Radiation Tolerant Enhancement Mode Gallium Nitride eGaN® FETs in DC-DC Converters

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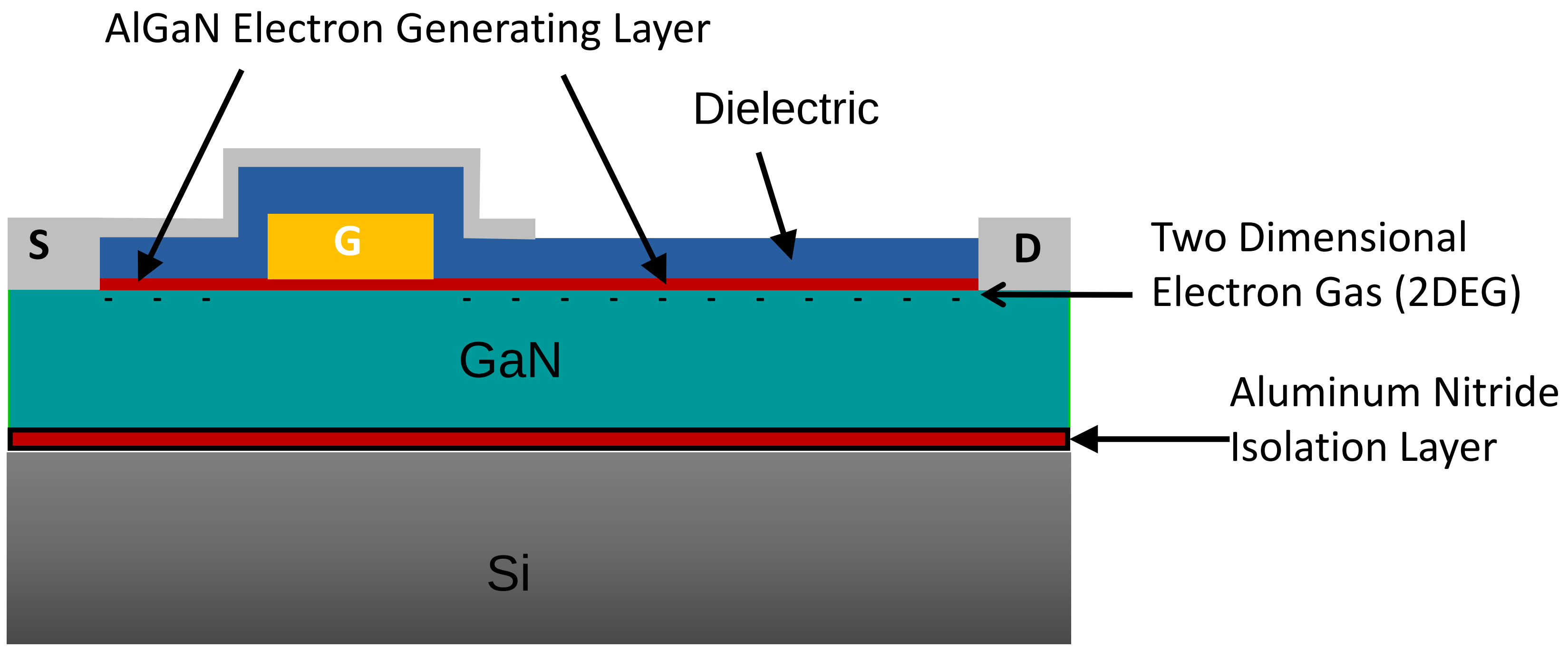
Efficient Power Conversion

Agenda

- Background
- Radiation Tolerance
- Forward Converter case study
- Other DC-DC converters
- Conclusions

eGaN® FET Structure



Parameter Comparison

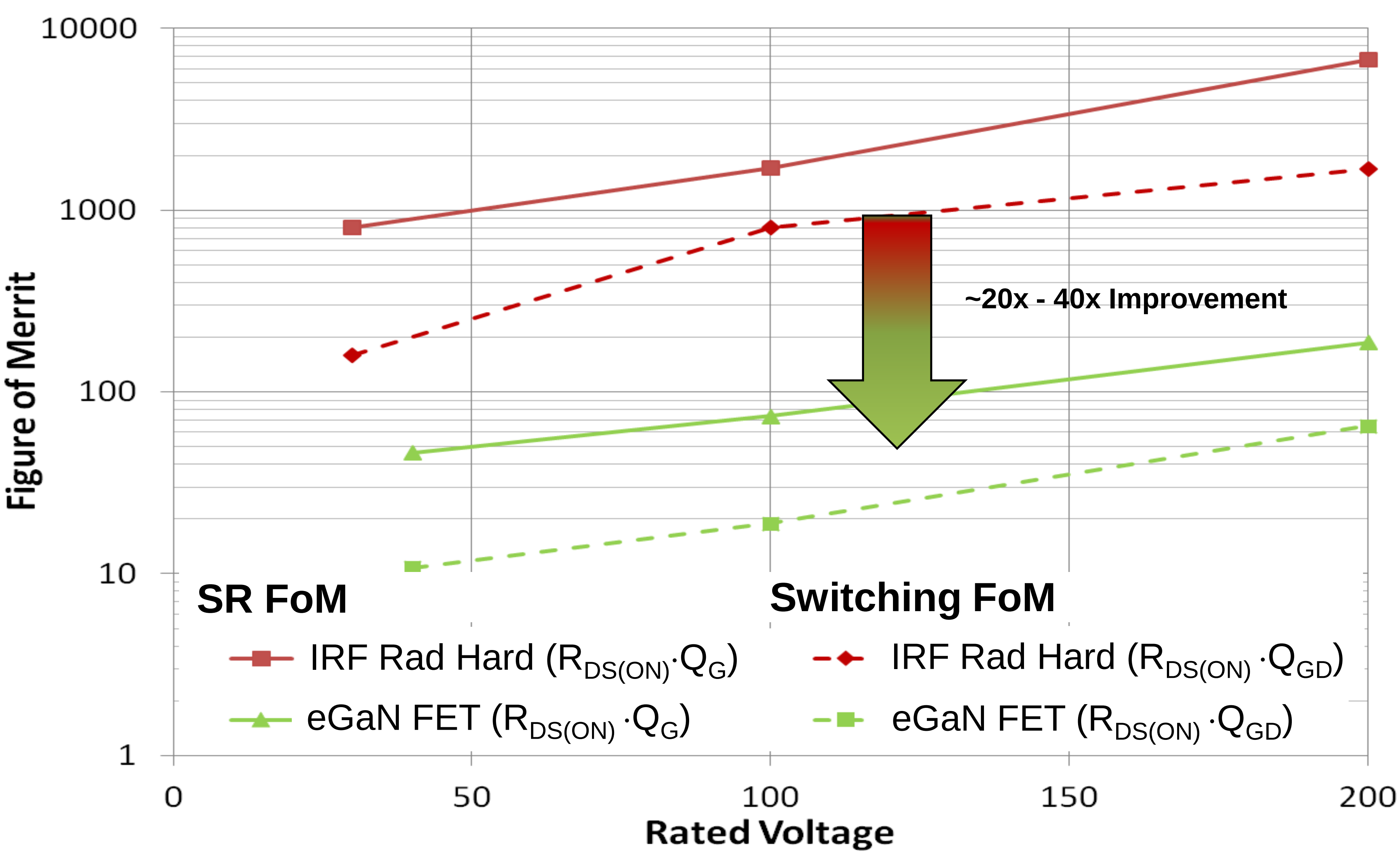
Parameter	Si MOSFET	GaN	Comment
$V_{GS(MAX)}$	±20 V	+6 V/ -5 V	
V_{SD} / body diode	1 V	1.5 V – 2.5 V	
$V_{GS(TH)}$	2 V – 4 V	0.7 V to 2.5 V	Logic- level device
R_G	≥1 Ω	0.5 Ω -0.8 Ω	
$R_{DS(ON)}$ change over temp	+70 %	+60 %	25ºC to 125ºC
$V_{GS(TH)}$ change over temp.	-33 %	-3 %	~ No temp. dependence
Q_{RR} (rev. recovery charge)	High	0	Schottky / SiC performance
For 100V devices			

