GaN as a Displacement Technology for Silicon in Power Management

Alexander Lidow PhD

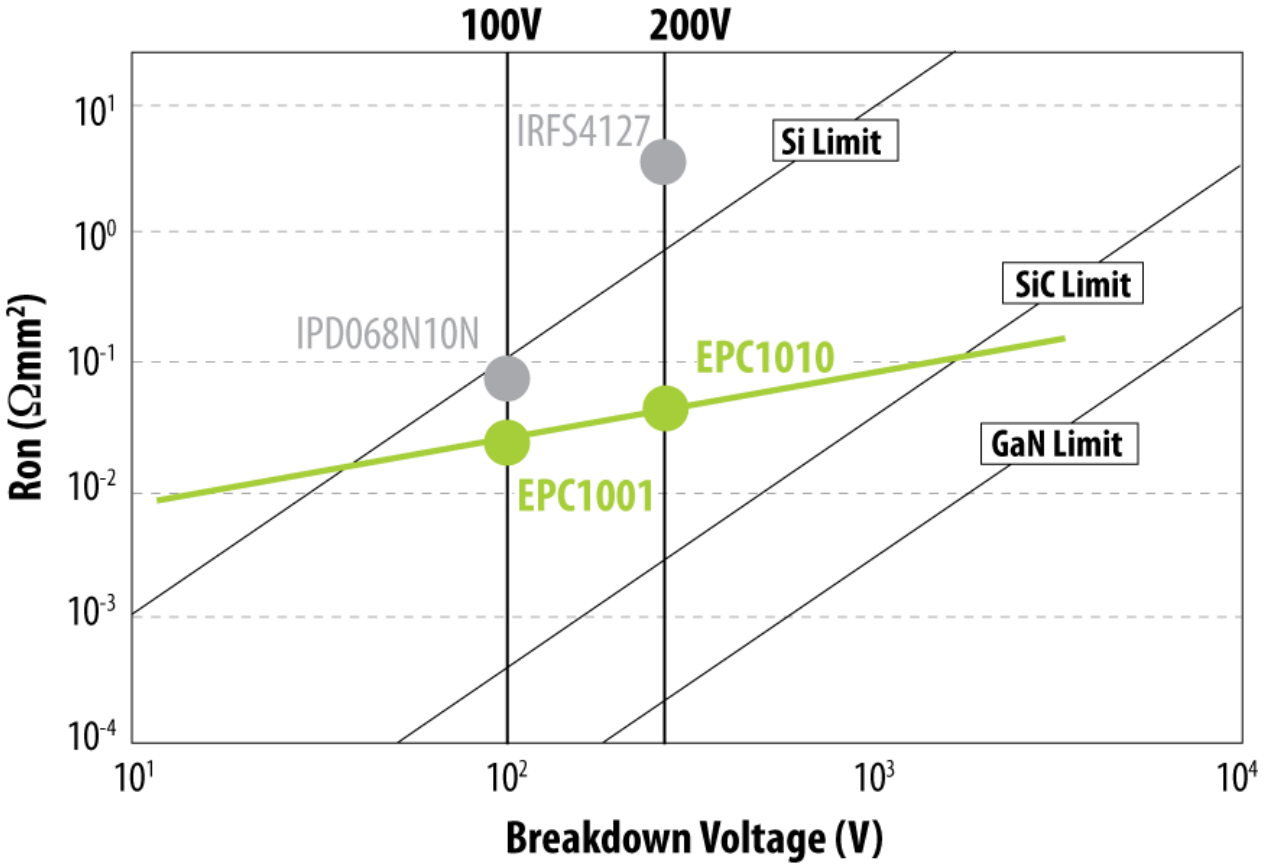
Efficient Power Conversion Corporation

Agenda

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

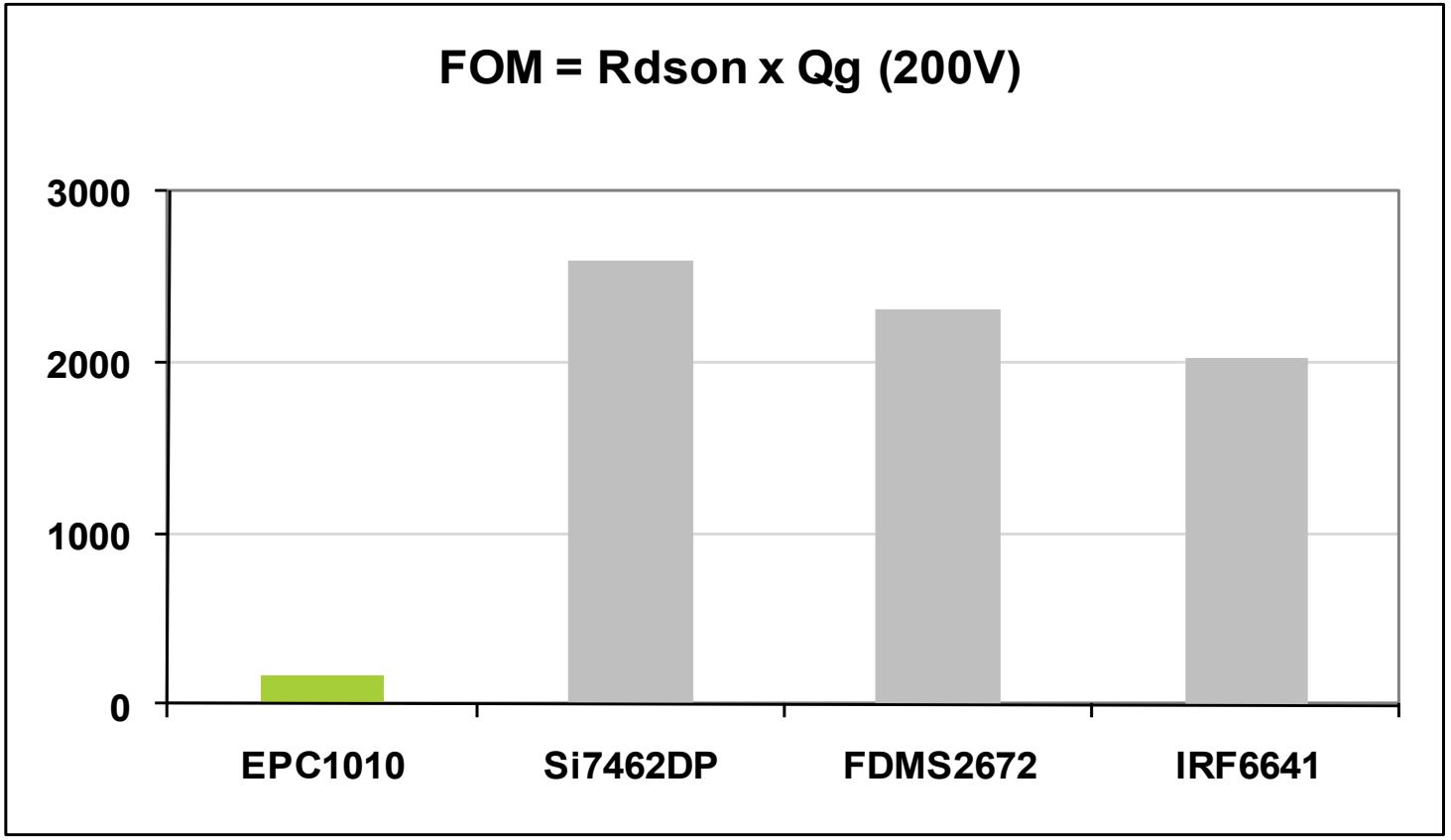
Why Gallium Nitride?

