iCE40 FPGA Product Family Qualification Summary

Lattice Document # MS – 107008 March 2021

Contents

1.0 LATTICE PRODUCT QUALIFICATION PROGRAM

Lattice Semiconductor Corp. maintains a comprehensive reliability qualification program to assure that each product achieves its reliability goals. After initial qualification, the continued high reliability of Lattice products is assured through ongoing monitor programs as described in Lattice Semiconductor's Reliability Monitor Program Procedure (Doc. #101667). All product qualification plans are generated in conformance with Lattice Semiconductor's Qualification Procedure (Doc. #100164) with failure analysis performed in conformance with Lattice Semiconductor's Failure Analysis Procedure (Doc. #100166). Both documents are referenced in Lattice Semiconductor's Quality Assurance Manual, which can be obtained upon request from a Lattice Semiconductor sales office. Figure 1.1 shows the Product Qualification Process Flow.

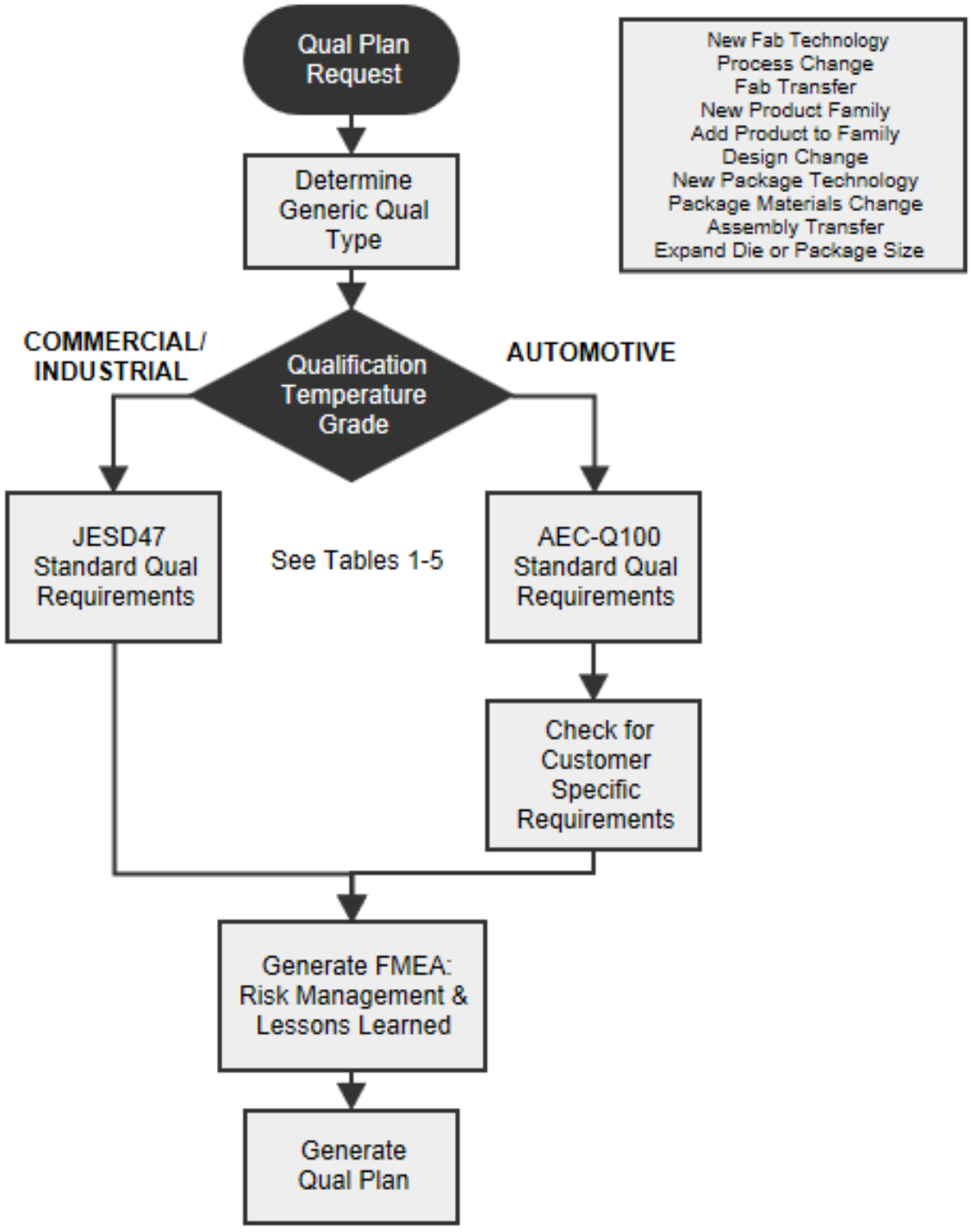
If failures occur during qualification, an 8D process is used to find root cause and eliminate the failure mode from the design, materials, or process. The effectiveness of any fix or change is validated through additional testing as required. Final testing results are reported in the qualification reports.

Product families are qualified based upon the requirements outlined in Table 1.2. In general, Lattice Semiconductor follows the current JEDEC Solid State Technology Association JESD47 Stress-Based Qualification testing methods. Package family qualification will include products with a wide range of circuit densities, package types, and package lead counts. Major changes to products, processes, or vendors require additional qualification before implementation in production.

Lattice Semiconductor maintains a regular reliability monitor program. The current Lattice Reliability Monitor Report can be found at Product Reliability Monitor Report.

Figure 1.0.1 Lattice Standard Product Qualification Process Flow

This diagram represents the standard qualification flow used by Lattice to qualify new Product Families. The target end market for the Product Family determines which flow options are used. The iCE40 Product Family was qualified using the Commercial / Industrial Qualification Option.



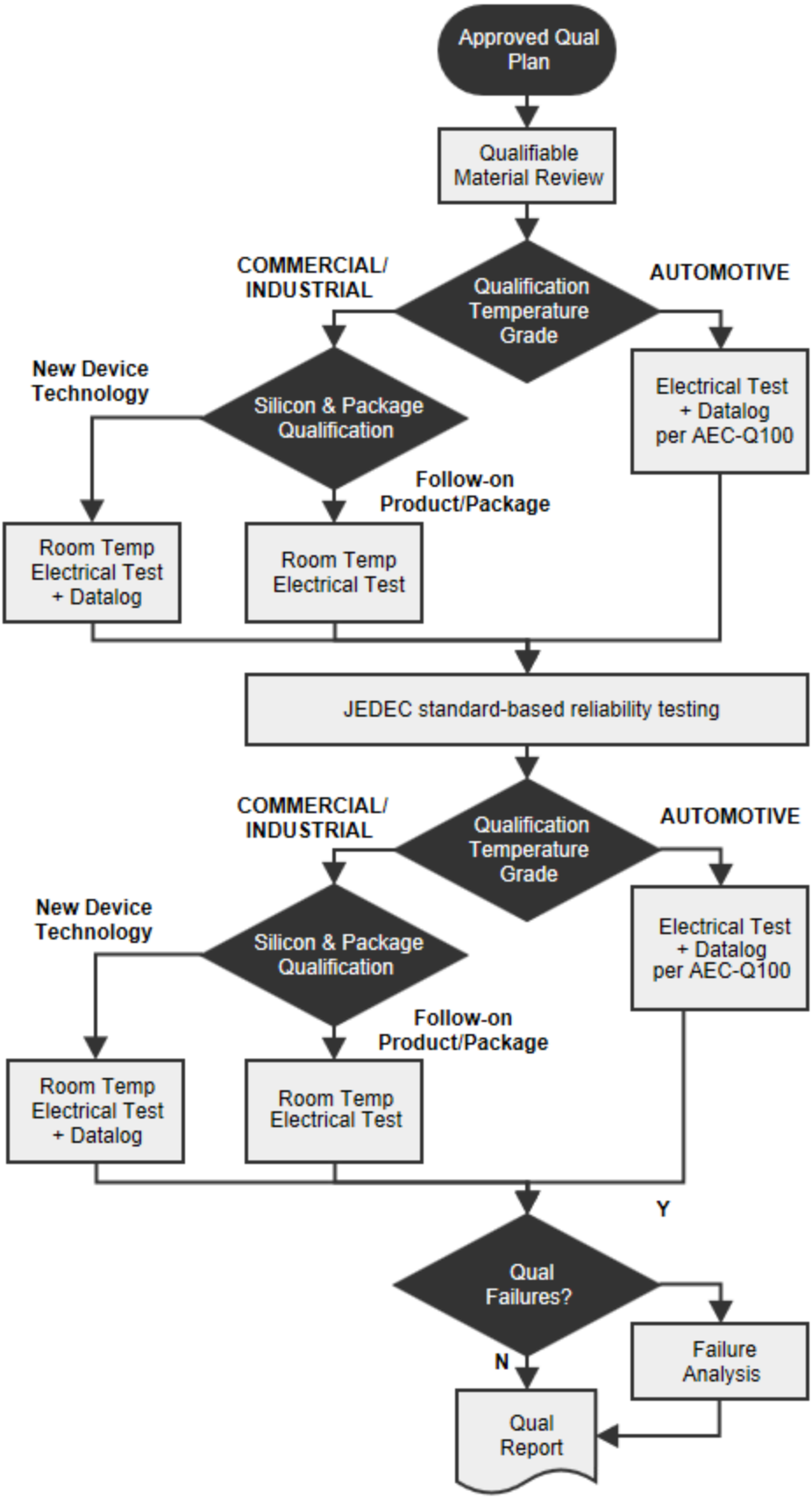

Approved Qual Plan
Qualifiable Material Review
COMMERCIAL/ INDUSTRIAL
Qualification Temperature Grade
AUTOMOTIVE
New Device Technology
Silicon & Package Qualification
Follow-on Product/Package
Electrical Test + Datalog per AEC-Q100
Room Temp Electrical Test + Datalog
Room Temp Electrical Test
JEDEC standard-based reliability testing
COMMERCIAL/ INDUSTRIAL
Qualification Temperature Grade
AUTOMOTIVE
New Device Technology
Silicon & Package Qualification
Follow-on Product/Package
Electrical Test + Datalog per AEC-Q100
Room Temp Electrical Test + Datalog
Room Temp Electrical Test
Y
Qual Failures?
N
Failure Analysis
Qual Report

Table 1.0.2 Qualification Tests for Components in Non-Hermetic Packages

TEST	STANDARD	TEST CONDITIONS
High Temperature Operating Life (HTOL)	JESD22-A108	≥125°C Tj and max operating supplies
Human Body Model ESD (HBM)	JS-001	25°C (Technology/Device dependent Performance Targets)
Charged Device Model ESD (CDM)	JESD22-C101 JS-002[1]	25°C (Technology/Device dependent Performance Targets)
Latch-Up (LU)	JESD78	Class II, +/-100mA trigger current and AMR operating supplies
Accelerated Soft Error Testing (ASER)	JESD89	25°C, Nominal operating supplies
Surface Mount Pre-conditioning (SMPC)	IPC/JEDEC J-STD-020 JESD-A113	Per appropriate MSL level per J-STD-020
High Temp Storage Life (HTSL)	JESD22-A103	Condition B
Temperature Cycling (TC)	JESD22-A104	Condition B, soak mode 2 (typical)
Temperature Humidity Bias, THB (85/85) or Biased HAST(HAST)	JESD22-A101 JESD22-A110	85°C, 85 % RH, max operating supplies or 110°C, 85 % RH, max operating supplies or 130°C, 85 % RH, max operating supplies
Unbiased Temperature/Humidity (UHAST)	JESD22-A118	110°C, 85 % RH or 130°C, 85 % RH

Table 1.0.3 Industry Standard Qualification Testing for WLCSP Packages

STRESS TEST	STANDARD	TEST CONDITIONS	PASS CONDITION	SAMPLE SIZE
Slow-Temperature Cycling	JEDEC JESD22-A104 IPC-JEDEC9701A	Condition G, soak mode 2 (-40°C to 125°C, 7.5 min soak) 1-2 CPH for 3000 cycles	208 Cycles, Zero fails	25 per lot x 3 lots
Bend Qualification	JEDEC JESD22-B113 IPC-JEDEC9702	200,000 bends of test boards at 1 to 3 Hz with maximum cross-head displacement of 4 mm	20,000 Bends, Zero fails	4 boards x 9 units/board x 3 lots
Drop Qualification Condition B (Handheld apps)	JEDEC JESD22-B111 IPC-JEDEC9703	1500Gs drops 0.5 millisecond duration half-sine pulse	30 drops, Zero fails	Zero (0). *QBS from 2900g drop test
Drop Qualification Condition H (Shipping)	JEDEC JESD-B104 IPC-JEDEC9703	2900Gs drops 0.3 millisecond duration half-sine pulse	30 drops, Zero fails	4 boards x 15 units/board

*QBS – Qualified-by-Similarity

[1] from 2017 update

2.0 QUALIFICATION DATA ICE40 PRODUCT FAMILY

The iCE40 devices are fabricated at TSMC and UMC on a 40nm non-volatile low power process, then assembled and tested at Advanced Semiconductor Engineering, Malaysia (ASEM), Advanced Semiconductor Engineering, Kaohsiung Taiwan (ASEK), and Amkor Technology Philippines (ATP). The iCE40 devices are available in ultra-low power (LP), ultra-low power with Embedded IP (LM), and high performance (HX) devices. The iCE40 384-csBGA is the lead product qualification vehicle and the iCE40 225-ucBGA the package qualification vehicle for this product family.

Product Family: iCE40

Packages offered: caBGA, csBGA, ucBGA, ucfBGA, TQFP, QFN, and WLCSP

Process Technology Node: 40 nm SRAM + OTP low power process

2.1 iCE40 Product Family Life Data

High Temperature Operating Life (HTOL) Test

The High Temperature Operating Life test is used to thermally accelerate those wear out and failure mechanisms that would occur as a result of operating the device continuously in a system application. Consistent with EIA/JESD22-A108 “Temperature, Bias, and Operating Life”, a pattern specifically designed to exercise the maximum amount of circuitry is programmed into the device and this pattern is continuously exercised at specified voltages as described in test conditions for each device type.

The Early Life Failure Rate (ELFR) test uses large samples sizes for a short duration (48hrs ≤ t ≤ 168 hrs) HTOL stress to determine the infant mortality rate of a device family.

iCE40 HTOL Conditions:
Stress Duration: 48 hours, 1000 hours
Stress Conditions: iCE40: HTOL Pattern, Vcc=1.26V, Vccio=3.47V $T_{JUNCTION}$ = ≥125°C
Method: EIA/JESD22-A108

Table 2.1 iCE40 Product Family Life Results

Product Name	Foundry	Lot #	Qty	48 Hrs Result	168 Hrs Result	500 Hrs Result	1000 Hrs Result	Cumulative Hours
iCE40HX8K	TSMC	1	79	N/A	N/A	N/A	0	79,000
iCE40HX8K	TSMC	2	80	N/A	N/A	N/A	0	80,000
iCE40HX8K	TSMC	3	80	N/A	N/A	N/A	0	80,000
iCE40LP384	UMC	1	78	0	0	0	0	78,000
iCE40LP384	UMC	2a	26	0	0	0	0	26,000
iCE40LP384	UMC	2b	27	N/A	0	0	0	27,000
iCE40LP384	UMC	2c	27	N/A	0	0	0	27,000
iCE40LP384	UMC	3	78	0	0	0	0	78,000
iCE40LM4K	UMC	1	60	0	0	0	N/A	30,000
iCE40LM4K	UMC	2	66	0	0	0	N/A	33,000
iCE40LM4K	UMC	3	50	0	0	0	N/A	25,000
iCE40LM4K	UMC	4*	93	0	0	0	0	93,000
iCE40LM4K	UMC	5*	89	0	0	0	0	89,000
iCE40LM4K	UMC	6*	84	0	0	0	0	84,000

Product Name	Foundry	Lot #	Qty	48 Hrs Result	168 Hrs Result	500 Hrs Result	1000 Hrs Result	Cumulative Hours
iCE5LP4K	UMC	1	92	0	0	0	N/A	46,000
iCE5LP4K	UMC	2	83	0	0	0	N/A	41,500
iCE40UL1K	UMC	1	64	N/A	0	0	0	64,000
iCE40UL1K	UMC	2	95	N/A	0	0	0	95,000
iCE40UL1K	UMC	3	64	N/A	0	0	0	64,000
iCE40UL1K	UMC	4	82	0	0	0	0	82,000
iCE40UP5K	UMC	1*	80	N/A	0	0	0	80,000
iCE40UP5K	UMC	2a*	79	N/A	1[1]	0	0	79,000
iCE40UP5K	UMC	2b*	250	0	0	0	0	250,000
iCE40UP5K	UMC	3*	80	N/A	0	0	0	80,000
iCE5LP4K	UMC	3*	100	N/A	0	0	0	100,000
iCE5LP4K	UMC	4*	100	N/A	0	0	0	100,000
iCE5LP4K	UMC	5*	100	N/A	0	0	0	100,000
iCE5LP4K	UMC	3*	1000	0	N/A	N/A	N/A	48,000
iCE5LP4K	UMC	4*	1000	0	N/A	N/A	N/A	48,000
iCE5LP4K	UMC	5*	1000	0	N/A	N/A	N/A	48,000
iCE5LP4K	UMC	6*	50	N/A	0	0	0	50,000
iCE5LP4K	UMC	7*	50	N/A	0	0	0	50,000
iCE5LP4K	UMC	8*	50	N/A	0	0	0	50,000
iCE5LP4K	UMC	9*	50	N/A	0	0	0	50,000
iCE5LP4K	UMC	10*	100	N/A	0	0	0	100,000
iCE5LP4K	UMC	11*	100	N/A	0	0	0	100,000
iCE5LP4K	UMC	12*	100	N/A	0	0	0	100,000
iCE5LP4K	UMC	10*	1000	0	N/A	N/A	N/A	48,000
iCE5LP4K	UMC	11*	1000	0	N/A	N/A	N/A	48,000
iCE5LP4K	UMC	12*	1000	0	N/A	N/A	N/A	48,000
iCE5LP4K	UMC	13*	50	N/A	0	0	0	50,000
iCE5LP4K	UMC	14*	50	N/A	0	0	0	50,000
iCE5LP4K	UMC	15*	50	N/A	0	0	0	50,000
iCE5LP4K	UMC	16*	50	N/A	0	0	0	50,000

[1] FAR #1644/LI1608013: non-systematic npu_leakage failure. Root cause unknown.

