

# Darnell Energy Summit 2015

The eGaN<sup>®</sup> FET  
Journey Continues

**The GaN Effect – How GaN is Changing the  
Way We Live**

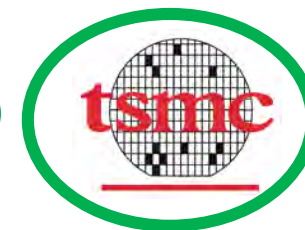
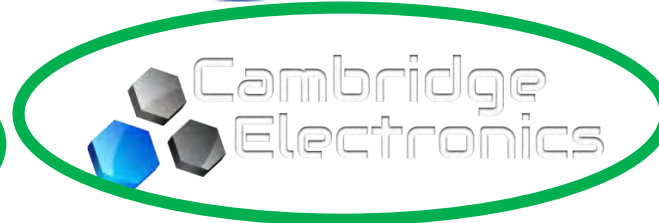
*Alex Lidow*

*Efficient Power Conversion Corporation*

- **Status of GaN Market**
- **Status of GaN Technology**
- **How is GaN Changing the Way We Live?**

# GaN is Growing

## Enhancement Mode Normally Off



## Depletion Mode Normally On



# MOSFET vs. eGaN Costs\*



	2010	2015
Starting Material	lower	lower
Epi Growth	<i>~higher</i>	<i>~same?</i>
Wafer Fab	lower	lower
Test	same	same
Assembly	lower	lower
<b>OVERALL</b>	<i>~higher</i>	<i>lower!</i>

\* Product with the same on resistance and voltage rating

# MOSFET vs. eGaN Costs\*



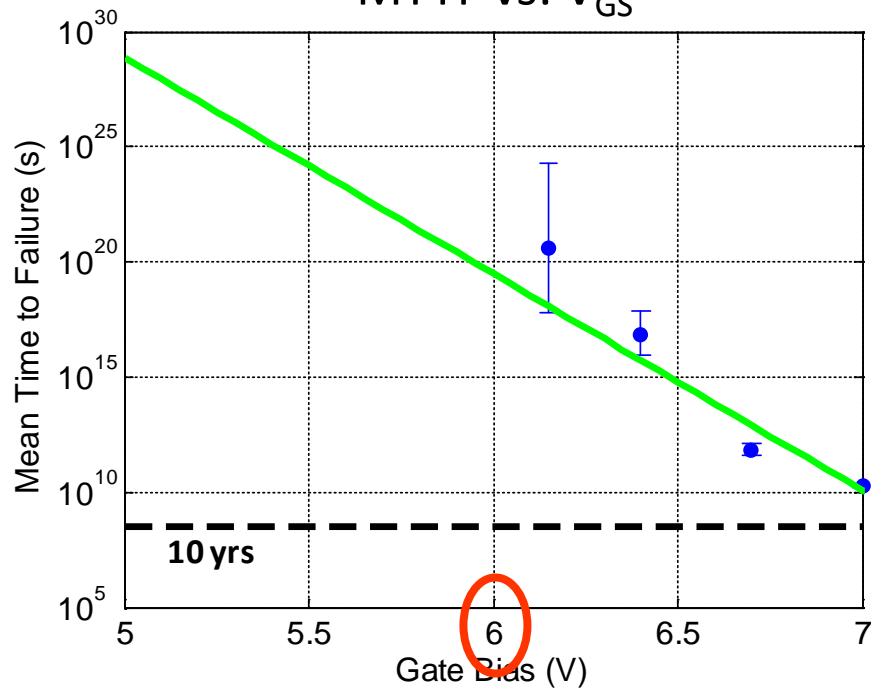
Active die  $<3 \text{ mm}^2$

	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>

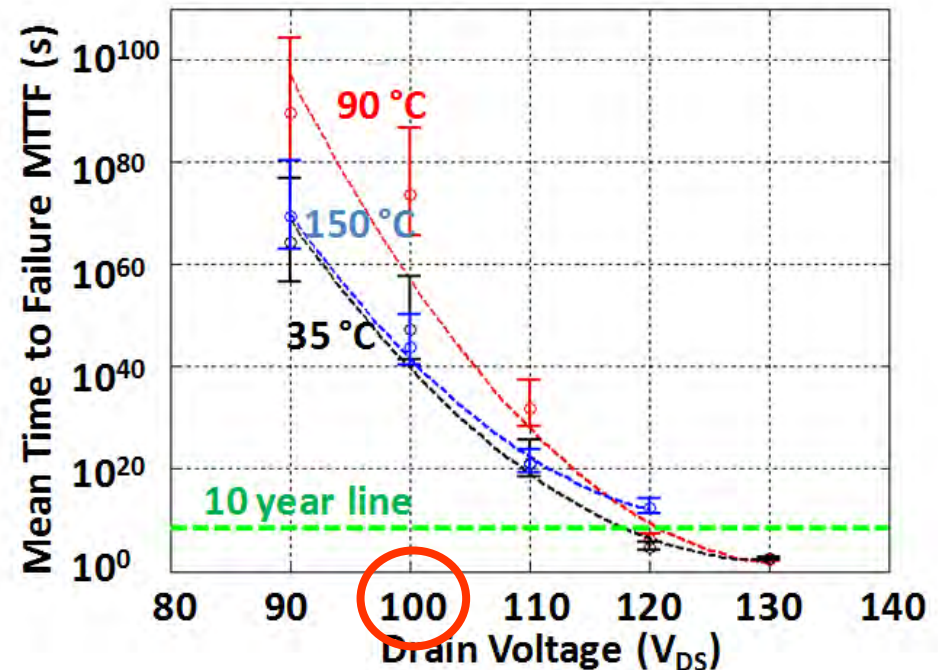
\* Product with the same on resistance and voltage rating

