HestiaPower

Hestia-Power 650V Silicon Carbide Schottky Barrier Diode (H3D Series) Qualification Report

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Introduction

The qualification test report is about Hestia-Power 650V silicon carbide (SiC) Schottky barrier diode (H3D Series). Based on these results and generic data from previous qualification report [1-7], the following part number are certified as qualified products. All qualification test methods and criteria are performed based on AEC-Q101 [8] or JEDEC Standards [9-13]. Before and after each qualification test, parameter verification is implemented as a minimum.

				H3D065E040
H3D065N020	H3D065A020	H3D065H020	H3D065F020	H3D065E020
H3D065N015	H3D065A015	H3D065H015		
H3D065N012	H3D065A012	H3D065H012		
H3D065N010	H3D065A010	H3D065H010		
H3D065N008	H3D065A008	H3D065H008		
H3D065N006	H3D065A006	H3D065H006		
H3D065N005	H3D065A005	H3D065H005		
H3D065N004	H3D065A004	H3D065H004		

			H3D065T020*	H3D065U020*
			H3D065T015*	H3D065U015*
H3D065X012	H3D065S012*	H3D065K012*	H3D065T012*	H3D065U012*
H3D065X010	H3D065S010*	H3D065K010*	H3D065T010*	H3D065U010*
H3D065X008	H3D065S008*	H3D065K008*	H3D065T008*	H3D065U008*
H3D065X006	H3D065S006*	H3D065K006*	H3D065T006*	H3D065U006*
H3D065X005	H3D065S005*	H3D065K005*	H3D065T005*	H3D065U005*
H3D065X004	H3D065S004*	H3D065K004*	H3D065T004*	H3D065U004*

Package types:

A = TO-220-R2L, H = TO-220-2L, X = TO-220-FP-R2L

S = TO-252-2L, K = TO-252-2L-1NC, T = TO-263-2L, U = TO-263-2L-1NC

N = bare die (top Al), F = TO-247-3L, E = TO-247-3L (dual die)

*Surface-mount devices (S, K, T and U series) qualified to MSL-3

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Failure Criteria

A device failure is defined as the device does not satisfy the specifications of its data sheet or exhibit external damage attributed to the environment test.

Definition of a Qualification Family

A qualification family is defined as meeting the following criteria based on AEC-Q101:

1. The same process technology.
2. The same fab site and fab process such as epi process and thickness, design rules, process flow, lithographic process, cell density, doping process, passivation process, front/back metal materials and thickness, and so on.
3. The same package assembly site and the same package type.
4. The same assembly process such as leadframe base material, die attach material and method, wirebond material and method, mold compound material, and so on.

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Qualification Test Item

The qualification test item of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 1.

Table 1：Hestia-Power 650V SiC Schottky Barrier Diode Qualification Test Item

Test Item	Test Condition	Reference
Parameter Verification	Evaluate Data Sheet Specifications	AEC-Q101-D
External Visual Inspection	Observe External Surfaces	AEC-Q101-D
Autoclave	T_a=121°C, 100%RH, 2atm, 96hr	JESD22-A102
Temperature Cycle	-65°C to 150°C, 1000cycles	JESD22-A104
Temperature Cycle	-55°C to 150°C, 1000cycles	JESD22-A104
H3TRB	V_R=100V, T_a=85°C, 85%RH, 1000hr	JESD22-A101
HAST	V_R=42V, T_a=130°C, 85%RH, 96hr	JESD22-A110
HTRB	V_R=650V, T_a=175°C, 1000hr	JESD22-A108
Intermittent Operating Life	ΔT_j>100°C, 15000cycles	MIL-STD-750 Method 1037
ESD-HBM	8000V	AEC-Q101-001
ESD-CDM	1000V	AEC-Q101-005

Note1: (V_R = reverse bias, T_a = ambient temperature, T_j = junction temperature)

Note2: HAST as alternative for H3TRB

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Qualification Test Description and Result

Parameter Verification (PV)

Parameter Verification is implemented to evaluate whether the devices is failure after each qualification test. According to AEC-Q101-REV-D, for diodes, there are minimum parameters which must be verified such as forward voltage (Vf), breakdown voltage (Vbd), and leakage current (Ir).

The parameter verification result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 2.

Table 2：Hestia-Power 650V SiC Schottky Barrier Diode Parameter Verification Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065H020	Evaluate Data Sheet Specifications	1	100	0	Pass
H3D065H012	Evaluate Data Sheet Specifications	1	100	0	Pass
H3D065H010	Evaluate Data Sheet Specifications	2	616	0	Pass
H3D065A020	Evaluate Data Sheet Specifications	1	385	0	Pass
H3D065A012	Evaluate Data Sheet Specifications	1	154	0	Pass
H3D065A010	Evaluate Data Sheet Specifications	2	810	0	Pass
H3D065A008	Evaluate Data Sheet Specifications	1	308	0	Pass
H3D065A005	Evaluate Data Sheet Specifications	1	445	0	Pass
H3D065X012	Evaluate Data Sheet Specifications	1	77	0	Pass
H3D065X005	Evaluate Data Sheet Specifications	1	385	0	Pass

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External Visual (EV)

External Visual is used to evaluate whether the device package has external physical damage during the qualification tests. No visual defects were found after each qualification test.

