Product Bulletin

November 2010 **#PB1227H**

Matte Tin Plating Whisker Data

Background

Due to increased worldwide environmental concerns, the need for halogen-free and lead-free (Pb-free) solutions in electronic components and systems has received increased attention within the semiconductor and electronics industries. Lattice is fully supportive of the various industry efforts throughout the world to phase out the use of undesirable elements, such as lead and halogens, from electronic equipment material and manufacturing processes.

Lattice has been shipping Pb-free (and RoHS compliant) products since 2003, supporting both the European Parliament Directive entitled "*Restrictions on the use Of Hazardous Substances*" (RoHS) and the Chinese Directive entitled "*Measures for the Administration of the Control of Pollution by Electronic Information Products*." These Directives prohibit the use of the following elements in electrical/electronic equipment sold after July 1, 2006 (European Directive) and March 1, 2007 (Chinese Directive): cadmium (Cd), lead (Pb), mercury (Hg), hexavalent chromium (Cr (VI)), polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs). All Lattice Pb-free products are compliant with these directives.

As evidence of Lattice's commitment to eco-friendly packaging, Lattice recently introduced the MachXO2™ family of low cost, low power, high performance PLDs and Platform Manager™ mixed-signal devices with halogen-free (also RoHS compliant) packages. Additionally, the ispMACH® 4000 family of CPLDs is also available in halogen-free packages. A Lattice halogen-free package meets the following; Bromine (Br) : ≤ 900ppm, Chlorine (Cl) : ≤ 900ppm, and Br + Cl : ≤ 1,500ppm.

Lattice's halogen-free packages are also free of antimony oxides and dioxins.

Matte Tin Plating

With the move to halogen-free and Pb-free components, many manufacturers are now using pure tin instead of tin/lead (Sn/Pb) plating on leadframe-based packages. Lattice has standardized on matte tin plating for all of its halogen-free and Pb-Free leadframe-based device packages (TQFP, PQFP, PLCC, etc.). The tin whisker formation issue has been studied over the years and it is now much better understood. Valid whisker tests and acceptance criteria have been established to ensure a reliable, long term component life.

Current accepted methods for whisker testing are those proposed by the National Electronics Manufacturing Initiative (NEMI), and the Joint Electron Device Engineering Council (JEDEC). The JEDEC "*Test Method for Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes*" (JESD22-A121A) published in July 2008 specifies test methods and equipment requirements. The JEDEC "*Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes*" (JESD201A) was approved and published in September 2008. Lattice and its assembly partners follow the guidelines set by JEDEC Standard (JESD22-A121A and JESD201A) as the basis for its whisker testing requirements.

Table 1. JEDEC Test Conditions from JESD22-A121 and JESD201

Table 4b — Manufacturing Process Change Acceptance Tests and Durations

Stress Type	Test Conditions	Precon-ditioning	Total Duration	
			Class 1 and 2 Products	Class 1A Products[4]
Temperature Cycling[1]	-55 +0/-10 °C to 85 +10/-0 °C, air to air; 10 minute soak; ~3 cycles/hour (typ.)	Per Table 4c	500 cycles	500 cycles
	-40 +0/-10 °C to 85 +10/-0 °C, air to air; 10 minute soak; ~3 cycles/hour (typ.)		500 cycles	500 cycles
Temperature / Humidity Storage	30 ±2 °C and 60 ±3% RH[2]	Per Table 4c	1500 hours	1000 hours
High Temperature / Humidity Storage	55 ±3 °C and 85 ±3 RH [3]	Per Table 4c	1500 hours	1000 hours

NOTE 1 Either Temperature Cycling Test Condition may be used.

NOTE 2 Previous data generated under uncontrolled ambient conditions may be substituted for this condition.

NOTE 3 Previous data generated under higher humidity conditions, e.g., 60 °C and 90-95% RH, are substitutable for this condition.

NOTE 4 For Class 1A products, using low CTE (<15 ppm/K , e.g., Alloy 42) leadframe, only the Temperature Cycling test will be performed for Manufacturing Process Change Acceptance.

