

# Update on GaN and SiC Activities Within JEDEC JC-70 Committee

Jeffrey Casady, Wolfspeed, JEDEC JC-70.2 Chair

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***With contributions from:***

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APEC 2019, Anaheim, CA

# Outline

- Motivation (enabling market growth)
- History & Structure
- GaN Results & Status
- SiC Results & Status
- How to Become Involved with JEDEC



# Market: WBG market to grow to \$1.8B by 2023

## SiC power market

- **SiC power** semiconductor market is ~ **\$1.4B by 2023** with a compound annual growth rate (CAGR) of **29%**

- Source: <https://www.i-micronews.com/report/product/power-sic-2018-materials-devices-and-applications.html>

## GaN power market

- **GaN power** business projected to reach ~ **\$423M by 2023**, with a compound annual growth rate (CAGR) of **93%**

- Source: <https://www.i-micronews.com/report/product/power-gan-2018-epitaxy-devices-applications-and-technology-trends.html>

# Purpose of Standards

- Enabling Market Growth
- Ramp Maturity of the Industry
- Accelerate industry-wide adoption by creating consistency across the supplier base
- Consistency that is important to the user

# Journey leading to JEDEC JC-70

- APEC 2016: Gauge Interest Meeting held which resulted in launching GaNSPEC DWG (JEDEC participated)
  - See “Standardization for Wide Bandgap Devices: GaNSPEC DWG,” Stephanie Watts Butler, APEC 2017
- At WiPDA 2016: With assistance from GaNSPEC, SiCSPEC DWG launched
  - See “Status of Wide Bandgap Device Qualification Standards Effort by New JEDEC Committee JC70,” Stephanie Watts Butler and Tim McDonald, APEC 2018
- At WiPDA 2017: First JEDEC JC-70 Meeting Held
  - See “Status of Wide Bandgap Device Qualification Standards Effort by New JEDEC Committee JC70,” Stephanie Watts Butler and Tim McDonald, APEC 2018

# JC-70 created October 2017

## (Committee for Wide Bandgap Power Electronic Conversion Semiconductors)



*Global Standards for the Microelectronics Industry*

- Products
  - discrete devices and integrated circuits; wide bandgap and ultra wide bandgap
  - power conversion circuits regardless of device type, polarity, mode of operation, packaging, electrical ratings, and end applications.
- RF/microwave amplification and signal conditioning applications generally not covered
- Industry standards concerned with
  - reliability verification and qualification procedures,
  - test methods and measurement techniques,
  - data sheet elements and device specifications,
  - unique packaging considerations
  - cataloging and consideration of mission profiles
  - formulation of terms, definitions, and symbols

# Membership JC-70

- Began with 23 member companies, now over 50
  - US, Europe, Middle East, and Asia
  - Global multinational corporations & technology startups
  - Power GaN and SiC semiconductor manufacturers, users of wide bandgap power devices, test and measurement equipment suppliers.
- 2 subcommittees:
  - JC-70.1 covers GaN
  - JC-70.2 covers SiC
- Each subcommittee has task groups
  - Comprised of industry experts
  - Technical experts from universities and national labs also contribute

