PRODUCT RELIABILITY REPORT

Platform: S650E2.0

--650V E-Mode GaN FET

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1. Product Information

Platform	S650E2.0
BV Rating(V)	650
Process Technology	GaN on Silicon

2. Scope

The testing matrix in this reliability report covers the reliability of INN650D140A (platform product) listed in the below table. Others as spin-off product have the same die process and design rules as INN650D140A.

A reliability qualification by similarity matrix approach is applied, as for the product numbers shown in below table formed by associated die family (same die process and design rules). The reason of reliability qualification by similarity is that all potential failure mechanisms for the product numbers in the table included could be represented by the samples of each individual test.

Category	Product Number	Package	BV Rating(V)
Platform	INN650D140A	DFN 8x8	650
Spin-off	INN650DA140A	DFN 5x6	650
Spin-off	INN650N140A	/	650
Spin-off	INN650D190A	DFN 8x8	650
Spin-off	INN650DA190A	DFN 5x6	650
Spin-off	INN650N190A	/	650
Spin-off	INN650D240A	DFN 8x8	650
Spin-off	INN650DA240A	DFN 5x6	650
Spin-off	INN650N240A	/	650
Spin-off	INN650D350A	DFN 8x8	650
Spin-off	INN650DA350A	DFN 5x6	650
Spin-off	INN650N350A	/	650
Spin-off	INN650DA500A	DFN 5x6	650
Spin-off	INN650N500A	/	650
Spin-off	INN650DA600A	DFN 5x6	650
Spin-off	INN650N600A	/	650
Spin-off	INN650N05	/	650
Spin-off	INN650N2K2A	/	650

Note: Wafer level products are verified on packaged device.

3. Reliability Tests

Innoscience's E-mode GaN FETs were subjected to a variety of reliability test under the condition referenced to typical for silicon-based power MOSFETs. These test items and results were shown as below:

Platform(INN650D140A)				
Test Items	**Test Conditions**	**Sample Size (Unit x Lot)**	**#Fail**	**Result**
HTRB	T=150°C, V_{DS}= 520V, 1000hrs	77 x 3	0 Fail	Pass
HTGB	T=150°C, V_{GS}= 6.5V, 1000hrs	77 x 3	0 Fail	Pass
TC	-55 to +150°C, Air, 1000Cys	77 x 3	0 Fail	Pass
HAST	T=130°C, RH=85%, V_{DS}=100V, 96hrs	77 x 3	0 Fail	Pass
H^3TRB	T=85°C, RH=85%, V_{DS}=520V, 1000hrs	77 x 3	0 Fail	Pass
MSL3	T=30°C, RH=60%, 3 x reflow, 192hrs	25 x 3	0 Fail	Pass
HBM	All Pins	3 x 1	0 Fail	Class 2
CDM	All Pins	3 x 1	0 Fail	Class C3
HTOL (QR-PFC)	Tj=125°C, Input: 90 Vac, Output: 20V/6.5A, F=120KHz(QR)/100KHz(PFC)	10 x 3	0 Fail	Pass

Spin-off Product				
Test Items	**Test Conditions**	**Sample Size/Product (Unit x Lot)/Product**	**#Fail**	**Result**
HTRB	T=150°C, V_{DS}= 520V, 168hrs	77 x 1	0 Fail	Pass
HTGB	T=150°C, V_{GS}= 6.5V, 168hrs	77 x 1	0 Fail	Pass
TC	-55 to +150°C, Air, 1000Cys	77 x 1	0 Fail	Pass
HAST	T=130°C, RH=85%, V_{DS}=100V, 96hrs	77 x 1	0 Fail	Pass
H^3TRB	T=85°C, RH=85%, V_{DS}=520V, 1000hrs	77 x 1	0 Fail	Pass
MSL3	T=30°C, RH=60%, 3 x reflow, 192hrs	25 x 1	0 Fail	Pass

High Temperature Reverse Bias (HTRB)

Parts were subjected to 80% of the rated drain-source voltage at the maximum rated temperature for a stress period of 1000 hours. The testing was done in accordance with the JEDEC Standard JESD22-A108.

Pass criteria: All units must pass the min/max limits of the datasheet.

Test Item	Product Number	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)
HTRB	INN650D140A	T=150°C, V_{DS}= 520V	0	77 x 3	1000
	INN650DA190A	T=150°C, V_{DS}= 520V	0	77 x 1	168
	INN650DA240A	T=150°C, V_{DS}= 520V	0	77 x 1	168
	INN650DA350A	T=150°C, V_{DS}= 520V	0	77 x 1	168
	INN650DA500A	T=150°C, V_{DS}= 520V	0	77 x 1	168
	INN650DA600A	T=150°C, V_{DS}= 520V	0	77 x 1	168
	INN650N05	T=150°C, V_{DS}= 520V	0	77 x 1	168
	INN650N2K2A	T=150°C, V_{DS}= 520V	0	77 x 1	168

High Temperature Gate Bias (HTGB)

Parts were subjected to 6.5V gate-source bias at the maximum rated temperature for a stress period of 1000 hours. The testing was done in accordance with the JEDEC Standard JESD22-A108.

Pass criteria: All units must pass the min/max limits of the datasheet.

Test Item	Product Number	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)
HTGB	INN650D140A	T=150°C, V_{GS}= 6.5V	0	77 x 3	1000
	INN650DA190A	T=150°C, V_{GS}= 6.5V	0	77 x 1	168
	INN650DA240A	T=150°C, V_{GS}= 6.5V	0	77 x 1	168
	INN650DA350A	T=150°C, V_{GS}= 6.5V	0	77 x 1	168
	INN650DA500A	T=150°C, V_{GS}= 6.5V	0	77 x 1	168
	INN650DA600A	T=150°C, V_{GS}= 6.5V	0	77 x 1	168
	INN650N05	T=150°C, V_{GS}= 6.5V	0	77 x 1	168
	INN650N2K2A	T=150°C, V_{GS}= 6.5V	0	77 x 1	168

Temperature Cycling (TC)

Parts were subjected to temperature cycling between -55°C and +150°C for a total of 1000 cycles. Heating rate and cooling rate of 15°C/min. Dwell time of 5 minutes were used in accordance with the JEDEC Standard JESD22-A104.
Pass criteria: All units must pass the min/max limits of the datasheet.