Smaller Die Sizes

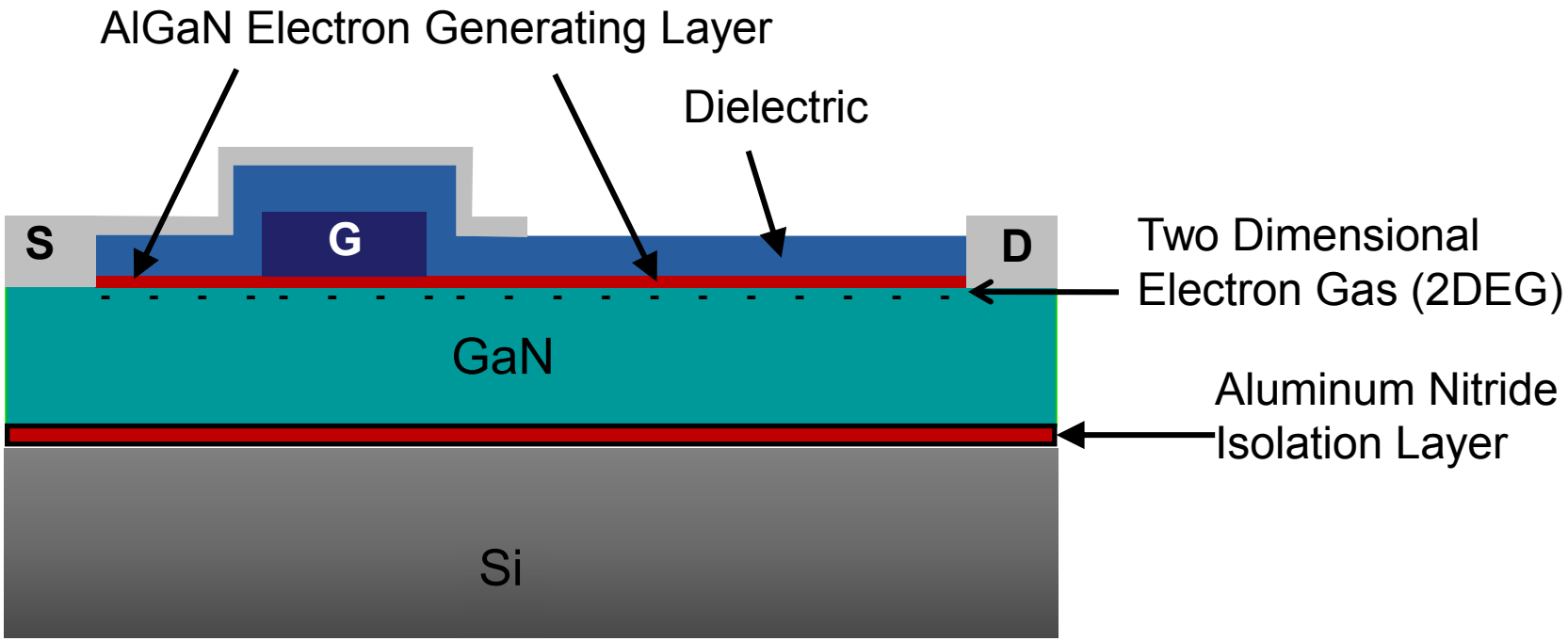


Why Gallium Nitride?

