Enhancement Mode Gallium Nitride (eGaN®) FETs for Efficient Power Conversion in Space

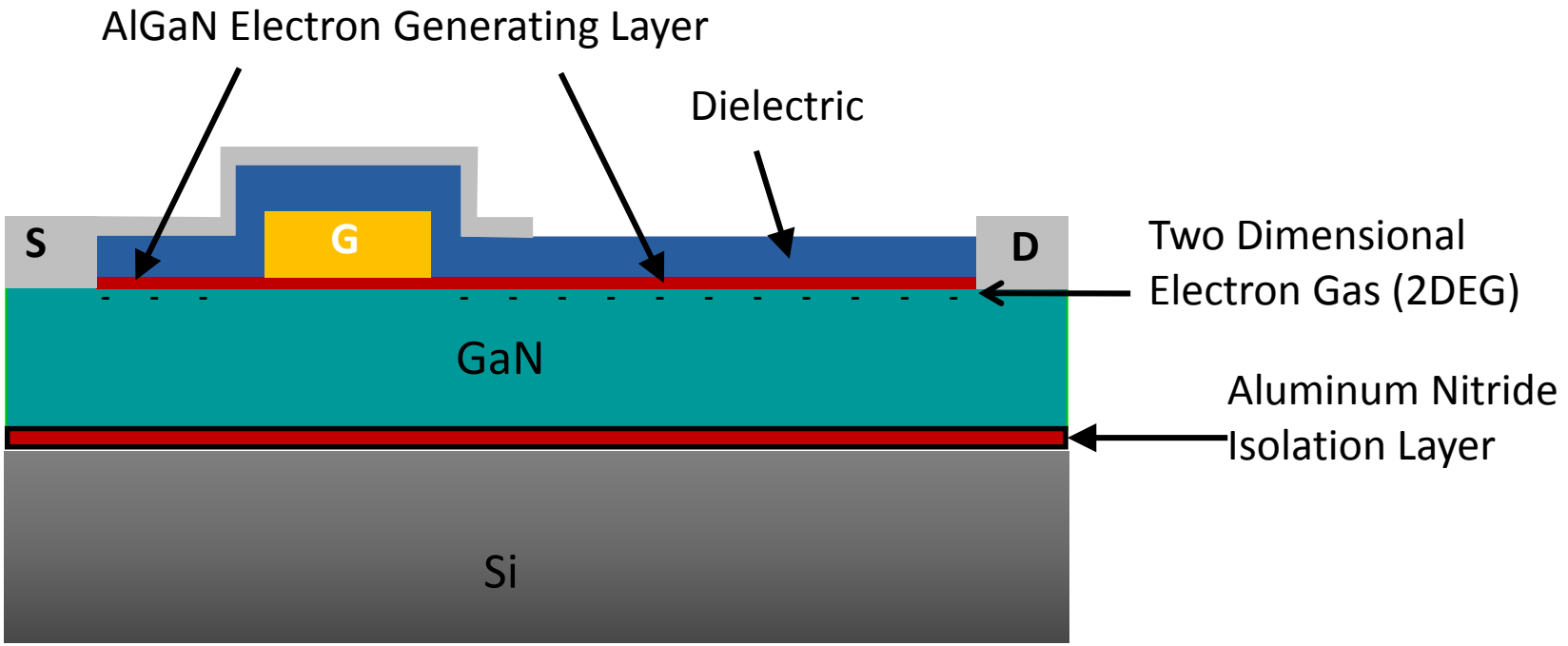
Alex Lidow
CEO and Co-founder
Efficient Power Conversion
April 2018

Agenda

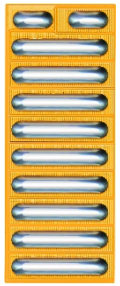
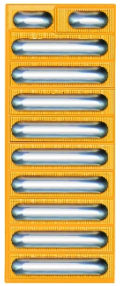
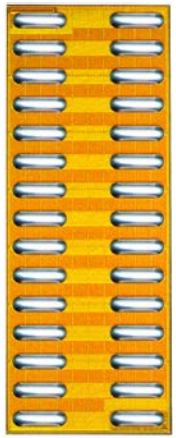
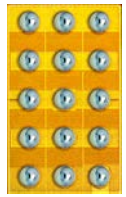
- GaN technology update
- Where has GaN been adopted?
- Why GaN in space?
- Why now?
- A look into the future
- Questions