# JC-70 Member List

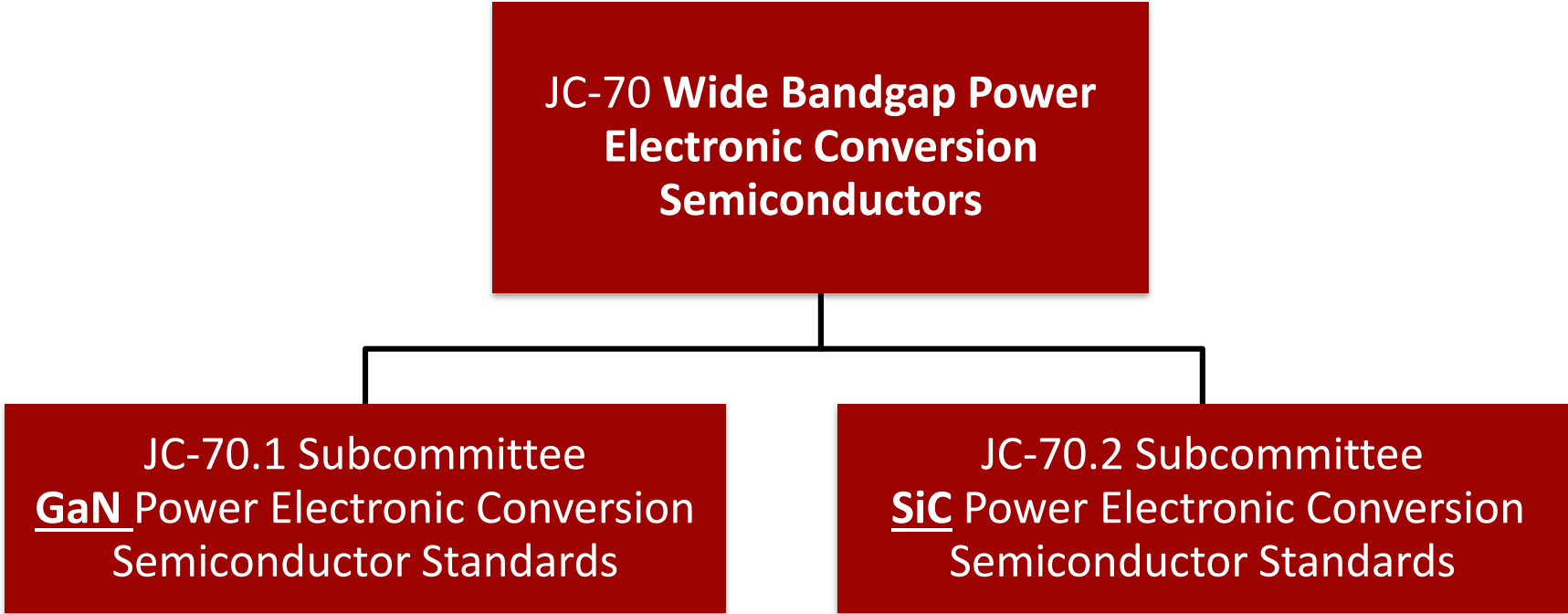
ABB  
Accel RF Instruments Corporation  
Alpha and Omega Semiconductor, Inc  
Analog Devices Inc.  
ChangXin Memory Technologies Inc.  
Dell Inc.  
Efficient Power Conversion Corp  
ExaGan  
Freebird Semiconductor Corporation  
GaN Systems  
GaN Ventures Semiconductor  
Hewlett Packard Enterprise Co  
Hirex Engineering  
Huawei Technologies Co. Ltd.  
Infineon  
Innoscience Technology Co., Ltd  
Intel  
John Deere Electronic Solutions  
Keysight Technologies Inc  
Lenovo  
Littelfuse  
M/A-COM Technology Solutions  
Mentor, a Siemens Company  
Micron Technology Inc  
Microchip Technology Inc.  
Navitas Semiconductor

Nexgen Power Systems  
Northrop Grumman Corporation  
NSWC Crane  
NXP Semiconductors  
ON Semiconductor  
Panasonic Corporation  
Power Integrations  
Renesas  
Rohde & Schwarz GmbH & Co KG  
Rohm Semiconductor  
Silicon Works  
STAr-Edge Technologies, Inc.  
STMicroelectronics  
Sumitomo Electric Industries  
Taiwan Semiconductor Mfg Company  
Tektronix  
Texas Instruments Inc  
The Boeing Company  
Transphorm  
U.S. Army AMRDEC  
Vishay Corporation  
VisIC Technologies  
Wolfspeed, a Cree Company  
Xi'an Semipower Electronic Technology  
Xiamen Sanan Integrated Circuit Co  
Yangtze Memory Technologies Co., Ltd

