PRODUCT RELIABILITY REPORT

Platform: B040E2.5

--40V E-Mode GaN FET

Reliability Department No. 39 Jin Yuan Er Rd. Hi-Tech District, Zhuhai City, 519085 Guangdong Province P.R. China Tel: 0756-3819888

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1. Product Information

Platform	B040E2.5
BV Rating(V)	40
Process Technology	GaN on Silicon

2. <u>Scope</u>

The testing matrix in this reliability report covers the reliability of INN040W048A (platform product) listed in the below table. Others as spin-off or new design products have the same die process and design rules as INN040W048A.

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	INN040W048A	WLCSP (2.1mmx2.1mm)	40
Spin off	INN040W080A	WLCSP (1.7mmx1.7mm)	40
Spin off	INN040W120A	WLCSP (1.2mmx1.7mm)	40
Spin off	INN040FQ012A	FCQFN (4.0mmx6.0mm)	40
Spin off	INV030FQ012A	FCQFN (4.0mmx6.0mm)	30

Note: INN040FQ012A as one spin-off product with new package, need Qual. 3lots environment related reliability. INV030FQ012A as a new design of INN040FQ012A, need Qual. 3lots device related reliability, package have the same process and design with INN040FQ012A, package related reliability reference to INN040FQ012A.

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3. Reliability Tests

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

Platform Product (INN040W048A)					
Test Items	Test Condition	Sample Size (Unit x Lot)	#Fail	Result	
MSL1	T=85°C, RH=85%, 3 x reflow, 168hrs	25 x 2	0 Fail	Pass	
HTRB	T=125°C, VD1=32V, 1000hrs	77 x 3	0 Fail	Pass	
HTRB	T=125°C, VD2=32V, 1000hrs	77 x 3	0 Fail	Pass	
HTGB	T=125°C, VG=5.5V, 1000hrs	77 x 3	0 Fail	Pass	
тс	-40 to +125°C, Air, 1000Cys	77 x 3	0 Fail	Pass	
H ³ TRB	T=85°C, RH=85%, VD1=32V, 1000hrs	77 x 3	0 Fail	Pass	
H ³ TRB	T=85°C, RH=85%, VD2=32V, 1000hrs	77 x 3	0 Fail	Pass	
HTSL	T=150°C, 1000hrs	77 x 3	0 Fail	Pass	
HTOL	Tj=125°C, Load current=7A, 1000hrs	32 x 3	0 Fail	Pass	
Drop test	Accelerometer: 1500G,Durations: 0.5ms, 90Drops	77 x 1	0 Fail	Pass	
Solderability	Pre-Con: 8hrs, Pb-free: 245±5°C, 5±0.5s	25 x 3	0 Fail	Pass	
НВМ	All Pins	3 x 1	0 Fail	Pass	
CDM	All Pins	3 x 1	0 Fail	Pass	

Spin off Product/New package Product					
Test Items	Test Condition	Sample Size (Unit x Lot)	#Fail	Result	
HTRB	T=125°C, VD1=32V, 168hrs	77 x 1	0 Fail	Pass	
HTRB	T=125°C, VD2=32V, 168hrs	77 x 1	0 Fail	Pass	
HTGB	T=125°C, VG=5.5V, 168hrs	77 x 1	0 Fail	Pass	
MSL3	T=30°C, RH=60%, 3 x reflow, 192hrs	25 x 2	0 Fail	Pass	
TC	-40 to +125°C, Air, 1000Cys	77 x 3	0 Fail	Pass	
H ³ TRB	T=85°C, RH=85%, VD1=32V, 1000hrs	77 x 3	0 Fail	Pass	
H ³ TRB	T=85°C, RH=85%, VD2=32V, 1000hrs	77 x 3	0 Fail	Pass	
HTSL	T=150°C, 1000hrs	77 x 3	0 Fail	Pass	
Drop test	Accelerometer: 1500G, Durations: 0.5ms, 90Drops	77 x 1	0 Fail	Pass	
Solderability	Pre-Con: 8hrs, Pb-free: 245 \pm 5°C, 5 \pm 0.5s	25 x 3	0 Fail	Pass	
HTOL	Tj=125°C, Load current, 168hrs	8 x1	0 Fail	Pass	
НВМ	All Pins	3 x 1	0 Fail	Pass	
CDM	All Pins	3 x 1	0 Fail	Pass	

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Moisture Sensitivity Level (MSL1)

Parts were baked at 125°C for 24 hours, and then subjected to 85%RH at 85°C for a stress period of 168 hours. 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)
MSL1	INN040W048A	T=85°C, RH=85%, 3 x reflow	0	25 x 2	168
MSL3	INN040FQ012A	T=30°C, RH=60%, 3 x reflow	0	25 x 2	192

