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Single-Event Effect Test Report International Rectifier 80SCLQ060SCS Schottky Diode

Ted Wilcox, Michael Campola, and Matt Joplin

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Ted Wilcox, Michael Campola, and Matt Joplin
Goddard Space Flight Center, Greenbelt, MD

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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International Rectifier
80SCLQ060SCS Schottky Diode

Ted Wilcox[1], Michael Campola[1], and Matt Joplin[1]

NASA Goddard Space Flight Center

Code 561.4, Radiation Effects and Analysis Group

8800 Greenbelt Rd

Greenbelt, MD 20771

Test Date: December 8, 2020

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[1]NASA Goddard Space Flight Center, Greenbelt, MD USA

I. Introduction

This study was undertaken to determine the destructive single event effect and degradation susceptibility of the 80SCL060SCS Schottky diode. The device was monitored for destructive events and degradation in the reverse bias current during exposure to a heavy ion beam at Texas A&M University's K500 Cyclotron.

II. Test Result Summary

The 80SCLQ060SCS did not experience any destructive single-event effects during heavy ion irradiation at a normal-incidence LET (linear energy transfer) of 42.7 MeVcm^2/mg under a reverse bias of 61.5 V and a fluence to 1x10^7/cm^2. Additional testing at higher LET and voltages also did not reveal any destructive effects.

III. Devices Under Test

The 80SCL060SCS Schottky diode is a dual diode with a common cathode Schottky rectifier rated for 60V reverse bias, 80A of forward current, and a maximum reverse bias leakage current of 0.3mA at 25C and a maximum forward voltage drop of 0.68V when conducting 40A of current. Seven devices were be prepared for testing by de-lidding the ceramic package. The lot date code of the devices tested is 1839. The device was provided in a hermetic surface mount SMD-1 ceramic package.

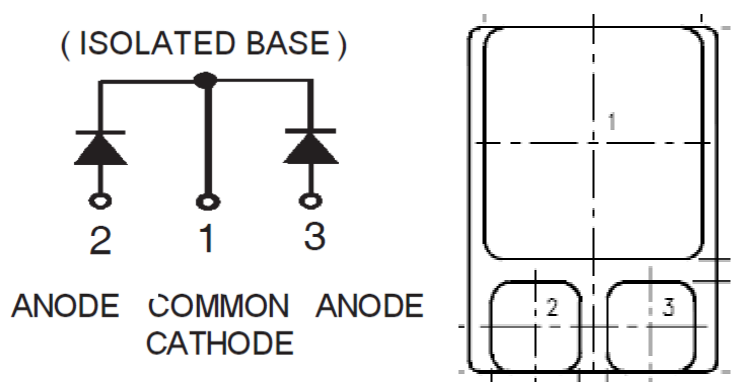

Figure 1. Device functional diagram [80SCLQ060 datasheet] and package pinout

IV. Test Facility

Facility: Texas A&M University Cyclotron Institute, K500 cyclotron, 25 MeV/amu tune

Flux: Approximately 2x10^{4}cm^{-2}s^{-1}.

Fluence: Testing was conducted to at least 1x10^{6}cm^{-2} at each test condition for three devices. A single device was tested to 1x10^{7}cm^{-2} at the worst-case planned test condition.

Ions / LET: A normal-incidence LET of at least 37 MeVcm^2/mg was required for destructive single event burnout testing. During this test, limited ions were available due to facility maintenance. The highest nominal LET was 25 MeV/amu Xe, at 42.7 MeVcm^2/mg. Beam degraders were used in four tests (noted in the results section) to obtain higher LETs for additional experiments.

V. Test Conditions

Test Temperature: Ambient temperature.

Operating Frequency: DC, Reverse bias

Power Supply Voltage: 61.5V worst case provides 70% derating to the maximum application transient (43 V) in the worst-case application (several applications vary). Other voltages of interest include 45 V (to barely envelope the 43 V worst-case transient), and 52 V to provide 70% derating to the 36 V worst-case transient of most applications. Note that the maximum datasheet reverse voltage is 60 V. Ground testing suggested no issues operating at 61.5 V or higher prior to testing.

Parameters of Interest: Power supply current (I_R), forward bias I-V curve for data sheet spec verification

VI. Test Methods

The primary test condition was steady-state operation under reverse bias. Reverse bias leakage current was continually monitored for degradation or catastrophic failure. Reverse bias current was logged to capture degradation, and any precipitous increase would indicate catastrophic failure.

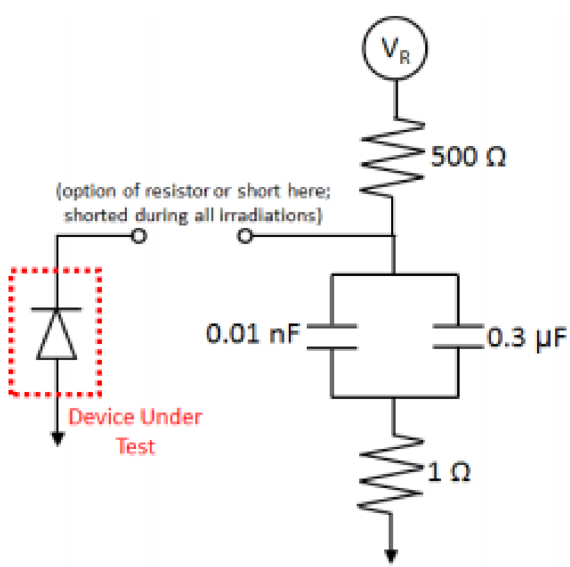

Figure 2. Test circuit of modified power MOSFET circuit

Pre-characterization of forward bias I-V curve and reverse bias leakage current was conducted on each sample prior to irradiation to establish that each device under test (DUT) met datasheet specifications. After each test run a forward bias I-V curve and reverse bias leakage current were captured and logged to record any changes or degradation in the behavior of the device.

