WHISKER TEST REPORT
(FINAL REPORT)

General Information

Factory	Amkor Technology Korea – ATK3
Plating Finish	Matte Sn
Package Type	LQFP
Plating Chemistry	Technistan-EP
Plating Line	K3T2
Post Plating Bake	150°C for 1 hour

Report Date : February 20, 2007
Whisker Test Report # : 20060644

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WHISKER TEST REPORT
(FINAL REPORT)

DISCLAIMER. The whisker test procedures identified in this report are used for determining the presence of tin whiskers and are performed by Amkor, pursuant to current industry-accepted JEDEC standards. The whisker test procedures used herein are unproven and may produce inconclusive results. Amkor makes no representation, warranty or guarantee of any kind with respect to the field performance, quality or freedom from whisker-related failures, of any package tested by Amkor using these procedures.

WHISKER TEST REPORT
(FINAL REPORT)

1. Purpose

1.1. Whisker Test on LQFP 144lds (EFTEC-64T Base Metal) Technistan-EP Chemistry.

2. Scope: Mark (✓) the scope on the following

☒ **Process**

New plating process	✓
Modified plating process	

☐ **Material**

New plating material	
Modified plating material	
Alternate source of material	
Alternate manufacturing site of material	

3. Conclusion

3.1. Total # of lots tested : (3) lot(s)

3.2. Comment :

3.2.1. Whisker length measurement method applied for all the whiskers observed was the Radial measurement method. Eighteen (18) terminations per readpoint were SEM inspected and 2 longest whiskers per lot per readpoint were measured and reported. Identified whiskers vary from one readpoint to another since the test objective was to track the longest whisker growth among the samples.

3.2.2. Post 500cyc, 1000cyc, & 1500cyc exposure at –55°C/+85°C TC conditions showed whisker growth in all 3 lots. Longest whiskers observed post 1500cyc were:
– TC without precon: comp#2, term#83 with 32.17µm;
– TC with 215°C simulated reflow: comp#1, term#9 with 43.50µm; and
– TC with 255°C simulated reflow: comp#1, term#1 with 27.12µm.

3.2.3. No whisker was observed in all 3 lots after 4000hrs exposure at 30°C/60%RH TH conditions.

3.2.4. Post 1000hrs & 2000hrs exposure at 55°C/85%RH TH conditions did not manifest any whisker in all 3 lots. At post 3216hrs, whisker was observed in lot-1 tested at TH without precon. At post 4000hrs, whiskers were observed in lot-1 and lot-3 tested both at TH without precon. Longest whisker observed was comp#4, term#32 with 16.69µm length.

3.2.5. Ten (10) terminations with whisker, which were found at the lead tip, have been invalidated after exposure to higher Temperature/Humidity (55°C/85%RH) conditions due to presence of surface corrosion. The invalidation was done per JEDEC Standard JESD201. Other terminations were inspected but no whisker was found. Verification results were detailed at the end of report under Appendix 5.4.3.

WHISKER TEST REPORT
(FINAL REPORT)

4. Package / Material Description

4.1. Package

Type	LQFP
Body size	20x20 mm
Lead Count	144L
Lead Pitch	0.50 mm
Lead to Lead Gap	0.28 mm

4.2. Material

Lead frame	
Base metal alloy	EFTEC-64T
Temper (1/2 hard, etc.)	N/A
Stamped/Etched L/F	Stamped
L/F thickness	0.13 mm
Barrier layer type	N/A
Barrier layer thickness	N/A

4.3. Process Dates

	Lot #1	Lot #2	Lot #3
Plating date/time	05/15/06 / 0900H	05/22/06 / 0930H	05/29/06 / 1000H
Post bake date/time	05/15/06 / 0930H	05/22/06 / 1000H	05/29/06 / 1030H
Simulated reflow date	07/13/06	07/13/06	07/13/06
Board assembly date	N/A	N/A	N/A
30°C/60%RH start date	07/13/06	07/13/06	07/13/06
55°C/85%RH start date	07/13/06	07/13/06	07/13/06
-55°C/85°C start date	07/13/06	07/13/06	07/13/06

