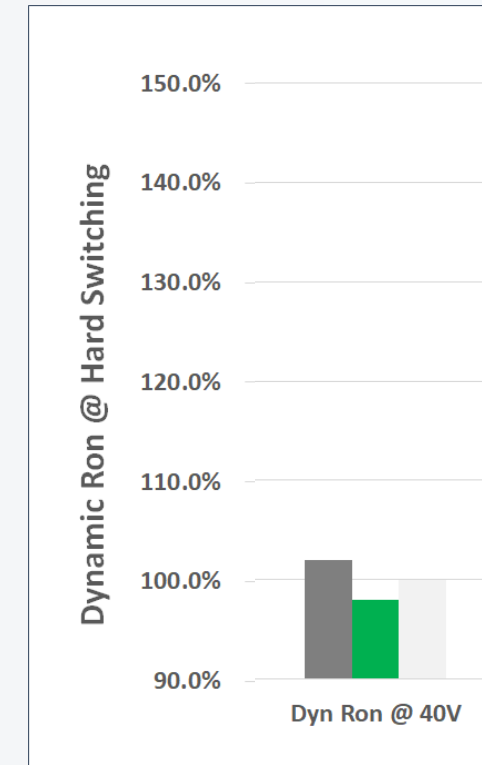
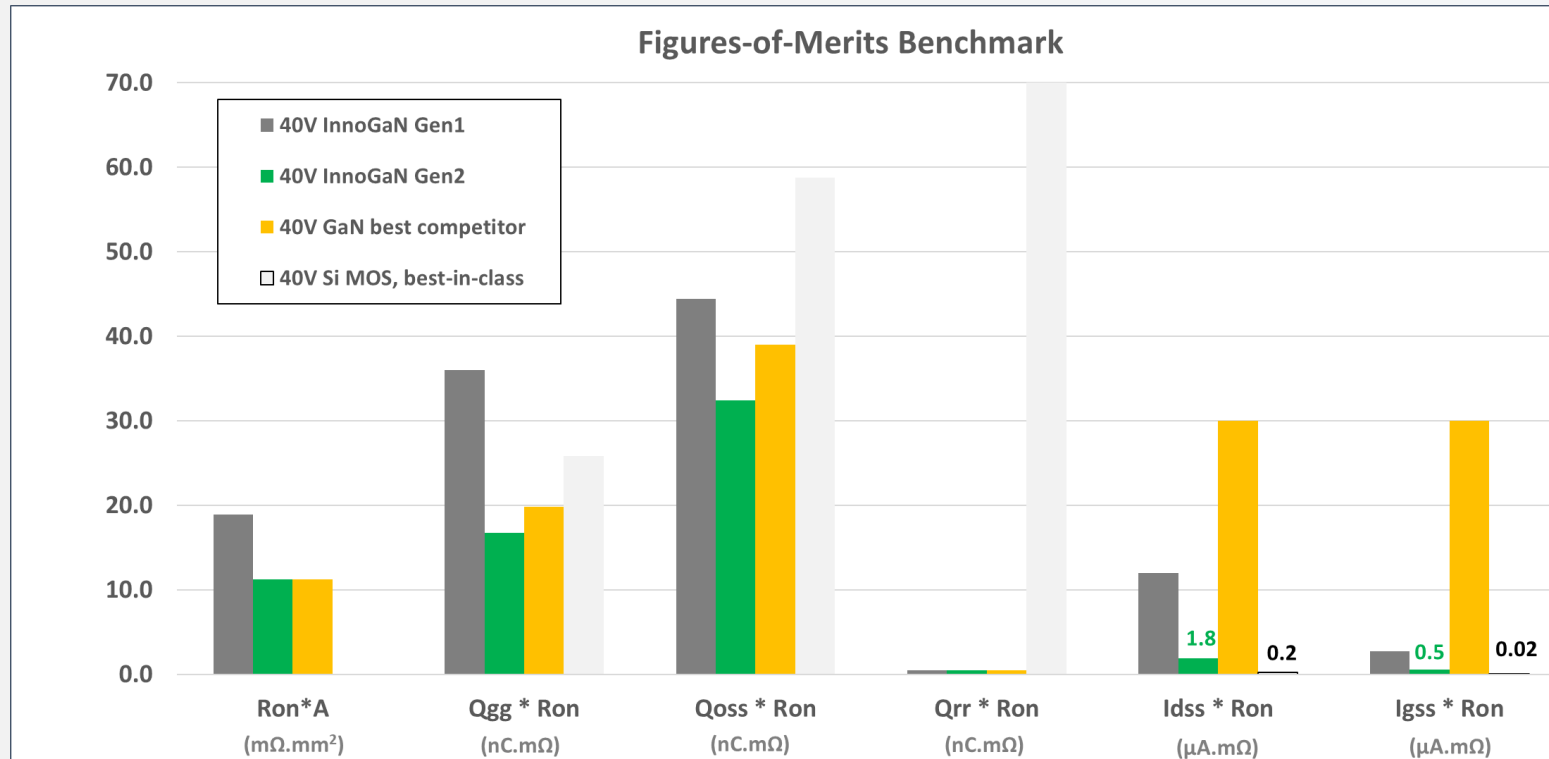
LV/MV GaN Technology Roadmap by Innoscience

Production

Pre-release



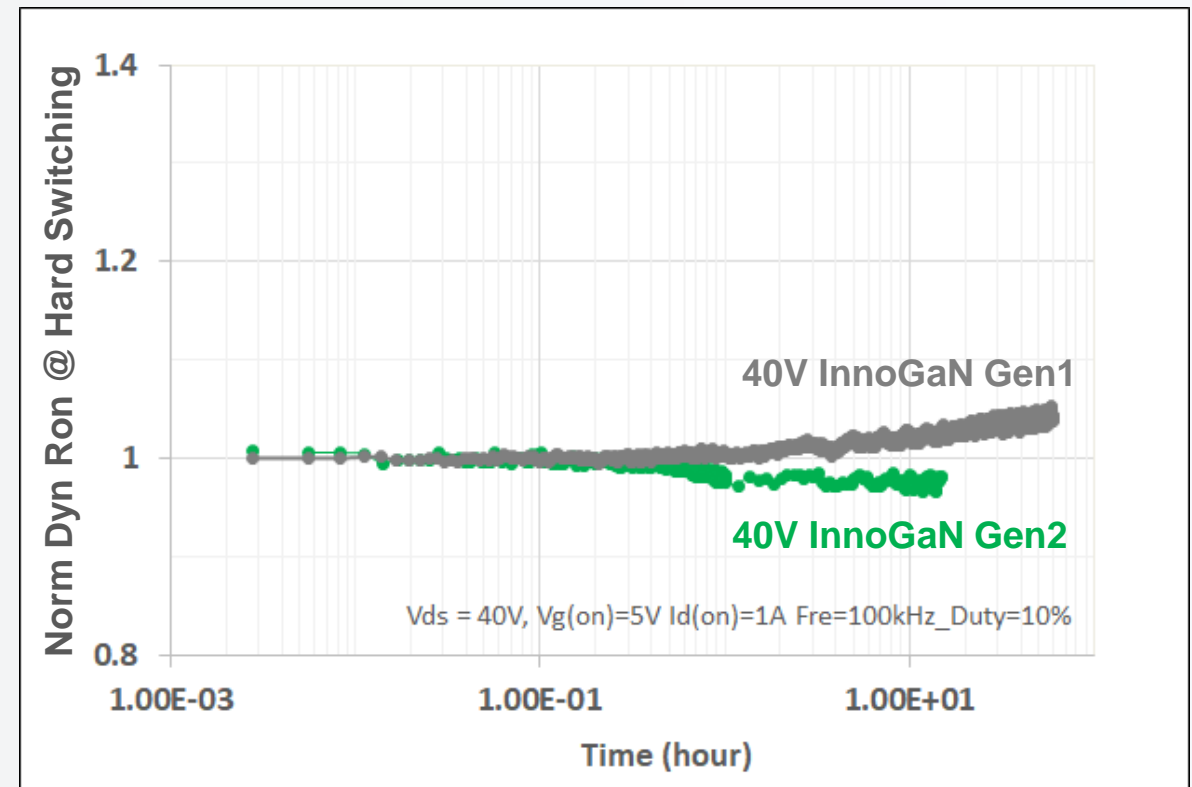
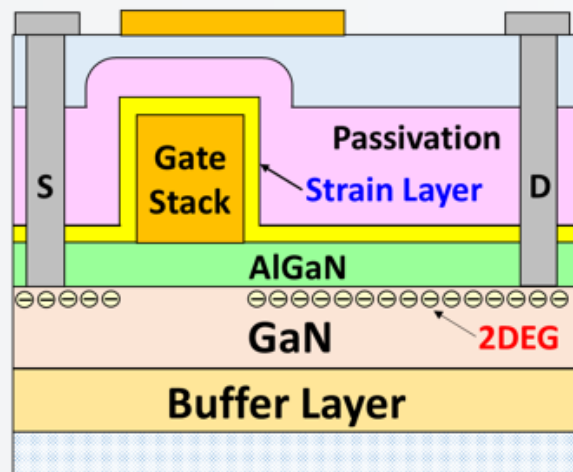
Innoscience vs. competitors in 40V range