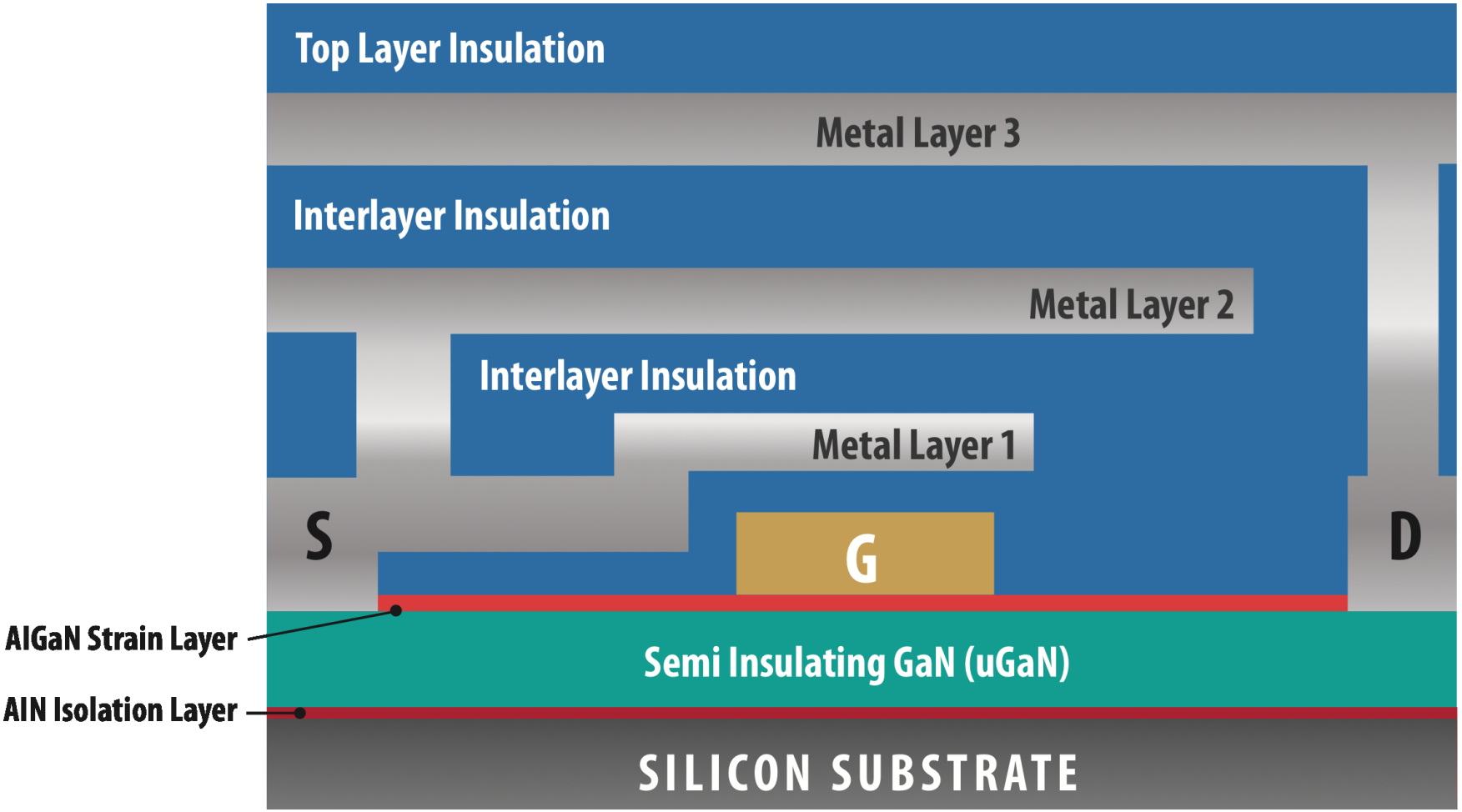
Better Figure of Merit



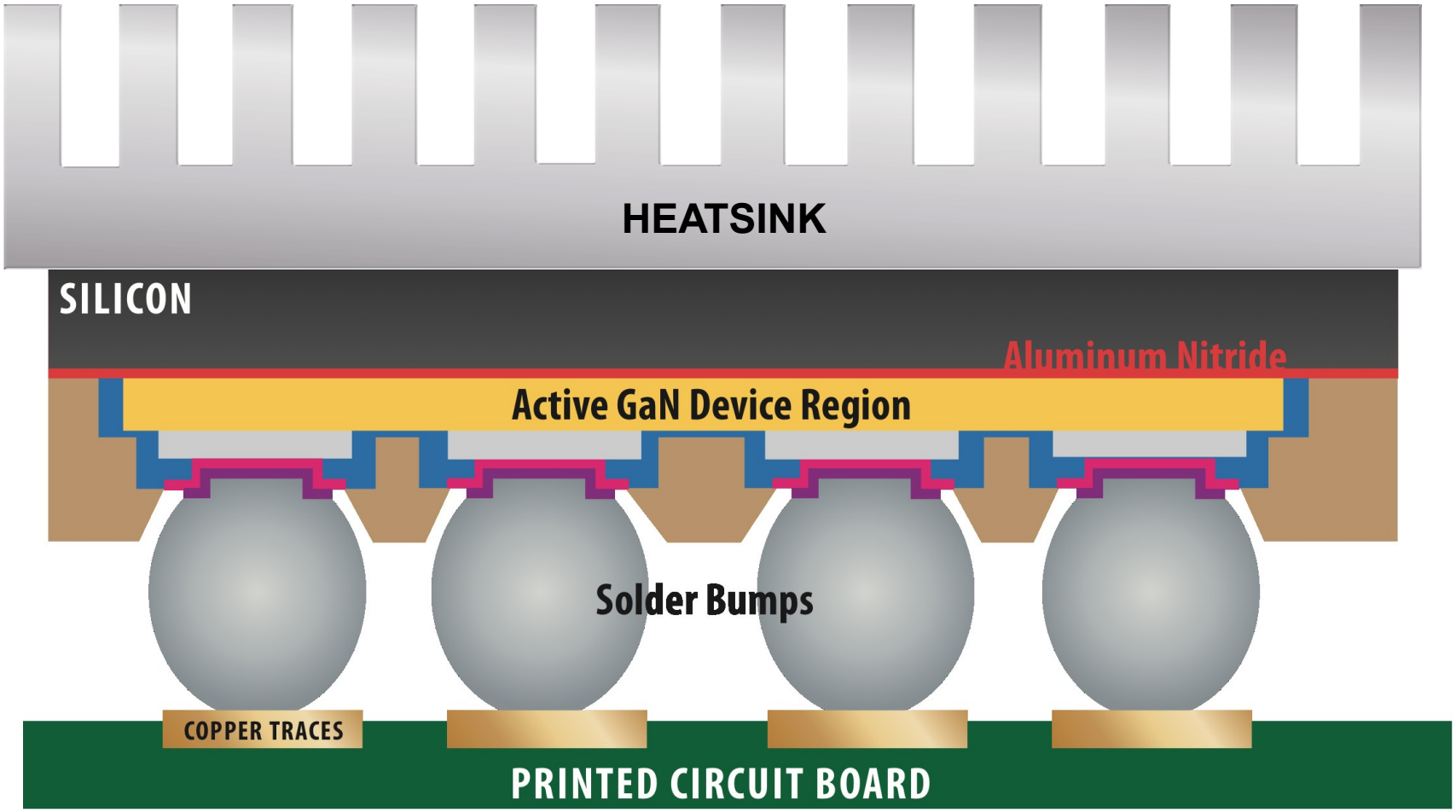
eGaN FET Structure



eGaN FET Structure



Flip Chip Assembly



Breaking Down the Barriers

- Does it enable significant new capabilities?
- Is it easy to use?
- Is it VERY cost effective to the user?
- Is it reliable?

Breaking Down the Barriers

- Does it enable significant new capabilities?
