PRODUCT RELIABILITY REPORT

Platform: S040E2.5

--40V E-Mode GaN FET

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1. Product Information

Platform	S040E2.5
BV Rating(V)	40
Process Technology	GaN on Silicon

2. Scope

The testing matrix in this reliability report covers the reliability of INN040FQ015A (platform product) listed in the below table. INN040FQ043A and INN030FQ015A as new design product has the same design rules as INN040FQ015A.

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	INN040FQ015A	FCQFN 5mmx4mm	40
New design	INN040FQ043A	FCQFN 3mmx4mm	40
New design	INN030FQ015A	FCQFN 5mmx4mm	30

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(INN040FQ015A)				
Test Items	**Test Conditions**	**Sample Size (Unit x Lot)**	**#Fail**	**Result**
MSL3	Ta=30°C, RH=60%, 3 x reflow, 192hrs	25 x 3	0 Fail	Pass
HTRB	Tj=150°C, VD=32V, 1000hrs	77 x 3	0 Fail	Pass
HTGB	Tj=150°C, VG=5.5V, 1000hrs	77 x 3	0 Fail	Pass
TC	-40 to +125°C, Air, 1000Cys	77 x 3	0 Fail	Pass
H^3TRB	Ta=85°C, RH=85%, VD=32V, 1000hrs	77 x 3	0 Fail	Pass
Solderability	Pre-Con: 8hrs Pb-free: 245±5°C, 5±0.5s	22 x 3	0 Fail	Pass
DHTOL	BUCK, Vin=12V, Vout=5V, Iout=15A, Fsw=1MHz, L=0.26uH, Tj=125°C	8 x 3	0 Fail	Pass
HBM	All Pins	3 x 1	0 Fail	Class 1B
CDM	All Pins	3 x 1	0 Fail	Class 2a

New Design Product(INN040FQ043A)				
Test Items	**Test Conditions**	**Sample Size/Product (Unit x Lot)/Product**	**#Fail**	**Result**
MSL3	Ta=30°C, RH=60%, 3 x reflow, 192hrs	25 x 3	0 Fail	Pass
HTRB	Tj=150°C, VD=40V, 1000hrs	77 x 3	0 Fail	Pass
LTRB	Tj=-40°C, VD=32V, 1000hrs	77 x 3	0 Fail	Pass
HTGB(+)	Tj=150°C, VG=6.0V, 1000hrs	77 x 3	0 Fail	Pass
HTGB(-)	Tj=150°C, VG=-4.0V, 1000hrs	77 x 3	0 Fail	Pass
LTGB(+)	Tj=-40°C, VG=6.0V, 1000hrs	77 x 3	0 Fail	Pass
LTGB(-)	Tj=-40°C, VG=-4.0V, 1000hrs	77 x 3	0 Fail	Pass
TC	-40 to +125°C, Air, 1000Cys	77 x 3	0 Fail	Pass
H^3TRB	Ta=85°C, RH=85%, VD=32V, 1000hrs	77 x 3	0 Fail	Pass
HAST	T=130℃, RH=85%, Vd=32V, 96hrs	77 x 3	0 Fail	Pass
uHAST	T=130℃, RH=85%, 96hrs	77 x 3	0 Fail	Pass

Solderability	Pre-Con: 8hrs Pb-free: 245±5°C, 5±0.5s	22 x 3	0 Fail	Pass
DHTOL	BUCK, Vin=32V, Vout=13.5V, Iout=10A, Fsw=1.2MHz, Tj=125°C, 1000hrs	22 x 3	0 Fail	Pass
HBM	All Pins	3 x 1	0 Fail	Class 1B
CDM	All Pins	3 x 1	0 Fail	Class 2a

New design Product(INN030FQ015A)				
Test Items	**Test Conditions**	**Sample Size (Unit x Lot)**	**#Fail**	**Result**
HTRB	Tj=150°C, VD=24V, 1000hrs	77 x 1	0 Fail	Pass
HTGB	Tj=150°C, VG=5.5V, 1000hrs	77 x 1	0 Fail	Pass
DHTOL	BUCK, Vin=24V, Vout=5V, Iout=15A, Fsw=500kHz, Tj=125°C, 1000hrs	8 x 1	0 Fail	Pass
HBM	All Pins	3 x 1	0 Fail	Class 1B
CDM	All Pins	3 x 1	0 Fail	Class 2a

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	INN040FQ015A	T=30°C, RH=60%, 3 x reflow	0	25x 3	192
	INN040FQ043A	T=30°C, RH=60%, 3 x reflow	0	25x 3	192

High Temperature Reverse Bias (HTRB)

Parts were subjected to 80%/100% 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	INN040FQ015A	Tj=150°C, V_{DS}= 32V	0	77 x 3	1000
	INN040FQ043A	Tj=150°C, V_{DS}= 40V	0	77 x 3	1000
	INN030FQ015A	Tj=150°C, V_{DS}= 24V	0	77 x 1	1000