# GaN Reliability is Excellent

### MTTF vs. $V_{GS}$

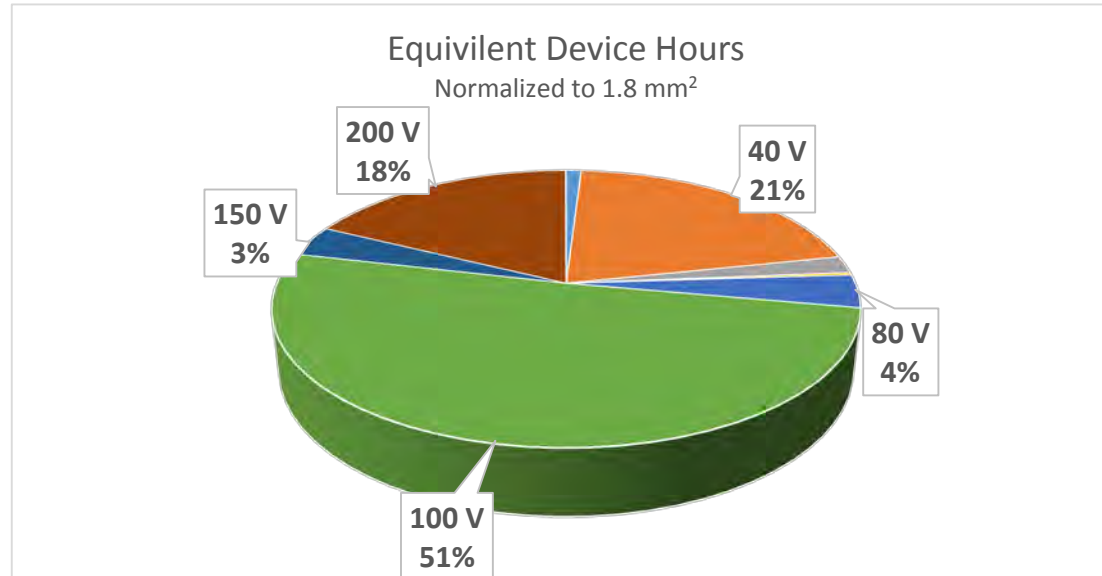


### MTTF vs. $V_{DS}$ and Temperature



Alex Lidow and Rob Strittmatter, "Enhancement Mode Gallium Nitride Transistor Reliability", IEEE First International Conference On DC Microgrids (ICDCM) 2015

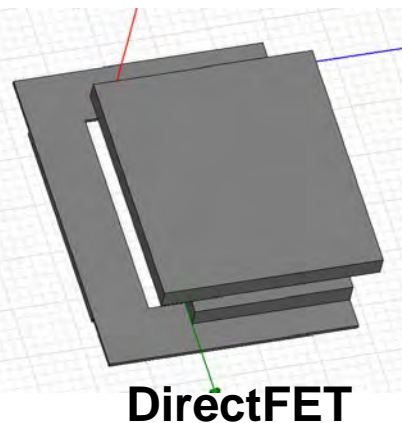
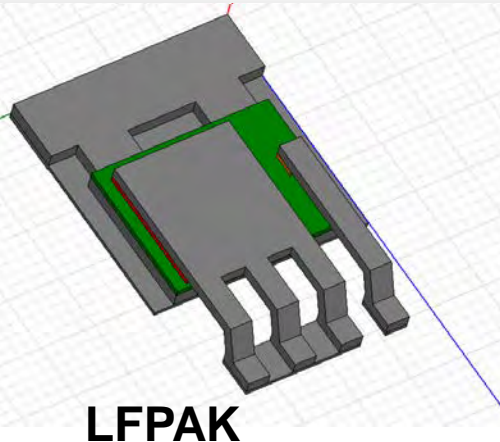
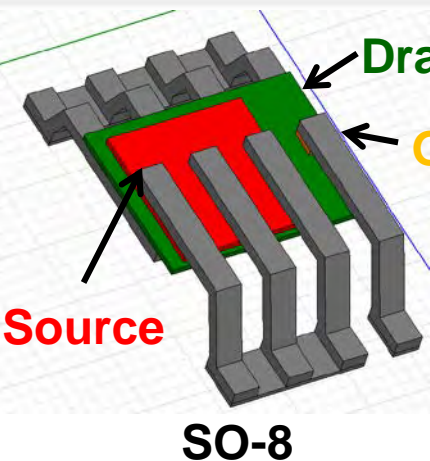
# GaN Field Reliability