- Is it easy to use?
- Is it VERY cost effective to the user?
- Is it reliable?

Buck Converter

Advantage:

- **High power density and high efficiency**

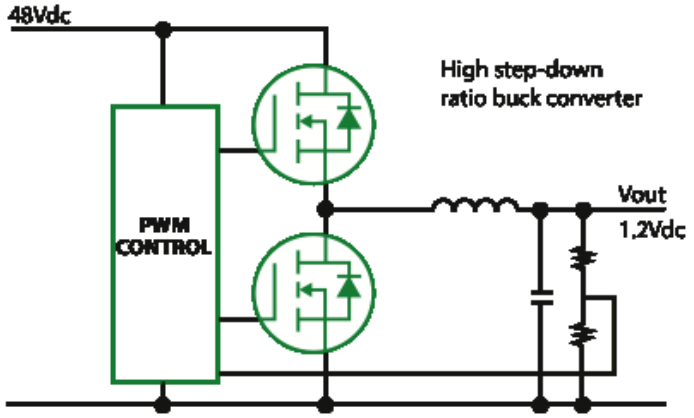
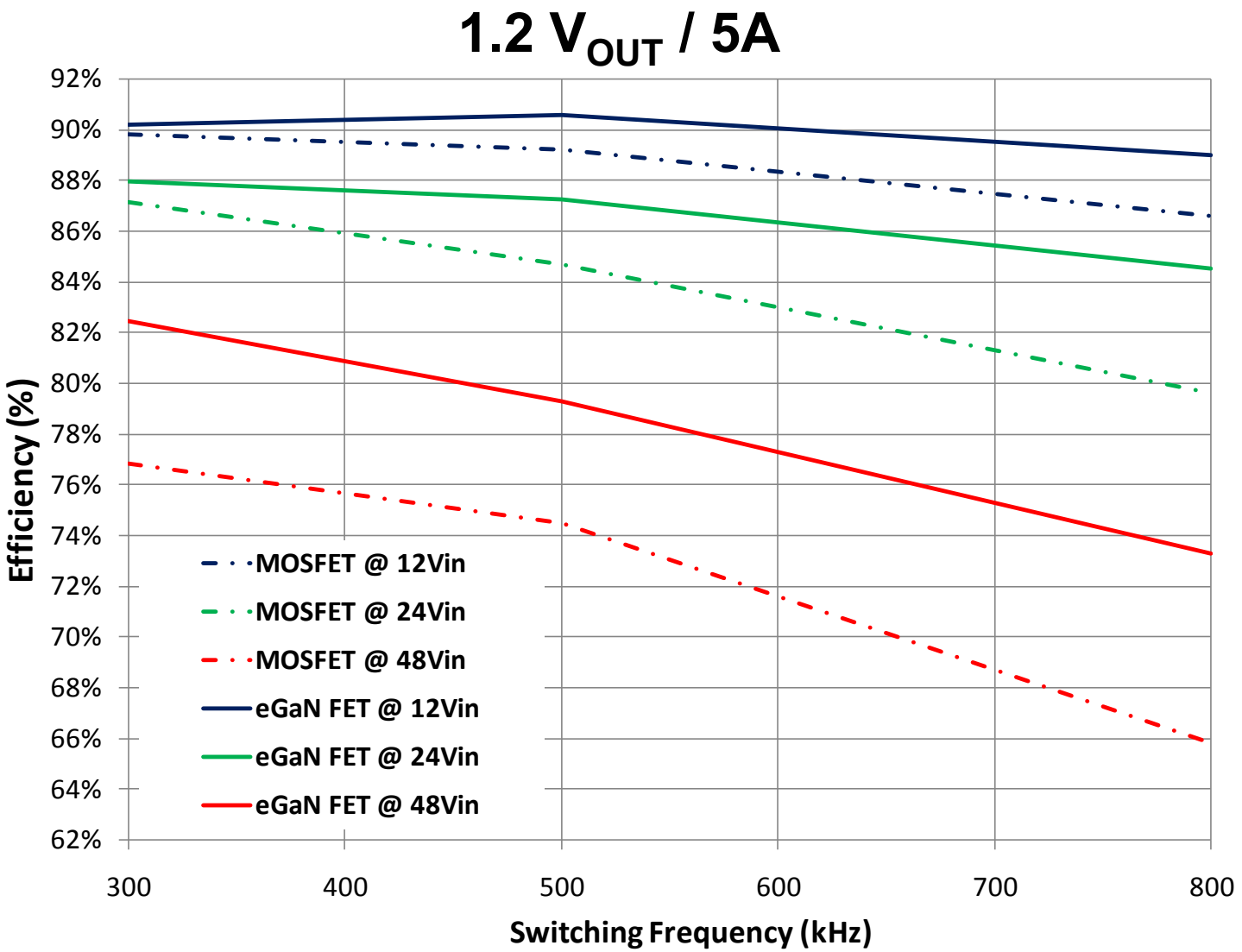


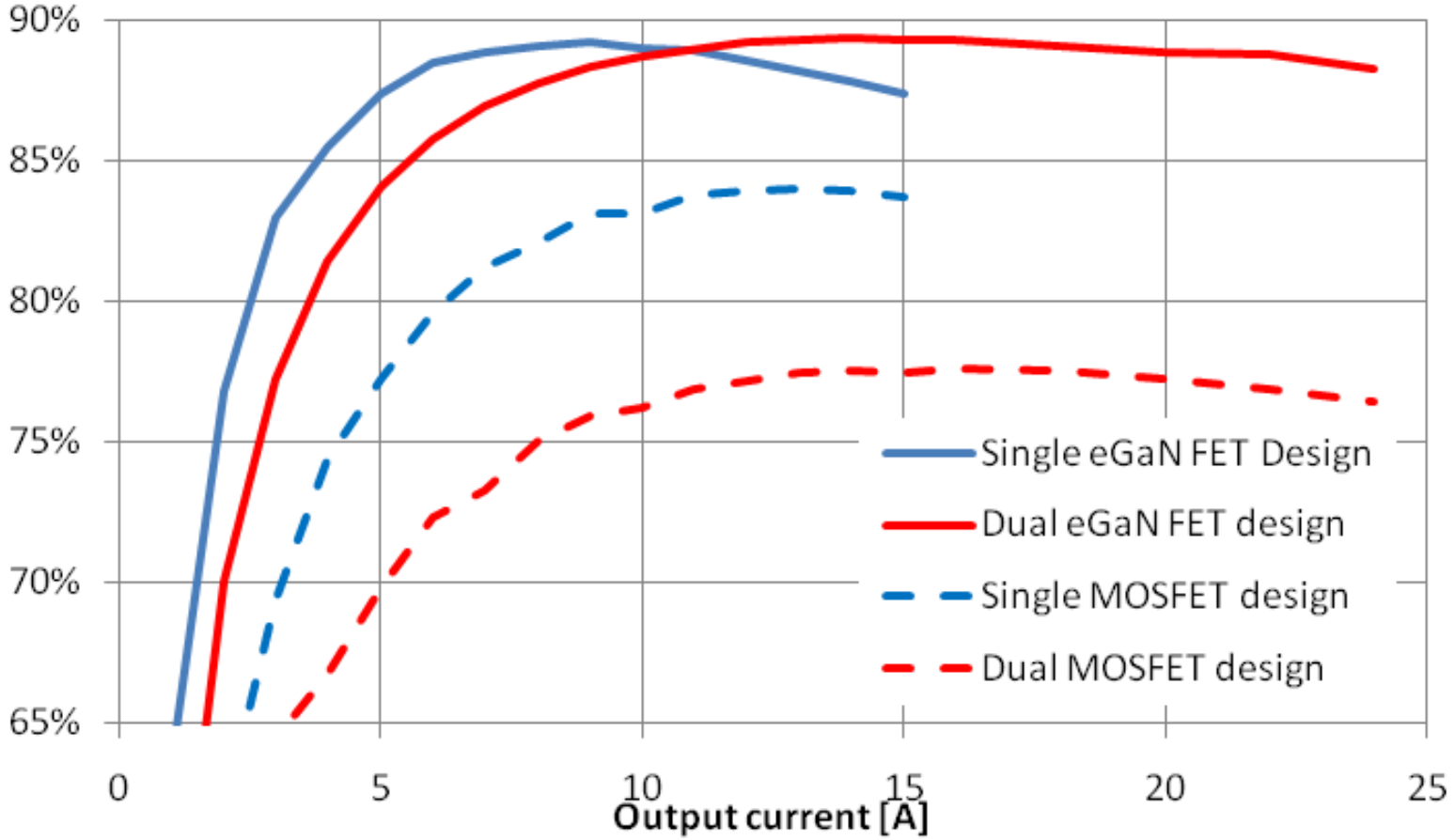
Figure 7 – Buck converter with an input voltage of 48 VDC and output voltage of 1.2 VDC

