New power electronics enable compact, cool and efficient xEV power train inverters

VisIC Technologies

FOR THE FIRST TIME IN TRANSPORTATION SEMICONDUCTORS ARE RESPONSIBLE FOR THE KEY VALUES OF VEHICLE

Driving Distance

>500km

Refuel time

Cost

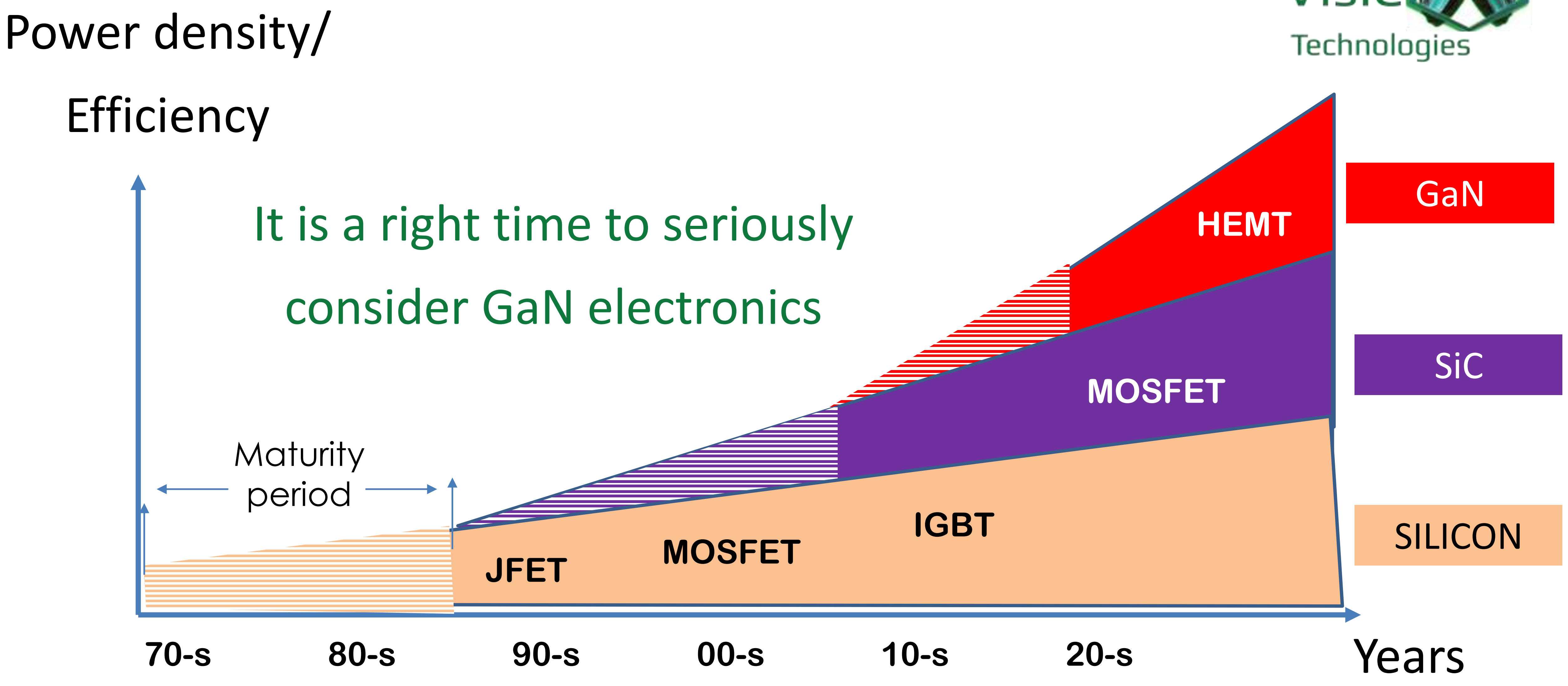
$

Driving satisfaction

0 to 60 mph

POWER ELECTRONICS

VisIC Technologies



OUTLINE

- GaN performance vs SiC MOSFET and Si IGBT
- GaN reliability
- GaN manufacturing cost vs SiC MOSFET
- VisIC product value

ABOUT US

We are experts in semiconductor design, power electronics and microelectronics packaging