- 40V Gen1 was a market introduction product
- 40V Gen2 is a best-in-class product
 - Leading our competitors in key performance figures
 - **Zero dynamic Ron** increase including under hard-switching conditions
 - **Low Idss** and **Igss** enable to enter mobile markets and direct-battery-connected applications

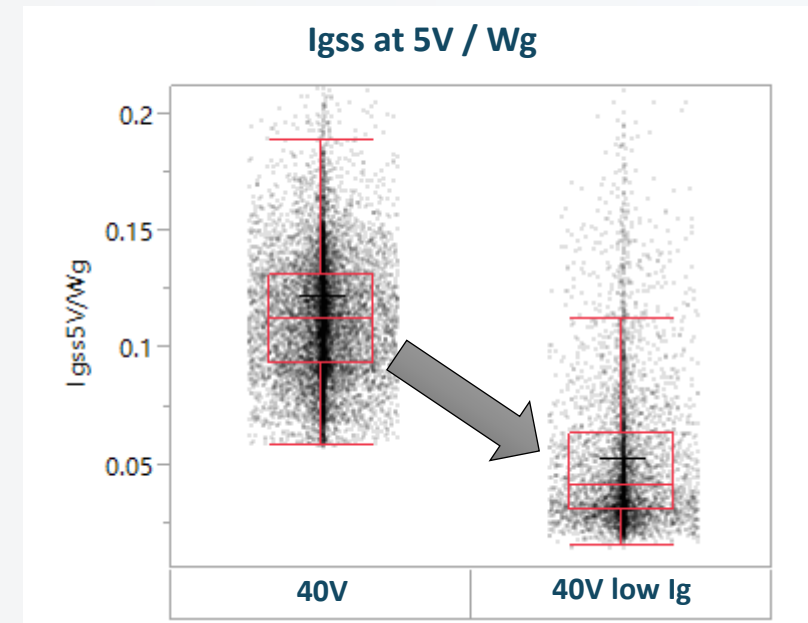
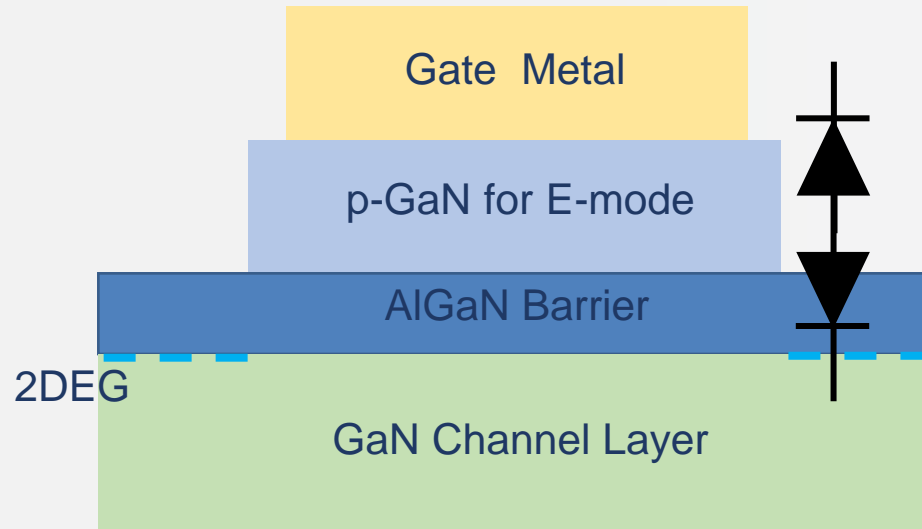
Examples of technology differentiations by Innoscience

- **Superior dynamic Ron capability (including hard-switching)** due to specially developed strain layer in combination with proprietary epitaxy
- Best-in-class **gate leakage current** due to gate module process
- Novel bi-directional device concept – 1st time right and 1st on market



Example: Gate leakage breakthrough on E-mode GaN

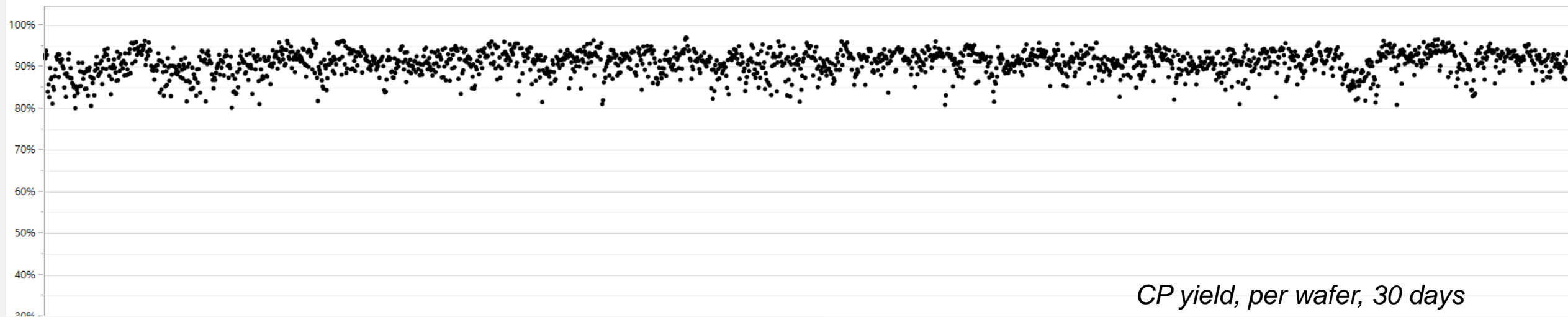
p-GaN HEMT Gate structure
(Back-to-back diodes in series)



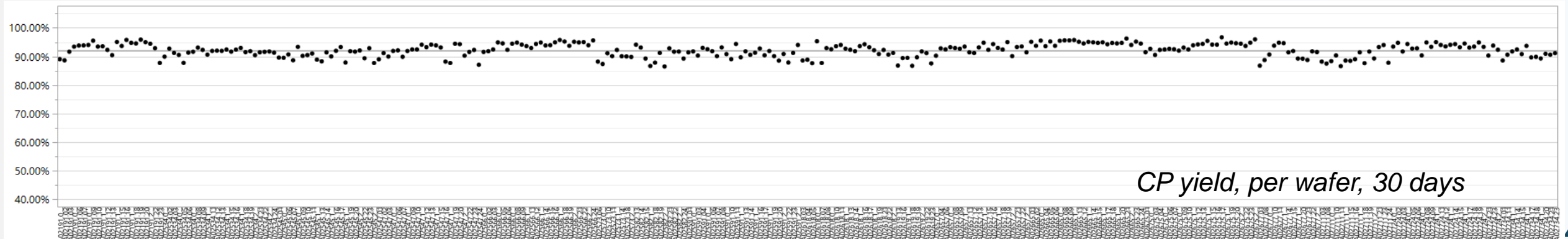
- Innoscience reduced the gate leakage by proprietary GaN epitaxial and process technology co-optimization
- Nearly 10x reduction of gate leakage, achieving $<3 \mu\text{A}$ at 85°C over the device lifetime making it suitable as a load switch inside smartphone

