National Aeronautics and Space Administration

Single-event Effect Report for EPC Series eGaN FETs: Proton testing for SEE and TNID effects

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JPL Publication 14-5 01/14

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NASA Electronic Parts and Packaging (NEPP) Program
Office of Safety and Mission Assurance

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NASA WBS: Please add
JPL Project Number: 104309
Task Number: 101249

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This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, and was sponsored by the National Aeronautics and Space Administration Electronic Parts and Packaging (NEPP) Program.

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1.0 EXECUTIVE SUMMARY

Previous testing of the Enhanced Power Conversion (EPC) eGaN FETs showed sensitivity to destructive single-event effects (SEE) effects to heavy ions. The presence of tungsten plugs in the gate area raises concerns that the device may be vulnerable to SEE from protons. Irradiation of biased and unbiased devices with heavy ion has results in some damage suspected of being due to total non-ionizing dose (TNID). Proton irradiation is a better radiation type to study this effect. This study presents the results of testing device with protons for SEE and TNID. No SEE in the EPC2012 device, the most sensitive device to SEE, were seen with 53 MeV protons at several angles. The devices continued to function after 1.5 Mrad (Si) of proton dose with only a slight shift in parameters. These results suggest that gross TNID will not be a factor in using these devices nor suffer from SEE due to protons. However, the device should be tested at with 500 MeV protons to guarantee to immunity proton SEE.

2.0 PURPOSE

The purpose of this testing was to characterize the newly available eGaN FET from EPC for radiation effects from protons. The devices were tested for SEE, such as Single-Event Gate Rupture (SEGR), as well as dose effects were also investigated.

3.0 TEST SAMPLES

The DUT listed in Table 3.0-1 were acquired commercially and stored under flight ESD conditions per D-57732. The EPC1012 and EPC2012 devices were selected for testing since they are the smallest die, which minimized the area for damage investigations, and the largest voltage rating, which maximized the sensitivity to SEE.

Table 3.0-1. List of devices that were tested.

Manufacturer	Part Number	VDS rating (max) [V]	Channel	LDC	Package
EPC	EPC2012	200	N	NA	Custom

4.0 PROCEDURE/SETUP

The general test procedure adhered to "The Test Guideline for Single Event Gate Rupture (SEGR) of Power MOSFETs" [JPL Publication 08-10 2/08]. Parts were serialized (if not already done), with controls marked prominently to distinguish them from test samples. Exposures were performed at ambient laboratory temperature. Since the packages from EPC were atypical, the DUTS had to be remounted in a dead-bug configuration for ion testing and testing with the ATE. Devices were verified to be functional after mounting on the test carrier, see Figure 4.0-1. The equipment used in this effort is listed in Table 4.0-1.

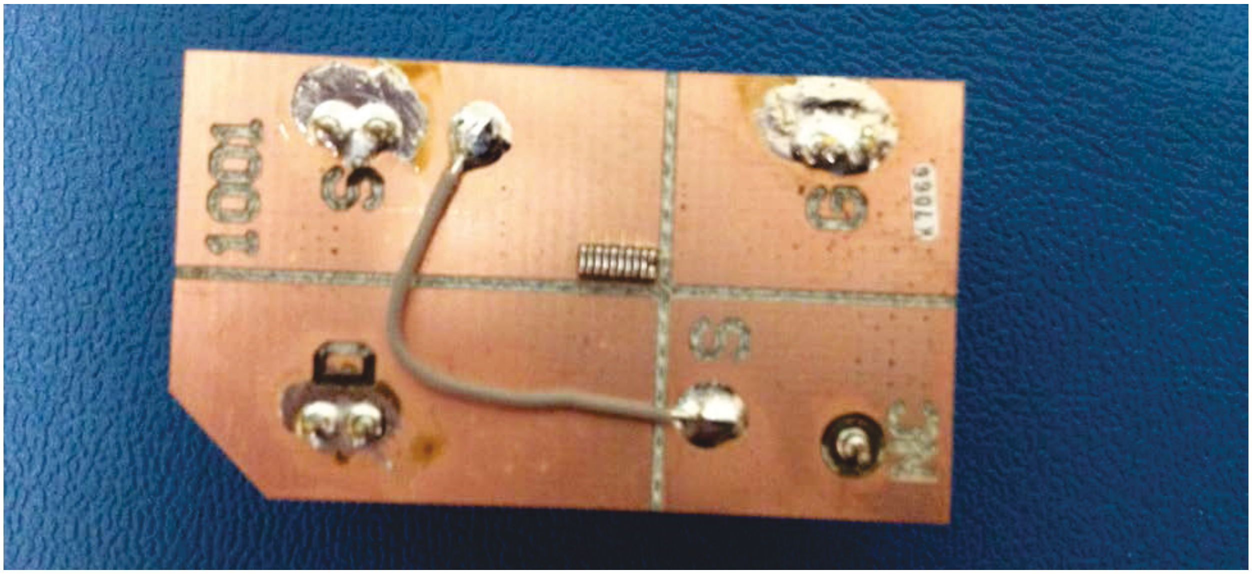

Figure 4.0-1. Dose testing carrier.