Core team with more than 120 years of relevant experience

Track record of few GaN technologies developed from scratch to qualification

VisIC Technologies has the highest performing product on market

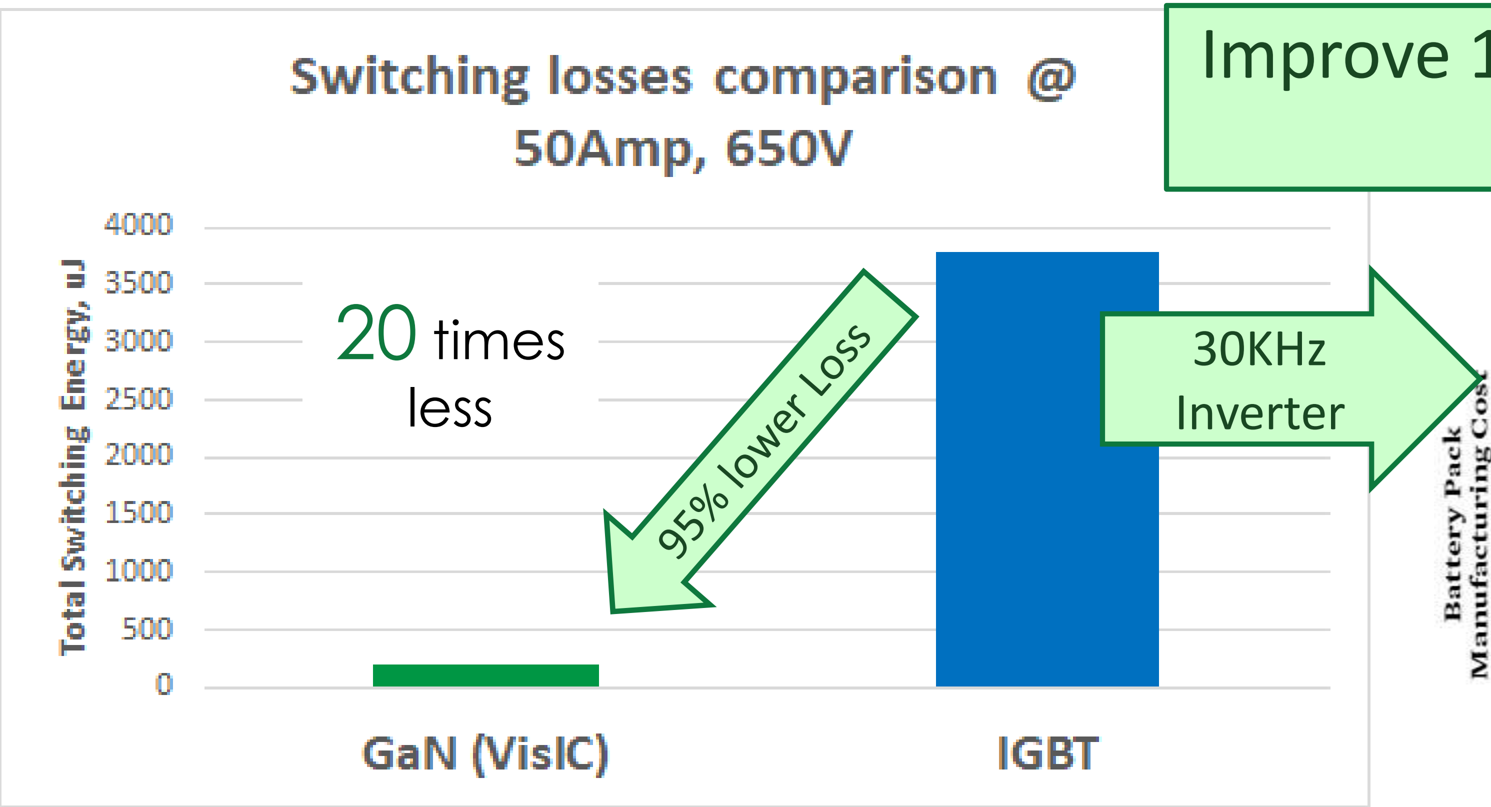
GaN TO FIT TO POWER TRAIN

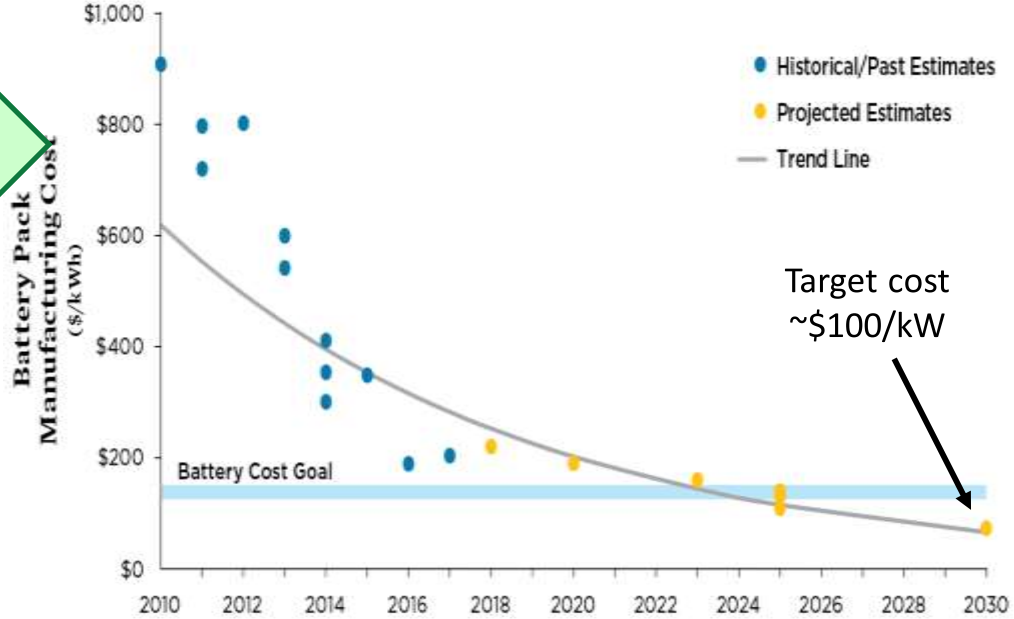
VisIC Technologies

- Easy to use → standard 0V to +15V driver
- High current capability → 1.7 kA to mOm
- High noise immunity → +5.5V threshold voltage
- Easy paralleling → 600A HB one driver demonstrated
- Reverse conductivity → no SiC diode (flywheel) required
- Single device per leg HB DC/DC CCM hard switching up to 9kW or 1 MHz [100 A @ 650V]

EFFICIENT GaN vs IGBT

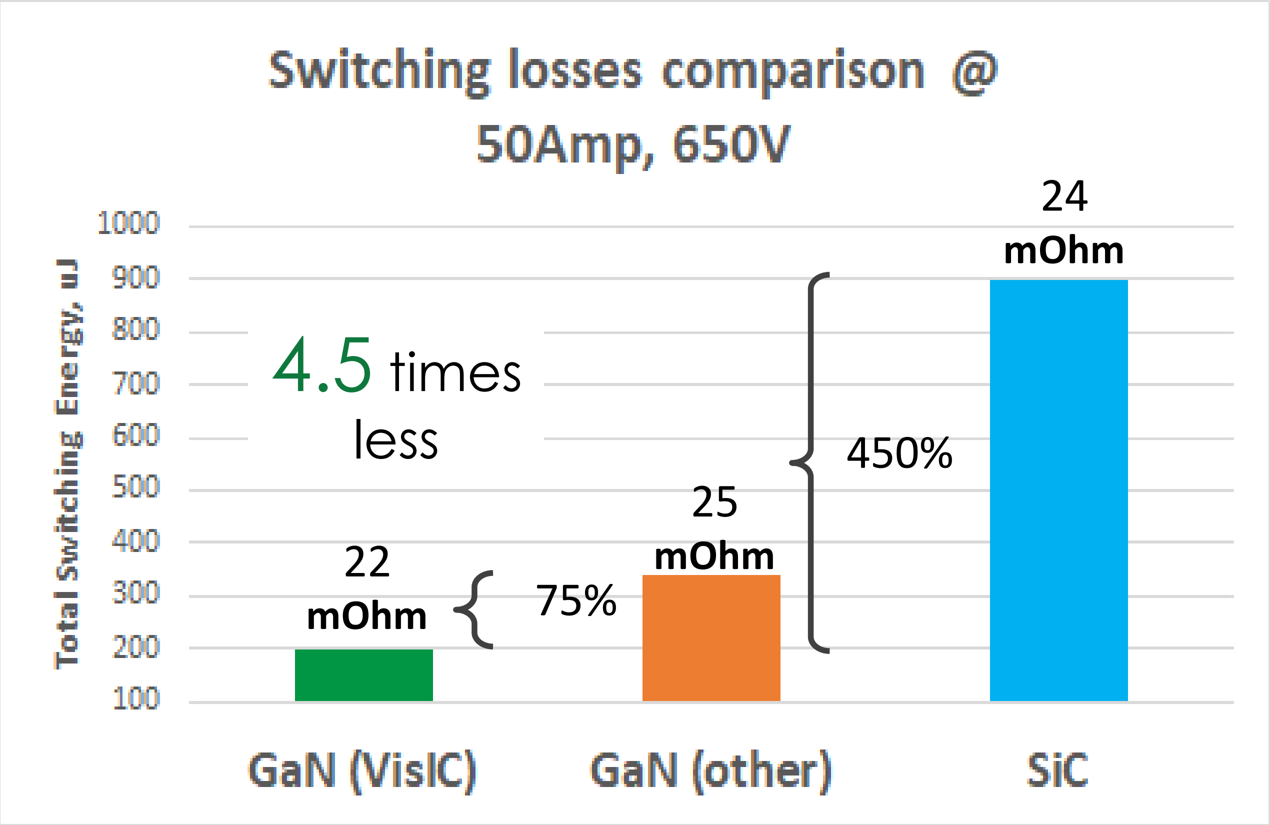
Improve 160kW Inverter efficiency by > 4%





Battery <u>cost saving</u>: 2024: > $1280, 2030 >$600

EFFICIENT GAN VS OTHER WIDE BAND GAP DEVICES



Comparison with:

