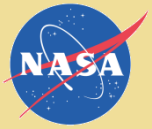

Reliability Assessment of Wide Bandgap Power Devices

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Scope of Work

- A NEPP collaborative effort among NASA Centers to address reliability of new COTS wide bandgap power devices

Approach

- Identify, acquire, and evaluate performance of emerging GaN (Gallium Nitride) & SiC (Silicon Carbide) power devices under the exposure to radiation, thermal cycling, and power cycling
- Document results and disseminate findings

Presentation

- Radiation & thermal cycling effects on GaN power FETs
- Wear-out board for dynamic power/thermal cycling

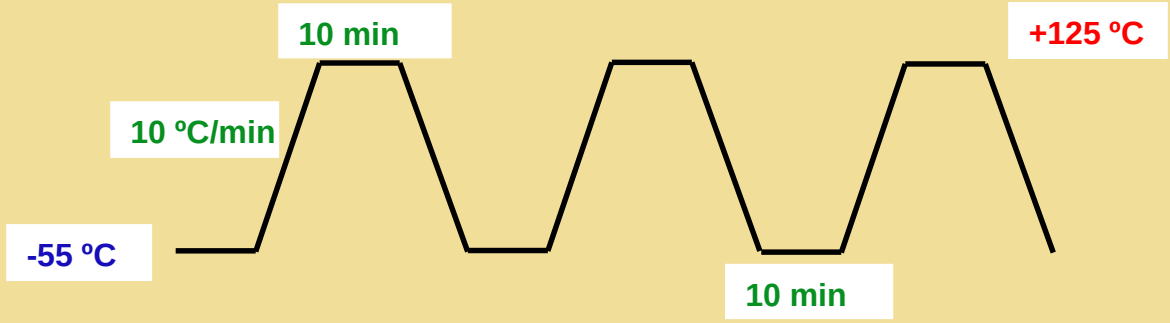
Radiation & Thermal Cycling Effects on GaN Power FETs

Manufacturer	Part #	Parameters	# Samples (control/Irradiated)	Radiation	Cycling
EPC	2012	200V, 3A, 100mΩ	15/26	✓	✓
GaN Systems	GS61008P	100V, 90A, 7.4mΩ	11/10	✓	✓
	GS66508P	650V, 30A, 52mΩ	4/0	Planned	✓

Radiation Exposure						
Device	Ion	Energy (MeV)	LET	Range (μm)	Dose (rads)	Facility
EPC	Xe	1569	40	124.5	8719.6	TAMU
GaN Systems	Ag	1569	41	121	6634	LBL

Thermal Cycling:

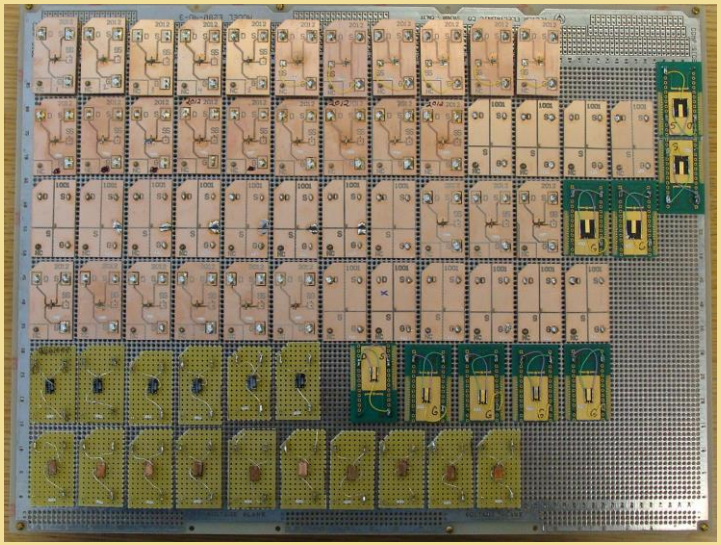
- 120 cycles (Ongoing)
- Rate: 10 ºC/min
- Range: -55 ºC to +125 ºC
- Soak time: 10 min