eGaN FET Structure

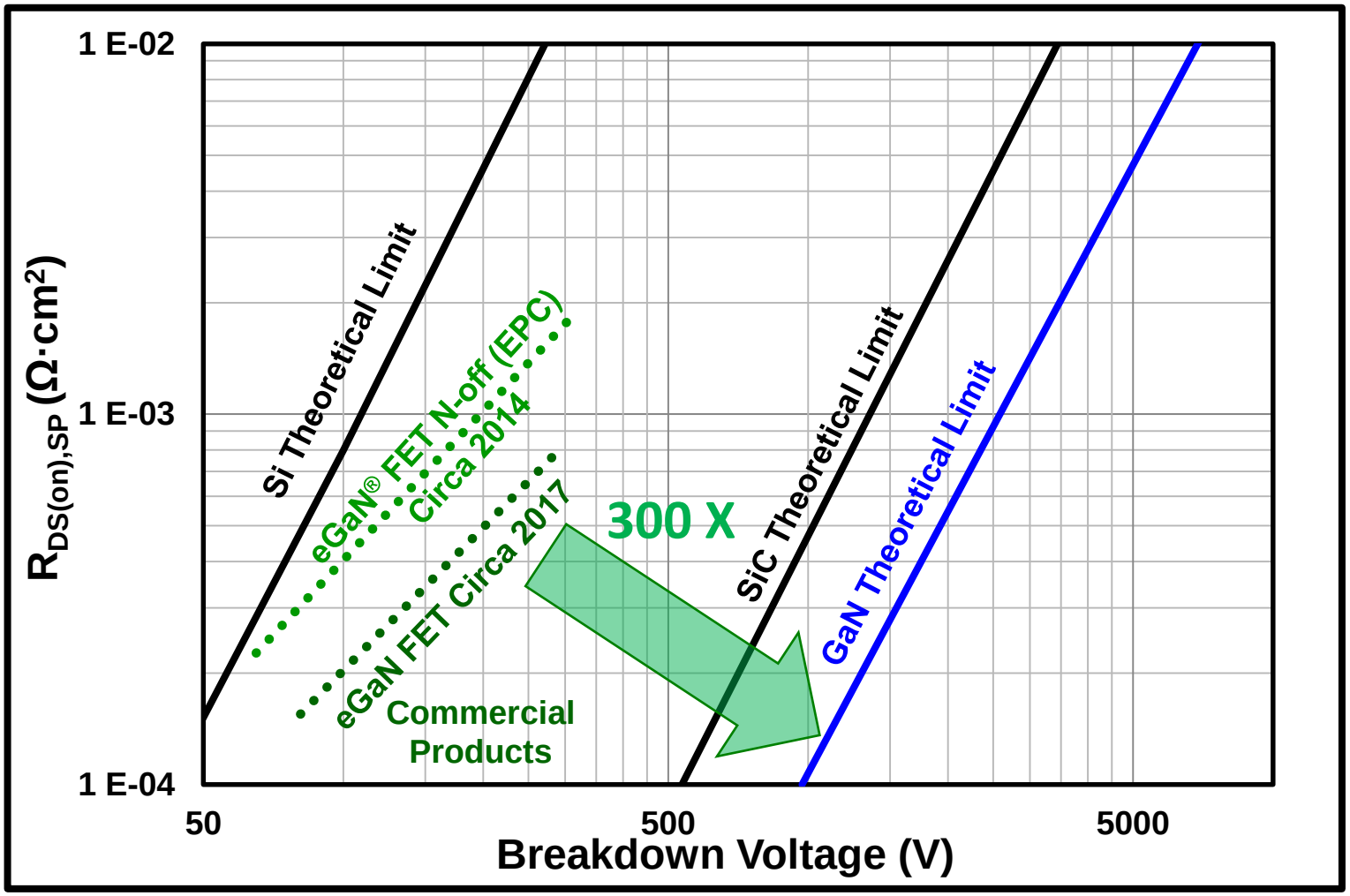
No Gate Oxide



eGaN Technology History

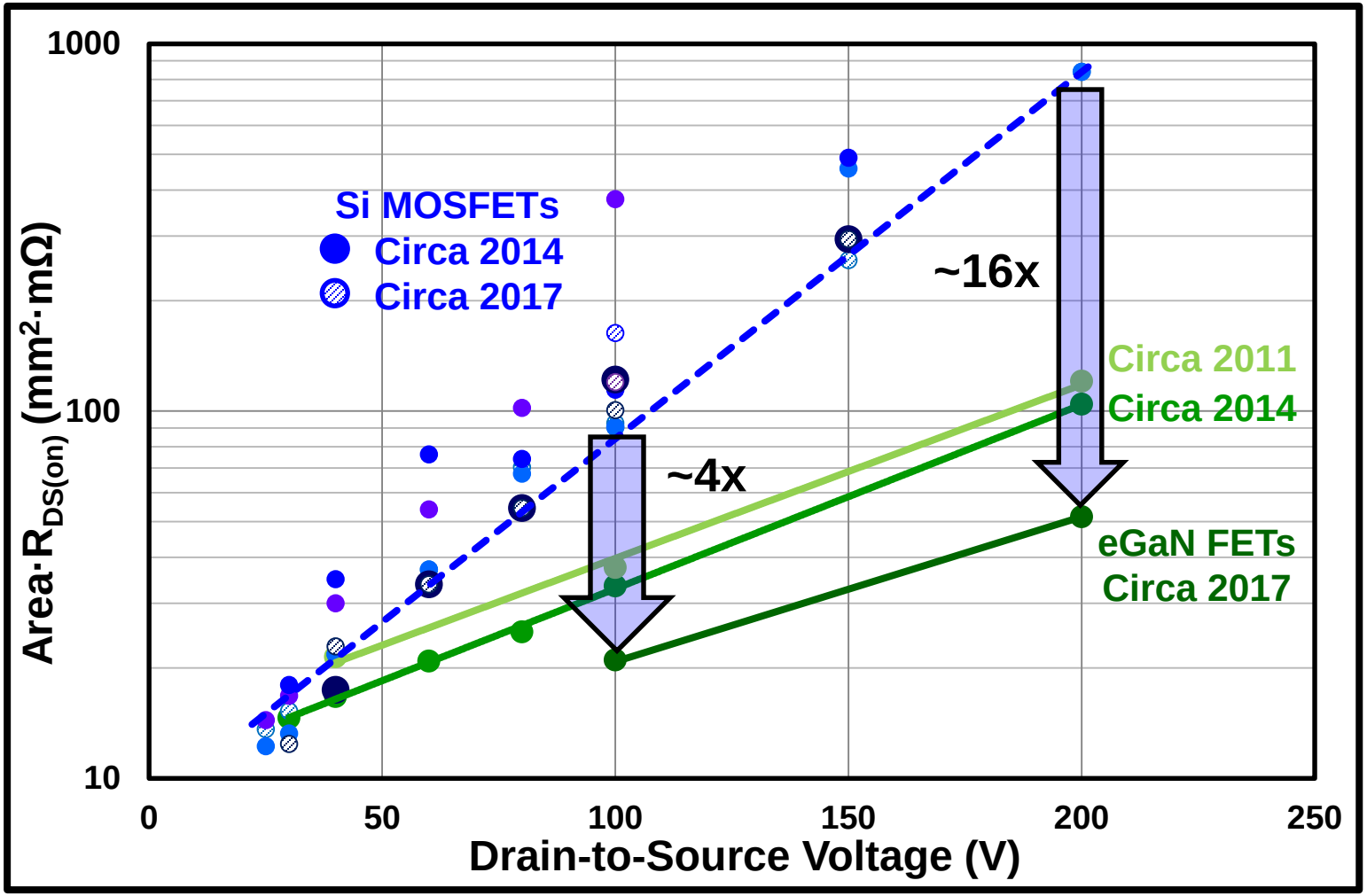
Technology	Gen 1	Gen 2	Gen 4	Gen 5
Product				
	2010	2011	2014	2017

Why Wide Bandgap



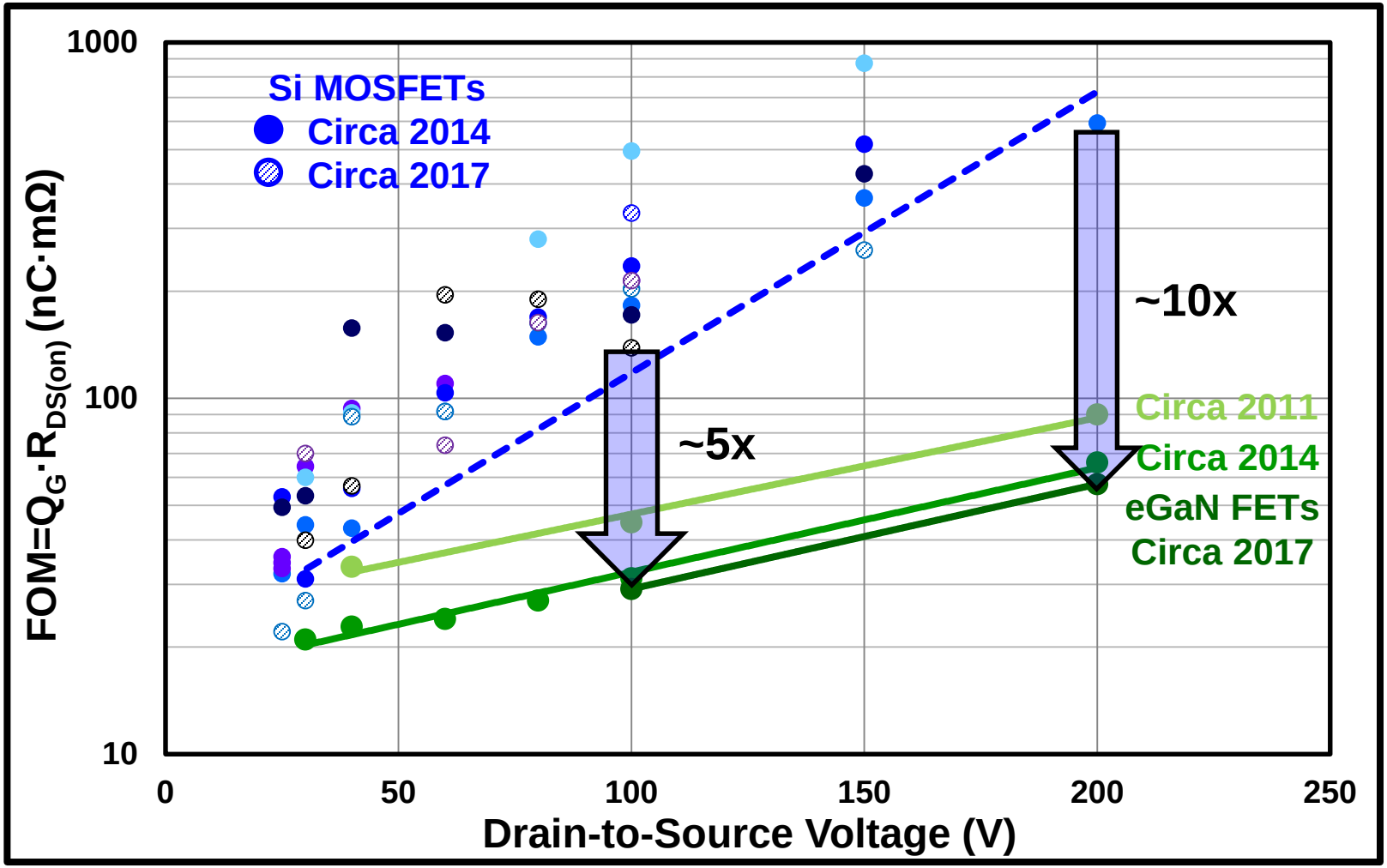
Theoretical Channel Resistance

Device Size Figure of Merit (FOM)



