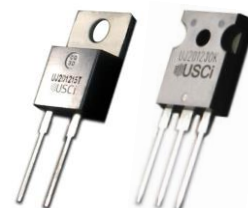


1200 V xR SiC Series
1200 V-15A, 10A, 5A / 30A, 20A Schottky Diodes



Product Qualification Report

Summary

This report delineates the reliability and qualification tests applied to the 1200 V SiC Schottky Diode product family from USCi packaged in 2 lead TO-220 or 3 lead TO-247 discrete platforms. USCi continuously strives for excellence by performing the harshest of reliability tests as outlined below in Table 1. A total of 1155 units, 770 in 2 lead TO-220 and 385 in 3 lead TO247, of the 1200 V devices were tested in 3 lots where the testing and failure criteria are based on *Stress Test Qualification for Automotive Grade Discrete Semiconductors* (AEC-Q101-REV-C) and the *Stress-Test-Driven Qualification of Integrated Circuits* (JESD471I). Additionally, 77 units each of the 10A-1200 V and 5A-1200 V devices were tested for 168 hours under High Temperature Reverse Bias (HTRB). All reliability tests were performed in an ISO 9001 certified facility.

Table 1: USCi’s Standard Reliability Qualification Tests
A: Tests Performed on 770 Units of 15A-1200 V Devices in 2 Lead TO-220

Test	Conditions	Sample Size	Reference Document
High Temperature Reverse Bias (HTRB)	$T_{amb}=175^{\circ}\text{C}$ for 1000 Hrs, $V=80\% V_{max}$	2 Lots of 154 devices (77pcs/Lot)	JESD22-A108C
Intermittent Operational Lifetime (IOL)	$\Delta T_j \geq 125^{\circ}\text{C}$, 4286 cycles (3.5 minutes on/ 3.5 minutes off)	2 Lots of 154 devices (77pcs/Lot)	AECQ101C & MIL-STD-750D METHOD 1036,1037
Temperature Humidity Bias Life Test (H3TRB)	$85^{\circ}\text{C}/85\% \text{RH}$, $V=100 \text{ V}$ 1000 Hrs	2 Lots of 154 devices (77pcs/Lot)	JESD22-A101C
Accelerated Moisture Resistance Unbiased Autoclave (AC)	$T_{amb}=121^{\circ}\text{C}$, 100% rh, 205 Kpa, 96 Hrs	2 Lots of 154 devices (77pcs/Lot)	JESD22-A102C
Temperature Cycling (TC)	-55°C to $+150^{\circ}\text{C}$ 2 cycles/Hr, 1000 cycles	2 Lots of 154 devices (77pcs/Lot)	JESD22-A104D, Cond H, Soak Mode 2

B: Tests Performed on 385 Units of 30/20A-1200 V Devices in 3 Lead TO-247

Test	Conditions	Sample Size	Reference Document
High Temperature Reverse Bias (HTRB)	$T_{amb}=175^{\circ}\text{C}$ for 1000 Hrs, $V=80\% V_{max}$	1 Lots of 77 devices (77pcs/Lot)	JESD22-A108C
Intermittent Operational Lifetime (IOL)	$\Delta T_j \geq 125^{\circ}\text{C}$, 3000 cycles (5 minutes on/ 5 minutes off)	1 Lots of 77 devices (77pcs/Lot)	AECQ101C & MIL-STD-750D METHOD 1036,1037
Temperature Humidity Bias Life Test (H3TRB)	$85^{\circ}\text{C}/85\% \text{RH}$, $V=100 \text{ V}$ 1000 Hrs	1 Lots of 77 devices (77pcs/Lot)	JESD22-A101C
Accelerated Moisture Resistance Unbiased Autoclave (AC)	$T_{amb}=121^{\circ}\text{C}$, 100% rh, 205 Kpa, 96 Hrs	1 Lots of 77 devices (77pcs/Lot)	JESD22-A102C
Temperature Cycling (TC)	-55°C to $+150^{\circ}\text{C}$ 2 cycles/Hr, 1000 cycles	1 Lots of 77 devices (77pcs/Lot)	JESD22-A104D, Cond H, Soak Mode 2

C: Tests Performed on 77 Units Each of 10A-1200 V and 5A-1200 V Devices

Test	Conditions	Sample Size	Reference Document
High Temperature Reverse Bias (HTRB)	$T_{amb}=175^{\circ}\text{C}$ for 168 Hrs, $V=80\% V_{max}$	1 Lots of 77 devices (77pcs/Lot)	JESD22-A108C

*Note: We have previously qualified both the 2 lead TO-220 and 3 lead TO-247 packages with a full 3 lots package qualification test.

