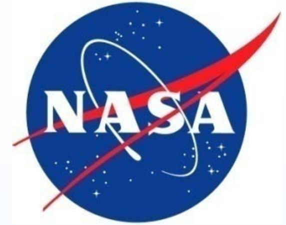
NEPP Electronic Technology Workshop 2012

National Aeronautics and Space Administration



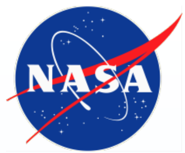

# Recent Power Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) Test Results

**Jean-Marie Lauenstein**

**Radiation Effects and Analysis Group**
**NASA Goddard Space Flight Center**
**Greenbelt, MD 20771 USA**

Presented by Jean-Marie Lauenstein at the NASA Electronic Parts and Packaging Program (NEPP) Electronics Technology Workshop (ETW), NASA Goddard Space Flight Center in Greenbelt, MD, June 11-13, 2012 and published on nepp.nasa.gov.

# Acknowledgments



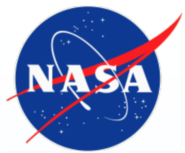

**Government:**

- **Defense Threat Reduction Agency**
- **NASA/GSFC Radiation Effects and Analysis Group**
  - Ken LaBel, Ray Ladbury, Hak Kim, Anthony Phan, Megan Casey, Alyson Topper, Stephen Cox, and Tim Irwin
- **NASA/JPL**

**Industry:**

- **Aeroflex**
- **Fuji**
- **International Rectifier**
- **Infineon Technologies**
- **Microsemi**
- **SEMICOA**
- **STMicro**
- **Texas Instruments**
- **Tower JAZZ**
- **Vishay Siliconix**

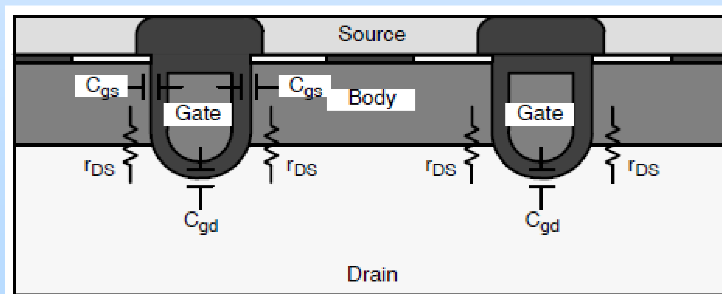
# Introduction



- **NEPP focus: Evaluate alternative power devices for space applications**
  - New technologies
  - New suppliers
- **<u>This talk:</u>**
  - Silicon power MOSFETs – part 1 (GSFC)
- **Other talks during this NEPP ETW:**
  - Silicon – part 2 (JPL)
  - Gallium Nitride
  - Silicon Carbide

# Vishay Commercial n-Type TrenchFET®

- **Previous tests of Vishay commercial p-channel 12 V and 200 V TrenchFETs® showed good total ionizing dose (TID) and single-event effect (SEE) performance**
  - Data presented at 2011 NEPP ETW
- **SUM45N25:**
  - commercial 250 V, 45 A, 0.058 Ω TrenchFET®
  - 175 °C junction temperature capability
  - ± 30 V gate rating