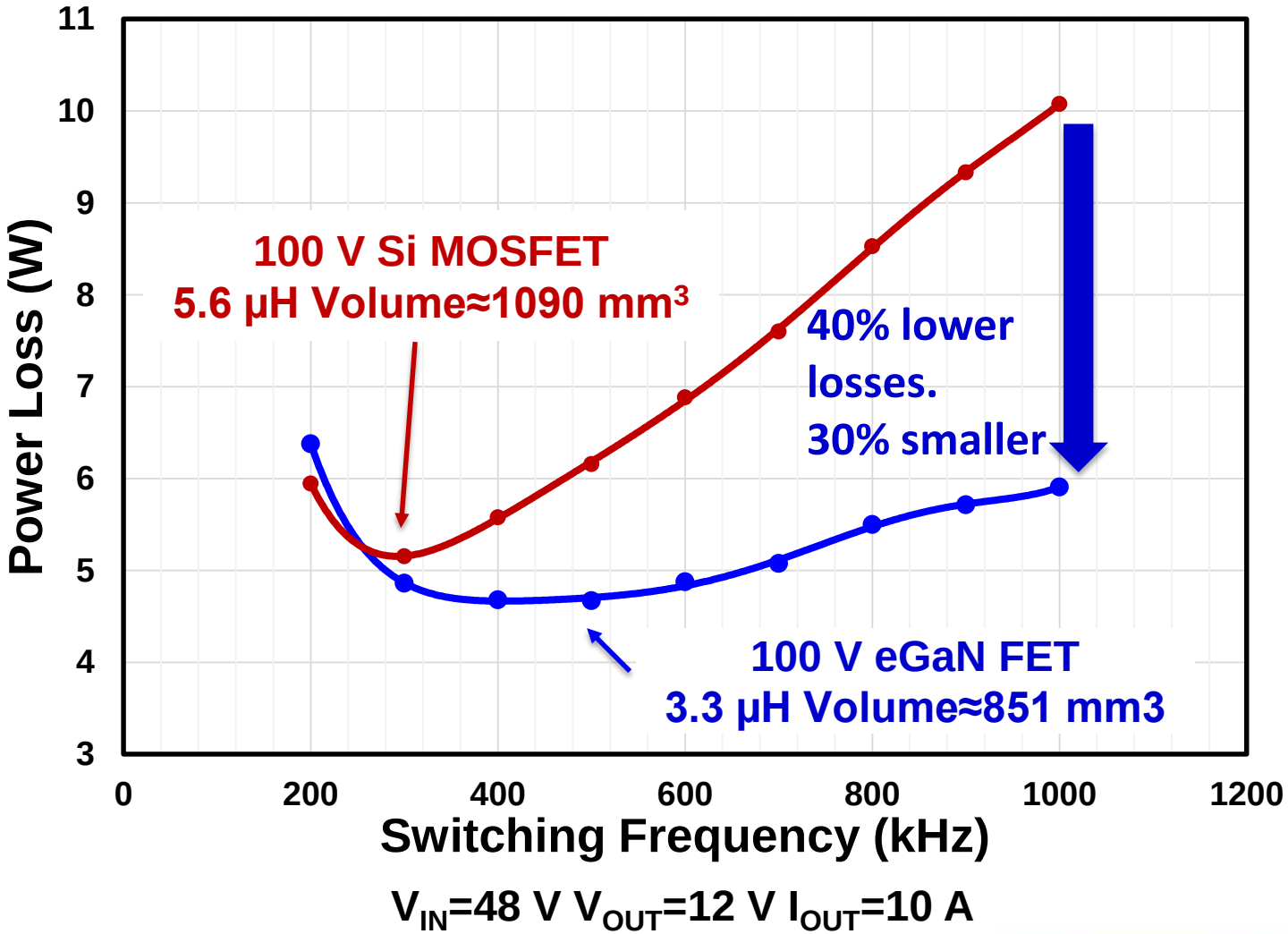
Actual Product Resistance

Gate Charge FOM Comparison



V_{DS}=0.5·V_{DSS}, I_{DS}=20 A

How GaN Compares with Si



V_{IN}=48 V V_{OUT}=12 V I_{OUT}=10 A

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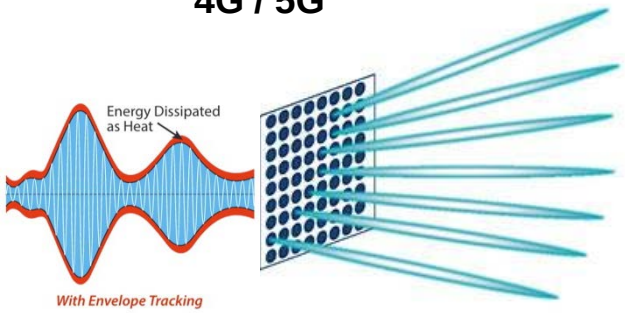
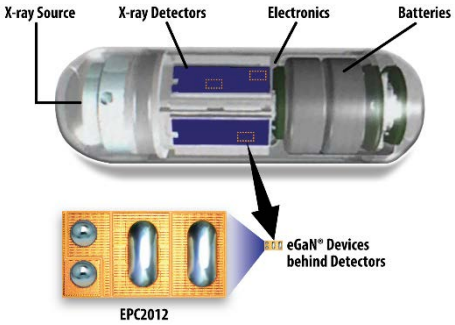
eGaN Technology is Changing the World

Emerging Markets Demanding eGaN Technology

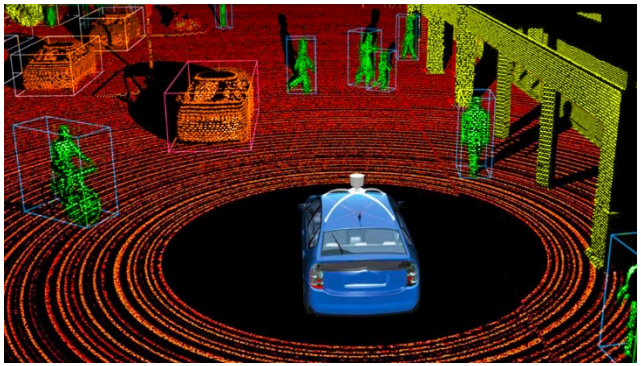
4G / 5G



Med Tech



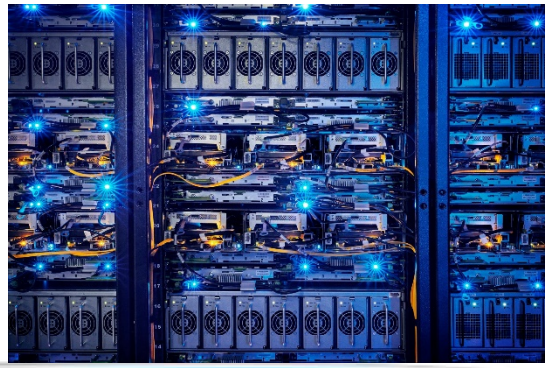
LiDAR



Wireless Power

Space

Computing

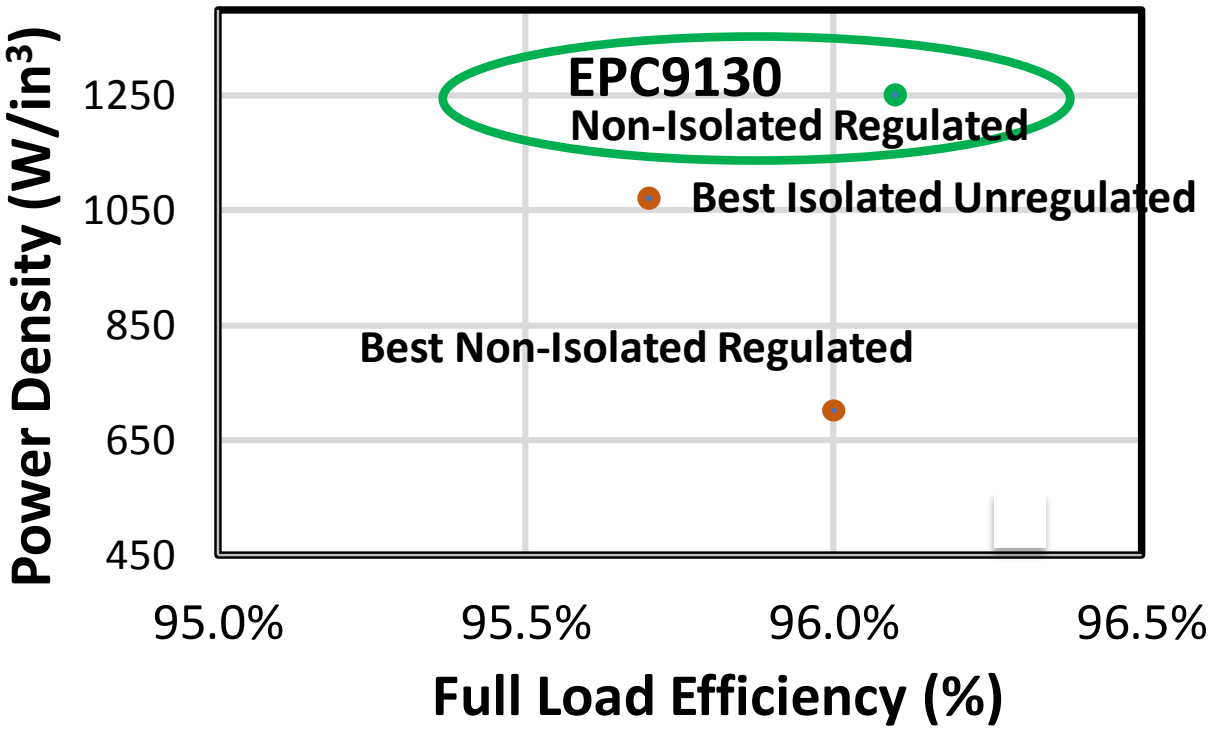


Target Space Applications

- High Power DC-DC Converters
- LiDAR
- Motor Drivers
- Linear Regulators
- RF Amplifiers
- Point of Load Switching Regulators
- Shunt Solar Array Regulators
- Fault Switches and Bus Isolators

DC-DC Conversion

Smaller. More Efficient. Lower Cost.