Device Figure of Merit

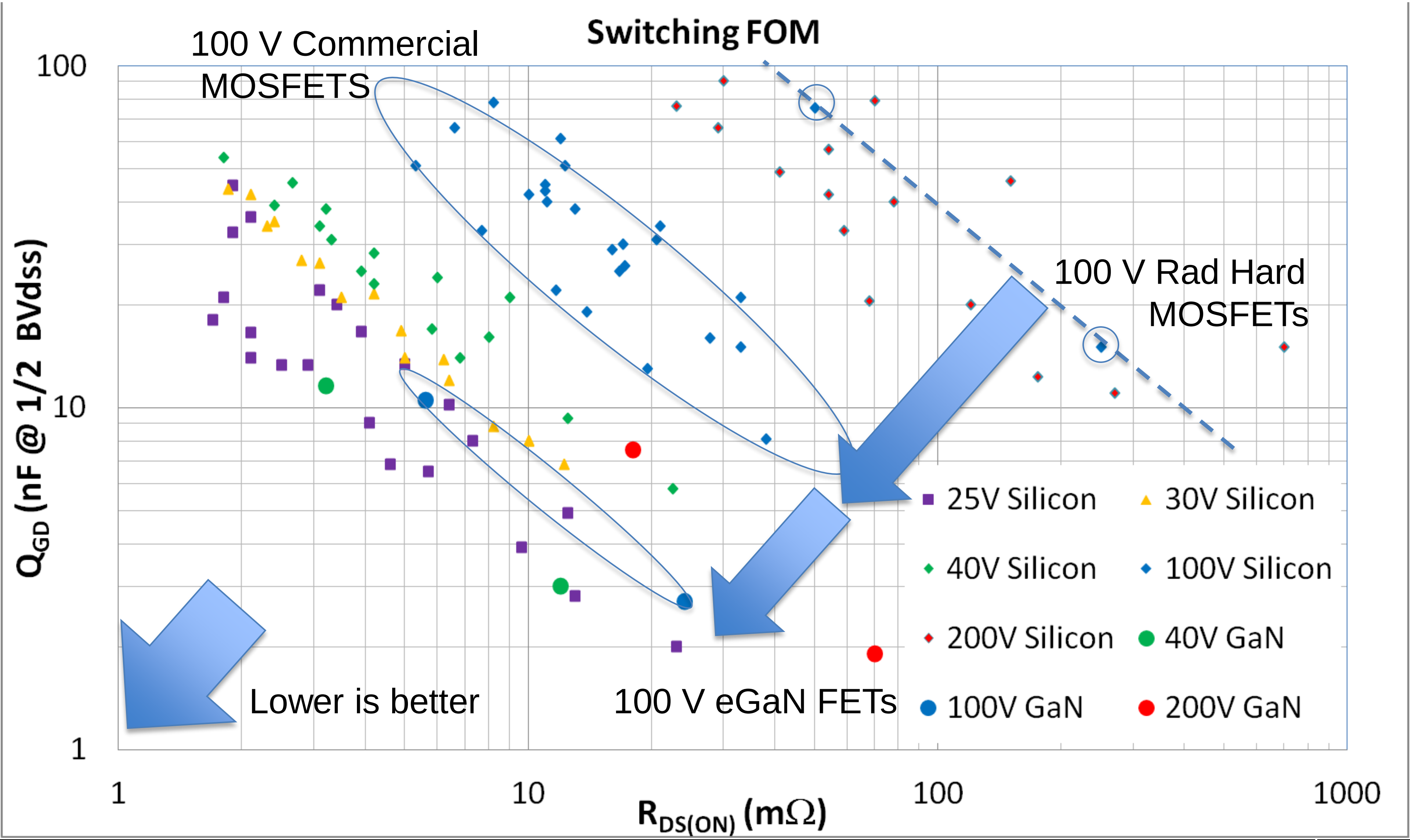
- Devices of different sizes / technologies can be compared using a Figure of Merit.
- For given technology, $R_{DS(ON)}$ x Q = ~ Constant

- Some typical FoMs:
- Synchronous rectifier (SR) performance α $R_{DS(ON)}$ x Q_G
- Switching performance α $R_{DS(ON)}$ x Q_{GD}