5. Attachments

5.1. Process Summary
5.2. Workmanship Summary
5.3. Whisker Test Summary and Photos
5.4. Appendix

WHISKER TEST REPORT
(FINAL REPORT)

5.1. Process Summary

Lot# : LOT-1

PROCESS	MACHINE/ EQUIPMENT	PARAMETERS		MATERIALS	
Plating	K3T2/Technic	**Belt Speed**	65 mm/sec		
		Descale		Descale Solution	Excel 90
		• Temperature	24°C		
		• Concentration – Salt	35.01 g/l		
		• Concentration – Acid	21.89 ml/l		
		Plating			
		• Current Density	115 ASF		
		• Ampere / Cell	175/175/172/175		
		• Concentration – Acid	11.10%		
		• Concentration – Tin	61.87 g/l		
		• Concentration – Pb	N/A		
		• Concentration – Bi	N/A		
		• Concentration – Additive (Additive-1)	5.64%		
		• Concentration – Additive (Additive-2)	4.06%		
		• Concentration – Additive (Additive C)	3.08%		
		• Concentration – Additive (Make up)	7.30%		
		• Concentration – Additive (Anti Oxidant)	11.81 ml/l		
		• Bath temperature	40°C		
		Impurities			
		• Carbon	0.0149%		
		• Pb in deposit (for Matte Sn, Sn/Bi)	11.97 ppm		
		• Cu	2.82 ppm		
		• Fe	91.05 ppm		
		• Ni	9.86 ppm		
		• Sn^{+4}	5.06 ppm		
Post Plating Bake	4-A / Hanseo	Hold Temperature	150°C		
		Dwell Time	60 minutes		
		Total Cycle Time	75 minutes		
Simulated Reflow @ 215°C	Vitronics	Peak Temperature	216°C		
		Dwell Time > 183°C	77 seconds		
Simulated Reflow @ 255°C	Vitronics	Peak Temperature	257°C		
		Dwell Time > 217°C	74 seconds		

WHISKER TEST REPORT
(FINAL REPORT)

Lot# : LOT-2

PROCESS	MACHINE/ EQUIPMENT	PARAMETERS		MATERIALS	
Plating	K3T2/Technic	**Belt Speed**	65 mm/sec		
		Descale		Descale Solution	Excel 90
		• Temperature	24°C		
		• Concentration – Salt	27.59 g/l		
		• Concentration – Acid	26.93 ml/l		
		Plating			
		• Current Density	115 ASF		
		• Ampere / Cell	170/175/172/173		
		• Concentration – Acid	10.33%		
		• Concentration – Tin	58.03 g/l		
		• Concentration – Pb	N/A		
		• Concentration – Bi	N/A		
		• Concentration – Additive (Additive-1)	5.86%		
		• Concentration – Additive (Additive-2)	4.47%		
		• Concentration – Additive (Additive C)	3.31%		
		• Concentration – Additive (Make up)	7.0%		
		• Concentration – Additive (Anti Oxidant)	11.11 ml/l		
		• Bath temperature	40°C		
		Impurities			
		• Carbon	0.0149%		
		• Pb in deposit (for Matte Sn, Sn/Bi)	11.97 pm		
		• Cu	2.82 ppm		
		• Fe	91.05 ppm		
		• Ni	9.86 ppm		
		• Sn^{+4}	5.06 ppm		
Post Plating Bake	4-A / Hanseo	Hold Temperature	150°C		
		Dwell Time	60 minutes		
		Total Cycle Time	75 minutes		
Simulated Reflow @ 215°C	Vitronics	Peak Temperature	216°C		
		Dwell Time > 183°C	77 seconds		
Simulated Reflow @ 255°C	Vitronics	Peak Temperature	257°C		
		Dwell Time > 217°C	74 seconds		

WHISKER TEST REPORT
(FINAL REPORT)