Efficiency vs Frequency



$12V_{IN}$ – 1.2 V_{OUT} Buck Converter

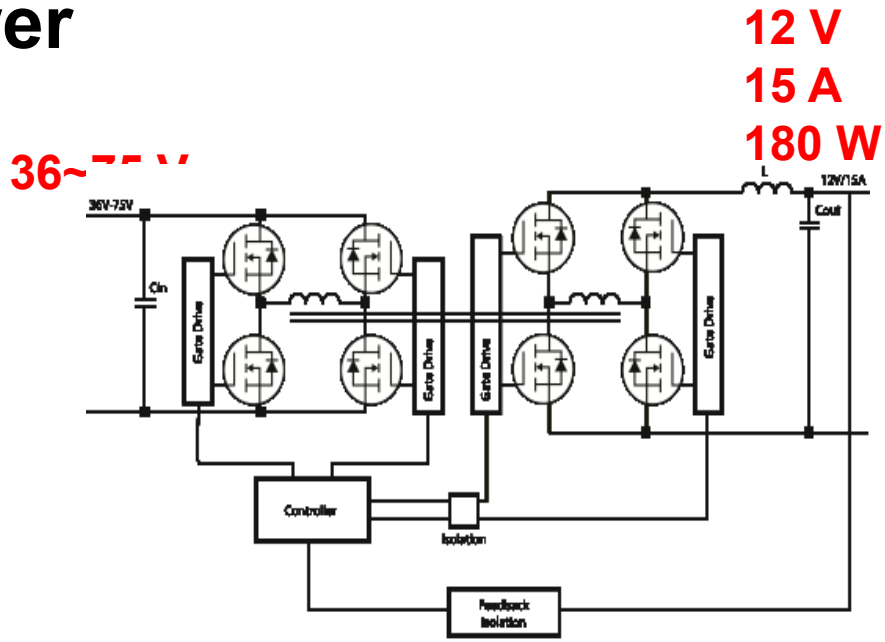
Efficiency at 1 MHz



Isolated Full Bridge Converter

Advantage:

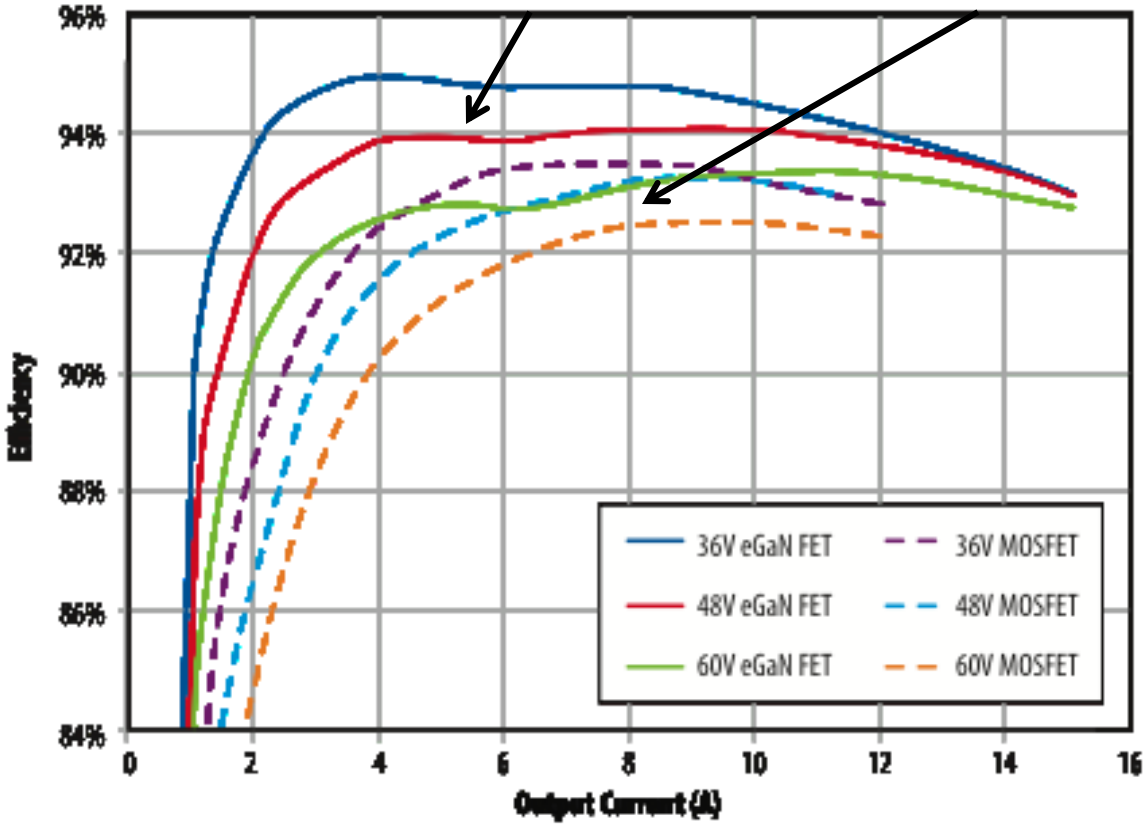
- **Isolation and high power density at high power**



