

EPC

EFFICIENT POWER CONVERSION

October, 2022

Agenda

- EPC Overview
- Rad Hard Strategy
- EPC GaN Devices Benefits
- EPC Portfolio & Roadmap
- Summary

EPC Overview

Strategy:

- Make GaN power conversion devices that are higher performance and lower cost compared with silicon

Status:

- Recognized leader in medium voltage GaN technology
- In production in automotive, industrial, telecom, medical, and space applications since 2010
- Flight Heritage

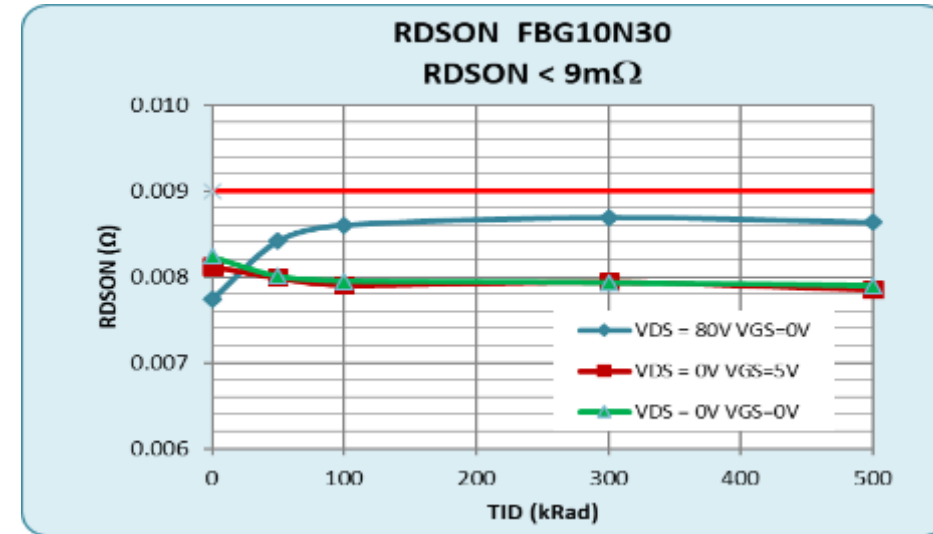
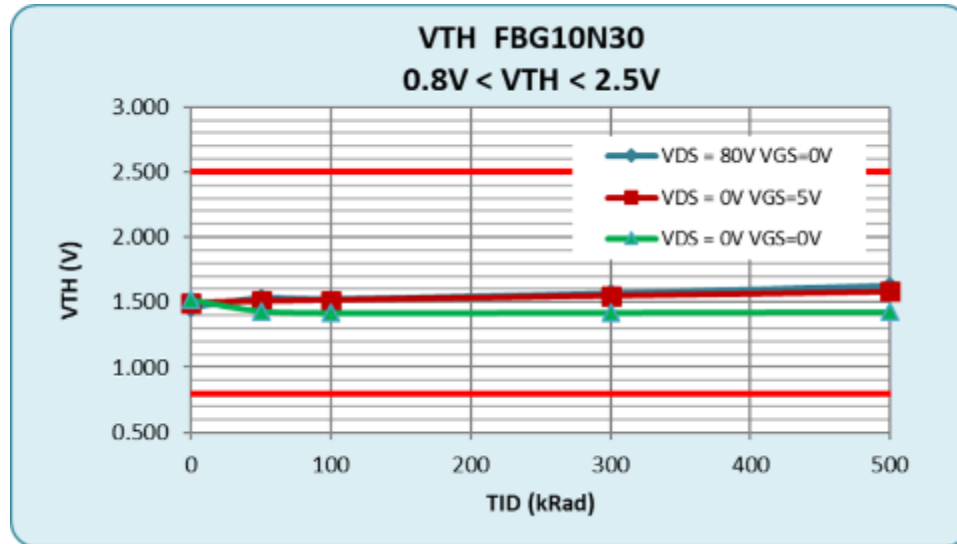
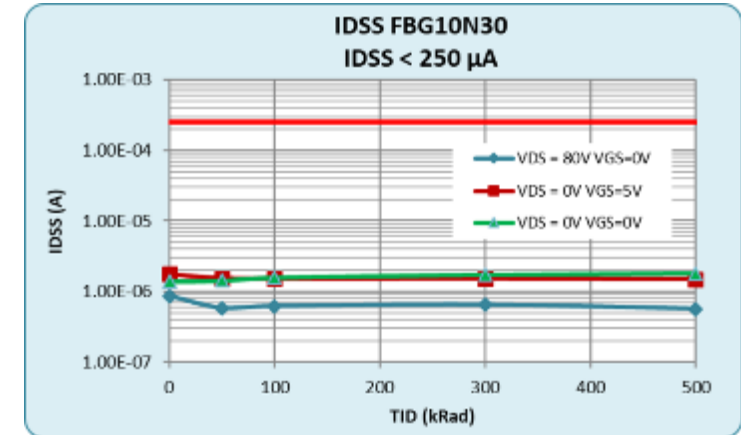
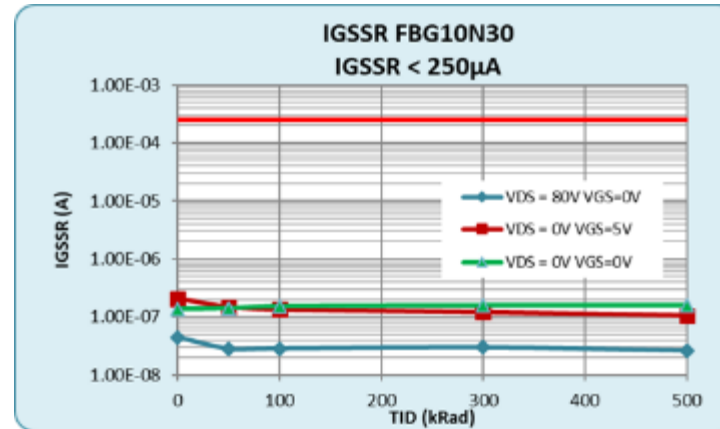
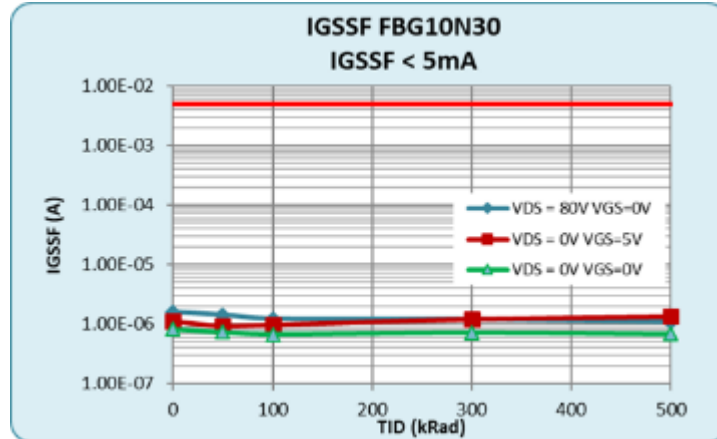
What is GaN-on-Si technology?