48 V – 12 V

Satellite DC Power Bus

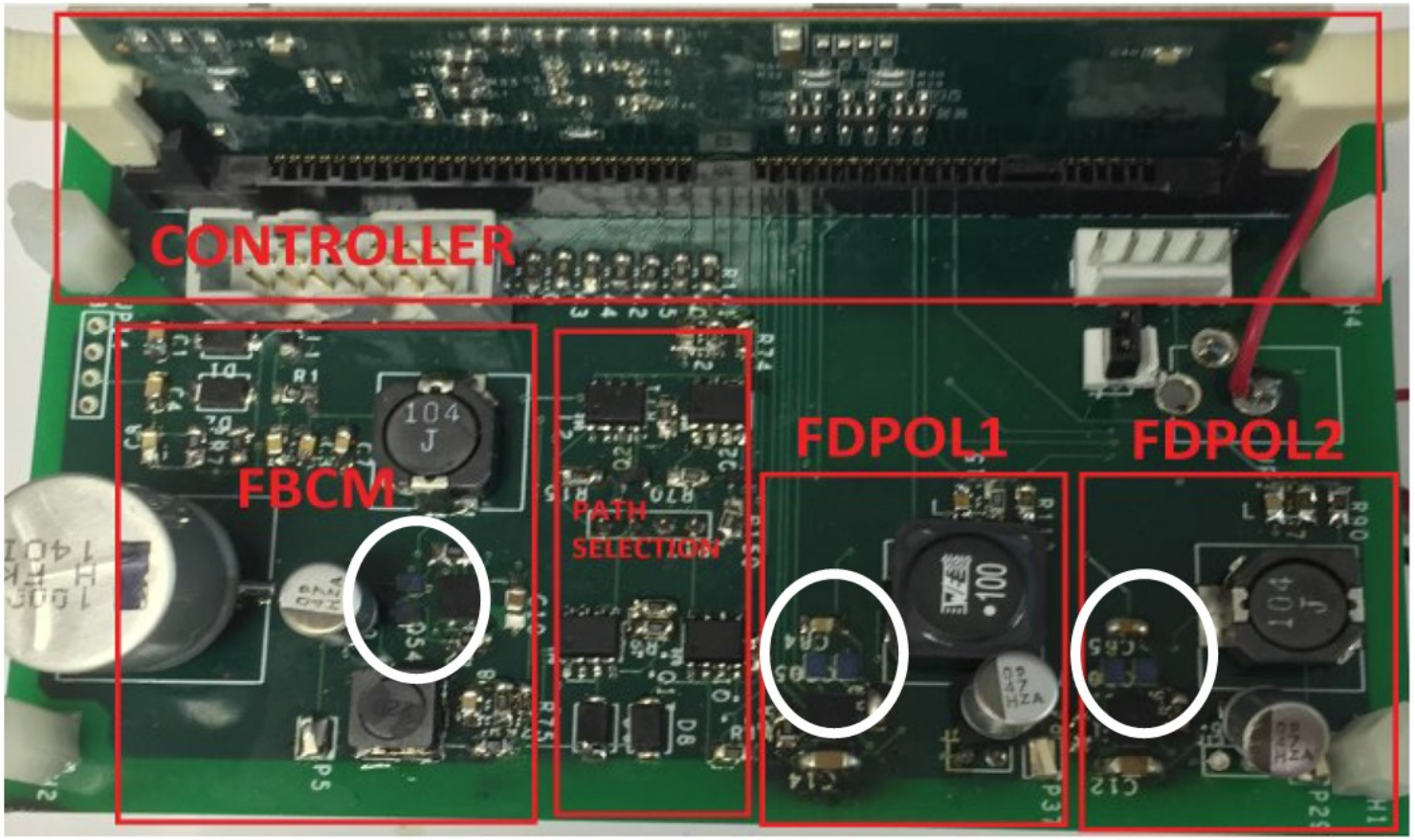
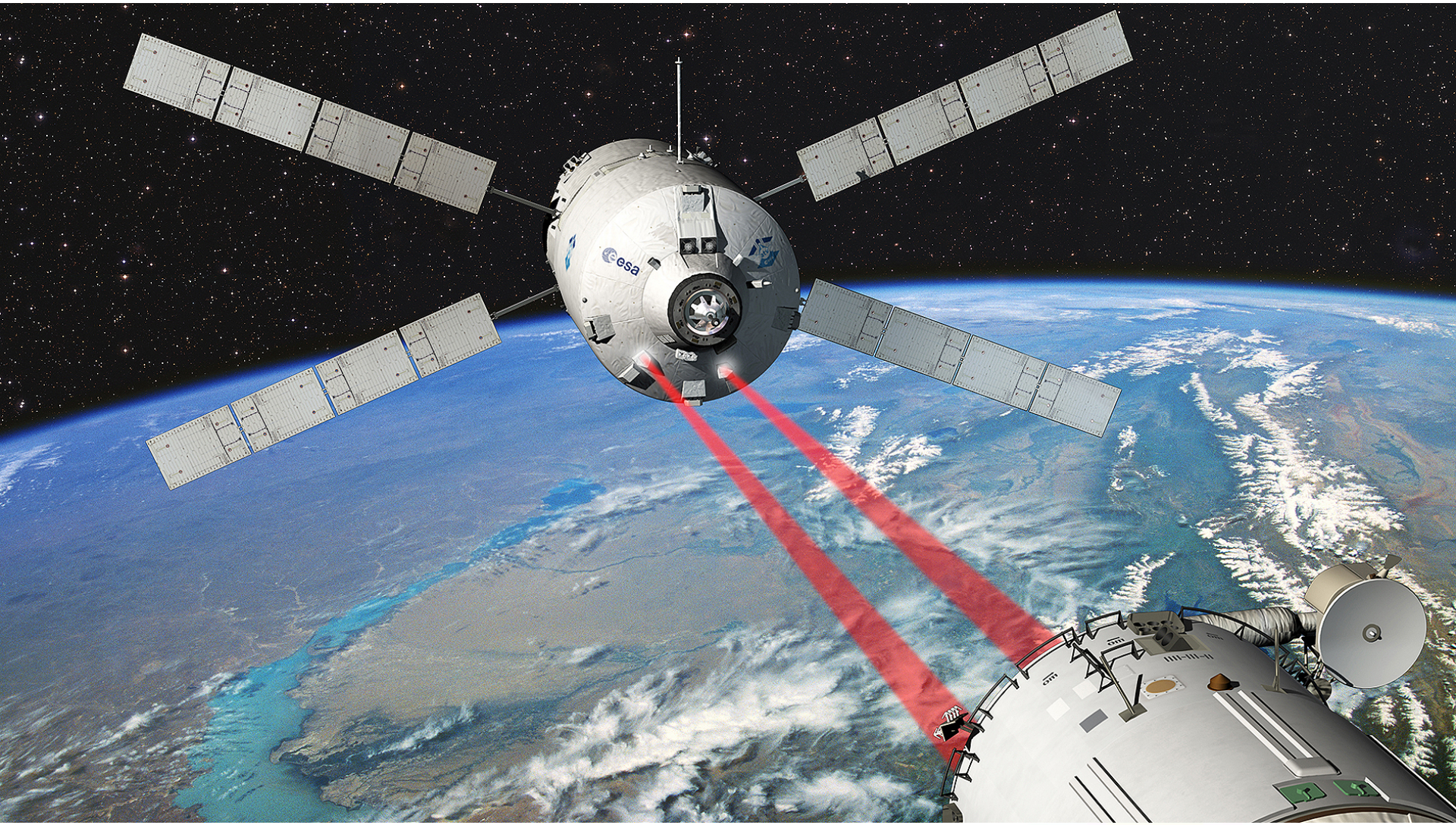
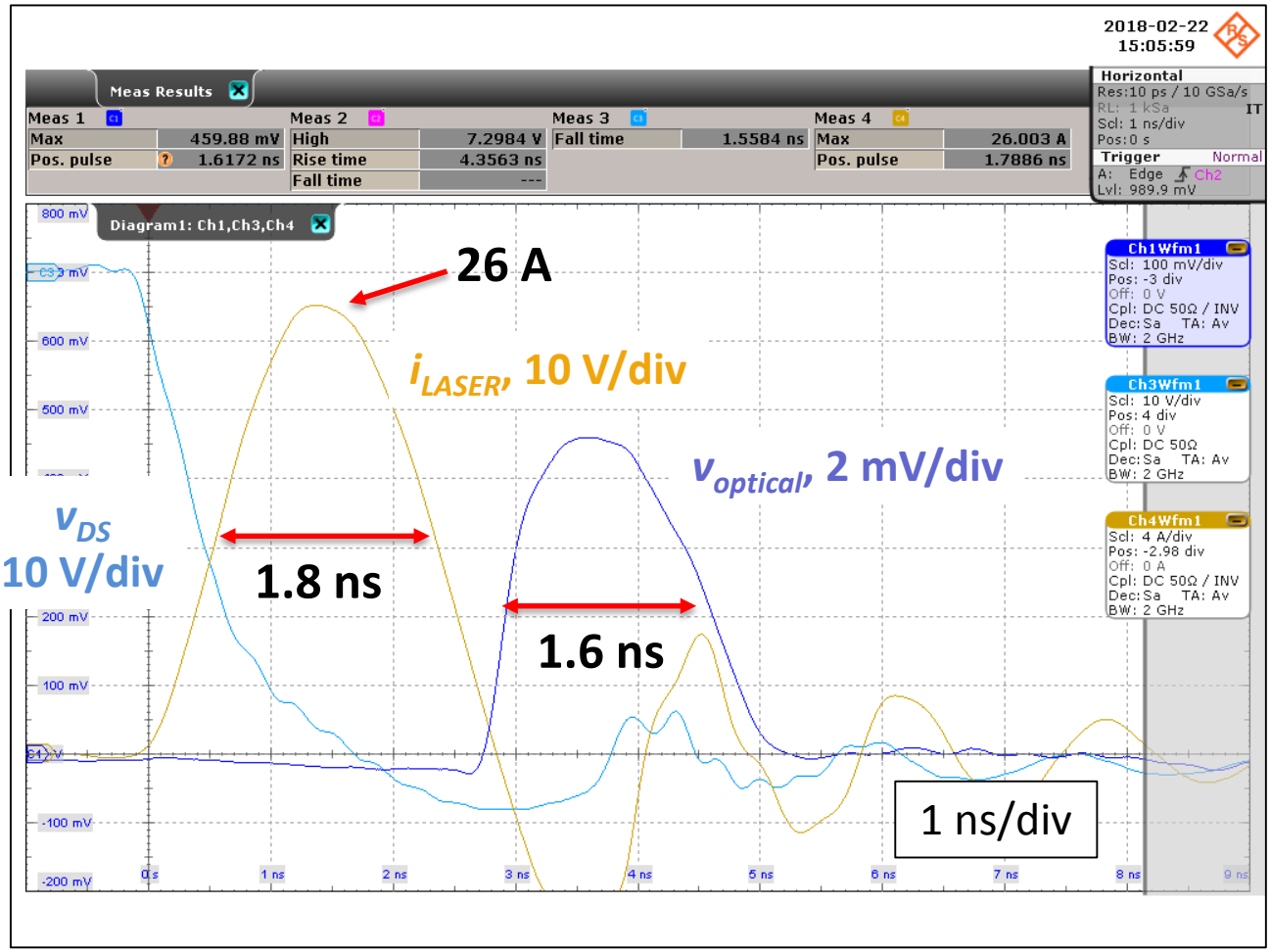