Device Figures of Merit

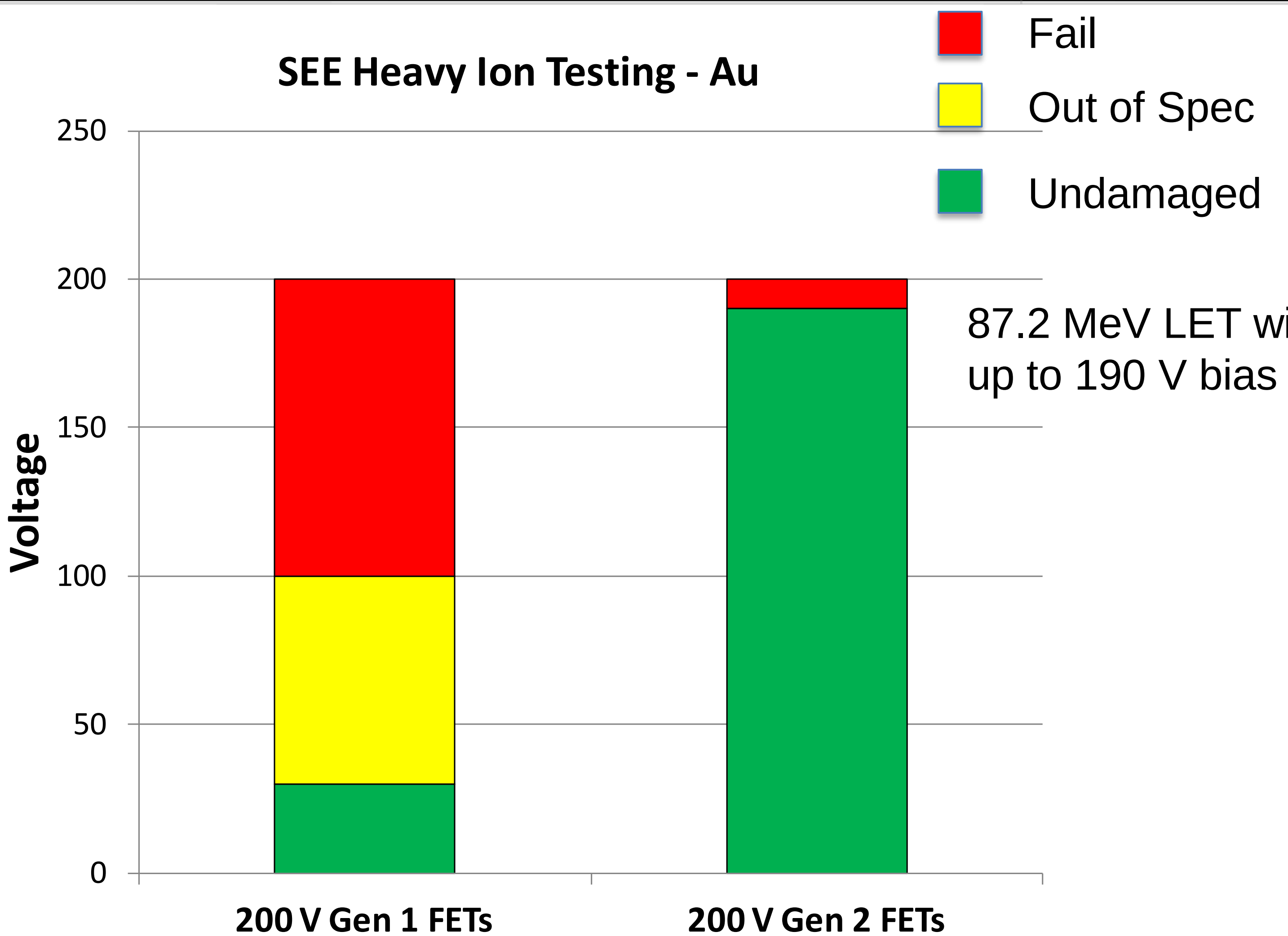


Silicon vs. GaN Comparison



Radiation Testing Results

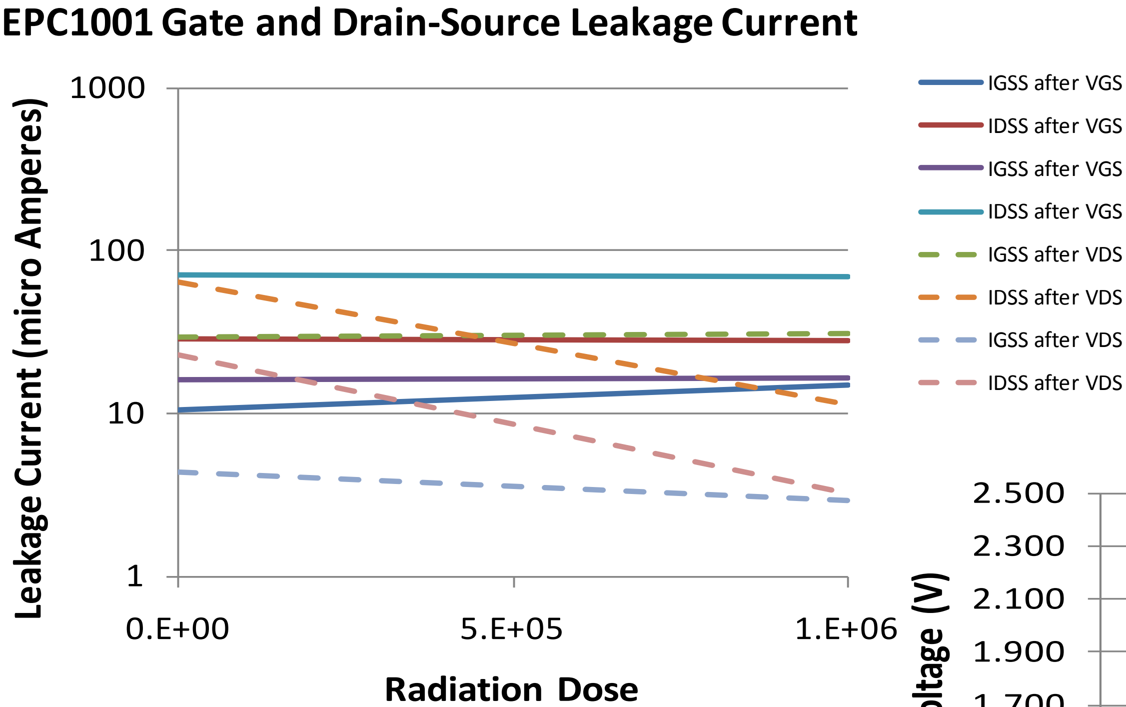
SEE Radiation Performance

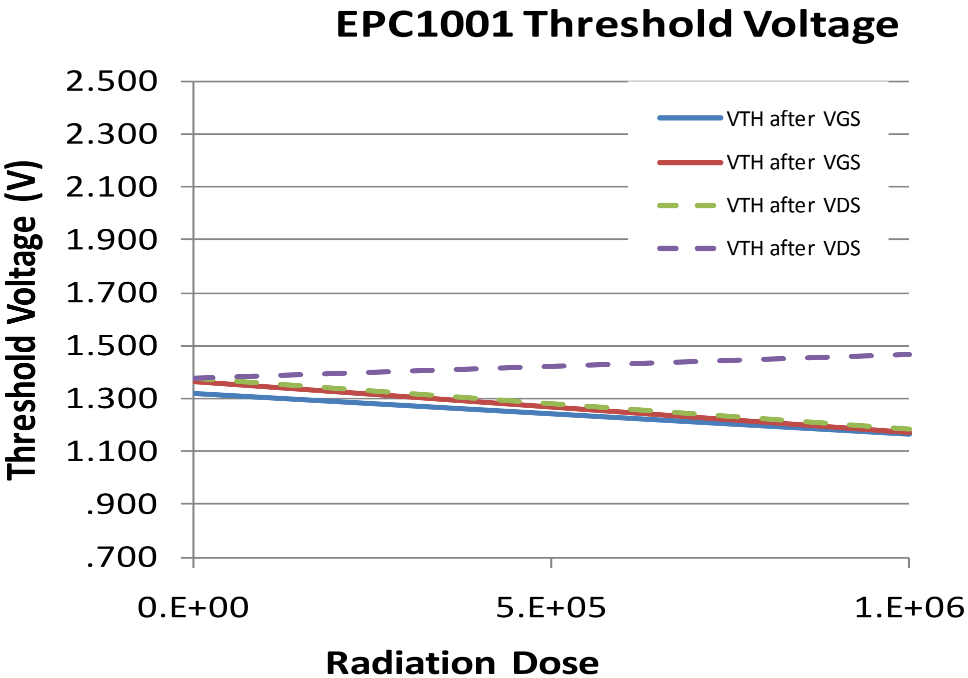


87.2 MeV LET with up to 190 V bias

MIL-STD-750E, METHOD 1080

Total Dose Results – 100 V



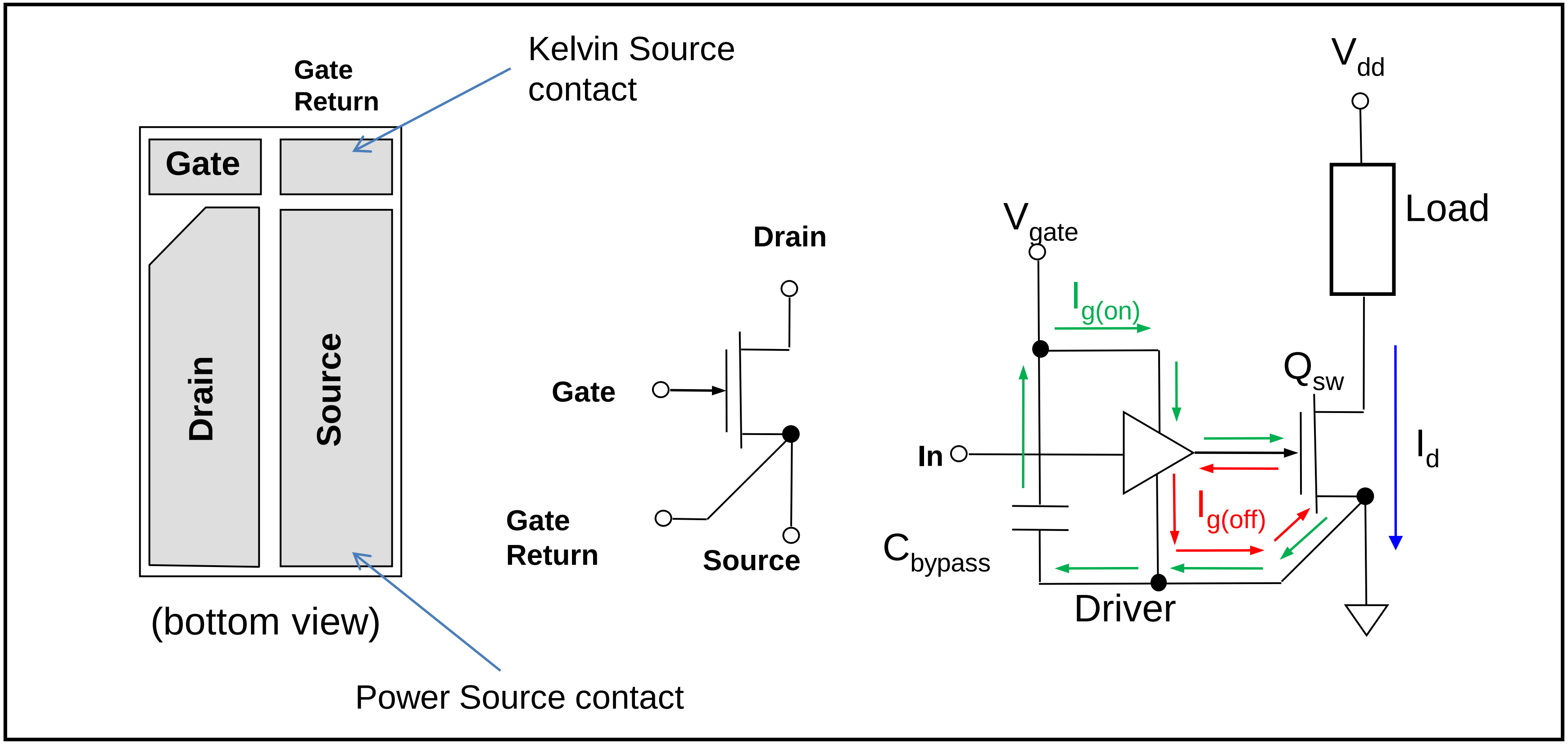


Data up to 1 MRad

MIL-STD-750E, METHOD 1019

RH Packaging

Package/ Drive Considerations

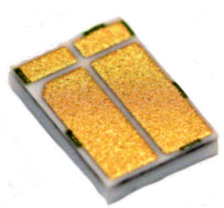


- 4 - Pad package separate drive loop from power loop.
- Separate Kelvin gate return minimizes common source inductance.