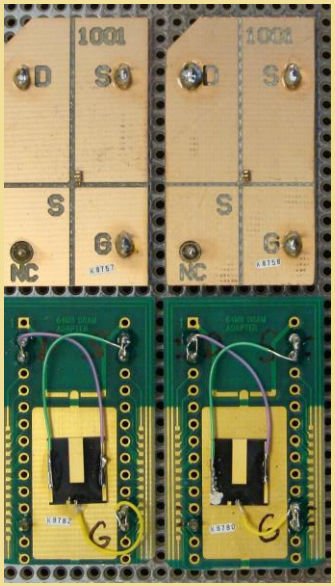


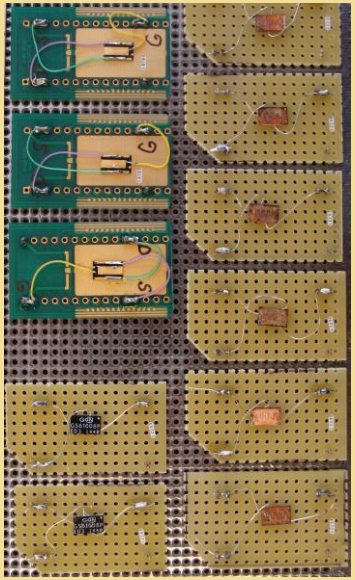
Test Setup

Parameters Investigated:

- I-V Output Characteristics
- Gate Threshold Voltage, V_{TH}
- Drain-Source On-Resistance, $R_{DS(on)}$
- Drain Leakage Current, I_{DSS}
- Gate Leakage current, I_{GSS}

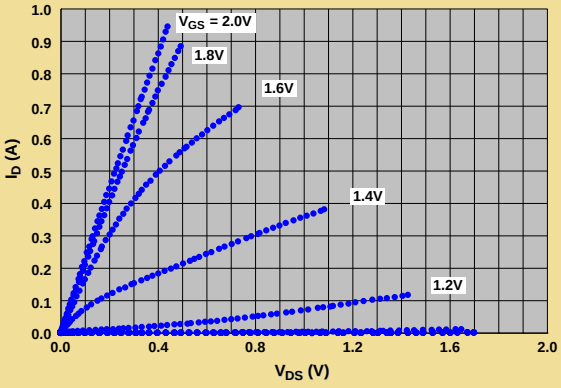




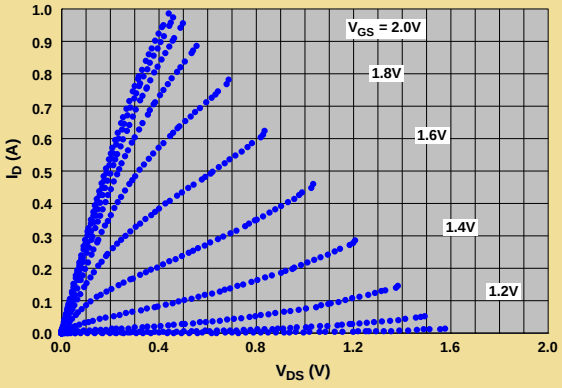


EPC2012 Enhancement Mode Power FET

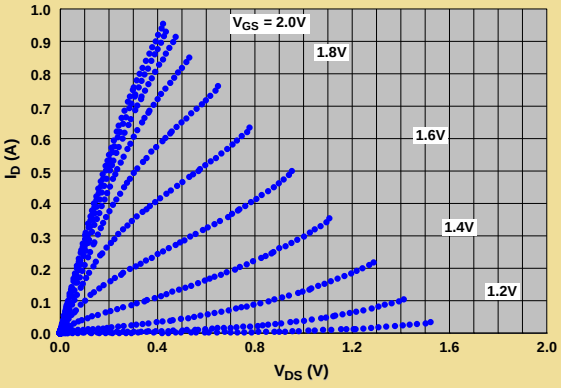
EPC2012	Pre-cycling		Post-cycling		Remarks
	Cont	Irrad	Cont	Irrad	• Control & irradiated parts remained functional after exposure to radiation & thermal cycling • Slight reduction in threshold voltage, modest increase in drain-source resistance & varying increase in leakage current with radiation • Insignificant effects of cycling on properties • Part-to-part variation in output characteristics • No alteration in device packaging or terminations
V_{TH} (V)	1.21	0.90	1.02	0.84	
I_{GSSF} (μA)	0.69	0.84	0.71	0.85	
I_{GSSR} (nA)	540	779	664	881	
I_{DSS} (μA)	0.17	383	0.19	440	
$R_{DS(on)}$ Normalized	1.0	1.33	1.06	1.04	