The testing included reverse bias values selected based on application values to allow 70% derating from passing voltages (reflective of NASA EEE-INST-002 electrical (non-radiation) diode standards), based on worst case application estimates and the corresponding maximum bias to achieve that derated value. The reverse bias was constant throughout the test run until the target fluence was reached (or destructive single-event effect (dSEE) occurred, which did not happen). In all cases, the reverse bias current was monitored in real-time to detect degradation or destructive failure.

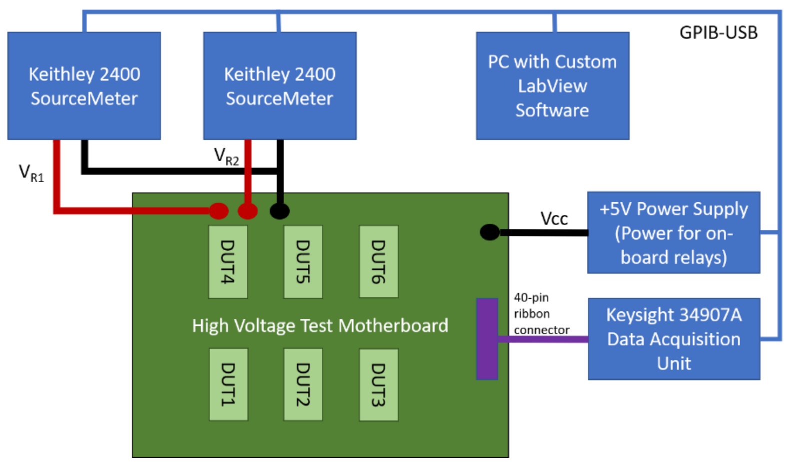

Figure 3. Block diagram of the test setup used during irradiation

VII. Test Performance

Personnel: Michael Campola (NASA)

The notional testing plan is provided below for reference as it existed in the test plan.

While the steps below are intended to guide the decision making, the ultimate goal is to find an LET at which three parts survive 1E6/cm^2 at 61.5 V_R. If that is not feasible, a maximum survivable voltage at an LET of 37 shall be determined (or highest LET possible).

1. Start with the available beam with highest normal-incidence LET. Test at normal incidence and ambient temperature only.
2. Test at V_R = 45 V, fluence to 1E6. Monitor I_R for precipitous increase indicating failure. (This is essentially a bare-minimum voltage to meet an application worst-case voltage of 43 V with a small margin.) If it passes, increase voltage to 52 V and repeat (this provides 70% derating to the 36 V worst-case voltages most of these parts will see). If passes, repeat at 61.5 V, (which

derates to the 43 V worst-case voltage of the worst usage of this part). Note that this is above datasheet limits; consider 60 V if you have any issues at 61.5 V.

2.1. If part in #2 passed all testing, repeat on two additional samples.

2.2. If all 3 samples pass at all voltages, testing is complete.

3. If parts in #2 fail at 45 V, reduce voltage to 30V and then increase in 3 V steps.

3.1.1. If parts fail below 45 V, reduce LET and repeat from 30V in 3 V steps.

VIII. Test Results

The 80SCLQ060SCS was irradiated with only one ion and tune, 25 MeV/amu Xe with a corresponding nominal LET of 42.7 MeVcm^2/mg, and only at normal incidence (worst-case for this technology). The device temperature was approximately room temperature, as is appropriate for this technology. The device was irradiated under reverse bias with the following conditions and results:

DUT ID#	Reverse Bias Voltage (V)	LET (MeVcm^2/mg)	Range (um)	Fluence (/cm^2)	Result
1	45	42.7	220	1E6	Pass
1	52	42.7	220	9.9E5	Pass
1	60	42.7	220	1E6	Pass
1	61.5	42.7	220	1E6	Pass
2	45	42.7	220	1E6	Pass
2	52	42.7	220	9.9E5	Pass
2	60	42.7	220	9.9E5	Pass
2	61.5	42.7	220	1E6	Pass
4	61.5	42.7	220	1E7	Pass
4	65	42.7	220	9.9E5	Pass
4	61.5	50	148.5	1E6	Pass
4	65	60	88.1	1E6	Pass

All three parts tested survived at least 1x10^6/cm^2 fluence at an LET of 42.7 MeVcm^2/mg at a reverse voltage of 61.5 V. This voltage is beyond the manufacturer's specification for maximum voltage and was selected to ensure a 70% derating factor for a worst-case application voltage of 43 V.

No testing ever caused a destructive failure, including a high fluence test to 1E7/cm^2 at 61.5 V and a high voltage test to 1E6/cm^2 at 65 V.

The tests with LETs of 50 and 60 MeVcm^2/mg were possible with use of facility beam degraders, as only a limited set of ions was made available during this test campaign. Degraders result in a wider spread of LET delivered to the part and reduced range. In both cases the part survived with no issue.

IX. Appendix 1: Schematic

The complete test board schematic is shown in Fig. 1. No additional schematic is needed.

X. Appendix 3: Equipment List as Tested.

MFG and P/N	Function	S/N or ECN	Calibration Status
Dell Laptop		2332208	NA
Keithley 2400	Source Measurement Unit	M161828	
Keithley 2400	Source Measurement Unit	M161220	
Keithley 2230-30-1	DC Power Supply	M164756	