Single event effects (SEE) results of a radiation hardened 100 V GaN power HEMT

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Introduction

GaN power transistors are starting to proliferate power systems in space application due to their superior performance over radiation hardened Si MOSFETs. While the GaN transistor is inherently tolerant to ionizing dose, there are concerns over its performance in a heavy ion environment. This paper summarizes the single event effects (SEE) testing results of IR HiRel's 100 V GaN power transistor.

Methods

The devices were SEE tested using the Superconducting Cyclotron at Texas A&M University. The DUTs were assembled in a TO-3 package with the die mounted 'dead bug' to access the active region.

Package DUTs were mounted on a test PCB in line with the beam at normal or angle incidence and irradiated while the Keithley SMUs measured in-situ voltages and currents.

Figure 1: Test PCB inline with beam

For Single event burnout (SEB) tests, VGS = 0 V and the VDS =100 V. All DUTs were tested to a fluence of 3E6 and later tested on an ATE to ensure a pass.

Angled SEE testing used Au, Kr, and Xe ions. Two rounds of angled testing were done. First with Au ions where the LET exceeded the rating of the device. Second with Kr and Xe ion, the LET was kept at 70MeV•cm²/mg.

In-situ measurements were used to capture gross failures and I_{DSS} leakage current increases during exposure.

Results

SEE results Au ion at normal incidence, LET = 70

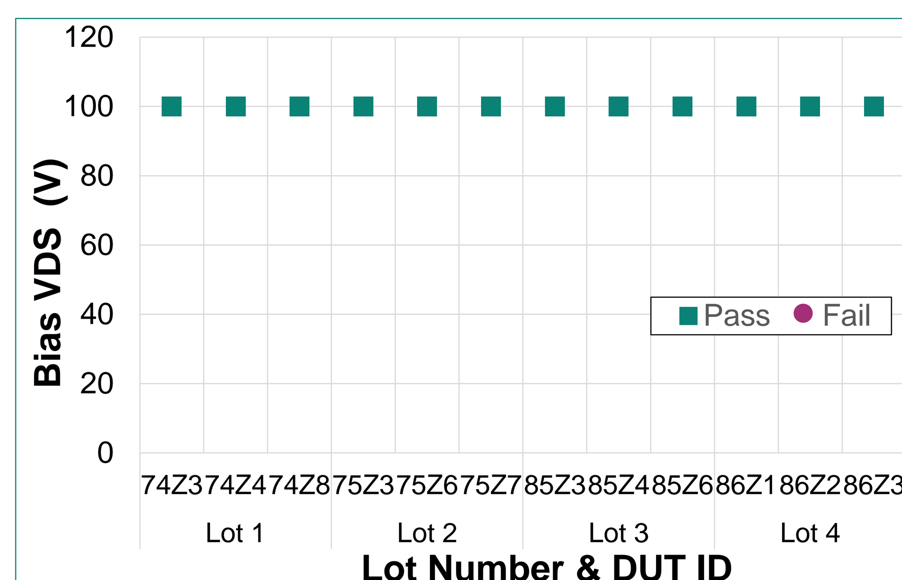

Figure 2: Pass/Fail SEE results, normal incidence

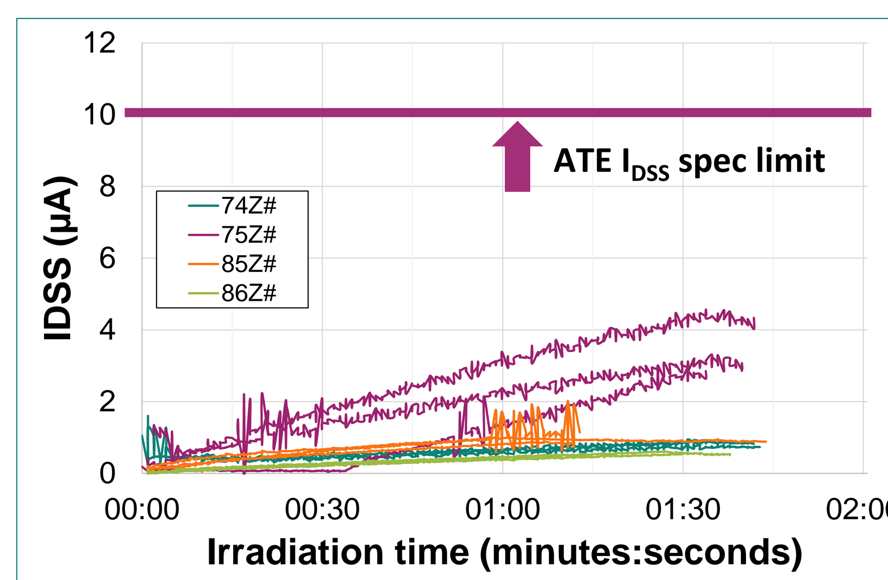

Figure 3: IDSS in-situ SEE measurements for figure 2

Figure 2 summarizes pass/fail results of the SEE SEB testing across 4 different fabrication lots of the rad hard 100 V GaN. Figure 3 shows in-situ I_{DSS} measurements for all the DUTs.