Table 4c — Preconditioning for Technology/ Manufacturing Process Change Acceptance Testing

Base Metal Alloy	Mitigation Technology	Test Condition	Precondition Treatment[1, 2, 3]
Copper Alloys	None	Temperature / Humidity Storage	Required for each test condition: A (no precondition) B+C (storage + SnPb reflow) B+D (storage + Pb-free reflow)
		High Temperature / Humidity Storage	
		Temperature Cycling	
	Ni Barrier Ni >1.25um	Temperature / Humidity Storage	A (no precondition) only
		High Temperature / Humidity Storage	A (no precondition) D (Pb-free reflow)4
		Temperature Cycling	A (no precondition) D (Pb-free reflow)4
	Other Underplate Process or Post Bake Process	Temperature / Humidity Storage	A (no precondition) only
		High Temperature / Humidity Storage	C (SnPb reflow) D (Pb-free reflow)[4]
		Temperature Cycling	C (SnPb reflow) D (Pb-free reflow)[4]
FeNi42 (e.g., Alloy 42)	None	Temperature / Humidity Storage	Required for each test condition: A (no precondition) C (SnPb reflow) D (Pb-free reflow)
		High Temperature / Humidity Storage	
		Temperature Cycling	

NOTE 1 Preconditioning treatments per JESD22A121 prior to indicated stresses in Tables 4a and 4b.

NOTE 2 Reflow assembly is optionally allowed for conditions C and D using the optional preconditioning reflow temperatures from JESD22A121 Table 3. If reflow assembly is used, the number of sample terminations inspected may need to be increased due to the reduction of termination area wetted by the board solder. The inspection increase should be based on achieving approximately the same area as an unwetted termination. Annex C describes the details for the reflow assembly process.

NOTE 3 The + symbol indicates sequential preconditioning in the order listed.

NOTE 4 If underplate/post bake process does not conform to JP002 sections 5.3 or 5.4.3 then condition B (4 weeks room ambient storage) must be used before conditions C and D.

Table 3 — Optional Preconditioning Reflow Profiles [1]

Profile Feature	Sn-Pb Profile	Pb-Free Profile
Average ramp-up rate (Ts_{max} to T_{peak})	3 °C/second max.	3 °C/second max.
Preheat: - Temperature Min (Ts_{min}) - Temperature Max (Ts_{max}) - Time (Ts_{min} to Ts_{max}) (t_S)	 100 °C 150 °C 60–120 seconds	 150 °C 200 °C 60–120 seconds
Time maintained above: - Temperature (T_L) - Time (t_L)	 183 °C 60–120 seconds	 217 °C 60–120 seconds
Lead or Solder Joint Temperature (T_{peak})	200–220 °C [2]	245–260 °C [3]
Average ramp-down Rate (T_{peak} to Ts_{max})	6 °C/second max.	6 °C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

NOTE 1 All temperatures refer to lead or solder joint temperature for components or the surface temperature for coupons.

NOTE 2 Maximum temperature of 220 °C ensures that the finish is not melted (i.e., melting point of pure Sn is 232 °C).

NOTE 3 Minimum temperature of 245 °C ensures that the finish is melted.

Lattice's assembly contractors have been actively monitoring tin whisker growth on various leadframe packages (criteria: maximum allowed whisker length <20µm for high temperature / humidity storage, <20µm for temperature / humidity storage, and <45µm for temperature cycling). Lattice also requires from their assembly contractors a one hour, 150ºC post plating annealing step and a minimum plating thickness of 400 micro inches as part of our whisker mitigation strategy.

Current assembly contractor whisker test results are shown in the Appendix A.

Conclusion

Per JEDEC Standard JESD201, there is no clear industry accepted understanding of tin whisker growth factors. Lattice will continue to monitor and report on our assembly partners' tin whisker test results to ensure consistent high quality lead frame plating in its halogen-free and Pb-free (RoHS compliant) packaging.

