

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



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

Stock Low-Beam



LED Low-Beam

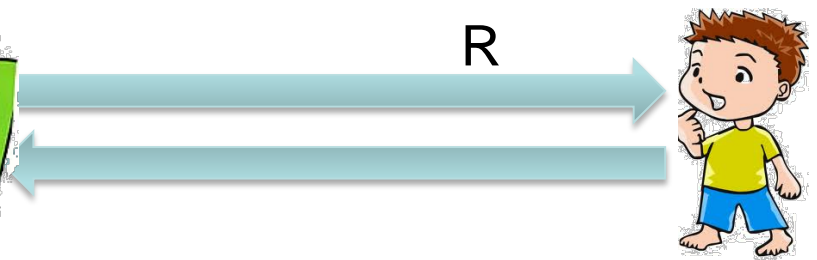


Why is GaN used in LiDAR?

$$R_{\text{MIN}} = (\Delta T_{\text{MIN(laser)}} \times C) / 2$$

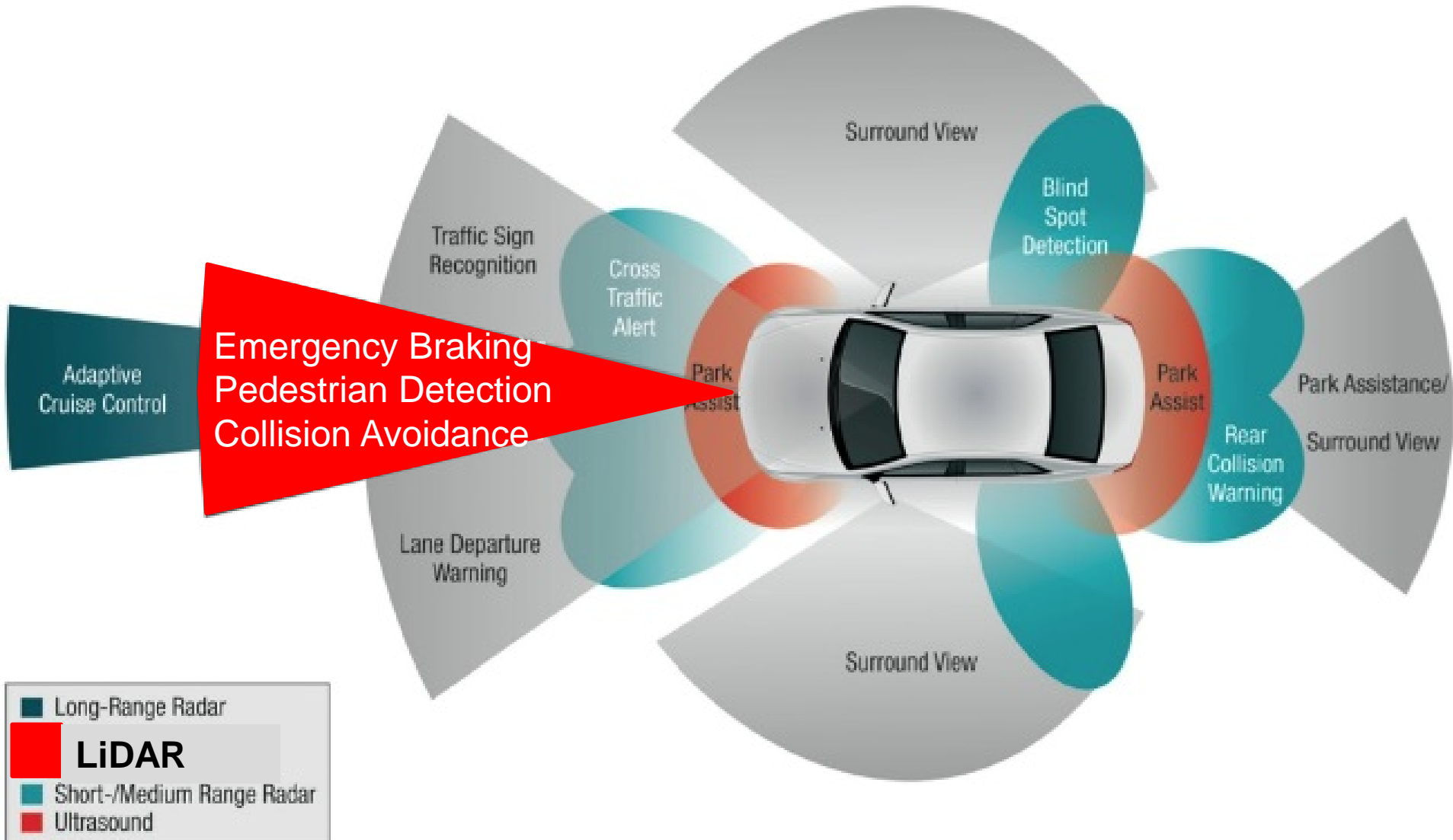
$$\Delta T_{\text{MIN(laser)}} = (T_{\text{RISE}} + T_{\text{FALL}})$$

