PRODUCT RELIABILITY REPORT

Platform: S650E2.5

--650V E-Mode GaN FET

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1. Product Information

Platform	S650E2.5
BV Rating(V)	650
Process Technology	GaN on Silicon

2. Scope

The testing matrix in this reliability report covers the reliability of INN650TA030AH (platform product) listed in the below table. Device spin-off products have the same die process and design rules with INN650TA030AH.

Reliability qualification by similarity matrix approach is applied, 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	INN650TA030AH	TOLL	650
Spin-off	INN650TA050AH	TOLL	650
Spin-off	INN650TA070AH	TOLL	650
Spin-off	INN650D070AH	DFN 8 x 8	650
Spin-off	INN650N070AH	Wafer	650

Note: INN650D070AH product compared to INN650TA030AH with same die process and design rules，But DFN8*8 as new package type need requalification.

Reliability test items and results were shown as below:

Platform product (INN650TA030AH)				
Test Items	**Test Conditions**	**Sample Size (Unit x Lot)**	**#Fail**	**Result**
HTRB	T=150°C, VDS= 560V	77 x 3	0 Fail	Pass
HTGB	T=150°C, VGS= 7V	77 x 3	0 Fail	Pass
HTGB (-)	T=150°C, VGS= -6V	77 x 3	0 Fail	Pass
LTRB	T=-40°C, VDS= 650V	77 x 1	0 Fail	Pass
LTGB	T=-40°C, VGS= 7V	77 x 1	0 Fail	Pass
LTGB (-)	T=-40°C, VGS= -6V	77 x 1	0 Fail	Pass
TC	-55 to +150°C, Air	77 x 3	0 Fail	Pass
HAST	T=130°C, RH=85%, VDS=100V	77 x 3	0 Fail	Pass
H3TRB	T=85°C, RH=85%, VDS=560V	77 x 3	0 Fail	Pass
HTS	T=150°C	77 x 3	0 Fail	Pass
IOL	ΔTj ≥ 100℃, Ton=Toff=2min	77 x 1	0 Fail	Pass
Solderability	1. Precondition: 8H 2. Pb-free, 245±5°C, 5±0.5S.	10 x 1	0 Fail	Pass
HTOL	Vplatform=450V,Irms=15A, Fre=65KHZ,Tj=125°C	8sets x 3	0 Fail	Pass
MSL3	T=30°C, RH=60%,3 x reflow	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

New package type product (INN650D070AH)				
Test Items	**Test Conditions**	**Sample Size (Unit x Lot)**	**#Fail**	**Result**
HTRB	T=150°C, V_{DS}= 560V	77 x 1	0 Fail	Pass
HTGB	T=150°C, V_{GS}= 7V	77 x 1	0 Fail	Pass
HTGB (-)	T=150°C, V_{GS}= -6V	77 x 1	0 Fail	Pass
TC	-55 to +150°C, Air	77 x 3	0 Fail	Pass
HAST	T=130°C, RH=85%, V_{DS}=100V	77 x 3	0 Fail	Pass
H^3TRB	T=85°C, RH=85%, V_{DS}=560V	77 x 3	0 Fail	Pass
Solderability	1. Precondition: 8H 2. Pb-free, 245±5°C, 5±0.5S.	10 x 1	0 Fail	Pass
MSL3	T=30°C, RH=60%,3 x reflow	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

Note: Wafer product reliability is 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:

High Temperature Reverse Bias (HTRB)

Parts were subjected to 560V 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	INN650TA030AH	T=150°C, V_{DS}= 560V	0	77 x 3	1000
	INN650TA050AH	T=150°C, V_{DS}= 560V	0	77 x 1	168
	INN650D070AH	T=150°C, V_{DS}= 560V	0	77 x 1	168

Note: INN650TA070AH/INN650N070AH the same device with INN650D070AH, refer to INN650D070AH.

High Temperature Gate Bias (HTGB)

Parts were subjected to 7V 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	INN650TA030AH	T=150°C, V_{GS}= 7V	0	77 x 3	1000
	INN650TA050AH	T=150°C, V_{GS}= 7V	0	77 x 1	168
	INN650D070AH	T=150°C, V_{GS}= 7V	0	77 x 1	168

Note: INN650TA070AH/INN650N070AH the same device with INN650D070AH, refer to INN650D070AH.

Negative High Temperature Gate Bias (HTGB-)

Parts were subjected to -6V 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-	INN650TA030AH	T=150°C, V_{GS}= -6V	0	77 x 3	1000
	INN650TA050AH	T=150°C, V_{GS}= -6V	0	77 x 1	168
	INN650D070AH	T=150°C, V_{GS}= -6V	0	77 x 1	168

Note: INN650TA070AH/INN650N070AH the same device with INN650D070AH, refer to INN650D070AH.

