The eGaN® FET Journey Continues in Space
Radiation Tolerant Enhancement Mode Gallium Nitride (eGaN®) FET Characteristics

Alexander Lidow
Chief Executive Officer
Efficient Power Conversion
Agenda

- Device Structure
- SEE Results
- Total Dose Results
- In Circuit Results
- What’s in the Future?
- Conclusions
eGaN® FET Structure

Dielectric

AlGaN Electron Generating Layer

D

G

Two Dimensional Electron Gas (2DEG)

Aluminum Nitride Isolation Layer

Si

GaN

S

D

AlGaN Electron Generating Layer

Dielectric
SEE Results
SEE Results - 2010

SEE Heavy Ion Testing - Au

- Fail
- Out of Spec
- Undamaged

MIL-STD-750E, METHOD 1080
The SEGR failure site of a first-generation 200 V eGaN FET occurred between metal layers and was caused by the inductance of long gate and source leads that allowed the gate-source voltage to exceed maximum limits.
SEE Results - 2011

SEE Heavy Ion Testing - Au

MIL-STD-750E, METHOD 1080

- Fail
- Out of Spec
- Undamaged
Total Dose Results
Total Dose Results – 40V

MIL-STD-750E, METHOD 1019
Total Dose Results – 100 V

EPC1001 Gate and Drain-Source Leakage Current

MIL-STD-750E, METHOD 1019
Total Dose Results - 200 V

EPC1010 Gate and Drain-Source Leakage Current

- IGSS after VDS
- IDSS after VDS
- IGSS after VGS
- IDSS after VGS

EPC1010 Threshold Voltage

- VTH after VDS
- VTH after VGS

MIL-STD-750E, METHOD 1019
In-Circuit Testing
Rad Hard Figure of Merit

<table>
<thead>
<tr>
<th>Rated Voltage</th>
<th>DC Current</th>
<th>Peak Current</th>
<th>$R_{DS(ON)}$ (mΩ)</th>
<th>$Q_g$</th>
<th>FOM ($Q_g \times R_{DS(ON)}$)</th>
<th>Die Dim (mils²)</th>
<th>Package Dim (mils²)</th>
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<tbody>
<tr>
<td>MGN 2915</td>
<td>40</td>
<td>33</td>
<td>150</td>
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<td>45</td>
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<td>224</td>
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<td>240</td>
<td>60</td>
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</table>

- 20x - 40x FOM Improvement
- 5-7x Die Size Reduction
- 30x – 40x Package Size Reduction
POL Efficiency Comparison

500 kHz
12 V_in

eGaN FETs = 92.5%
Rad Hard MOSFETs = 84%
Parallel FET Buck Converter

Efficiency at 1 MHz  12 V$_{\text{IN}}$ – 1.2 V$_{\text{OUT}}$

State-of-the-Art Commercial MOSFETs
What’s in the Future?
Beyond 600 Volts

- Rated $R_{DS(on)}$ (mΩ)
- Rated $V_{DSS(MAX)}$

- Year:
  - 2009
  - 2011
  - 2012

- Values:
  - 25 mΩ
  - 400 mΩ
  - 200 mΩ
  - 250 mΩ

LGA Package
Beyond Discrete Devices

**Driver On Board**

Discrete eGaN FET with Driver

Full-Bridge with Driver and Level Shift
Conclusions

• eGaN FETs have exceptional Heavy Ion hardness

• eGaN FETs have performed exceptionally well when submitted for Total Ionizing Dose ($^{60}$Co) up to 1 MRad and beyond

• eGaN FETs have demonstrated extraordinary efficiency in a high frequency point-of-load converter

• Future integration of driver and control functions can significantly improve system radiation tolerance.
The end of the road for silicon…..

…is the beginning of the eGaN FET journey!