$$(T_{\text{RISE}} + T_{\text{FALL}})_{\text{GaN}} = (T_{\text{RISE}} + T_{\text{FALL}})_{\text{Si}} / 10$$





LiDAR Sensors





Enhanced Vision





Autonomous Driving





Electric Drive – GaN or SiC?



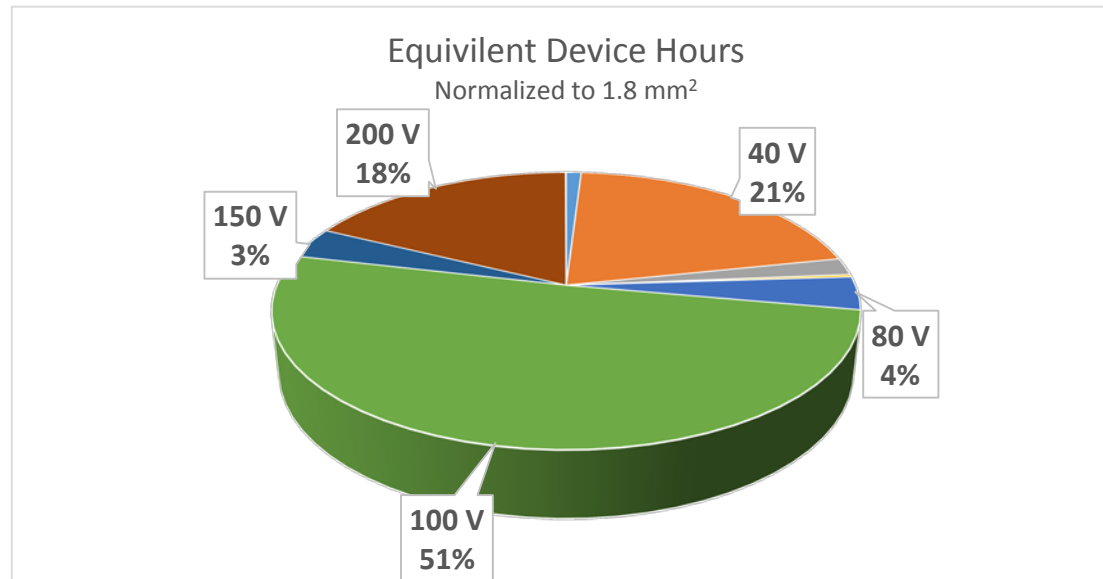
- Reliability
- Cost
- Bus Voltage Selection
- Integration Opportunities and Needs



Electric Drive – GaN or SiC?



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



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
- **Cost**
- Bus Voltage Selection
- Integration Opportunities and Needs



MOSFET vs. eGaN Costs*



| | 2014 | 2016 |
|-------------------|----------------|---------------|
| Starting Material | lower | lower |
| Epi Growth | <i>~higher</i> | <i>~same</i> |
| Wafer Fab | lower | lower |
| Test | same | same |
| Assembly | lower | lower |
| OVERALL | ~higher | lower! |

* Product with the same on resistance and voltage rating



MOSFET vs. eGaN Costs*



Active die $<3 \text{ mm}^2$

| | 2014 | 2016 |
|-------------------|---------------|---------------|
| Starting Material | lower | lower |
| Epi Growth | <i>~same</i> | <i>~same?</i> |
| Wafer Fab | lower | lower |
| Test | same | same |
| Assembly | lower | lower |
| OVERALL | <i>lower!</i> | <i>lower!</i> |