- Similar Rdson
- Similar current
- Similar voltage rating

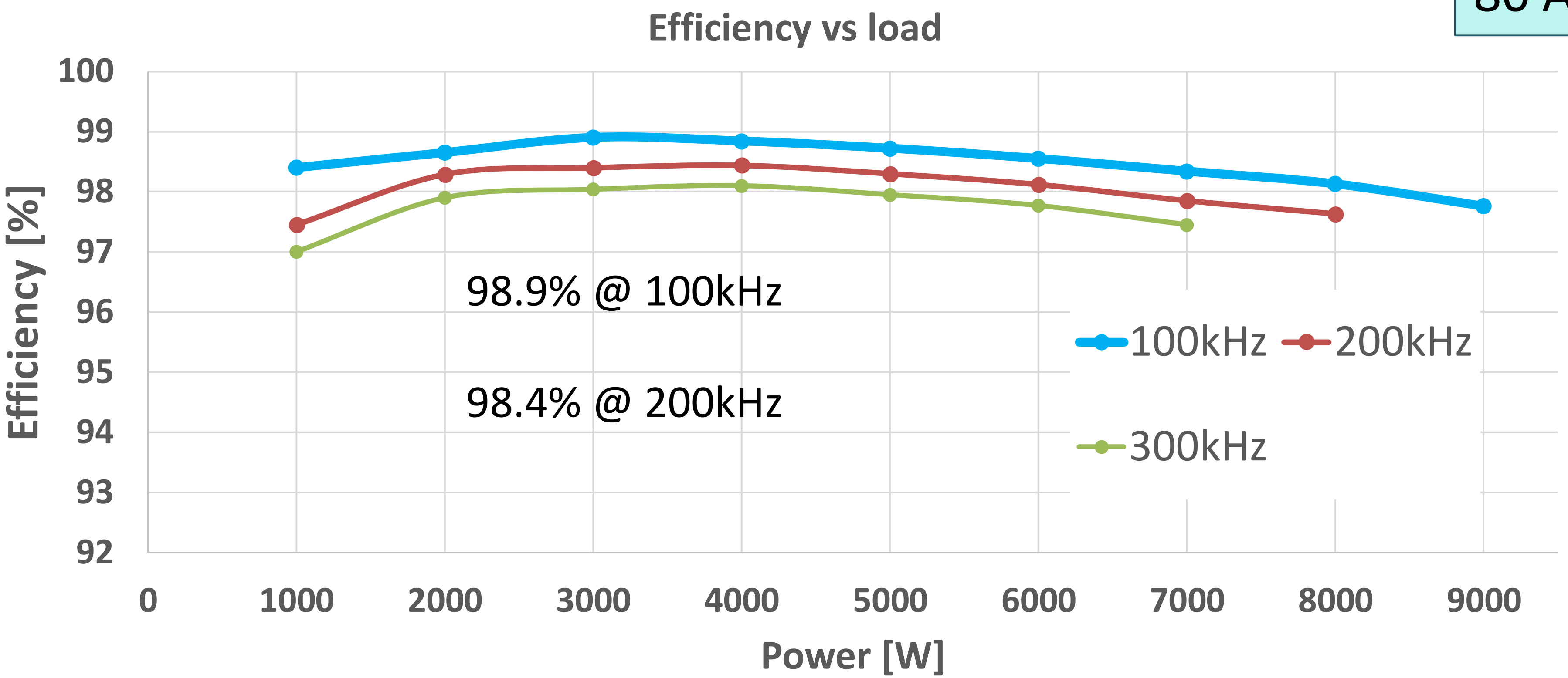
VisIC GaN is superior over other GaN & SiC solutions

1kW to 9kW with Liquid Cooling

- Tested in a Buck converter, 400V to 200V; CCM; hard switching
- Dead time - 75nS
- Inductor 340uH

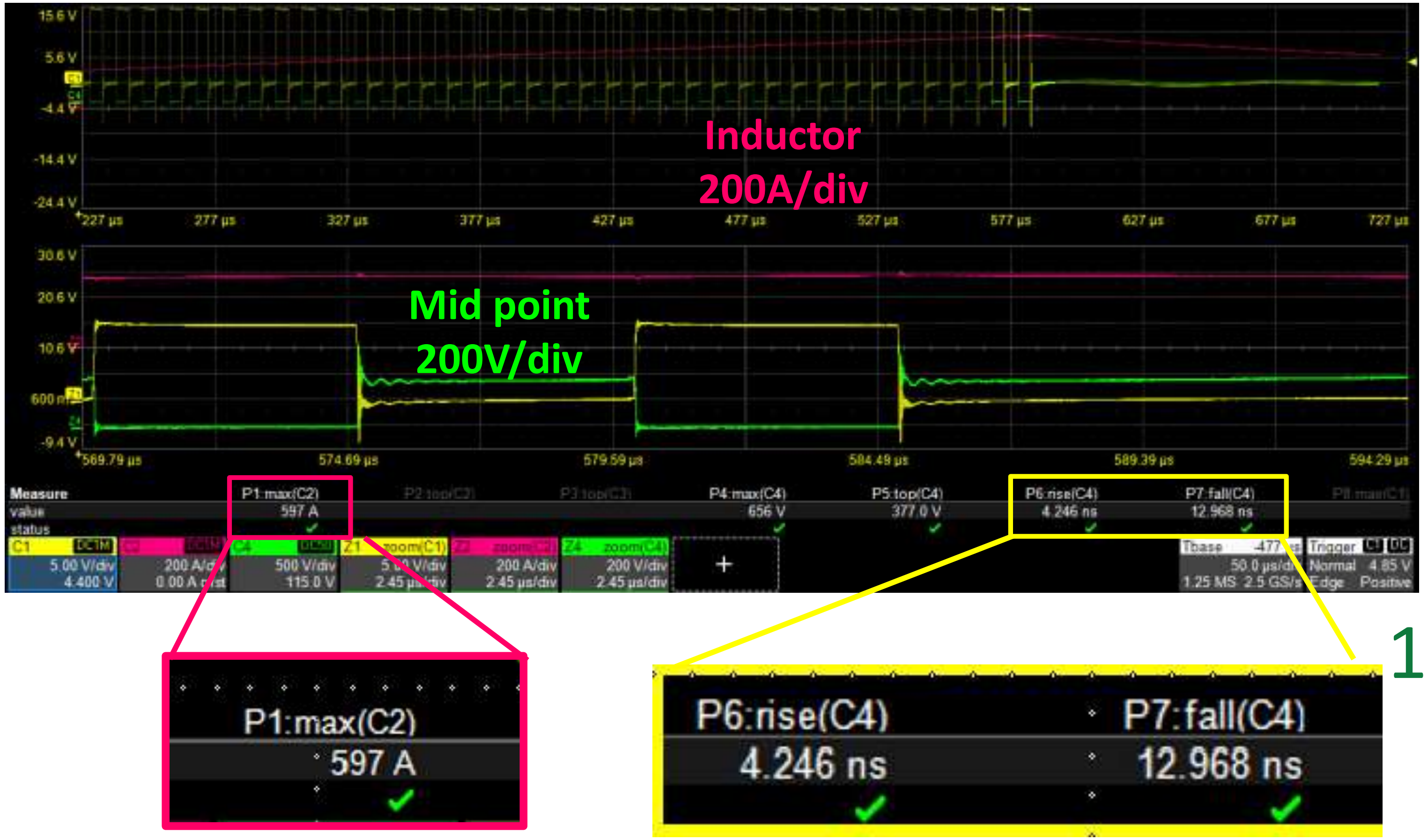
- Liquid Cooling
- 28°C ambient temperature