*Vcc=1.42V (Absolute Maximum Rating for Vcc)

iCE40 HTOL Cumulative Result / Sample Size = 1 / 8,886
iCE40 Cumulative Life Testing Device Hours = 2,998,500
iCE40 Long Term Failure Rate = 8.7 FITs
iCE40 FIT Assumptions: CL=60%, AE=0.7eV, Tjref=55C

2.2 iCE40 Product Family High Temperature Data Retention Results

High Temperature Data Retention (HTRX)

The iCE40™ devices are SRAM-based FPGAs. iCE40 LP and iCE40 HX devices have an on-chip, one-time programmable NVCM (Non-volatile Configuration Memory) to store SRAM configuration data. The on-chip NVCM allows the device to configure the SRAM instantly at power-up and greatly enhances the design security by eliminating the need to use an external memory device.

iCE40 Data Retention (HTRX) Conditions:

Stress Duration: 168, 1000 hours
Temperature: 150°C ambient
Method: Lattice Document # 101925 and JESD22-A103C / JESD22-A117A

Table 2.2.1 NVCM High Temperature Retention Results

Product Name	Package	Foundry	Lot #	Qty	168 Hrs Result	1000 Hrs Result	Cumulative Hours
iCE40LP384	81ucBGA	UMC	Lot #1	223	0	0	223,000
iCE40LP384	81ucBGA	UMC	Lot #2a	220	0	0	220,000
iCE40LP384	81ucBGA	UMC	Lot #3	226	0	0	226,000
iCE5LP4K	36 WLCSP	UMC	Lot #1	169	0	0	169,000
iCE5LP4K	36 WLCSP	UMC	Lot #2	179	0	0	179,000

iCE40 Cumulative HTRX Failure Rate = 0 / 1,017
iCE40 Cumulative HTRX Device Hours = 1,017,000

Table 2.2.2 NVCM Read Cycling

Product Name	Package	Foundry	Lot #	Qty	Cycling Temp	1K CYC	10K CYC	100K CYC
iCE40LP384	81ucBGA	UMC	Lot #1	160	25°C	0	0	0
iCE40LP384	81ucBGA	UMC	Lot #2a	160	25°C	0	0	0
iCE40LP384	81ucBGA	UMC	Lot #3	160	25°C	0	0	0
iCE5LP4K	36 WLCSP	UMC	Lot #1	110	25°C	0	0	0
iCE5LP4K	36 WLCSP	UMC	Lot #2	122	25°C	0	0	0

2.3 iCE40 Product Family – Electrostatic Discharge (ESD) and Latchup (LU) Data

Electrostatic Discharge-Human Body Model (HBM)

iCE40 product family was tested per the EIA/JESD22-A114/JS-001 Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM) procedure.

All units were Class tested at room ambient prior to reliability stress and after reliability stress. No failures were observed within the passing classification.

Table 2.3.1 iCE40 ESD-HBM Data

Product	16 WLCSP 1.4x1.4 mm 0.35mm pitch	25 WLCSP 1.71x1.71 mm 0.35mm pitch	30 WLCSP 2.15x2.55 mm 0.4mm pitch	36 WLCSP 2.1x2.1 mm 0.35mm pitch	CM36 ucfBGA 2.5x2.5 mm 0.4mm pitch	CM36 ucBGA 2.5x2.5 mm 0.4mm pitch	CM49 ucBGA 3x3mm 0.4mm pitch	CM81 ucBGA 4x4mm 0.4mm pitch	CM121 ucBGA 5x5mm 0.4mm pitch	CB81 csBGA 5x5mm 0.5mm pitch	CB121 csBGA 6x6mm 0.5mm pitch	CB121 caBGA 9x9mm 0.8mm pitch	CB132 csBGA 8x8mm 0.5mm pitch	CM225 ucBGA 7x7mm 0.4mm pitch	CT256 caBGA 14x14mm 0.8mm pitch	TQ100 TQFP 14x14mm 0.5mm pitch	TQ144 TQFP 20x20mm 0.5mm pitch	QN32 QFN 5x5mm 0.5mm pitch	QN48 QFN 7x7mm 0.5mm pitch	QN84 QFN 7x7mm 0.5mm pitch
iCE40HX1K													HBM>2kV Class 2 QBS			HBM>2kV Class 2	HBM>2kV Class 2			
iCE40HX4K													HBM>2kV Class 2 QBS				HBM>2kV Class 2			
iCE40HX8K												HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS	HBM>2kV Class 2	HBM>2kV Class 2 QBS					
iCE40LM1K		HBM>2kV Class 2 QBS				HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS													
iCE40LM2K		HBM>2kV Class 2 QBS				HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS													
iCE40LM4K		HBM>2kV Class 2				HBM>2kV Class 2	HBM>2kV Class 2													
iCE40LP384						HBM>2kV Class 2	HBM>2kV Class 2 QBS	HBM>2kV Class 2										HBM>2kV Class 2		
iCE40LP640	HBM>2kV Class 2 QBS					HBM>2kV Class 2														
iCE40LP1K	HBM>2kV Class 2					HBM>2kV Class 2	HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS									HBM>2kV Class 2 QBS
iCE40LP4K								HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS					HBM>2kV Class 2 QBS						
iCE40LP8K								HBM>2kV Class 2 QBS	HBM>2kV Class 2 QBS					HBM>2kV Class 2						

Product	16 WLCSP 1.4x1.4 mm 0.35mm pitch	25 WLCSP 1.71x1.71 mm 0.35mm pitch	30 WLCSP 2.15x2.55 mm 0.4mm pitch	36 WLCSP 2.1x2.1 mm 0.35mm pitch	CM36 ucfBGA 2.5x2.5 mm 0.4mm pitch	CM36 ucBGA 2.5x2.5 mm 0.4mm pitch	CM49 ucBGA 3x3mm 0.4mm pitch	CM81 ucBGA 4x4mm 0.4mm pitch	CM121 ucBGA 5x5mm 0.4mm pitch	CB81 csBGA 5x5mm 0.5mm pitch	CB121 csBGA 6x6mm 0.5mm pitch	CB121 caBGA 9x9mm 0.8mm pitch	CB132 csBGA 8x8mm 0.5mm pitch	CM225 ucBGA 7x7mm 0.4mm pitch	CT256 caBGA 14x14mm 0.8mm pitch	TQ100 TQFP 14x14mm 0.5mm pitch	TQ144 TQFP 20x20mm 0.5mm pitch	QN32 QFN 5x5mm 0.5mm pitch	QN48 QFN 7x7mm 0.5mm pitch	QN84 QFN 7x7mm 0.5mm pitch
iCE40UL640	HBM>2kV Class 2					HBM>2kV Class 2														
iCE40UL1K	HBM>2kV Class 2					HBM>2kV Class 2														
iCE5LP1K				HBM>2kV Class 2	HBM>2kV Class 2 QBS														HBM>2kV Class 2 QBS	
iCE5LP2K				HBM>2kV Class 2	HBM>2kV Class 2 QBS														HBM>2kV Class 2 QBS	
iCE5LP4K				HBM>2kV Class 2	HBM>2kV Class 2														HBM>2kV Class 2	
iCE40UP5K			[1]HBM>2kV Class 2																[1]HBM>2kV Class 2	
iCE40UP3K			[1]HBM>2kV Class 2 QBS																	

HBM classification for Commercial/Industrial products, per AEI/JESD22-A114/[1]JS001.
All HBM levels indicated are dual-polarity (±).
HBM worst-case performance is the package with the smallest RLC parasitics. All other packages for a given product are qualified-by-similarity (QBS).

Electrostatic Discharge-Charged Device Model (CDM)

iCE40 product family was tested per the EIA/JESD22-C101/JS-002, Field-Induced Charged-Device Model Test Method for Electrostatic-Discharge-Withstand Thresholds of Microelectronic Components procedure.

All units were Class tested at room ambient prior to reliability stress and after reliability stress. No failures were observed within the passing classification.

Table 2.3.2 iCE40 ESD-CDM Data

Product	16 WLCSP 1.4x1.4mm 0.35mm pitch	25 WLCSP 1.71x1.71 mm 0.35mm pitch	30 WLCSP 2.15x2.55 mm 0.4mm pitch	36 WLCSP 2.1x2.1 mm 0.35mm pitch	CM36 ucfBGA 2.5x2.5 mm 0.4mm pitch	CM36 ucBGA 2.5x2.5 mm 0.4mm pitch	CM49 ucBGA 3x3mm 0.4mm pitch	CM81 ucBGA 4x4mm 0.4mm pitch	CM121 ucBGA 5x5mm 0.4mm pitch	CB81 csBGA 5x5mm 0.5mm pitch	CB121 csBGA 6x6mm 0.5mm pitch	CB121 caBGA 9x9mm 0.8mm pitch	CB132 csBGA 8x8mm 0.5mm pitch	CM225 ucBGA 7x7mm 0.4mm pitch	CT256 caBGA 14x14mm 0.8mm pitch	TQ100 TQFP 14x14mm 0.5mm pitch	TQ144 TQFP 20x20mm 0.5mm pitch	QN32 QFN 5x5mm 0.5mm pitch	QN48 QFN 7x7mm 0.5mm pitch	QN84 QFN 7x7mm 0.5mm pitch
iCE40HX1K													CDM>1kV Class IV QBS			CDM>1kV Class IV	[3]CDM>1kV Class IV			
iCE40HX4K													CDM>1kV Class IV QBS				CDM>1kV Class IV			
iCE40HX8K												CDM>1kV Class IV QBS	CDM>1kV Class IV QBS	CDM>1kV Class IV	CDM>1kV Class IV QBS					
iCE40LM1K		[2]CDM>1kV Class IV QBS				[2]CDM>1kV Class IV QBS	[2]CDM>1kV Class IV QBS													
iCE40LM2K		[2]CDM>1kV Class IV QBS				[2]CDM>1kV Class IV QBS	[2]CDM>1kV Class IV QBS													
iCE40LM4K		[2]CDM>1kV Class IV				[2]CDM>1kV Class IV	[2]CDM>1kV Class IV													
iCE40LP384						CDM>1kV Class IV	CDM>1kV Class IV QBS	CDM>1kV Class IV										CDM>1kV Class IV		
iCE40LP640	CDM>1kV Class IV QBS					CDM>1kV Class IV														
iCE40LP1K	CDM>1kV Class IV QBS					CDM>1kV Class IV	CDM>1kV Class IV QBS	CDM>1kV Class IV QBS	[1]CDM>1kV Class IV QBS	CDM>1kV Class IV QBS	[1]CDM>1kV Class IV QBS									CDM>1kV Class IV QBS
iCE40LP4K								CDM>1kV Class IV QBS	CDM>1kV Class IV QBS					CDM>1kV Class IV QBS						
iCE40LP8K								CDM>1kV Class IV QBS	CDM>1kV Class IV QBS					CDM>1kV Class IV						
iCE40UL640	[2]CDM>1kV Class IV					[2]CDM>1kV Class IV														
iCE40UL1K	[2]CDM>1kV Class IV					[2]CDM>1kV Class IV														

Product	16 WLCSP 1.4x1.4mm 0.35mm pitch	25 WLCSP 1.71x1.71 mm 0.35mm pitch	30 WLCSP 2.15x2.55 mm 0.4mm pitch	36 WLCSP 2.1x2.1 mm 0.35mm pitch	CM36 ucfBGA 2.5x2.5 mm 0.4mm pitch	CM36 ucBGA 2.5x2.5 mm 0.4mm pitch	CM49 ucBGA 3x3mm 0.4mm pitch	CM81 ucBGA 4x4mm 0.4mm pitch	CM121 ucBGA 5x5mm 0.4mm pitch	CB81 csBGA 5x5mm 0.5mm pitch	CB121 csBGA 6x6mm 0.5mm pitch	CB121 caBGA 9x9mm 0.8mm pitch	CB132 csBGA 8x8mm 0.5mm pitch	CM225 ucBGA 7x7mm 0.4mm pitch	CT256 caBGA 14x14mm 0.8mm pitch	TQ100 TQFP 14x14mm 0.5mm pitch	TQ144 TQFP 20x20mm 0.5mm pitch	QN32 QFN 5x5mm 0.5mm pitch	QN48 QFN 7x7mm 0.5mm pitch	QN84 QFN 7x7mm 0.5mm pitch
iCE5LP1K				CDM>1kV Class IV	CDM>1kV Class IV QBS														CDM>1kV Class IV QBS	
iCE5LP2K				CDM>1kV Class IV	CDM>1kV Class IV QBS														CDM>1kV Class IV QBS	
iCE5LP4K				CDM>1kV Class IV	CDM>1kV Class IV														CDM>1kV Class IV	
iCE40UP5K			[4]CDM>1kV C3																[4]CDM>1kV C3	
iCE40UP3K			[4]CDM>1kV C3 QBS																	

[1] iCE40LP1K PLLVCC & PLLVSS pins CDM>500V. [2] Qualified-by-similarity using CM225 test package.
[3] iCE40HX1K PLLVCC & PLLVSS pins CDM>500V (Class III).
CDM classification for Commercial/Industrial products, per EIA/JESD22-C101/[4]JS-002.
All CDM levels indicated are dual-polarity (±).
CDM worst-case performance is the package with the largest bulk capacitance. All other packages for a given product are qualified-by-similarity (QBS).

Latch-Up

iCE40 product family was tested per the JEDEC EIA/JESD78 IC Latch-up Test procedure.

All units were Class tested at room ambient prior to reliability stress and after reliability stress. No failures were observed within the passing classification.