Technology maturity – volume production data

- 40V InnoGaN Gen1 → **90.7%** average CP yield

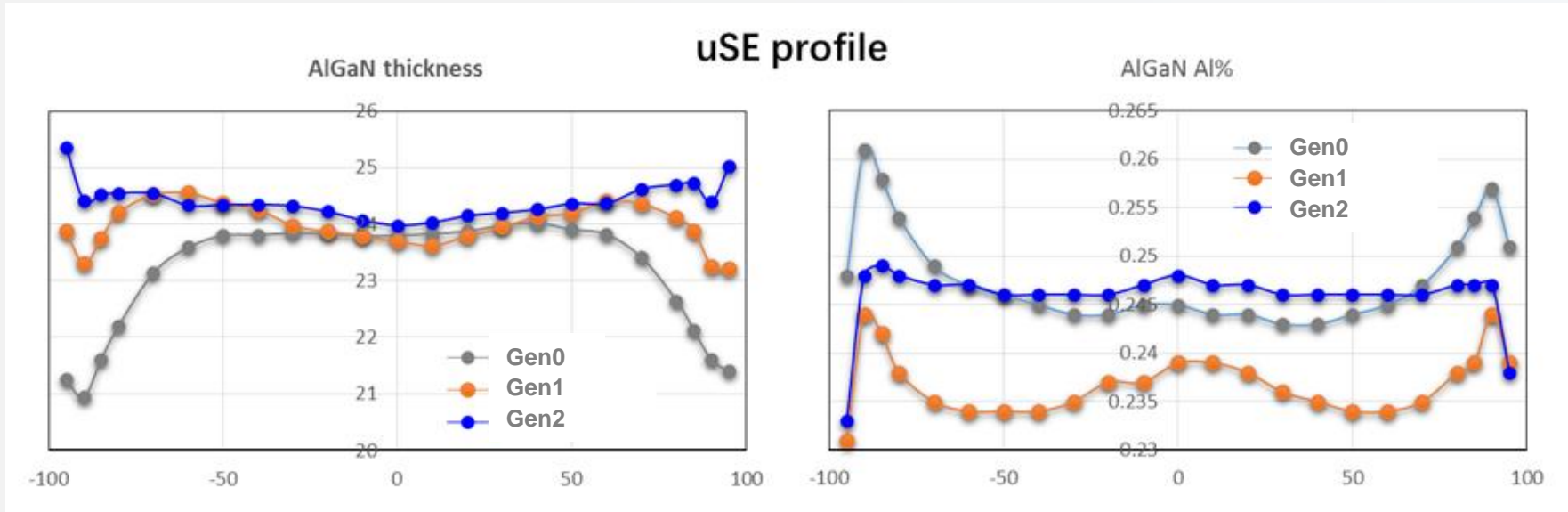


- 40V BiGaN Gen2.5 → **90.9%** average CP yield

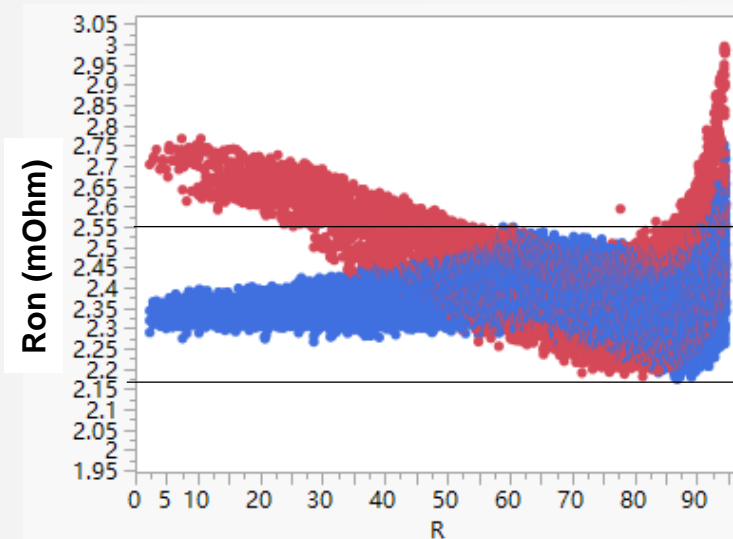
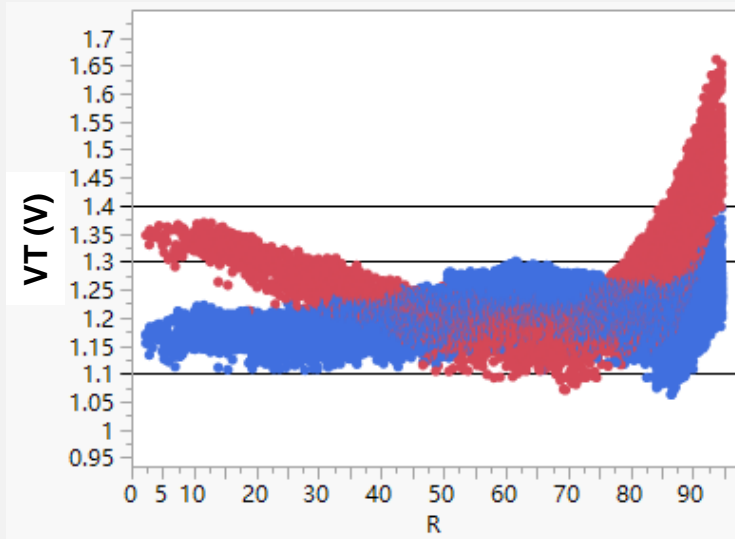


Epitaxy manufacturing control

- The control of AlGaN barrier determines uniformity of Ron, VT and other key device parameters



