The eGaN® FET Journey Begins

Alexander Lidow PhD
Efficient Power Conversion Corporation
Agenda

• Overview of EPC eGaN® FET technology
• The opportunity to improve efficiency and performance
• Future Products
• Conclusions
Overview of eGaN FET Technology
eGaN FETs Structure

AlGaN Electron Generating Layer

Dielectric

GaN

Si

Aluminum Nitride Isolation Layer
eGaN FETs Structure
Flip Chip Assembly
The Opportunity to Improve Efficiency
Topologies Explored

Buck Converter

Forward Converter

Flyback Converter

Full Bridge Isolated Converter
**Buck Converter**

**Advantage:**
- High power density and high efficiency

*Figure 7 – Buck converter with an input voltage of 48 VDC and output voltage of 1.2 VDC*
48V - 1.2V Efficiency Comparison

![Graph showing efficiency comparison between 500kHz GaN FET, 500kHz MOSFET, and 300kHz MOSFET.](image-url)
Efficiency vs $V_{\text{IN}}$ @ $V_{\text{OUT}} = 1.2$ V / 5A

- 100V eGaN FET vs 60V MOSFET
- 40V eGaN FET vs 40V MOSFET

- 300kHz MOSFET
- 500kHz MOSFET
- 800kHz MOSFET
- 300kHz eGaN FET
- 500kHz eGaN FET
- 800kHz eGaN FET

Input Voltage (V) vs Efficiency (%)
Efficiency vs Frequency @ 1.2Vout / 5A

- Efficiency (%)
- Switching Frequency (kHz)

- MOSFET @ 12Vin
- MOSFET @ 24Vin
- MOSFET @ 48Vin
- eGaN FET @ 12Vin
- eGaN FET @ 24Vin
- eGaN FET @ 48Vin

- 62%
- 64%
- 66%
- 68%
- 70%
- 72%
- 74%
- 76%
- 78%
- 80%
- 82%
- 84%
- 86%
- 88%
- 90%
- 92%
A 24V-1.2V Buck converter was built with both with eGaN FETs and state-of-the-art silicon power MOSFETs
Buck Size Comparison

184 mm²

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$V_{DS}$ (V)</td>
<td>$R_{DS(OH)}$ (max)</td>
</tr>
<tr>
<td>eGaN FET</td>
<td>40</td>
<td>16 mΩ</td>
</tr>
<tr>
<td>MOSFET</td>
<td>30</td>
<td>15 mΩ</td>
</tr>
</tbody>
</table>
A 24V-1.2V Buck converter with eGaN FETs is 50% smaller and has 30% less power losses at 800 kHz.
Flyback Converter

Advantage:
• Low cost at low power density

![Diagram of Flyback Converter]

- 36~57 V
- 4.5 A
- 13W
Flyback Converter

![Graph showing efficiency vs. output current for different devices at 300kHz and 500kHz]

- 300kHz Mosfet
- 300kHz eGaN FET
- 500kHz MOSFET
- 500kHz eGaN FET

Efficiency vs. Output Current (A)
Forward Converter

Advantage:
• High power density at lower power
Forward Converter

![Graph: Efficiency vs. Output Current (Adc)]

- 300 kHz eGaN FET
- 500 kHz eGaN FET
- 300 kHz MOSFET
- 500 kHz MOSFET
Isolated Full Bridge Converter

Advantage:
• Isolation and high power density at high power

36~75 V

12 V
15 A
180 W
Isolated 1/8 Brick

Efficiency comparison @ 12 V_{OUT}

eGaN FET @ 333 kHz vs MOSFET @ 250 kHz
Isolated 1/8 Brick
EPC Product Plans
Beyond 600 Volts

EPC’s eGaN FET products will extend to 600V in 2011 and to 900V and 1200V in 2012 if there is adequate customer interest.
Beyond Discrete Devices

**Driver On Board**

Discrete FET with Driver

Full-Bridge with Driver and Level Shift
Conclusions

• Enhancement mode gallium nitride on silicon (eGaN®) technology opens up a new set of options for improving overall system efficiency.

• For each of the four most common topologies for low voltage power conversion, eGaN FETs demonstrated significant improvement in performance compared with the best power MOSFETs.

• In the future, eGaN technology will allow even higher power density and cost reductions through higher levels of integration.
The end of the road for Silicon ...

... is the beginning of the GaN journey!