Table 2.3.3 iCE40 I/O Latch Up >100mA @ HOT (105°C) Data

Product	16 WLCSP 1.4x1.4mm 0.35mm pitch	25 WLCSP 1.71x1.71mm 0.35mm pitch	30 WLCSP 2.15x2.55mm 0.4mm pitch	36 WLCSP 2.1x2.1mm 0.35mm pitch	CM36 ucfBGA 2.5x2.5mm 0.4mm pitch	CM36 ucBGA 2.5x2.5mm 0.4mm pitch	CM49 ucBGA 3x3mm 0.4mm pitch	CM81 ucBGA 4x4mm 0.4mm pitch	CM121 ucBGA 5x5mm 0.4mm pitch	CB81 csBGA 5x5mm 0.5mm pitch	CB121 csBGA 6x6mm 0.5mm pitch	CB121 caBGA 9x9mm 0.8mm pitch	CB132 csBGA 8x8mm 0.5mm pitch	CM225 ucBGA 7x7mm 0.4mm pitch	CT256 caBGA 14x14mm 0.8mm pitch	TQ100 TQFP 14x14mm 0.5mm pitch	TQ144 TQFP 20x20mm 0.5mm pitch	QN32 QFN 5x5mm 0.5mm pitch	QN48 QFN 7x7mm 0.5mm pitch	QN84 QFN 7x7mm 0.5mm pitch
iCE40HX1K													> +/- 100mA Class II Level A QBS			> +/- 100mA Class II Level A	> +/- 100mA Class II Level A			
iCE40HX4K													> +/- 100mA Class II Level A QBS				> +/- 100mA Class II Level A QBS			
iCE40HX8K												> +/- 100mA Class II Level A QBS	> +/- 100mA Class II Level A QBS	> +/- 100mA Class II Level A	> +/- 100mA Class II Level A					
iCE40LM1K		**> +/- 100mA Class II Level A QBS				**> +/- 100mA Class II Level A QBS	**> +/- 100mA Class II Level A QBS													
iCE40LM2K		**> +/- 100mA Class II Level A QBS				**> +/- 100mA Class II Level A QBS	**> +/- 100mA Class II Level A QBS													
iCE40LM4K		**> +/- 100mA Class II Level A				**> +/- 100mA Class II Level A	**> +/- 100mA Class II Level A													
iCE40LP384						> +/- 100mA Class II Level A	> +/-100mA Class II Level A QBS	> +/-100mA Class II Level A										> +/- 100mA Class II Level A		
iCE40LP640	> +/-100mA Class II Level A QBS					> +/- 100mA Class II Level A QBS														
iCE40LP1K	> +/-100mA Class II Level A					> +/- 100mA Class II Level A	> +/-100mA Class II Level A QBS	> +/-100mA Class II Level A QBS	> +/- 100mA Class II Level A	> +/- 100mA Class II Level A	> +/- 100mA Class II Level A									> +/- 100mA Class II Level A

Product	16 WLCSP 1.4x1.4mm 0.35mm pitch	25 WLCSP 1.71x1.71mm 0.35mm pitch	30 WLCSP 2.15x2.55mm 0.4mm pitch	36 WLCSP 2.1x2.1mm 0.35mm pitch	CM36 ucfBGA 2.5x2.5mm 0.4mm pitch	CM36 ucBGA 2.5x2.5mm 0.4mm pitch	CM49 ucBGA 3x3mm 0.4mm pitch	CM81 ucBGA 4x4mm 0.4mm pitch	CM121 ucBGA 5x5mm 0.4mm pitch	CB81 csBGA 5x5mm 0.5mm pitch	CB121 csBGA 6x6mm 0.5mm pitch	CB121 caBGA 9x9mm 0.8mm pitch	CB132 csBGA 8x8mm 0.5mm pitch	CM225 ucBGA 7x7mm 0.4mm pitch	CT256 caBGA 14x14mm 0.8mm pitch	TQ100 TQFP 14x14mm 0.5mm pitch	TQ144 TQFP 20x20mm 0.5mm pitch	QN32 QFN 5x5mm 0.5mm pitch	QN48 QFN 7x7mm 0.5mm pitch	QN84 QFN 7x7mm 0.5mm pitch
									QBS	QBS	QBS									QBS
iCE40LP4K								> +/-100mA Class II Level A QBS	> +/-100mA Class II Level A QBS					> +/-100mA Class II Level A QBS						
iCE40LP8K								> +/-100mA Class II Level A QBS	> +/-100mA Class II Level A QBS					> +/-100mA Class II Level A						
iCE40UL640	> +/-100mA Class II Level A					> +/-100mA Class II Level A														
iCE40UL1K	> +/-100mA Class II Level A					> +/-100mA Class II Level A														
iCE5LP1K				> +/-100mA Class II Level A	> +/-100mA Class II Level A QBS														> +/-100mA Class II Level A QBS	
iCE5LP2K				> +/-100mA Class II Level A	> +/-100mA Class II Level A QBS														> +/-100mA Class II Level A QBS	
iCE5LP4K				> +/-100mA Class II Level A	> +/-100mA Class II Level A														> +/-100mA Class II Level A	
iCE40UP5K			> +/-100mA Class II Level A																> +/-100mA Class II Level A	
iCE40UP3K			> +/-100mA Class II Level A QBS																	

** Qualified-by-similarity using CM225 test package.
I-Test LU classification for Commercial/Industrial products, per JESD78.
All IO-LU levels indicated are dual-polarity (±).
IO-LU worst-case performance is the package with access to the most IOs. All other packages for a given product are qualified-by-similarity (QBS).

Table 2.3.4 iCE40 Vcc Latch Up >1.5X @ HOT (105°C) Data

Product	16 WLCSP 1.4x1.4mm 0.35mm pitch	25 WLCSP 1.71x1.71 mm 0.35mm pitch	30 WLCSP 2.15x2.55 mm 0.4mm pitch	36 WLCSP 2.1x2.1m m 0.35mm pitch	CM36 ucfBGA 2.5x2.5m m 0.4mm pitch	CM36 ucBGA 2.5x2.5m m 0.4mm pitch	CM49 ucBGA 3x3mm 0.4mm pitch	CM81 ucBGA 4x4mm 0.4mm pitch	CM121 ucBGA 5x5mm 0.4mm pitch	CB81 csBGA 5x5mm 0.5mm pitch	CB121 csBGA 6x6mm 0.5mm pitch	CB121 caBGA 9x9mm 0.8mm pitch	CB132 csBGA 8x8mm 0.5mm pitch	CM225 ucBGA 7x7mm 0.4mm pitch	CT256 caBGA 14x14mm 0.8mm pitch	TQ100 TQFP 14x14mm 0.5mm pitch	TQ144 TQFP 20x20mm 0.5mm pitch	QN32 QFN 5x5mm 0.5mm pitch	QN48 QFN 7x7mm 0.5mm pitch	QN84 QFN 7x7mm 0.5mm pitch
iCE40HX1K													> 1.5x Vcc Class II QBS			> 1.5x Vcc Class II	> 1.5x Vcc Class II			
iCE40HX4K													> 1.5x Vcc Class II QBS				> 1.5x Vcc Class II			
iCE40HX8K												> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II	> 1.5x Vcc Class II					
iCE40LM1K		**> 1.5x Vcc Class II QBS				**> 1.5x Vcc Class II QBS	**> 1.5x Vcc Class II QBS													
iCE40LM2K		**> 1.5x Vcc Class II QBS				**> 1.5x Vcc Class II QBS	**> 1.5x Vcc Class II QBS													
iCE40LM4K		**> 1.5x Vcc Class II				**> 1.5x Vcc Class II	**> 1.5x Vcc Class II													
iCE40LP384						> 1.5x Vcc Class II	> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II										> 1.5x Vcc Class II		
iCE40LP640	> 1.5x Vcc Class II QBS					> 1.5x Vcc Class II QBS														
iCE40LP1K	> 1.5x Vcc Class II					> 1.5x Vcc Class II	> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II QBS									> 1.5x Vcc Class II QBS
iCE40LP4K								> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II QBS					> 1.5x Vcc Class II QBS						
iCE40LP8K								> 1.5x Vcc Class II QBS	> 1.5x Vcc Class II QBS					> 1.5x Vcc Class II						
iCE40UL640	> 1.5x Vcc Class II					> 1.5x Vcc Class II														
iCE40UL1K	> 1.5x Vcc Class II					> 1.5x Vcc Class II														
iCE5LP1K				> 1.5x Vcc Class II	> 1.5x Vcc Class II QBS														> 1.5x Vcc Class II QBS	
iCE5LP2K				> 1.5x Vcc Class II	> 1.5x Vcc Class II QBS														> 1.5x Vcc Class II QBS	

Product	16 WLCSP 1.4x1.4mm 0.35mm pitch	25 WLCSP 1.71x1.71 mm 0.35mm pitch	30 WLCSP 2.15x2.55 mm 0.4mm pitch	36 WLCSP 2.1x2.1m m 0.35mm pitch	CM36 ucfBGA 2.5x2.5m m 0.4mm pitch	CM36 ucBGA 2.5x2.5m m 0.4mm pitch	CM49 ucBGA 3x3mm 0.4mm pitch	CM81 ucBGA 4x4mm 0.4mm pitch	CM121 ucBGA 5x5mm 0.4mm pitch	CB81 csBGA 5x5mm 0.5mm pitch	CB121 csBGA 6x6mm 0.5mm pitch	CB121 caBGA 9x9mm 0.8mm pitch	CB132 csBGA 8x8mm 0.5mm pitch	CM225 ucBGA 7x7mm 0.4mm pitch	CT256 caBGA 14x14mm 0.8mm pitch	TQ100 TQFP 14x14mm 0.5mm pitch	TQ144 TQFP 20x20mm 0.5mm pitch	QN32 QFN 5x5mm 0.5mm pitch	QN48 QFN 7x7mm 0.5mm pitch	QN84 QFN 7x7mm 0.5mm pitch
iCE5LP4K				> 1.5x Vcc Class II	> 1.5x Vcc Class II														> 1.5x Vcc Class II	
iCE40UP5K			> 1.5x Vcc Class II																> 1.5x Vcc Class II	
iCE40UP3K			> 1.5x Vcc Class II QBS																	

** Qualified-by-similarity using CM225 test package.
Vsupply Over-voltage Test LU classification for Commercial/Industrial products, per JESD78.
Vcc-LU worst-case performance is the package with access to the most individual power rails. All other packages for a given product are qualified-by-similarity (QBS).

2.4 iCE40 Product Family SEU and SEL

Soft Error Rate testing is conducted to characterize the sensitivity of SRAM storage and device logic elements to high energy neutron and alpha particle radiation. Charge induced by the impact of these particles can collect at sensitive nodes in the device, and result in changes in the internal electrical states of the device. While these changes do not cause immediate damage to the device, they can cause a logical error in device operation.

Lattice Semiconductor characterizes neutron sensitivity by testing at the LANSCE Facility at Los Alamos National Laboratories or at the TRIUMF facility in Vancouver, British Columbia, Canada. The neutron beams at these facilities closely match the energy distribution of neutrons occurring due to cosmic ray collisions in the atmosphere. Neutron testing conforms to JEDEC JESD-89 requirements.

Alpha particles originate in the packaging materials used to surround the silicon circuit. Impurities in the mold compound and in interconnect materials emit alpha particles as part of radioactive decay. The range of penetration of alpha particles in silicon is limited. Only alpha particles generated in the package materials and interconnect can reach the die surface and cause upsets.

Lattice Semiconductor characterizes alpha particle sensitivity using calibrated sources. Americium-241 is used to model the decay products of Po-210 and Pb-210 in the lead solder die-package interconnects. Thorium-232 is used to model the decay products of Th-232, Th-228, Ra-226, U-238, etc., from impurities in the packaging materials. Alpha particle testing is done at the Lattice factory and conforms to JEDEC JESD-89.

Soft Error Tests

Neutron SRAM SER Rate – This characteristic is the rate of upset of Configuration RAM and Embedded Block RAM cells during neutron testing. Devices are configured with a logic pattern, exposed to measured neutron doses, and the device configuration was read back from the device. Changed bits are identified through pattern comparison. Neutron testing is normalized to the published neutron flux rate for New York City (NYC) at sea level. This rate is measured as Failures in Time (FITs) normalized per million bits in the device to allow for translation across the device families densities.

Neutron SRAM SEL Rate – This test looks for evidence of latch up due to soft error upsets. The test is conducted at maximum VCC and temperature conditions. Devices are configured with a logic pattern, exposed to measured neutron doses, and the device configuration was read back from the device. Voltage and current is monitored. Devices are check for functional recovery after exposure. This consists of verification that the devices reconfigure correctly with or without a power cycle. It is considered a failure if the part cannot recover. Neutron testing is normalized to the published neutron flux rate for New York City at sea level. This rate is measured as Failures in Time (FITs) normalized per million bits in the device to allow for translation across the device families densities.

Alpha SRAM SER Rate – This characteristic is the rate of upset of Configuration RAM and Embedded Block RAM (EBR) cells during alpha particle testing. Devices are configured with a logic pattern, exposed for a fixed time period to a calibrated alpha particle source, and the device configuration was read back from the device. Changed bits are identified through pattern comparison. Alpha particle testing is normalized to a background rate of 0.001alpha/cm2-hr based on characterization of packaging materials. This rate is measured at Failures in Time (FITs) normalized per million bits in the device to allow for translation across the device families densities as Failures in Time (FITs) normalized per million bits in the device to allow for translation across the device families densities.

Environmental Consideration

The neutron failure rate observed in the field is affected by the shape and strength of the Magnetosphere. It is affected by the operating altitude. It is affected by any material intervening between the part and the atmosphere. Lattice Semiconductor uses the NYC standard (14 N/cm^2*hrs) to normalize the data. Customers will need to adjust the numbers if the use conditions are significantly different than NYC.

Device utilization also has a measurable impact on the observed failure rate. A SEU event in an unused circuit is very unlikely to disturb operation. Lattice Semiconductor assumed 100% utilization to calculate the FIT rate and MTBFF data in the following tables. The FIT rate experienced by the customer will be less due to the reduced utilization of the device resources.

For devices that support SED and applications that use the SED (Soft Error Detect) circuits, there is no de-rating because all the SRAM cells are scanned whether they are utilized or not in the customer application.

Neutron Testing

The parts were tested at the TRIUMF facility in Vancouver, BC, Canada. A neutron particle beam was used to accelerate the Soft Error failure rate due to neutron collisions in the semiconductor devices. The neutron beam at TRIUMF correlates to the energy distribution found around the globe. Both static and dynamic patterns were used to generate the SEU (Soft Error Upset) rate and test for SEL (Soft Error Latch-up).

Neutron SEL Test Conditions:

Device: iCE40LP8K and iCE40HX8K
Stress Duration: Twenty-six test samples at 20 minutes duration each
(20 minutes is equivalent to 7,800 years of exposure vs. the NYC standard of 14 N/cm^2*hr.)
Temperature: >85°C (greater than the maximum Industrial temperature).
Voltage: 1.26 volts (max operating voltage)
Method: JEDEC JESD89

Table 2.4.1 iCE40 SEL Data

Product	Permanent functional failure observed?	Voltage excursions observed (>20%)	Failure to re-program	Power cycles required to recover operation	Average number of configuration SEU events	Average number of EBR SEU events
iCE408K	None	None	None	None	19	5.5

Calculated FIT rate with 60% confidence = 0.2 FITs.

Neutron SEU Test Conditions:

Device: iCE40LP8K and iCE40HX8K
Stress Duration: Thirty-two test samples at 20 minutes average duration each
(3 minutes is equivalent to 7,800 years of exposure vs. the NYC standard of 14 N/cm^2*hr.)
Temperature: Ambient
Voltage: 1.20 volts (nominal operating voltage)
Method: JEDEC JESD89

Table 2.4.2 iCE40 Neutron SEU Data

Product	Configuration FITs/Mb	EBR FITs/Mb	Average number of configuration SEU events	Average number of EBR SEU events
iCE408K	122	217	19	6
stDev	41	244		

Table 2.4.3 iCE40 Neutron MTBFF Data

Device	Configuration Usable bit count	EBR Usable bit count	Configuration FITs	EBR FITs	1 Part MTBFF (in years)
iCE40LP384	58,240	0K	8	0	14,269
iCE40LP 640	100,000	32K	13	7	8,781
iCE40LP1K	191,232	64K	24	14	4,756
iCE40LP4K	435,000	80K	53	18	2,154
iCE40LP8K	948,736	128K	116	28	984
iCE40LM1K	145,000	64K	18	14	6,342
iCE40LM2K	270,000	80K	33	18	3,459
iCE40LM4K	461,824	80K	53	18	2,154
iCE40HX1K	191,232	64K	24	14	4,756
iCE40HX4K	435,000	80K	53	18	2,154
iCE40HX8K	948,736	128K	116	18	984
iCE40UL640	100,000	56K	13	13	8,781
iCE40UL1K	188,416	56K	23	13	4,963
iCE5LP1K	155,000	64K	19	14	6,008
iCE5LP2K	285,000	80K	35	18	3,262
iCE5LP4K	487,168	80K	60	18	1,903

The MTBFF numbers assume EBR is mitigated by ECC.
The FIT and MTBFF data assumes 100% utilization for configuration and EBR.
Virtual devices are scaled by available LUT counts.
FIT numbers are rounded up (no fractions).

Alpha Testing

The parts were tested at Lattice Semiconductor. Several alpha radiation sources were used to accelerate the soft error failure rate due to alpha particles from the package material used in the semiconductor devices. The radiation sources correlate to the know sources of alpha particles in package materials. Both static and dynamic patterns were used to generate the SEU (Soft Error Upset) rate.

