The eGaN® FET Journey Continues

Enhancement-Mode Gallium Nitride Transistors in Automotive Applications
Agenda

• Why eGaN® FETs?
• Infotainment
• Safety
• Electric Drive
• Summary

eGaN® is a registered trademark of Efficient Power Conversion Corporation
Why eGaN FETs in Cars

- Speed
- Size
- Reliability
- Cost
Infotainment

• The Smartphone Takeover
• Cockpit Wireless Power
• High Resolution Class-D Audio
Smartphone Takeover

Pro

• Superior navigation and mapping systems without fixed antenna
• Fully synchronized with entertainment library
• Fully linked to the Internet
• Large Apps library
• Untethered Operation

Con

• Safety concerns
• Cell phone battery drain
Wireless Charging
eGaN FETs for Class D Audio

- High efficiency
- Small and light weight
- Low EMI
- Fast switching and no diode recovery
- High output linearity and low crossover distortion
Safety Applications

- High Intensity Headlamps
- LiDAR Sensing
- Enhanced Vision
- Driverless Vehicles
High Intensity Headlamps

- Improved Vision
- Frequencies above AM band
- Compact Assembly
- Simple Thermal Management
- Lower EMI

Stock Low-Beam

LED Low-Beam
Why is GaN used in LiDAR?

\[ R_{\text{MIN}} = \frac{(\Delta T_{\text{MIN(laser)}} \times C)}{2} \]

\[ \Delta T_{\text{MIN(laser)}} = (T_{\text{RISE}} + T_{\text{FALL}}) \]

\[ (T_{\text{RISE}} + T_{\text{FALL}})_{\text{GaN}} = \frac{(T_{\text{RISE}} + T_{\text{FALL}})_{\text{Si}}}{10} \]
LiDAR Sensors

Emergency Braking
Pedestrian Detection
Collision Avoidance
Enhanced Vision
Autonomous Driving
Electric Drive – GaN or SiC?

- Reliability
- Cost
- Bus Voltage Selection
- Integration Opportunities and Needs
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Field Reliability

10B total device hours

73 Field Returns (17 Good, 55 Failed)
- 16 Layout Related – Addressed with Layout Section of Design Support
- 37 Assembly Related – Addressed with Assembly Web Page
- 1 Physical Abuse
- 1 Device degradation (addressed in Gen 4)

1 Failure in 10B Hours equals 0.1 FIT
Electric Drive – GaN or SiC?

- Reliability
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## MOSFET vs. eGaN Costs*

<table>
<thead>
<tr>
<th>Process Stage</th>
<th>2014</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Material</td>
<td>lower</td>
<td>lower</td>
</tr>
<tr>
<td>Epi Growth</td>
<td>~higher</td>
<td>~same</td>
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<tr>
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*Product with the same on resistance and voltage rating*
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Active die <3 mm²
# MOSFET vs. eGaN Costs

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<tr>
<th>Device</th>
<th>TDS(MAX)</th>
<th>RDS(on) (max)</th>
<th>QOSS (typ @50%BV)</th>
<th>QGD (typ @50%BV)</th>
<th>QG (typ @5V)</th>
<th>Device Area</th>
<th>Price Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPC2035</td>
<td>60 V</td>
<td>45 mΩ</td>
<td>3 nC</td>
<td>0.16 nC</td>
<td>1.2 nC</td>
<td>0.81 mm²</td>
<td>$ 0.360</td>
</tr>
<tr>
<td>FDS5351</td>
<td>60 V</td>
<td>42 mΩ</td>
<td>7 nC</td>
<td>3.5 nC</td>
<td>19 nC</td>
<td>31 mm²</td>
<td>$ 0.382</td>
</tr>
<tr>
<td>EPC2036</td>
<td>100 V</td>
<td>65 mΩ</td>
<td>4 nC</td>
<td>0.15 nC</td>
<td>1 nC</td>
<td>0.81 mm²</td>
<td>$ 0.376</td>
</tr>
<tr>
<td>FDMS8622</td>
<td>100 V</td>
<td>88 mΩ</td>
<td>6.5 nC</td>
<td>1.3 nC</td>
<td>2.8 nC</td>
<td>32.5 mm²</td>
<td>$ 0.396</td>
</tr>
</tbody>
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0.9mm x 0.9 mm

Price Comparison

- **EPC2035** 1Ku $0.360, 10Ku $0.293, 100Ku $0.230
- **FDS5351** 1Ku $0.382, 10Ku $0.313, 100Ku $0.285
- **EPC2036** 1Ku $0.376, 10Ku $0.306, 100Ku $0.240
- **FDMS8622** 1Ku $0.396, 10Ku $0.324, 100Ku $0.295
Electric Drive – GaN or SiC?

- Reliability
- Cost
- Bus Voltage Selection
- Integration Opportunities and Needs
Domain of Dominance

- **GaN-on-Silicon**
- **MOSFET**
- **IGBT**
- **SiC**

**DC Current Capability x Rated Voltage**

- 600 V
- 900 V
- 1700 V
- 10,000 V

- 1 X
- 1.5 X
- 2 – 3X

**EV Drive**
Electric Drive – GaN or SiC?

- Reliability
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GaN Integration

**eGaN FET**

**Discrete Device**

2014

**Integrated Power Devices**

2016

**Power Devices Integrated with Analog IC Functions**

GaN Integration
Summary

• GaN technology has made inroads in many automotive applications.
• There is still an open question about EV drives.
• EPC expects Automotive Qualification by 2016.
Where is GaN going...

Thank You