
EPC
EFFICIENT POWER CONVERSION
THE GaN JOURNEY BEGINS

The Journey

- Why Gallium Nitride?
- Breaking down the barriers
- What the future might hold

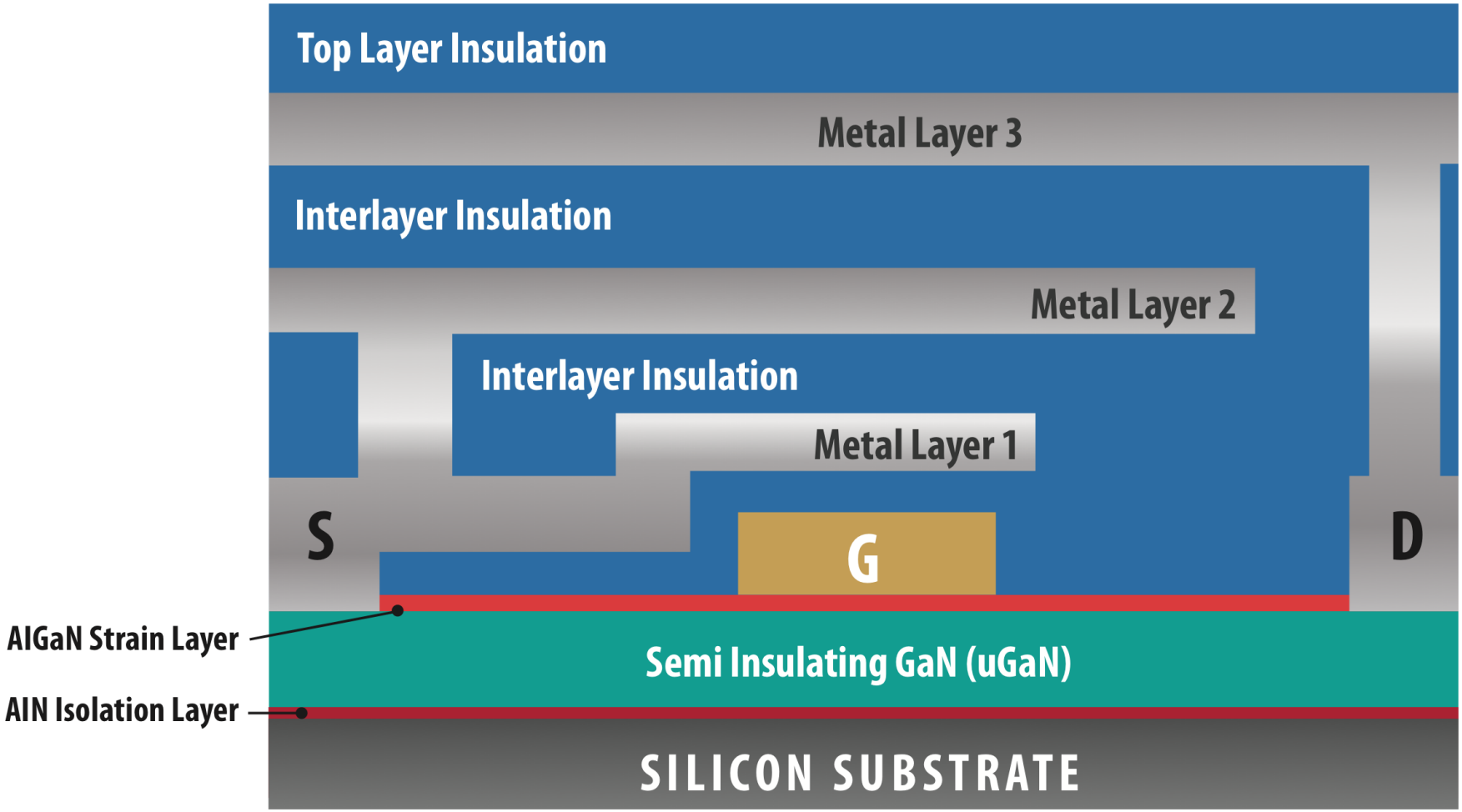
Why Gallium Nitride?

- GaN offers superior performance compared with both silicon and silicon carbide
  - *R_{DSON} x Area*
  - *Very high switching speed*
  - *High Voltage Capability at low $R_{DS(ON)}$*
  - *Body Diode has no Q_{RR}*

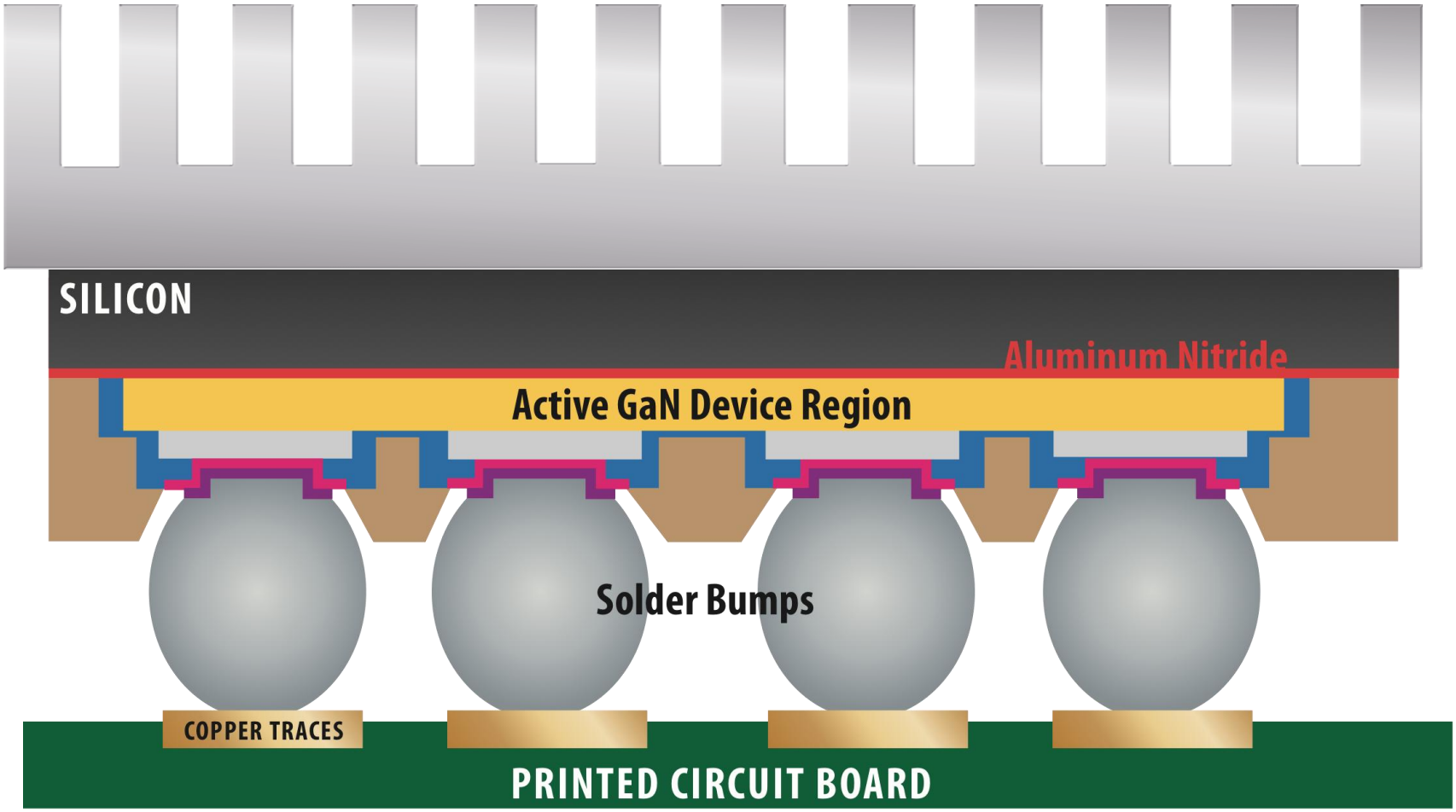
Why Gallium Nitride?