- GaN-on-Si technology is the recognized displacement technology for commercial as well as Rad Hard Si MOSFETs
- EPC is the largest producer of GaN-on-Si power devices and leads the < 400 V market
- GaN-on-Si FETs are smaller, higher performance, more rad hard, and more rugged than Si power MOSFETs
- eGaN technology, developed by EPC, is very Rad Hard
- GaN-on-Si technology can be integrated while preserving extraordinary radiation hardness

Rad Hard Strategy

- EPC Space offers Hi Rel parts in package meeting all radiation hardness requirements.
- EPCC serves the Hi Rel market with standard and high lead CSP products
- EPCC offers a High Lead Rad Hard family in CSP that meet all TID specs (> 1 Mrad) & SEL/SEB LET level $85 \text{ MeV}/(\text{mg}/\text{cm}^2)$.
- Key applications: DC-DC power, motor drives, lidar, ion thrusters

Gamma Radiation – eGaN Transistors

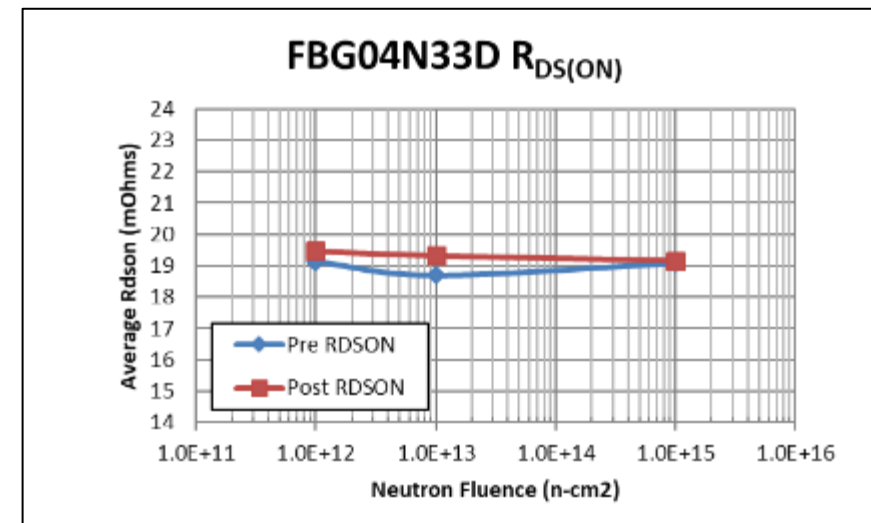
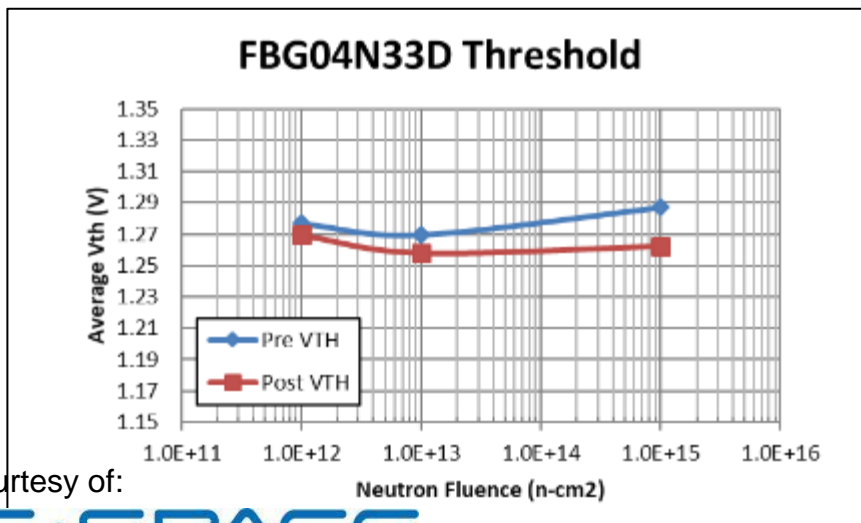
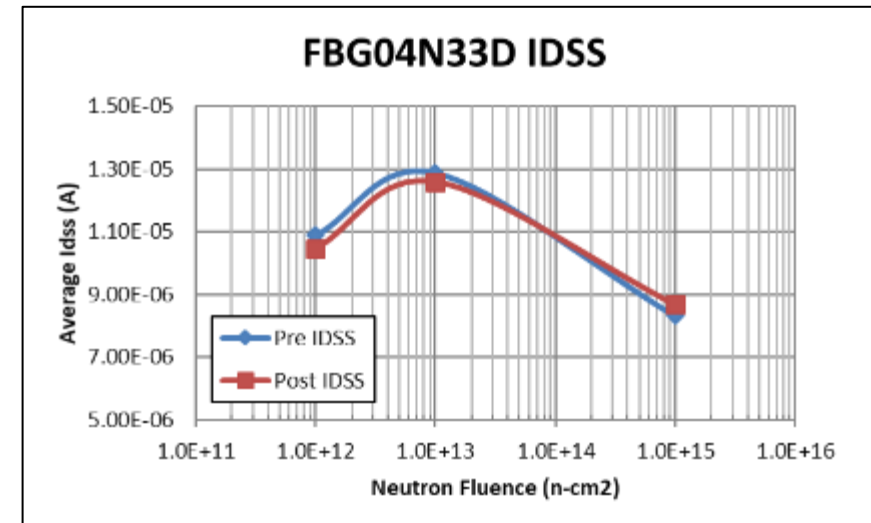
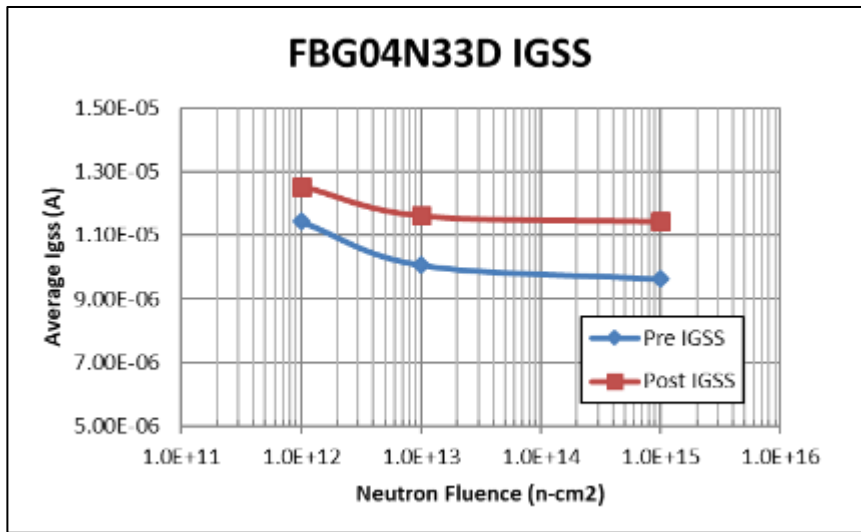