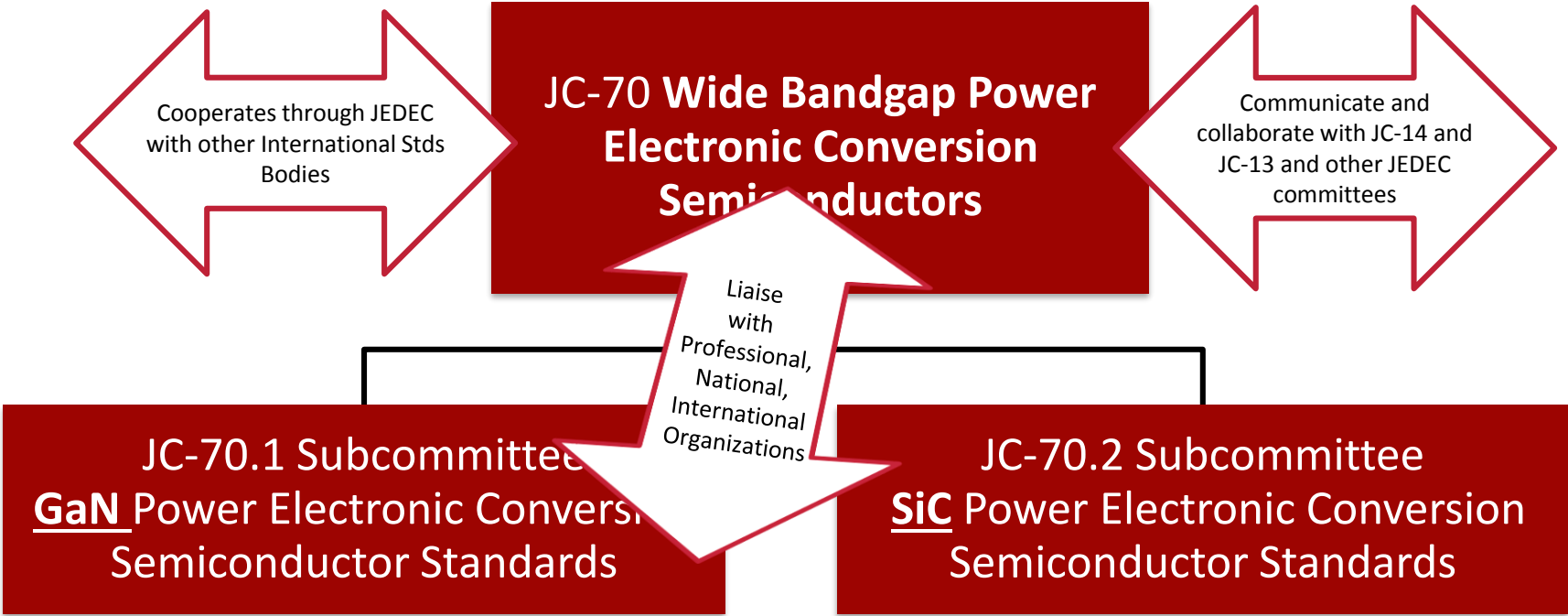
52....and growing!



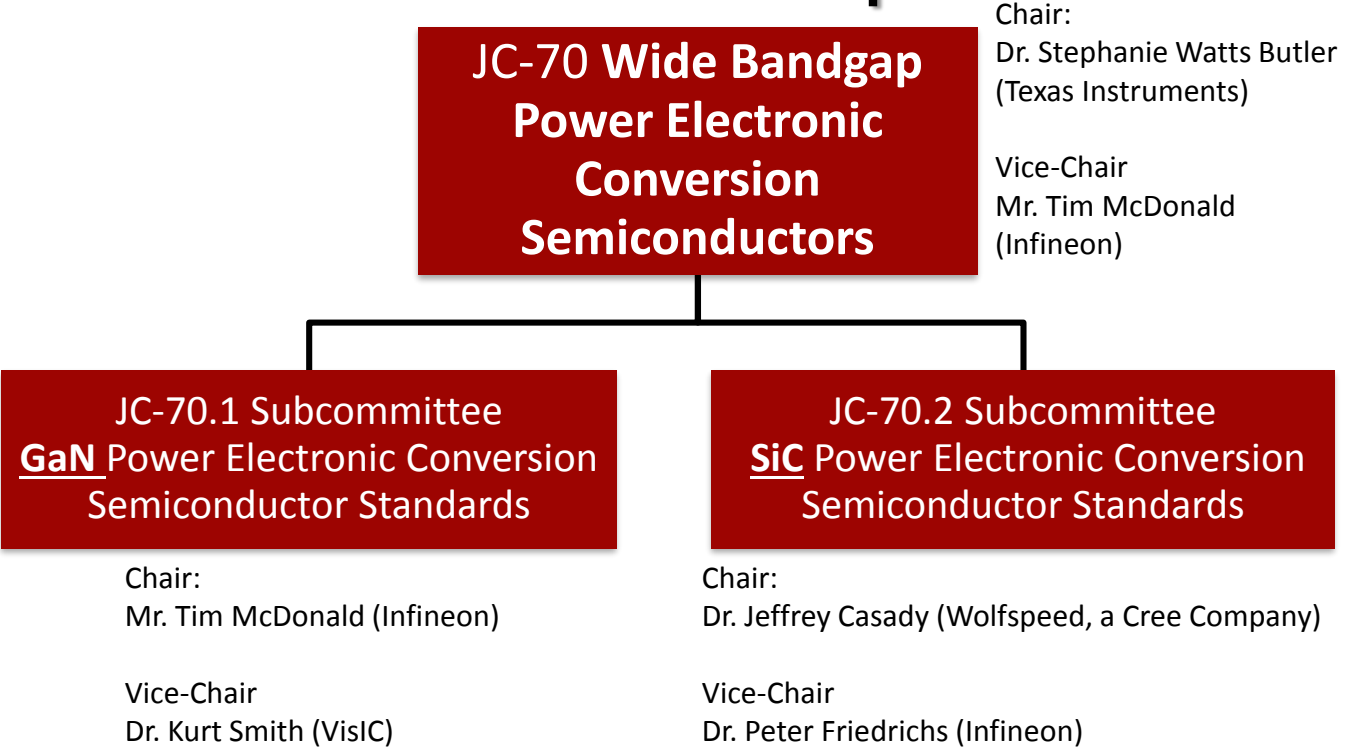
# JC-70 Structure: Wide Bandgap (GaN & SiC)