- **Device-grade gallium nitride can be grown on top of silicon wafers and processed in standard CMOS facilities**
- **GaN-on-silicon offers the advantage of self-isolation and therefore efficient power devices can now be made monolithically**
- **EPC has developed proprietary technology for the first *enhancement-mode* devices (eGaN™) to be offered on the market!**

Device Construction



Flip Chip Assembly



Breaking Down the Barriers

Does it enable significant new capabilities?

Is it VERY cost effective to the user?

Is it reliable?

Is it easy to use?

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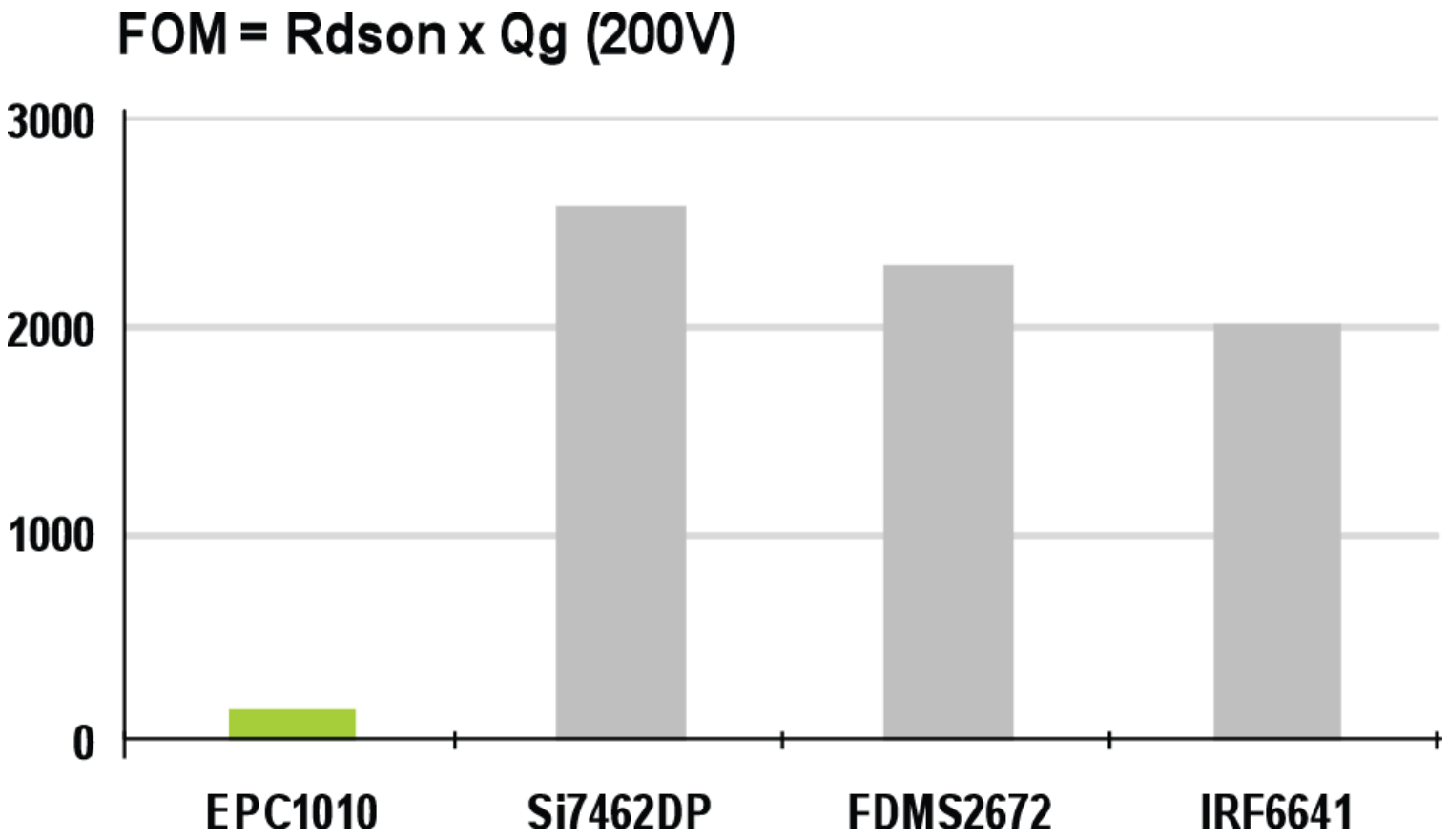
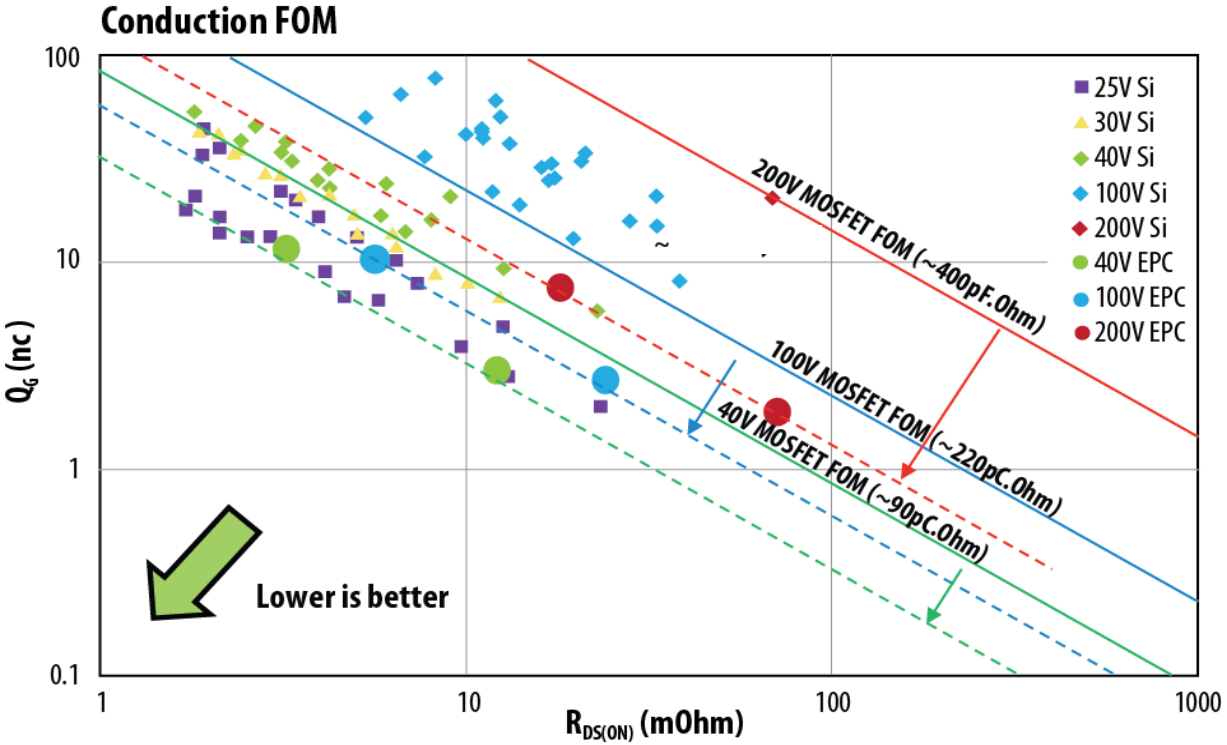
eGaN FETs are Higher Performance: Figure of Merit