Figure 12: GaN CubeSat EPS

LiDAR



LiDAR



V_{BUS} = 75 V, I_{peak} = 26 A, 1.8 ns with Excelitas TPGAD1S09H surface mount laser

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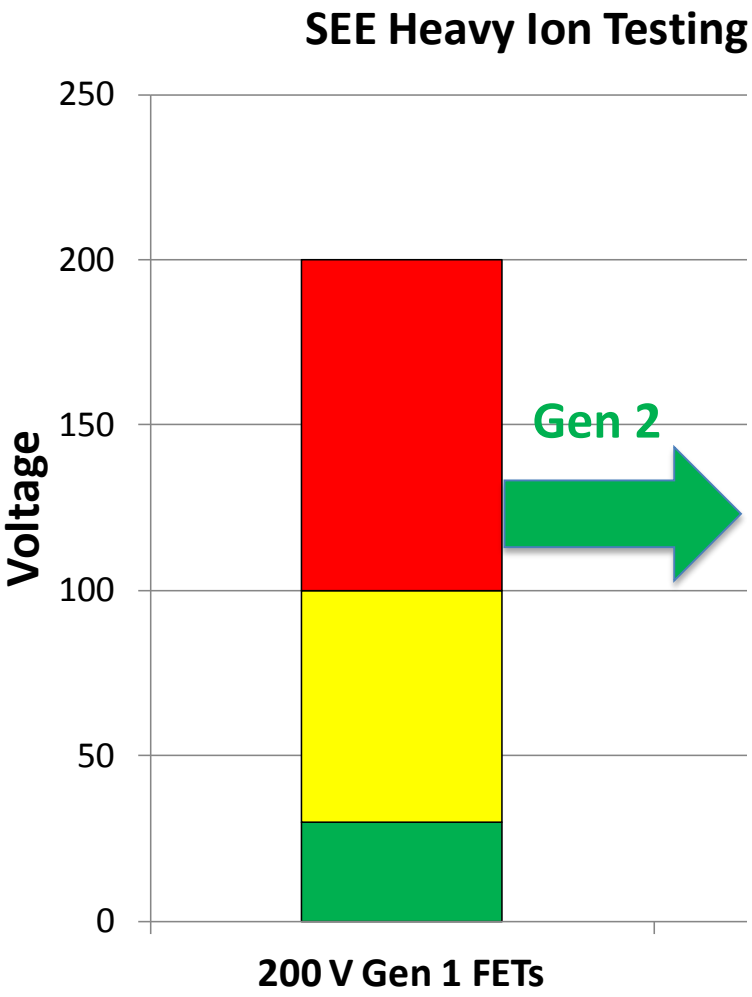
Why GaN in Space?

- Its very radiation tolerant.
- Its more efficient than the best commercial Si MOSFETs.
- Its much smaller than the best Si MOSFETs.
- Its much lower cost than the best Si MOSFETs.
- It has a demonstrated track record of reliability.

200V Device Single Event Effect Result Examples



Fail

Out of Spec

Undamaged

87.2 MeV LET with up to 190 V bias

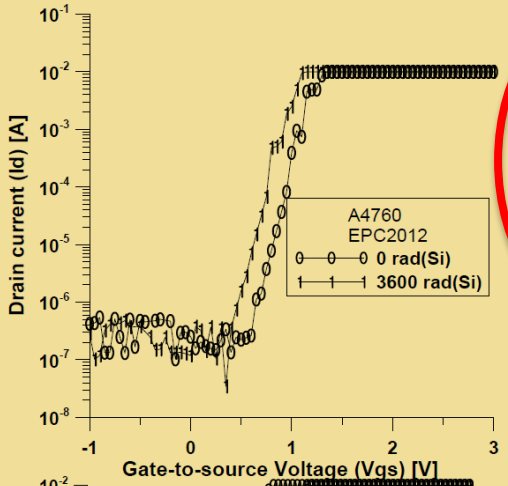
MIL-STD-750E, METHOD 1080

200V Device Single Event Effect Result Examples

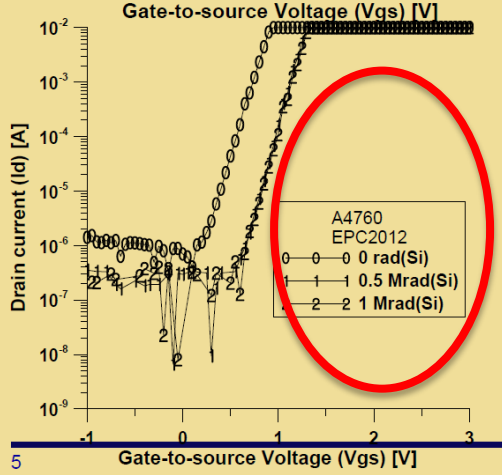
National Aeronautics and Space Administration

Radiation test results XE 51 LET

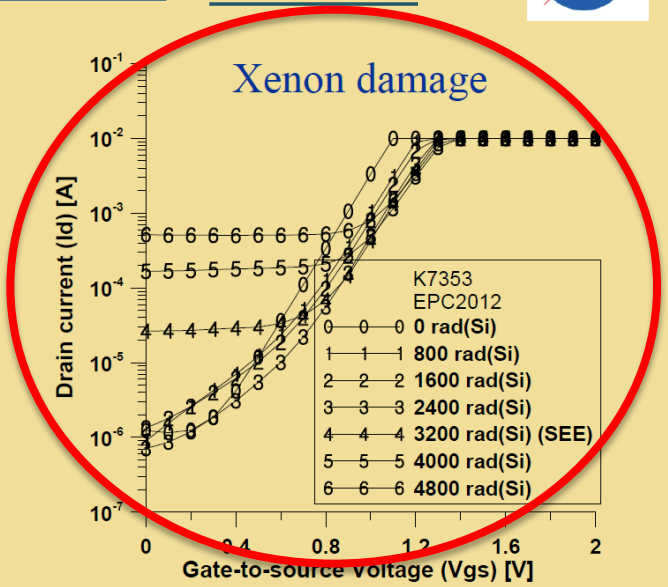
Proton damage

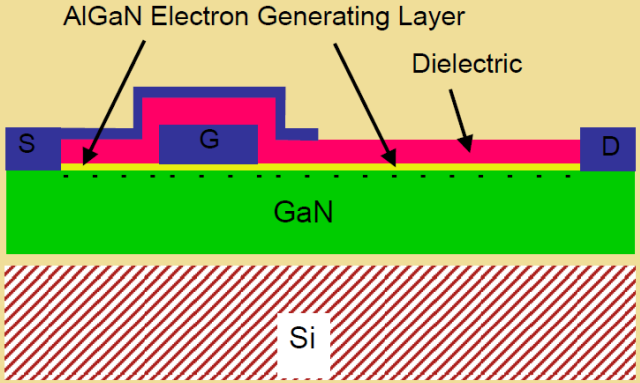


No SEE from protons.