Alpha SEU Test Conditions:

Device: iCE40LP8K and iCE40HX8K
Stress Duration: Twelve test samples at sixty seven minutes average duration each (equivalent years of exposure depends on the package material)
Temperature: Ambient
Voltage: 1.20 volts (nominal operating voltage)
Method: JEDEC JESD89

Table 2.4.4 iCE40 Alpha SEU Data

Product	Wire bond packages (WBP) Mold material (0.01 Alpha/hr)		WLCSP Underfill and SnAgCu (0.0004 Alpha/hr)		Average number of configuration SEU events	Average number of EBR SEU events
	Configuration (FITs/Mb)	EBR (FITs/Mb)	Configuration (FITs/Mb)	EBR (FITs/Mb)		
iCE408K	16	125	7	50	18	8
StDev	19	64	8	26		

Table 2.4.5 iCE40 Alpha MTBFF Data

Device	Configuration	EBR	Wire bond packages			WLCSP		
			Configuration	EBR	1 Part	Configuration	EBR	1 Part
	Usable bit count	Usable bit count	FITs	FITs	MTBFF (in years)	FITs	FITs	MTBFF (in years)
iCE40LP384	58,240	0K	12	0	10,015			
iCE40LP 640	100,000	32K				1	2	145,812
iCE40LP1K	191,232	64K	38	71	3,050	2	3	76,249
iCE40LP4K	435,000	80K	86	89	1,341			
iCE40LP8K	948,736	128K	186	142	615			
iCE40LM1K	145,000	64K	29	71	4,023	2	3	100,560
iCE40LM2K	270,000	80K	53	89	2,161	3	4	54,005
iCE40LM4K	461,824	80K	86	89	1,341	4	4	31,574
iCE40HX1K	191,232	64K	38	71	3,050			
iCE40HX4K	435,000	80K	86	89	1,341			
iCE40HX8K	948,736	128K	186	142	615			
iCE40UL640	100,000	56K	20	62	5,833	1	3	145,812
iCE40UL1K	188,416	56K	37	62	3,096	2	3	77,389
iCE5LP1K	155,000	64K				2	3	94,073
iCE5LP2K	285,000	80K				3	4	51,163
iCE5LP4K	487,168	80K				4	4	29,931

The MTBFF numbers assume EBR is mitigated by ECC.
The FIT and MTBFF data assumes 100% utilization for configuration and EBR.
Virtual devices are scaled by available LUT counts.
FIT numbers are rounded up (no fractions).

SPI Flash

The iCE40 family allows the use of low cost SPI FLASH memories to store configuration memory data. These SPI FLASH devices are available for use in system configuration. As part of the characterization effort for neutron SER sensitivity of the Lattice products, Lattice tested samples of SPI FLASH memory devices from different manufacturers. There were no observed failures. The charge residing on FLASH cells is far larger than the charge created during a neutron collision or an alpha particle emission. SPI FLASH is effectively immune to SEU.

Table 2.4.6 SPI FLASH Neutron Test Results

Density	Device	Exposure Duration	Fluence N/cm^2	Number Bits Flipped
512KB	SST25VF512A	10 Hours	1.37E11	0
	M25P05-A			0
1MB	SST25VF010A			0
	M25P10-A			0
2MB	SST25V020			0
4MB	STS25LF040A			0
	STS25VF040			0

3.0 PACKAGE QUALIFICATION DATA FOR ICE40 PRODUCT FAMILY

The iCE40 devices are assembled and tested at Advanced Semiconductor Engineering, Malaysia (ASEM), Advanced Semiconductor Engineering, Kaohsiung Taiwan (ASEK), and Amkor Technology Philippines (ATP). Package qualification tests include Surface Mount Pre-Conditioning (SMPC), Temperature Cycling (T/C), Biased HAST (BHAST), UnBiased HAST (UHAST), Autoclave (Pressure Pot) and High Temperature Storage (HTSL). Electrical test is performed pre- and post-stress. Mechanical evaluation tests include Scanning Acoustic Tomography (SAT) and Visual Package Inspection.

Table 3.0.1 Summary of ASEM, ASEK, and ATP Reliability Test Conditions and Results

Stress	Assembly Site	Test Vehicle	Package Type	Stress Conditions	# of Lots	Cumulative Device Units/Hours/Cycles	# of Fails
SMPC	ASEM	iCE40HX8K	256caBGA	3x 260°C reflow	2	280 units	0
SMPC	ASEM	iCE40HX4K	144TQFP	3x 260°C reflow	3	735 units	0
SMPC	ASEM	iCE40HX1K	100TQFP	3x 260°C reflow	2	380 units	0
SMPC	ASEM	iCE40LP8K	225ucBGA	3x 260°C reflow	3	420 units	0
SMPC	ASEM	iCE40LP1K	84QFN	3x 260°C reflow	2	380 units	0
SMPC	ASEM	iCE40LP384	81ucBGA	3x 260°C reflow	3	1,200 units	0
SMPC	ASEM	iCE40LP384	36ucBGA	3x 260°C reflow	3	249 units	0
SMPC	ASEM	iCE40LP384	32QFN	3x 260°C reflow	3	1,190 units	0
SMPC	ATP	iCE40LM4K	49ucBGA	3x 260°C reflow	5	1,082 units	0
SMPC	ATP	iCE40LM4K	36ucBGA	3x 260°C reflow	3	255 units	0
SMPC	ASEK	iCE40LM4K	25WLCSP	3x 260°C reflow	3	718 units	0
SMPC	ASEM	ICE40LM4K	36ucBGA	3x 260°C reflow	3	231 units	0
SMPC	ASEM	iCE5LP4K	48QFN	3x 260°C reflow	3	1,152 units	0
SMPC	ASEK	iCE5LP4K	36WLCSP	3x 260°C reflow	9	3,112 units	1
SMPC	ATT	iCE5LP4K	36WLCSP	3x 260°C reflow	6	2,878 units	0
SMPC	ATT/ATP	iCE5LP4K	36ucfBGA	3x 260°C reflow	4	916 units	0
SMPC	ATP	iCE40UL1K	36ucBGA	3x 260°C reflow	3	1,192 units	0
SMPC	ASEK	iCE40UL1K	16WLCSP	3x 260°C reflow	3	483 units	0
SMPC	ASEM	ICE40UL1K	36ucBGA	3x 260°C reflow	3	768 units	0
SMPC	ASEM	iCE40UP5K	48QFN	3x 260°C reflow	3	1,814 units	0
SMPC	ASEK	iCE40UP5K	48QFN	3x 260°C reflow	3	1,200 units	0
SMPC	ASEK	iCE40UP5K	30WLCSP	3x 260°C reflow	3	1,453 units	1
SMPC	ATP	ICE40HX8K	121caBGA	3x 260°C reflow	3	1,500 units	0
SMPC	ASEK	ICE40HX8K	121caBGA	3x 260°C reflow	3	648 units	0
TC	ASEM	iCE40HX8K	256caBGA	-55°C to 125°C	2	35,000 cycles	0
TC	ASEM	iCE40HX4K	144TQFP	-55°C to 125°C	3	168,000 cycles	0
TC	ASEM	iCE40HX1K	100TQFP	-55°C to 125°C	2	35,000 cycles	0
TC	ASEM	iCE40LP8K	225ucBGA	-55°C to 125°C	3	52,500 cycles	0
TC	ASEM	iCE40LP1K	84QFN	-55°C to 125°C	2	35,000 cycles	0
TC	ASEM	iCE40LP384	81ucBGA	-55°C to 125°C	3	238,000 cycles	0
TC	ASEM	iCE40LP384	36ucBGA	-55°C to 125°C	3	240,000 cycles	0
TC	ASEM	iCE40LP384	32QFN	-55°C to 125°C	3	234,000 cycles	0
TC	ATP	iCE40LM4K	49ucBGA	-55°C to 125°C	5	280,000 cycles	0
TC	ATP	iCE40LM4K	36ucBGA	-55°C to 125°C	3	168,000 cycles	0
TC	ASEK	iCE40LM4K	25WLCSP	-55°C to 125°C	3	165,200 cycles	0
TC	ASEM	ICE40LM4K	36ucBGA	-55°C to 125°C	3	161,700 cycles	0
TC	ASEM	iCE5LP4K	48QFN	-55°C to 125°C	3	191,100 cycles	0
TC	ASEK	iCE5LP4K	36WLCSP	-55°C to 125°C	9	646,000 cycles	0
TC	ATT	iCE5LP4K	36WLCSP	-55°C to 125°C	6	443,800 cycles	0
TC	ATT/ATP	iCE5LP4K	36ucfBGA	-55°C to 125°C	4	232,400 cycles	0
TC	ATP	iCE40UL1K	36ucBGA	-55°C to 125°C	3	195,300 cycles	0
TC	ASEK	iCE40UL1K	16WLCSP	-55°C to 125°C	3	195,300 cycles	0
TC	ASEM	ICE40UL1K	36ucBGA	-55°C to 125°C	3	161,700 cycles	0
TC	ASEM	iCE40UP5K	48QFN	-55°C to 125°C	3	270,000 cycles	0
TC	ASEK	iCE40UP5K	48QFN	-55°C to 125°C	3	161,700 cycles	0
TC	ASEK	iCE40UP5K	30WLCSP	-55°C to 125°C	3	269,000 cycles	0
TC	ATP	ICE40HX8K	121caBGA	-55°C to 125°C	3	178500 cycles	0
TC	ASEK	ICE40HX8K	121caBGA	-55°C to 125°C	3	161,700 cycles	0

Stress	Assembly Site	Test Vehicle	Package Type	Stress Conditions	# of Lots	Cumulative Device Units/Hours/Cycles	# of Fails
BHAST	ASEM	iCE40HX8K	256caBGA	85%RH, 130°C, 96 hours	2	4,800 hours	0
BHAST	ASEM	iCE40HX4K	144TQFP	85%RH, 130°C, 96 hours	3	21,888 hours	0
BHAST	ASEM	iCE40HX1K	100TQFP	85%RH, 130°C, 96 hours	2	4,800 hours	0
BHAST	ASEM	iCE40LP8K	225ucBGA	85%RH, 130°C, 96 hours	3	7,200 hours	0
BHAST	ASEM	iCE40LP1K	84QFN	85%RH, 130°C, 96 hours	2	4,800 hours	0
BHAST	ASEM	iCE40LP384	81ucBGA	85%RH, 110°C, 264 hours	3	62,832 hours	0
BHAST	ASEM	iCE40LP384	32QFN	85%RH, 130°C, 96 hours	3	22,080 hours	0
BHAST	ATP	iCE40LM4K	49ucBGA	85%RH, 110°C, 264 hours	3	61,512 hours	1
BHAST	ASEK	iCE40LM4K	25WLCSP	85%RH, 110°C, 264 hours	3	75,504 hours	0
BHAST	ASEM	iCE5LP4K	48QFN	85%RH, 130°C, 96 hours	2	16,128 hours	3
BHAST	ASEM	iCE5LP4K	48QFN	85%RH, 110°C, 264 hours	1	22,176 hours	1
BHAST	ASEK	iCE5LP4K	36WLCSP	85%RH, 110°C, 264 hours	9	200,904 hours	1
BHAST	ATT	iCE5LP4K	36WLCSP	85%RH, 110°C, 264 hours	6	133,056 hours	0
BHAST	ATT/ATP	iCE5LP4K	36ucfBGA	85%RH, 110°C, 264 hours	3	66,000 hours	0
BHAST	ASEK	iCE40UL1K	16WLCSP	85%RH, 110°C, 264 hours	2	16,632 hours	0
BHAST	ASEM	ICE40UL1K	36ucBGA	85%RH, 110°C, 264 hours	3	19,800 hours	0
BHAST	ASEK	iCE40UP5K	30WLCSP	85%RH, 130°C, 96 hours	3	17,664 hours	0
BHAST	ASEK	iCE40UP5K	48QFN	85%RH, 130°C, 96 hours	3	22,176 hours	0
THB	ASEK	iCE40UP5K	48QFN	85%RH, 85°C, 1000 hours	3	334,000 hours	1
THB	ATP	ICE40HX8K	121caBGA	85%RH, 85°C, 1000 hours	3	252,000 hours	1
THB	ASEK	ICE40HX8K	121caBGA	85%RH, 85°C, 1000 hours	3	75,000 hours	0
Autoclave	ASEM	iCE40HX1K	100TQFP	100%RH, 121°C, 96 hours	2	8,640 hours	0
Autoclave	ASEM	iCE40LP1K	84QFN	100%RH, 121°C, 96 hours	2	8,640 hours	0
UHAST	ASEK	iCE40LM4K	25WLCSP	85%RH, 110°C, 396 hours	3	62,304 hours	0
UHAST	ATP	iCE40UL1K	36ucBGA	85%RH, 110°C, 264 hours	3	75,768 hours	0
UHAST	ASEK	iCE40UL1K	16WLCSP	85%RH, 110°C, 264 hours	1	25,080 hours	0
UHAST	ASEK	iCE40UL1K	16WLCSP	85%RH, 130°C, 96 hours	2	6,720 hours	0
UHAST	ASEM	ICE40UL1K	36ucBGA	85%RH, 110°C, 264 hours	3	60,984 hours	0
UHAST	ASEM	iCE5LP4K	48QFN	85%RH, 130°C, 96 hours	3	27,648 hours	0
UHAST	ATT/ATP	iCE5LP4K	36ucfBGA	85%RH, 130°C, 96 hours	3	74,712 hours	0
UHAST	ASEK	iCE5LP4K	36WLCSP	85%RH, 110°C, 264 hours	6	133,056 hours	0
UHAST	ATT	iCE5LP4K	36WLCSP	85%RH, 110°C, 264 hours	6	133,056 hours	0
UHAST	ASEM	iCE40UP5K	48QFN	85%RH, 130°C, 96 hours	3	51,648 hours	1
UHAST	ASEK	iCE40UP5K	48QFN	85%RH, 130°C, 96 hours	3	22,176 hours	0
UHAST	ASEK	iCE40UP5K	30WLCSP	85%RH, 130°C, 96 hours	3	25,920 hours	0
UHAST	ATP	ICE40HX8K	121caBGA	85%RH, 110°C, 264 hours	3	67,320 hours	0
UHAST	ASEK	ICE40HX8K	121caBGA	85%RH, 110°C, 264 hours	3	63,360 hours	0
HTSL	ASEM	iCE40HX8K	256caBGA	150°C, 1000 hours	2	154,000 hours	0
HTSL	ASEM	iCE40HX4K	144TQFP	150°C, 1000 hours	3	240,000 hours	0
HTSL	ASEM	iCE40HX1K	100TQFP	150°C, 1000 hours	2	154,000 hours	0
HTSL	ASEM	iCE40LP8K	225ucBGA	150°C, 1000 hours	3	229,000 hours	0
HTSL	ASEM	iCE40LP1K	84QFN	150°C, 1000 hours	2	154,000 hours	0
HTSL	ASEM	iCE40LP384	81ucBGA	150°C, 1000 hours	3	233,000 hours	0
HTSL	ASEM	iCE40LP384	32QFN	150°C, 1000 hours	3	235,000 hours	0
HTSL	ATP	iCE40LM4K	49ucBGA	150°C, 1000 hours	5	382,000 hours	0
HTSL	ASEK	iCE40LM4K	25WLCSP	150°C, 1000 hours	3	238,000 hours	0
HTSL	ASEM	iCE5LP4K	48QFN	150°C, 1000 hours	3	288,000 hours	0
HTSL	ASEK	iCE5LP4K	36WLCSP	150°C, 1000 hours	9	866,000 hours	0
HTSL	ATT	iCE5LP4K	36WLCSP	150°C, 1000 hours	6	300,000 hours	0
HTSL	ATT/ATP	iCE5LP4K	36ucfBGA	150°C, 1000 hours	3	252,000 hours	0
HTSL	ATP	iCE40UL1K	36ucBGA	150°C, 1000 hours	3	280,000 hours	0
HTSL	ASEK	iCE40UL1K	16WLCSP	150°C, 1000 hours	3	271,000 hours	0
HTSL	ASEM	ICE40UL1K	36ucBGA	150°C, 1000 hours	3	231,000 hours	0
HTSL	ASEM	iCE40UP5K	48QFN	150°C, 1000 hours	3	269,000 hours	0
HTSL	ASEK	iCE40UP5K	48QFN	150°C, 1000 hours	3	231,000 hours	0
HTSL	ASEK	iCE40UP5K	30WLCSP	150°C, 1000 hours	3	270,000 hours	0
HTSL	ATP	ICE40HX8K	121caBGA	150°C, 1000 hours	3	254,500 hours	1
HTSL	ASEK	ICE40HX8K	121caBGA	150°C, 1000 hours	3	240,000 hours	0

3.1 Family Qualification

The generation and use of generic data applied across a family of packages emanating from one base assembly process is a Family Qualification, or Qualification-by-Similarity. For the package stresses BHAST, UHAST and HTSL, these are considered generic for a given Package Technology. T/C is considered generic up to an evaluated die size + package size + 10%, for a given Package Technology. Surface Mount Pre-Conditioning (SMPC) is considered generic up to an evaluated Peak Reflow temperature, for a given Package Technology. The following table demonstrates the package stresses qualification matrix.