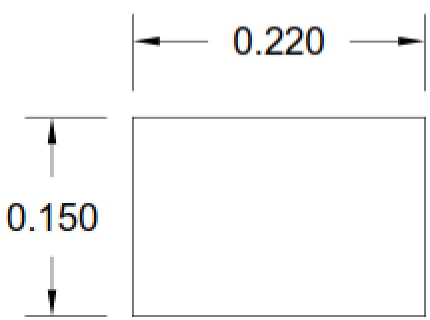
1st Gen RH GaN Product line

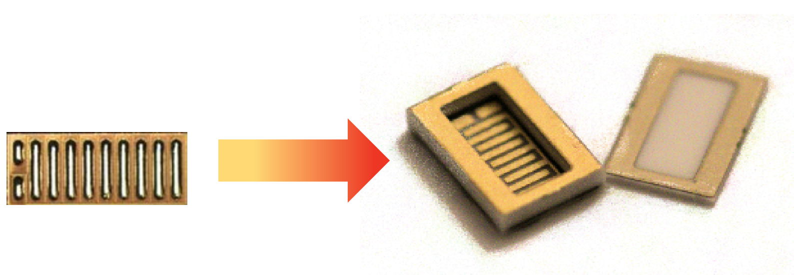
PART NO.	VOLTAGE	CURRENT	PEAK	$R_{DS(ON)}$ (mΩ)	Q_G (nC)	FOM $Q_G * R_{DS(ON)}$
MGN2915U4A	40 V	33 A	150 A	4	11.6	46.4
MGN2914U4A	40 V	10 A	40 A	16	3	48
MGN2905U4A	60 V	25 A	100 A	7	10	70
MGN2909U4A	60 V	6 A	25 A	30	2.4	72
MGN2901U4A	100 V	25 A	100 A	7	10.5	73.5
MGN2907U4A	100 V	6 A	25 A	30	2.7	81
MGN2911U4A	150 V	12 A	40 A	25	6.7	167.5
MGN2913U4A	150 V	3 A	12 A	100	1.7	170
MGN2910U4A	200 V	12 A	40 A	25	7.5	187.5
MGN2912U4A	200 V	3 A	12 A	100	1.9	190

(Preliminary)



U4A



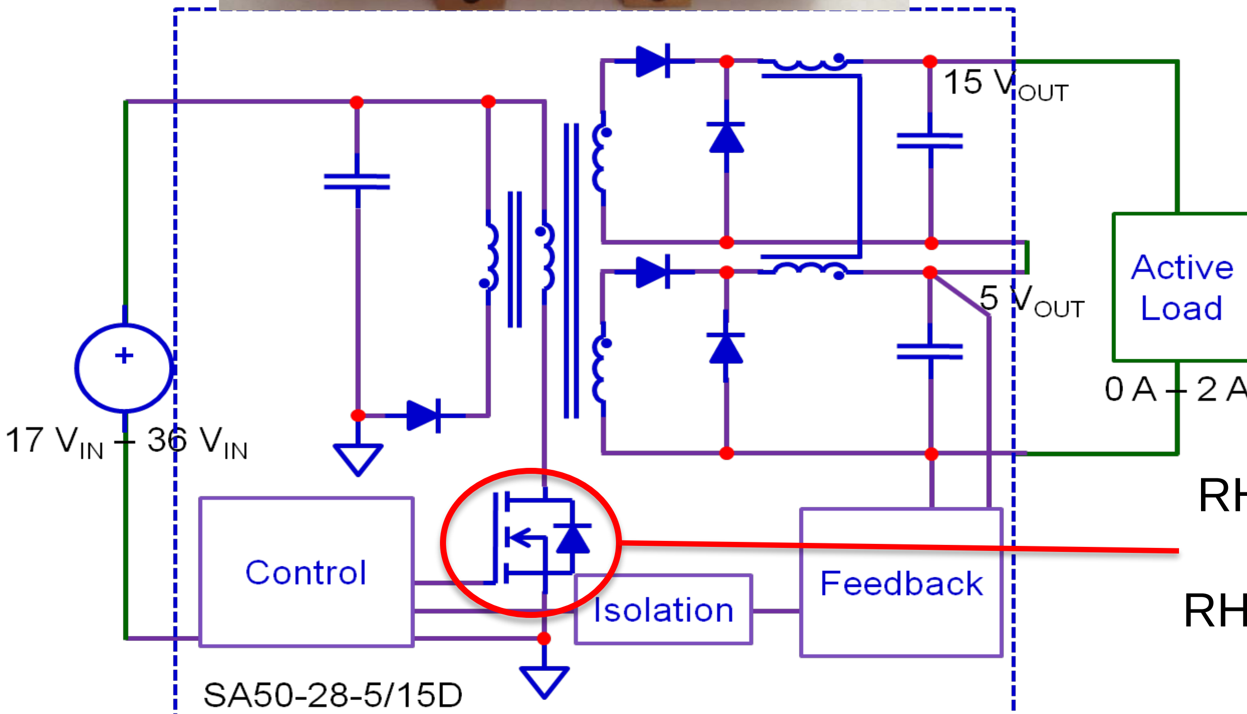


U4A

Forward Converter

Forward Converter Case-Study

50 W / 225 kHz

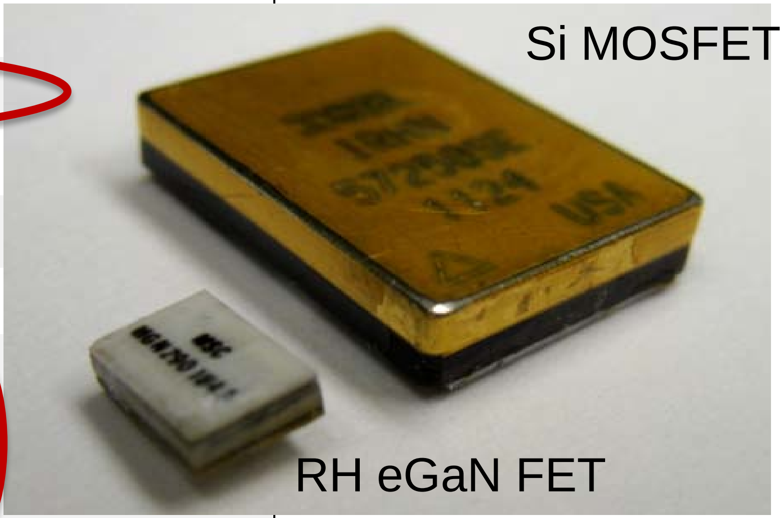


Outputs in series allow up to 2 A / 40 W output

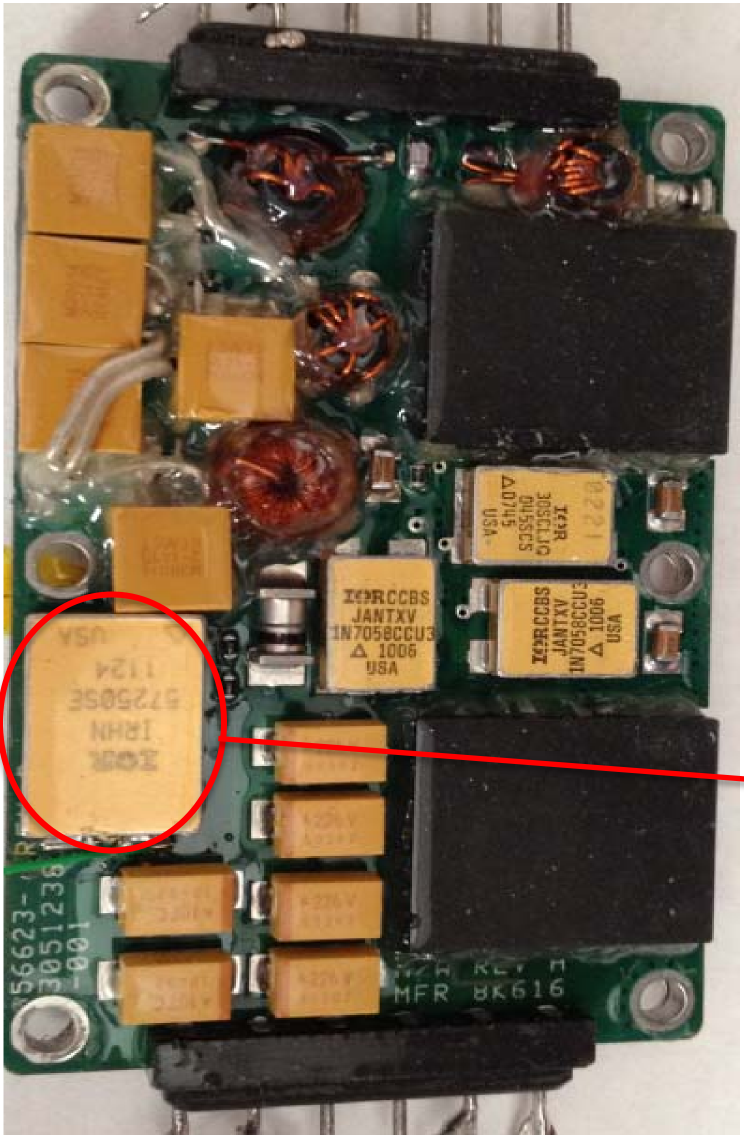
RH 200 V, 60 mΩ MOSFET
Replace with
RH 200 V, 25 mΩ eGaN FET