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)
		T=125°C, VD1=32V, VD2=VG=0V	0	77 x 3	1000
	INN040W048A	T=125°C, VD2=32V, VD1=VG=0V	0	77 x 3	1000
HTRB		T=125°C, VD1=32V, VD2=VG=0V	0	77 x 1	168
	11110400080A	T=125°C, VD2=32V, VD1=VG=0V	0	77 x 1	168
	INN040W120A	T=125°C, VD1=32V, VD2=VG=0V	0	77 x 1	168
		T=125°C, VD2=32V, VD1=VG=0V	0	77 x 1	168
	INN040FQ012A	T=125°C, VD1=32V, VD2=VG=0V	0	77 x 1	168
		T=125°C, VD2=32V, VD1=VG=0V	0	77 x 1	168
		T=150°C, VD1=24V, VD2=VG=0V	0	77 x 3	1000
	INV030FQ012A	T=150°C, VD2=24V, VD1=VG=0V	0	77 x 3	1000

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High Temperature Gate Bias (HTGB)

Parts were subjected to 5.5V 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)
		T=125°C, VG=5.5V,	0	77 × 2	1000
	INN040W048A	VD1=VD2=Vsub=0V	0	77 X 3	1000
НТGВ		T=125°C, VG=5.5V,	0	77 x 1	168
	11110400080A	VD1=VD2=Vsub=0V	0		
	INN040W120A	T=125°C, VG=5.5V,	0	77 x 1	168
		VD1=VD2=Vsub=0V			
	INN040FQ012A	T=125°C, VG=5.5V,	0	77 x 1	168
		VD1=VD2=Vsub=0V			
		T=150°C, VG=5.5V,	0	77 x 3	1000
	INVUSUFQUIZA	VD1=VD2=Vsub=0V			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)
тс	INN040W048A	-40 to +125°C, Air	0	77 x 3	1000
	INN040FQ012A	-40 to +125°C, Air	0	77 x 3	1000

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High Humidity, High Temperature Reverse Bias (H³TRB)

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 data	asheet.
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Test Item	Product Number	Test Condition	Fail #	Sample Size (Unit x Lot)	Duration (Hrs)
		T=85°C, RH=85%, VD1=32V,	0	77 × 2	1000
H³TRB		VD2=VG=0V	0	// X 3	1000
	1111104070040A	T=85°C, RH=85%, VD2=32V,	0	77 x 3	1000
		VD1=VG=0V			
	INN040FQ012A	T=85°C, RH=85%, VD1=32V,	0	77 x 3	1000
		VD2=VG=0V	0		
		T=85°C, RH=85%, VD2=32V,	0	77 x 3	1000
		VD1=VG=0V			

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	INN040W048A	T=150°C	0	77 x 3	1000
	INN040FQ012A	T=150°C	0	77 x 3	1000

High Temperature Operating Life (HTOL)

Parts were subjected to a dynamic operating mode (on/off =2min/2min) with 7A on current and 20V

off drain bias at junction temperature 125°C for a stress period of 1000 hours. The testing was done

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in accordance with the Qual. Plan.

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)
HTOL	INN040W048A	Tj=125°C, Load current=7A	0	32 x 3	1000
	INN040W080A	Tj=125°C, Load current=7A	0	8 x 1	168
	INN040FQ012A	Tj=125°C, Load current=25A	0	8 x 1	168

Drop Test

Parts were subjected to half wave sin 1500G, 0.5ms for a stress period of 90 drops. The testing was done in accordance with the JEDEC joint standard JESD22-B111.

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)
Drop test	INN040W048A	Accelerometer: 1500G,	0	77 x 1	90
		Durations: 0.5ms			
	INN040FQ012A	Accelerometer: 1500G,	0	77 x 1	90
		Durations: 0.5ms			

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 was wetting >95%

Test Item	Product Number	Test Condition	Sample Size (Unit x Lot)	Fail criteria
Solderability	INN040W048A	Pre-Con: 8hrs	25 x 3	0 Fail
		Pb-free: 245 \pm 5°C, 5 \pm 0.5s		
	INN040FQ012A	Pre-Con: 8hrs	25 v 3	0 Fail
		Pb-free: 245 \pm 5°C, 5 \pm 0.5s	23 × 3	0 Tan

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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.

Test Item	Product Number	Test Condition	Passed Voltage	JEDEC Class
HBM		All Pins	(±) 400V	Class 1A
CDM	11110400048A	All Pins	(±) 750V	Class C2b
HBM		All Pins	(±) 400V	Class 1A
CDM	11110400080A	All Pins	(±) 550V	Class C2a
HBM		All Pins	(±) 350V	Class 1A
CDM	INN040W120A	All Pins	(±) 500V	Class C2a
HBM		All Pins	(±) 500V	Class 1B
CDM	INN040FQ012A	All Pins	(±) 750V	Class C2b
HBM		All Pins	(±) 800V	Class 1B
CDM	INVUSUFQUIZA	All Pins	(±) 300V	Class C1

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

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	May/30/2022	Weihong Li	Blanck, Director/Felix, VP
1.1	Add product INN040W080A	Jan./11/2023	Weihong Li	Blanck, Director
1.2	Add product INN040W120A	Feb./14/2023	Weihong Li	Blanck, Director
1.3	Add product INN040FQ012A	Jun./15/2023	Leileichen	Blanck, Director
1.4	Add product INV030FQ012A	Aug./15/2024	Peng Qiu	Leilei Chen, Manager/Jianping, VP

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