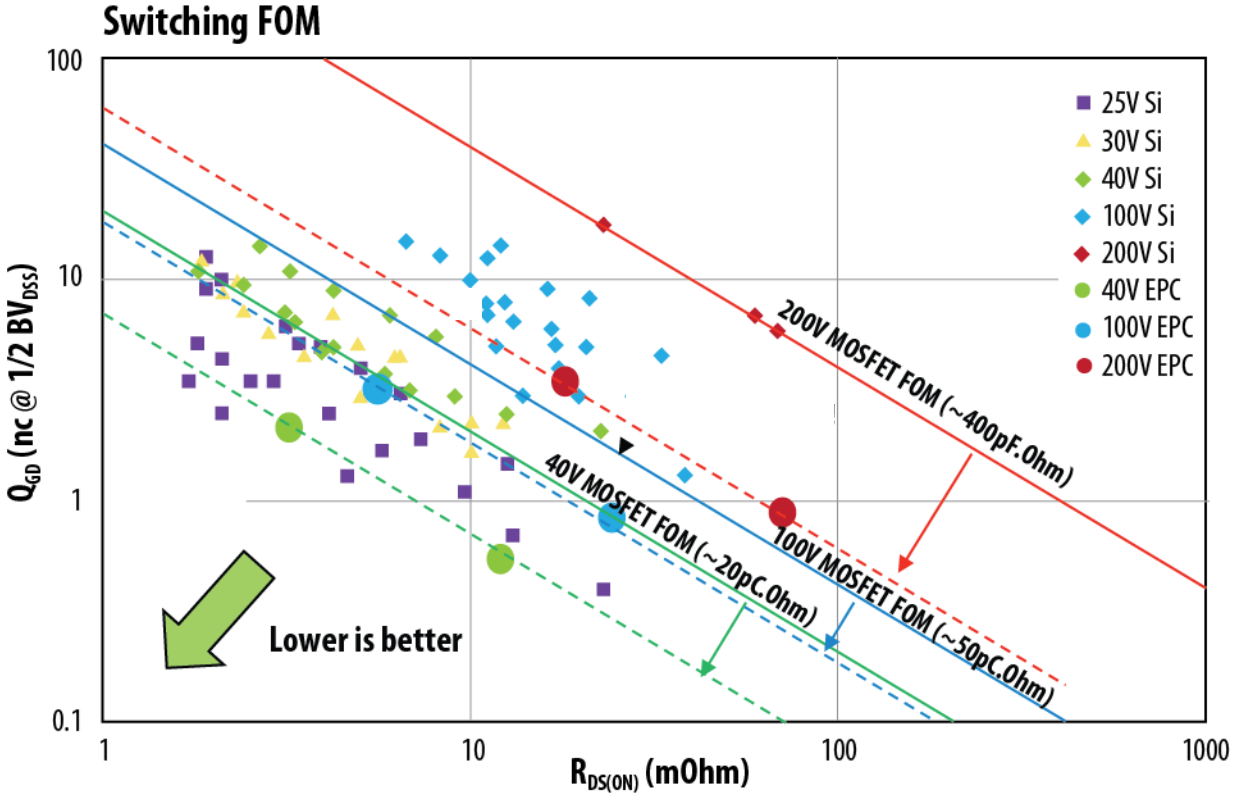


eGaN FETs are Higher Performance: *Conduction* Figure of Merit



- The Conduction Figure of Merit is the best predictor of relative device performance when the transistor is used in a rectifier function
- The relative performance between eGaN and silicon is more pronounced as the rated voltage increases