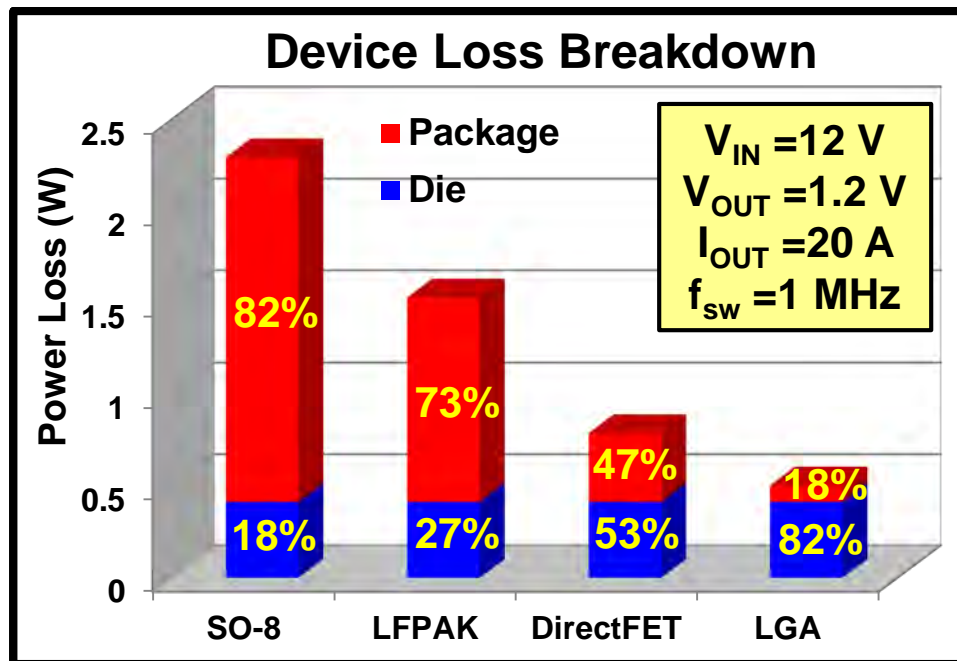
## 10B total device hours

- 73 Field Returns (17 Good, 55 Failed)
  - 16 Layout Related
  - 37 Assembly Related
  - 1 Physical Abuse
  - 1 Device degradation (addressed in Gen 4)
- 1 Failure in 10B Hours equals 0.1 FIT