# JC-70 Structure: interaction and relationships



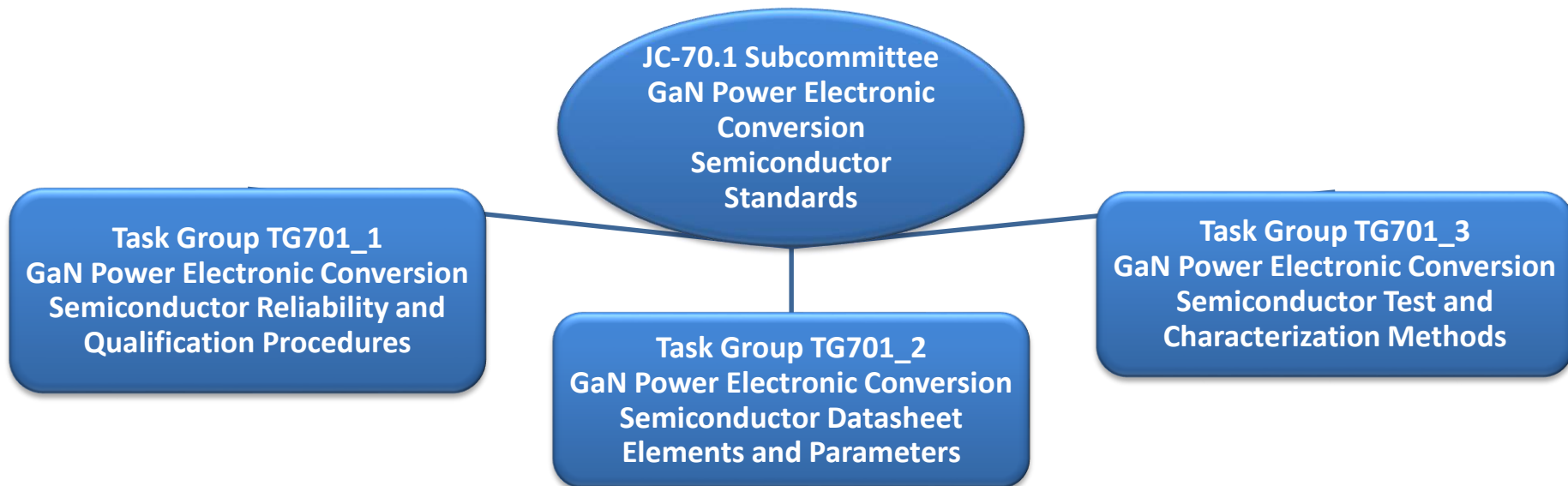
# JC-70 Structure: Leadership



# HOW JEDEC Committee JC-70.1 structure (GaN)



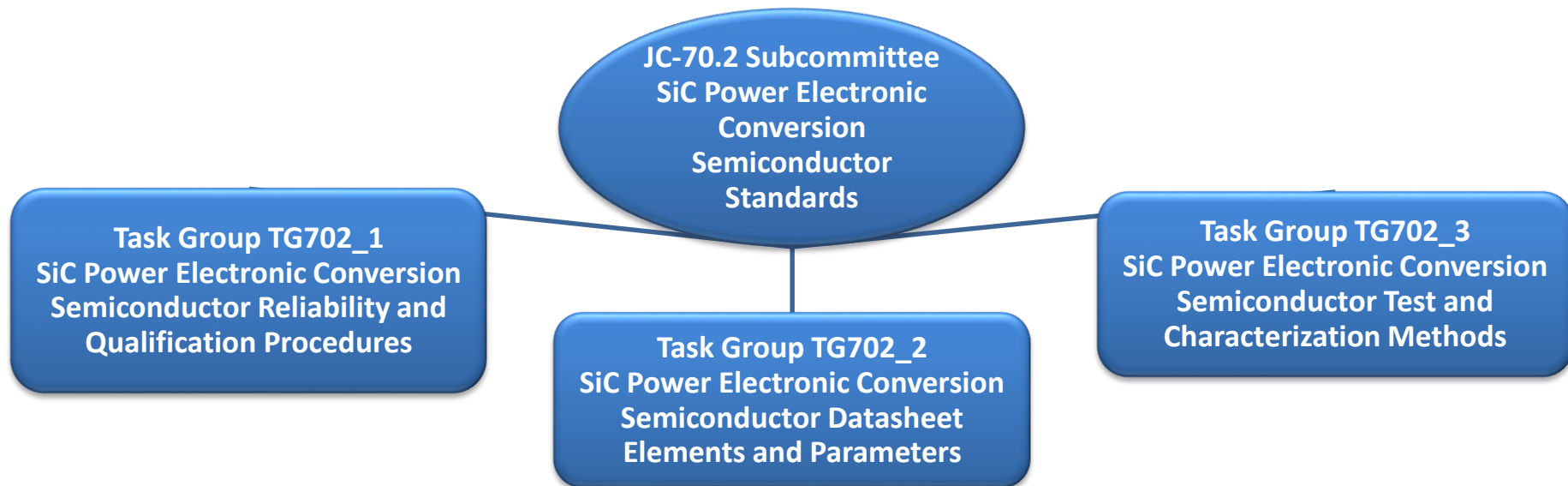
*Global Standards for the Microelectronics Industry*



# HOW JEDEC Committee JC-70.2 structure (SiC)



*Global Standards for the Microelectronics Industry*



# Results & Status for GaN JC-70.1

# First Guideline Published January 16, 2019

- **JEP173: Dynamic On-Resistance Test Method Guidelines for GaN HEMT Based Power Conversion Devices**
  - <https://www.jedec.org/standards-documents/docs/jep173>
- **Address key need of user community:**
  - Method for measurement of Drain-to-Source Resistance in the ON-state ( $RDS_{(ON)}$ ) encompassing dynamic effects
- **Dynamic effects are characteristic of GaN power FETs**
  - The value of the resulting measured  $RDS_{(ON)}$  is method dependent
- **Help accelerate industry-wide adoption of GaN by ensuring consistency across the supplier base**

# Proposed Items for GaN Guidelines/Standards

Presented at  