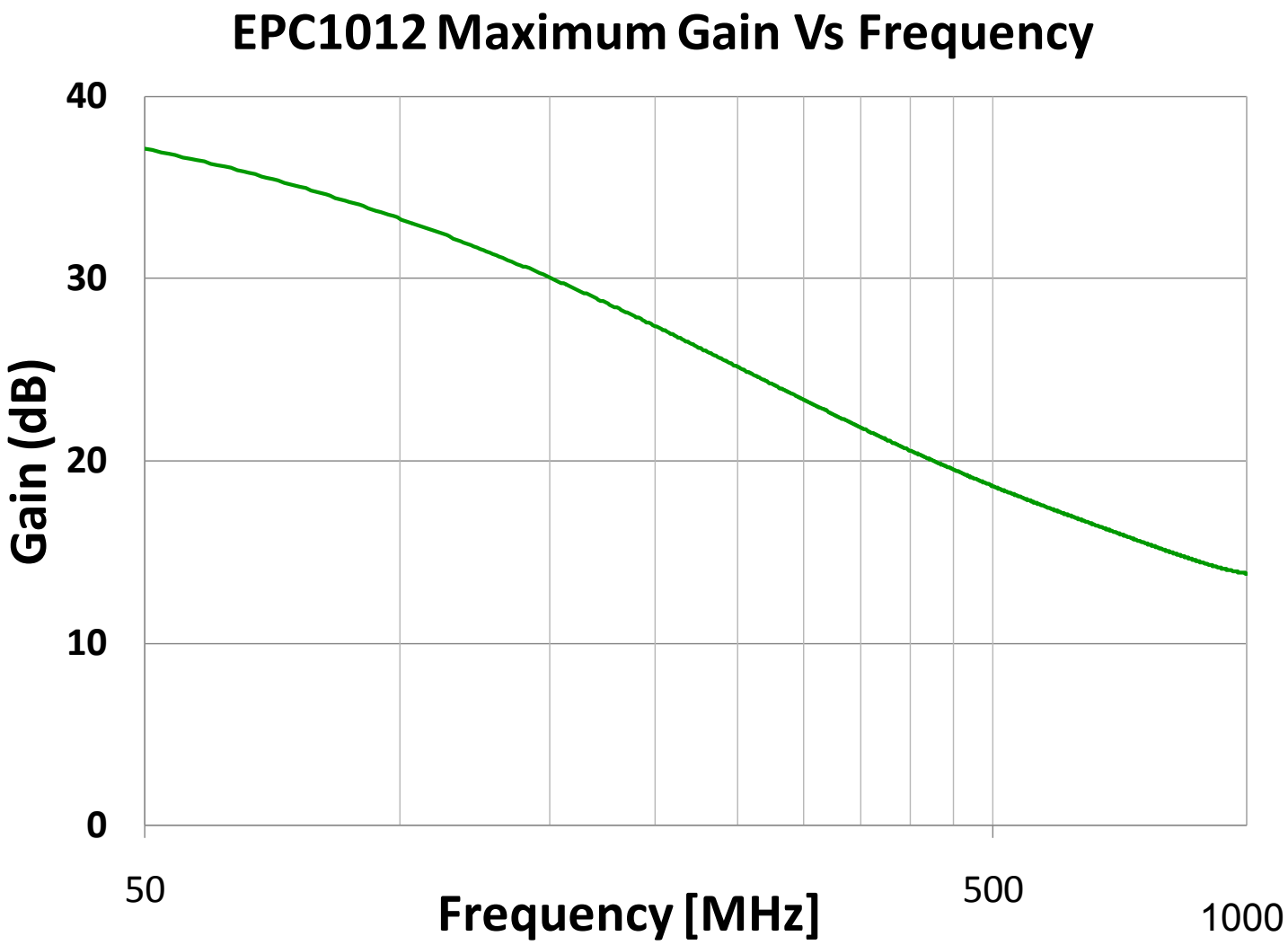
Isolated Full Bridge Converter

Efficiency comparison @ 12 V_{OUT}

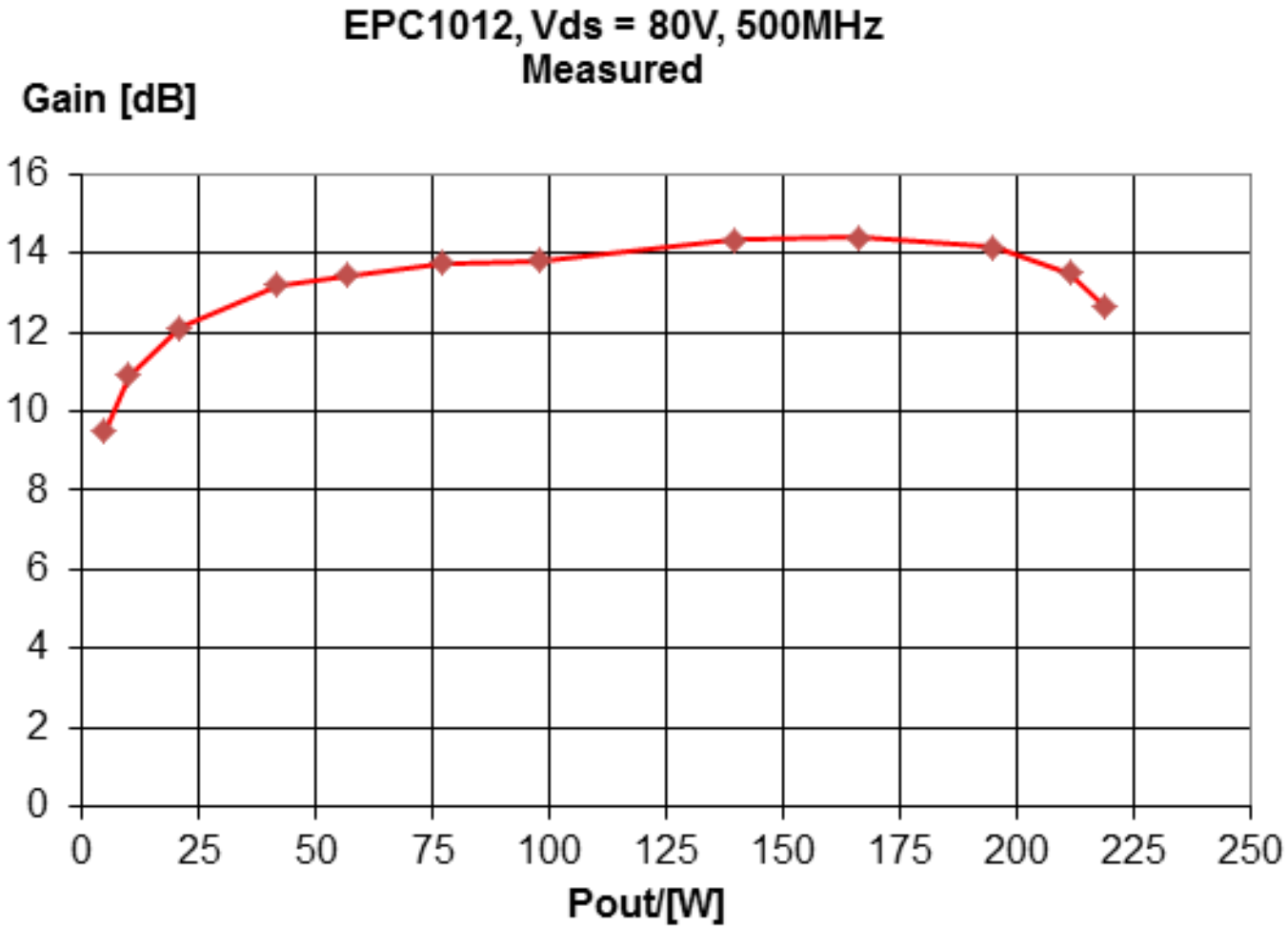
eGaN FET @ 333 kHz vs MOSFET @ 250 kHz



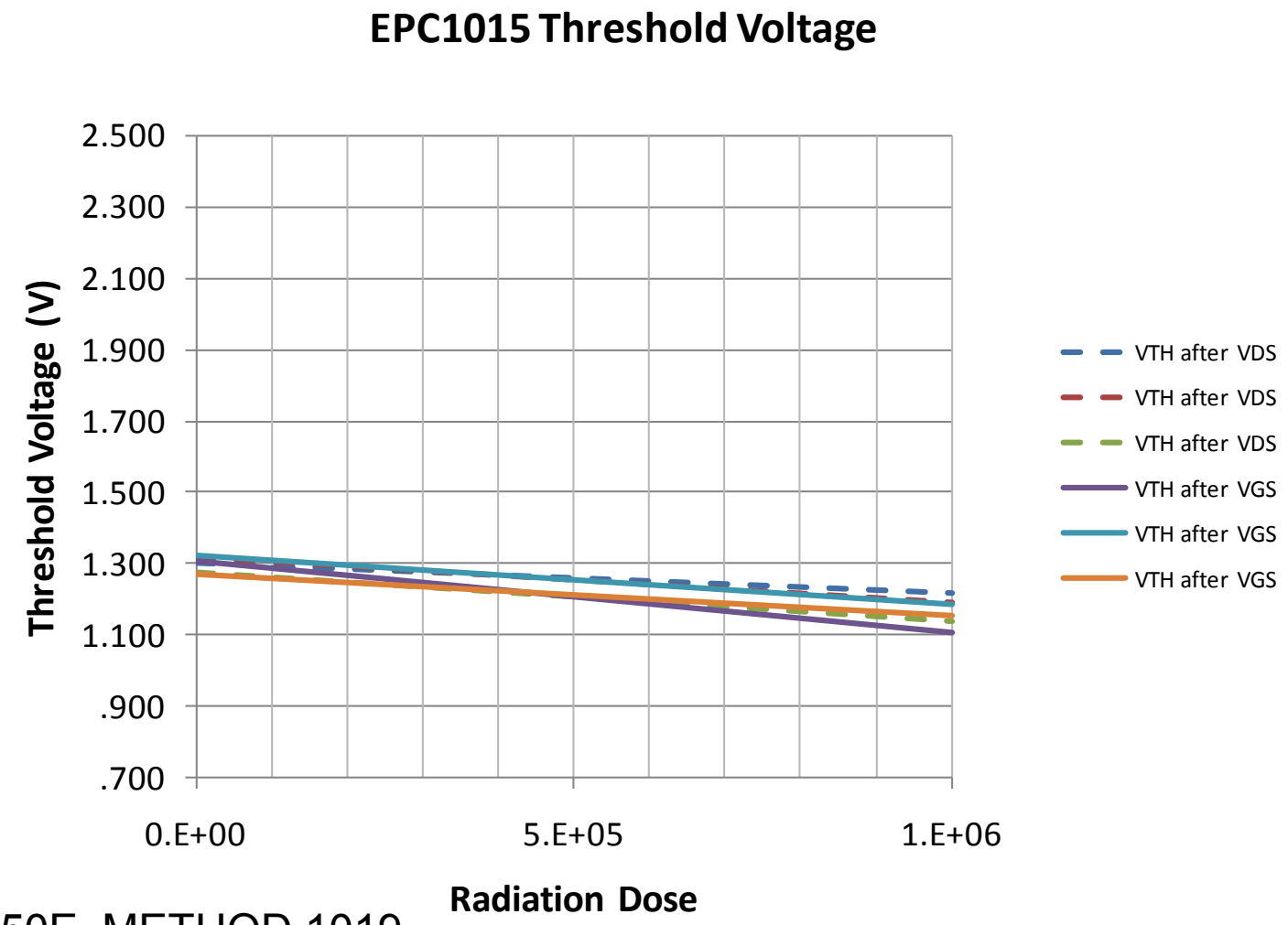
High Frequency Capabilities



High Frequency Capabilities



Radiation Tolerance



MIL-STD-750E, METHOD 1019

Breaking Down the Barriers

- Does it enable significant new capabilities?
- Is it easy to use?
- Is it VERY cost effective to the user?
- Is it reliable?

Is it easy to use?

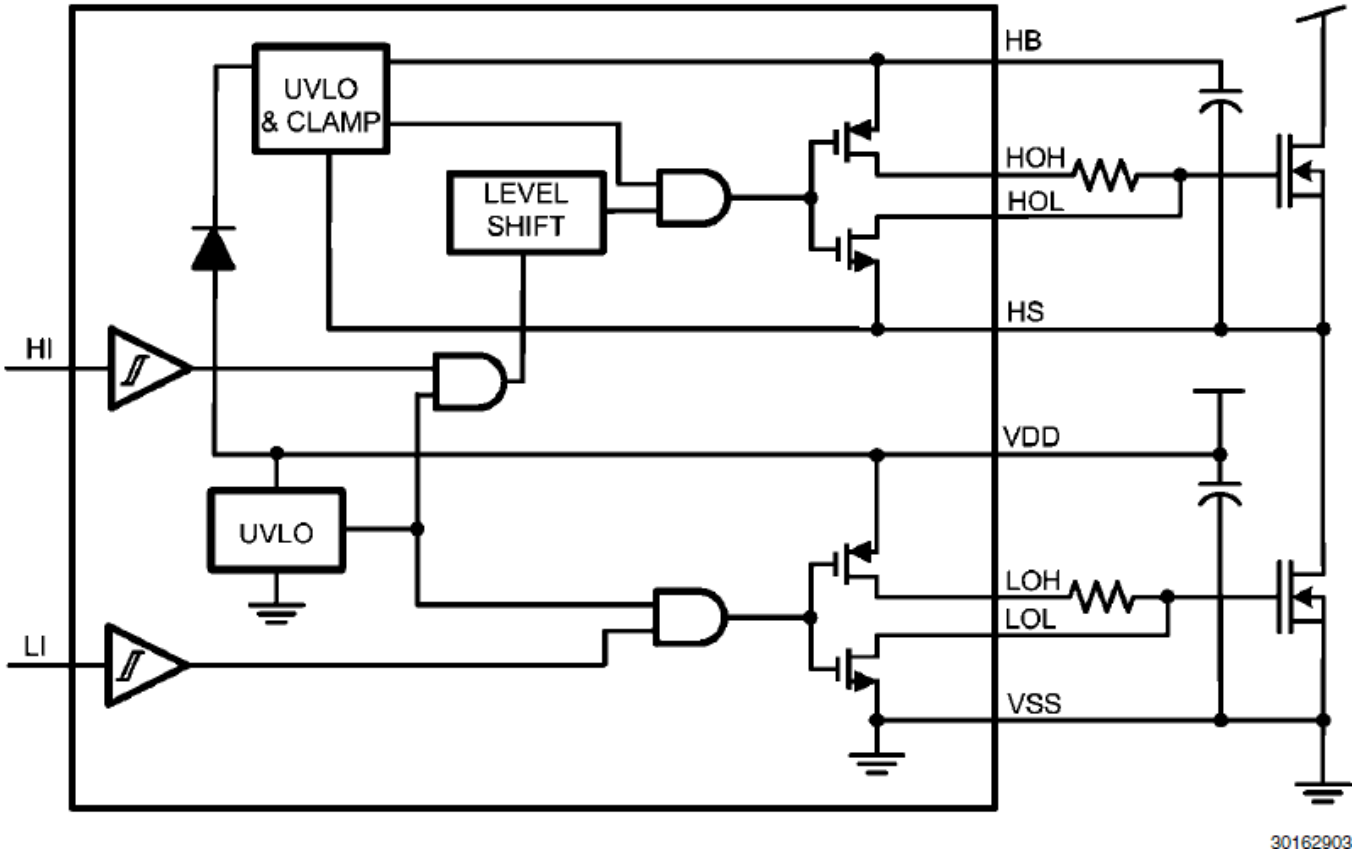
It's just like a MOSFET

except for TWO things

(1)
The high frequency capability makes circuits using eGaN FETs sensitive to layout

(2)
eGaN FETs have a lower maximum gate voltage than power MOSFETs

Integrated Gate Driver Solution



LM5113 from National Semiconductor

Breaking Down the Barriers

- Does it enable significant new capabilities?
- Is it easy to use?
- Is it VERY cost effective to the user?
- Is it reliable?

Silicon Vs eGaN Wafer Costs

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

Breaking Down the Barriers

- Does it enable significant new capabilities?
- Is it easy to use?
- Is it VERY cost effective to the user?
- Is it reliable?