Results courtesy of:

EPC · SPACE

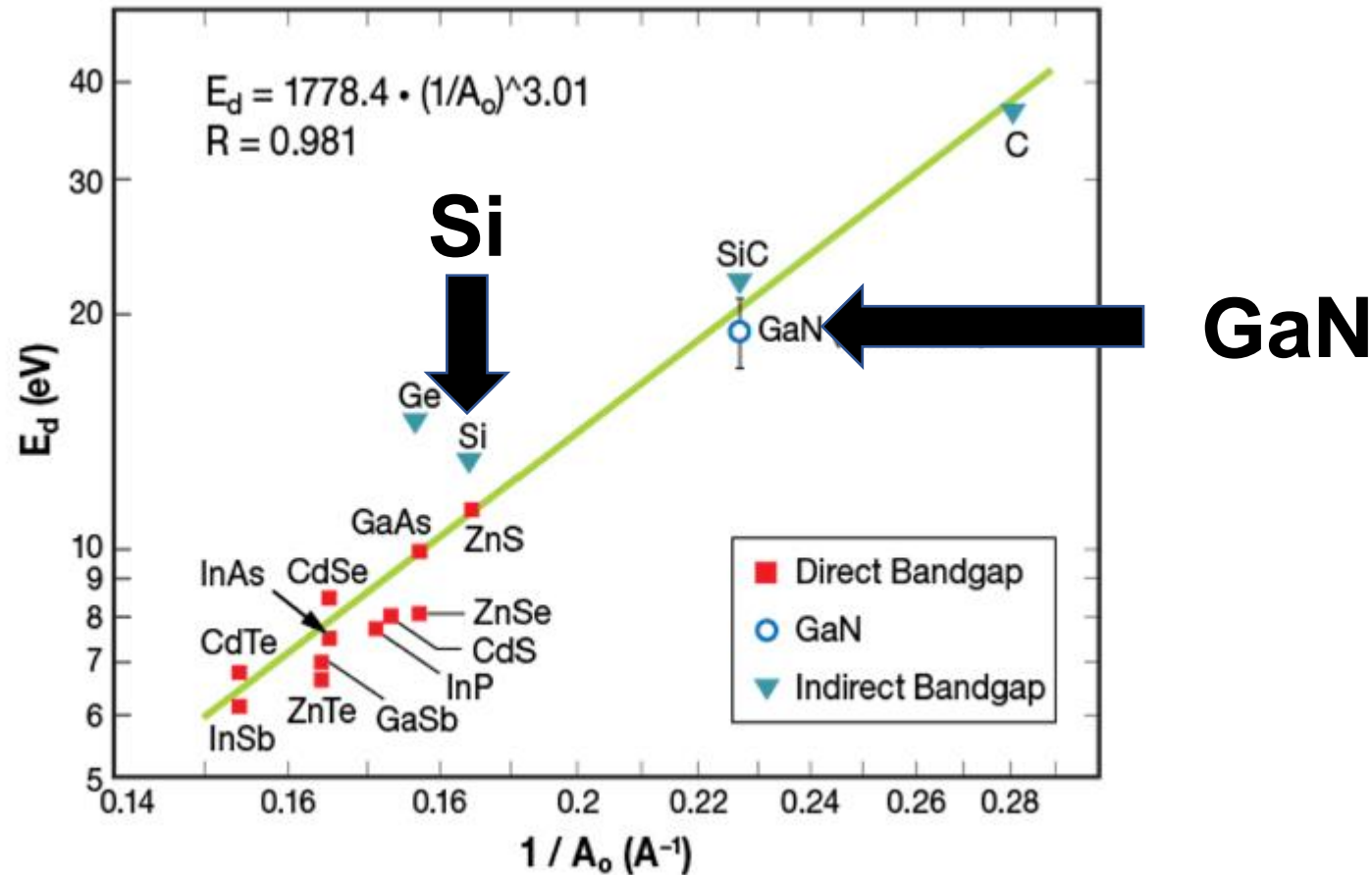
EPC – POWER CONVERSION TECHNOLOGY LEADER

Neutron Radiation