**APEC 2018**

## REL

- List of Failure Mechanisms & Resulting Failure Mode
- Focusing on Charge Trapping, Charge Injection, Hot Electron, ~~Corrosion~~, TDDB Like Mechanism, ~~Delam~~
- Corresponding Acceleration & Stress Procedure

## Test

- Dynamic  $R_{DS}(ON)$
- ~~Thermal Resistance (only for cascodes)~~
- Safe Operating Area (SOA)

Caution: Work in Progress

## Datasheet

- Include effect of Dynamic  $R_{DS}(ON)$
- Nomenclature of parameters to adjust for uniqueness of GaN power transistors
- Transistor circuit symbol to reflect distinctive operation GaN HEMTs



# Proposed Items for GaN Guidelines/Standards

## REL

- List of Failure Mechanisms & Resulting Failure Mode (summarizing Literature)
- Offstate voltage/temperature Reliability
- Switching Reliability
- Stress Procedures & Acceleration
- List of Failure Mechanisms & Resulting Failure Mode

## Test

- ✓ **Dynamic  $R_{DS}(ON)$**
- Switching reliability test methods

## Datasheet

- Include effect of Dynamic  $R_{DS}(ON)$
- GaN power transistors specific voltage ratings
- Transistor circuit symbol to reflect distinctive operation GaN HEMTs