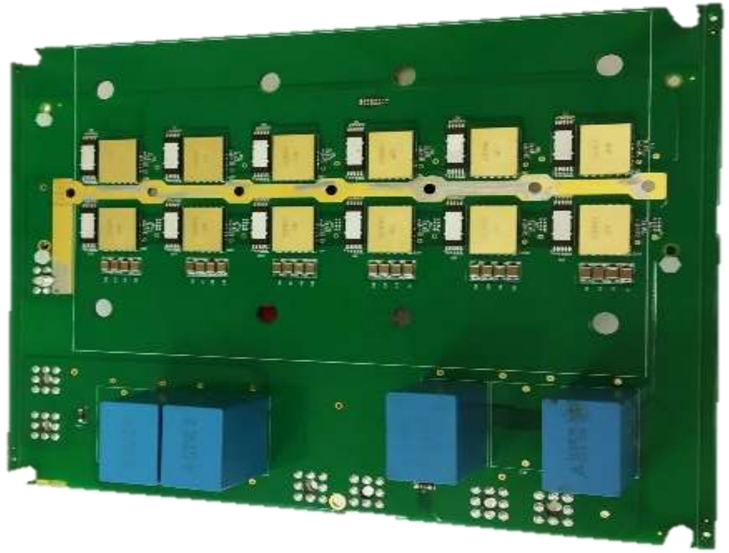
22 mOhm
80 A 650V



HIGH POWER CAPABILITY

600A t_{rise}4.25ns t_{fall}13ns





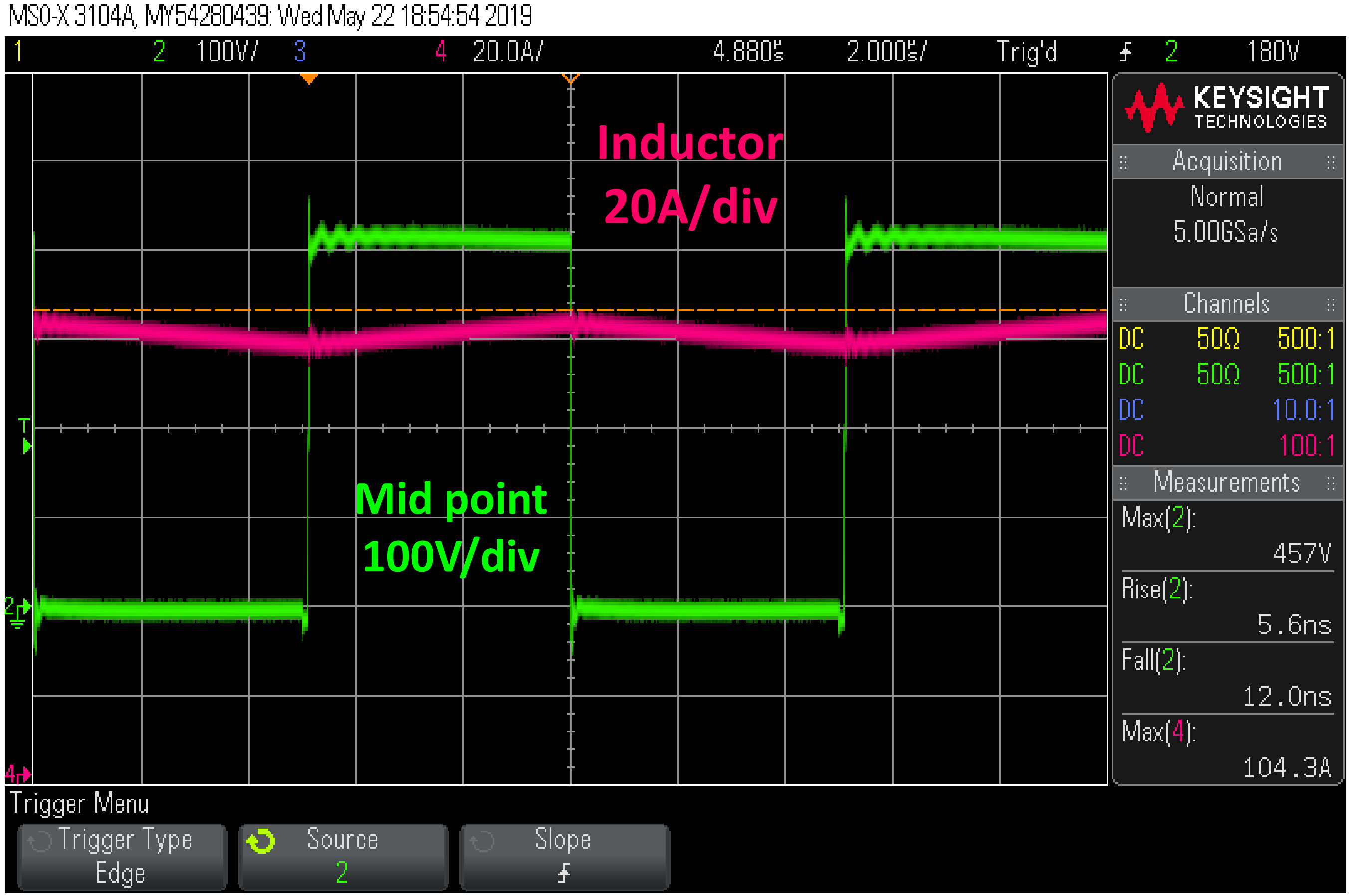
6xHB parallel

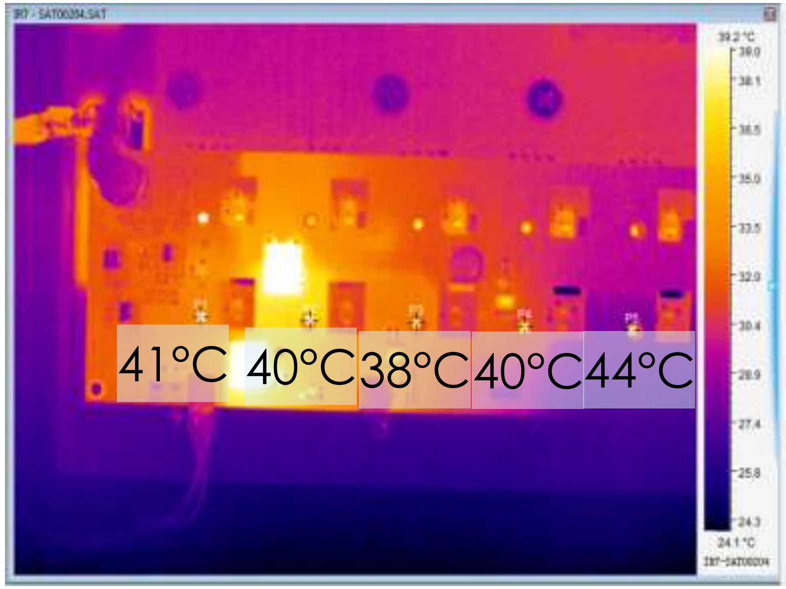
1 driver, no flywheel diodes

test board available

CURRENT DISTRIBUTION

HB CCM hard switch 100A 20 kW



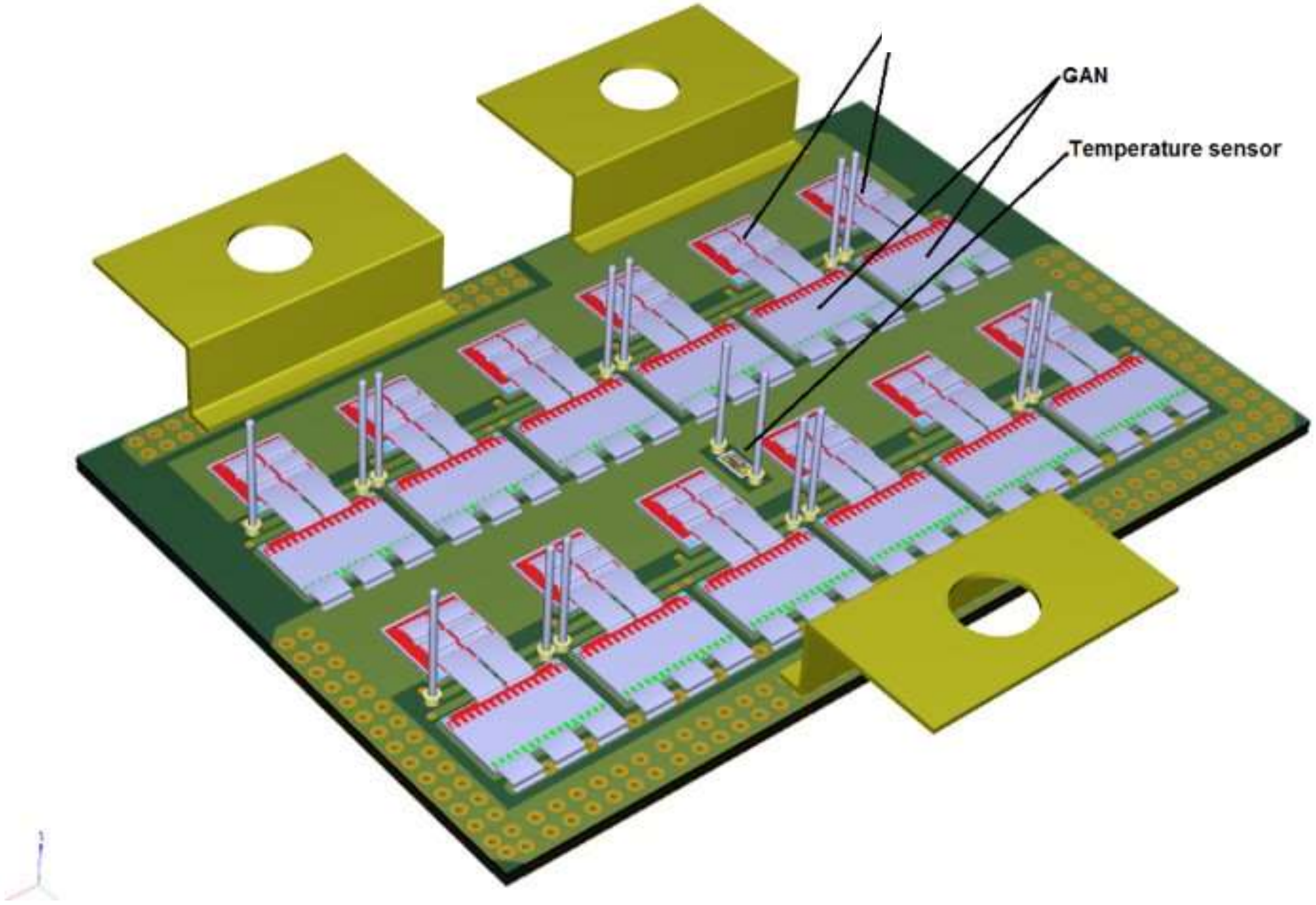


t_{rise} 5.6ns

t_{fall} 12ns

Thermal read out shows uniform current distribution