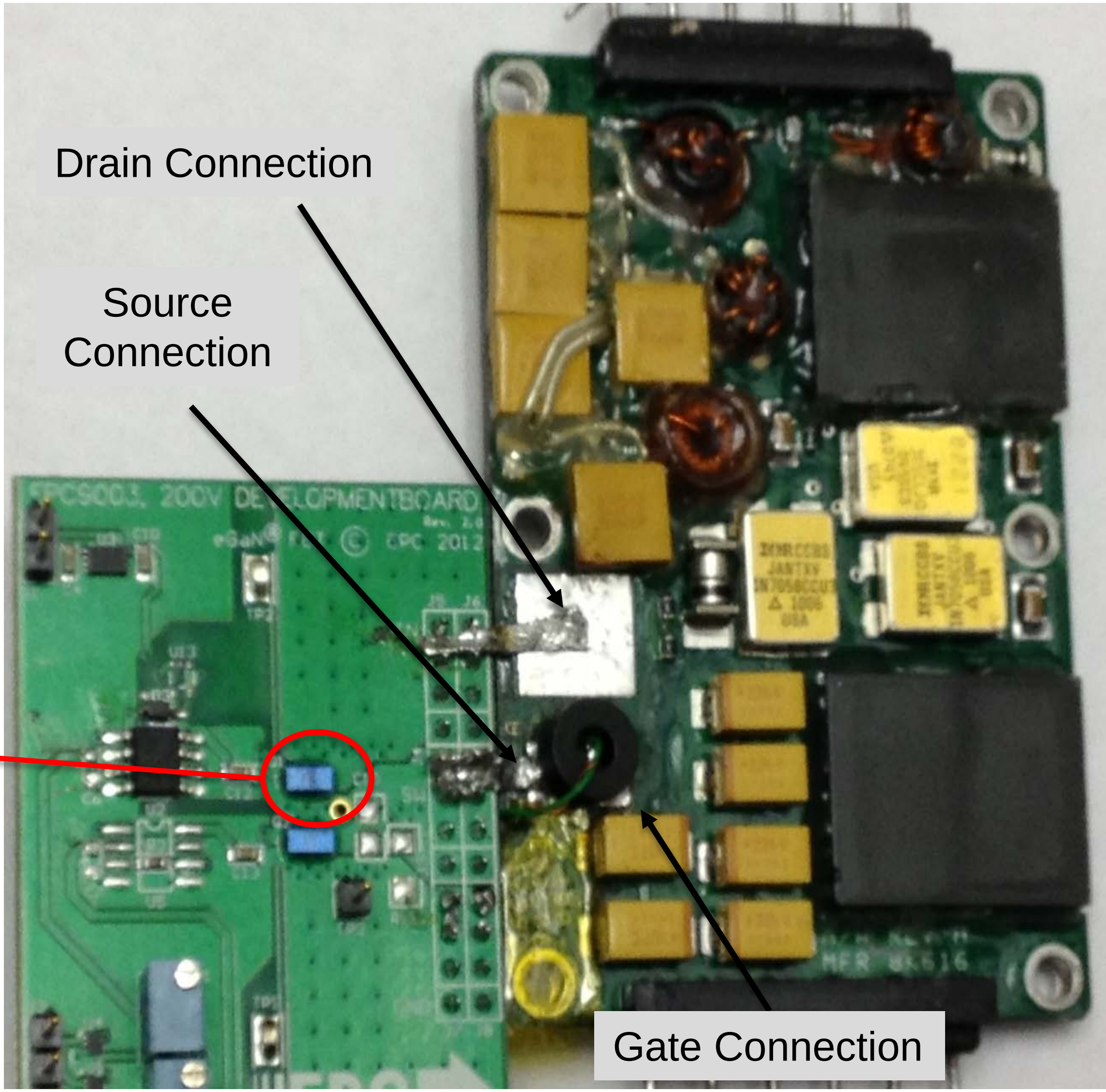
Device Comparison

	GaN	Silicon			
	MGN2910	IRHN57250SE	Units	Performance Ratio	Method
BV_{DSS}	200	200	V		
$R_{DS(ON)}$	0.025	0.06	Ω	2.4	
Q_G	7.5	132	nC	18	
Q_{GS}	2	45	nC	23	
Q_{GD}	2.6	60	nC	23	
$Q_G * R_{DS(ON)}$	0.19	7.9	nC-Ω	42	
$Q_{GS} * R_{DS(ON)}$	0.05	2.7	nC-Ω	54	
$Q_{GD} * R_{DS(ON)}$	0.065	3.6	nC-Ω	55	
Demonstrated SEE SOA at 84 LET (V_G= 0 V)	190	200	V	1	MIL-STD750E Method 1080
Demonstrated TID Capability	>1000	100	kRAD(Si)	>10	MIL-STD750E Method 1019