0-92 mm range	Gen2 EPI
AlGaN thickness	1 nm
Al%	< 1.0 %

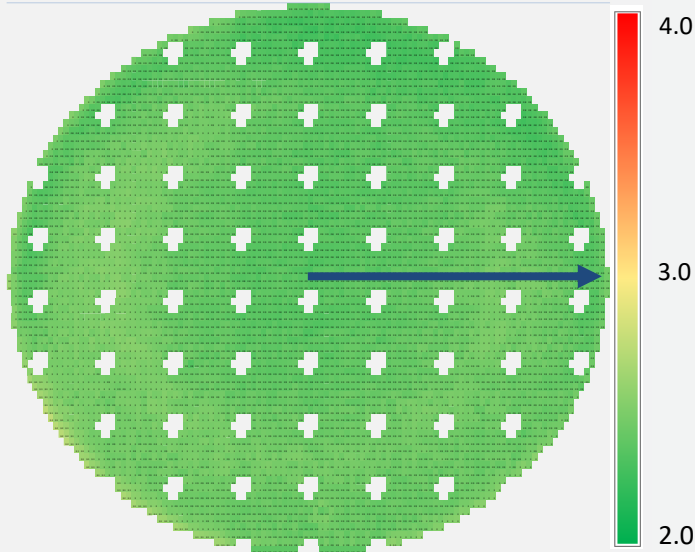


0-92 mm range	Gen2 EPI
VT	± 0.15 V
Ron	± 0.2 mOhm

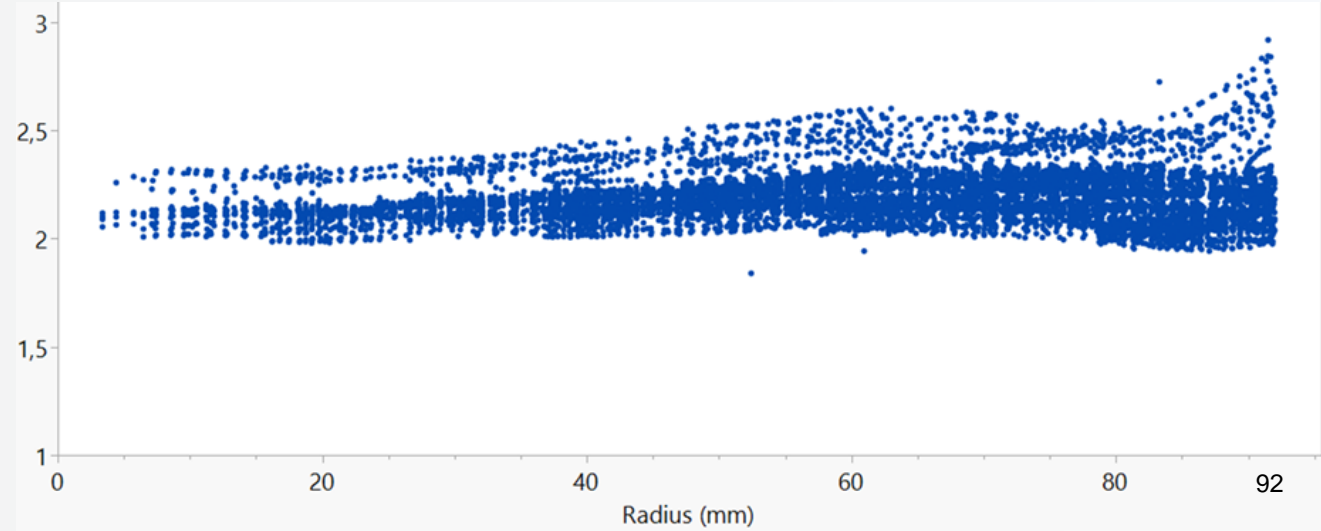
Manufacturing maturity – baseline & process corners

Tested: 1700 devices per wafer

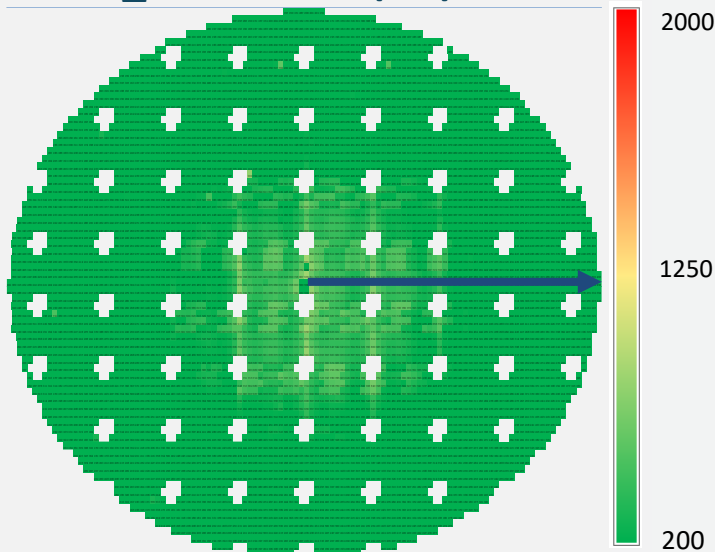
Ron at 25C (mΩ)



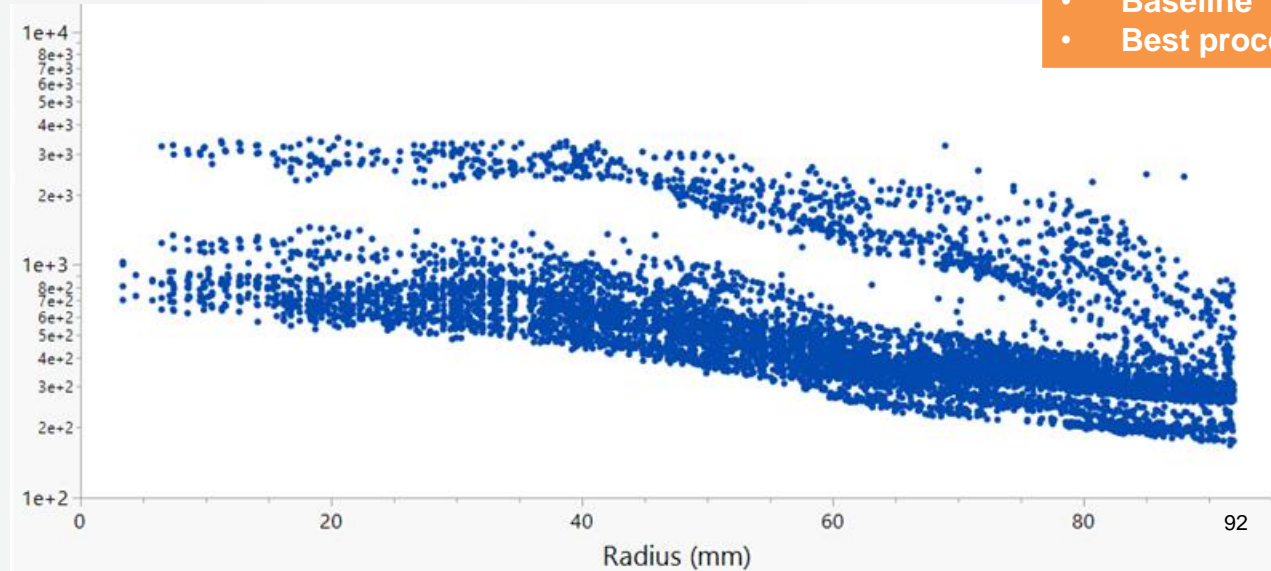
Ron at 25C (mΩ)



Idss_32V at 25C (nA)