Table 3.1.1 ASEK Qualification-By-Similarity Matrix

<table>
<tr><th rowspan="3">FOUNDRY</th><th rowspan="3">DEVICE</th><th rowspan="3">STRESS</th><th colspan="2">caBGA</th><th colspan="3">QFN</th><th colspan="5">WLCSP</th></tr>
<tr><td>121-pin</td><td>256-pin</td><td>32-pin</td><td>48-pin</td><td>84-pin</td><td>16-pin</td><td>16-pin</td><td>25-pin</td><td>30-pin</td><td>36-pin</td></tr>
<tr><td>9x9mm, 0.8mm pitch</td><td>14x14mm, 0.8mm pitch</td><td>5x5mm, 0.5mm pitch</td><td>7x7mm, 0.5mm pitch</td><td>7x7mm, 0.5mm pitch</td><td>1.4x1.48mm, 0.35mm pitch</td><td>1.4x1.4mm, 0.35mm pitch</td><td>1.71x1.71mm, 0.35mm pitch</td><td>2.15x2.55mm, 0.4mm pitch</td><td>2.08x2.08mm, 0.35mm pitch</td></tr>
<tr><td colspan="3"></td><td colspan="10">ASEK</td></tr>
<tr><td rowspan="10">TSMC</td><td>ICE40HX1K</td><td></td><td colspan="2">QBS (1)</td><td colspan="3" rowspan="7">Package not offered</td><td colspan="5" rowspan="7">Package not offered</td></tr>
<tr><td>ICE40HX4K</td><td></td><td colspan="2">QBS (1)</td></tr>
<tr><td rowspan="5">ICE40HX8K</td><td>SMPC</td><td colspan="2">MSL3</td></tr>
<tr><td>TC</td><td colspan="2">700 cyc</td></tr>
<tr><td>HTSL</td><td colspan="2">1000 hr</td></tr>
<tr><td>UHAST</td><td colspan="2">264 hr</td></tr>
<tr><td>THB</td><td colspan="2">1000 hr</td></tr>
<tr><td>ICE40LP1K</td><td></td><td colspan="2" rowspan="4">Package not offered</td><td colspan="3" rowspan="4">Package not offered</td><td rowspan="4">Q3'21</td><td colspan="4" rowspan="4">Package not offered</td></tr>
<tr><td>ICE40LP4K</td><td></td></tr>
<tr><td>ICE40LP8K</td><td></td></tr>
<tr><td>ICE40LP640</td><td></td></tr>
<tr><td rowspan="8">UMC</td><td>ICE5LP1K</td><td></td><td colspan="2" rowspan="7">Package not offered</td><td rowspan="7">Package not offered</td><td rowspan="7">Package not offered in site</td><td rowspan="7">Package not offered</td><td colspan="5" rowspan="7">Package not offered</td><td>QBS (6)</td></tr>
<tr><td>ICE5LP2K</td><td></td><td>QBS (6)</td></tr>
<tr><td rowspan="5">ICE5LP4K</td><td>SMPC</td><td>MSL3</td></tr>
<tr><td>TC</td><td>700 cyc</td></tr>
<tr><td>HTSL</td><td>1000 hr</td></tr>
<tr><td>BHAST</td><td>264 hr</td></tr>
<tr><td>UHAST</td><td>264 hr</td></tr>
</table>

FOUNDRY	DEVICE	STRESS	caBGA		QFN			WLCSP				
			121-pin	256-pin	32-pin	48-pin	84-pin	16-pin	16-pin	25-pin	30-pin	36-pin
			9x9mm, 0.8mm pitch	14x14mm, 0.8mm pitch	5x5mm, 0.5mm pitch	7x7mm, 0.5mm pitch	7x7mm, 0.5mm pitch	1.4x1.48mm, 0.35mm pitch	1.4x1.4mm, 0.35mm pitch	1.71x1.71mm, 0.35mm pitch	2.15x2.55mm, 0.4mm pitch	2.08x2.08mm, 0.35mm pitch
			ASEK									
UMC	ICE40LP384		Package not offered		Package not offered in site	Package not offered		Package not offered				
	ICE40UP3K		Package not offered		Package not offered	QBS (5)	Package not offered	Package not offered			QBS (4)	Package not offered
	ICE40UP5K	SMPC				MSL3					MSL1	
		TC				700 cyc					700 cyc	
		HTSL				1000 hr					1000 hr	
		BHAST				96 hr					96 hr	
		UHAST				96 hr					96 hr	
	ICE40LM1K		Package not offered		Package not offered			Package not offered		QBS (2)	Package not offered	
	ICE40LM2K									QBS (2)		
	ICE40LM4K	SMPC								MSL1		
		TC								700 cyc		
		HTSL								1000 hr		
		BHAST								264 hr		
		UHAST								264 hr		
		Bend								20,000 cyc		
		Drop								30 drops		
		Slow TC								208 cyc		
	ICE40UL1K	SMPC	Package not offered		Package not offered			Package not offered	MSL1	Package not offered		
		TC							700 cyc			
		HTSL							1000 hr			
		BHAST							264 hr			
		UHAST							264 hr			
		Bend							20,000 cyc			
		Drop							30 drops			
		Slow TC							208 cyc			
	ICE40UL640								QBS (3)			

(1) QBS to ICE40HX8K-BG121
(2) QBS to ICE40LM4K-SWG25
(3) QBS to ICE40UL1K-SWG16
(4) QBS to ICE40UP5K-UWG30
(5) QBS to ICE40UP5K-SG48
(6) QBS to ICE5LP4K-SWG36

*iCE40 products that are built in this assembly technology and manufactured in the package types shown are qualified-by-similarity (QBS) using the family generic data from the product/package combinations above.

Table 3.1.2 ASEM Qualification-By-Similarity Matrix

FOUNDRY	DEVICE	STRESS	QFP		ucBGA					csBGA			caBGA		QFN		
			100-pin	144-pin	36-pin	49-pin	81-pin	121-pin	225-pin	81-pin	121-pin	132-pin	121-pin	256-pin	32-pin	48-pin	84-pin
			14x14mm, 0.5mm pitch	20x20mm, 0.5mm pitch	2.5x2.5mm, 0.4mm pitch	3x3mm, 0.4mm pitch	4x4mm, 0.4mm pitch	5x5mm, 0.4mm pitch	7x7mm, 0.4mm pitch	5x5mm, 0.5mm pitch	6x6mm, 0.5mm pitch	8x8mm, 0.5mm pitch	9x9mm, 0.8mm pitch	14x14mm, 0.8mm pitch	5x5mm, 0.5mm pitch	7x7mm, 0.5mm pitch	7x7mm, 0.5mm pitch
			ASEM														
TSMC	ICE40HX1K	SMPC	**MSL3**	QBS (1)	Package not offered				QBS (3)	Package not offered		QBS (3)	Package not offered in site	QBS (3)	Package not offered		
		TC	**700 cyc**														
		BHAST	**96 hr**														
		Autoclave	**96 hr**														
		HTSL	**1000 hr**														
	ICE40HX4K	SMPC	QBS (1)	**MSL3**					QBS (3)			QBS (3)		QBS (3)			
		TC		**700 cyc**													
		BHAST		**264 hr**													
		HTSL		**1000 hr**													
	ICE40HX8K	SMPC	QBS (1)						QBS (3)			QBS (3)		**MSL3**			
		TC												**700 cyc**			
		BHAST												**264 hr**			
		HTSL												**1000 hr**			
	ICE40LP1K		Package not offered		QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)	Package not offered	Package not offered		Package not offered		
	ICE40LP4K				QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)						
	ICE40LP8K	TC			QBS (3)	QBS (3)	Q3'21	QBS (3)	QBS (3)	QBS (3)	QBS (3)						
	ICE40LP640				QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)	QBS (3)						

FOUNDRY	DEVICE	STRESS	QFP		ucBGA					csBGA			caBGA		QFN		
			100-pin	144-pin	36-pin	49-pin	81-pin	121-pin	225-pin	81-pin	121-pin	132-pin	121-pin	256-pin	32-pin	48-pin	84-pin
			14x14mm, 0.5mm pitch	20x20mm, 0.5mm pitch	2.5x2.5mm, 0.4mm pitch	3x3mm, 0.4mm pitch	4x4mm, 0.4mm pitch	5x5mm, 0.4mm pitch	7x7mm, 0.4mm pitch	5x5mm, 0.5mm pitch	6x6mm, 0.5mm pitch	8x8mm, 0.5mm pitch	9x9mm, 0.8mm pitch	14x14mm, 0.8mm pitch	5x5mm, 0.5mm pitch	7x7mm, 0.5mm pitch	7x7mm, 0.5mm pitch
			ASEM														
UMC	ICE5LP1K		Package not offered		Package not offered					Package not offered			Package not offered		Package not offered	QBS (4)	Package not offered
	ICE5LP2K															QBS (4)	
	ICE5LP4K	SMPC														**MSL3**	
		TC														**700 cyc**	
		BHAST														**96 hr, 264 hr**	
		UHAST														**96 hr**	
		HTSL														**1000 hr**	
	ICE40LP384	SMPC	Package not offered		**MSL3**	Q3'21	**MSL3**	Package not offered		Package not offered			Package not offered		**MSL3**	Package not offered	
		TC			**1000 cyc**	**QBS (2)**	**1000 cyc**								**700 cyc**		
		BHAST			**264 hr**	Q3'21	**264 hr**								**96 hr**		
		HTSL			**1000 hr**		**1000 hr**								**1000 hr**		
	ICE40UP3K		Package not offered		Package not offered					Package not offered			Package not offered		Package not offered	QBS (5)	Package not offered
	ICE40UP5K	SMPC														**MSL3**	
		TC														**700 cyc**	
		THB														**1000 hr**	
		UHAST														**96 hr**	
		HTSL														**1000 hr**	
	ICE40LM1K		Package not offered		QBS (6)	Package not offered in site	Package not offered			Package not offered			Package not offered		Package not offered		
	ICE40LM2K																
	ICE40LM4K	SMPC			**MSL3**												
		TC			**700 cyc**												
	ICE40UL1K	SMPC	Package not offered		**MSL3**	Package not offered				Package not offered			Package not offered		Package not offered		
		TC			**700 cyc**												
		HTSL			**1000 hr**												
		UHAST			**264 hr**												
		BHAST			**264 hr**												
	ICE40UL640				QBS (6)												

(1) QBS to ICE40HX4K-TN144
(2) QBS to ICE40LP384-UMG36 (TC only)
(3) QBS to ICE40HX8K-BC256A (HTSL, UHAST, BHAST) only, and ICE40LP8K-UMG81 (TC only)
(4) QBS to ICE5LP4K-SG48
(5) QBS to ICE40UP5K-SG48
(6) QBS to ICE40UL1K-UMG36 (HTSL, UHAST, BHAST, THB) only, and ICE40LM4K-UMG36 (TC only)

*iCE40 products that are built in this assembly technology and manufactured in the package types shown are qualified-by-similarity (QBS) using the family generic data from the product/package combinations above.

Table 3.1.3 ATP Qualification-By-Similarity Matrix

FOUNDRY	DEVICE	STRESS	ucfBGA	ucBGA					caBGA	
			36-pin	36-pin	49-pin	81-pin	121-pin	225-pin	121-pin	256-pin
			2.5x2.5mm, 0.4mm pitch	2.5x2.5mm, 0.4mm pitch	3x3mm, 0.4mm pitch	4x4mm, 0.4mm pitch	5x5mm, 0.4mm pitch	7x7mm, 0.4mm pitch	9x9mm, 0.8mm pitch	14x14mm, 0.8mm pitch
			ATP							
TSMC	ICE40HX1K		Package not offered	Package not offered				Package not offered in site	QBS (5)	Package not offered in site
	ICE40HX4K								QBS (5)	
	ICE40HX8K	SMPC							MSL3	
		TC							700 cyc	
		BHAST							1000 hr	
		BHAST							264 hr	
		HTSL							1000 hr	
	ICE40LP1K		Package not offered	Package not offered in site					Package not offered	
	ICE40LP4K									
	ICE40LP8K									
	ICE40LP640									
UMC	ICE5LP1K		QBS (1)	Package not offered					Package not offered	
	ICE5LP2K		QBS (1)							
	ICE5LP4K	SMPC	MSL3							
		TC	700 cyc							
		BHAST	264 hr							
		UHAST	264 hr							
		HTSL	1000 hr							
	ICE40LP384		Package not offered	Package not offered in site		Package not offered			Package not offered	
	ICE40UP3K		Package not offered	Package not offered					Package not offered	
	ICE40UP5K									
	ICE40LM1K		Package not offered	QBS (3)	QBS (3)	Package not offered			Package not offered	
	ICE40LM2K			QBS (3)	QBS (3)					
	ICE40LM4K	SMPC		MSL3	MSL3					
		TC		700 cyc	700 cyc					
		BHAST		QBS (3)	264 hr					
		HTSL		QBS (3)	1000 hr					

FOUNDRY	DEVICE	STRESS	ucfBGA	ucBGA					caBGA	
			36-pin	36-pin	49-pin	81-pin	121-pin	225-pin	121-pin	256-pin
			2.5x2.5mm, 0.4mm pitch	2.5x2.5mm, 0.4mm pitch	3x3mm, 0.4mm pitch	4x4mm, 0.4mm pitch	5x5mm, 0.4mm pitch	7x7mm, 0.4mm pitch	9x9mm, 0.8mm pitch	14x14mm, 0.8mm pitch
			ATP							
UMC	ICE40UL1K	SMPC	Package not offered	**MSL3**	Package not offered				Package not offered	
		TC		**700 cyc**						
		UHAST		**264 hr**						
		HTSL		**1000 hr**						
	ICE40UL640			**QBS (4)**						

(1) QBS to ICE5LP4K-UFG36
(2) QBS to ICE40LP384-UMG36 (TC only)
(3) QBS to ICE40LM4K-UMG49 + additional TC extension on ICE40LM4K-UMG36
(4) QBS to ICE40UL1K-UMG36
(5) QBS to ICE40HX8K-BG121

*iCE40 products that are built in this assembly technology and manufactured in the package types shown are qualified-by-similarity (QBS) using the family generic data from the product/package combinations above.

Table 3.1.4 ATT Qualification-By-Similarity Matrix

FOUNDRY	DEVICE	STRESS	WLCSP				
			16-pin	16-pin	25-pin	30-pin	36-pin
			1.4x1.48mm, 0.35mm pitch	1.4x1.4mm, 0.35mm pitch	1.71x1.71mm, 0.35mm pitch	2.15x2.55mm, 0.4mm pitch	2.08x2.08mm, 0.35mm pitch
			ATP				
TSMC	ICE40HX1K		Package not offered				
	ICE40HX4K						
	ICE40HX8K						
	ICE40LP1K		Package not offered in site	Package not offered			
	ICE40LP4K						
	ICE40LP8K						
	ICE40LP640						
UMC	ICE5LP1K		Package not offered				QBS (1)
	ICE5LP2K						QBS (1)
	ICE5LP4K	SMPC					MSL1
		TC					700 cyc
		HTSL					1000 hr
		BHAST					264 hr
		UHAST					264 hr
		Bend					20,000 cyc
		Drop					30 drops
		Slow TC					208 cyc
	ICE40LP384		Package not offered				
	ICE40UP3K		Package not offered			Package not offered in site	Package not offered
	ICE40UP5K						
	ICE40LM1K		Package not offered		Package not offered in site	Package not offered	
	ICE40LM2K						
	ICE40LM4K						
	ICE40UL1K		Package not offered	Package not offered in site	Package not offered		
	ICE40UL640						

(1) QBS to ICE5LP4K-SWG36

*iCE40 products that are built in this assembly technology and manufactured in the package types shown are qualified-by-similarity (QBS) using the family generic data from the product/package combinations above.

3.2 Surface Mount Preconditioning Testing (SMPC)

The Surface Mount Preconditioning (SMPC) Test is used to model the surface mount assembly conditions during component solder processing. All devices stressed through High Temperature Storage, Temperature Cycling, Un-biased HAST and Biased HAST were preconditioned. This preconditioning is consistent with J-STD-020D.1 and JEDEC JESD22-A113 "Preconditioning Procedures of Plastic Surface Mount Devices Prior to Reliability Testing".