* Product with the same on resistance and voltage rating

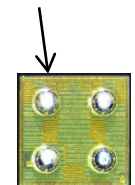


MOSFET vs. eGaN Costs



| | | | | | | | Price Comparison | | |
|----------|-----------------------|------------------------------|--|---|-----------------------------|----------------------|------------------|----------|----------|
| Device | V _{DS} (MAX) | R _{DS(on)} (max) | Q _{oss} (typ @50%B _V) | Q _{GD} (typ @50%B _V) | Q _G (typ @5V) | Device Area | 1Ku | 10Ku | 100Ku |
| EPC2035 | 60 V | 45 mΩ | 3 nC | 0.16 nC | 1.2 nC | 0.81 mm ² | \$ 0.360 | \$ 0.293 | \$ 0.230 |
| FDS5351 | 60 V | 42 mΩ | 7 nC | 3.5 nC | 19 nC | 31 mm ² | \$ 0.382 | \$ 0.313 | \$ 0.285 |
| EPC2036 | 100 V | 65 mΩ | 4 nC | 0.15 nC | 1 nC | 0.81 mm ² | \$ 0.376 | \$ 0.306 | \$ 0.240 |
| FDMS8622 | 100 V | 88 mΩ | 6.5 nC | 1.3 nC | 2.8 nC | 32.5 mm ² | \$ 0.396 | \$ 0.324 | \$ 0.295 |

0.9mm x 0.9 mm





Electric Drive – GaN or SiC?



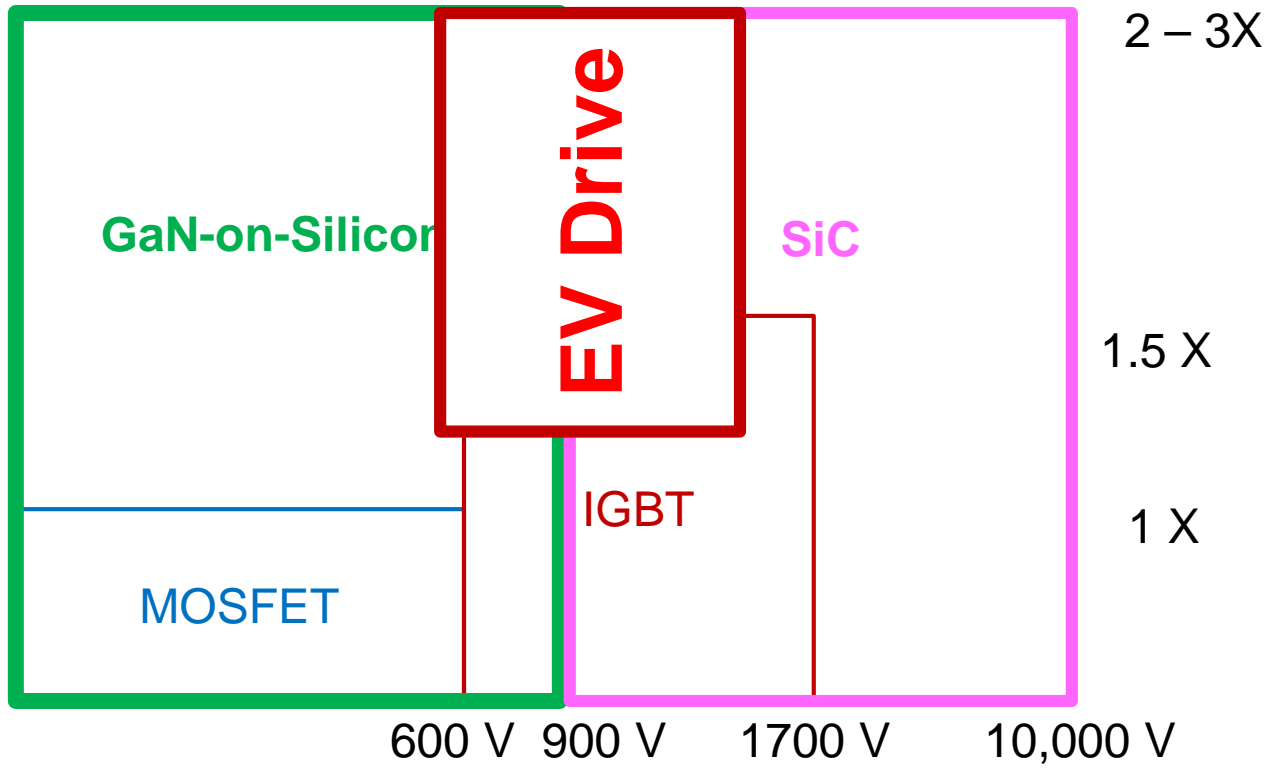
- Reliability
- Cost
- **Bus Voltage Selection**
- Integration Opportunities and Needs