Control



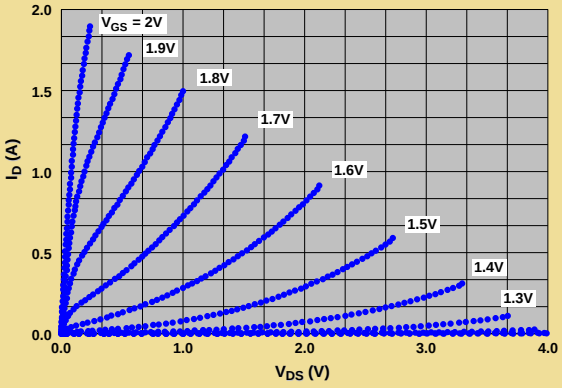
Irradiated



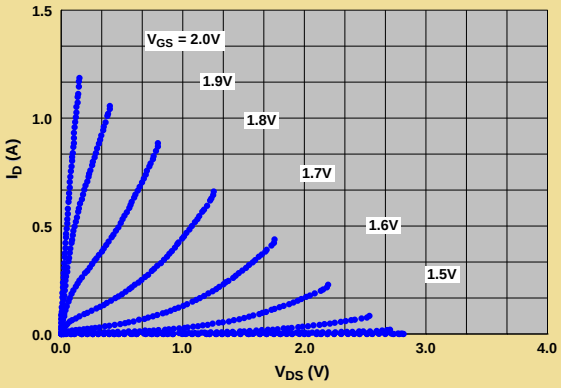
Post-cycling

GaN Systems Enhancement Mode Power FET

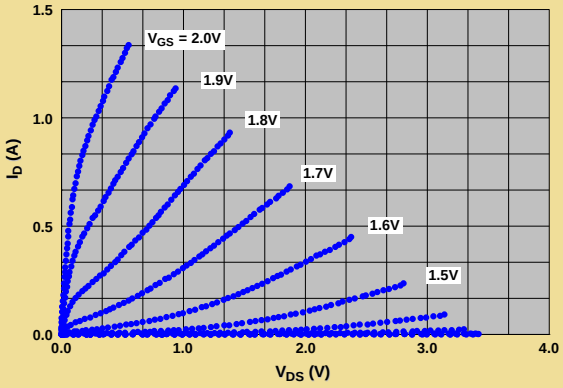
GS61008P	Pre-cycling		Post-cycling		Remarks
	Cont	Irrad	Cont	Irrad	• Control & irradiated parts remained functional after exposure to radiation & thermal cycling • Slight reduction in threshold voltage & modest increase in drain-source resistance with radiation; 1 device had significant increase in leakage current • Insignificant effects of cycling on properties • Part-to-part variation in output characteristics • No alteration in device packaging or terminations
V_{TH} (V)	1.21	0.95	0.97	1.04	
I_{GSSF} (μA)	58.8	35.9	35	68	
I_{GSSR} (nA)	1.54	1.41	1.21	1.31	
I_{DSS} (μA)	1.40	1.24	4.94	72.2	
$R_{DS(on)}$ Normalized	1.0	1.33	1.02	0.87	