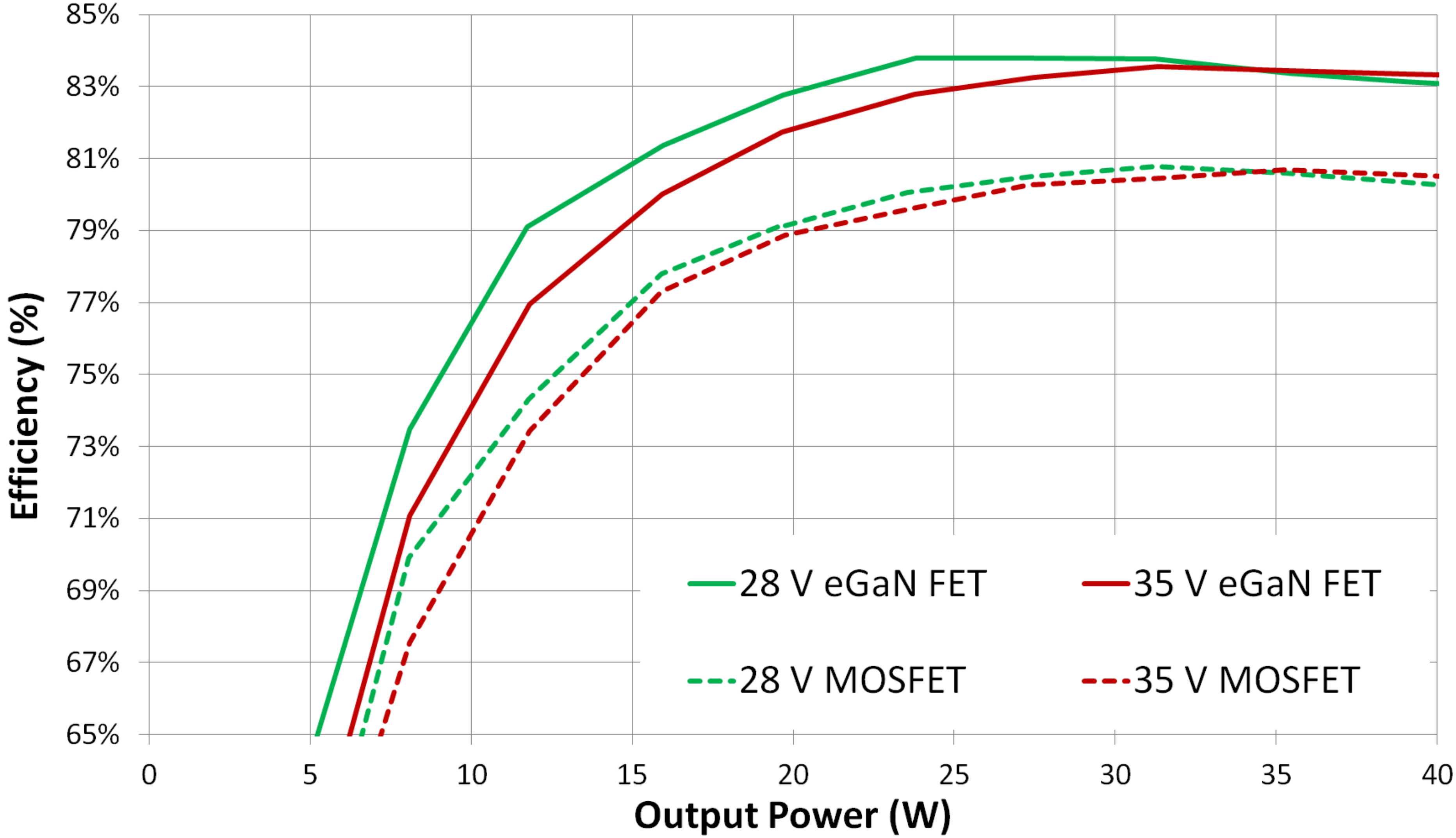
Experimental Setup



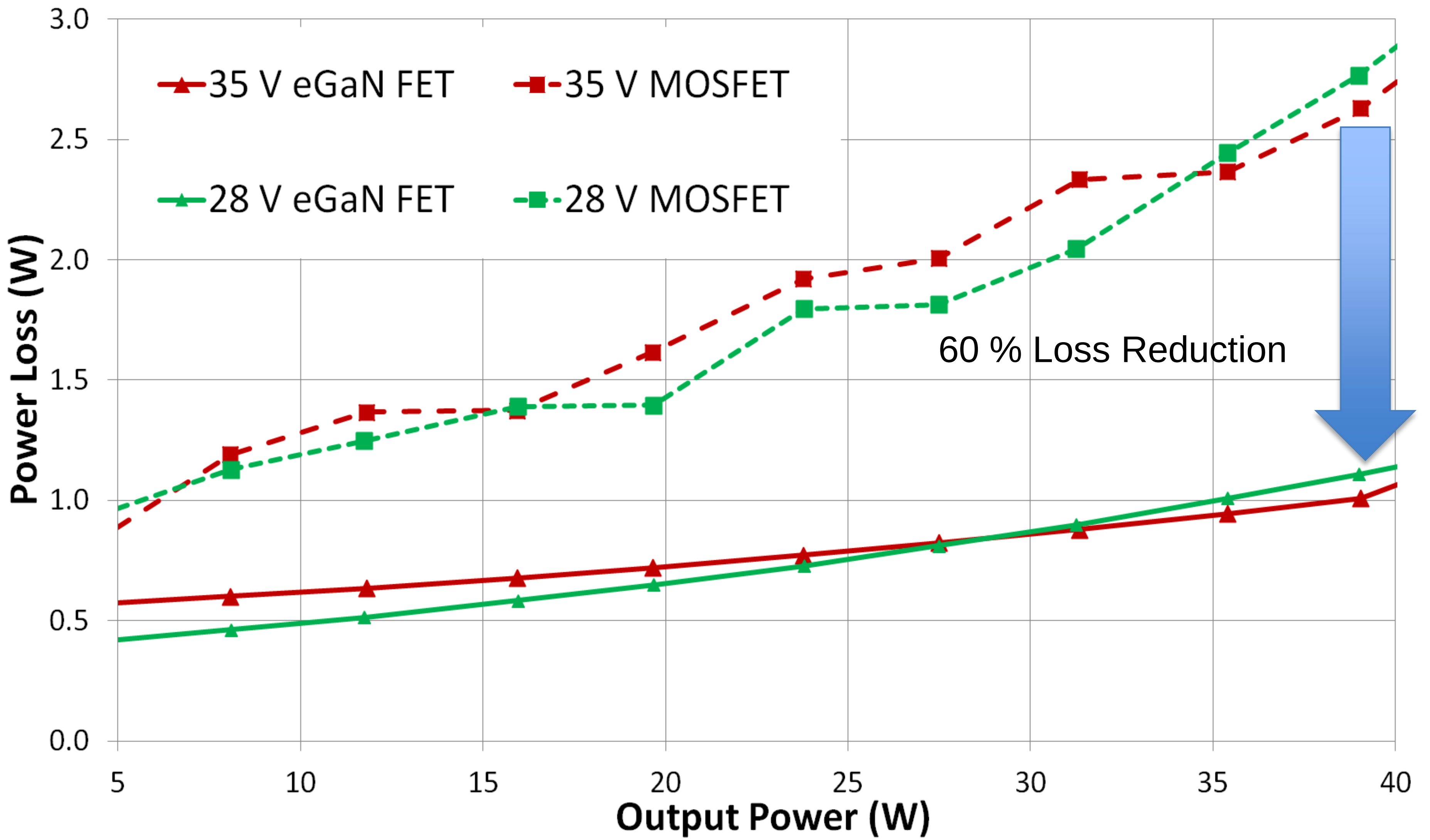


Efficiency Results

2.5 % – 5 % improvement in Efficiency

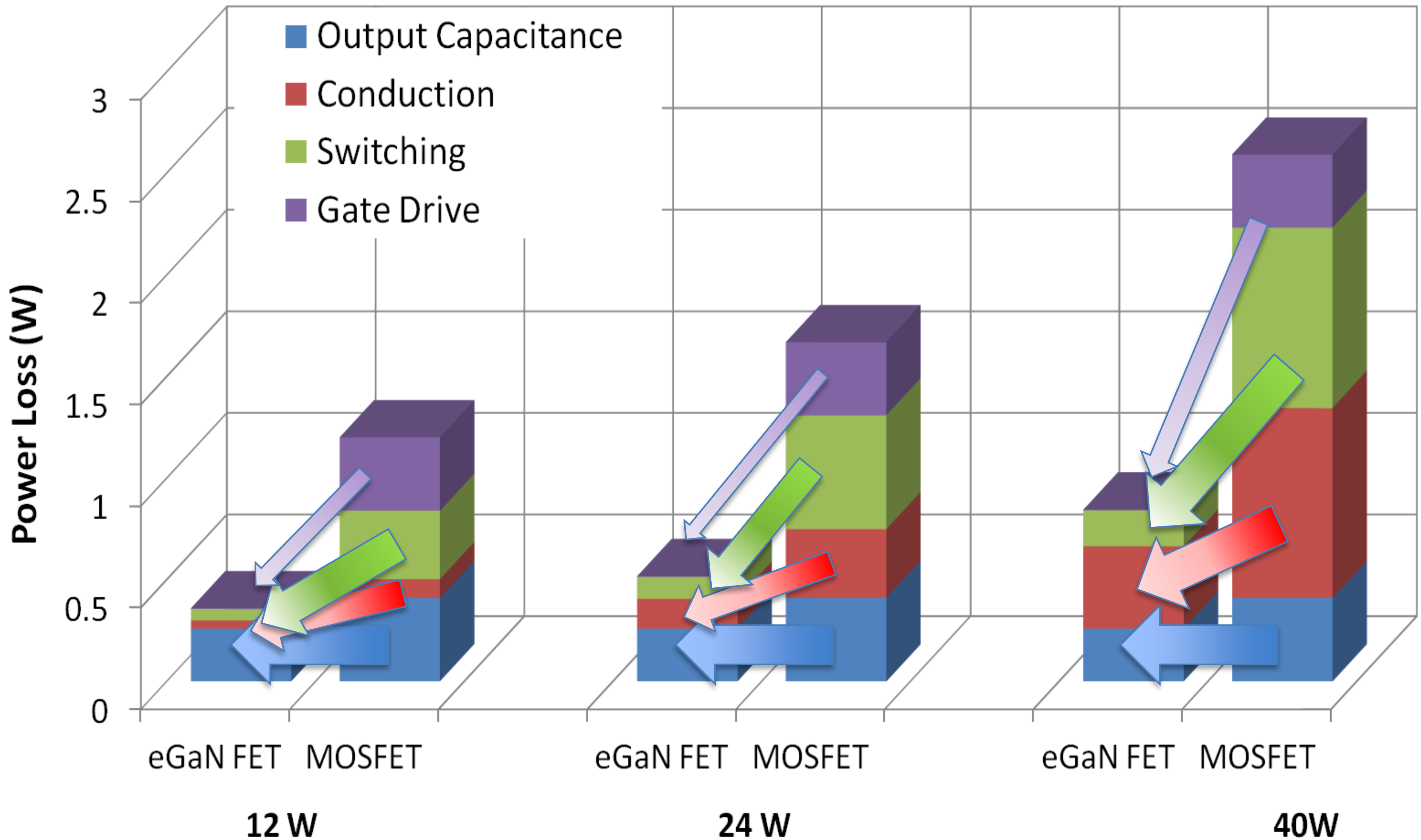


Estimated Device Losses



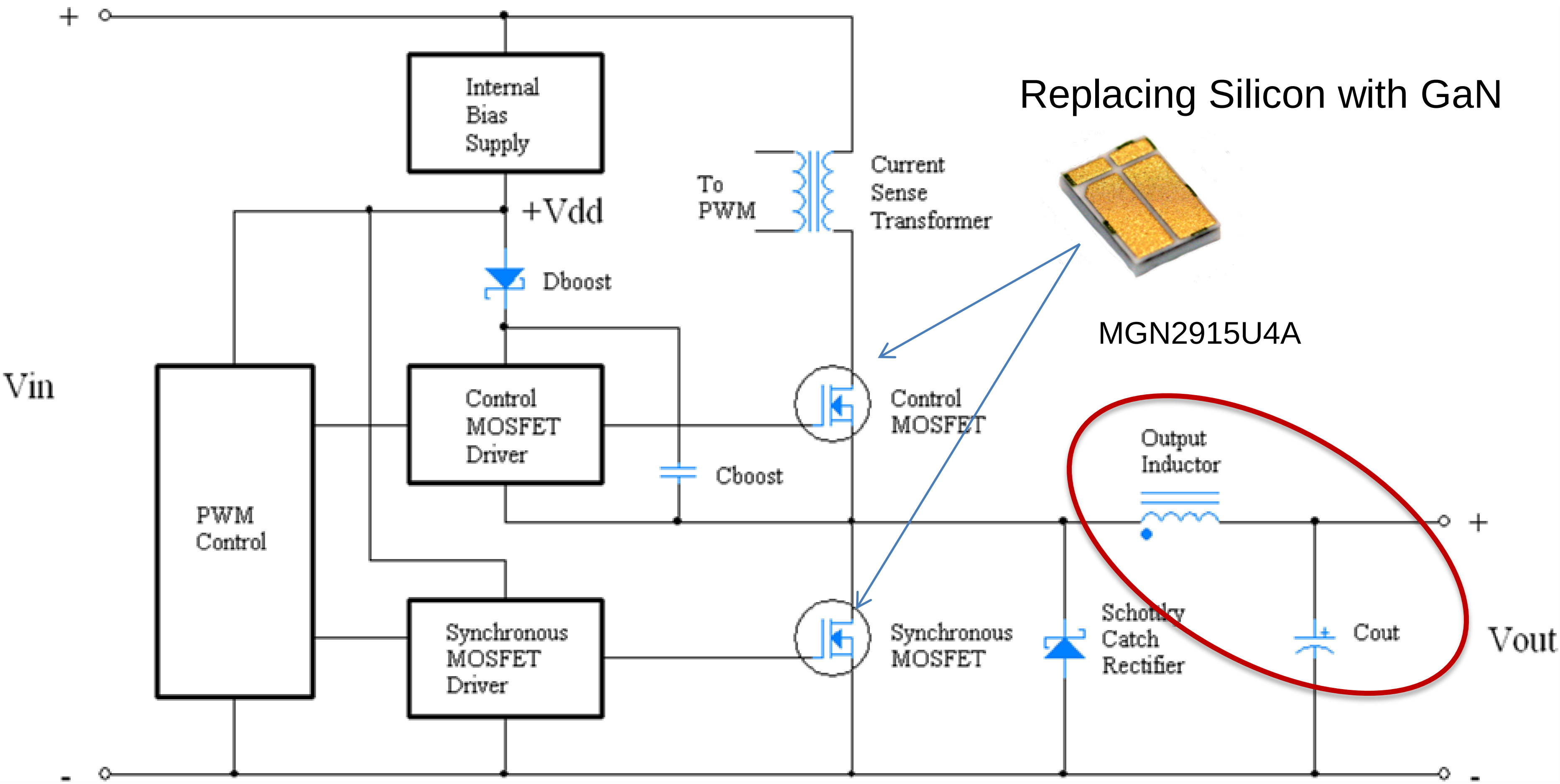