# Chipscale Packaging Sets the Benchmark

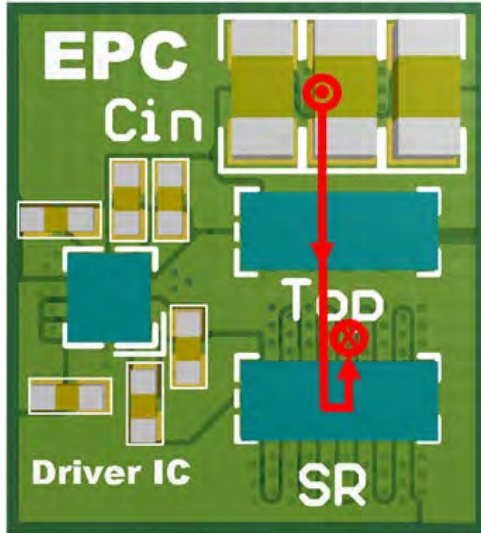


**LGA eGaN FET**

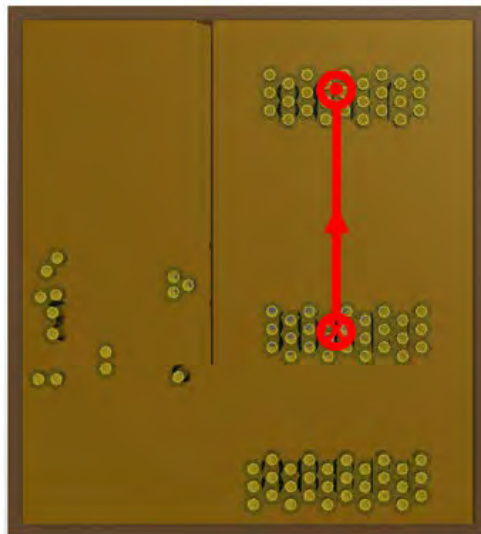




# Optimal Layout is Important

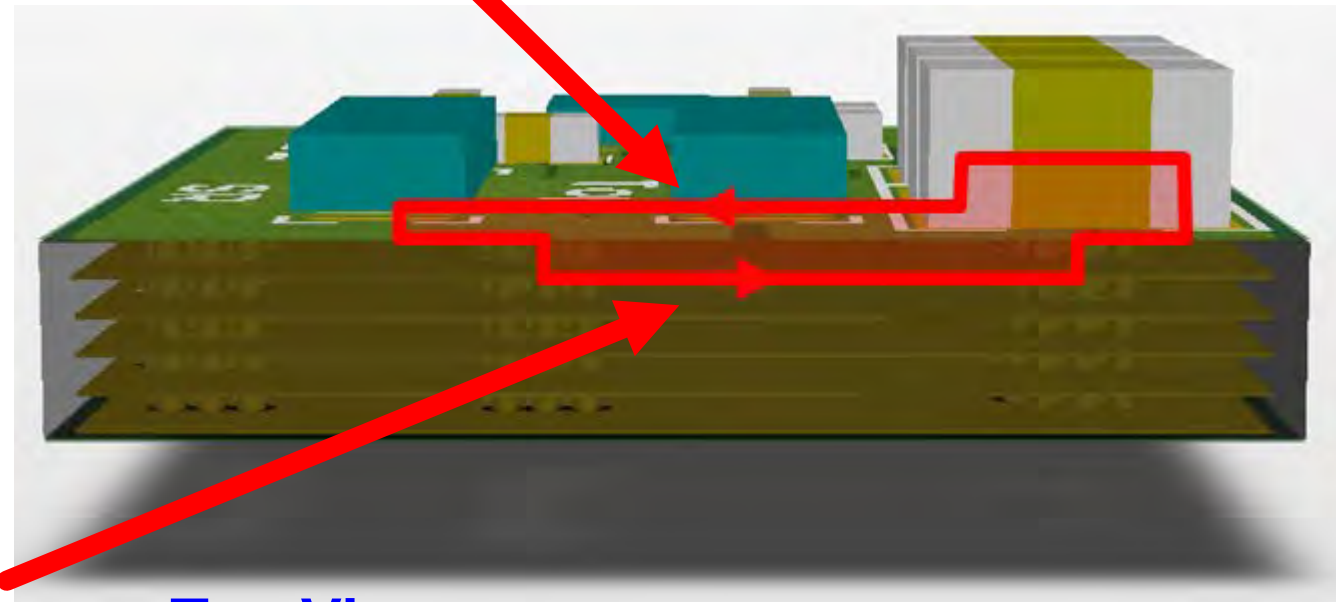


**Top View**



**Top View  
Inner Layer 1**

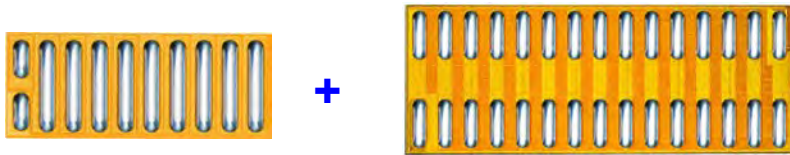
**Side View**



D. Reusch and J. Strydom, "Understanding the Effect of PCB Layout on Circuit Performance in a High Frequency Gallium Nitride Based Point of Load Converter," Applied Power Electronics Conference and Exposition (APEC), pp.649-655, 2013

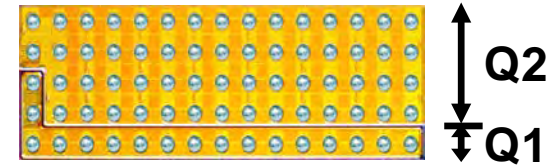
# GaN Integration Takes it to the Next Level

## Generation 2/4 Discrete HB

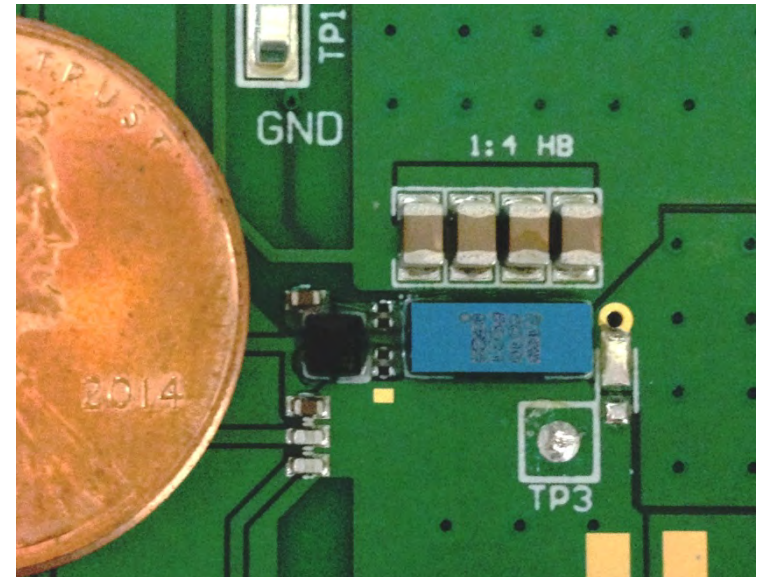
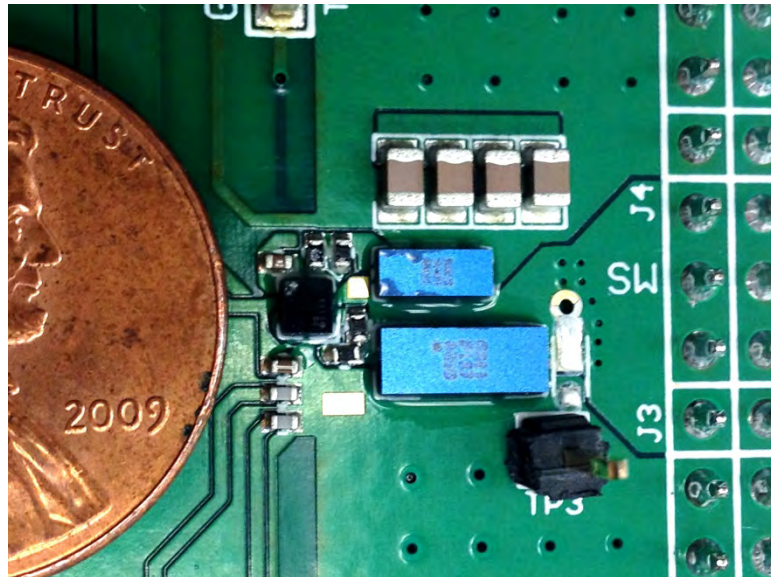


Top Switch (Q1)    Bottom Switch (Q2)