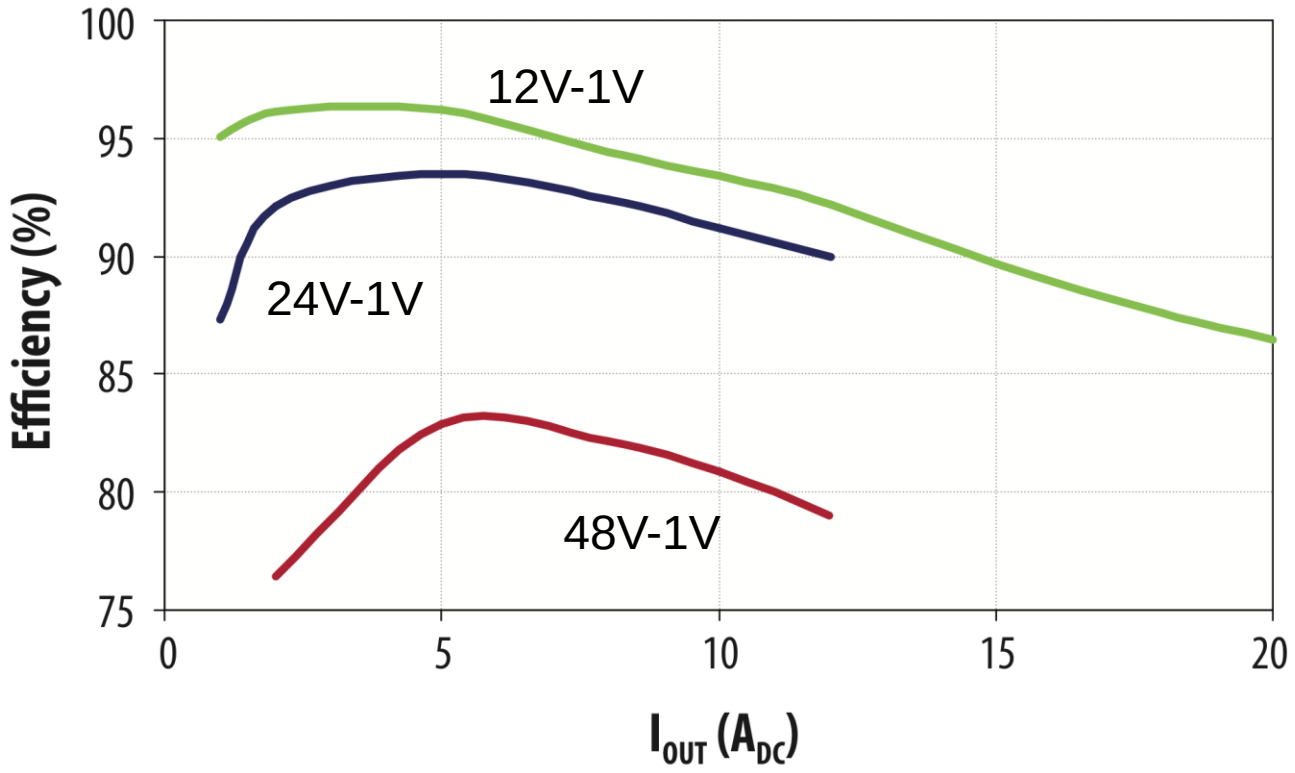
eGaN FETs are Higher Performance *Switching* Figure of Merit



- The Switching Figure of Merit is the best predictor of relative device performance in hard switched converters
- The relative performance between eGaN and silicon is even greater than for conduction FOM