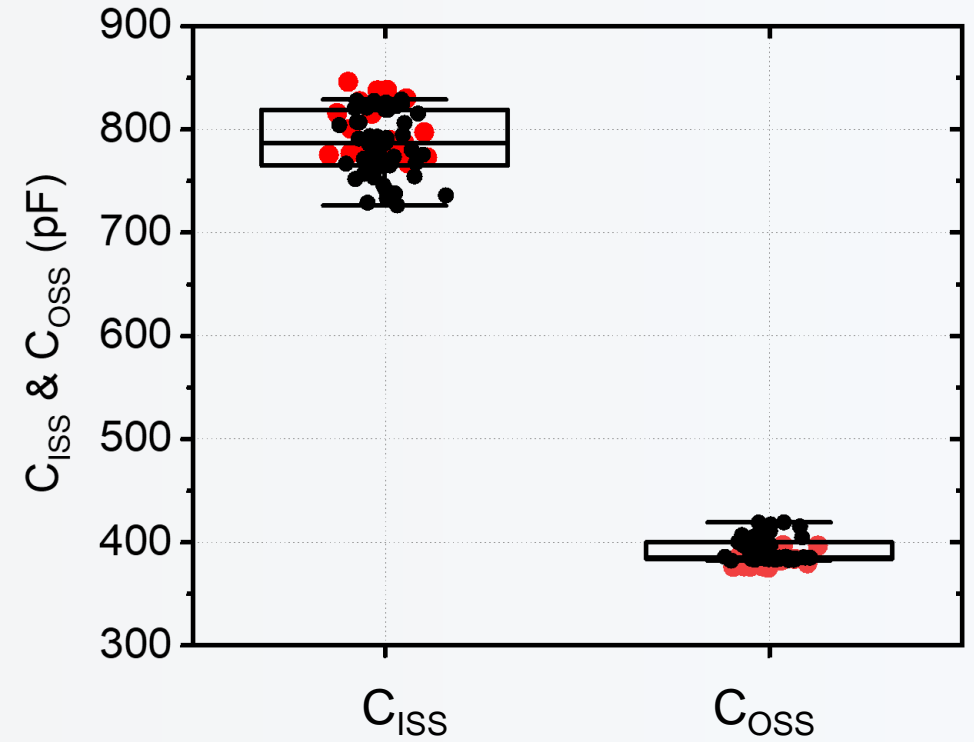
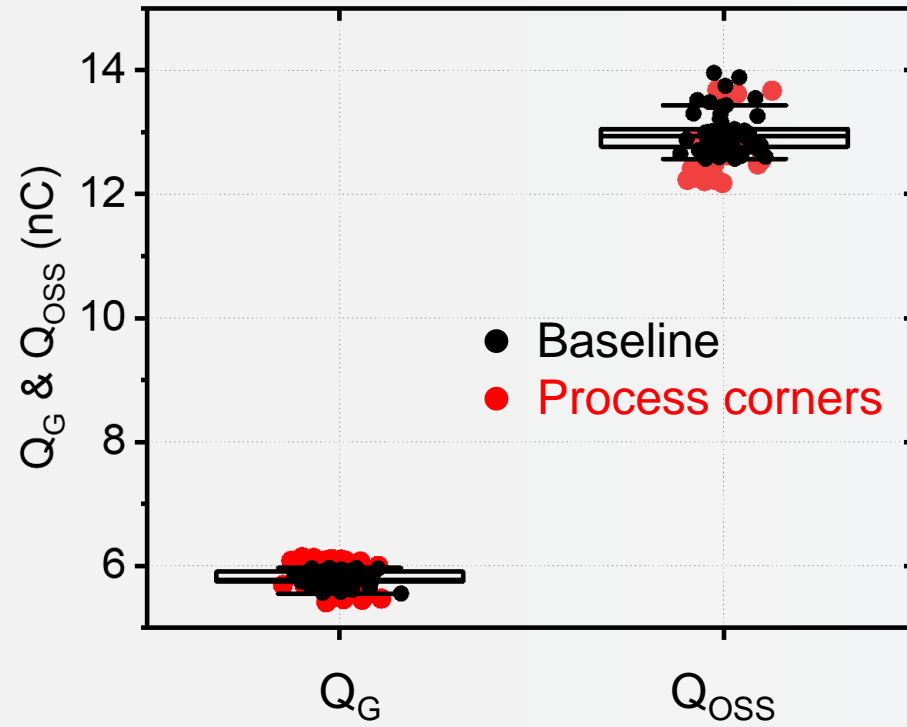


Idss_32V at 25C (nA)



- Worst process corner
- Baseline
- Best process corner

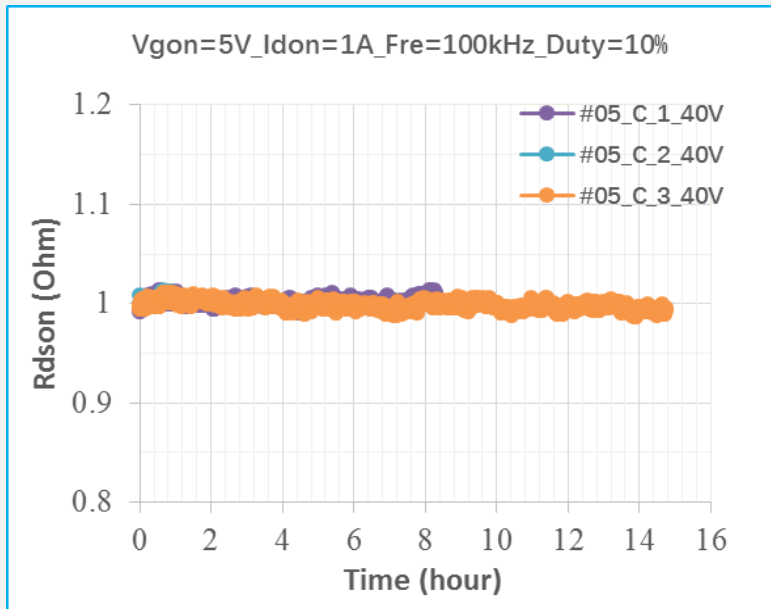
Switching parameters – baseline & process corners



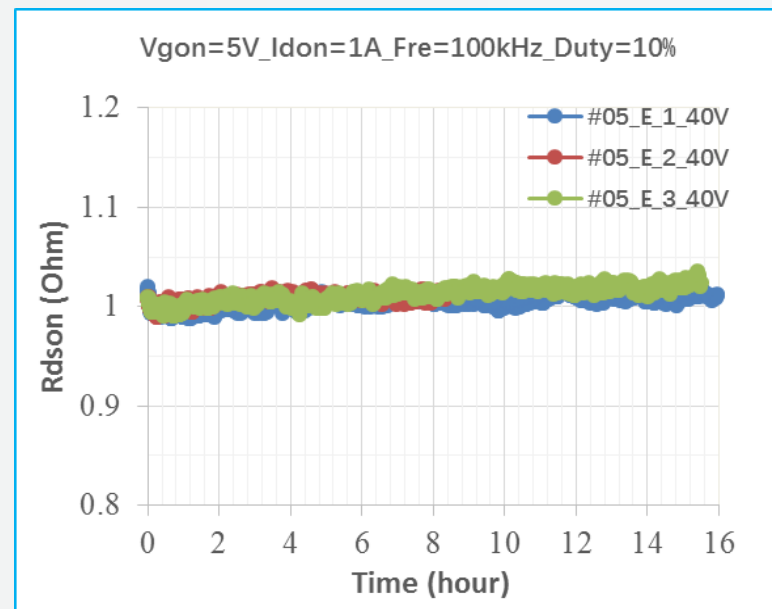
Dynamic Ron – hard switching conditions

Tested: 1700 devices per wafer

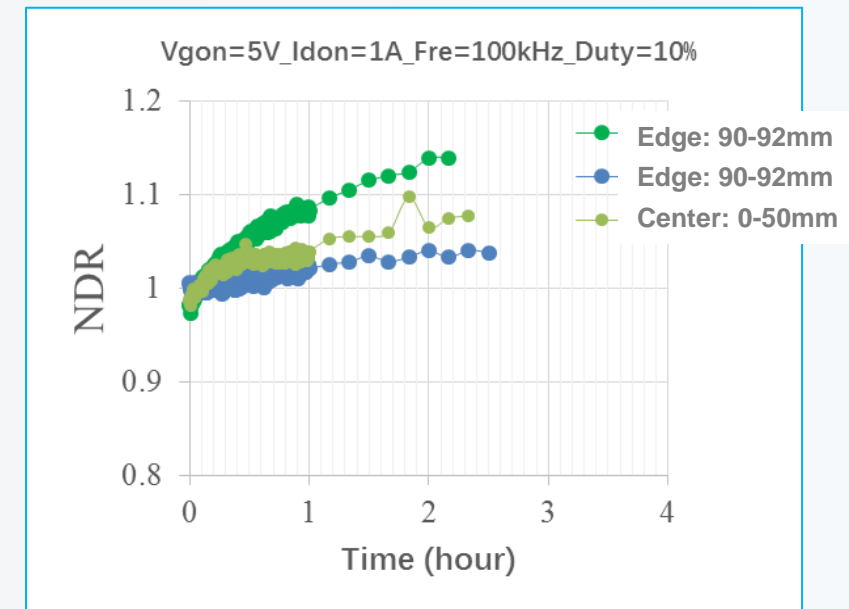
Wafer location: 0-50mm



Wafer location: 90-92 mm



Accelerated Vds=56V



Rated voltage and over-voltage capability

	40V Gen1, INN040LA015A
Qualification voltage (JEDEC, standard)	32V
Rated voltage	40V
Dynamic Ron guaranteed	40V
Repetitive unclamped inductive switching	58V <i>(fail at surge Vds >96V)</i>
Min guaranteed DC BVdss	60V
Typical DC BVdss 25C / 150C	72V / 69V

First GaN device inside the Smartphone (40V Bi-GaN)