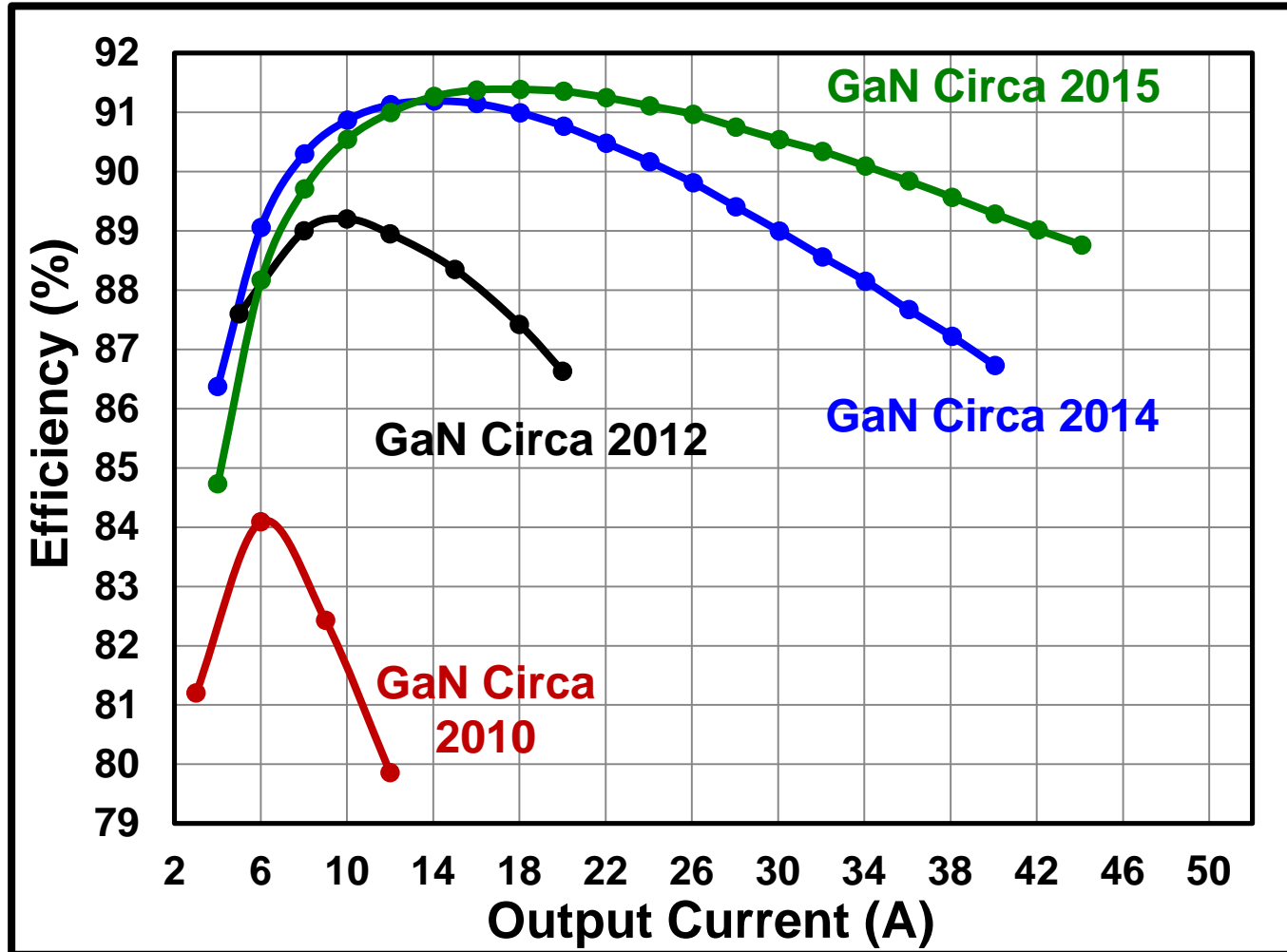
## Generation 4 Monolithic 1:4 HB



33 % die size reduction

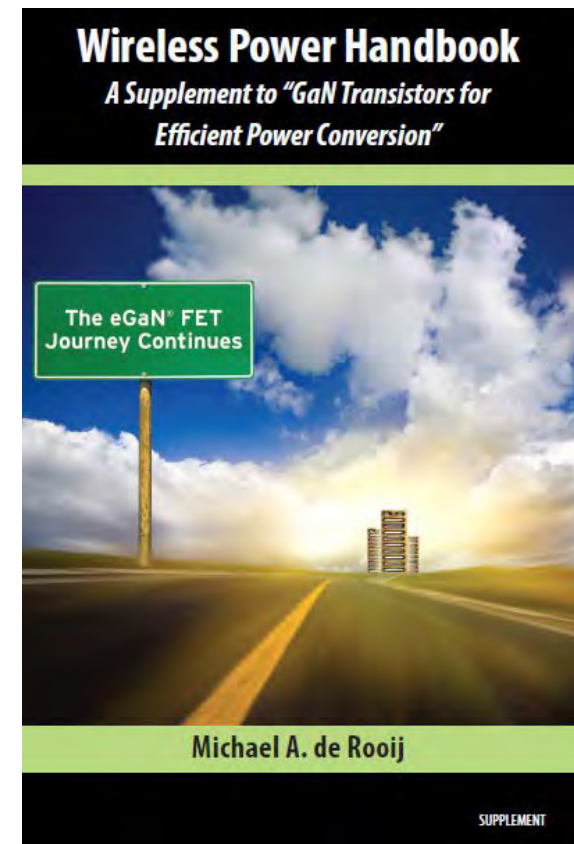
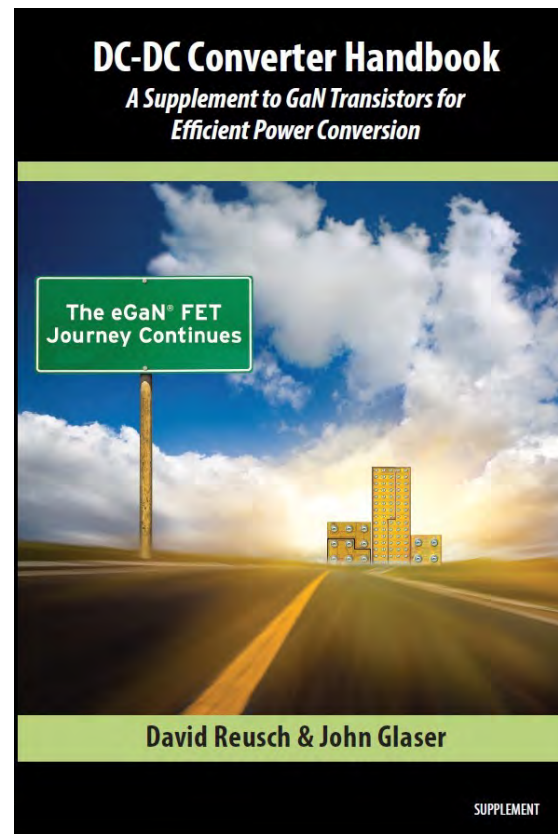
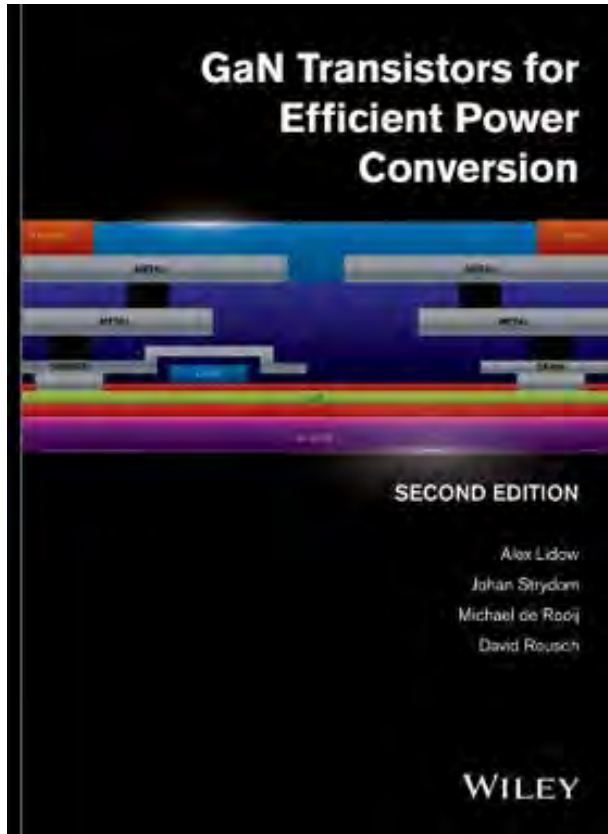


# GaN is On a Steep Learning Curve

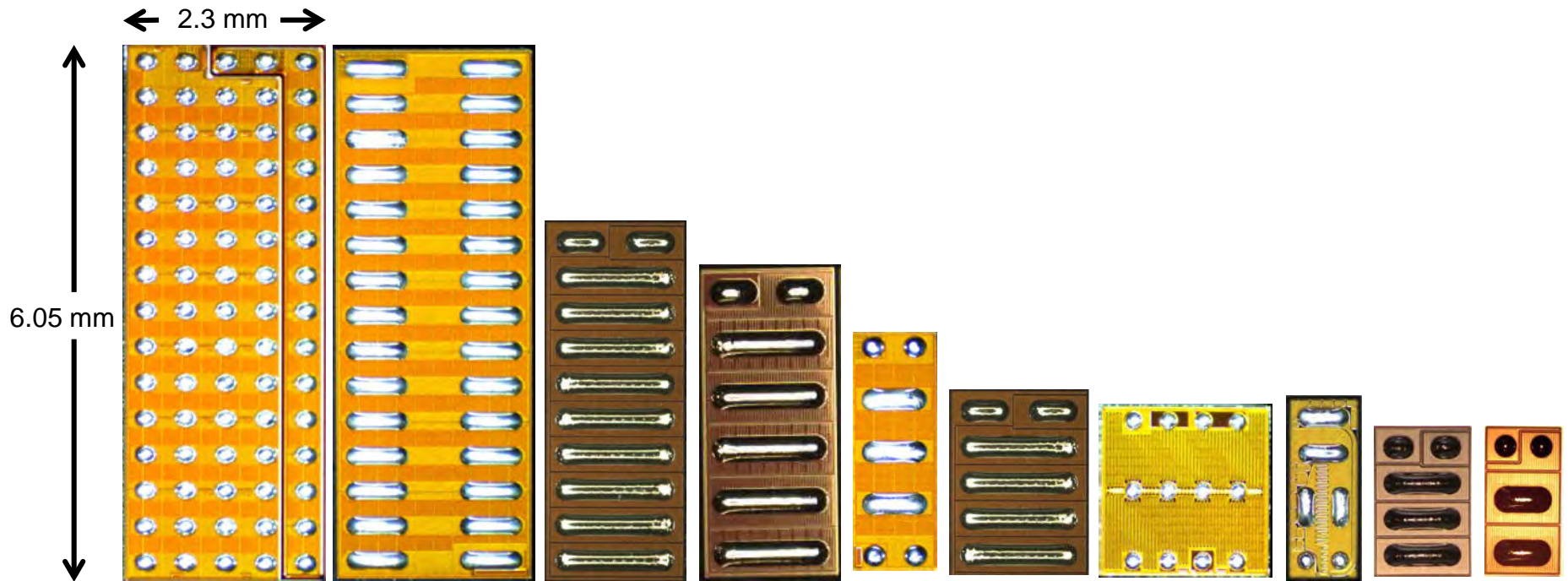


$V_{IN}=12\text{ V}$   $V_{OUT}=1.2\text{ V}$   $f_{sw}=1\text{ MHz}$

# The Learning Curve is Being Communicated



# eGaN<sup>®</sup> FET Product Line is Expanding



- BGA or LGA Package
- Extremely small PCB footprint
- Minimal inductance and resistance
- RoHS and MSL 1