Converter Efficiency

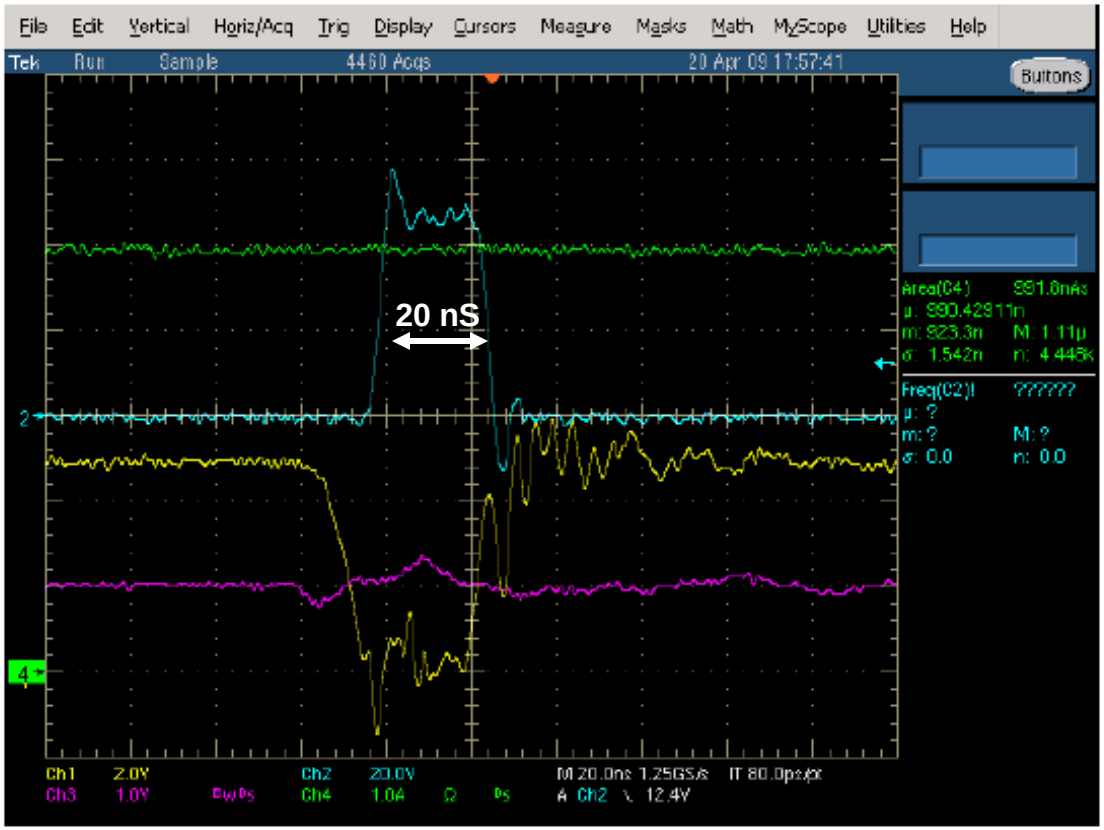
EPC1001 at 250 kHz



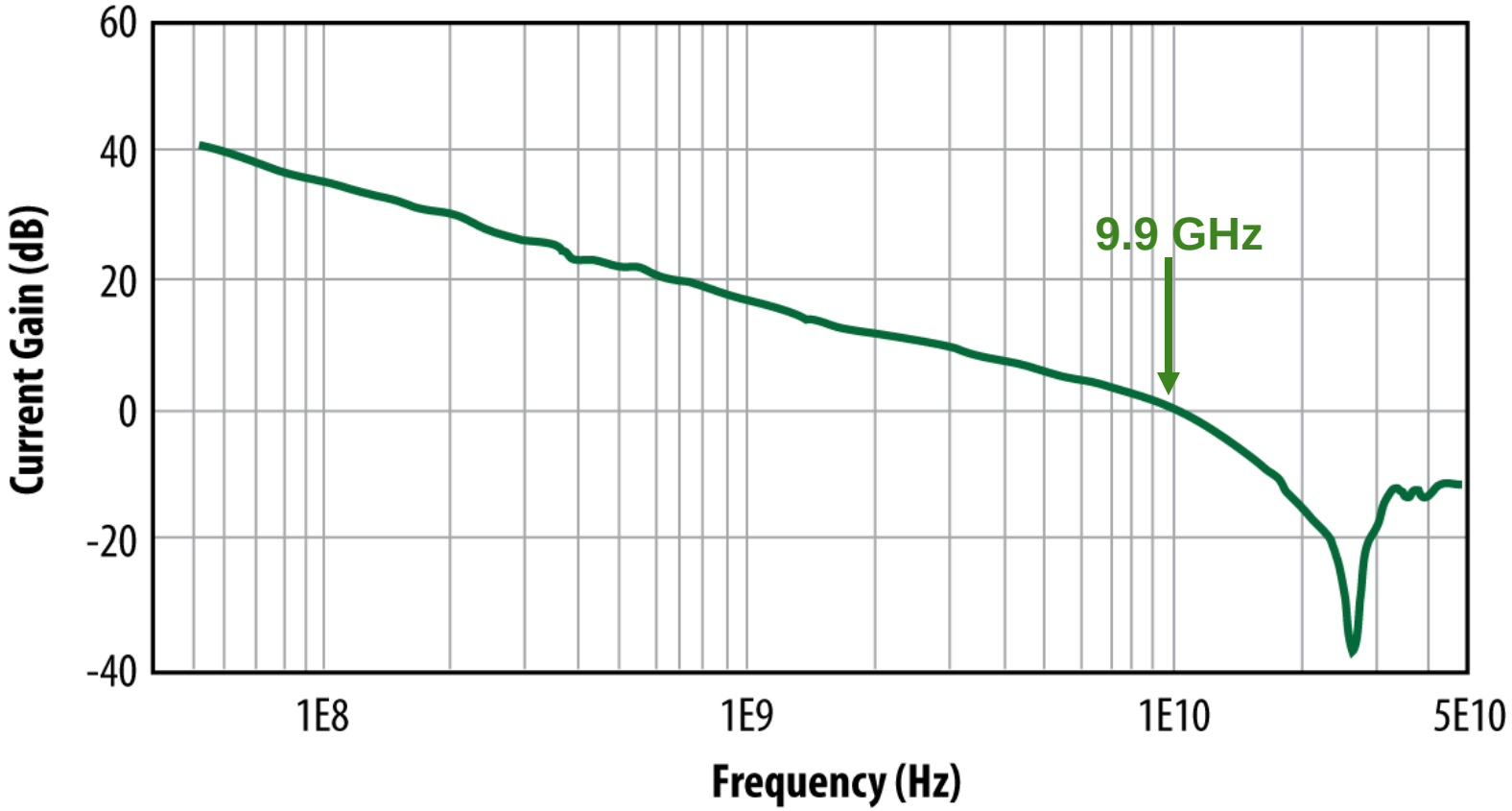
Reduction of light load efficiency and high conversion voltage efficiency is mostly due to the limitations of the commercial driver IC

48V – 1V Conversion (*1MHz*)

GaN switching speed is limited by the driver circuit



Gigahertz Capability



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eGaN FETs are cost effective

Smaller Die Sizes

The on-resistance ($R_{DS(ON)}$) for a given device area is a key determinant of product cost.

The elimination of the package further reduces cost

200V Silicon Device (30 milli Ohms)

200V GaN Device (25 milli Ohms)

eGaN Transistors are cost effective

	2010	2015
Starting Material	same	same
Epi Growth	higher	same
Wafer Fab	same	lower
Test	same	same
Assembly	lower	lower
OVERALL	**higher**	**lower**

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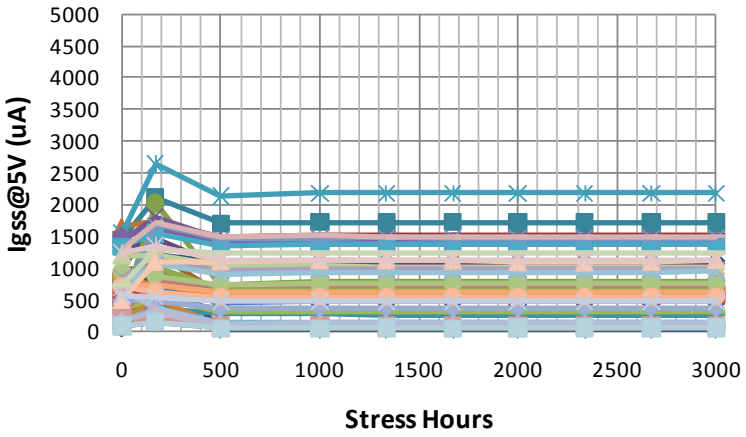
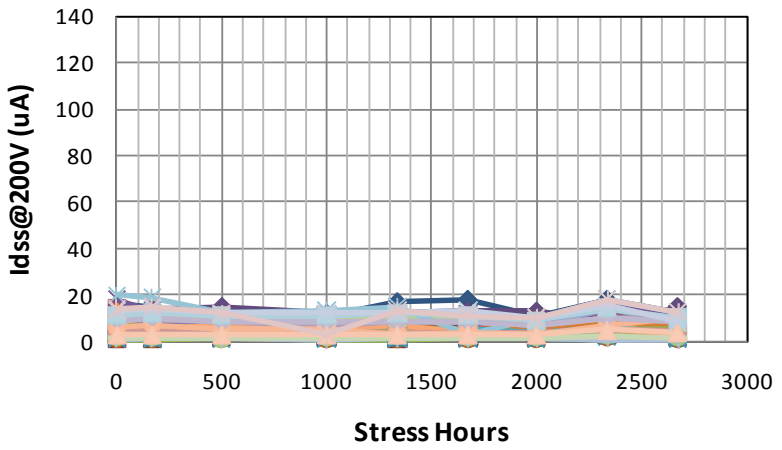
eGaN FETs are reliable

Devices are well behaved after HTRB, HTGB, THB, and Temp Cycling Stress.