Device Loss Comparison

Improvement in BOTH conduction and switching losses



Other DC-DC converters

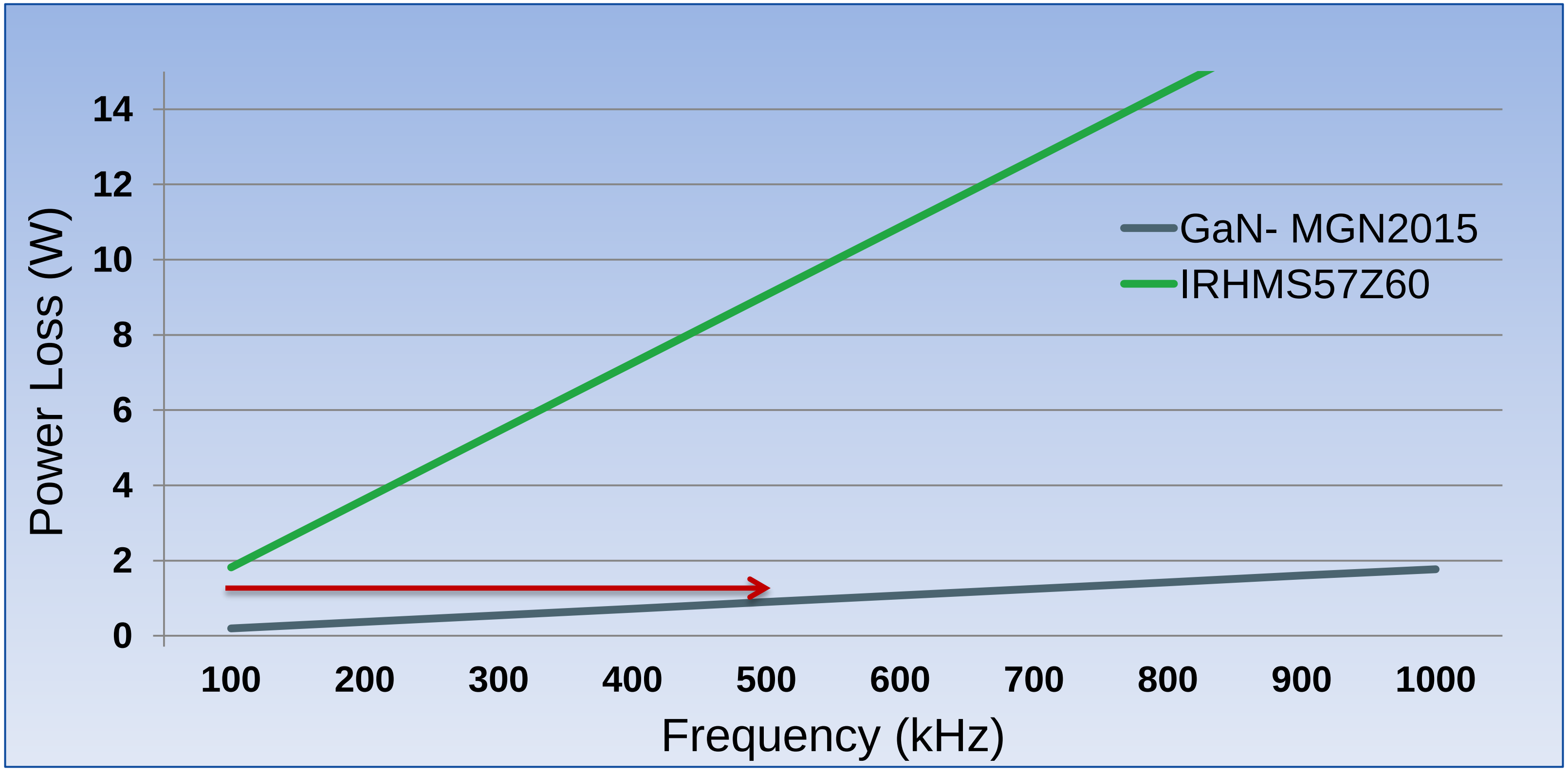
Synchronous Buck POL



- eGaN FET allows increased switching frequency
- Reduced size / weight of passive components