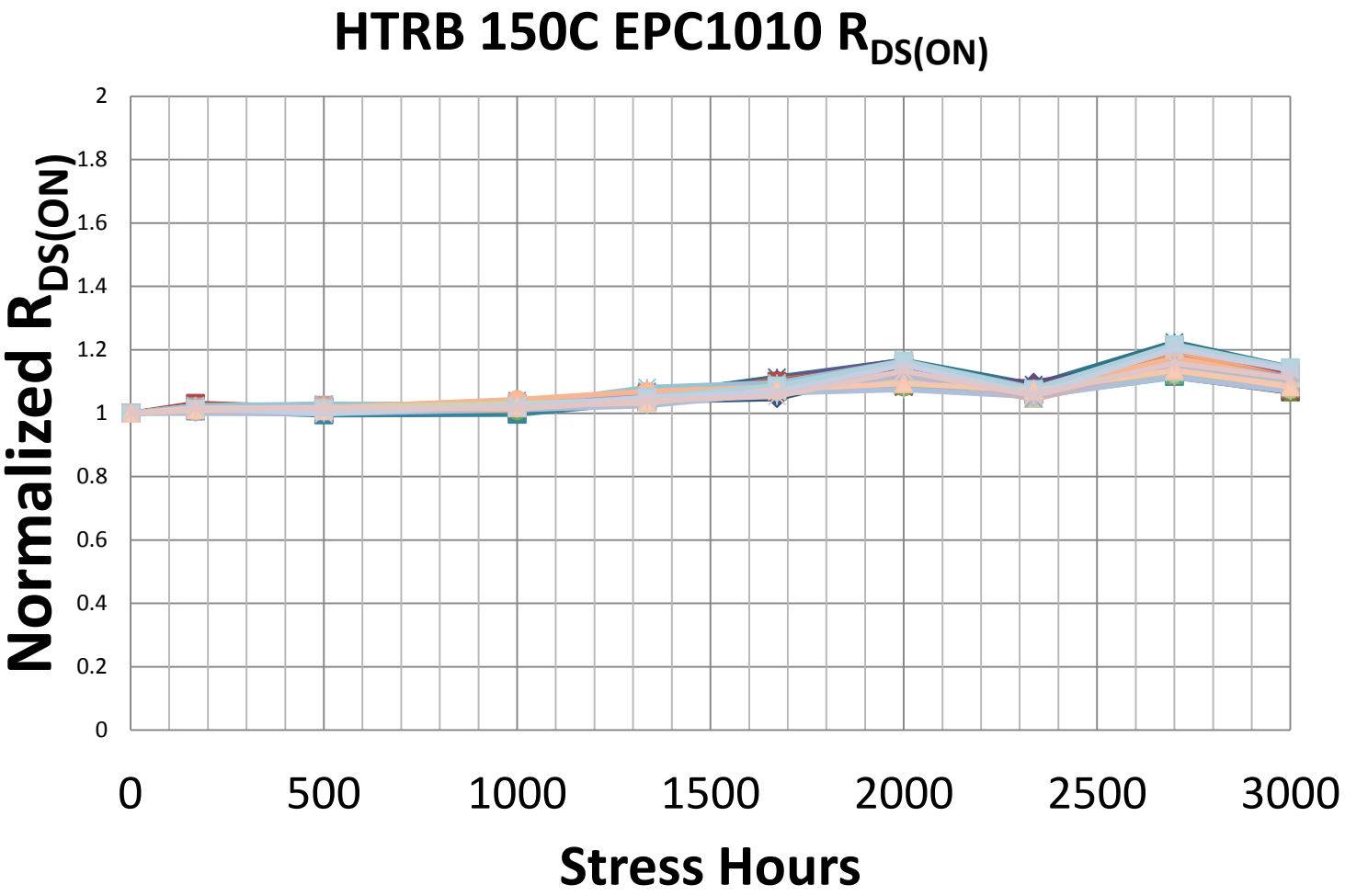
Reliability Key Issues

- Current Collapse
- Temperature Cycling and Humidity Sensitivity
- Operating Life

Reliability Key Issues

- Current Collapse
- Temperature Cycling and Humidity Sensitivity
- Operating Life

No Current Collapse

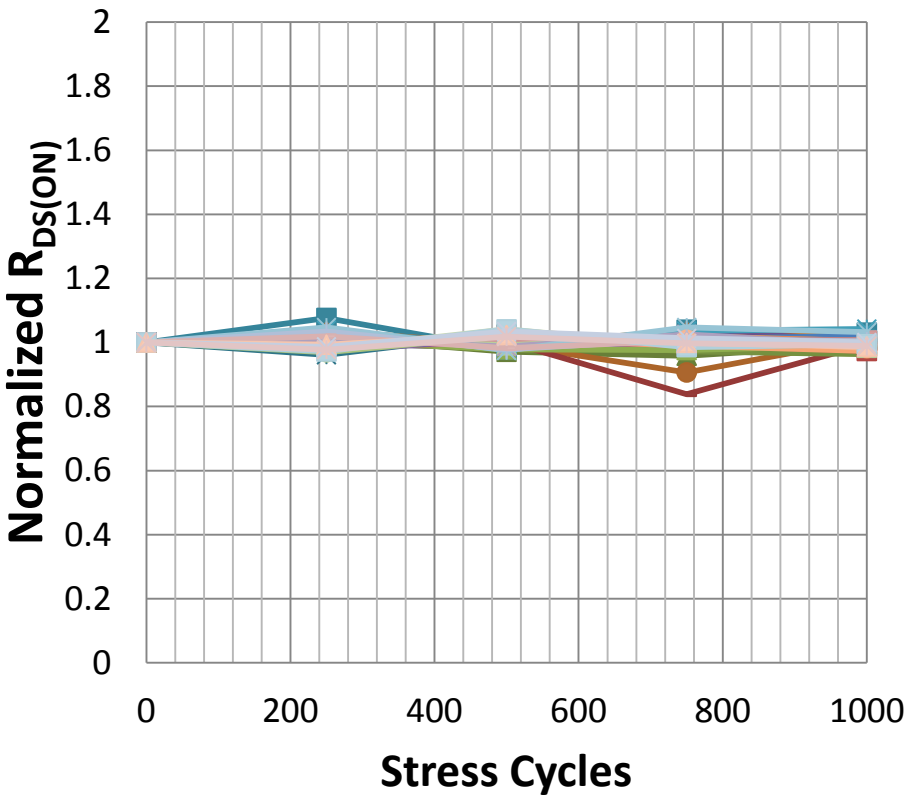


Reliability Key Issues

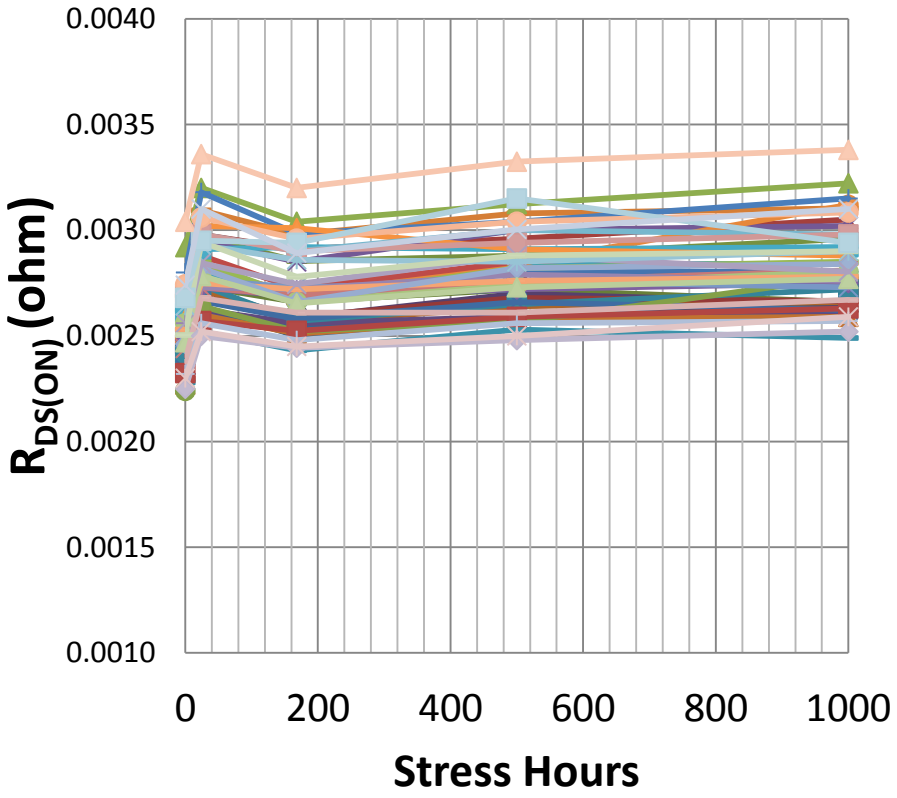
- Current Collapse
- Temperature Cycling and Humidity Sensitivity
- Operating Life