SEE results Au ion at angle incidence, LET>70

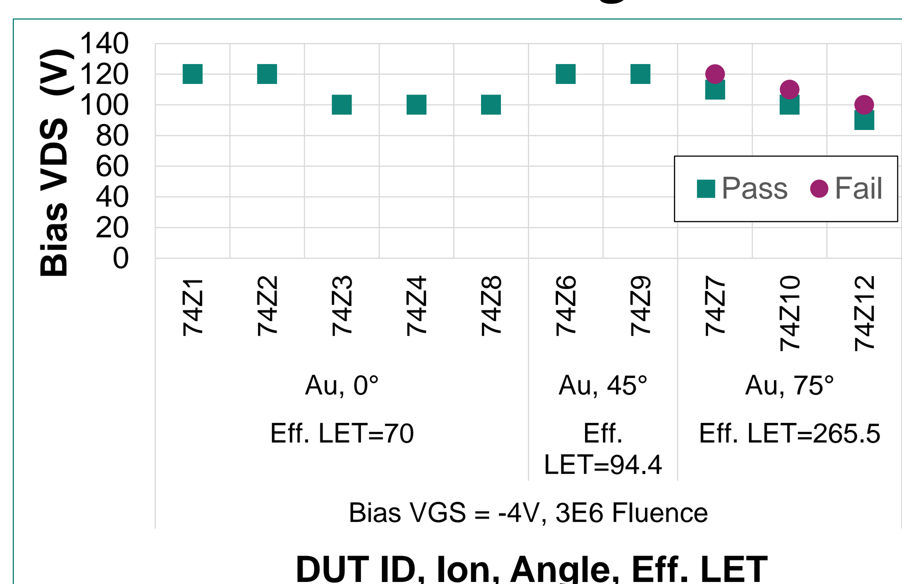

Figure 4: Pass/Fail SEE results, angle, LET > 70MeV

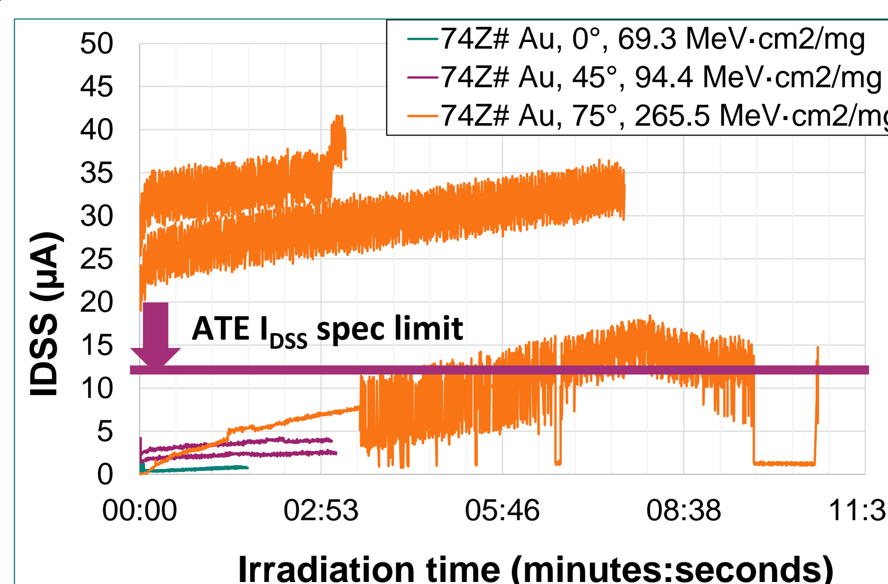

Figure 5: IDSS in-situ SEE measurements, for figure 4

Figure 4 summarizes pass/fail results of the angled SEE testing. Figure 5 shows in-situ I_{DSS} measurements. All test were done using Au ions with a max effective LET = 265.5MeV•cm²/mg.