# How is GaN Changing the Way We Live?

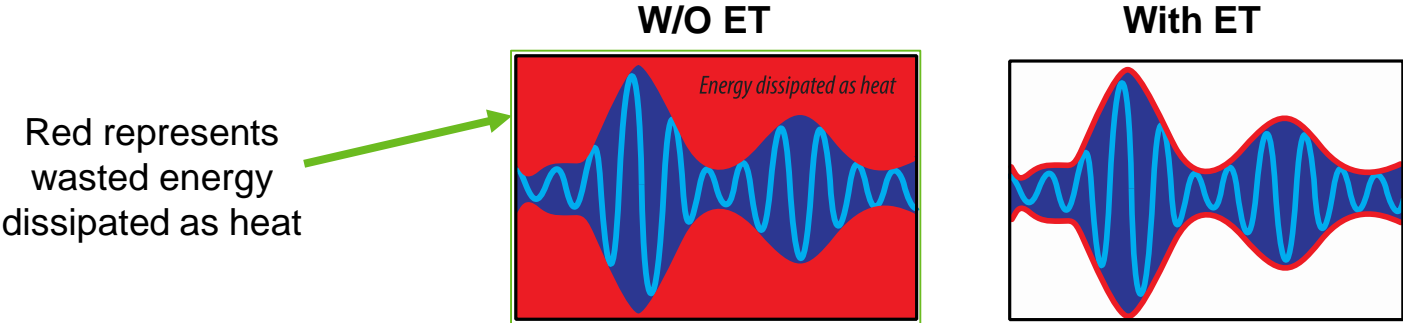
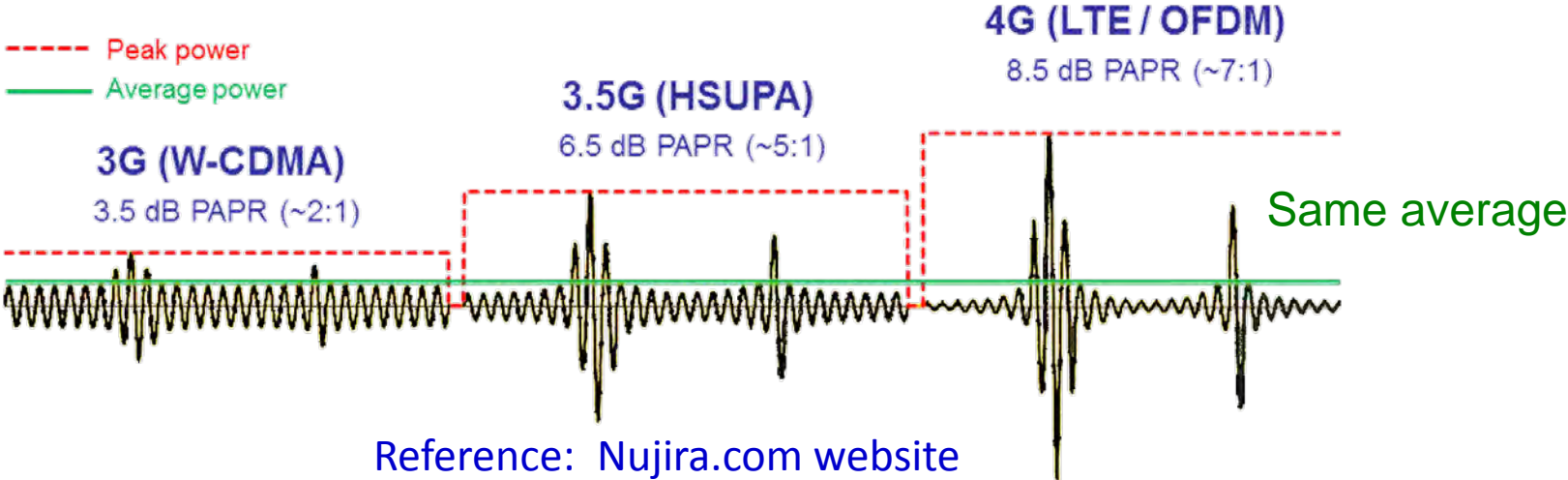
## Designer

- **Less Resistance**
- **Faster**
- **Smaller**
- **Cheap/Reliable**
- **Easy to Use**
- **Enabler of New Applications**

## Consumer

- **More Bandwidth**
- **No Power Cords**
- **Improved Health**
- **Augmented Reality**
- **Autonomous Cars**
- **Improved Energy Efficiency**