Surface Mount Preconditioning (MSL3): (24 hours bake @ 125°C; 30°C/60% RH soak for 192 hours; 3X passes of reflow simulation) performed before all package stresses.
MSL3 Packages: caBGA, csBGA, ucfBGA, ucBGA, TQFP, and QFN

Surface Mount Preconditioning (MSL1): (24 hours bake @ 125°C; 85°C/85% RH soak for 168 hours; 3X passes of reflow simulation) performed before all package stresses.
MSL1 Packages: WLCSP

Method: J-STD-020 and JESD22-A113

Table 3.2 Surface Mount Precondition Data

Product Name	Package	Assembly Site	Lot Number	Moisture Soak Level	3X Reflow Temperature	Quantity	# of Fails
iCE40UL1K	16WLCSP	ASEK	Lot #1	MSL1	260°C	112	0
iCE40UL1K	16WLCSP	ASEK	Lot #2	MSL1	260°C	256	0
iCE40UL1K	16WLCSP	ASEK	Lot #3	MSL1	260°C	115	0
iCE40LM4K	25WLCSP	ASEK	Lot #1	MSL1	260°C	240	0
iCE40LM4K	25WLCSP	ASEK	Lot #2	MSL1	260°C	239	0
iCE40LM4K	25WLCSP	ASEK	Lot #3	MSL1	260°C	239	0
iCE5LP4K	36WLCSP	ASEK	Lot #1	MSL1	260°C	191	1[1]
iCE5LP4K	36WLCSP	ASEK	Lot #2	MSL1	260°C	184	0
iCE5LP4K	36WLCSP	ASEK	Lot #3	MSL1	260°C	192	0
iCE5LP4K	36WLCSP	ASEK	Lot #4	MSL1	260°C	419	0
iCE5LP4K	36WLCSP	ASEK	Lot #5	MSL1	260°C	448	0
iCE5LP4K	36WLCSP	ASEK	Lot #6	MSL1	260°C	444	0
iCE5LP4K	36WLCSP	ASEK	Lot #7	MSL1	260°C	409	0
iCE5LP4K	36WLCSP	ASEK	Lot #8	MSL1	260°C	414	0
iCE5LP4K	36WLCSP	ASEK	Lot #9	MSL1	260°C	411	0
iCE5LP4K	36WLCSP	ATT	Lot #1	MSL1	260°C	531	0
iCE5LP4K	36WLCSP	ATT	Lot #2	MSL1	260°C	531	0
iCE5LP4K	36WLCSP	ATT	Lot #3	MSL1	260°C	589	0
iCE5LP4K	36WLCSP	ATT	Lot #4	MSL1	260°C	417	0
iCE5LP4K	36WLCSP	ATT	Lot #5	MSL1	260°C	400	0
iCE5LP4K	36WLCSP	ATT	Lot #6	MSL1	260°C	410	0
iCE40UP5K	30WLCSP	ASEK	Lot #1	MSL1	260°C	485	0
iCE40UP5K	30WLCSP	ASEK	Lot #2	MSL1	260°C	484	1[2]
iCE40UP5K	30WLCSP	ASEK	Lot #3	MSL1	260°C	485	0
iCE40LP384	32QFN	ASEM	Lot #1	MSL3	260°C	397	0
iCE40LP384	32QFN	ASEM	Lot #2	MSL3	260°C	397	0
iCE40LP384	32QFN	ASEM	Lot #3	MSL3	260°C	396	0
iCE40LP1K	84QFN	ASEM	Lot #1	MSL3	260°C	190	0
iCE40LP1K	84QFN	ASEM	Lot #2	MSL3	260°C	190	0
iCE5LP4K	48QFN	ASEM	Lot #1	MSL3	260°C	384	0
iCE5LP4K	48QFN	ASEM	Lot #2	MSL3	260°C	384	0
iCE5LP4K	48QFN	ASEM	Lot #3	MSL3	260°C	384	0
iCE40UP5K	48QFN	ASEM	Lot #1	MSL3	260°C	604	0

Product Name	Package	Assembly Site	Lot Number	Moisture Soak Level	3X Reflow Temperature	Quantity	# of Fails
iCE40UP5K	48QFN	ASEM	Lot #2	MSL3	260°C	605	0
iCE40UP5K	48QFN	ASEM	Lot #3	MSL3	260°C	605	0
iCE40UP5K	48QFN	ASEK	Lot #1	MSL3	260°C	400	0
iCE40UP5K	48QFN	ASEK	Lot #2	MSL3	260°C	400	0
iCE40UP5K	48QFN	ASEK	Lot #3	MSL3	260°C	400	0
iCE40HX1K	100TQFP	ASEM	Lot #1	MSL3	260°C	190	0
iCE40HX1K	100TQFP	ASEM	Lot #2	MSL3	260°C	190	0
iCE40HX4K	144TQFP	ASEM	Lot #1	MSL3	260°C	245	0
iCE40HX4K	144TQFP	ASEM	Lot #2	MSL3	260°C	245	0
iCE40HX4K	144TQFP	ASEM	Lot #3	MSL3	260°C	245	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #1	MSL3	260°C	85	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #2	MSL3	260°C	277	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #3	MSL3	260°C	277	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #4	MSL3	260°C	277	0
iCE40LP384	36ucBGA	ASEM	Lot #1	MSL3	260°C	83	0
iCE40LP384	36ucBGA	ASEM	Lot #2	MSL3	260°C	83	0
iCE40LP384	36ucBGA	ASEM	Lot #3	MSL3	260°C	83	0
iCE40LM4K	36ucBGA	ATP	Lot #1	MSL3	260°C	85	0
iCE40LM4K	36ucBGA	ATP	Lot #2	MSL3	260°C	85	0
iCE40LM4K	36ucBGA	ATP	Lot #3	MSL3	260°C	85	0
iCE40UL1K	36ucBGA	ATP	Lot #1	MSL3	260°C	412	0
iCE40UL1K	36ucBGA	ATP	Lot #2	MSL3	260°C	399	0
iCE40UL1K	36ucBGA	ATP	Lot #3	MSL3	260°C	381	0
iCE40LM4K	49ucBGA	ATP	Lot #1	MSL3	260°C	165	0
iCE40LM4K	49ucBGA	ATP	Lot #2	MSL3	260°C	243	0
iCE40LM4K	49ucBGA	ATP	Lot #3	MSL3	260°C	165	0
iCE40LM4K	49ucBGA	ATP	Lot #4	MSL3	260°C	254	0
iCE40LM4K	49ucBGA	ATP	Lot #5	MSL3	260°C	255	0
iCE40LP384	81ucBGA	ASEM	Lot #1	MSL3	260°C	400	0
iCE40LP384	81ucBGA	ASEM	Lot #2	MSL3	260°C	400	0
iCE40LP384	81ucBGA	ASEM	Lot #3	MSL3	260°C	400	0
iCE40LP8K	225ucBGA	ASEM	Lot #1	MSL3	260°C	140	0
iCE40LP8K	225ucBGA	ASEM	Lot #2	MSL3	260°C	140	0
iCE40LP8K	225ucBGA	ASEM	Lot #3	MSL3	260°C	140	0
iCE40HX8K	256caBGA	ASEM	Lot #1	MSL3	260°C	140	0
iCE40HX8K	256caBGA	ASEM	Lot #2	MSL3	260°C	140	0
ICE40HX8K	121caBGA	ATP	Lot #1	MSL3	260°C	500	0
ICE40HX8K	121caBGA	ATP	Lot #2	MSL3	260°C	500	0
ICE40HX8K	121caBGA	ATP	Lot #3	MSL3	260°C	500	0
ICE40HX8K	121caBGA	ASEK	Lot #1	MSL3	260°C	216	0
ICE40HX8K	121caBGA	ASEK	Lot #2	MSL3	260°C	216	0
ICE40HX8K	121caBGA	ASEK	Lot #3	MSL3	260°C	216	0
ICE40LM4K	36ucBGA	ASEM	Lot #1	MSL3	260°C	77	0
ICE40LM4K	36ucBGA	ASEM	Lot #2	MSL3	260°C	77	0
ICE40LM4K	36ucBGA	ASEM	Lot #3	MSL3	260°C	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #1	MSL3	260°C	256	0
ICE40UL1K	36ucBGA	ASEM	Lot #2	MSL3	260°C	256	0
ICE40UL1K	36ucBGA	ASEM	Lot #3	MSL3	260°C	256	0

[1] FAR #1442/SC1407013: One unit SRAM readback fail due to random fab defect.
[2] FAR #1645/LI1608039: non-systematic failure. Root cause unknown.

Cumulative SMPC Failure Rate = 2 / 24,237

3.3 Temperature Cycling (TC)

The Temperature Cycling test is used to accelerate those failures resulting from mechanical stresses induced by differential thermal expansion of adjacent films, layers and metallurgical interfaces in the die and package. Devices are tested at 25°C after exposure to repeated cycling between -55°C and +125°C in an air environment consistent with JEDEC JESD22-A104 “Temperature Cycling”, Condition B temperature cycling requirements. Prior to Temperature Cycling testing, all devices are subjected to Surface Mount Preconditioning.

MSL3 Packages: caBGA, csBGA, ucfBGA, ucBGA, TQFP, and QFN
MSL1 Packages: WLCSP
Stress Duration: 700 and 1000 cycles
Stress Conditions: Temperature cycling between -55°C to 125°C

Method: JESD22-A104, Condition B

Table 3.3 Temperature Cycling Data

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	1x Stress Duration	Quantity	# of Fails
iCE40UL1K	16WLCSP	ASEK	Lot #1	-55°C to 125°C	700 cycles	92	0
iCE40UL1K	16WLCSP	ASEK	Lot #2	-55°C to 125°C	700 cycles	95	0
iCE40UL1K	16WLCSP	ASEK	Lot #3	-55°C to 125°C	700 cycles	92	0
iCE40LM4K	25WLCSP	ASEK	Lot #1	-55°C to 125°C	700 cycles	78	0
iCE40LM4K	25WLCSP	ASEK	Lot #2	-55°C to 125°C	700 cycles	79	0
iCE40LM4K	25WLCSP	ASEK	Lot #3	-55°C to 125°C	700 cycles	79	0
iCE40UP5K	30WLCSP	ASEK	Lot #1	-55°C to 125°C	1000 cycles	90	0
iCE40UP5K	30WLCSP	ASEK	Lot #2	-55°C to 125°C	1000 cycles	89	0
iCE40UP5K	30WLCSP	ASEK	Lot #3	-55°C to 125°C	1000 cycles	90	0
iCE5LP4K	36WLCSP	ASEK	Lot #1	-55°C to 125°C	700 cycles	95	0
iCE5LP4K	36WLCSP	ASEK	Lot #2	-55°C to 125°C	700 cycles	94	0
iCE5LP4K	36WLCSP	ASEK	Lot #3	-55°C to 125°C	700 cycles	96	0
iCE5LP4K	36WLCSP	ASEK	Lot #4	-55°C to 125°C	700 cycles	104	0
iCE5LP4K	36WLCSP	ASEK	Lot #5	-55°C to 125°C	700 cycles	104	0
iCE5LP4K	36WLCSP	ASEK	Lot #6	-55°C to 125°C	700 cycles	108	0
iCE5LP4K	36WLCSP	ASEK	Lot #7	-55°C to 125°C	700 cycles	108	0
iCE5LP4K	36WLCSP	ASEK	Lot #8	-55°C to 125°C	700 cycles	108	0
iCE5LP4K	36WLCSP	ASEK	Lot #9	-55°C to 125°C	700 cycles	106	0
iCE5LP4K	36WLCSP	ATT	Lot #1	-55°C to 125°C	700 cycles	105	0
iCE5LP4K	36WLCSP	ATT	Lot #2	-55°C to 125°C	700 cycles	106	0
iCE5LP4K	36WLCSP	ATT	Lot #3	-55°C to 125°C	700 cycles	106	0
iCE5LP4K	36WLCSP	ATT	Lot #4	-55°C to 125°C	700 cycles	104	0
iCE5LP4K	36WLCSP	ATT	Lot #5	-55°C to 125°C	700 cycles	107	0
iCE5LP4K	36WLCSP	ATT	Lot #6	-55°C to 125°C	700 cycles	106	0
iCE40LP384	32QFN	ASEM	Lot #1	-55°C to 125°C	1000 cycles	77	0
iCE40LP384	32QFN	ASEM	Lot #2	-55°C to 125°C	1000 cycles	77	0
iCE40LP384	32QFN	ASEM	Lot #3	-55°C to 125°C	1000 cycles	80	0
iCE5LP4K	48QFN	ASEM	Lot #1	-55°C to 125°C	700 cycles	91	0
iCE5LP4K	48QFN	ASEM	Lot #2	-55°C to 125°C	700 cycles	91	0
iCE5LP4K	48QFN	ASEM	Lot #3	-55°C to 125°C	700 cycles	91	0
iCE40UP5K	48QFN	ASEM	Lot #1	-55°C to 125°C	1000 cycles	90	0
iCE40UP5K	48QFN	ASEM	Lot #2	-55°C to 125°C	1000 cycles	90	0
iCE40UP5K	48QFN	ASEM	Lot #3	-55°C to 125°C	1000 cycles	90	0
iCE40UP5K	48QFN	ASEK	Lot #1	-55°C to 125°C	700 cycles	77	0
iCE40UP5K	48QFN	ASEK	Lot #2	-55°C to 125°C	700 cycles	77	0
iCE40UP5K	48QFN	ASEK	Lot #3	-55°C to 125°C	700 cycles	77	0

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	1x Stress Duration	Quantity	# of Fails
iCE40LP1K	84QFN	ASEM	Lot #1	-55°C to 125°C	700 cycles	25	0
iCE40LP1K	84QFN	ASEM	Lot #2	-55°C to 125°C	700 cycles	25	0
iCE40HX1K	100TQFP	ASEM	Lot #1	-55°C to 125°C	700 cycles	25	0
iCE40HX1K	100TQFP	ASEM	Lot #2	-55°C to 125°C	700 cycles	25	0
iCE40HX4K	144TQFP	ASEM	Lot #1	-55°C to 125°C	700 cycles	80	0
iCE40HX4K	144TQFP	ASEM	Lot #2	-55°C to 125°C	700 cycles	80	0
iCE40HX4K	144TQFP	ASEM	Lot #3	-55°C to 125°C	700 cycles	80	0
iCE40LP384	36ucBGA	ASEM	Lot #1	-55°C to 125°C	1000 cycles	81	0
iCE40LP384	36ucBGA	ASEM	Lot #2	-55°C to 125°C	1000 cycles	81	0
iCE40LP384	36ucBGA	ASEM	Lot #3	-55°C to 125°C	1000 cycles	78	0
iCE40LM4K	36ucBGA	ATP	Lot #1	-55°C to 125°C	700 cycles	80	0
iCE40LM4K	36ucBGA	ATP	Lot #2	-55°C to 125°C	700 cycles	80	0
iCE40LM4K	36ucBGA	ATP	Lot #3	-55°C to 125°C	700 cycles	80	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #1	-55°C to 125°C	700 cycles	79	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #2	-55°C to 125°C	700 cycles	91	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #3	-55°C to 125°C	700 cycles	87	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #4	-55°C to 125°C	700 cycles	75	0
iCE40UL1K	36ucBGA	ATP	Lot #1	-55°C to 125°C	700 cycles	96	0
iCE40UL1K	36ucBGA	ATP	Lot #2	-55°C to 125°C	700 cycles	96	0
iCE40UL1K	36ucBGA	ATP	Lot #3	-55°C to 125°C	700 cycles	87	0
iCE40LM4K	49ucBGA	ATP	Lot #1	-55°C to 125°C	700 cycles	80	0
iCE40LM4K	49ucBGA	ATP	Lot #2	-55°C to 125°C	700 cycles	80	0
iCE40LM4K	49ucBGA	ATP	Lot #3	-55°C to 125°C	700 cycles	80	0
iCE40LM4K	49ucBGA	ATP	Lot #4	-55°C to 125°C	700 cycles	80	0
iCE40LM4K	49ucBGA	ATP	Lot #5	-55°C to 125°C	700 cycles	80	0
iCE40LP384	81ucBGA	ASEM	Lot #1	-55°C to 125°C	1000 cycles	81	0
iCE40LP384	81ucBGA	ASEM	Lot #2	-55°C to 125°C	1000 cycles	77	0
iCE40LP384	81ucBGA	ASEM	Lot #3	-55°C to 125°C	1000 cycles	80	0
iCE40LP8K	225ucBGA	ASEM	Lot #1	-55°C to 125°C	700 cycles	25	0
iCE40LP8K	225ucBGA	ASEM	Lot #2	-55°C to 125°C	700 cycles	25	0
iCE40LP8K	225ucBGA	ASEM	Lot #3	-55°C to 125°C	700 cycles	25	0
iCE40HX8K	256caBGA	ASEM	Lot #1	-55°C to 125°C	700 cycles	25	0
iCE40HX8K	256caBGA	ASEM	Lot #2	-55°C to 125°C	700 cycles	25	0
ICE40HX8K	121caBGA	ATP	Lot #1	-55°C to 125°C	700 cycles	85	0
ICE40HX8K	121caBGA	ATP	Lot #2	-55°C to 125°C	700 cycles	85	0
ICE40HX8K	121caBGA	ATP	Lot #3	-55°C to 125°C	700 cycles	85	0
ICE40HX8K	121caBGA	ASEK	Lot #1	-55°C to 125°C	700 cycles	77	0
ICE40HX8K	121caBGA	ASEK	Lot #2	-55°C to 125°C	700 cycles	77	0
ICE40HX8K	121caBGA	ASEK	Lot #3	-55°C to 125°C	700 cycles	77	0
ICE40LM4K	36ucBGA	ASEM	Lot #1	-55°C to 125°C	700 cycles	77	0
ICE40LM4K	36ucBGA	ASEM	Lot #2	-55°C to 125°C	700 cycles	77	0
ICE40LM4K	36ucBGA	ASEM	Lot #3	-55°C to 125°C	700 cycles	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #1	-55°C to 125°C	700 cycles	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #2	-55°C to 125°C	700 cycles	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #3	-55°C to 125°C	700 cycles	77	0

Cumulative Temp Cycle Failure Rate = 0 / 6,491
Cumulative Device Temp Cycles = 4,919,000

3.4 Biased Highly Accelerated Temperature and Humidity Stress Test (BHAST) or Steady-State Temperature Humidity Bias Life Test (THB)

Highly Accelerated Stress Test (HAST) testing uses both pressure and temperature to accelerate penetration of moisture into the package and to the die surface. The BHAST test is used to accelerate threshold shifts in the MOS device associated with moisture diffusion into the gate oxide region as well as electrochemical corrosion mechanisms within the device package. Consistent with JEDEC JESD22-A110 “Highly-Accelerated Temperature and Humidity Stress Test”, the biased HAST conditions are either 96 hours exposure at 130°C and 85% relative humidity, or 264 hours exposure at 110°C and 85% relative humidity.