SEE results Au ion at angle incidence, LET = 70

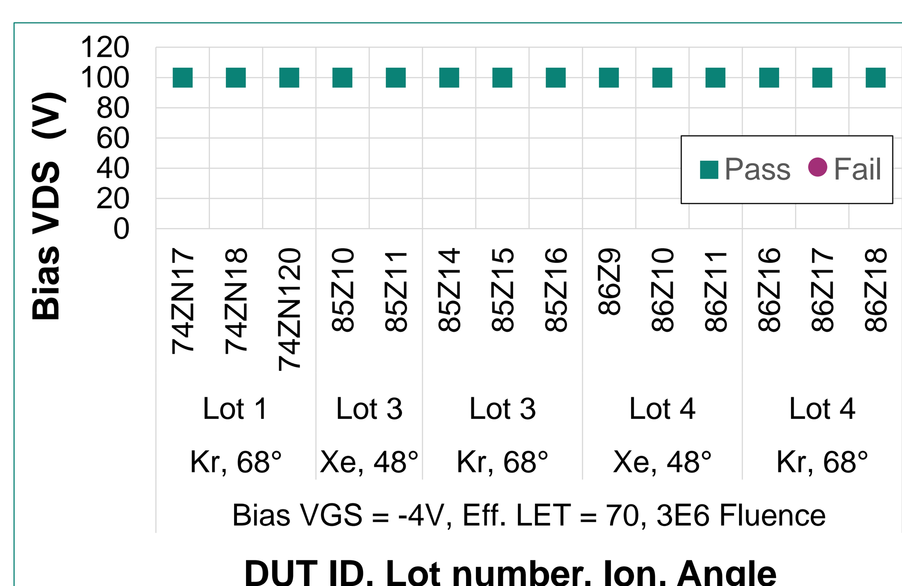

Figure 6: Pass/Fail SEE results, angle, LET = 70MeV

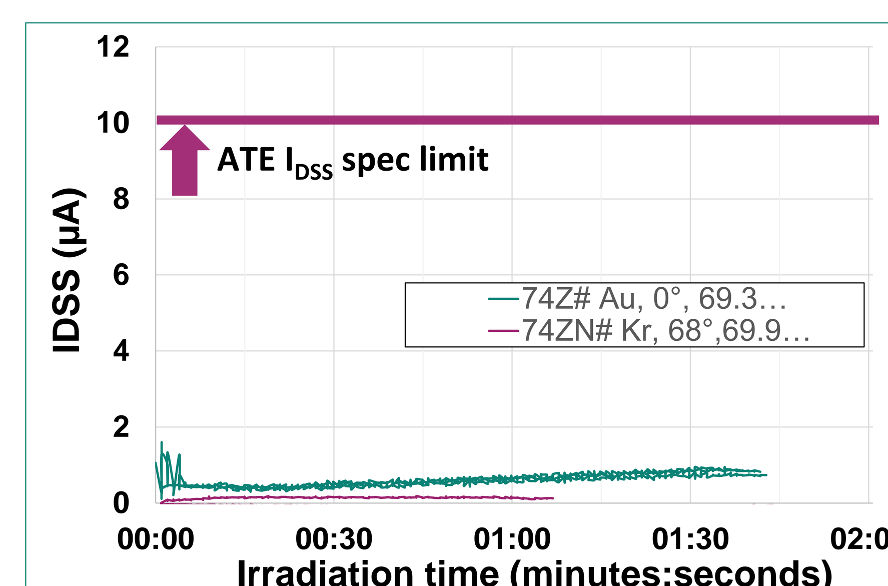

Figure 7: IDSS in-situ SEE measurements, for figure 6

Figure 6 summarizes pass/fail results of the angled SEE testing with a max effective LET = 70MeV•cm²/mg. Figure 7 compares in-situ I_{DSS} measurements of normal and angle incidence (Au 0° vs. Kr 68°).

Conclusions

The test results show that IR HiRel's 100 V rad hard GaN power transistor is robust against destructive SEE and can be used in space applications reliably.

The data shows:

1. There is no lot-to-lot variation in the design and devices pass the full rating of 100 V.
   - Figure 4 shows that there is headroom in the survivability as two devices were tested at 120 V and passed.
2. Extreme angled testing was performed with Au ions. The DUTs passed 45° angle testing with Au ions, which generated an effective LET of 94.4MeV•cm²/mg at 120 V.
   - DUTS only failed when the angle was increased to 75° to generate an effective LET of 275.5MeV•cm²/mg.
3. Angled testing where the LET was held constant at 70MeV•cm²/mg demonstrated consistent performance among all the DUTs and across 4 different wafer lots.

Acknowledgements

Our sincere gratitude to the designers and radiation test engineers that worked diligently to perfect and test the radiation performance of these parts for intended application, including:

- Jackson Heun, applications engineer
- Srinivasan Kannan, lead design engineer
- Josemari Mapa, product marketing engineer
- Eric Reich, radiation test engineer
- Todd Thorp, lead product engineer