Table 4.0-1. Equipment used in this effort.

Unit	Function	Make	Calibration	JPL SN
HP4156	Parametric ATE	Agilent	20091219	TDB
HP4142	SEE ATE	Agilent	20111013	887633
Laptop	SEE control PC	Toshiba	NA	2220673

4.1 Electrical Tests

Electrical tests were performed in accordance with "The Test Guideline for Single Event Gate Rupture (SEGR) of Power MOSFETs" [JPL Publication 08-10 2/08]. All devices were verified to work by testing with a HP4156. The transfer and characteristic curves of each device were acquired to a maximum current of 10 mA on any terminal of the device.

4.2 Failure Criteria

Failure criteria were classified in accordance with "The Test Guideline for Single Event Gate Rupture (SEGR) of Power MOSFETs" [PL Publication 08-10 2/08]. However, any change in device parameters was noted for this exploratory effort.

4.3 Setup

Failure criteria were classified in accordance with "The Test Guideline for Single Event Gate Rupture (SEGR) of Power MOSFETs" [PL Publication 08-10 2/08]. Figure 4.3-1 shows the setup used in this experiment. An HP4142 forced the voltage and read a current with three independent SMUs. The background current on the board with no DUT was recorded to be ~0.5 nA in each device location.

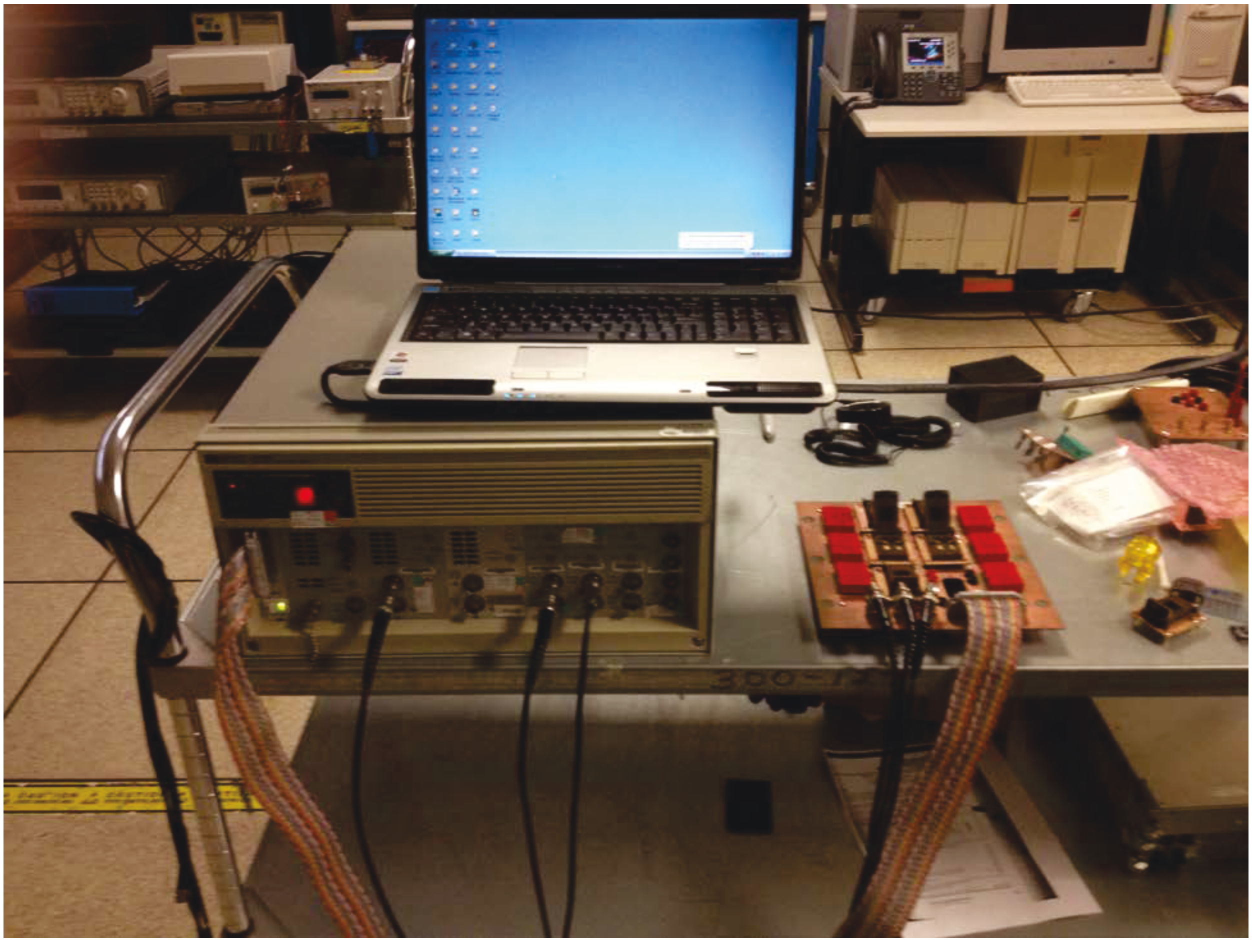