Domain of Dominance



DC Current Capability x Rated Voltage





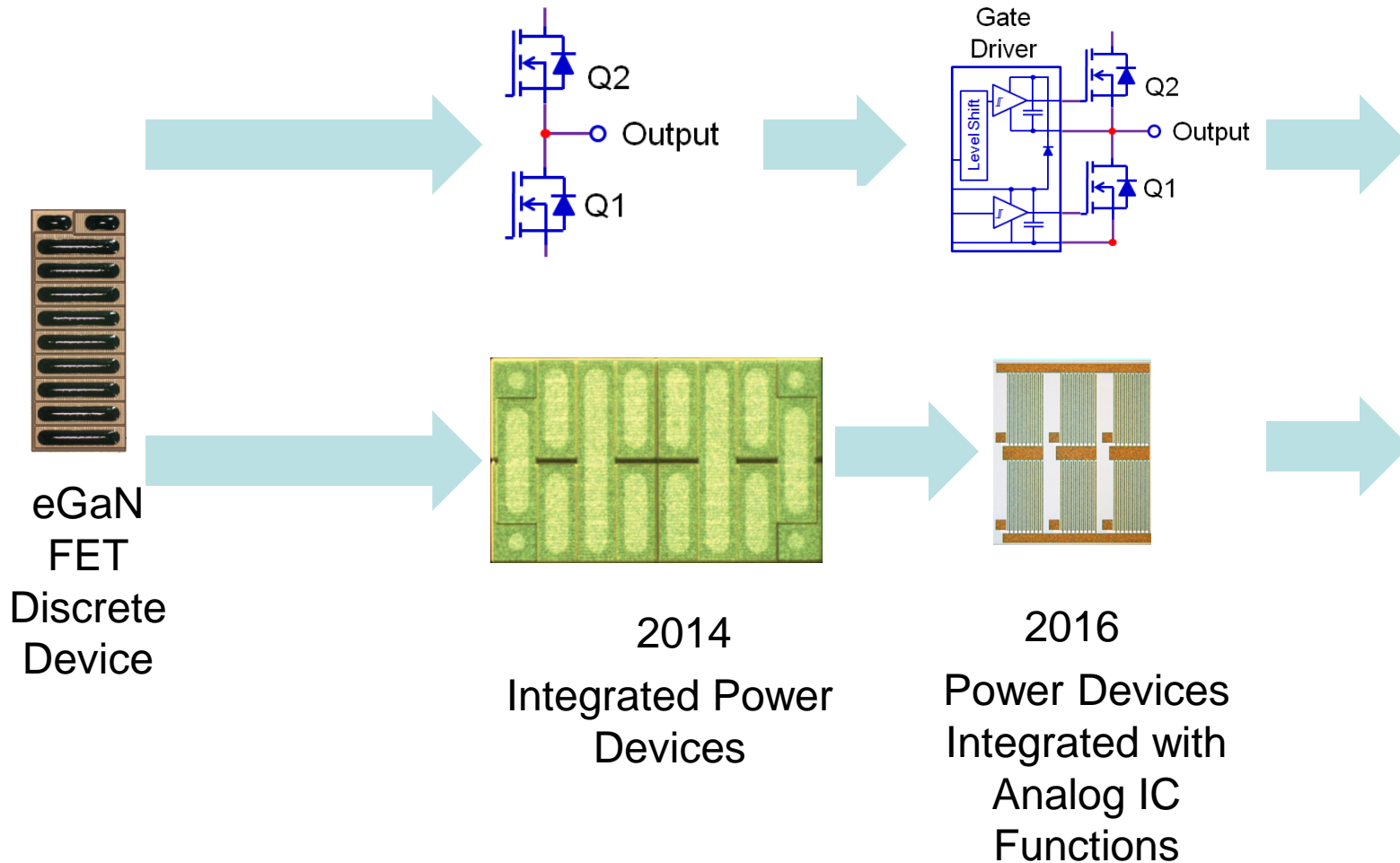
Electric Drive – GaN or SiC?



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



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.**

EPC

EFFICIENT POWER CONVERSION

Where is GaN going...

Thank You