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News

Bi-GaN bi-directional GaN HEMTs used inside smartphones

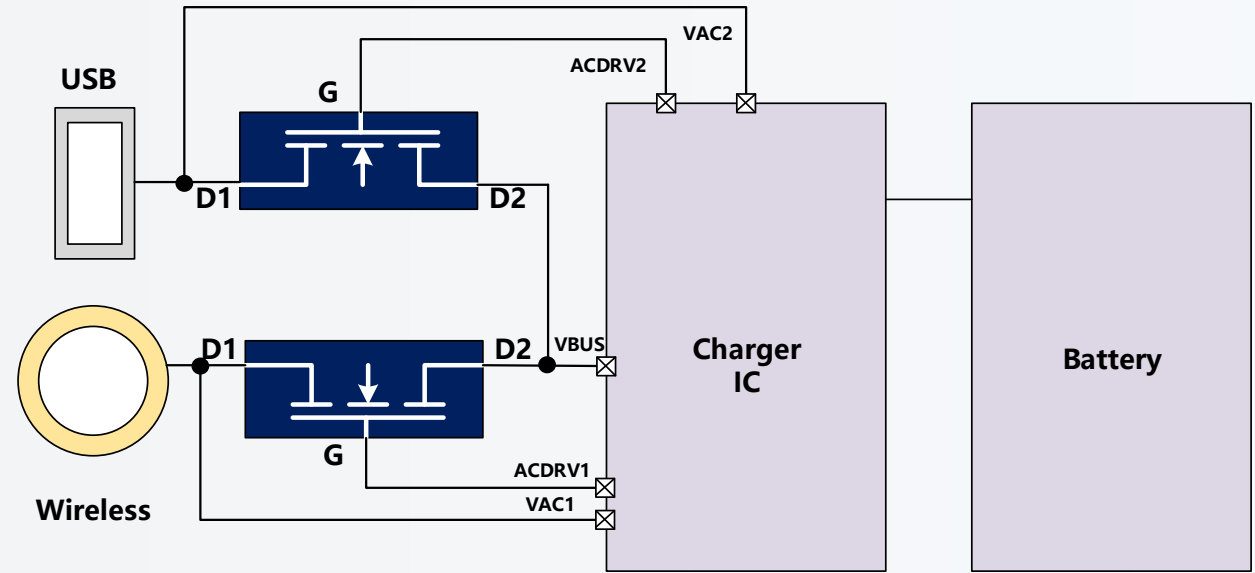
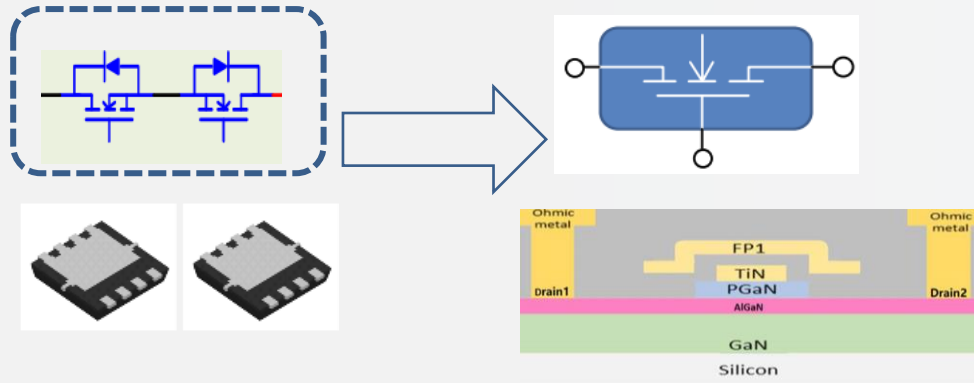
September 3, 2022 [Press Release](#)

Bi-GaN bi-directional GaN HEMTs save space and facilitate fast charging without suffering from reliability-limiting and potentially dangerous rises in temperature

Innoscience Technology, the company founded to create a global energy ecosystem based on high-performance, low-cost gallium-nitride-on-silicon (GaN-on-Si) power solutions, today announced the Bi-GaN series of bi-directional GaN HEMT devices that save space and facilitate fast charging without suffering from reliability-limiting and potentially dangerous rises in temperature that can sometimes be seen in traditional silicon devices. Innoscience has also revealed that leading consumer electronics and mobile communications company, OPPO, is using the new BiGaN devices inside its phone handset to control the battery's charging and discharging currents. This is the first time that such protection, based on GaN technology, has been included in the phone itself – previously the circuitry had to be incorporated inside the charger.

The World's 1st BiGaN in Mass Production

INN040W048A is Bi-directional switch as **OVP (Over Voltage Protection)** application in **Tier1 Smartphone OEMs** to help reduce heat and size

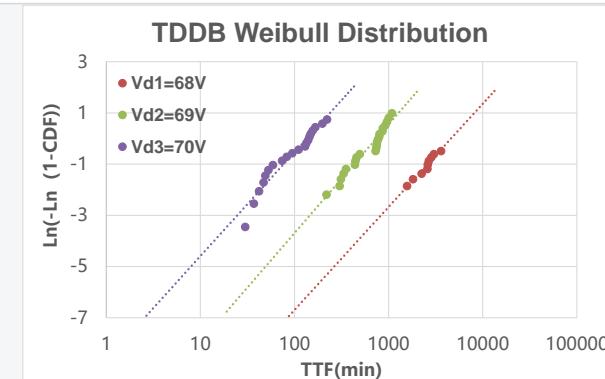
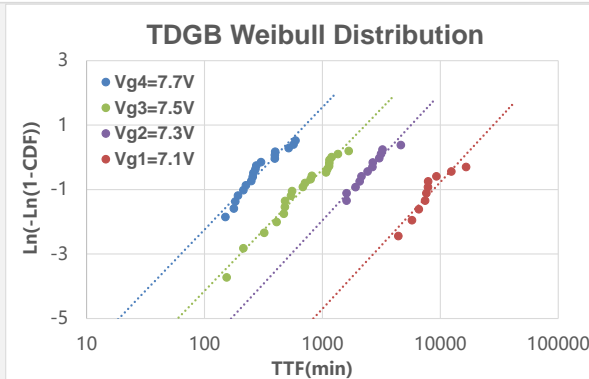
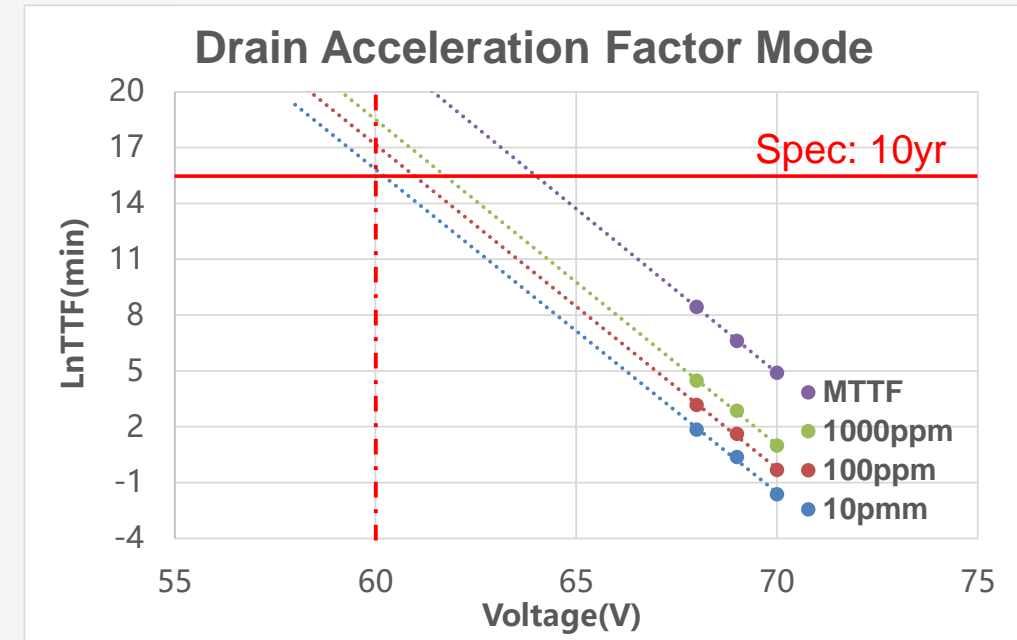
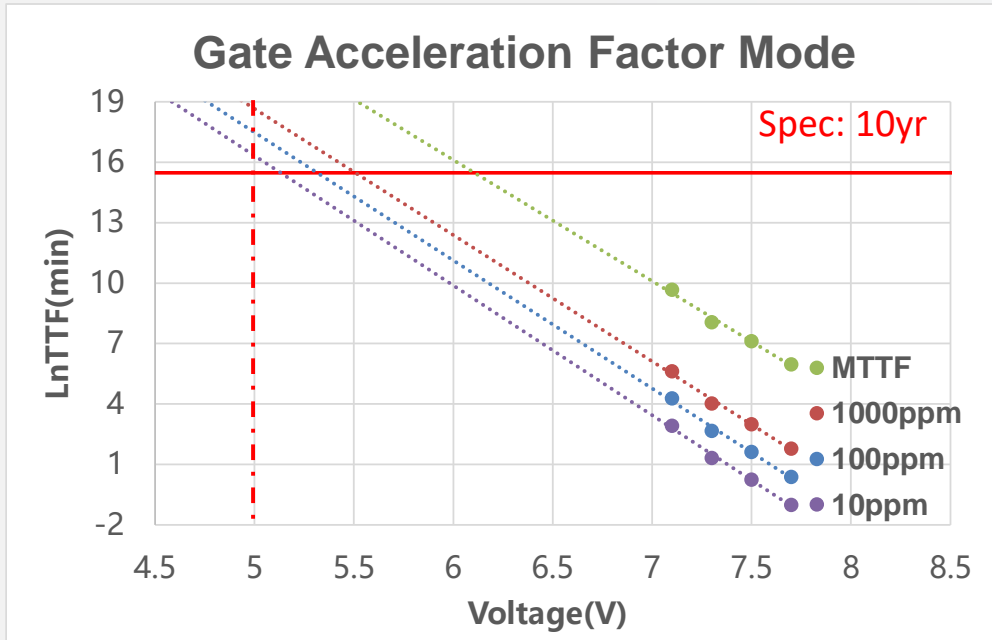