Steady-State Temperature Humidity Bias Life Test (THB) uses temperature, humidity and bias, minus the pressure, to accelerate the penetration of moisture through the external protective material or along the interface between the external protective material and the metallic conductors that pass through. The stress usually activates the same failure mechanism as BHAST but with a lower acceleration factor, hence, units are subjected to a longer stress time of 1000 hours at 85°C and 85% relative humidity, consistent with JEDEC JESD22-A101 “Steady-State Temperature Humidity Bias Life Test”.

Prior to BHAST or THB, all Pb-free wirebonded devices are subjected to Surface Mount Preconditioning. This is a relatively new requirement consistent with JESD47 for Pb-free, wirebonded packages (WLCSP packages not included).

MSL3 Packages: caBGA, csBGA, ucfBGA, ucBGA, TQFP, and QFN
MSL1 Packages: WLCSP
Stress Conditions: Vcc= Max operating condition and 130°C or 110°C and 85% RH (BHAST) or 85°C and 85% RH (THB)
Stress Duration: 96 Hrs, 264 Hrs or 1000 Hrs respectively

Method: JESD22-A110 (HAST); JESD22-A101 (THB)

Table 3.4 BHAST/THB Data

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	Stress Duration	Quantity	# of Fails
iCE40UL1K	16WLCSP	ASEK	Lot #1	110°C	264 Hrs	31	0
iCE40UL1K	16WLCSP	ASEK	Lot #3	110°C	264 Hrs	32	0
iCE40LM4K	25WLCSP	ASEK	Lot #1	110°C	264 Hrs	96	0
iCE40LM4K	25WLCSP	ASEK	Lot #2	110°C	264 Hrs	96	0
iCE40LM4K	25WLCSP	ASEK	Lot #3	110°C	264 Hrs	94	0
iCE40UP5K	30WLCSP	ASEK	Lot #1	130°C	96 Hrs	35	0
iCE40UP5K	30WLCSP	ASEK	Lot #2	130°C	96 Hrs	35	0
iCE40UP5K	30WLCSP	ASEK	Lot #3	130°C	96 Hrs	115	0
iCE5LP4K	36WLCSP	ASEK	Lot #1	110°C	264 Hrs	78	0
iCE5LP4K	36WLCSP	ASEK	Lot #2	110°C	264 Hrs	86	0
iCE5LP4K	36WLCSP	ASEK	Lot #4	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #5	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #6	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #7	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #8	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #9	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #1	110°C	264 Hrs	84	0

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	Stress Duration	Quantity	# of Fails
iCE5LP4K	36WLCSP	ATT	Lot #2	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #3	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #4	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #5	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #6	110°C	264 Hrs	84	0
iCE40LP384	32QFN	ASEM	Lot #1	130°C	96 Hrs	77	0
iCE40LP384	32QFN	ASEM	Lot #2	130°C	96 Hrs	77	0
iCE40LP384	32QFN	ASEM	Lot #3	130°C	96 Hrs	76	0
iCE5LP4K	48QFN	ASEM	Lot #1	130°C	96 Hrs	84	2[1]
iCE5LP4K	48QFN	ASEM	Lot #2	130°C	96 Hrs	84	1[1]
iCE5LP4K	48QFN	ASEM	Lot #3	110°C	264 Hrs	84	1[1]
iCE40UP5K	48QFN	ASEM	Lot #2	85°C	1000 Hrs	84	0
iCE40UP5K	48QFN	ASEM	Lot #3	85°C	1000 Hrs	84	0
iCE40UP5K	48QFN	ASEM	Lot #4	130°C	96 Hrs	45	0
iCE40UP5K	48QFN	ASEM	Lot #5	130°C	96 Hrs	45	0
iCE40UP5K	48QFN	ASEK	Lot #1	130°C	96 Hrs	77	0
iCE40UP5K	48QFN	ASEK	Lot #2	130°C	96 Hrs	77	0
iCE40UP5K	48QFN	ASEK	Lot #3	130°C	96 Hrs	77	0
iCE40LP1K	84QFN	ASEM	Lot #1	130°C	96 Hrs	25	0
iCE40LP1K	84QFN	ASEM	Lot #2	130°C	96 Hrs	25	0
iCE40HX1K	100TQFP	ASEM	Lot #1	130°C	96 Hrs	25	0
iCE40HX1K	100TQFP	ASEM	Lot #2	130°C	96 Hrs	25	0
iCE40HX4K	144TQFP	ASEM	Lot #1	130°C	96 Hrs	76	0
iCE40HX4K	144TQFP	ASEM	Lot #2	130°C	96 Hrs	76	0
iCE40HX4K	144TQFP	ASEM	Lot #3	130°C	96 Hrs	76	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #1	110°C	264 Hrs	84	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #2	110°C	264 Hrs	84	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #3	110°C	264 Hrs	82	0
iCE40LM4K	49ucBGA	ATP	Lot #2	110°C	264 Hrs	78	0
iCE40LM4K	49ucBGA	ATP	Lot #4	110°C	264 Hrs	77	1[2]
iCE40LM4K	49ucBGA	ATP	Lot #5	110°C	264 Hrs	78	0
iCE40LP384	81ucBGA	ASEM	Lot #1	110°C	264 Hrs	79	0
iCE40LP384	81ucBGA	ASEM	Lot #2	110°C	264 Hrs	79	0
iCE40LP384	81ucBGA	ASEM	Lot #3	110°C	264 Hrs	80	0
iCE40LP8K	225ucBGA	ASEM	Lot #1	130°C	96 Hrs	25	0
iCE40LP8K	225ucBGA	ASEM	Lot #2	130°C	96 Hrs	25	0
iCE40LP8K	225ucBGA	ASEM	Lot #3	130°C	96 Hrs	25	0
iCE40HX8K	256caBGA	ASEM	Lot #1	130°C	96 Hrs	25	0
iCE40HX8K	256caBGA	ASEM	Lot #2	130°C	96 Hrs	25	0
iCE40HX8K	121caBGA	ATP	Lot #1	85°C	1000 Hrs	84	0
iCE40HX8K	121caBGA	ATP	Lot #2	85°C	1000 Hrs	84	0
iCE40HX8K	121caBGA	ATP	Lot #3	85°C	1000 Hrs	84	1[3]
iCE40HX8K	121caBGA	ASEK	Lot #1	85°C	1000 Hrs	25	0
iCE40HX8K	121caBGA	ASEK	Lot #2	85°C	1000 Hrs	25	0
iCE40HX8K	121caBGA	ASEK	Lot #3	85°C	1000 Hrs	25	0

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	Stress Duration	Quantity	# of Fails
ICE40UL1K	36ucBGA	ASEM	Lot #1	110°C	264 Hrs	25	0
ICE40UL1K	36ucBGA	ASEM	Lot #2	110°C	264 Hrs	25	0
ICE40UL1K	36ucBGA	ASEM	Lot #3	110°C	264 Hrs	25	0

[1] FAR#1528 – 4u fail opens due to lifted ball bond. CA/PA in place.

[2] FAR#1437 – 1u pin-to-pin short due to random assembly defect.

[3] FAR#1801 – 1u fail opens due to lifted ball bond. CA/PA in place.

Cumulative BHAST failure Rate = 5 / 3,748
Cumulative BHAST device hours = 764,136

Cumulative THB failure Rate = 2 / 579
Cumulative THB device hours = 579,000

3.5 Unbiased HAST

Highly Accelerated Stress Test (HAST) testing uses both pressure and temperature to accelerate penetration of moisture into the package and to the die surface. HAST conditions are 264 hours exposure at 110°C and 85% relative humidity. Prior to Unbiased HAST testing, all devices are subjected to Surface Mount Preconditioning.

MSL3 Packages: caBGA, csBGA, ucfBGA, ucBGA, TQFP, and QFN
MSL1 Packages: WLCSP
Stress Conditions: 130°C, 110°C, and 85% RH
Stress Duration: 96 Hrs and 264 Hrs

Method: JESD22-A118

Table 3.5 Unbiased HAST Data

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	1x Stress Duration	Quantity	# of Fails
iCE40UL1K	16-WLCSP	ASEK	Lot #1	130°C	96 Hrs	35	0
iCE40UL1K	16-WLCSP	ASEK	Lot #2	110°C	264 Hrs	95	0
iCE40UL1K	16-WLCSP	ASEK	Lot #3	130°C	96 Hrs	35	0
iCE40LM4K	25WLCSP	ASEK	Lot #1	110°C	264 Hrs	80	0
iCE40LM4K	25WLCSP	ASEK	Lot #2	110°C	264 Hrs	77	0
iCE40LM4K	25WLCSP	ASEK	Lot #3	110°C	264 Hrs	79	0
iCE40UP5K	30WLCSP	ASEK	Lot #1	130°C	96 Hrs	35	0
iCE40UP5K	30WLCSP	ASEK	Lot #2	130°C	96 Hrs	35	0
iCE40UP5K	30WLCSP	ASEK	Lot #3	130°C	96 Hrs	115	0
iCE5LP4K	36WLCSP	ASEK	Lot #1	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #2	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #3	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #4	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #5	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ASEK	Lot #6	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #1	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #2	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #3	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #4	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #5	110°C	264 Hrs	84	0
iCE5LP4K	36WLCSP	ATT	Lot #6	110°C	264 Hrs	84	0
iCE5LP4K	48-QFN	ASEM	Lot #1	130°C	96 Hrs	96	0
iCE5LP4K	48-QFN	ASEM	Lot #2	130°C	96 Hrs	96	0
iCE5LP4K	48-QFN	ASEM	Lot #3	130°C	96 Hrs	96	0
iCE40UP5K	48-QFN	ASEM	Lot #1	130°C	192 Hrs	90	0
iCE40UP5K	48-QFN	ASEM	Lot #2	130°C	192 Hrs	89	0
iCE40UP5K	48-QFN	ASEM	Lot #3	130°C	192 Hrs	90	0
iCE40UP5K	48-QFN	ASEK	Lot #1	130°C	96 Hrs	77	0
iCE40UP5K	48-QFN	ASEK	Lot #2	130°C	96 Hrs	77	0
iCE40UP5K	48-QFN	ASEK	Lot #3	130°C	96 Hrs	77	0
iCE5LP4K	36-ucfBGA	ATT/ATP	Lot #1	110°C	264 Hrs	95	0
iCE5LP4K	36-ucfBGA	ATT/ATP	Lot #2	110°C	264 Hrs	94	0
iCE5LP4K	36-ucfBGA	ATT/ATP	Lot #3	110°C	264 Hrs	94	0
iCE40UL1K	36-ucBGA	ATP	Lot #1	110°C	264 Hrs	96	0
iCE40UL1K	36-ucBGA	ATP	Lot #2	110°C	264 Hrs	96	0
iCE40UL1K	36-ucBGA	ATP	Lot #3	110°C	264 Hrs	95	0
iCE40HX8K	121caBGA	ATP	Lot #1	110°C	264 Hrs	85	0
iCE40HX8K	121caBGA	ATP	Lot #2	110°C	264 Hrs	85	0
iCE40HX8K	121caBGA	ATP	Lot #3	110°C	264 Hrs	85	0

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	1x Stress Duration	Quantity	# of Fails
iCE40HX8K	121caBGA	ASEK	Lot #1	110°C	264 Hrs	77	0
iCE40HX8K	121caBGA	ASEK	Lot #2	110°C	264 Hrs	77	0
iCE40HX8K	121caBGA	ASEK	Lot #3	110°C	264 Hrs	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #1	110°C	264 Hrs	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #2	110°C	264 Hrs	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #3	110°C	264 Hrs	77	0

Cumulative UHAST failure Rate = 0 / 3,669
Cumulative UHAST device hours = 819,216

3.6 High Temperature Storage Life

The High Temperature Storage Life test is used to determine the effect of time and temperature, under storage conditions, for thermally activated failure mechanisms. Consistent with JEDEC JESD22-A103, the devices are subjected to high temperature storage Condition B: +150 (-0/+10) °C for 1000 hours. Prior to High Temperature Storage, all devices are subjected to Surface Mount Preconditioning. This is a relatively new requirement consistent with JESD47 for Pb-free, wirebonded packages (WLCSP packages not included).

MSL3 Packages: caBGA, csBGA, ucfBGA, ucBGA, TQFP, and QFN
MSL1 Packages: WLCSP*
Stress Duration: 1000 hours
Temperature: 150°C (ambient)

Method: JESD22-A-103

Table 3.6 High Temperature Storage Life Data

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	Stress Duration	Quantity	# of Fails
iCE40UL1K	16WLCSP	ASEK	Lot #1	150°C	1000 Hrs	85	0
iCE40UL1K	16WLCSP	ASEK	Lot #2	150°C	1000 Hrs	96	0
iCE40UL1K	16WLCSP	ASEK	Lot #3	150°C	1000 Hrs	90	0
iCE40LM4K	25WLCSP	ASEK	Lot #1	150°C	1000 Hrs	80	0
iCE40LM4K	25WLCSP	ASEK	Lot #2	150°C	1000 Hrs	79	0
iCE40LM4K	25WLCSP	ASEK	Lot #3	150°C	1000 Hrs	79	0
iCE40UP5K	30WLCSP	ASEK	Lot #1	150°C	1000 Hrs	90	0
iCE40UP5K	30WLCSP	ASEK	Lot #2	150°C	1000 Hrs	90	0
iCE40UP5K	30WLCSP	ASEK	Lot #3	150°C	1000 Hrs	90	0
iCE5LP4K	36WLCSP	ASEK	Lot #1	150°C	1000 Hrs	191	0
iCE5LP4K	36WLCSP	ASEK	Lot #2	150°C	1000 Hrs	185	0
iCE5LP4K	36WLCSP	ASEK	Lot #3	150°C	1000 Hrs	190	0
iCE5LP4K	36WLCSP	ASEK	Lot #4	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ASEK	Lot #5	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ASEK	Lot #6	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ASEK	Lot #7	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ASEK	Lot #8	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ASEK	Lot #9	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ATT	Lot #1	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ATT	Lot #2	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ATT	Lot #3	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ATT	Lot #4	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ATT	Lot #5	150°C	1000 Hrs	50	0
iCE5LP4K	36WLCSP	ATT	Lot #6	150°C	1000 Hrs	50	0
iCE40LP384	32QFN	ASEM	Lot #1	150°C	1000 Hrs	79	0
iCE40LP384	32QFN	ASEM	Lot #2	150°C	1000 Hrs	79	0
iCE40LP384	32QFN	ASEM	Lot #3	150°C	1000 Hrs	77	0
iCE5LP4K	48QFN	ASEM	Lot #1	150°C	1000 Hrs	96	0
iCE5LP4K	48QFN	ASEM	Lot #2	150°C	1000 Hrs	96	0
iCE5LP4K	48QFN	ASEM	Lot #3	150°C	1000 Hrs	96	0
iCE40UP5K	48QFN	ASEM	Lot #1	150°C	1000 Hrs	90	0
iCE40UP5K	48QFN	ASEM	Lot #2	150°C	1000 Hrs	90	0
iCE40UP5K	48QFN	ASEM	Lot #3	150°C	1000 Hrs	89	0
iCE40UP5K	48QFN	ASEK	Lot #1	150°C	1000 Hrs	77	0
iCE40UP5K	48QFN	ASEK	Lot #2	150°C	1000 Hrs	77	0
iCE40UP5K	48QFN	ASEK	Lot #3	150°C	1000 Hrs	77	0

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	Stress Duration	Quantity	# of Fails
iCE40LP1K	84QFN	ASEM	Lot #1	150°C	1000 Hrs	77	0
iCE40LP1K	84QFN	ASEM	Lot #2	150°C	1000 Hrs	77	0
iCE40HX1K	100TQFP	ASEM	Lot #1	150°C	1000 Hrs	77	0
iCE40HX1K	100TQFP	ASEM	Lot #2	150°C	1000 Hrs	77	0
iCE40HX4K	144TQFP	ASEM	Lot #1	150°C	1000 Hrs	80	0
iCE40HX4K	144TQFP	ASEM	Lot #2	150°C	1000 Hrs	80	0
iCE40HX4K	144TQFP	ASEM	Lot #3	150°C	1000 Hrs	80	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #1	150°C	1000 Hrs	85	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #2	150°C	1000 Hrs	82	0
iCE5LP4K	36ucfBGA	ATT/ATP	Lot #3	150°C	1000 Hrs	85	0
iCE40UL1K	36ucBGA	ATP	Lot #1	150°C	1000 Hrs	96	0
iCE40UL1K	36ucBGA	ATP	Lot #2	150°C	1000 Hrs	94	0
iCE40UL1K	36ucBGA	ATP	Lot #3	150°C	1000 Hrs	90	0
iCE40LM4K	49ucBGA	ATP	Lot #1	150°C	1000 Hrs	69	0
iCE40LM4K	49ucBGA	ATP	Lot #2	150°C	1000 Hrs	79	0
iCE40LM4K	49ucBGA	ATP	Lot #3	150°C	1000 Hrs	75	0
iCE40LM4K	49ucBGA	ATP	Lot #4	150°C	1000 Hrs	80	0
iCE40LM4K	49ucBGA	ATP	Lot #5	150°C	1000 Hrs	79	0
iCE40LP384	81ucBGA	ASEM	Lot #1	150°C	1000 Hrs	78	0
iCE40LP384	81ucBGA	ASEM	Lot #2	150°C	1000 Hrs	78	0
iCE40LP384	81ucBGA	ASEM	Lot #3	150°C	1000 Hrs	77	0
iCE40LP8K	225ucBGA	ASEM	Lot #1	150°C	1000 Hrs	77	0
iCE40LP8K	225ucBGA	ASEM	Lot #2	150°C	1000 Hrs	75	0
iCE40LP8K	225ucBGA	ASEM	Lot #3	150°C	1000 Hrs	77	0
iCE40HX8K	256caBGA	ASEM	Lot #1	150°C	1000 Hrs	77	0
iCE40HX8K	256caBGA	ASEM	Lot #2	150°C	1000 Hrs	77	0
iCE40HX8K	121caBGA	ATP	Lot #1	150°C	1000 Hrs	85	0
iCE40HX8K	121caBGA	ATP	Lot #2	150°C	1000 Hrs	85	0
iCE40HX8K	121caBGA	ATP	Lot #3	150°C	1000 Hrs	85	1[1]
iCE40HX8K	121caBGA	ASEK	Lot #1	150°C	1000 Hrs	77	0
iCE40HX8K	121caBGA	ASEK	Lot #2	150°C	1000 Hrs	77	0
iCE40HX8K	121caBGA	ASEK	Lot #3	150°C	1000 Hrs	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #1	150°C	1000 Hrs	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #2	150°C	1000 Hrs	77	0
ICE40UL1K	36ucBGA	ASEM	Lot #3	150°C	1000 Hrs	77	0

[1] FAR#1802 – 1u fail opens due to lifted ball bond. CA/PA in place.