Figure 4.3-1. Setup used for SEE testing. The entire system is transported to a heavy ion site.

5.0 SOURCE REQUIREMENTS

The ion source was the UC-Davis cyclotron using the 53 MeV tune.

6.0 BIAS CONDITION/FIXTURES

Bias condition during the biased irradiations were in accordance with "The Test Guideline for Single Event Gate Rupture (SEGR) of Power MOSFETs" [PL Publication 08-10 2/08]. Unbiased parts were exposed in a manner that protects them against ESD.

7.0 RESULTS

Figure 7.0-1 shows a typical response of EPC2012 to low levels of proton dose. The effect is to lower the threshold voltage slightly; this has been observed repeatedly. Figure 7.0-2 presents a typical results of a device irradiated to high levels of proton dose. The threshold-voltage increase from the initial decrease rebounds and saturates. This has been seen for all tested device. No SEE or prompt increases in drain current were seen. The SEE testing was done at various angles to induce SEE from secondary particles in the tungsten plugs. Figure 7.0-3 shows the similar effects from xenon heavy ion testing. In contrast, the heavy effects are considered to be gate damage that increase gate-to-source leakage since the proton induced TNID without any SEE.

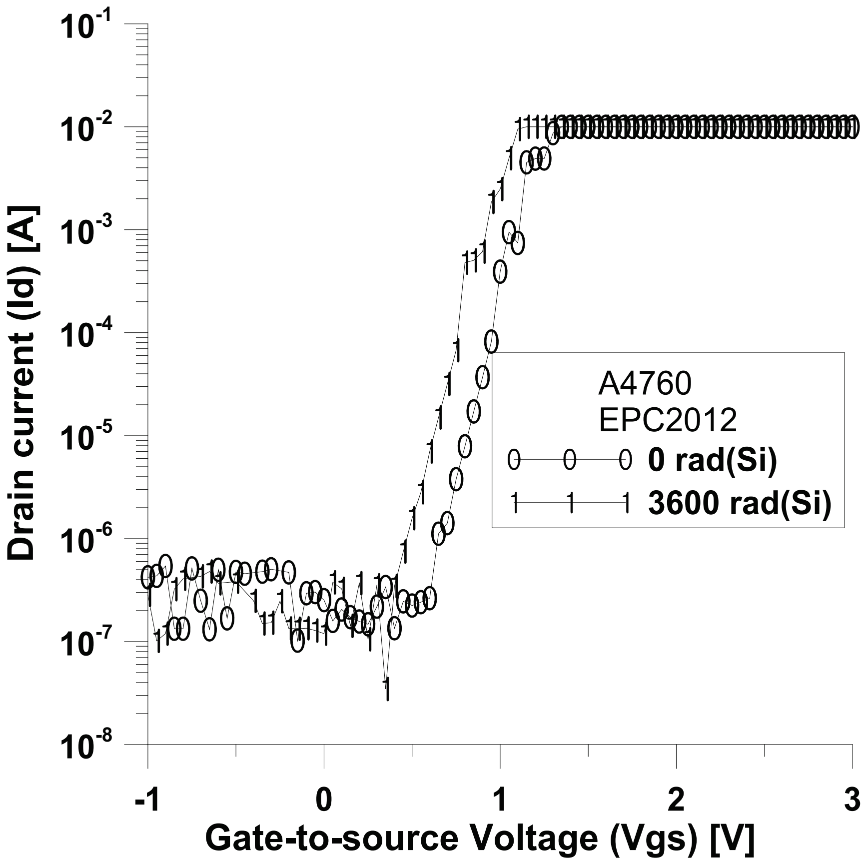

Figure 7.0-1. Transfer I-V for an ECP2012 after irradiation with 50 MeV protons.