TC and H3TRB

EPC2001 $R_{DS(ON)}$ after TC -40 to 125°C



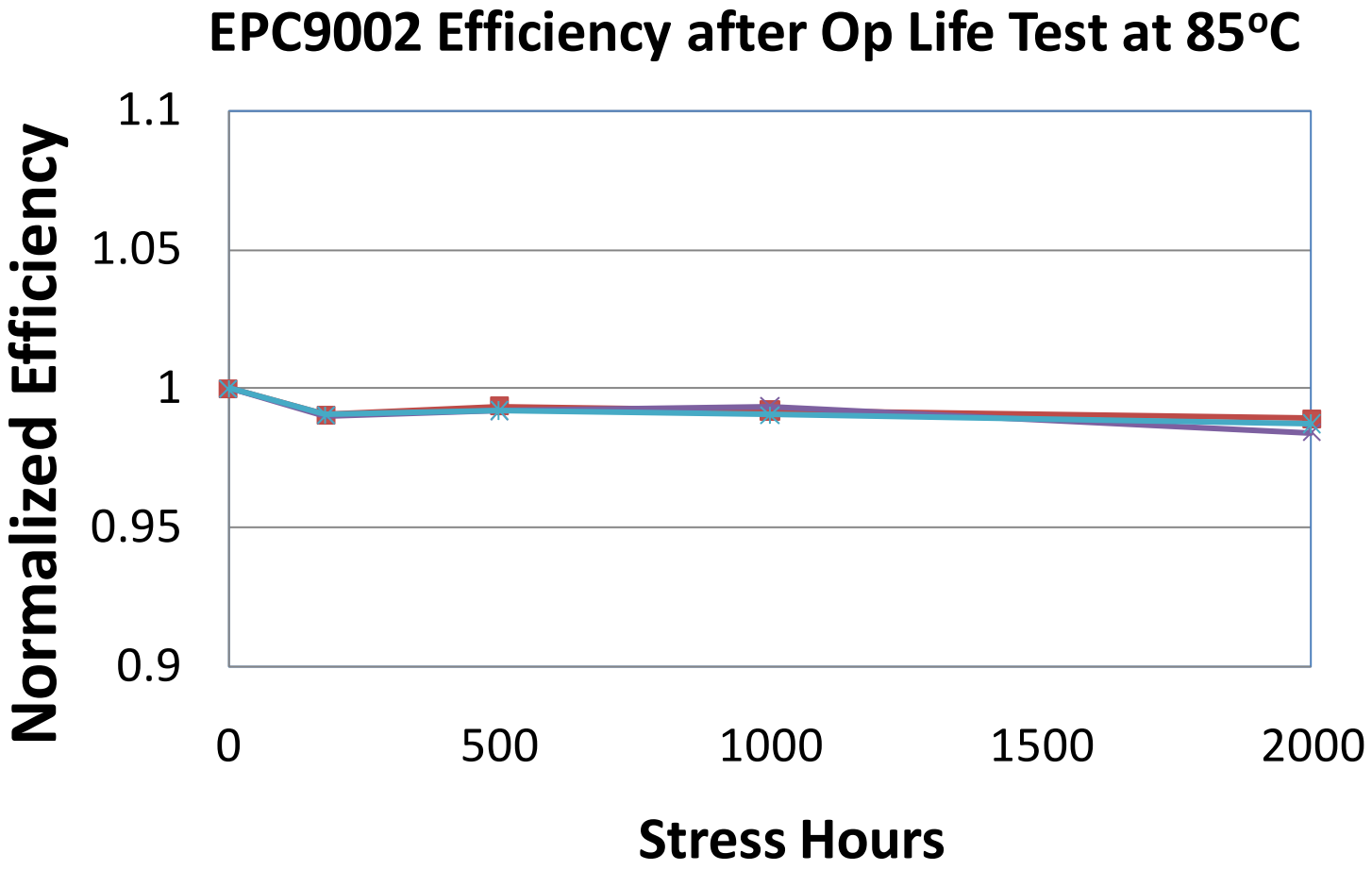
EPC2015 $R_{DS(ON)}$ after 40V at 85°C/85%RH



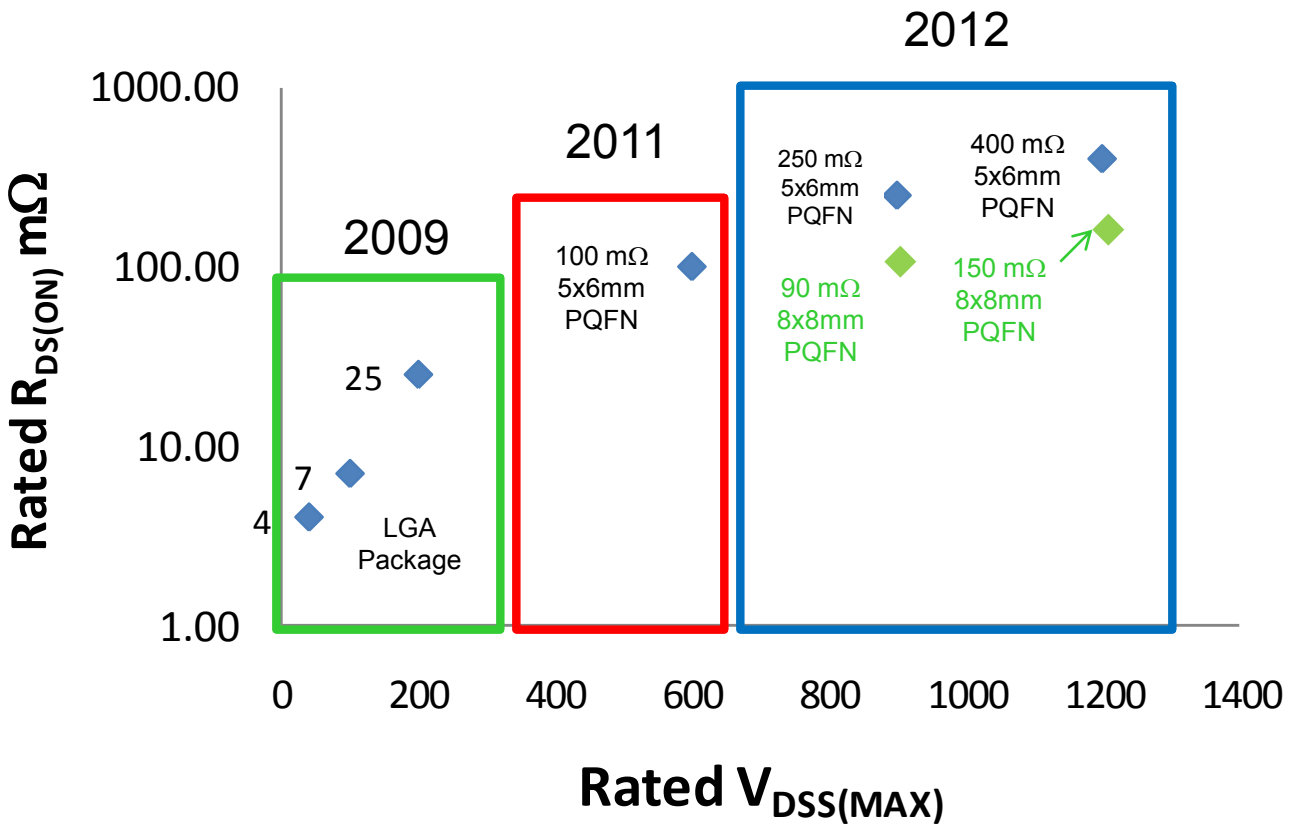
Reliability Key Issues

- Current Collapse
- Temperature Cycling and Humidity Sensitivity
- Operating Life

Operating Life

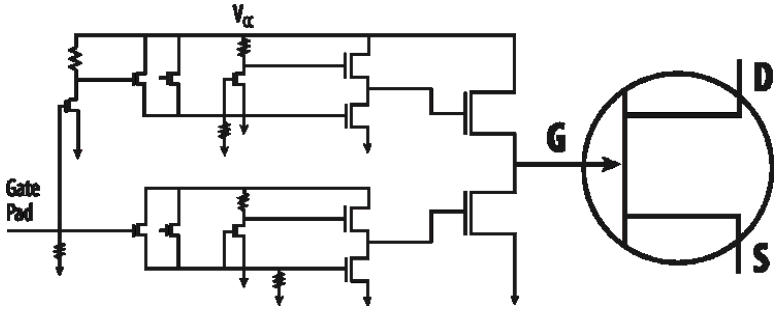


Beyond 600 Volts

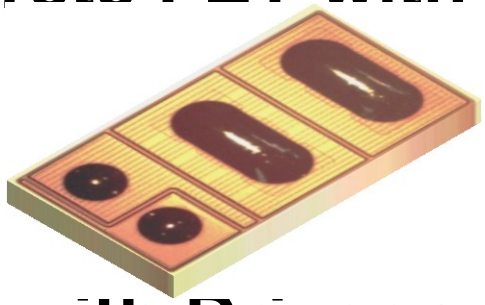


Beyond Discrete Devices

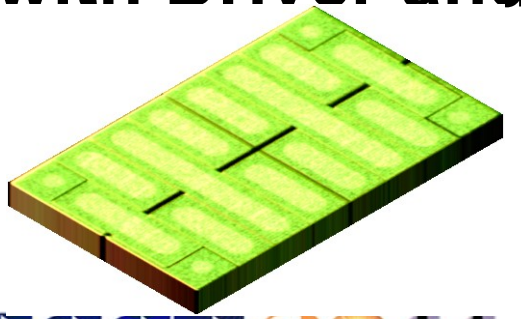
Driver On Board



Discrete FET with Driver



Full-Bridge with Driver and Level Shift



Is eGaN a Displacement Technology?

- Many new applications are enabled due to quantum leap in frequency capability
- Devices are easy to use because they are similar to a power MOSFETs and commercial IC drivers are available
- The technology will soon be lower cost-per-function than silicon.
- Reliability testing shows that parts are capable in commercial applications.

EPC
EFFICIENT POWER CONVERSION

The end of the road for silicon…..

is the beginning of the eGaN FET journey!