Parameters	Silicon solution	GaN competitor	INN040W048A
V_{DS} (V)	40V	40V	40V
# of Devices	2pcs	2pcs	1pc
Devices size	2*2mm*3mm	2*2.5mm*1.5mm	1*2.1mm*2.1mm
Gate Leakage (85C, max)	<0.1uA	<800uA (Too high to use)	<3uA (meets customer request)
On Resistance(typ.)	11mΩ	6mΩ	4mΩ
Cell-phone case Temp. Rise	~2° C	~1.1° C	~0.5° C

40V BiGaN reliability ready for smartphone era

10ppm failure rate exceeds 20years at the forward gate voltage of 5.0 V (V_{GD}) and 125 °C.

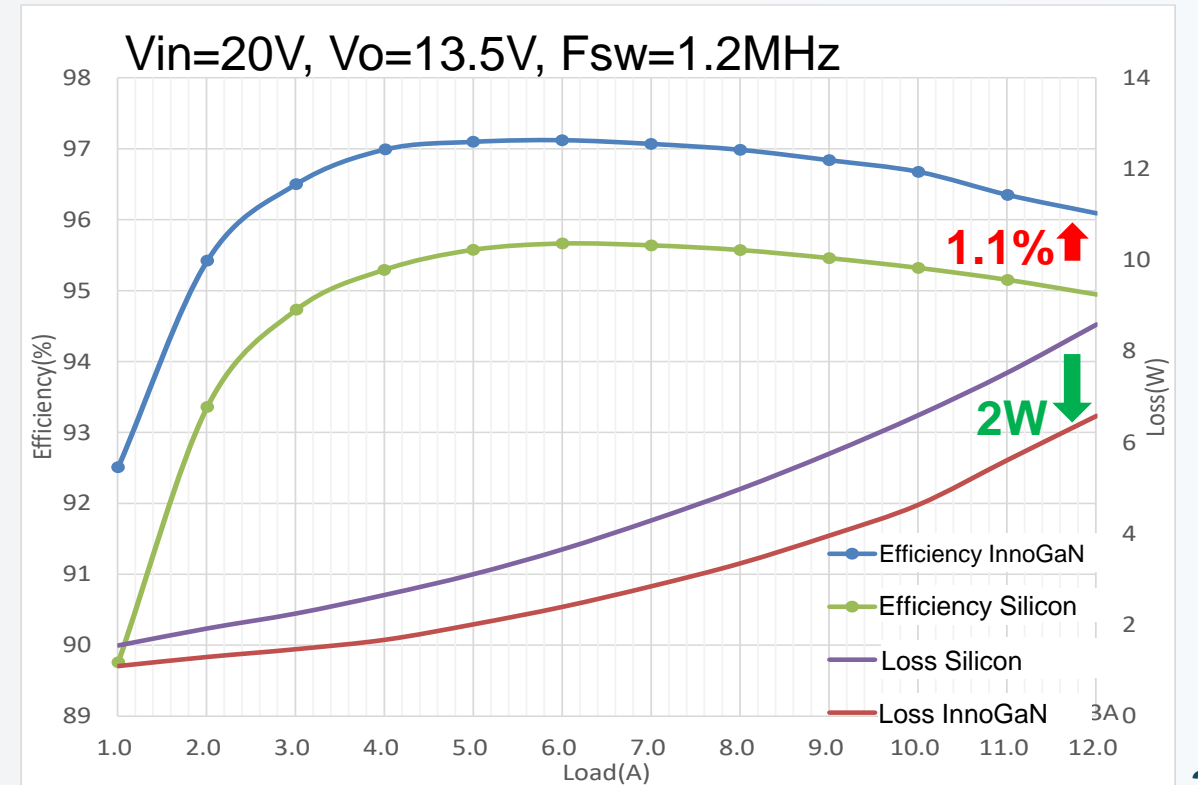
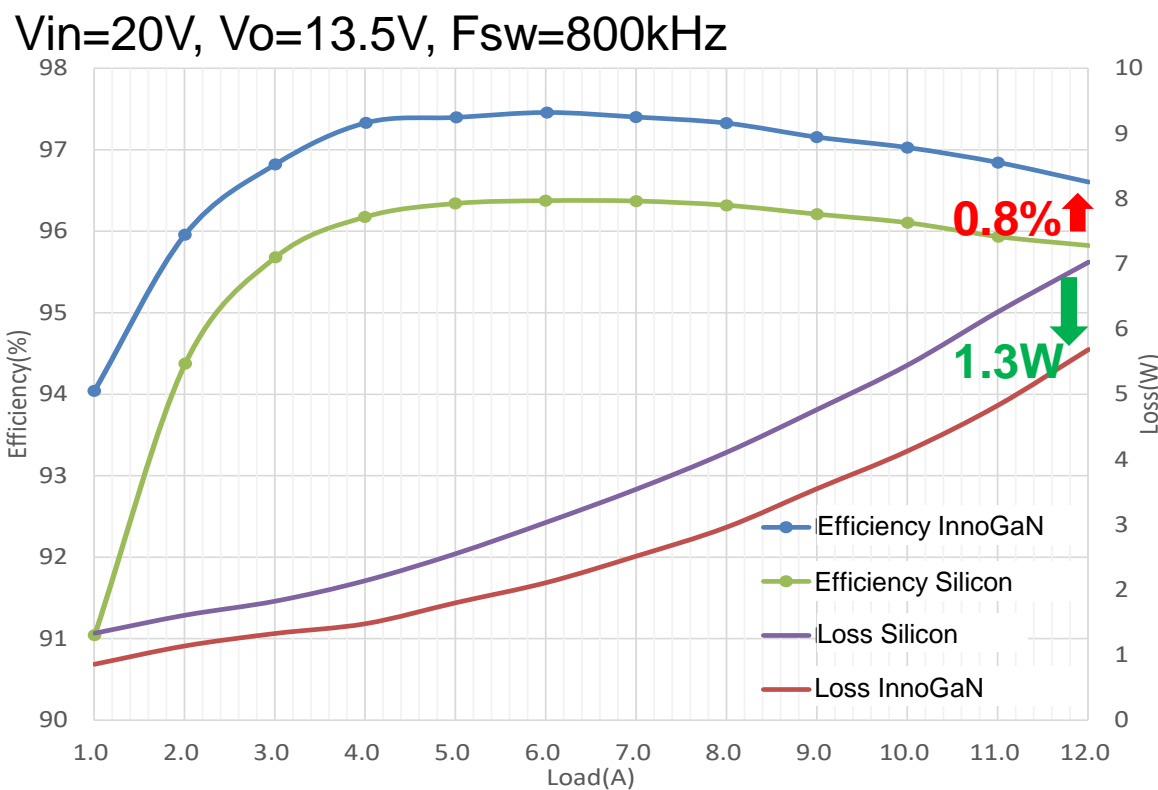
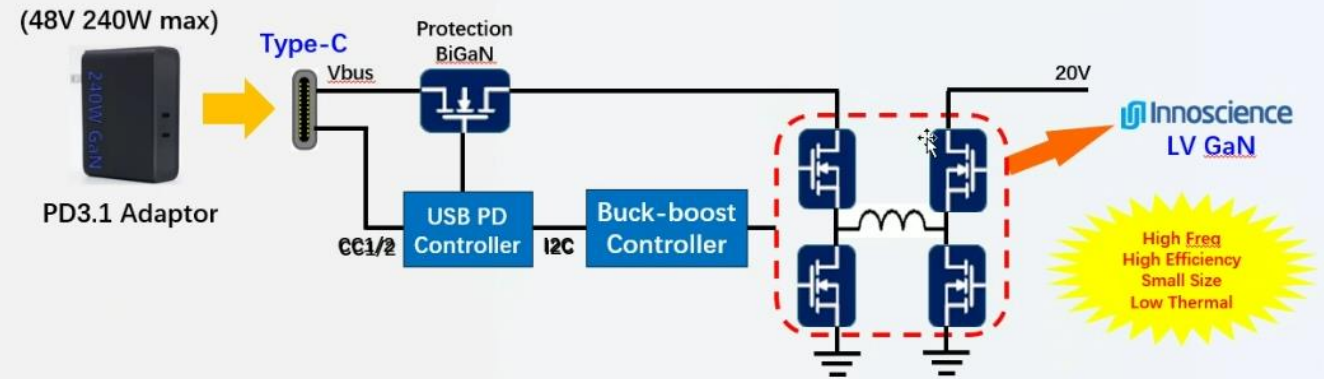
10ppm failure rate exceeds 10,000 years at the operating voltage of 32 V (V_{DD}) and 125 °C