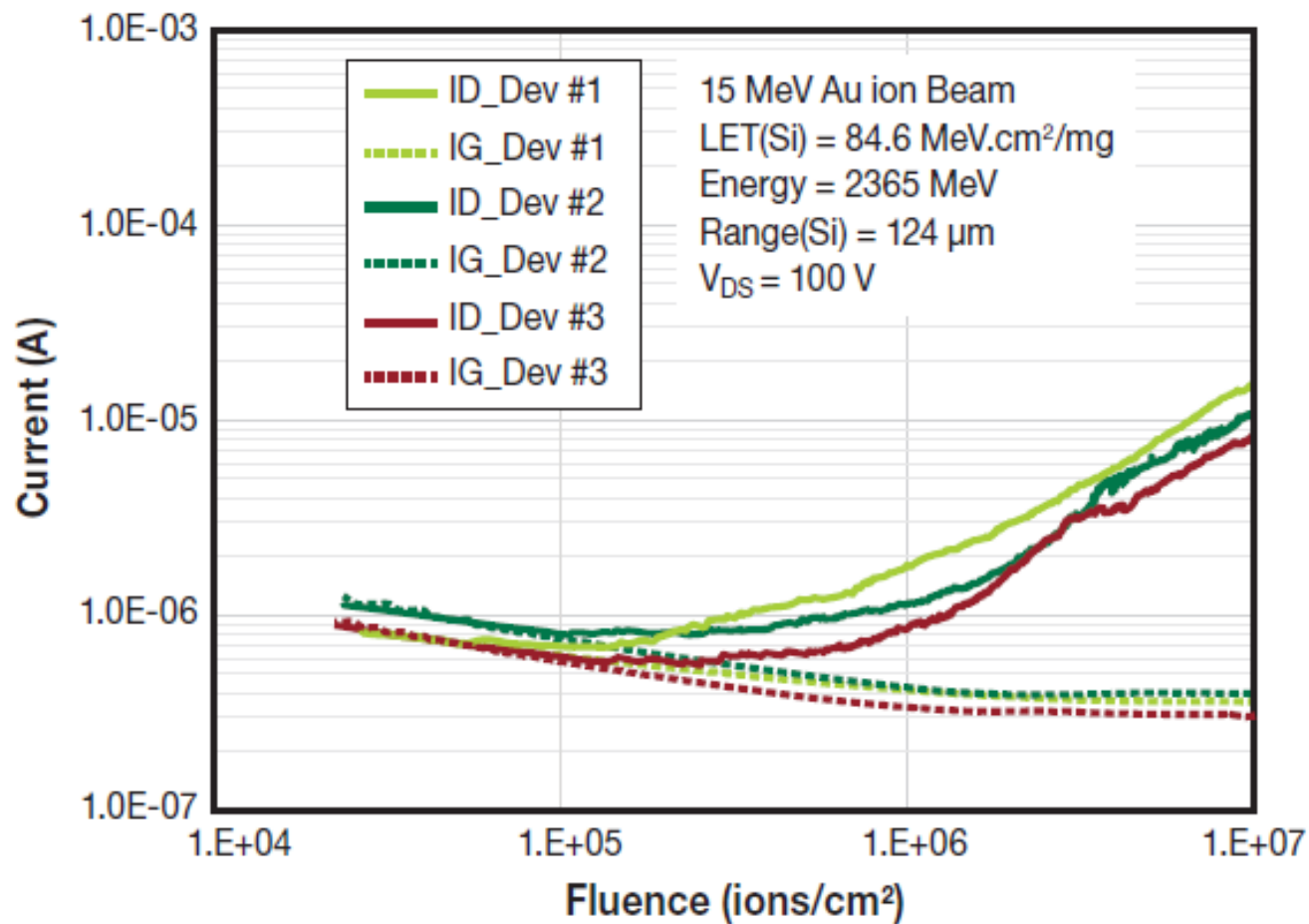


Results courtesy of:

Displacement Damage



Single Event



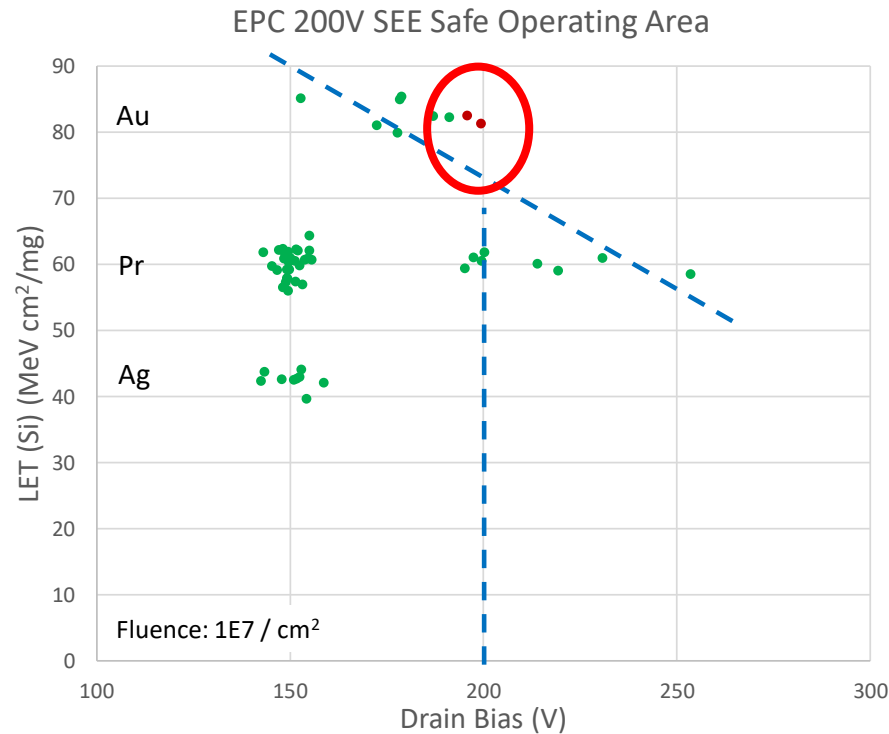
Results courtesy of:

EPC · SPACE

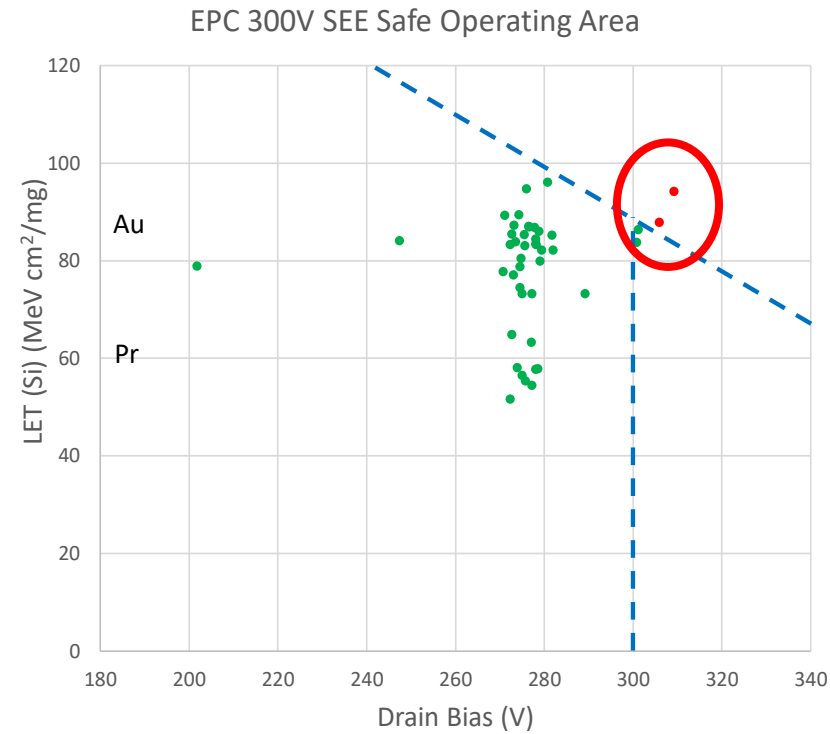
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SEE Safe Operating Area

EPC Space 40 V to 100 V products all stay within data sheet limits after 1 E06 dose at 85 LET



FBG20N18



FBG30N04

Results courtesy of:

EPC · SPACE

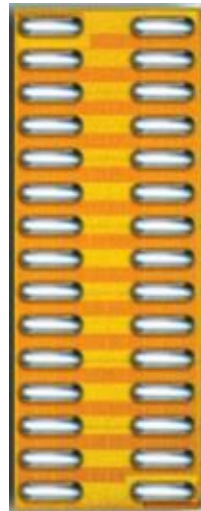
EPC – POWER CONVERSION TECHNOLOGY LEADER

Why GaN in Space

- Superior radiation and electrical performance vs. Rad Hard MOSFETs: Smaller, Lighter, More Rad Hard
- Superior R_{DSon} , Q_g , Q_{gd} , Q_{oss} for hard & soft switching efficiency

	EPC7019	IRHNA57Z60
V_{DS}	40 V	40 V
I_d	90 A	75 A
R_{DSon}	1.5 m Ω	3.5 m Ω
Q_g	18 nC	200 nC
Q_{gd}	2.4 nC	40 nC
Size	13.9 mm ²	236 mm ²
SEE LET (MeV/(mg/cm ²))	85	40
Radiation Level	> 1 Mrad	300 kRads

EPC7019



	EPC7014	IRHLUB770Z4/JANSR2N7616UB/ RHLUB730Z4/JANSF2N7616UB
V_{DS}	60 V	60 V
I_d	2.4 A	0.8 A
R_{DSon}	340 m Ω	680 m Ω
Q_g	0.2 nC	3.6 nC
Q_{gd}	0.03 nC	1.8 nC
Size	0.8 mm ²	9 mm ²
SEE LET (MeV/(mg/cm ²))	85	85
Radiation Level	> 1 Mrad	100 kRads/ 300 kRads