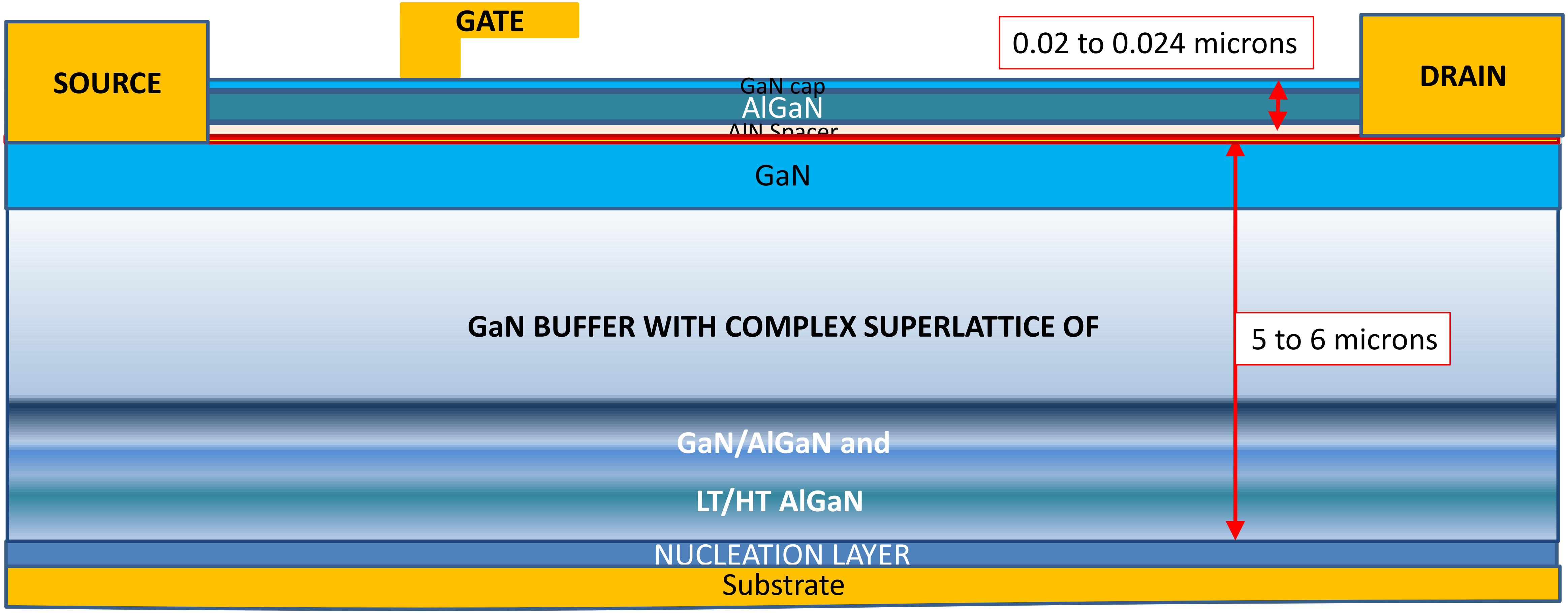
MODULE



- 600A rms current
- 650V blocking voltage
- Footprint 45mm x 80 mm

GaN TRANSISTOR

Two main failure mechanisms (FM): lateral or vertical breakdown:



FAILURE MECHANISMS ARE IDENTIFIED

Two main failure mechanisms (FM):

1. Lateral time dependent dielectric breakdown [LTDDB]
2. Vertical time dependent dielectric breakdown [VTDDB]

LATERAL:

Defects build up in drain-gate access region.