*SMPC not required for WLCSP packages.

Cumulative HTSL failure Rate = 1 / 5,763
Cumulative HTSL device hours = 5,763,000

3.7 Unbiased Autoclave

The Unbiased Autoclave test uses both pressure and temperature to accelerate penetration of moisture into the package and to the die surface. It is a highly accelerated test used to identify failure mechanisms internal to the package and is destructive. Consistent with JEDEC JESD22-A102C "Accelerated Moisture Resistance – Unbiased Autoclave", the Unbiased Autoclave conditions are 96 hours exposure at 121°C and 100% relative humidity. Prior to Unbiased Autoclave testing, all devices are subjected to Surface Mount Preconditioning.

MSL3 Packages: caBGA, csBGA, ucfBGA, ucBGA, TQFP, and QFN
MSL1 Packages: WLCSP
Stress Duration: 96 hours
Temperature: 121°C (ambient)

Method: JESD22-A102

Table 3.7 Unbiased Autoclave Data

Product Name	Package	Assembly Site	Lot Number	Stress Temperature	Stress Duration	Quantity	# of Fails
iCE40LP1K	84-QFN	ASEM	Lot #1	121°C	96 Hrs	45	0
iCE40LP1K	84-QFN	ASEM	Lot #2	121°C	96 Hrs	45	0
iCE40HX1K	100-TQFP	ASEM	Lot #1	121°C	96 Hrs	45	0
iCE40HX1K	100-TQFP	ASEM	Lot #2	121°C	96 Hrs	45	0

Cumulative Unbiased Autoclave failure Rate = 0 / 180
Cumulative Unbiased Autoclave device hours = 17,280

4.0 BOARD LEVEL RELIABILITY (BLR) STRESS METHODS

Reliability testing methods for surface mount electronic components in Wafer Level Chip Scale Packaging (WLCSP) assembled onto printed circuit boards (PCB) are focused on the stresses observed by the manufacturing and test processes and the applications associated with handheld electronic products. The handheld electronic products fit into the consumer and portable market segments with products such as cameras, calculators, cell phones, pagers, palm size PCs, PCMCIA cards, and the like.

Special daisy chain test vehicles are constructed for board level reliability (BLR) testing to emulate as closely as possible, the design, material sets and assembly processes of the actual product being qualified.

BLR PCB test boards are designed per JEDEC JESD22-B111 requirements: 0.8mm thick board with 1+6+1 stack (8 layers) layup coated with OSP “Organic Surface Protection”. Units are arranged in a 3x5 configuration on the board measuring 77mm x 132mm. One side provides VIP “Via-In-Pad” connections to the BGA and the flip side provides NVIP “No-VIP” (surface-trace) connections. The design of pad to surface traces must avoid trace cracks. BGA balls mount to NSMD “Non Solder Mask Defined” pads on the PCB.

Board Level Slow-Temperature Cycling (the slowest speed BLR stress) is intended to evaluate and compare the PCB performance of surface mount electronics components in an environment that accelerates solder joint fatigue and creep for handheld electronic products and applications. Pass/fail event detection is accomplished using resistance measurements. All stress tests are performed in accordance with IPC-JEDEC9701A & JESD22-A104D, condition G, soak mode 2. Repeated slow-temperature cycling of printed circuit boards from -40C to +125C, for up to 3,000 cycles. Handheld electronic products passing criteria is 208 cycles.

Board Level Cyclic Bend Test (the medium speed BLR stress) is intended to evaluate and compare the PCB performance of surface mount electronics components in an environment that accelerates various assembly and test operations and actual use conditions such as repeated key-presses in mobile phone during the life of the product for handheld electronic products and applications. Pass/fail event detection is accomplished using datalogging ‘opens’ detectors. All stress tests are performed in accordance with IPC-JEDEC9702 & JEDEC JESD22-B113A. Repeated bending of printed circuit boards at 1 to 3 Hz cyclic frequency for up to 200,000 cycles with maximum cross-head displacement of 4 mm. Handheld electronic products passing criteria is 20,000 cycles.

Board Level Drop & Mechanical Shock (the instantaneous BLR stress) is intended to evaluate and compare PCB drop performance of surface mount electronic components for handheld electronic product applications in an accelerated test environment determine the compatibility of the component(s) to withstand moderately severe shocks as a result of suddenly applied forces or abrupt change in motion produced by handling, transportation or field operation. Further, handheld electronic products are more prone to being dropped during their useful service life because of their size and weight. Pass/fail event detection is accomplished using datalogging 'opens' detectors. All stress tests are performed in accordance with IPC-JEDEC9703 & JEDEC JESD22-B111 (drop) and JESD-B104C (shock). Repeated drop testing of printed circuit boards at 1500g, 0.5 millisecond half-sine pulse and 2900g, 0.3 millisecond half-sine pulse for up to 1,000 drops. Handheld electronic products passing criteria is 30 drops.

Table 4.0.1 Slow-Temperature Cycling

Assembly Site	Product & Package	Die Size (mm)	Ball Pitch (mm)	Temp Range (C) & Dwell time (min)	Cycles per hour	Sample Size	Consumer >208 cycles min.	1st Fail (Cycles)	N (63.2%) (Cycles)	% Fails @ 1,000 Cycles
ASEK	iCE40LP1K 16-WLCSP	1.40 x 1.48	0.35	-40°C to +125°C & 7.5 min at each endpoint	1.2	270 units from 3 lots	*QBS	*QBS	*QBS	*QBS
ASEK	iCE40UL1K 16-WLCSP	1.41x 1.41	0.35	-40°C to +125°C & 5 min at each endpoint	1.5	225 units from 3 lots	Pass	N/A	N/A	0
ASEK	iCE40UL640 16-WLCSP	1.41x 1.41	0.35	-40°C to +125°C & 5 min at each endpoint	1.5	225 units from 3 lots	*QBS	*QBS	*QBS	*QBS
ASEK	iCE40LM4K 25WLCSP	1.71 x 1.71	0.35	-40°C to +125°C & 7.5 min at each endpoint	1.2	270 units from 3 lots	Pass	322	2,884	N/A
ASEK	iCE5LP4K 36-WLCSP	2.1 x 2.1	0.35	-40°C to +125°C & 5 min at each endpoint	1.5	267 units from 3 lots	Pass	N/A	N/A	0
ASEK	iCE5LP2K 36-WLCSP	2.1 x 2.1	0.35	-40°C to +125°C & 5 min at each endpoint	1.5	267 units from 3 lots	**QBS	**QBS	**QBS	**QBS
ASEK	iCE5LP1K 36-WLCSP	2.1 x 2.1	0.35	-40°C to +125°C & 5 min at each endpoint	1.5	267 units from 3 lots	**QBS	**QBS	**QBS	**QBS

*Package types shown are qualified-by-similarity (QBS) using iCE40UL1K 16-WLCSP package.
**Package types shown are qualified-by-similarity (QBS) using iCE5LP4K 36-WLCSP package.

Table 4.0.2 Bend Testing

Assembly Site	Product & Package	Die Size (mm)	Ball Pitch (mm)	Cross-head Displacement	Frequency (Hz)	Sample Size	Consumer >20,000 bends	1st Fail (Cycles)	N (63.2%) (Cycles)	% Fails @ 100,000 Cycles
ASEK	iCE40LP1K 16-WLCSP	1.40 x 1.48	0.35	4 mm	1	108 units from 3 lots	*QBS	*QBS	*QBS	*QBS
ASEK	iCE40UL1K 16-WLCSP	1.41x 1.41	0.35	4 mm	1	54 units from 3 lots	Pass	N/A	N/A	0
ASEK	iCE40UL640 16-WLCSP	1.41 x 1.41	0.35	4 mm	1	54 units from 3 lots	*QBS	*QBS	*QBS	*QBS
ASEK	iCE40LM4K 25WLCSP	1.71 x 1.71	0.35	4 mm	1	108 units from 3 lots	Pass	No fails	N/A	0
ASEK	iCE5LP4K 36-WLCSP	2.1 x 2.1	0.35	4 mm	1	108 units from 3 lots	Pass	N/A	N/A	0
ASEK	iCE5LP2K 36-WLCSP	2.1 x 2.1	0.35	4 mm	1	108 units from 3 lots	**QBS	**QBS	**QBS	**QBS
ASEK	iCE5LP1K 36-WLCSP	2.1 x 2.1	0.35	4 mm	1	108 units from 3 lots	**QBS	**QBS	**QBS	**QBS

*Package types shown are qualified-by-similarity (QBS) using iCE40UL1K 16-WLCSP package.
**Package types shown are qualified-by-similarity (QBS) using iCE5LP4K 36-WLCSP package.

Table 4.0.3 Drop & Mechanical Shock Testing

Assembly Site	Product & Package	Die Size	Ball Pitch (mm)	Drop & Shock Force Gs	Drop & Shock Waveform	Sample Size	JEDEC >30 drops	1st Fail (Drops)	N (63.2%) (Drops)	% Fails @ 1,000 Drops
ASEK	iCE40LP1K 16-WLCSP	1.40 x 1.48	0.35	2900	0.3 ms half-sine pulse	180 units from 3 lots	*QBS	*QBS	*QBS	*QBS
ASEK	iCE40UL1K 16-WLCSP	1.41 x 1.41	0.35	2900	0.3 ms half-sine pulse	177 units from 3 lots	Pass	N/A	N/A	0
ASEK	iCE40UL640 16-WLCSP	1.41 x 1.41	0.35	2900	0.3 ms half-sine pulse	177 units from 3 lots	*QBS	*QBS	*QBS	*QBS
ASEK	iCE40LM4K 25WLCSP	1.71 x 1.71	0.35	2900	0.3 ms half-sine pulse	180 units from 3 lots	Pass	1,229	N/A	0
ASEK	iCE5LP4K 36-WLCSP	2.1 x 2.1	0.35	2900	0.3 ms half-sine pulse	178 units from 3 lots	Pass	0	N/A	0
ASEK	iCE5LP2K 36-WLCSP	2.1 x 2.1	0.35	2900	0.3 ms half-sine pulse	178 units from 3 lots	**QBS	**QBS	**QBS	**QBS
ASEK	iCE5LP1K 36-WLCSP	2.1 x 2.1	0.35	2900	0.3 ms half-sine pulse	178 units from 3 lots	**QBS	**QBS	**QBS	**QBS

*Package types shown are qualified-by-similarity (QBS) using iCE40UL1K 16-WLCSP package.
**Package types shown are qualified-by-similarity (QBS) using iCE5LP4K 36-WLCSP package.

5.0 ADDITIONAL PACKAGE FAMILY DATA

Table 5.0.1 iCE40 Product Family Bills of Material by Package Type and Assembly Site

Attributes	Saw-Singulated BGA				TQFP	QFN		WLCSP
Assembly Site	ASEM		ATP	ASEK	ASEM	ASEM	ASEK	ASEK / ATT (iCE5LP only)
Die Family (Product Line)	iCE40LM iCE40UL	iCE40LP iCE40HX	iCE40LM iCE40UL iCE40HX	iCE40HX	iCE40HX	iCE40LP iCE40UP	iCE40UP	iCE40LM iCE40LP iCE40UL iCE5LP iCE40UP
Fabrication Process Technology	40nm							
Package Type	ucBGA	ucBGA	ucBGA	caBGA	TQFP	QFN	QFN	WLCSP
		csBGA	caBGA					
		caBGA						
Ball/Lead Counts	36	36, 49, 81, 225	36	121	100, 144	32, 48, 84	48	16, 25, 30, 36
		81, 121, 132	121*					
		256						
Die Attach Material	Hitachi FH-900T-25_HR9004		Lintec LE5000 P12AS	ATB-125	Hitachi FH-900T-25_HR9004	Hitachi FH-900T-25_HR9004	NEX-130CTX	N/A
Mold Compound Supplier/ID	KEG1250 LKDS		Hitachi-GE110LS-V	KE-G1250AAS	CEL9204HF10AK-G1 or G700SY	G770HCD	G631SH	
Wire Bond Material	Gold Flash Palladium-coated Copper (AuPCC+)	Palladium-coated Copper (PdCu)	Palladium-coated Copper (PdCu)	Gold Flash Palladium-coated Copper (AuPCC+)	Copper (Cu)	Palladium-coated Copper (PdCu)	Gold Flash Palladium-coated Copper (AuPCC+)	
Lead Finish Plating or BGA Ball	SAC105	SAC305	SAC105/ SAC125*	SAC105	Matte Sn			SAC405
Substrate	CCL HL832NX(AHS)	HL832NX-A			N/A			
PBO	N/A							HD8820
UBM	N/A							Ti/Cu/Cu
RDL	N/A							Ti/Cu/Cu
Coating Film	N/A							Lintec LC2850

6.0 REVISION HISTORY

Table 6.0.1 iCE40 FPGA Product Family Qualification Summary Revisions

Date	Revision	Change Summary
July 2012	A	Initial document release covering iCE40LP and iCE40HX
October 2012	B	Update terminology
April 2013	C	New iCE40LP8K CM81 product/package combination added
September 2013	D	Update document to add LP384 data
November 2013	E	Update document to include WLCSP devices
January 2014	F	Update LM4K WLCSP data
May 2014	G	Update LM4K HTOL data; and 144 TQFP, CM36 & CM49 package data; added Data Retention table, change “Extension” to “Similarity”
August 2014	H	Update to include new product iCE40 Ultra (iCE5); update 36/49 ucBGA packages; add SER data
September 2014	I	iCE5 update
October 2014	J	Update Qual Flowchart; add extended stress data to TC stress
December 2014	K	Add new product, iCE40UL-640, 16-WLCSP
April 2015	L	Update iCE40UL1K, 16-WLCSP data
May 2015	M	Update iCE40UL-640-CM36 and iCE40UL-1K-CM36 data
June 2015	N	Add iCE5LP4K-36ucfBGA, iCE5LP4K-48QFN data
July 2016	O	Add resolved failures information and HTOL lot data
October 2017	P	Add new product, iCE40UP5K (ThunderPlus) 30WLCSP and 48QFN data.
April 2018	Q	New ICE40HX8K 121caBGA (9x9 0.8mm pitch) product/package combination added
May 2019	R	iCE5LP update
October 2019	S	Add iCE40UP5K (ThunderPlus) 48QFN ASEK qualification data
December 2020	T	Qualification of alternate assembly site (ASEK)
March 2021	U	Add ICE40 CM36 (2.5x2.5mm) ASEM Qualification Data

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