EPC7014



Why GaN in Space

- Superior radiation and electrical performance vs. Rad Hard MOSFETs: Smaller, Lighter, More Rad Hard
- Superior R_{DSon} , Q_g , Q_{gd} , Q_{oss} for hard & soft switching efficiency

	EPC7004	IRHNA67160
V_{DS}	100 V	100 V
I_d	60 A	56 A
R_{DSon}	7 m Ω	10 m Ω
$Q_{g\ typ}$	6.4 nC	170 nC
Q_{gd}	1.1 nC	80 nC
Size	6.56 mm ²	236 mm ²
SEE LET (MeV/(mg/cm ²))	85	85
Radiation Level	> 1 Mrad	300 kRads

EPC7004



	EPC7007	IRHNA67260
V_{DS}	200 V	200 V
I_d	20 A	56 A
R_{DSon}	25 m Ω	28 m Ω
$Q_{g\ typ}$	5.4 nC	240 nC
Q_{gd}	1 nC	60 nC
Size	5.76 mm ²	236 mm ²
SEE LET (MeV/(mg/cm ²))	85 (200 V)	85 (170 V)
Radiation Level	> 1 Mrad	300 kRads

EPC7007



EPC7 Rad Hard eGaN FET Roadmap

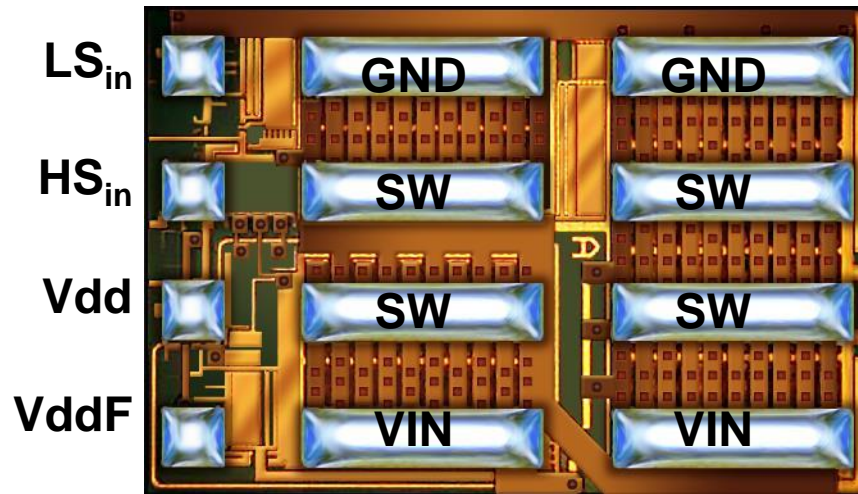


RH Device	Voltage	ID	Samples	Production
EPC7018	100	90	Now	Q2 2023
EPC7004	100	60	Now	Q2 2023
EPC7003	100	10	Q4 2022	Q2 2023
EPC7031	100	2	Q1 2023	Q3 2023
EPC7014	60	2	Now	Q2 2023
EPC7020	200	48	Q4 2022	Q2 2023
EPC7007	200	20	Now	Q2 2023
EPC7017	200	0.45 (pulse)	Q1 2023	Q2 2023
EPC7019	40	95	Now	Q3 2023
EPC7001	40	30	Q1 2023	Q3 2023
EPC7002	40	8	Q1 2023	Q3 2023
EPC7008	300	4	Q2 2023	Q4 2023
EPC7030	300	40	Q2 2023	Q4 2023
EPC7011	Rad Hard Power Stage IC		Q3 2023	Q4 2023

- High Lead Rad Hard family in CSP
- TID specs (> 1 Mrad)
- SEL/SEB LET level 85 MeV/(mg/cm²).
- EPC Space offers Hi Rel parts in package meeting all radiation hardness requirements.