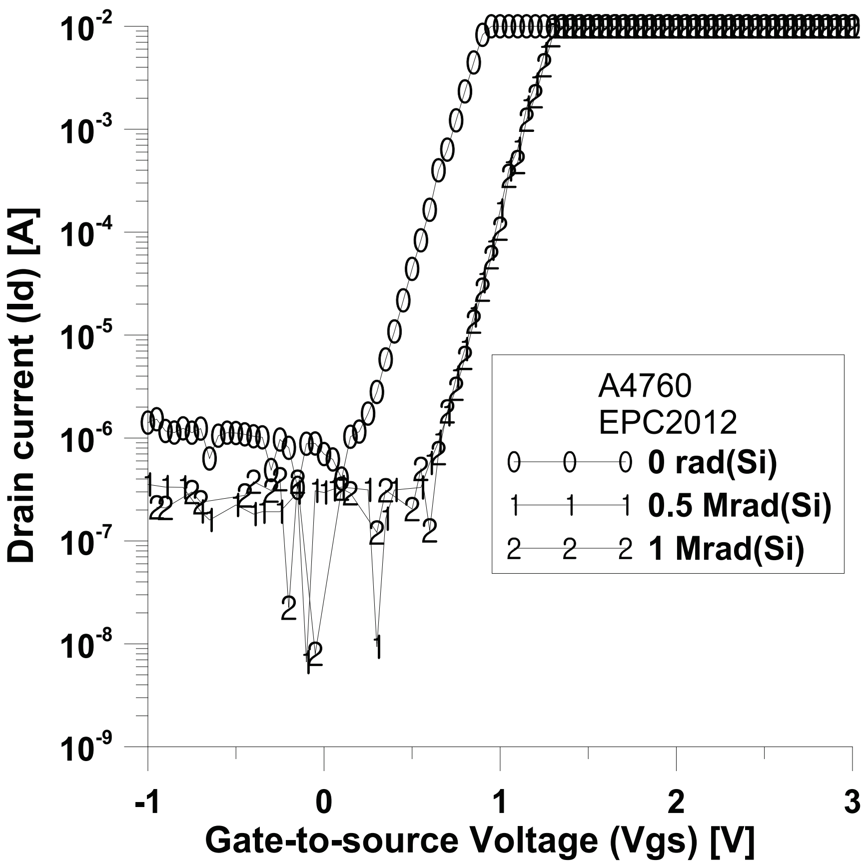

Figure 7.0-2. Transfer I-V for an ECP2012 after irradiation with 50 MeV protons.

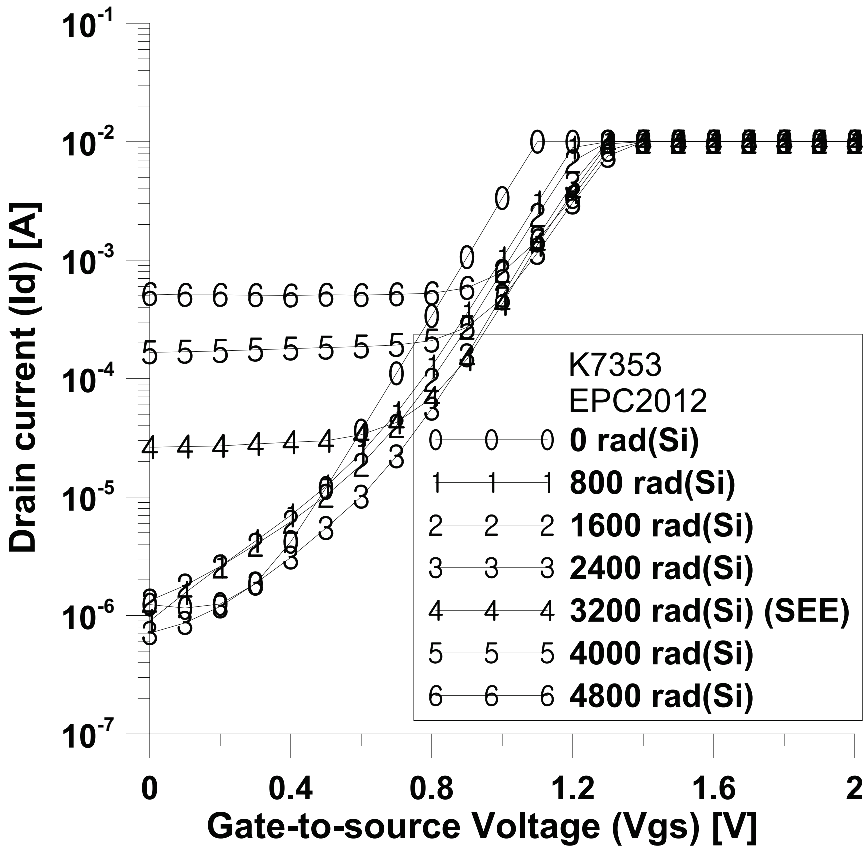

Figure 7.0-3. Transfer I-V for an ECP2012 after irradiation with 25 MeV/amu xenon ions.