The external visual result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 3.

Table 3：Hestia-Power 650V SiC Schottky Barrier Diode External Visual Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065H020	Observe External Surfaces	1	100	0	Pass
H3D065H012	Observe External Surfaces	1	100	0	Pass
H3D065H010	Observe External Surfaces	2	616	0	Pass
H3D065A020	Observe External Surfaces	1	385	0	Pass
H3D065A012	Observe External Surfaces	1	154	0	Pass
H3D065A010	Observe External Surfaces	2	810	0	Pass
H3D065A008	Observe External Surfaces	1	308	0	Pass
H3D065A005	Observe External Surfaces	1	445	0	Pass
H3D065X012	Observe External Surfaces	1	77	0	Pass
H3D065X005	Observe External Surfaces	1	385	0	Pass

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Autoclave (AC)

Autoclave testing is used to determine the moisture resistance of non-hermetic packaged device. The device is subjected to highly humid atmosphere under pressure to force moisture into package. If there are weaknesses such as delamination and metallization corrosion, moisture can penetrate through the protective layer and leads to qualification failure.

The autoclave result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 4.

Table 4：Hestia-Power 650V SiC Schottky Barrier Diode Autoclave Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065H020	T_a=121°C, 100%RH, 2atm, 96hr	1	25	0	Pass
H3D065H012	T_a=121°C, 100%RH, 2atm, 96hr	1	25	0	Pass
H3D065H010	T_a=121°C, 100%RH, 2atm, 96hr	2	154	0	Pass
H3D065A020	T_a=121°C, 100%RH, 2atm, 96hr	1	77	0	Pass
H3D065A012	T_a=121°C, 100%RH, 2atm, 96hr	1	77	0	Pass
H3D065A010	T_a=121°C, 100%RH, 2atm, 96hr	2	154	0	Pass
H3D065A008	T_a=121°C, 100%RH, 2atm, 96hr	1	77	0	Pass
H3D065A005	T_a=121°C, 100%RH, 2atm, 96hr	1	77	0	Pass
H3D065X012	T_a=121°C, 100%RH, 2atm, 96hr	1	77	0	Pass
H3D065X005	T_a=121°C, 100%RH, 2atm, 96hr	1	77	0	Pass

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Temperature Cycle (TC)

Temperature Cycle testing is used to evaluate the ability of devices and solder interconnects when mechanical stresses are induces by alternating low- and high-temperature cycles. The coefficient of thermal expansion (CTE) mismatch between materials results in mechanical stresses and permanent changes in electrical and/or physical characteristics.

The temperature cycle result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 5.

Table 5：Hestia-Power 650V SiC Schottky Barrier Diode Temperature Cycle Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065A020	-65℃ to 150℃, 1000cycles	1	77	0	Pass
H3D065A010	-65℃ to 150℃, 1000cycles	1	77	0	Pass
H3D065A010	-55℃ to 150℃, 1000cycles	1	77	0	Pass
H3D065A005	-65℃ to 150℃, 1000cycles	1	77	0	Pass
H3D065X005	-65℃ to 150℃, 1000cycles	1	77	0	Pass

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H3TRB / HAST

High humidity, high temperature reverse bias (H3TRB) or highly accelerated stress test (HAST) testing is performed to determine the reliability of non-hermetic packaged device in humid environments. Temperature, humidity, and bias conditions are applied to accelerate the penetration of moisture through the external protective material and lead to moisture-related failure.

The H3TRB/HAST result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 6.

Table 6：Hestia-Power 650V SiC Schottky Barrier Diode H3TRB Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065H020	V_R=100V, T_a=85°C, 85%RH, 1000hr	1	25	0	Pass
H3D065H012	V_R=100V, T_a=85°C, 85%RH, 1000hr	1	25	0	Pass
H3D065H010	V_R=100V, T_a=85°C, 85%RH, 1000hr	2	154	0	Pass
H3D065A020	V_R=100V, T_a=85°C, 85%RH, 1000hr	1	77	0	Pass
H3D065A010	V_R=100V, T_a=85°C, 85%RH, 1000hr	2	154	0	Pass
H3D065A008	V_R=100V, T_a=85°C, 85%RH, 1000hr	1	77	0	Pass
H3D065A005	V_R=42V, T_a=130°C, 85%RH, 96hr	1	77	0	Pass
H3D065X005	V_R=42V, T_a=130°C, 85%RH, 96hr	1	77	0	Pass

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HTRB

High temperature reverse bias (HTRB) testing is designed to evaluate the breakdown robustness of devices under high temperature and high electric field. The device is stressed by 100% of its reverse blocking voltage under high temperature can result in early-life failure and field-accelerated failure.

The HTRB result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 7.