Xenon damage

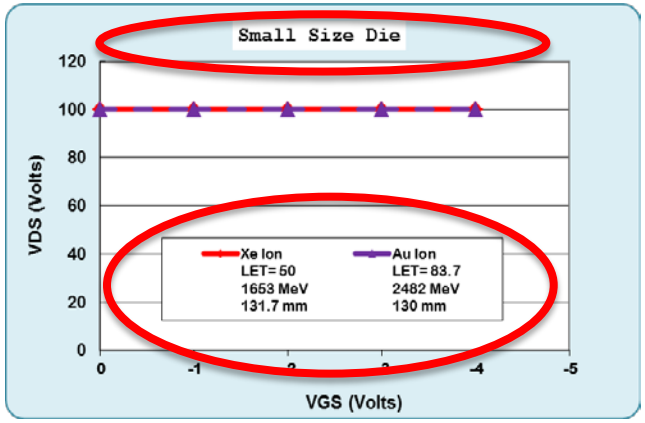


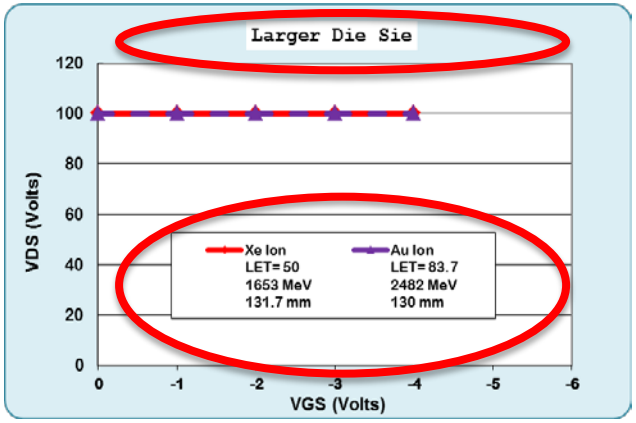


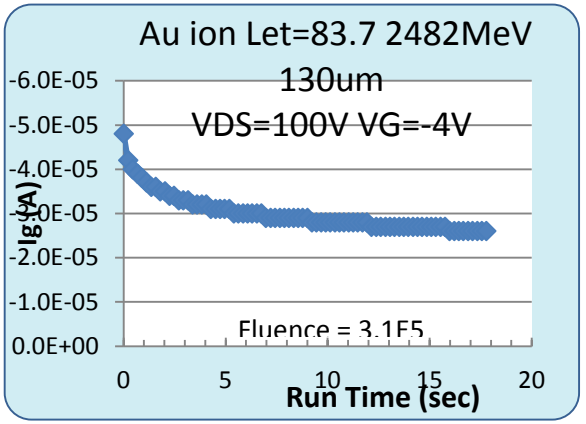
5

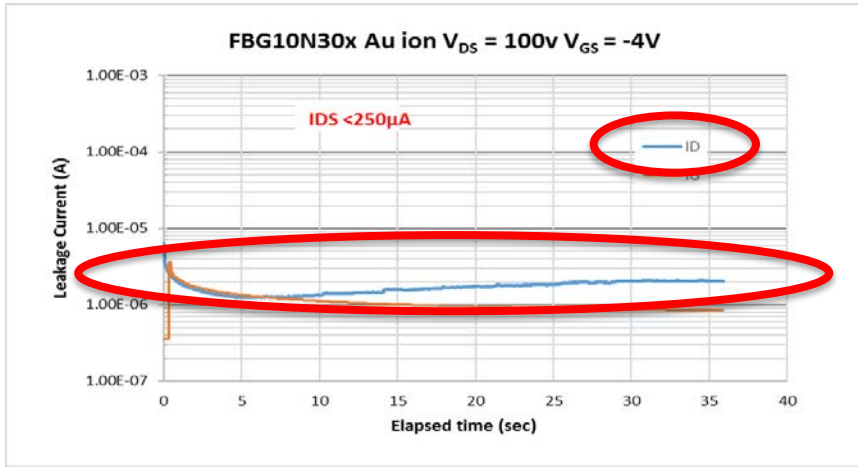
www.nasa.gov

100V Device Single Event Effect (SEE)