Lot# : LOT-3

PROCESS	MACHINE/ EQUIPMENT	PARAMETERS		MATERIALS	
Plating	K3T2/Technic	**Belt Speed**	65 mm/sec		
		Descale		Descale Solution	Excel 90
		• Temperature	24°C		
		• Concentration – Salt	31.78 g/l		
		• Concentration – Acid	23.61 ml/l		
		Plating			
		• Current Density	115 ASF		
		• Ampere / Cell	175/172/175/172		
		• Concentration – Acid	11.26%		
		• Concentration – Tin	59.59 g/l		
		• Concentration – Pb	N/A		
		• Concentration – Bi	N/A		
		• Concentration – Additive (Additive-1)	5.71%		
		• Concentration – Additive (Additive-2)	4.09%		
		• Concentration – Additive (Additive C)	2.98%		
		• Concentration – Additive (Make up)	7.40%		
		• Concentration – Additive (Anti Oxidant)	10.41 ml/l		
		• Bath temperature	40°C		
		Impurities			
		• Carbon	0.0149%		
		• Pb in deposit (for Matte Sn, Sn/Bi)	8.39 pm		
		• Cu	2.82 ppm		
		• Fe	91.05 ppm		
		• Ni	9.86 ppm		
		• Sn^{+4}	5.06 ppm		
Post Plating Bake	4-A / Hanseo	Hold Temperature	150°C		
		Dwell Time	60 minutes		
		Total Cycle Time	75 minutes		
Simulated Reflow @ 215°C	Vitronics	Peak Temperature	216°C		
		Dwell Time > 183°C	77 seconds		
Simulated Reflow @ 255°C	Vitronics	Peak Temperature	257°C		
		Dwell Time > 217°C	74 seconds		

WHISKER TEST REPORT
(FINAL REPORT)

5.2. Plating Workmanship Summary

Lot# : LOT-1

Process / SPEC No.	Test Item	SPEC # or Criteria	# Failure / S. Size	Test Data			Result
				MAX	MIN	AVG	
001-0530-2011	Visual	001-0322-2595	0/5strips	N/A	N/A	N/A	PASSED
001-0522-2571	Plating thickness	400 – 700µ" (10 – 17.50µm)	0/10points	537	416	476.80	PASSED
001-0522-2571	Deposit composition	100% Sn	N/A	N/A	N/A	N/A	100% Sn
Surface of Deposit	Grain size range	N/A	N/A	2.55	2.15	2.41	

Lot# : LOT-2

Process / SPEC No.	Test Item	SPEC # or Criteria	# Failure / S. Size	Test Data			Result
				MAX	MIN	AVG	
001-0530-2011	Visual	001-0322-2595	0/5strips	N/A	N/A	N/A	PASSED
001-0522-2571	Plating thickness	400 – 700µ" (10 – 17.50µm)	0/10points	544	421	476	PASSED
001-0522-2571	Deposit composition	100% Sn	N/A	N/A	N/A	N/A	100% Sn
Surface of Deposit	Grain size range	N/A	N/A	1.90	1.70	1.77	

Lot# : LOT-3

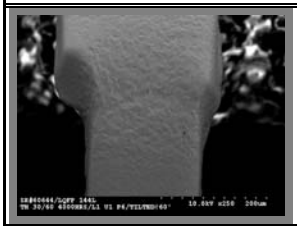
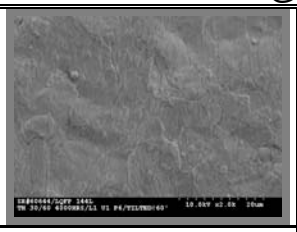
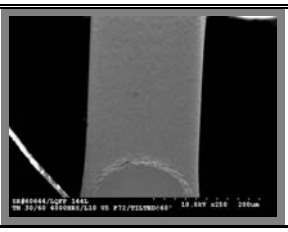
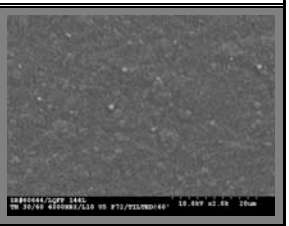
Process / SPEC No.	Test Item	SPEC # or Criteria	# Failure / S. Size	Test Data			Result
				MAX	MIN	AVG	
001-0530-2011	Visual	001-0322-2595	0/5strips	N/A	N/A	N/A	PASSED
001-0522-2571	Plating thickness	400 – 700µ" (10 – 17.50µm)	0/10points	533	416	482.40	PASSED
001-0522-2571	Deposit composition	100% Sn	N/A	N/A	N/A	N/A	100% Sn
Surface of Deposit	Grain size range	N/A	N/A	1.56	1.39	1.45	