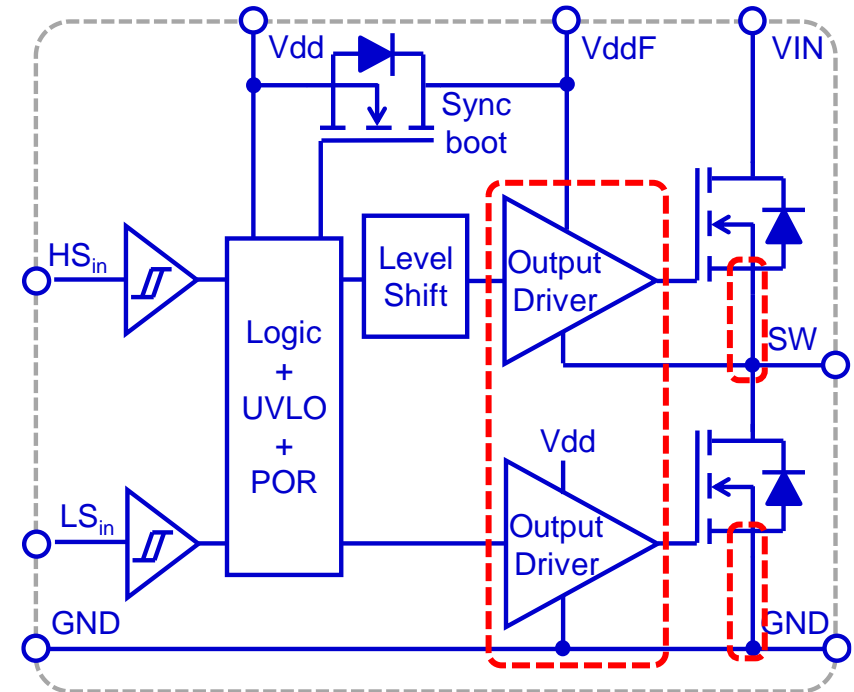
Rad Hard Power Stage

EPC7011



- Near zero common source inductance
- Driver matched to FETs
- Thermal balancing
- Layout friendly

$50 V_{DSmax}$, $R_{DS(on)_{typ}} = 8,5 m\Omega$

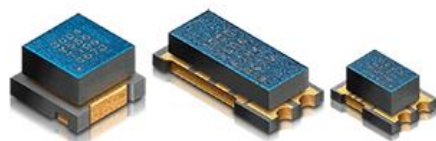


Footprint compatible to
EPC2152

Package Products Example



High Reliability Ceramic Discretes



High Reliability Die Adaption Product



“GaN Driving GaN Technology”

Ultra fast Low-side eGaN drivers

Ultra fast Dual Low-side eGaN drivers

High/low-side Half bridge with integrated
HEMT Power Switches

Flight Heritage

- Since 2017 over 100,200 Radiation Hardened EPC SPACE GaN HEMT power devices flying successfully in LEO and GEO for both commercial and military programs
- Successfully completed numerous space programs with several US prime contractors along with many NASA programs

Summary

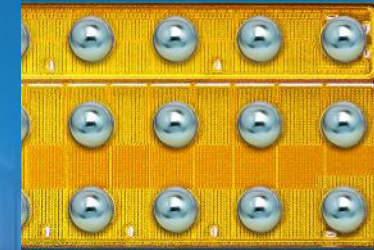
- When exposed to various forms of radiation, eGaN devices are more rugged than Rad Hard MOSFETs
- eGaN offers superior electrical performance compared to aging silicon power MOSFET
- eGaN are the most efficient, smallest, and most reliable solution for spaceborne systems
- EPC & EPC Space offer a full portfolio of CSP & packages parts for all Rad Hard needs
 - Discrete FETs, Power Stages, Drivers



GaN Power Devices and Applications

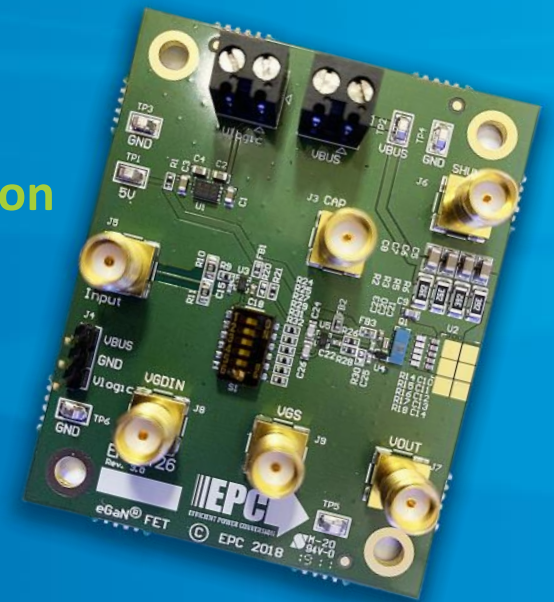
Edited by Alex Lidow, Ph.D.

First Edition



FETs and ICs

Education Kits



How To GaN Video Series

epc-co.com



Space

Smaller, Lighter, Reliable

- Superior radiation and electrical performance vs. Rad Hard MOSFETs
- EPCC serves the Hi Rel market with standard and high lead CSP products
- EPC Space offers packaged and certified Rad Hard GaN devices
- Key applications: DC-DC power, motor drives, lidar, ion thrusters