• Transient Voltage Aspects

Caution: Work in Progress

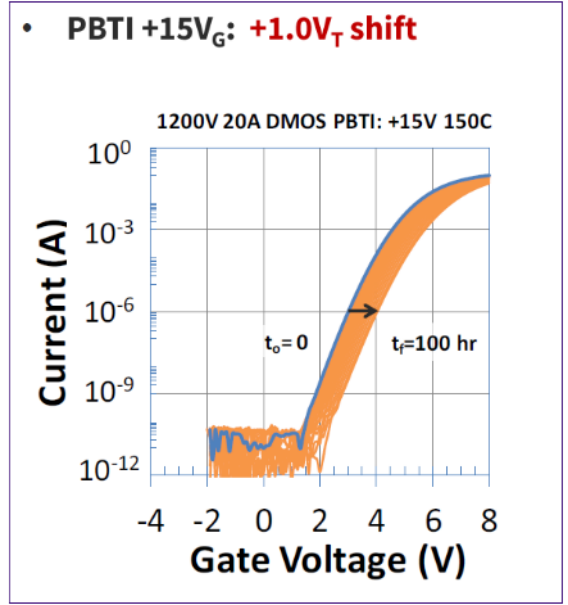
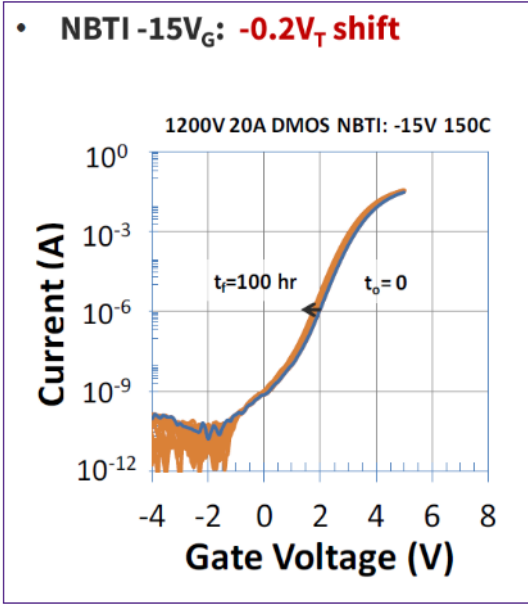
# Results & Status for SiC JC-70.2

## Example topic

SiC  $V_{TH}$  stability

# SiC MOSFET $V_{TH}$ influenced by temperature and bias

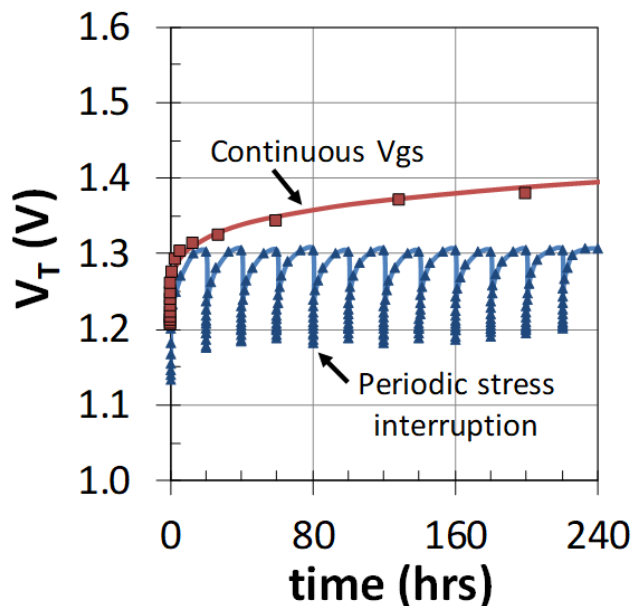
- Negative Bias Temperature Instability (NBTI) shown as example at -15V, 150°C
- Positive Bias Temperature Instability (PBTI) shown as example at +15V, 150°C
- How is this shift measured, qualified, standardized?



D. Lichtenwalner, et al, "Electrical Properties & Interface Structure of SiC MOSFETs with Barium Interface Passivation," 11<sup>th</sup> European Conf. on SiC & Related Materials, Sept. 2016, Greece.