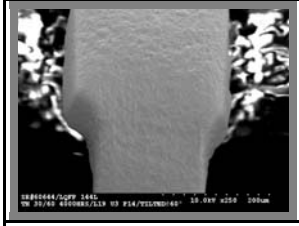
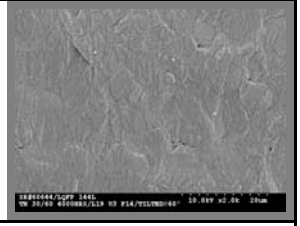
WHISKER TEST REPORT
(FINAL REPORT)

5.3. Whisker Test Summary

5.3.1. Ambient Temperature/Humidity (30°C/60%RH)

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3216 hr	4000 hr
Lot-1	Comp # 1 / Term # 6	none	none	none	none	none
Lot-2	Comp # 5 / Term # 72	none	none	none	none	none
Lot-3	Comp # 3 / Term # 14	none	none	none	none	none

SEM Photo @ Post 4000 hr	
 	 
Lot-1: No whisker observed	Lot-2: No whisker observed

SEM Photo @ Post 4000 hr	
 	
Lot-3: No whisker observed	

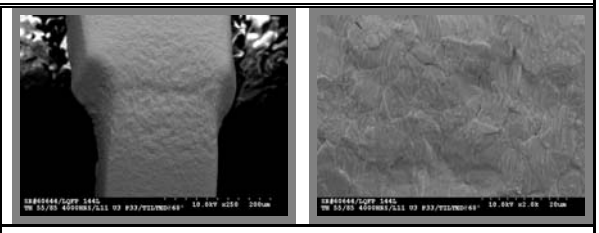
WHISKER TEST REPORT
(FINAL REPORT)

5.3.2. High Temperature/Humidity (55°C/85%RH)

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3216 hr	4000 hr
Lot-1	Comp # 4 / Term # 32	None	none	none	10.72µm	16.69µm
Lot-2	Comp # 3 / Term # 33	None	none	none	none	none
Lot-3	Comp # 4 / Term # 12	None	none	none	none	11.09µm

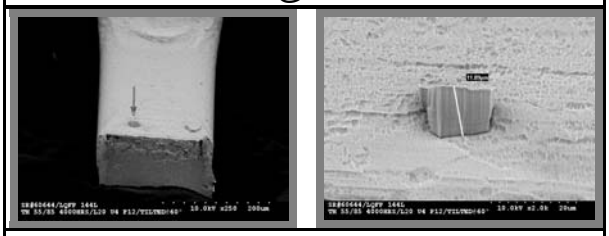
SEM Photo @ Post 4000 hr

Lot-1: Longest whisker growth of 16.69µm



Lot-2: No whisker observed

SEM Photo @ Post 4000 hr

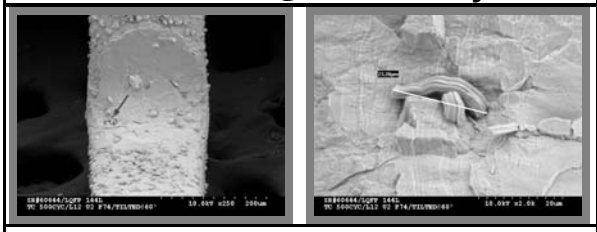
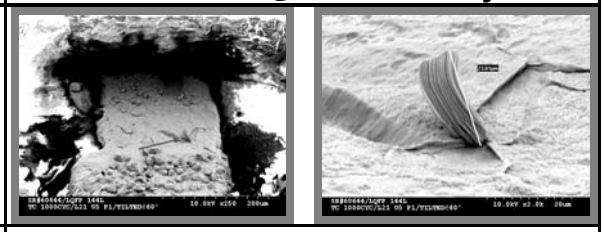