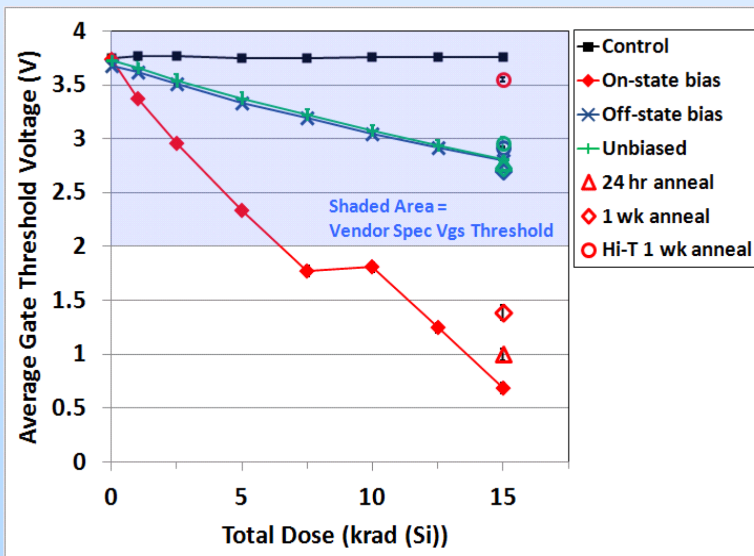



**Example TrenchFET® cross section.**

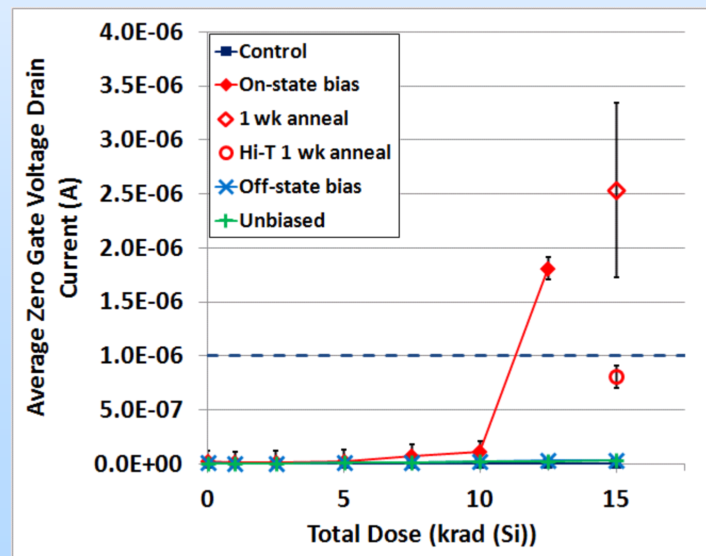
***(From: Vishay Siliconix AN605)***

# Vishay SUM45N25 Commercial n-Type TrenchFET® TID Results

- **Bias conditions:**
  - On-state: gate-source voltage (Vgs) = 18V; drain-source voltage (Vds) = 0V
  - Off-state: Vds = 190V; Vgs = 0V
  - Unbiased: Vds = Vgs = 0V
- **Dose rate:** 517 rad(Si)/min, with 2.62 rad(Si)/min overnight dose from 7.5 krad(Si) to 10 krad(Si) total dose steps




Gate Threshold Voltage

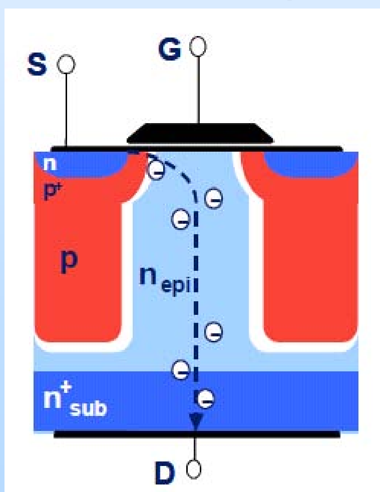



Drain Current at 0 Vgs

Presented by Jean-Marie Lauenstein at the NASA Electronic Parts and Packaging Program (NEPP) Electronics Technology Workshop (ETW), NASA Goddard Space Flight Center in Greenbelt, MD, June 11-13, 2012 and published on nepp.nasa.gov.

# Infineon Radiation-Hardened n-Type Superjunction (SJ) MOSFET

- **Infineon Technologies is first to develop a radiation-hardened version of a superjunction power MOSFET**
  - Superjunction process should prove SEE-hardened:
    - Fields develop fairly evenly both laterally and vertically, reducing the peak field strength, thus impact ionization important for single-event burnout (SEB)
    - Reduced field strength + lateral fields reduce peak transient $E_{ox}$ following an ion strike, important for single-event gate rupture (SEGR)