Drain-Gate voltage /E-field is an acceleration factor

VERTICAL:

Leakage current is possible due to conductive Silicon substrate

Drain-Substrate voltage/E-field is an acceleration

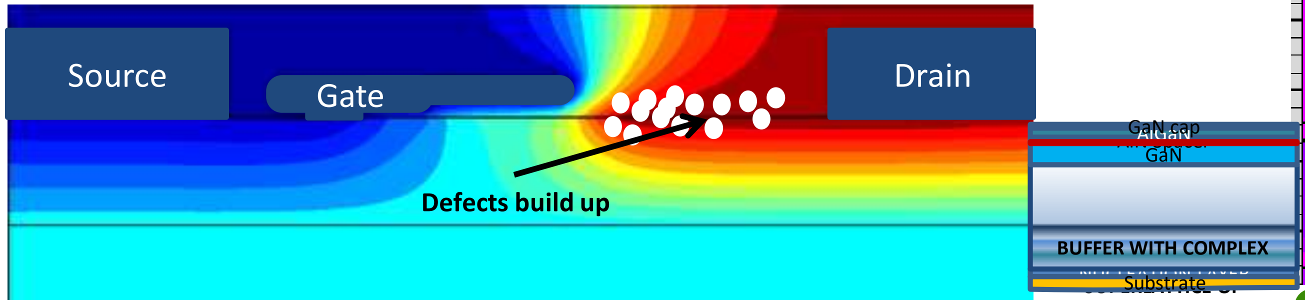


Fig.1 Typical lateral TDDB failure formation

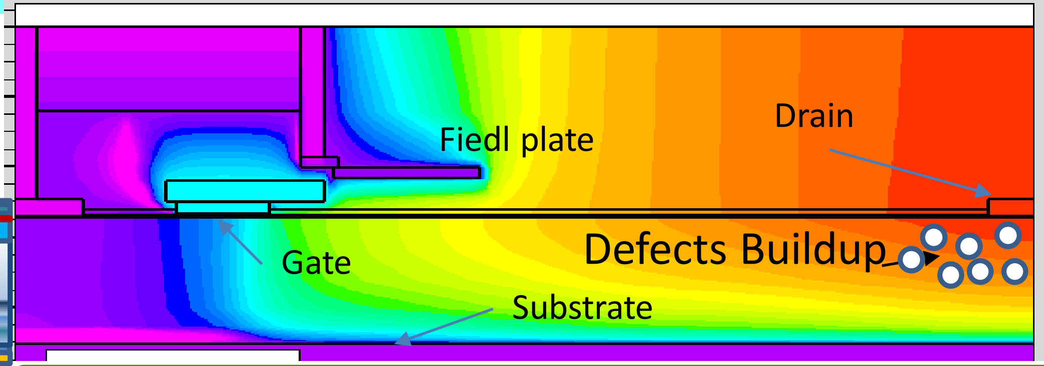


Fig2. Typical vertical TDDB failure formation

LIFETIME PREDICTION

VisIC Technologies

Predicting operation lifetime requires extrapolating accelerated testing results back to nominal operating conditions

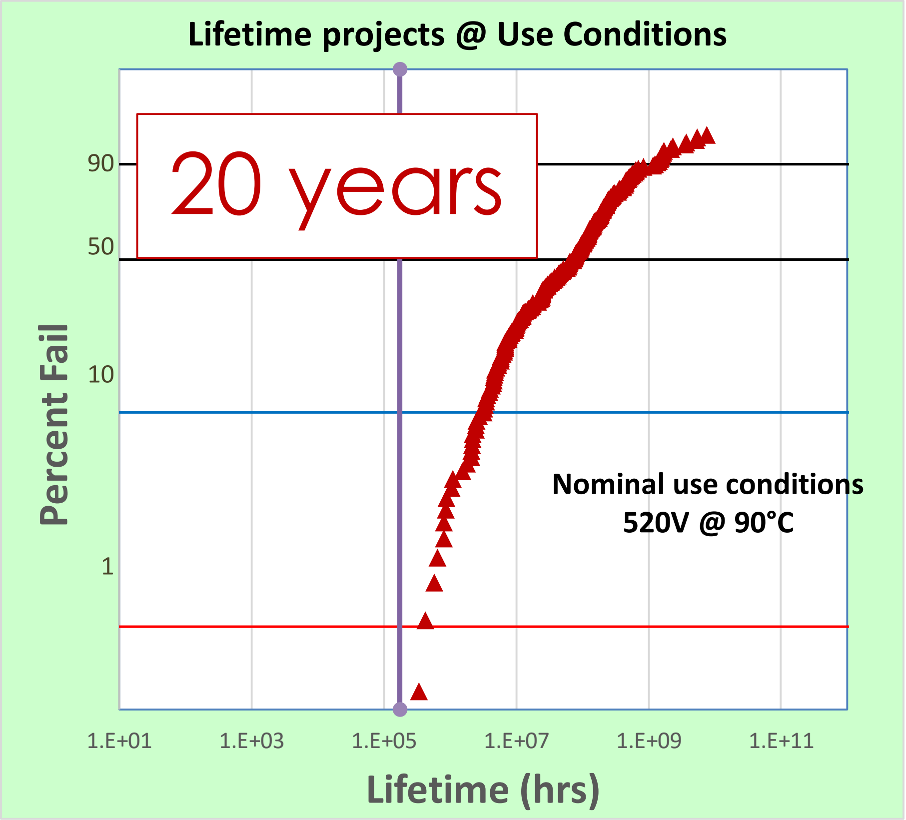
Nominal use conditions are conditions that the device will be used during operations

Analysis extrapolates to use conditions through acceleration factors (AF)

Field AF: $\gamma = 0.35V^{-1}$

Temperature AF: Ea =0.54ev (preliminary)

<u>Conservative while testing in progress</u>



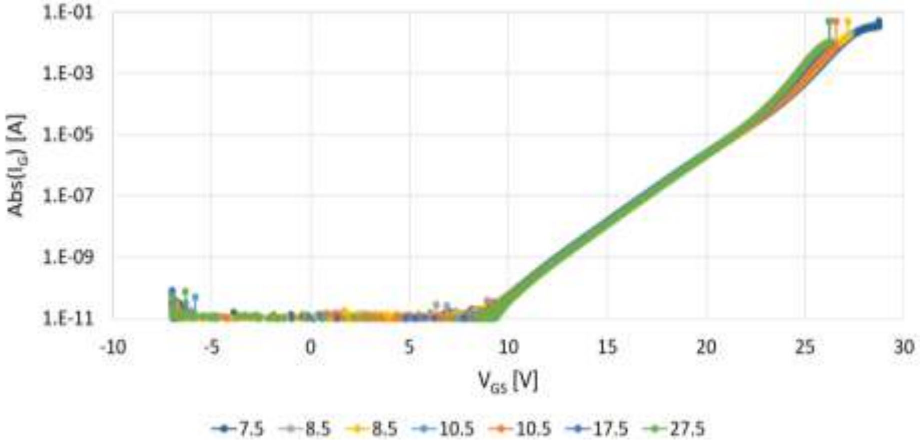
FORWARD BIAS LIFETIME PREDICTION

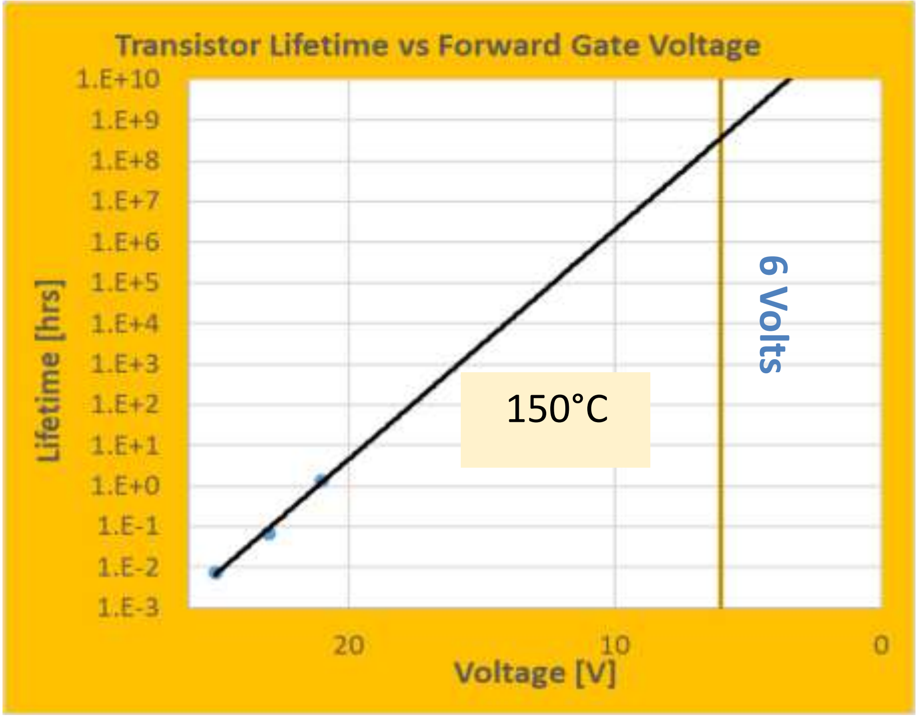
VisIC's GaN HEMT is extremely reliable under forward bias condition