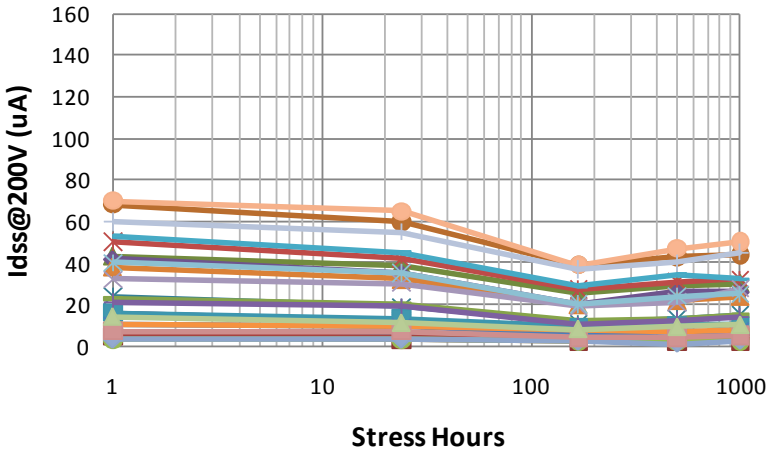
HTGB 6V at 125C EPC1001 Igss



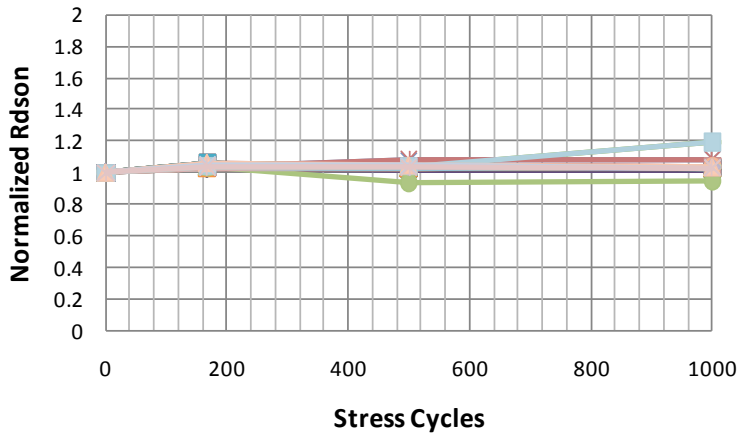
HTRB 150C EPC1010 Idss



THB 85C/85RH 100Vds EPC1010 Idss

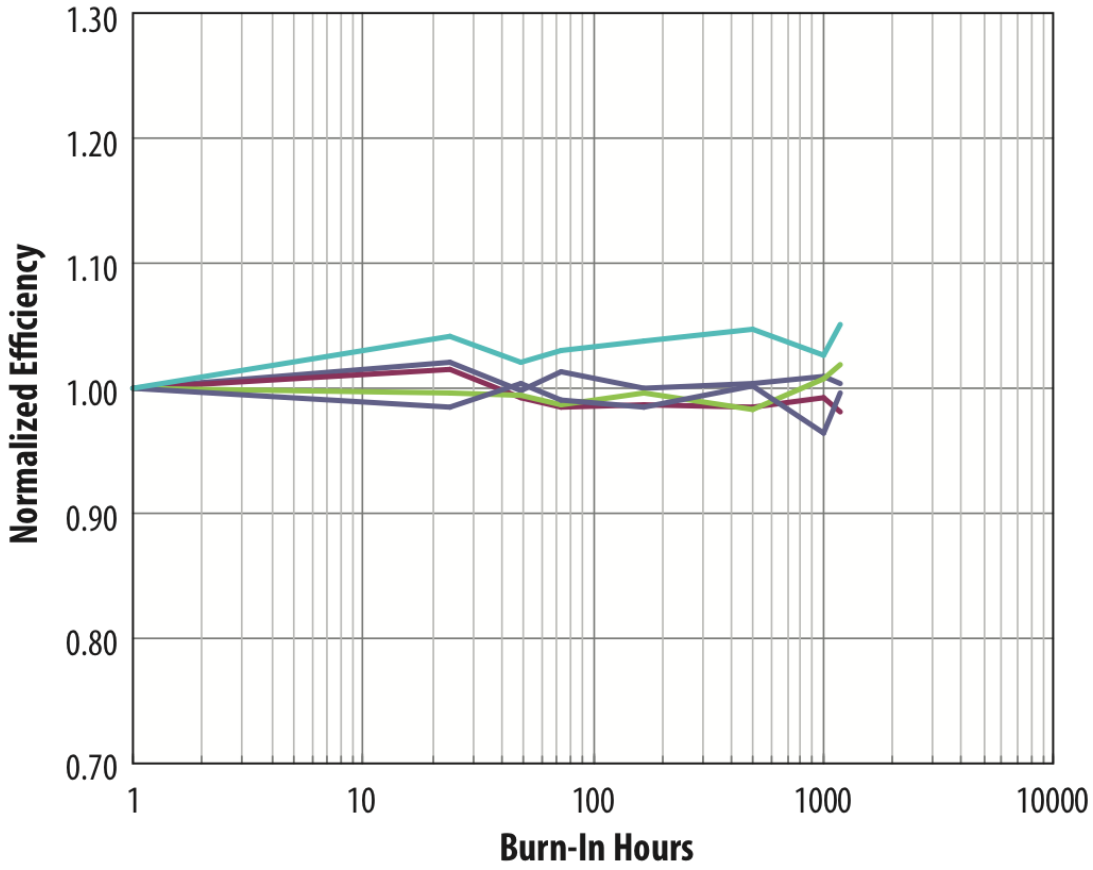


TC -40C/+125C EPC1012 Rdson



Power Supply Life Tests

48V-1V Converters show no change in efficiency after 1200 hours of operation



Breaking Down the Barriers

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eGaN FETs are easy to use

It's just like a MOSFET

except for TWO things

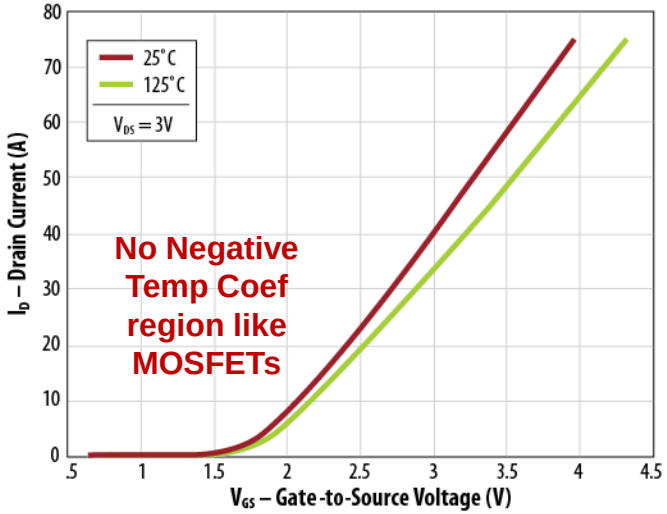
(1)