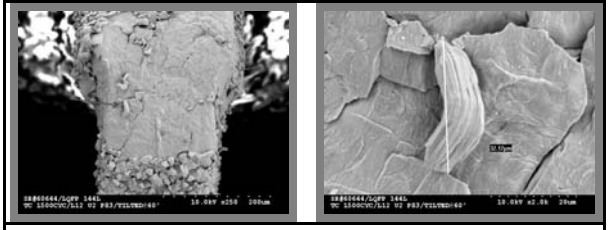
Lot-3: Longest whisker growth of 11.09µm

WHISKER TEST REPORT
(FINAL REPORT)

5.3.3. Thermal Cycling (-55/85°C)

Lot No.	Component # / Termination #	Readpoints			
		0 cyc	500 cyc	1000 cyc	1500 cyc
Lot-1	Comp # 1 / Term # 7	none	20.65µm	-	-
	Comp # 2 / Term # 6	none	17.98µm	19.11µm	27.11µm
	Comp # 1 / Term # 6	none	-	22.13µm	-
	Comp # 1 / Term # 12	none	-	-	25.93µm
Lot-2	Comp # 2 / Term # 74	none	23.20µm	22.97µm	-
	Comp # 4 / Term # 4	none	21.10µm	22.19µm	-
	Comp # 2 / Term # 83	none	-	-	32.17µm
	Comp # 4 / Term # 6	none	-	-	23.45µm
Lot-3	Comp # 2 / Term # 20	none	17.31µm	22.48µm	28.23µm
	Comp # 5 / Term # 1	none	18.06µm	23.81µm	-
	Comp # 5 / Term # 6	none	-	-	29.59µm

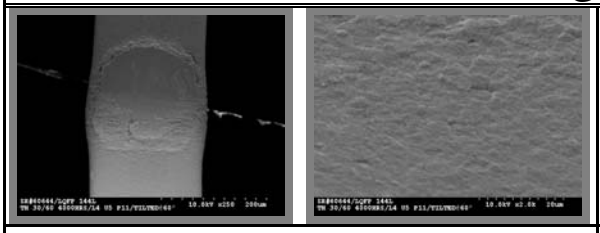
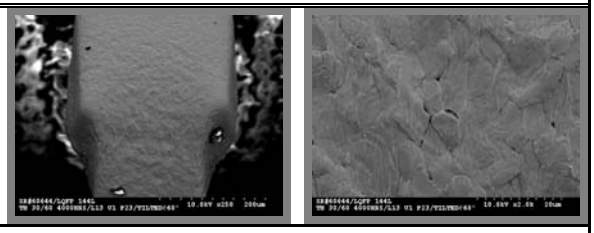
SEM Photo @ Post 500 cyc	SEM Photo @ Post 1000 cyc
	
Longest whisker growth of 23.20µm	Longest whisker growth of 23.81µm

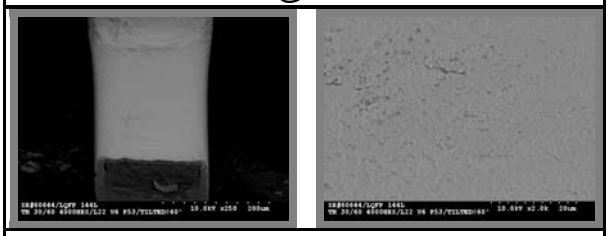
SEM Photo @ Post 1500 cyc

Longest whisker growth of 32.17µm

WHISKER TEST REPORT
(FINAL REPORT)

5.3.4. Ambient Temperature/Humidity (30°C/60%RH) post 215°C simulated reflow

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3216 hr	4000 hr
Lot-1	Comp # 5 / Term # 11	none	none	none	none	none
Lot-2	Comp # 1 / Term # 23	none	none	none	none	none
Lot-3	Comp # 6 / Term # 53	none	none	none	none	none