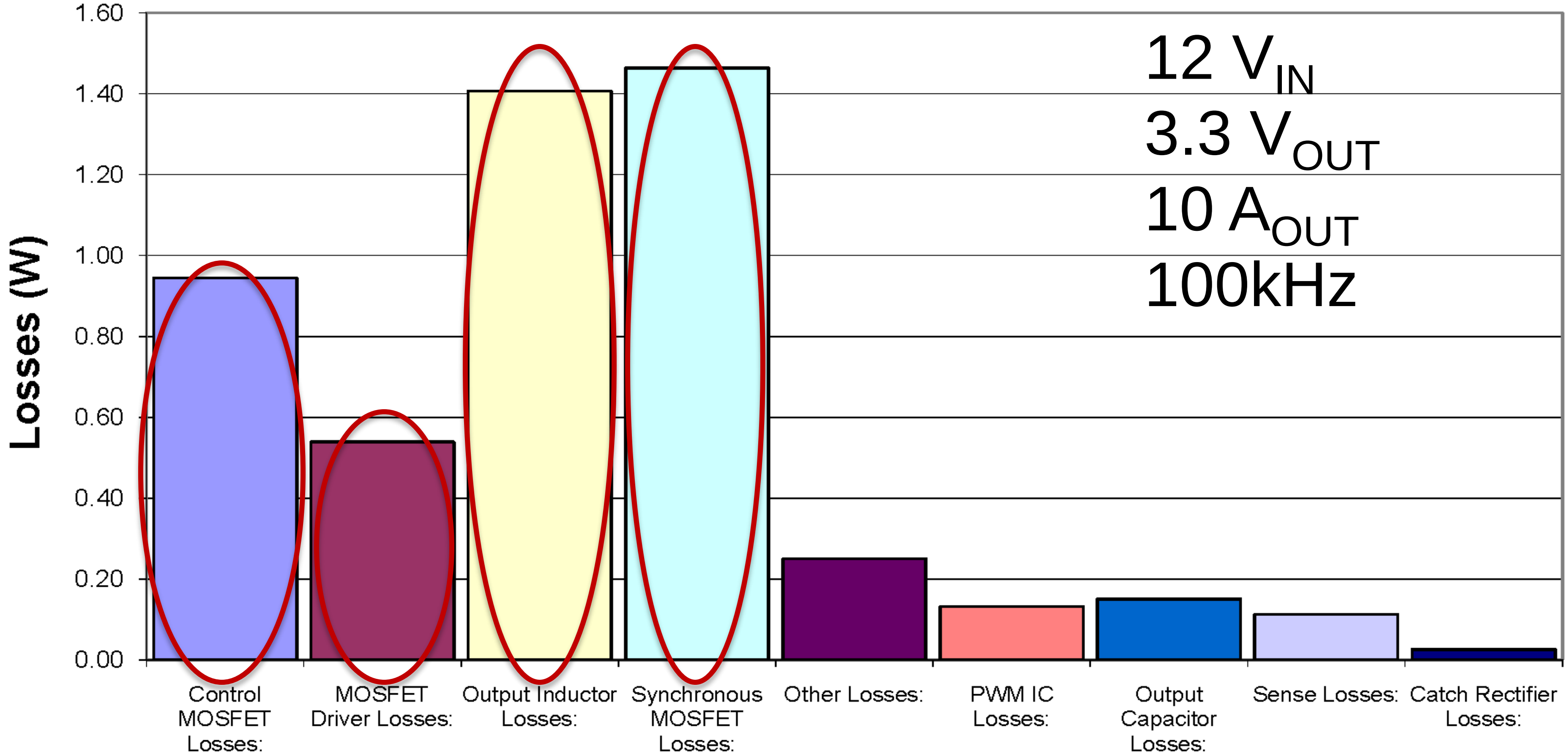
GaN vs. Silicon

Nearly a 10:1 improvement in power dissipated



- Irms= 2A, Vcc= 24Vdc, Duty= 50%, Rds(on)= .0045 ohms
- Power MOSFET losses can be prohibitive @ 500KHz
- eGaN FET power loss @ 500kHz < Power MOSFET @ 100kHz!

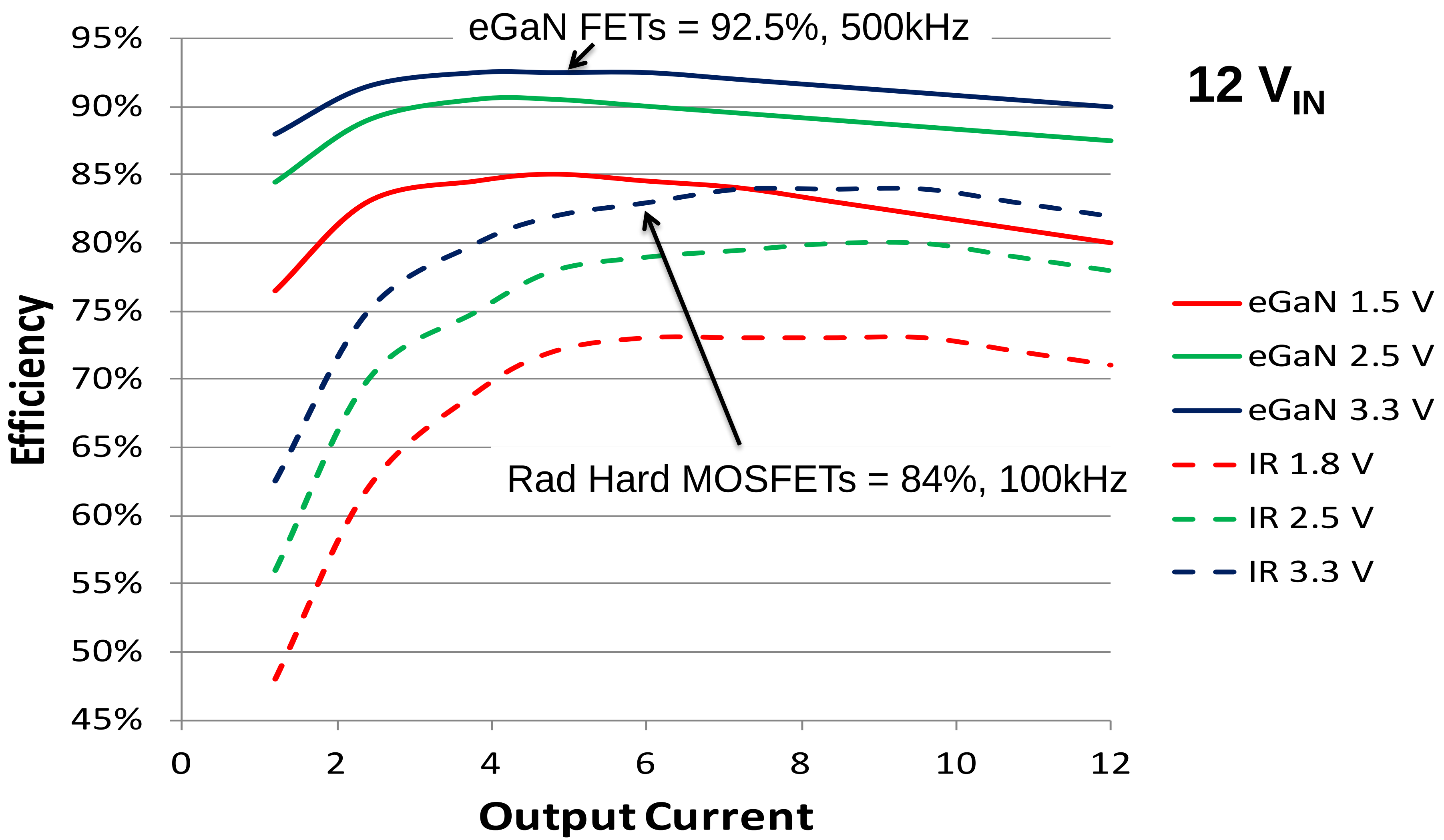
Low voltage POL



MOSFET= IRHNJ57Z30_Typ **MOSFET Driver = SG1644_Typ**

- Highest loss: MOSFETs and Inductor

POL Efficiency Comparison



Conclusions

- eGaN FETs have exceptional Heavy Ion hardness and TID capability beyond 1MRad
- RH eGaN FETs offer at least 3x improvement in device losses.
- This improvement allows increased switching frequency and efficiency while reducing overall size and weight.
- eGaN FETs allow RH DC-DC to be on par with current commercial power supplies.

EPC
EFFICIENT POWER CONVERSION

The end of the road for silicon…..

is the beginning of the eGaN FET journey!