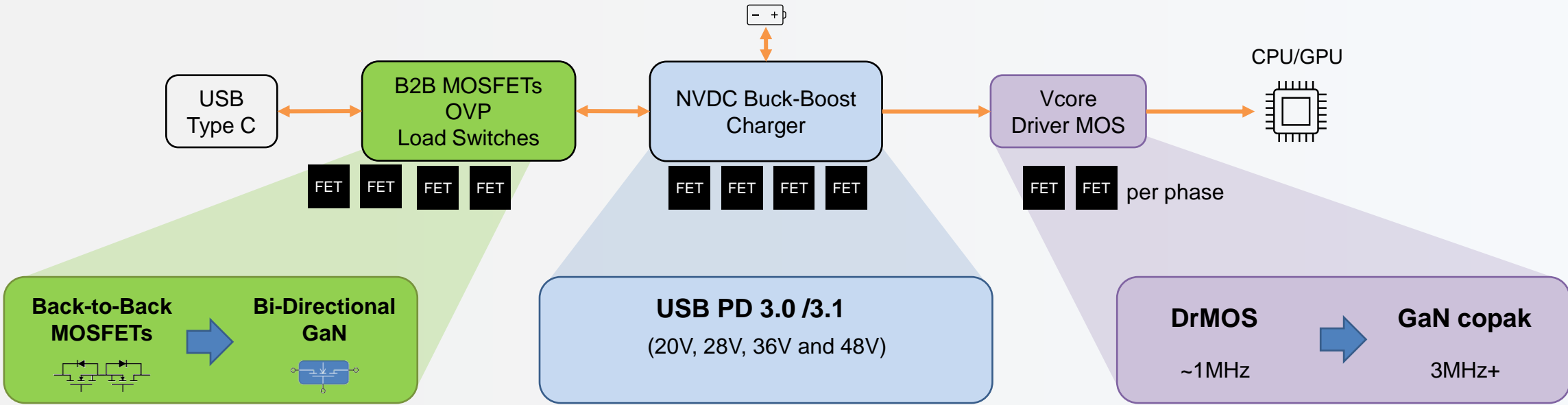
40V InnoGaN on Buck-Boost Applications (notebook)

40V InnoGaN solution is 60% smaller than Si and 1.1% more efficient

FETs	Size	Total Size
Silicon	5*6mm *4PCS	120 mm ²
GaN	3*4mm *4PCS	48 mm ²



Next Gen Compute Platform Powered by Innoscience



BiGaN™ vs B2B MOSFETs

- 70% smaller solution size
- 50% lower on resistance*
- 40% lower temperature rise*

InnoGaN™ vs Silicon

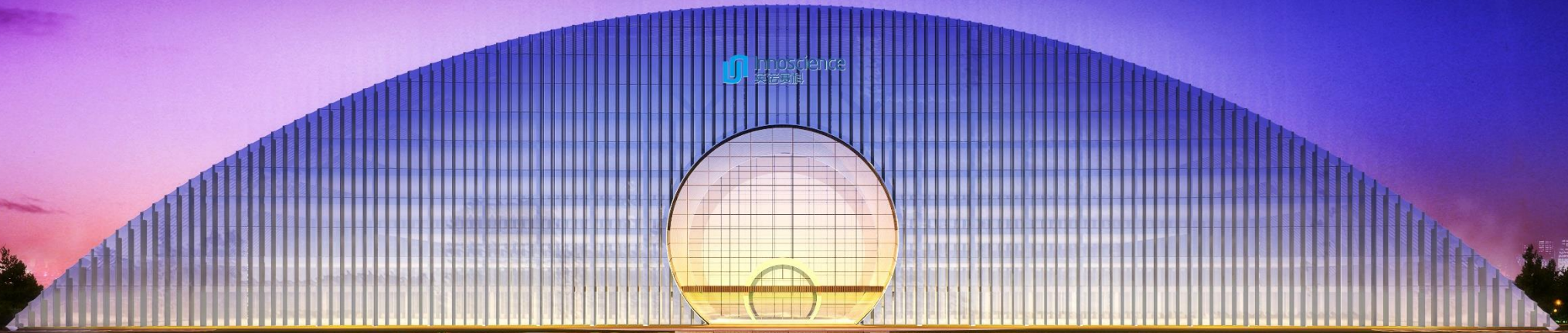
- 2x F_{sw} without impacting efficiency*
- 30% lower operating temperature*
- 75% smaller solution size

GaN copak vs DrMOS

- 1% higher efficiency
- 46% higher power density
- 36%+ smaller solution size

Concluding remarks

- Innoscience offers unique combination of GaN technology, manufacturing, and best-in-class products
- Great position to unlock the vast potential of LV GaN in power supplies
- Manufacturing capacity with high yield & low ppm levels at low-cost enables entry to smartphones or other very high-volume markets



POWER THE FUTURE