**Example superjunction MOSFET cross section.**

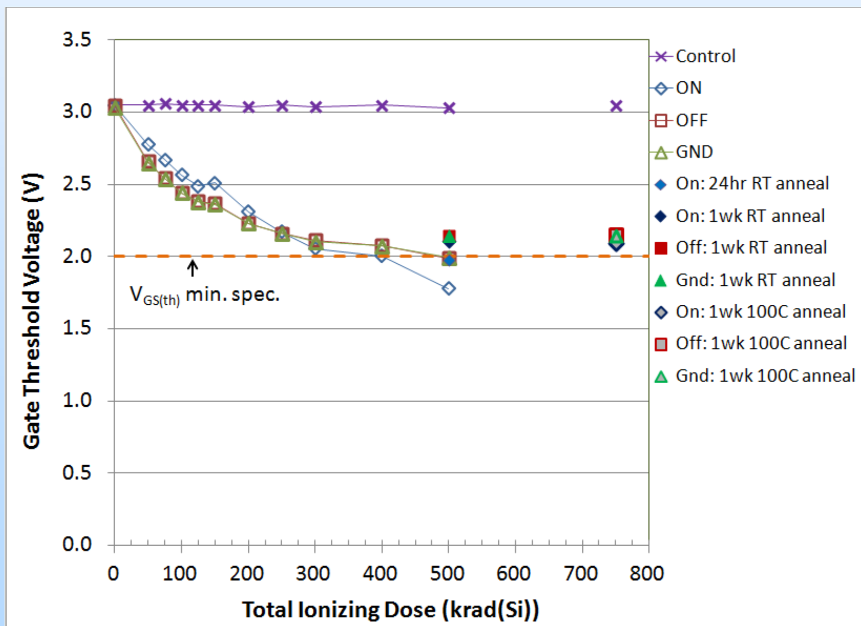
***(Infineon Technologies Application Note AN-CoolMOS-CP-01)***

**Device tested: BUY25CS54A**

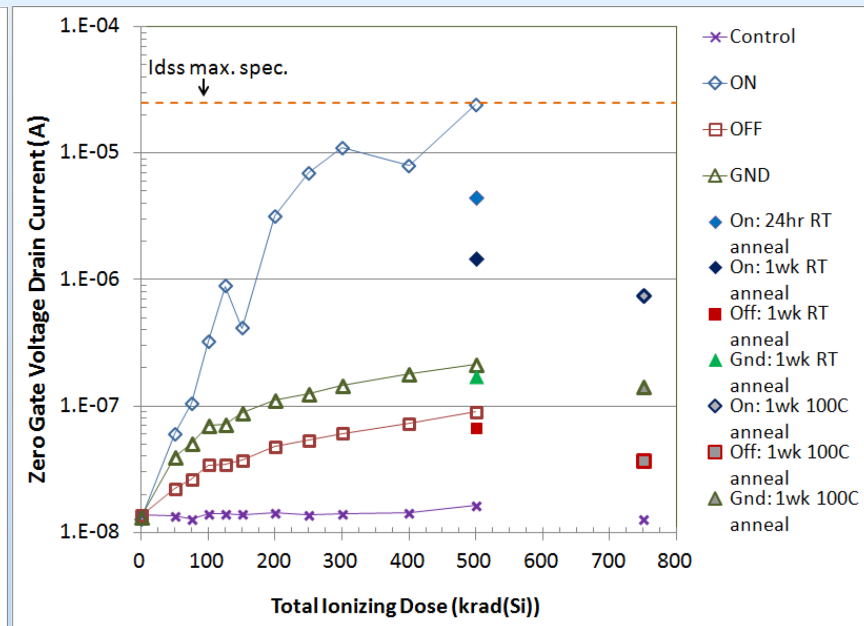
- 250 V, 54 A, 0.030 Ω
- 100 krad(Si) rating

# Infineon BUY25CS54A n-Type SJ MOSFET TID Results

- **Bias conditions:**
  - On-state: Vgs = 12V; Vds = 0V
  - Off-state: Vds = 200V; Vgs = 0V
  - Unbiased: Vds = Vgs = 0V
- **Dose rate:** 940 rad(Si)/min with lower overnight rates



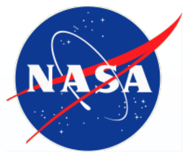

Gate Threshold Voltage




Drain Current at 0 Vgs

Presented by Jean-Marie Lauenstein at the NASA Electronic Parts and Packaging Program (NEPP) Electronics Technology Workshop (ETW), NASA Goddard Space Flight Center in Greenbelt, MD, June 11-13, 2012 and published on nepp.nasa.gov.

# SEE Tests



- **Planned this summer:**
  - Infineon 250 V SJ MOSFET (BUY25CS54A)
  - Aeroflex 250 V vertical MOSFET (VDMOS) (RAD7264)
  - Fuji 500 V VDMOS (JAXA-R-2SK4188)
  - SEMICOA -100 V p-type VDMOS (2N7425)
  - Vishay 250 V trenchFET® (SUM45N25)
  - Tower JAZZ 40 V lateral MOSFET (LDMOS) (test chip)

***Stay tuned for these and more test results!***