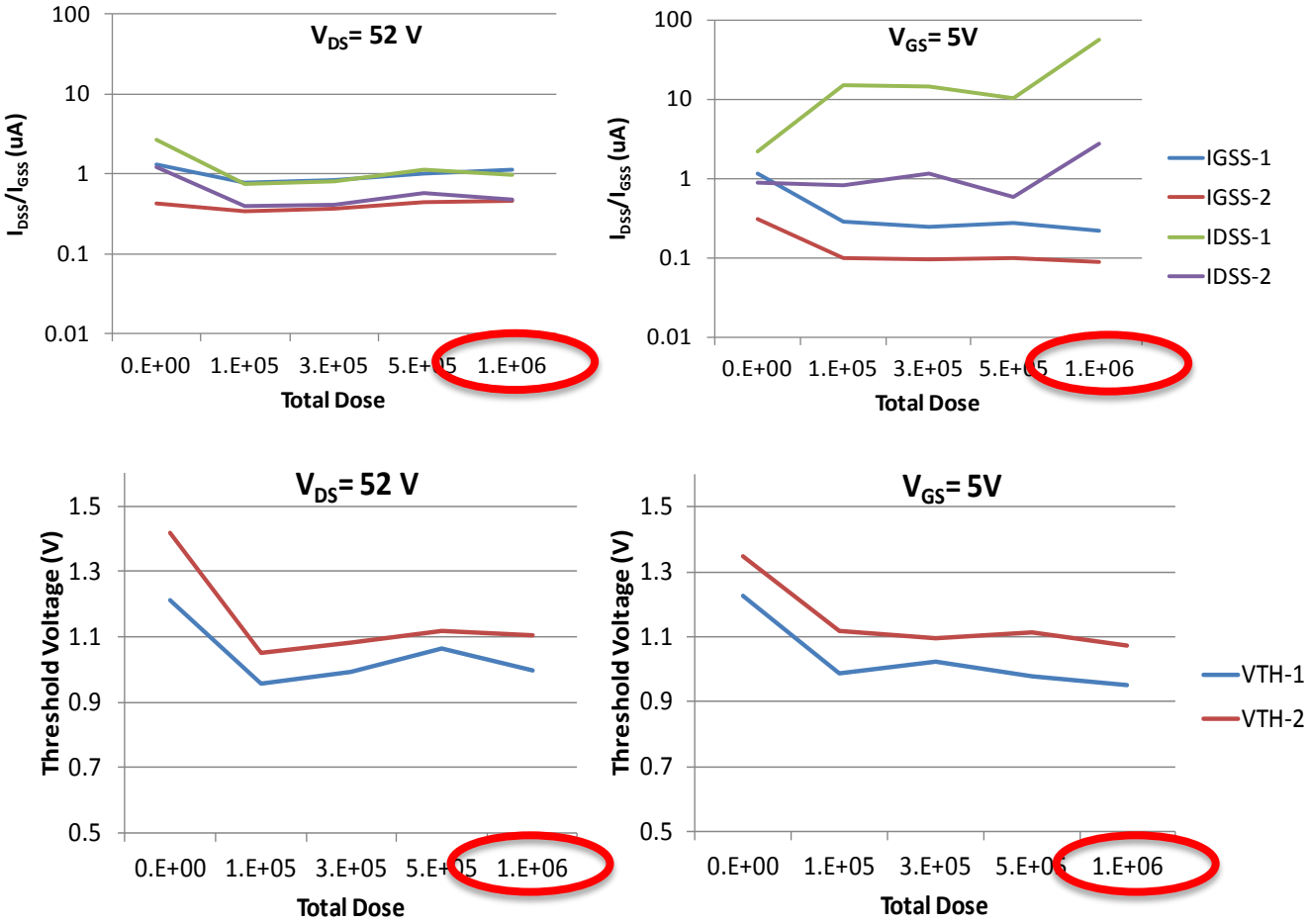




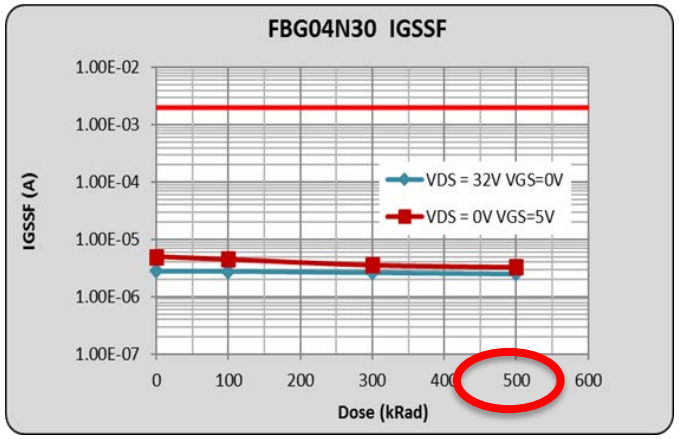
TEST	TYPICAL ENVIRONMENT			
SEE SOA	Ion	LET MeV/mg/cm²	Range mm	Energy MeV
	Xe	50.8	125	1583
	Au	84.6	124	2365

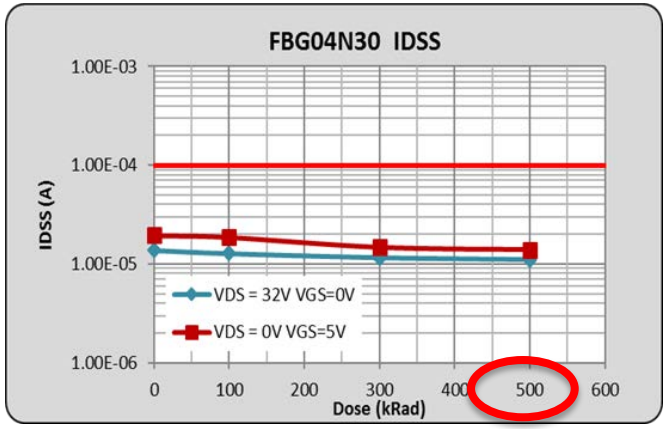
Courtesy of Freebird Semiconductor Corporation

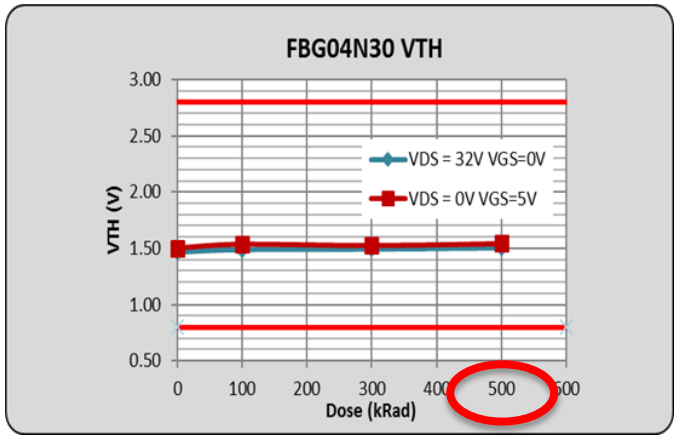
100V TID Response

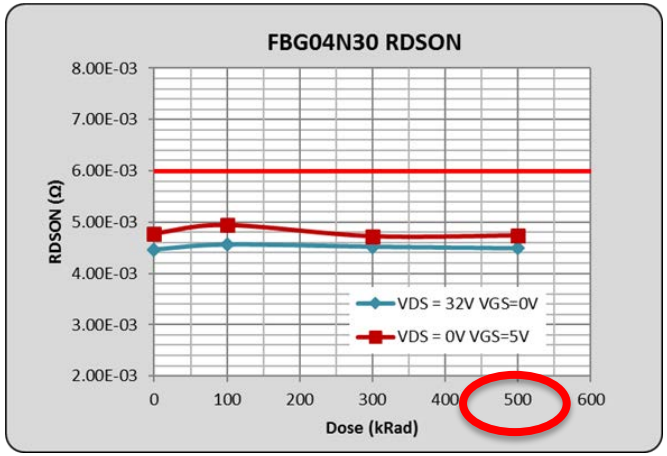


40V TID Response





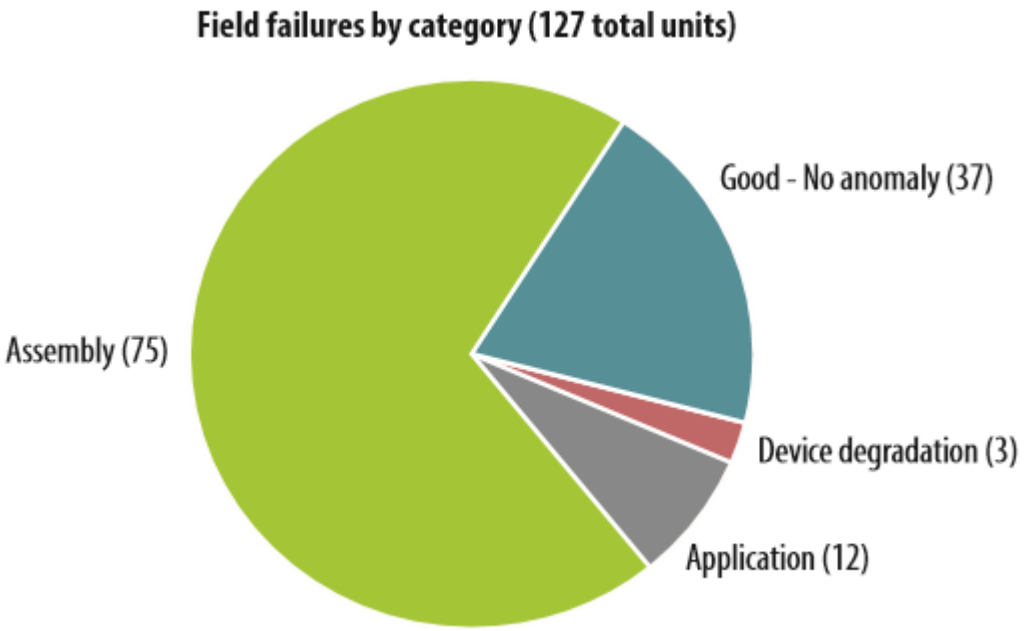




Courtesy of Freebird Semiconductor Corporation

Reliability of eGaN FETs

30+B Hours in the Field



http://epc-co.com/epc/Portals/0/epc/documents/product-training/Reliability%20Report%20Phase%208.pdf

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- Why now?
- A look into the future
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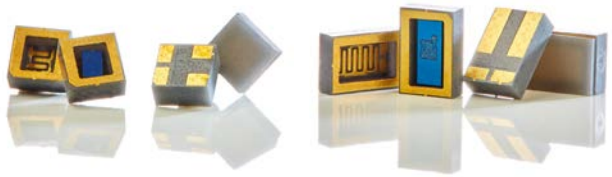
Why Now?

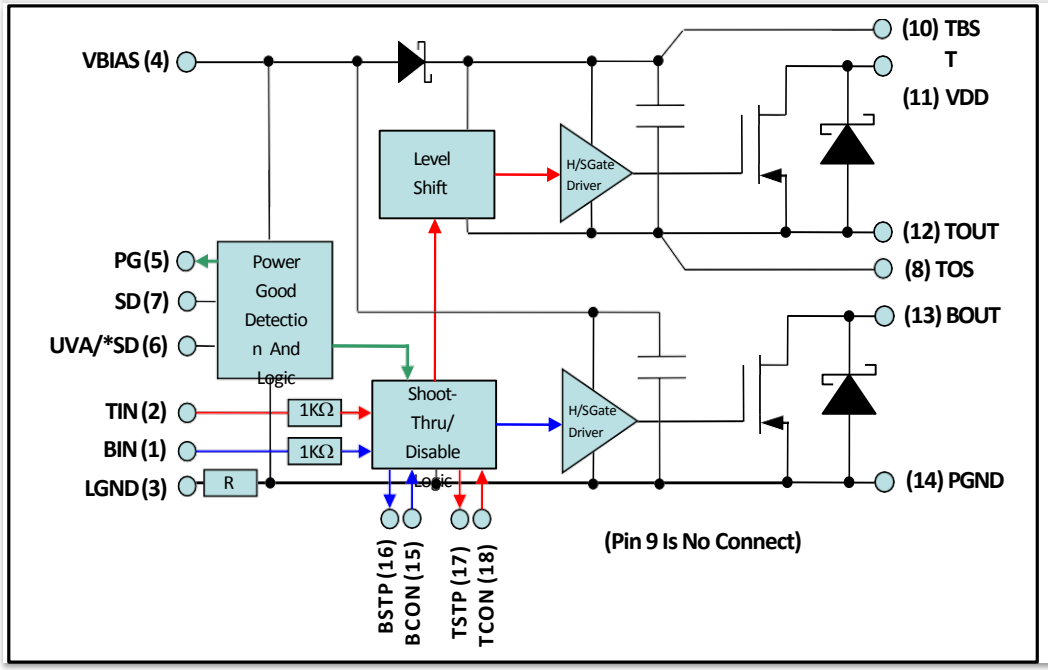
- Millions and millions of parts in the field.
- Billions of hours of field experience.
- Many experienced design and evaluation professionals.
- There is a growing support ecosystem.