Low Temperature Reverse Bias (LTRB)

Parts were subjected to 80% of the rated 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	INN040FQ043A	Tj=-40°C, V_{DS}= 32V	0	77 x 3	1000

High Temperature Gate Bias (HTGB+)

Parts were subjected to 5.5V/6.0V 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(+)	INN040FQ015A	Tj=150°C, V_{GS}= 5.5V	0	77 x 3	1000
	INN040FQ043A	Tj=150°C, V_{GS}= 6.0V	0	77 x 3	1000
	INN030FQ015A	Tj=150°C, V_{GS}= 5.5V	0	77 x 1	1000

Negative High Temperature Gate Bias (HTGB-)

Parts were subjected to -4V 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(-)	INN040FQ043A	Tj=150°C, V_{GS}= -4.0V	0	77 x 3	1000

Low Temperature Gate Bias (LTGB+)

Parts were subjected to 6.0V 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(+)	INN040FQ043A	Tj=-40°C, V_{GS}= 6.0V	0	77 x 3	1000

Negative Low Temperature Gate Bias (LTGB-)

Parts were subjected to -4V 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(-)	INN040FQ043A	Tj=-40°C, V_{GS}= -4.0V	0	77 x 3	1000

Temperature Cycling (TC)

Parts were subjected to temperature cycling between -40°C and +125°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	INN040FQ015A	-40 to +125°C, Air	0 Fail	77 x 3	1000
	INN040FQ043A	-40 to +125°C, Air	0 Fail	77 x 3	1000

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	INN040FQ015A	T=85°C, RH=85%, V_{DS}=32V	0	77 x 3	1000
	INN040FQ043A	T=85°C, RH=85%, V_{DS}=32V	0	77 x 3	1000

Highly Accelerated Temperature and Humidity Stress Test (HAST)

Parts were subjected to 80% of the rated 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	INN040FQ043A	Vd=32V, RH=85%, T=130℃	0	77 x 3	96

Accelerated Moisture Resistance- Unbiased HAST (uHAST)

Parts were subjected at 85%RH and 130°C for a stress period of 96 hours. The testing was done in accordance with the JEDEC Standard JESD22-A118.

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)
uHAST	INN040FQ043A	RH=85%, T=130℃	0	77 x 3	96

Solderability

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

Pass criteria: All samples pin solder area were wetting >95%.

Test Item	Product Number	Test Condition	# Fail	Sample Size (Unit x Lot)
Solderability	INN040FQ015A	Pre-Con: 8hrs Pb-free: 245±5°C, 5±0.5s	0 Fail	25 x 3
	INN040FQ043A	Pre-Con: 8hrs Pb-free: 245±5°C, 5±0.5s	0 Fail	25 x 3

Dynamic High Temperature Operating Life (DHTOL)

Parts were subjected to DC-to-DC system test adapted BUCK topology at Tj=125°C for a stress period of 1000 hours. The testing was done in accordance with the JEDEC standard JEP-180.

Pass criteria: All units efficiency shift lower 0.2%.

Test Item	Product Number	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)
DHTOL	INN040FQ015A	BUCK, Vin=12V, Vout=5V, Iout=15A, Fsw=500KHz, Tj=125°C	0 Fail	8 x 3	1000
	INN040FQ043A	BUCK, Vin=32V, Vout=13.5V, Iout=10A, Fsw=1.2MHz, Tj=125°C	0 Fail	22 x 3	1000
	INN030FQ015A	BUCK, Vin=24V, Vout=5V, Iout=15A, Fsw=500KHz, Tj=125°C	0 Fail	8 x 1	1000

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	INN040FQ015A	All Pins	(±) 500V	Class 1B
CDM	INN040FQ015A	All Pins	(±) 500V	Class 2a
HBM	INN040FQ043A	All Pins	(±) 500V	Class 1B
CDM	INN040FQ043A	All Pins	(±) 500V	Class 2a
HBM	INN030FQ015A	All Pins	(±) 500V	Class 1B
CDM	INN030FQ015A	All Pins	(±) 500V	Class 2a

Parts were mounted on to FR4 adaptor cards. Adaptor cards with two copper layers were used. The copper layer thickness was between 1 and 2 oz. SAC305 solder was used to mount the DUTs onto the adaptor cards.

Revision/Updated History

Revision	Reason for Change	Date	Prepared by	Approved by
1.0	Final release	Dec./01/2022	Ziliang Liu	Blanck, Director
1.1	Add INN040FQ043A uHAST/ 100%full rating HTRB results;	Mar./28/2023	Ziliang Liu	Blanck, Director
1.2	Add INN040FQ043A LTRB/HTGB(-)/LTGB(+)/LTGB(-) /DHTOL/ESD more samples results	Jan./10/2024	Ziliang Liu	Blanck, Director
1.3	Add INN030FQ015A Qual. Result	Jan./31/2024	Peng Qiu	Blanck, Director