# Enabling More Wireless Bandwidth

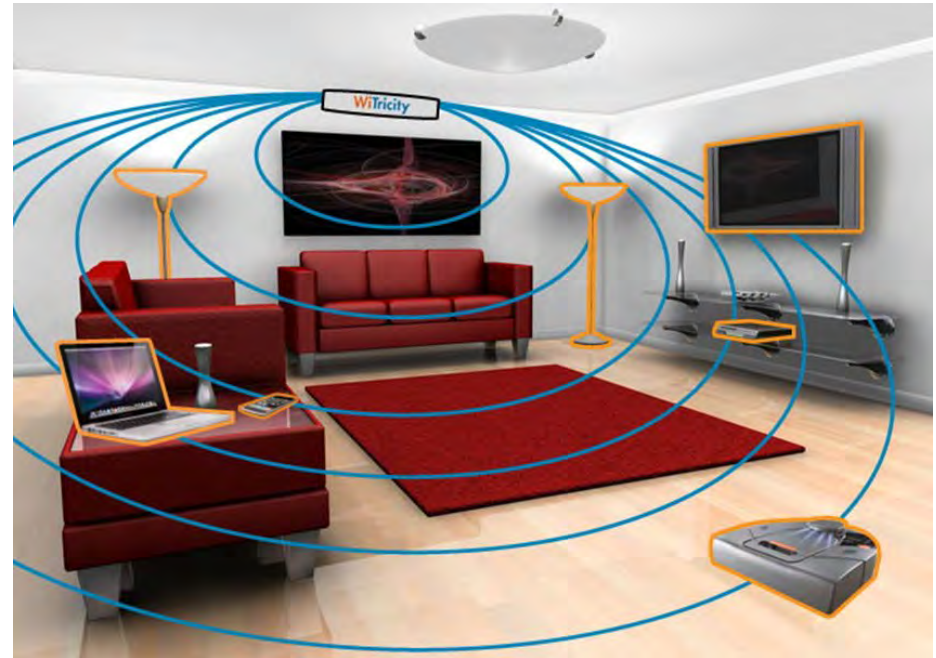




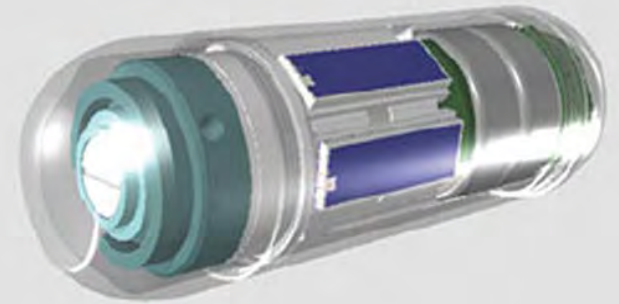
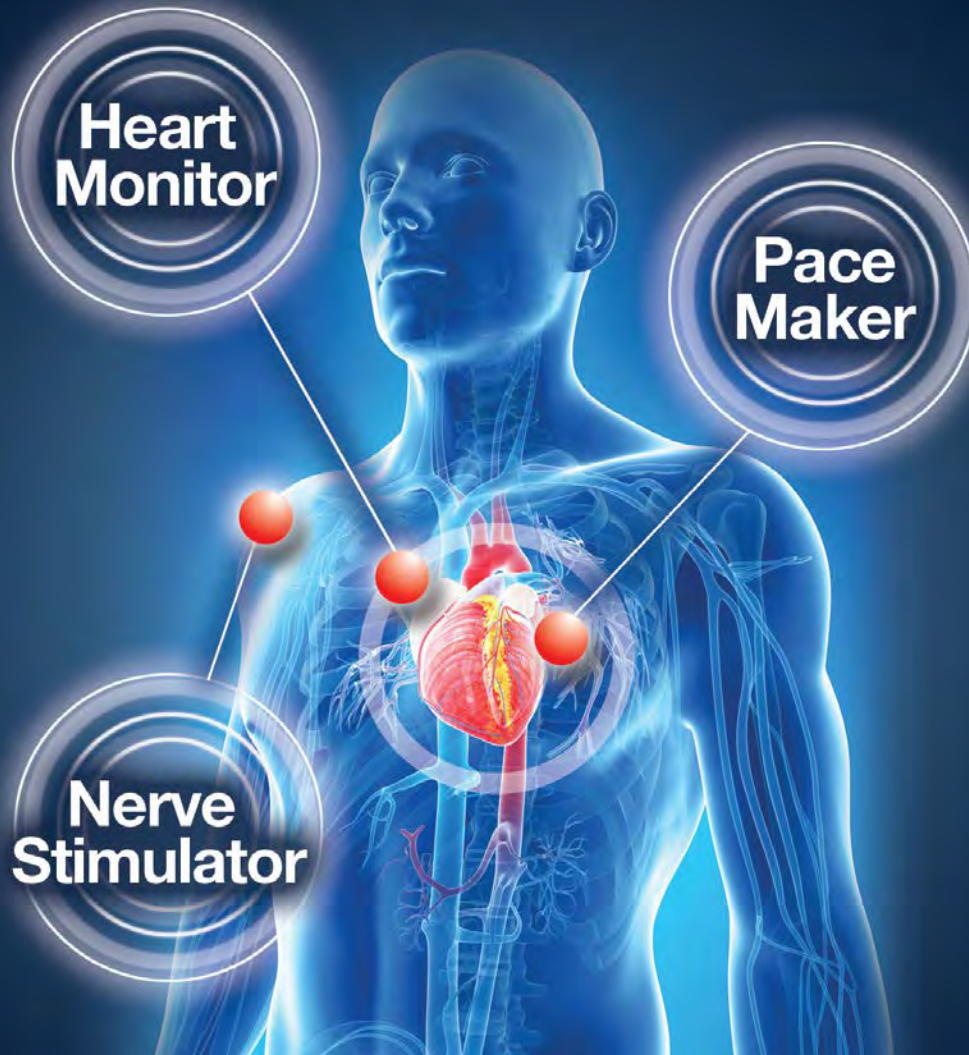
# Bringing the Internet to the World



# Untethering the Consumer



# Improved Medical Care



# LiDAR



# Higher Energy Efficiency



- **GaN is rapidly improving**
- **GaN transistors are replacing silicon power MOSFETs and LDMOS**
- **GaN is Changing the Way We Live!**

# Powering Innovation at the Speed of GaN