Test Item	Product Number	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Cys)
TC	INN650D140A	-55 to +150°C, Air	0	77 x 3	1000
	INN650DA240A	-55 to +150°C, Air	0	77 x 1	1000
	INN650DA500A	-55 to +150°C, Air	0	77 x 3	1000

Highly Accelerated Temperature and Humidity Stress Test (HAST)

Parts were subjected to 100V drain-source bias at 85%RH and 130°C for a stress period of 96 hours. The testing was done in accordance with the JEDEC Standard JESD22-A110.
Pass criteria: All units must pass the min/max limits of the datasheet.

Test Item	Product Number	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)
HAST	INN650D140A	T=130°C, RH=85%, V_{DS}=100V	0	77 x 3	96
	INN650DA240A	T=130°C, RH=85%, V_{DS}=100V	0	77 x 1	96
	INN650DA500A	T=130°C, RH=85%, V_{DS}=100V	0	77 x 3	96

High Humidity, High Temperature Reverse Bias (H^3TRB)

Parts were subjected to 80% of the rated drain-source bias at 85%RH and 85°C for a stress period of 1000 hours. The testing was done in accordance with the JEDEC Standard JESD22-A101.
Pass criteria: All units must pass the min/max limits of the datasheet.

Test Item	Product Number	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)
H^3TRB	INN650D140A	T=85°C, RH=85%, V_{DS}=520V	0	77 x 3	1000
	INN650DA240A	T=85°C, RH=85%, V_{DS}=520V	0	77 x 1	1000
	INN650DA500A	T=85°C, RH=85%, V_{DS}=520V	0	77 x 3	1000

Moisture Sensitivity Level (MSL3)

Parts were baked at 125°C for 24 hours, and then subjected to 60%RH at 30°C for a stress period of 192hours. The parts were also subjected to three cycles of Pb-free reflow in accordance with the IPC/JEDEC standard J-STD-020.

Pass criteria: All units must pass the min/max limits of the datasheet.

Test Item	Product Number	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)
MSL3	INN650D140A	T=30°C, RH=60%, 3 x reflow	0	25x 3	192
	INN650DA240A	T=30°C, RH=60%, 3 x reflow	0	25x 1	192
	INN650DA500A	T=30°C, RH=60%, 3 x reflow	0	25x 3	192

Electro-Static discharge (ESD)

Parts were subjected to HBM (ESDA/JEDEC JS-001) and CDM (ESDA/JEDEC JS-002) test to guarantee that the device can with stand electrostatic voltages during handling.

Pass criteria: All units must pass the min/max limits of the datasheet.

Test Item	Product Number	Test Condition	Passed Voltage	JEDEC Class
HBM	INN650D140A	All Pins	(±) 2000V	Class 2
CDM	INN650D140A	All Pins	(±) 2000V	Class C3
HBM	INN650DA190A	All Pins	(±) 2000V	Class 2
CDM	INN650DA190A	All Pins	(±) 2000V	Class C3
HBM	INN650DA240A	All Pins	(±) 2000V	Class 2
CDM	INN650DA240A	All Pins	(±) 2000V	Class C3
HBM	INN650DA350A	All Pins	(±) 2000V	Class 2
CDM	INN650DA350A	All Pins	(±) 2000V	Class C3
HBM	INN650DA500A	All Pins	(±) 2000V	Class 2
CDM	INN650DA500A	All Pins	(±) 2000V	Class C3
HBM	INN650DA600A	All Pins	(±) 2000V	Class 2
CDM	INN650DA600A	All Pins	(±) 2000V	Class C3
HBM	INN650N05	All Pins	(±) 2000V	Class 2
CDM	INN650N05	All Pins	(±) 2000V	Class C3
HBM	INN650N2K2A	All Pins	(±) 1000V	Class 1C
CDM	INN650N2K2A	All Pins	(±) 500V	Class C2a

High Temperature Operating Life (HTOL)

Parts were subjected to AC-to-DC system test adapted QR topology at Tj=125°C for a stress period of 1000 hours.
Pass criteria: All units efficiency shift lower 0.2%.

Test Item	Product Number	Application	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)
HTOL	INN650D140A	QR-PFC	Tj=125°C, Input: 90 Vac, Output: 20V/6.5A , F=120KHz(QR)/100KHz(PFC)	0	10 x 3	1000

Revision/Updated History

Revision	Reason for Change	Date	Prepared by	Approved by
1.0	Final release	Nov./27/2021	Huahui Wang	Blanck, Director/Felix, Vice President
1.1	1. Add INN650N05 2. Update ESD information	Jan./25/2022	Huahui Wang	Blanck, Director/Felix, Vice President
1.2	Add INN650DA2K2A	Apr./1/2022	Huahui Wang	Blanck, Director/Felix, Vice President
1.3	Modify HTOL test condition	Apr./11/2022	Huahui Wang	Blanck, Director/Felix, Vice President
1.4	1. Add INN650DA190A 2. Add INN650DA350A 3. Add INN650DA600A	May/25/2022	Huahui Wang	Blanck, Director/Felix, Vice President
1.5	1. Add INN650N05 2. Updated ESD information	July/28/2022	Huahui Wang	Blanck, Director/Felix, Vice President