Appendix A: Current Whisker Test Results (2010)

Assembly Partner #1				
LEADFRAME	PRECON	AMBIENT (30degC / 60%RH)	THT (55degC / 85%RH)	TCT (-55degC / +85degC)
		1500HRS	1500HRS	1500CYC
C7025	No precon(A)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKERS Inspection result: 0 / 384 leads	NO WHISKERS Inspection result: 0 / 384 leads	NO WHISKERS Inspection result: 0 / 384 leads
		PASS	**PASS**	**PASS**
	SnPb reflow(B)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKERS Inspection result: 0 / 384 leads	NO WHISKERS Inspection result: 0 / 384 leads	MAX LENGTH : 19.30µm Inspection result: 11 / 384 leads
		PASS	**PASS**	**PASS**
	Pb free reflow(C)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKERS Inspection result: 0 / 384 leads	NO WHISKERS Inspection result: 0 / 384 leads	MAX LENGTH : 17.85µm Inspection result: 16 / 384 leads
		PASS	**PASS**	**PASS**

Assembly Partner #2				
LEADFRAME	PRECON	AMBIENT (30degC / 60%RH)	THT (55degC / 85%RH)	TCT (-55degC / +85degC)
		4000HRS	4000HRS	1500CYC
C7025	No precon(A)	Total s/size: 10 units		
		NO WHISKERS Inspection result: 0 / 900 leads	NA	NA
		PASS		
	SnPb reflow(B)		Total s/size: 10 units	Total s/size: 10 units
		NA	NO WHISKERS Inspection result: 0 / 900 leads	NO WHISKERS Inspection result: 0 / 720 leads
			PASS	**PASS**
	Pb free reflow(C)		Total s/size: 10 units	Total s/size: 10 units
		NA	NO WHISKERS Inspection result: 0 / 900 leads	NO WHISKERS Inspection result: 0 / 720 leads
			PASS	**PASS**

Appendix A: Current Whisker Test Results (Cont'd)

Assembly Partner #3				
LEADFRAME	PRECON	AMBIENT (30degC / 60%RH) 4000HRS	THT (55degC / 85%RH) 4000HRS	TCT (-55degC / +85degC) 1500CYC
C151	No precon(A)	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**
	SnPb reflow(B)	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**
	Pb free reflow(C)	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**	Total s/size: 54 units NO WHISKERS Inspection result: 0 / 864 leads **PASS**
C194	No precon(A)	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**
	SnPb reflow(B)	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units MAX LENGTH : 36.7µm Inspection result: 6 / 2592 leads **PASS**
	Pb free reflow(C)	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**
C7025	No precon(A)	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units MAX LENGTH : 32.4µm Inspection result: 4 / 2592 leads **PASS**
	SnPb reflow(B)	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**
	Pb free reflow(C)	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**	Total s/size: 162 units NO WHISKERS Inspection result: 0 / 2592 leads **PASS**

Appendix A: Current Whisker Test Results (Cont'd)

Assembly Partner #4				
LEADFRAME	PRECON	AMBIENT (30degC / 60%RH)	THT (55degC / 85%RH)	TCT (-55degC / +85degC)
		1500HRS	1500HRS	500CYC
C194	No precon(A)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKER Inspection result: 0 / 96 leads	NO WHISKERS Inspection result: 0 / 96 leads	MAX LENGTH : 16.82µm Inspection result: 2 / 96 leads
		PASS	**PASS**	**PASS**
	SnPb reflow(B)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKERS Inspection result: 0 / 96 leads	NO WHISKERS Inspection result: 0 / 96 leads	MAX LENGTH : 13.08µm Inspection result: 2 / 96 leads
		PASS	**PASS**	**PASS**
	Pb free reflow(C)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKERS Inspection result: 0 / 96 leads	NO WHISKERS Inspection result: 0 / 96 leads	MAX LENGTH : 11.08µm Inspection result: 2 / 96 leads
		PASS	**PASS**	**PASS**
EFTEC64T (C18045)	No precon(A)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKERS Inspection result: 0 / 96 leads	NO WHISKERS Inspection result: 0 / 96 leads	MAX LENGTH : 21.08µm Inspection result: 2 / 96 leads
		PASS	**PASS**	**PASS**
	SnPb reflow(B)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKERS Inspection result: 0 / 96 leads	NO WHISKERS Inspection result: 0 / 96 leads	MAX LENGTH : 14.99µm Inspection result: 2 / 96 leads
		PASS	**PASS**	**PASS**
	Pb free reflow(C)	Total s/size: 6 units	Total s/size: 6 units	Total s/size: 6 units
		NO WHISKERS Inspection result: 0 / 96 leads	NO WHISKERS Inspection result: 0 / 96 leads	MAX LENGTH : 11.19µm Inspection result: 2 / 96 leads
		PASS	**PASS**	**PASS**