High Temperature Reverse Bias (HTRB)

The HTRB test for Schottky Diodes is designed to accelerate the failure modes at the Schottky interface as well as the edge termination process under reverse bias by testing the device at steady state reverse voltage and increasing the ambient temperature. The device junction temperature is related to the ambient temperature and the leakage current through:

$$T_j = (R_{th,case} + R_{th,heatsink})I_{leak}V_r + T_{Amb}$$

Intermittent Operational Lifetime (IOL)

Intermittent operational lifetime testing is aimed at accelerating failure modes associated with the stresses on all bonds and interfaces between the chip and mounting surfaces by subjecting

the devices to repeated turn on and off of current. Self-heating within the device creates a junction temperature rise given by:

$$\Delta T_j = (R_{th,case} + R_{th,heatsink}) I_f V_f$$

Temperature Humidity Bias Life Test (H3TRB)

High-humidity, high-temperature reverse bias (H3TRB) testing is performed to evaluate the reliability of non-hermetic packaged devices in humid environments while undergoing reverse bias. H3TRB is designed to accelerate failure modes associated with moisture penetration through the external protective material (encapsulant or potting), and includes internal corrosion, internal oxidation.

Accelerated Moisture Resistance Unbiased Autoclave (AC)

Unbiased autoclave testing evaluates the moisture resistance integrity of non-hermetic packaged solid state devices using a moisture condensing environment under high pressure. The test accelerates moisture penetration through the external protective material (encapsulant or potting) or along the interface between the external protective material and the metal conductors passing through it.

Temperature Cycling (TC)

Temperature cycling is to evaluate the robustness of the whole package when undergoing extreme temperature swings while the devices are unbiased. Temperature cycling is used to identify failure modes associated from a mismatch in the coefficient of thermal expansion (CTE) between dissimilar materials of all the materials in the complete package.

Failure Criteria

Test failure criteria are defined by the AECQ101-REV C and JESD47I documents, summarized below as any device exhibiting the following:

1. Devices not meeting the electrical test limits defined in the device datasheet specification after performing each stress test.
2. Devices not remaining within $\pm 20\%$ of the initial reading of each test after completion of environmental testing.
3. Any device exhibiting external physical damage attributable to the environmental test.

For any failure found, the root cause is found by implementing a Failure Mode Effect Analysis (FMEA) and is used to determine if the failure results from mishandling, ESD, test-equipment

failure, or a data-acquisition failure. Any device failing for these reasons will be removed from the test and not counted as a qualification failure.

Summary of Reliability Qualification Results

Table 2 and Table 3 show the summaries of the Pre- and Post-Stress Parametric Verification Results at 25°C of all the 1200 V devices used for the qualification tests. Table 4 summarizes the failures and results for each test condition.

Table 2 Summary of Pre-stress Data
A: 770 Units of 15A-1200 V Devices in 2 Lead TO-220

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.55	0.03	1.47	1.69
Reverse Leakage, IR (Rated Voltage)	μA		375	41.2	27.7	5.7	220.7

B: 231 Units of 30A-1200 V Devices in 3 Lead TO-247

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.63	0.02	1.59	1.68
Reverse Leakage, IR (Rated Voltage)	μA		375	37.6	31.2	11.5	217.8

C: 154 Units of 20A-1200 V Devices in 3 Lead TO-247

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.50	0.01	1.46	1.51
Reverse Leakage, IR (Rated Voltage)	μA		250	45.2	26.4	12.9	154.6

D: 77 Units of 10A-1200 V Devices in 2 Lead TO-220

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.51	0.01	1.50	1.53
Reverse Leakage, IR (Rated Voltage)	μA		250	32.6	11.6	11.8	68.8

E: 77 Units of 5A-1200 V Devices in 2 Lead TO-220

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.46	0.01	1.43	1.48
Reverse Leakage, IR (Rated Voltage)	μA		190	55.8	21.6	20.3	111.2

Table 3 Summary of Post-stress Data

A: 770 Units of 15A-1200 V Devices in 2 Lead TO-220

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.55	0.03	1.47	1.67
Reverse Leakage, IR (Rated Voltage)	μA		360	39.6	26.9	4.9	221.1