Control



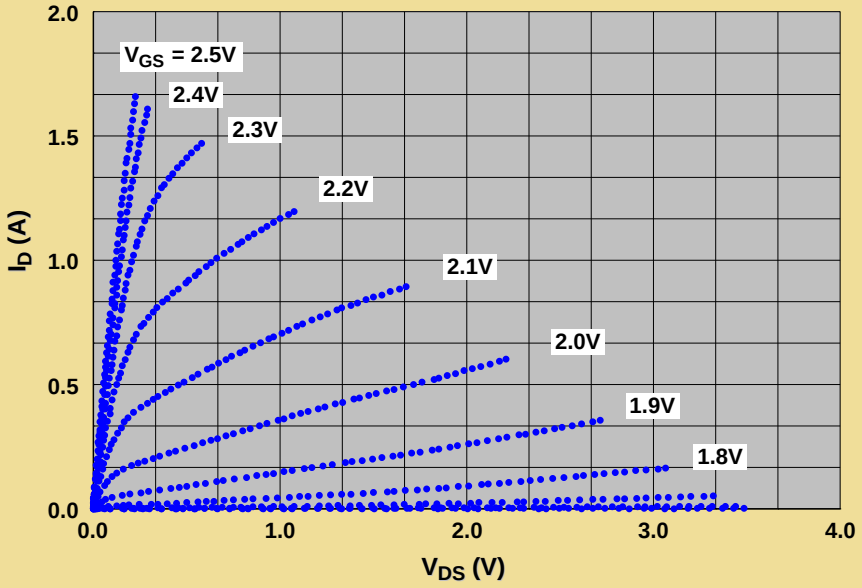
Irradiated



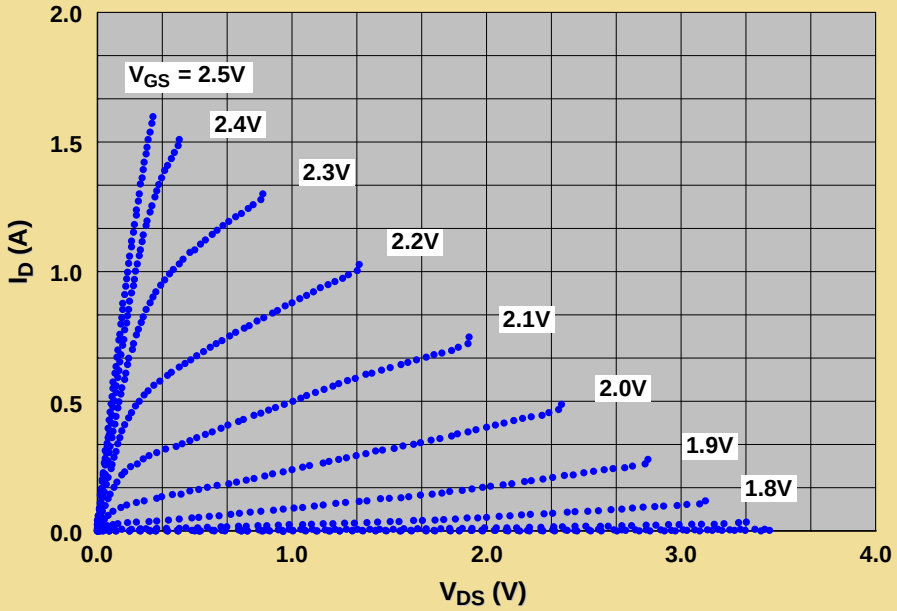
Post-cycling

GaN Systems Enhancement Mode Power FET

GS66508P	Pre-cycling	Post-cycling	Remarks
	Control	Control	• Parts remained functional after exposure to thermal cycling with no significant changes in properties • Part-to-part variation in output characteristics • No alteration in device packaging or terminations
V_{TH} (V)	1.59	1.41	
I_{GSSF} (μA)	471.5	465.7	
I_{GSSR} (nA)	0.41	0.33	
I_{DSS} (μA)	6.37	5.53	
$R_{DS(on)}$ Normalized	1.0	1.08	