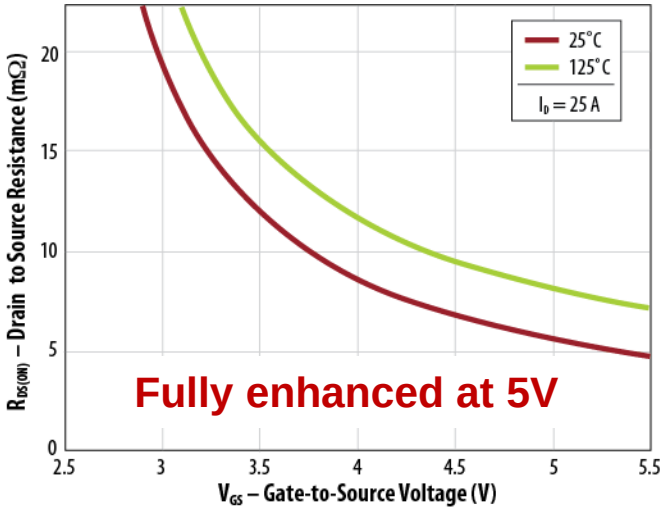
The high frequency capability makes circuits using GaN transistors very sensitive to layout

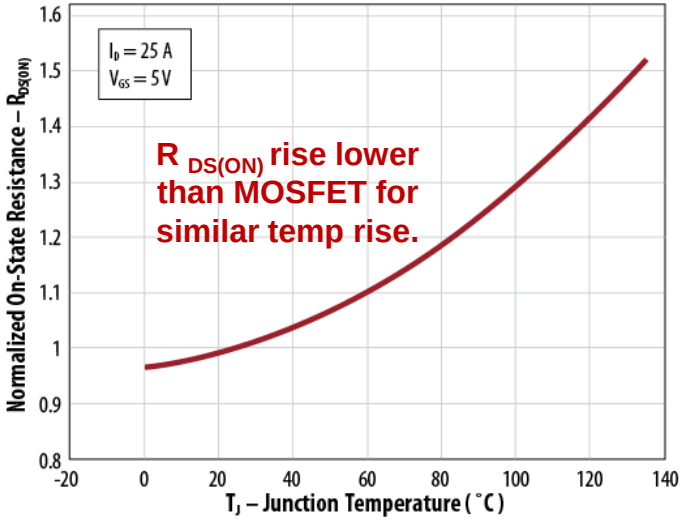
(2)

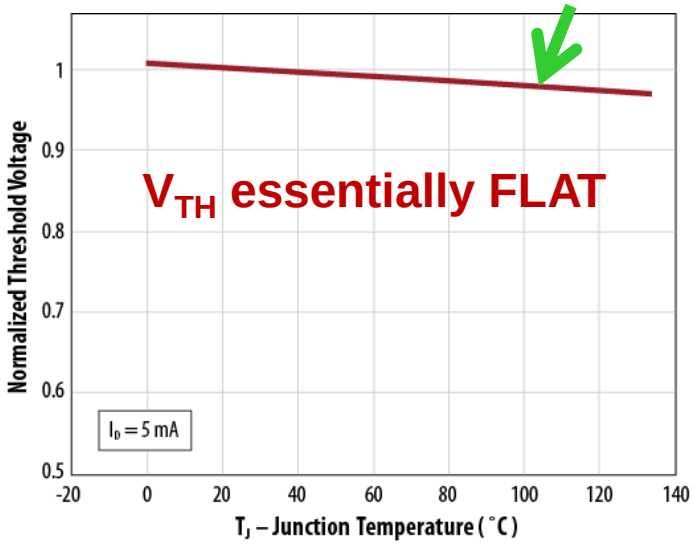
GaN transistors are more sensitive to gate rupture than power MOSFETs