Table 7：Hestia-Power 650V SiC Schottky Barrier Diode HTRB Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065H020	V_R=650V, T_a=175°C, 1000hr	1	25	0	Pass
H3D065H012	V_R=650V, T_a=175°C, 1000hr	1	25	0	Pass
H3D065H010	V_R=650V, T_a=175°C, 1000hr	2	154	0	Pass
H3D065A020	V_R=650V, T_a=175°C, 1000hr	1	77	0	Pass
H3D065A012	V_R=650V, T_a=175°C, 1000hr	1	77	0	Pass
H3D065A010	V_R=650V, T_a=175°C, 1000hr	2	154	0	Pass
H3D065A008	V_R=650V, T_a=175°C, 1000hr	1	77	0	Pass
H3D065A005	V_R=650V, T_a=175°C, 1000hr	1	77	0	Pass
H3D065X005	V_R=650V, T_a=175°C, 1000hr	1	77	0	Pass

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Intermittent Operating Life (IOL)

Intermittent Operating Life testing is used to accelerate the failure cause due to thermal mechanism. When he device is switched from zero bias to forward bias to achieve a variation in junction temperature (T_j) greater than 100℃, the coefficient of thermal expansion (CTE) mismatch between materials results in mechanical stresses and permanent changes in electrical and/or physical characteristics.

The intermittent operating life result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 8.

Table 8：Hestia-Power 650V SiC Schottky Barrier Diode IOL Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065H020	ΔT_j>100°C, 15000cycles	1	25	0	Pass
H3D065H012	ΔT_j>100°C, 15000cycles	1	25	0	Pass
H3D065H010	ΔT_j>100°C, 15000cycles	2	154	0	Pass
H3D065A020	ΔT_j>100°C, 15000cycles	1	77	0	Pass
H3D065A010	ΔT_j>100°C, 15000cycles	2	154	0	Pass
H3D065A008	ΔT_j>100°C, 15000cycles	1	77	0	Pass
H3D065A005	ΔT_j>100°C, 15000cycles	1	77	0	Pass
H3D065X005	ΔT_j>100°C, 15000cycles	1	77	0	Pass

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Electrostatic Discharge (ESD)

Electrostatic Discharge testing is implemented to evaluate the robustness of electrostatic charge accumulation. The source of electrostatic discharge is including of human body, robot arm, product packaging and so on.

Human Body Model (HBM)

Electrostatic Discharge - Human Body Model testing is used to simulate the electrostatic charge transfers from human body to devices through pin during manual device handling.

The ESD-HBM result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 9.

Table 9：Hestia-Power 650V SiC Schottky Barrier Diode ESD-HBM Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065A005	8000V	1	30	0	PASS
H3D065A010	8000V	2	20	0	PASS

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Charged Device Model (CDM)

Electrostatic Discharge – Charged Device Model is used to simulate the electrostatic charge that accumulating in devices and discharge during manual device handling or pin grounding.

The ESD-CDM result of Hestia-Power 650V SiC Schottky barrier diode is outlined in Table 10.

Table 10：Hestia-Power 650V SiC Schottky Barrier Diode ESD-CDM Result

Device	Test Condition	Lots	Total Sample Size	Failed Size	Result
H3D065A005	1000V	1	30	0	PASS
H3D065A010	1000V	2	20	0	PASS

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Conclusion

Hestia-Power 650V SiC Schottky barrier diode (H3D Series) passed the qualification test based on JEDEC Standards or AEC-Q101-D. In total, 3380 devices were from 12 batches evaluated in reliability stress test. As a result, no failure sample was found. The qualification result of Hestia-Power 650V SiC Schottky barrier diode (H3D Series) is done and summarized in Table11.

Table 11：Hestia-Power 650V SiC Schottky Barrier Diode (H3D Series) Qualification Result

Test Item	Total Sample Size	Failed Size	Result
Parameter Verification (PV)	3380	0	PASS
External Visual Inspection (EV)	3380	0	PASS
Autoclave (AC)	820	0	PASS
Temperature Cycle (TC)	385	0	PASS
H3TRB / HAST	666	0	PASS
HTRB	743	0	PASS
Intermittent Operating Life (IOL)	666	0	PASS
ESD-HBM	50	0	PASS
ESD-CDM	50	0	PASS

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Reference

[1] Hestia-Power JBS 650V TO-220-2L (H-type) family qual. Report

[2] Hestia-Power JBS 650V TO-252-2L (S-type and K-type) family qual. Report

[3] Hestia-Power JBS 650V TO-263-2L (T-type and U-type) family qual. Report

[4] Hestia-Power JBS 650V TO-247-3L (F-type) family qual. Report

[5] Hestia-Power JBS TO-247-3L (E-type) family qual. Report

[6] Hestia-Power JBS 650V TO-220-2L (A-type) family qual. Report

[7] Hestia-Power JBS 650V TO-220-FP-2L (X-type) family qual. Report

[8] AEC-Q101-D Automotive Electronics Council Q101 REV D

[9] JESD22-A101 Steady State Temperature Humidity Bias Life Test

[10] JESD22-A102 Accelerated Moisture Resistance – Unbiased Autoclave

[11] JESD22-A104 Temperature Cycling

[12] JESD22-A108 Temperature, Bias, and Operating Life

[13] MIL-STD-750 Military Standard 750

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