10,000 years

Tested HEMT only devices at accelerated conditions

Increased leakage regime consistent with TDDB failure mechanism





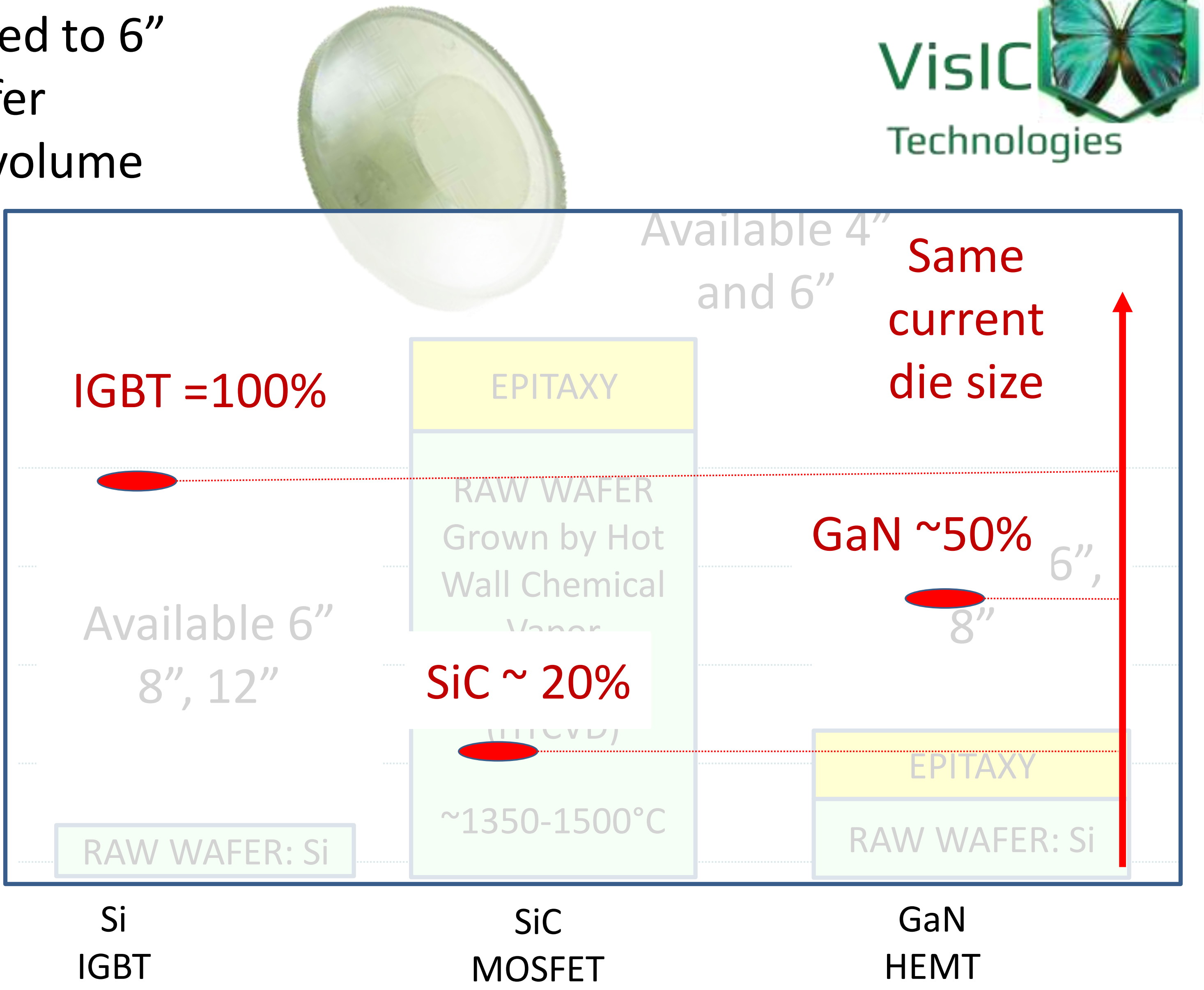
$$Model : ttf \propto e^{-\gamma V}$$

COST

SEMICONDUCTOR COMPONENT COST

- YIELD
- BACK SIDE
- FRONT SIDE
- EPITAXY
- RAW WAFER

Normalized to 6" wafer
Similar volume

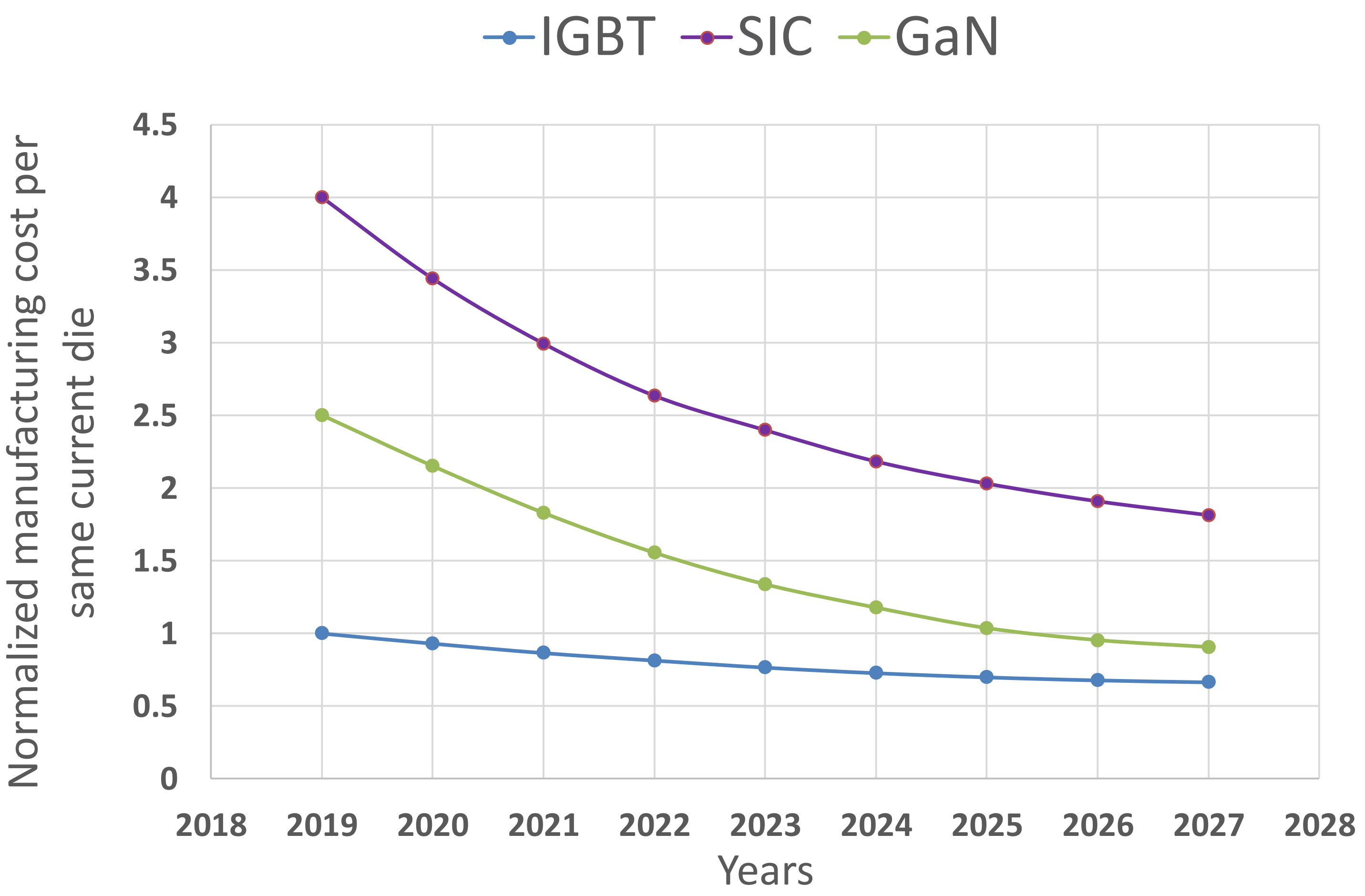


COST

VisIC Technologies

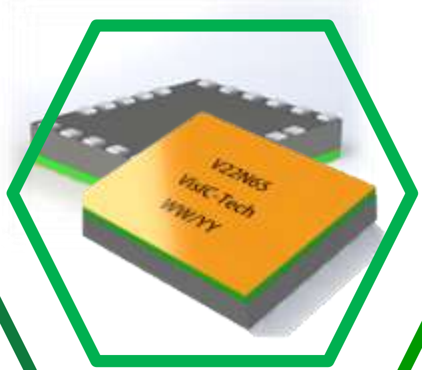
SEMICONDUCTOR COMPONENT COST

- YIELD
- BACK SIDE
- FRONT SIDE
- EPITAXY
- RAW WAFER



GaN SOLUTION

HIGH CURRENT, HIGH EFFICIENCY:
RIGHT PERFORMANCE



RIGHT COST STRUCTURE

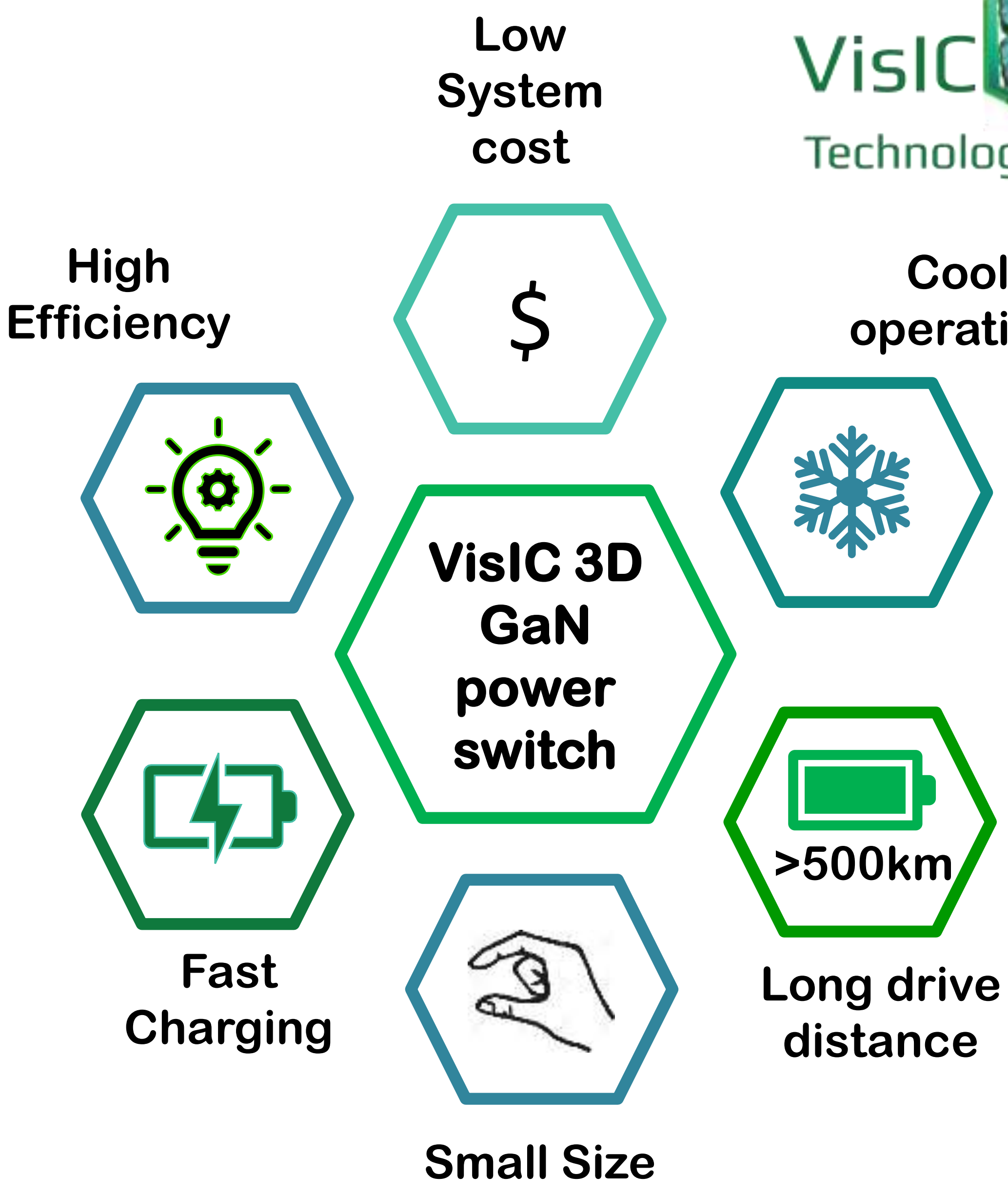
RIGHT RELIABILITY

GaN SOLUTION

VisIC Technologies

- GaN is the new generation semiconductor
- GaN is 500 times more suitable for power than Silicon

The proprietary and exclusive VisIc development allows a disruptive power switch with proprietary 3D technology to enable efficient, low cost and small size system for EV's efficient power train and fast charging system



Lowest
RDS(ON) of
650V device

VisIC Technologies

Thank you for attention

www.visic-tech.com

D-mode vs E-mode

VisIC Technologies

	E-mode (GaN System design)	D-mode (VisIC design)
Die area [mm.sq]: for mOhm	840	652
# of Masks	16	14
Current capacity: Amp per mOhm	1450	1760
Total Switching Energy, µJ @ 50A	~350	~200
V_{TH} Noise immunity (Miller Spike)	1.5V	5.5V

VisIC's benefits

- Die area, # of Masks → **Lower cost in volume**
- Current capacity, Total Switching Energy → **More power density**
- V_{TH} Noise immunity → **More system robustness**

VisIC design for automotive qualification AEC-Q101 @ 650V (100%)