Low Temperature Reverse Bias (LTRB)

Parts were subjected to 650V drain-source voltage at -40℃ for a stress period of 1000 hours.

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)
LTRB	INN650TA030AH	T=-40°C, V_{DS}= 650V	0	77 x 1	1000

Low Temperature Gate Bias (LTGB)

Parts were subjected to 7V gate-source bias at -40℃ for a stress period of 1000 hours.

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)
LTGB	INN650TA030AH	T=-40°C, V_{GS}= 7V	0	77 x 1	1000

Negative Low Temperature Gate Bias (LTGB-)

Parts were subjected to -6V gate-source bias at -40℃ for a stress period of 1000 hours.

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)
LTGB-	INN650TA030AH	T=-40°C, V_{GS}= -6V	0	77 x 1	1000

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	INN650TA030AH	-55 to +150°C, Air	0	77 x 3	1000
	INN650D070AH	-55 to +150°C, Air	0	77 x 3	1000

Note: Other Spin off product is qualified by matrix.

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	INN650TA030AH	T=130°C, RH=85%, V_{DS}=100V	0	77 x 3	96
	INN650D070AH	T=130°C, RH=85%, V_{DS}=100V	0	77 x 3	96

Note: Other Spin off product is qualified by matrix.

High Humidity, High Temperature Reverse Bias (H3TRB)

Parts were subjected to 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	INN650TA030AH	T=85°C, RH=85%, V_{DS}=560V	0	77 x 3	1000
	INN650D070AH	T=85°C, RH=85%, V_{DS}=560V	0	77 x 3	1000

Note: Other Spin off product is qualified by matrix.

High Temperature Storage Life (HTSL)

Parts were subjected to 150°C for a stress period of 1000 hours. The testing was done in accordance with the JEDEC Standard JESD22-A103.

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)
HTSL	INN650TA030AH	T=150°C	0	77 x 3	1000
	INN650D070AH	T=150°C	0	77 x 3	1000

Note: Other Spin off product is qualified by matrix.

Intermittent Operational Life (IOL)

Parts are subjected to power cycled ΔTj≥100°C temperature range. Devices are heated through internal electrical power dissipation with combined gate and drain bias, and a regulated drain current. The testing was done in accordance with the Standard MIL-STD-750.

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 (cycles)
IOL	INN650TA030AH	ΔTj≥100℃,Ton=Toff=2min	0	77 x 1	15000

Solderability

Parts were subjected to surface mount process then reflow test. The testing was done in accordance with the Standard J-STD-002.

Pass criteria: Wetting area > 95%.

Test Item	Product Number	Test Condition	#Fail	Sample Size (Unit x Lot)
Solderability	INN650TA030AH	1. Precondition: 8H 2. Pb-free, 245±5°C, 5±0.5S.	0	10 x 1
	INN650D070AH	1. Precondition: 8H 2. Pb-free, 245±5°C, 5±0.5S.	0	10 x 1

Note: Other Spin off product is qualified by matrix.

High Temperature Operating Life (HTOL)

Parts were subjected to system test adapted H-bridge topology at Tj=125°C for a stress period of 1000 hours.

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

Test Item	Product Number	Application	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)

HTOL	INN650TA030AH	H-bridge	Vplatform=450V,Irms=15A, Fre=65KHZ,Tj=125°C	0	8sets x 3	1000

Note: Other Spin off product is qualified by matrix.

Moisture Sensitivity Level (MSL)

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	INN650TA030AH	T=30°C, RH=60%, 3 x reflow	0	25x 3	192
	INN650D070AH	T=30°C, RH=60%, 3 x reflow	0	25x 3	192

Note: Other Spin off product is qualified by matrix.

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	INN650TA030AH	All Pins	(±) 2000V	Class 2
CDM	INN650TA030AH	All Pins	(±) 1000V	Class C3
HBM	INN650TA050AH	All Pins	(±) 2000V	Class 2
CDM	INN650TA050AH	All Pins	(±) 1000V	Class C3
HBM	INN650TA070AH	All Pins	(±) 2000V	Class 2
CDM	INN650TA070AH	All Pins	(±) 1000V	Class C3
HBM	INN650D070AH	All Pins	(±) 2000V	Class 2
CDM	INN650D070AH	All Pins	(±) 1000V	Class C3

Note: Wafer level product is verified on packaged device.

Revision/Updated History

Revision	Reason for Change	Date	Prepared by	Approved by
1.0	Final release	Jan./31/2024	David Liao	Blanck, Director