Ecosystem

FREEBIRD RADIATION HARDENED PRODUCT TYPES

FBG series: High-Rel ceramic discretes



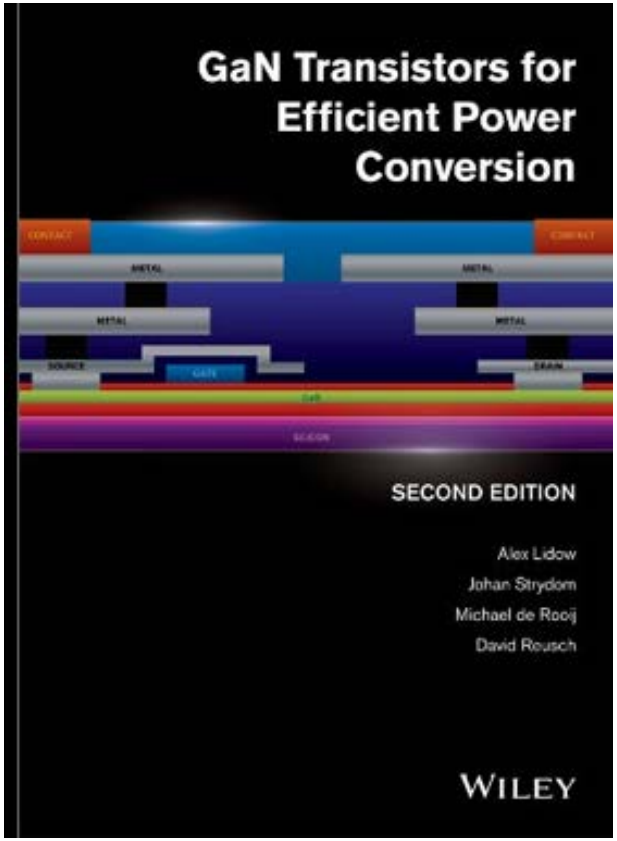


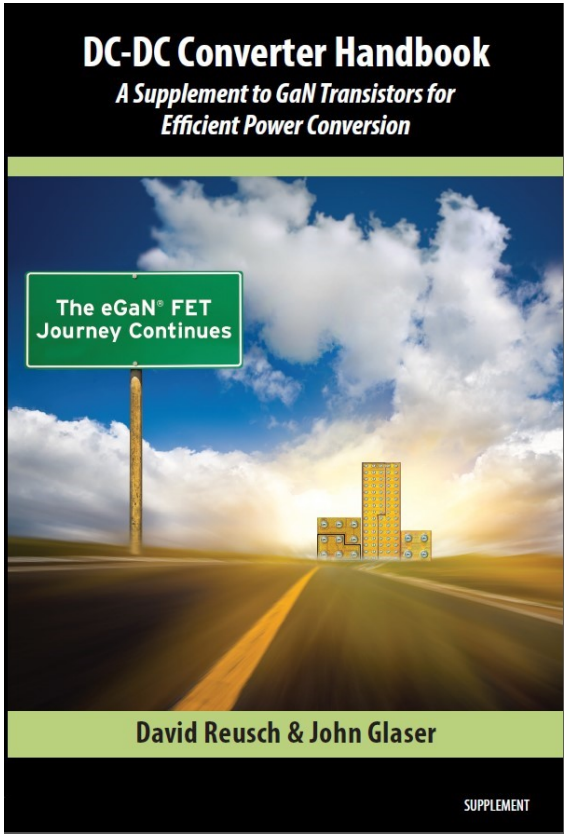
Courtesy of Freebird Semiconductor Corporation

Ecosystem

Renasas/Intersil Rad Hard IC Drivers and eGaN FETs

Ecosystem


GaN Transistors for Efficient Power Conversion
SECOND EDITION
Alex Lidow
Johan Strydom
Michael de Rooij
David Reusch
WILEY


DC-DC Converter Handbook
A Supplement to GaN Transistors for Efficient Power Conversion
The eGaN® FET Journey Continues
David Reusch & John Glaser
SUPPLEMENT

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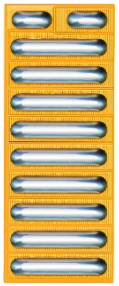
eGaN Technology History

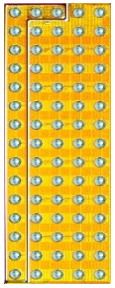
Technology	Gen 1	Gen 4	Gen 5

Product

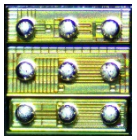
Discrete



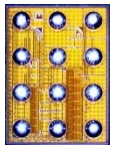
Monolithic Half-Bridge IC



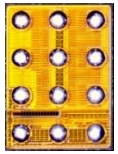
Wireless Charging IC



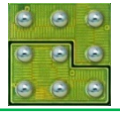
DC-DC IC

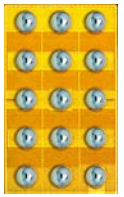


LiDAR IC



Envelope Tracking IC

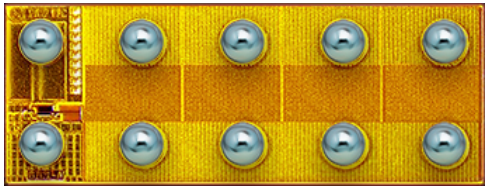




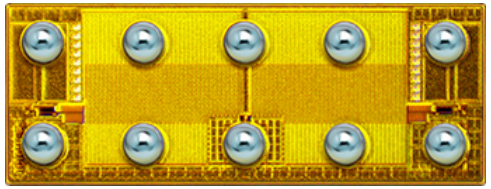
2010 2014 2015 2016 2017…

eGaN Integrated Circuits

- Combined driver and power output FET
- GaN-on-Si = high radiation tolerance.

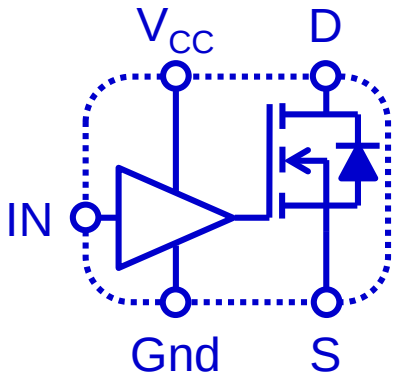


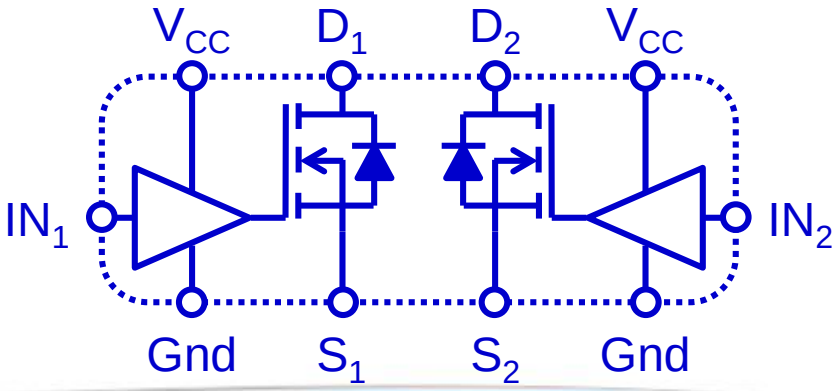
2.9 mm x 1.1 mm,
600 µm pitch



EPC2112: 200 V Driver + FET

EPC2115: Dual 150 V Drivers + FETs





Summary

- eGaN devices are far superior to Si MOSFETs in power conversion. *Always*.
- eGaN devices are very radiation tolerant.
- There is a growing ecosystem of products that make using eGaN devices easy and low-risk.

EPC
EFFICIENT POWER CONVERSION

The end of the road for silicon…

but a clear road ahead for GaN FETs and ICs!