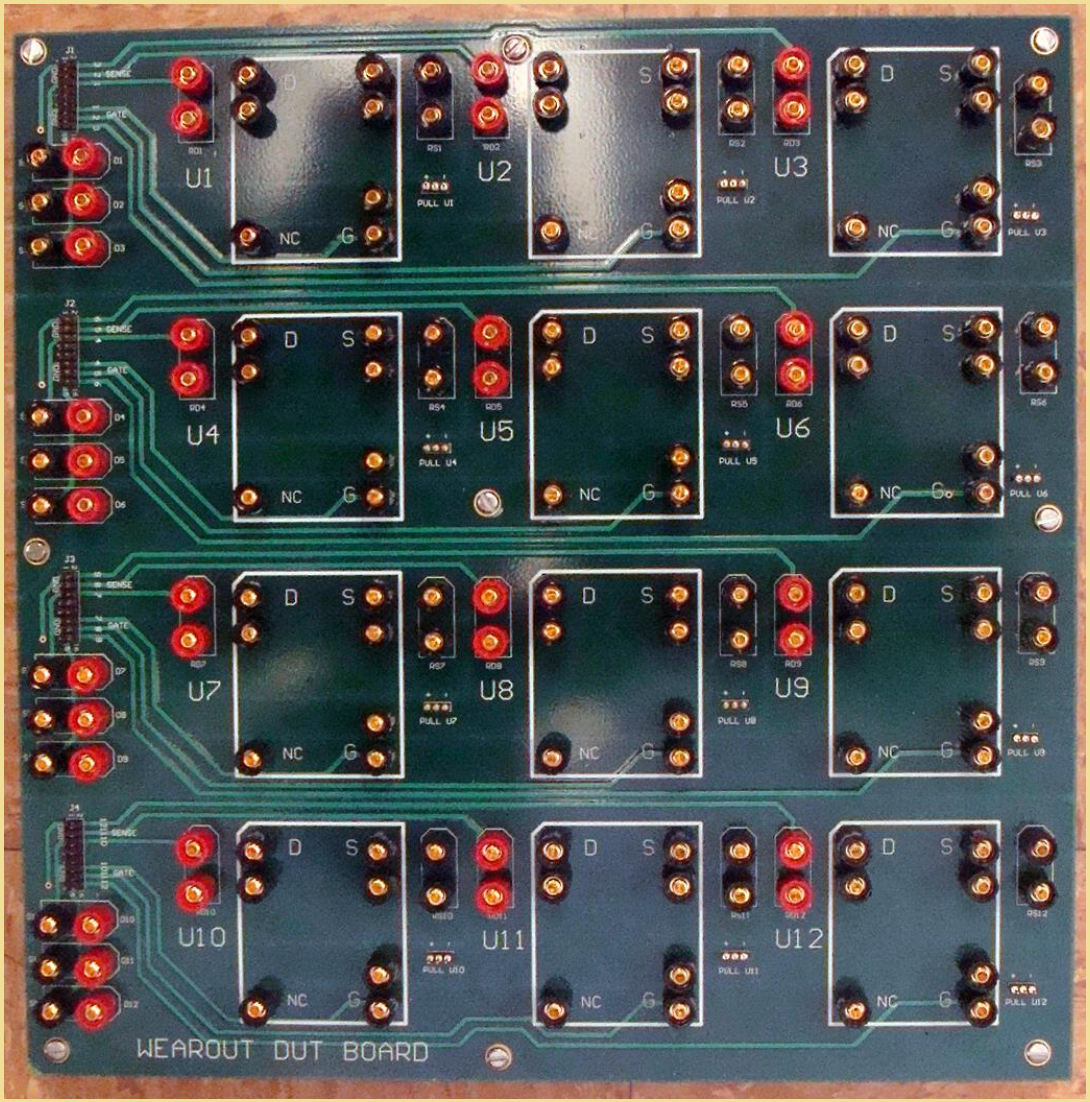


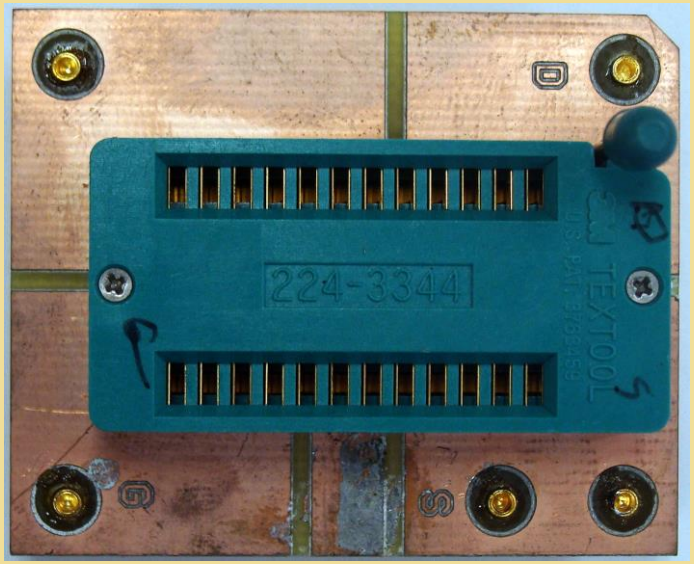
Pre-cycling

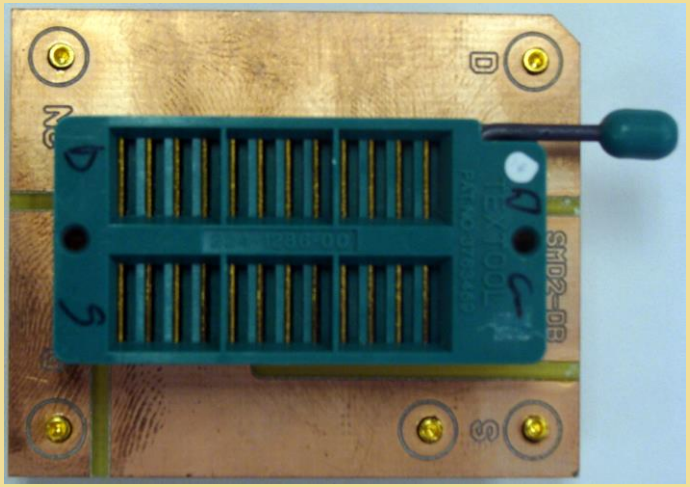


Post-cycling

Wear-out board for dynamic power/thermal cycling







Planned Work

- Continue multi-stress tests on control and irradiated GaN & SiC power devices
- Power Cycling
  - Static (Gate DC voltage)
  - Dynamic (Gate AC voltage)

ACKNOWLEDGMENT

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