eGaN Characteristics



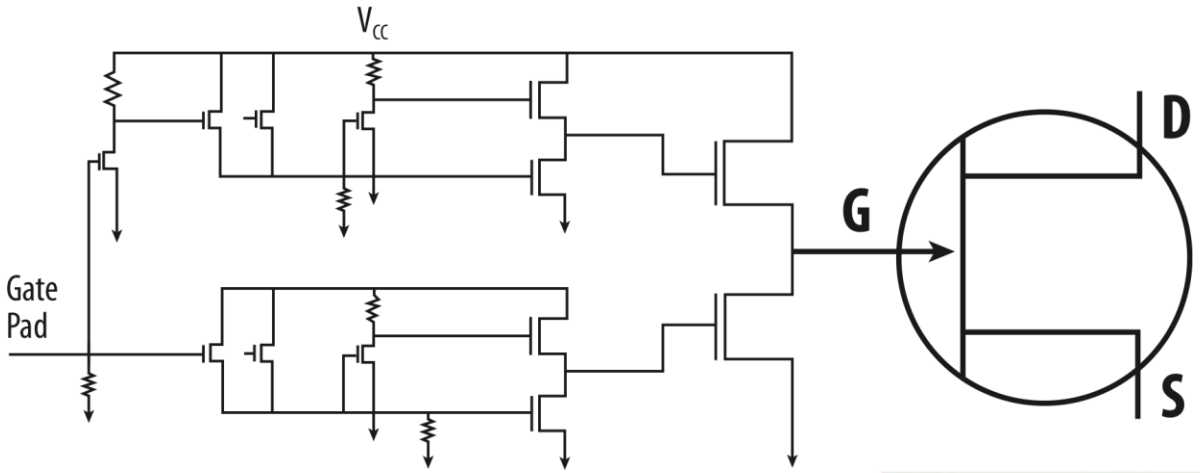


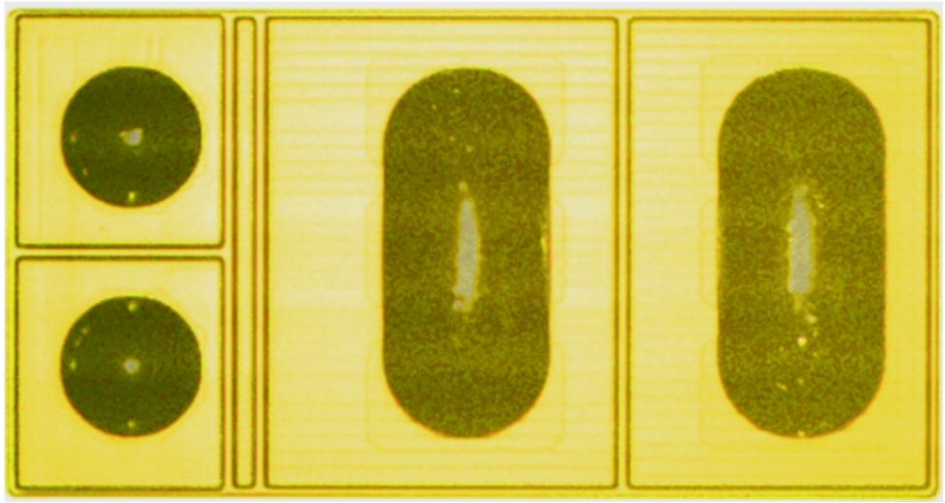




What the Future Holds

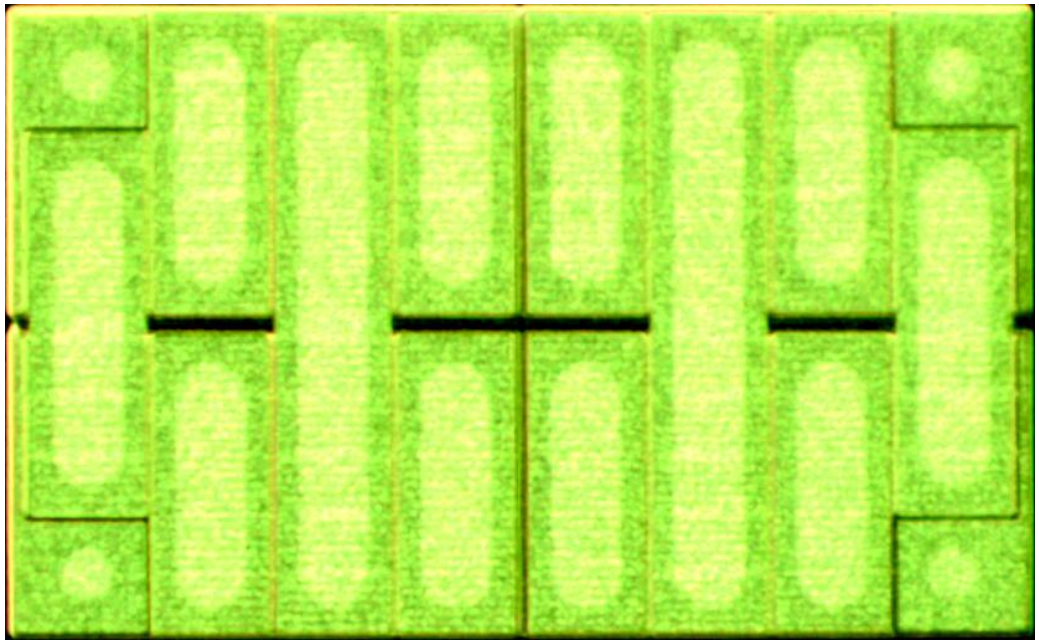
Driver On Board





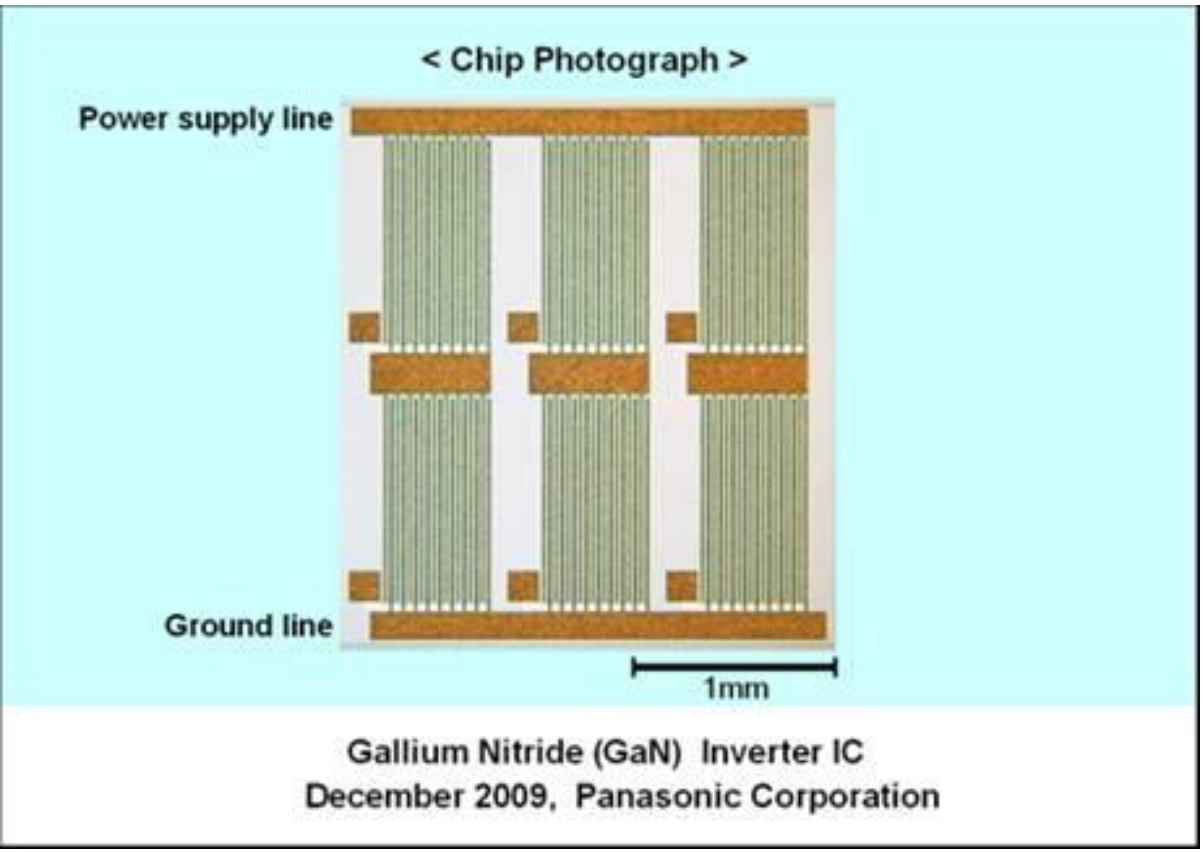
What the Future Holds

Full-Bridge with Driver



What the Future Holds

Three Phase Monolithic Motor Drive



Gallium Nitride (GaN) Inverter IC
December 2009, Panasonic Corporation

Hybrid POL

Conclusions

- Many new applications are enabled due to eGaN's quantum leap in frequency capability
- After over one year on the market, eGaN has started to replace MOSFETs in many high performance applications
- Basic product reliability has been established
- The largest impediment to the rapid adoption of eGaN is the need for a low-cost, high-performance gate drive.

The end of the road for Silicon ...

... is the beginning of the GaN journey!