# Silicon Carbide threshold voltage

## Test methods influence results



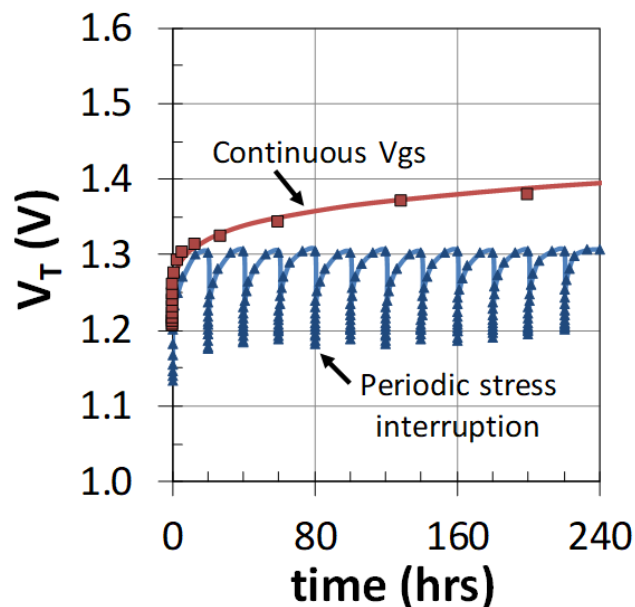
S. Sabri, et al, "SiC Power Device Reliability Studies," 13<sup>th</sup> Annual SiC MOS Workshop, Aug. 2018, University of Maryland, USA.

## JC-70.2 Task Group scope evaluation

- Industry standards concerned with
  - reliability verification and qualification procedures,
  - test methods and measurement techniques
  - data sheet elements and device specifications
  - unique packaging considerations
  - cataloging and consideration of mission profiles
  - formulation of terms, definitions, and symbols

# Silicon Carbide threshold voltage

## Test methods influence results



## JC-70.2 Task Group (TG) evaluations

- Does it affect datasheet?
- Does it affect reliability?
- Does it influence common measurements by all suppliers?
- Are new guidelines or standards needed?

S. Sabri, et al, "SiC Power Device Reliability Studies," 13<sup>th</sup> Annual SiC MOS Workshop, Aug. 2018, University of Maryland, USA.

# Proposed Items focus for SiC Guidelines/Standards

## REL

- BTI
- ALT-HTRB
  - GaN collaboration?
- Body Diode
- neutron radiation
- TDDDB
- Corresponding Acceleration & Stress Procedure
- dV/dt
  - Perhaps most difficult to address
- List of Failure Mechanisms & Resulting Failure Mode

## Test

- Vth measurement
- Qg Measurement
- Short-circuit measurement

## Datasheet

- TBD

Caution: Work in Progress

# Acknowledgments

- JEDEC Staff
- Mikhail Guz, JEDEC Secretary to JC-70, Consultant, IP and Technology Experts
- JC-70.1 Task Group Leaders

## TG701\_1 (REL) Co-Chairs:

- Sameh Khalil (Infineon)
- Mark Wasilewski (ON)
- Sandeep Bahl (TI)
- Kurt Smith (VisIC)

## TG701\_2 (Datasheet) Co-Chairs

- Peter Di Maso (GaNSystems)
- Nick Fichtenbaum (Navitas)

## TG701\_3 (Test) Co-Chairs:

- Deepak Veerreddy (Infineon)
- Jaume Roig (ON)

- JC-70.2 Task Group Leaders

## TG702\_1 (REL) Co-Chairs:

- Don Gajewski (Wolfspeed)

## TG702\_2 (Datasheet) Co-Chairs

- Christian Mueller (Infineon)
- Mehrdad Baghaie Yazdi (ON)

## TG702\_3 (Test) Co-Chairs:

- Thomas Basler (Infineon)
- Ryo Takeda (Keysight)

- Entire Membership of JC-70, JC-70.1, and JC-70.2 and their Task Groups
- The University and National Lab Community





# How to Join

- Interested companies worldwide are welcome to join JEDEC to participate in this important standardization effort.
- Find more information about membership
  - <https://www.jedec.org/join-jedec>
- or contact [Emily Desjardins](#) to learn more
  - [emilyd@jedec.org](mailto:emilyd@jedec.org)

# Key Takeaways



- First guideline issued
- Impact of being early in technology lifecycle
- SiC Guidelines & Standards progressing
- SiC & GaN Topics can be same AND different
- How to participate

<https://www.jedec.org/join-jedec>

*Thank  
You*