B: 231 Units of 30A-1200 V Devices in 3 Lead TO-247

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.63	0.02	1.59	1.68
Reverse Leakage, IR (Rated Voltage)	μA		360	33.3	28.4	9.5	220.0

C: 154 Units of 20A-1200 V Devices in 3 Lead TO-247

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.50	0.01	1.47	1.52
Reverse Leakage, IR (Rated Voltage)	μA		250	41.1	24.3	12.8	154.5

D: 77 Units of 10A-1200 V Devices in 2 Lead TO-220

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.52	0.01	1.50	1.53
Reverse Leakage, IR (Rated Voltage)	μA		250	31.8	11.3	11.4	68.1

E: 77 Units of 5A-1200 V Devices in 2 Lead TO-220

Parameter	Unit	LSL	USL	Mean	STD.DEV.	Min	Max
Forward Voltage, VF (Rated Current)	V		1.70	1.46	0.01	1.43	1.48
Reverse Leakage, IR (Rated Voltage)	μA		190	55.5	21.1	20.6	110.4

Table 4: Summary of Qualification Results

A: 770 Units of 15A-1200 V Devices in 2 Lead TO-220

Test	Conditions	Sample Size	Failed
High Temperature Reverse Bias (HTRB)	T _{amb} =175°C for 1000 Hrs, V=80% V _{max}	2 Lots of 154 devices (77pcs/Lot)	0
Intermittent Operational Lifetime (IOL)	ΔTj ≥125°C, 4286 cycles (3.5 minutes on/ 3.5 minutes off)	2 Lots of 154 devices (77pcs/Lot)	0
Temperature Humidity Bias Life Test (H3TRB)	85°C/85% RH, V=100 V 1000 Hrs	2 Lots of 154 devices (77pcs/Lot)	0
Accelerated Moisture Resistance Unbiased Autoclave (AC)	T _{amb} =121°C, 100% rh, 205 Kpa, 96 Hrs	2 Lots of 154 devices (77pcs/Lot)	0
Temperature Cycling (TC)	-55°C to +150°C 2 cycles/Hr, 1000 cycles	2 Lots of 154 devices (77pcs/Lot)	0

B: 385 Units of 30/20A-1200 V Devices in 3 Lead TO-247

Test	Conditions	Sample Size	Failed
High Temperature Reverse Bias (HTRB)	T _{amb} =175°C for 1000 Hrs, V=80% V _{max}	1 Lots of 77 devices (77pcs/Lot)	0
Intermittent Operational Lifetime (IOL)	ΔTj ≥125°C, 3000 cycles (5 minutes on/ 5 minutes off)	1 Lots of 77 devices (77pcs/Lot)	0
Temperature Humidity Bias Life Test (H3TRB)	85°C/85% RH, V=100 V 1000 Hrs	1 Lots of 77 devices (77pcs/Lot)	0
Accelerated Moisture Resistance Unbiased Autoclave (AC)	T _{amb} =121°C, 100% rh, 205 Kpa, 96 Hrs	1 Lots of 77 devices (77pcs/Lot)	0
Temperature Cycling (TC)	-55°C to +150°C 2 cycles/Hr, 1000 cycles	1 Lots of 77 devices (77pcs/Lot)	0

C: 77 Units Each of 10A-1200 V and 5A-1200 V Devices

Test	Conditions	Sample Size	Failed
High Temperature Reverse Bias (HTRB)	$T_{amb}=175^{\circ}\text{C}$ for 168 Hrs, $V=80\% V_{max}$	1 Lots of 77 devices (77pcs/Lot)	0

USCi’s xR 1200 V Schottky Diode products were selected and stress tested in an ISO 9001 certified facility according to *JESD47I* and *AECQ101-Rev C* guidelines as outlined in this report. The devices tested met all electrical performance requirements, and no failures were observed in any of the qualification tests. Based on these results, USCi’s xR 1200 V Schottky Diode products UJ2D1215T, UJ2D1210T, UJ2D1205T, UJ2D1230K, and UJ2D1220K, are certified† as qualified product according to USCi’s internal requirements.

† This report and its conclusions do not imply any guarantee, warranty, or suitability for any purpose regarding the products mentioned. Results represent the particular devices tested, which were randomly selected according to the sampling plan described herein.

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