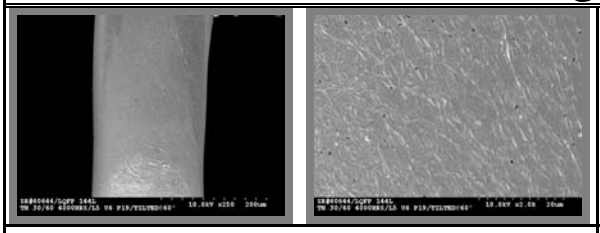
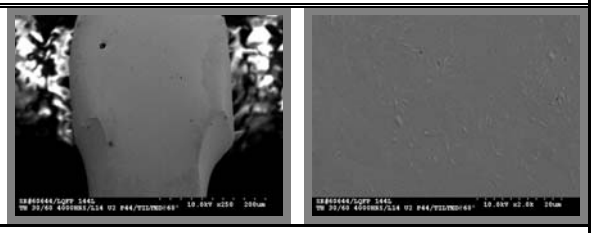
SEM Photo @ Post 4000 hr	
	
Lot-1: No whisker observed	Lot-2: No whisker observed

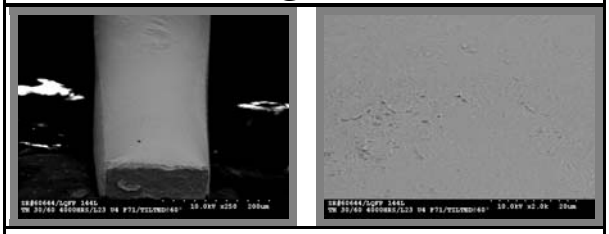
SEM Photo @ Post 4000 hr	
	
Lot-3: No whisker observed	

WHISKER TEST REPORT
(FINAL REPORT)

5.3.5. Ambient Temperature/Humidity (30°C/60%RH) post 255°C simulated reflow

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3216 hr	4000 hr
Lot-1	Comp # 6 / Term # 19	none	none	none	none	none
Lot-2	Comp # 2 / Term # 44	none	none	none	none	none
Lot-3	Comp # 4 / Term # 71	none	none	none	none	none

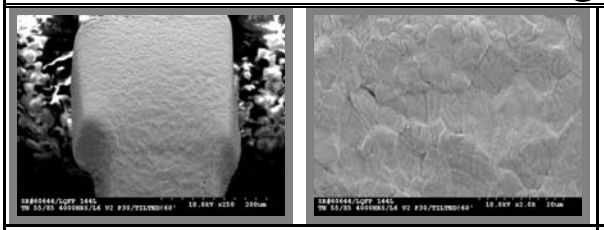
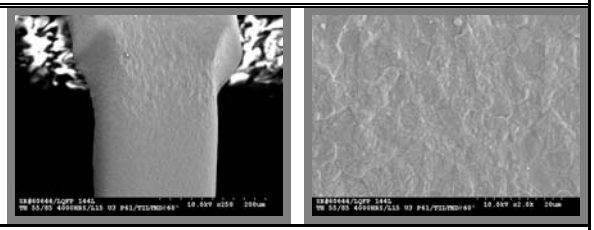
SEM Photo @ Post 4000 hr	
	
Lot-1: No whisker observed	Lot-2: No whisker observed

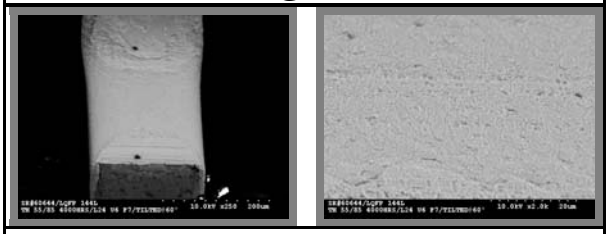
SEM Photo @ Post 4000 hr	
	
Lot-3: No whisker observed	

WHISKER TEST REPORT
(FINAL REPORT)

5.3.6. High Temperature/Humidity (55°C/85%RH) post 215°C simulated reflow

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3216 hr	4000 hr
Lot-1	Comp # 2 / Term # 30	none	none	none	none	none
Lot-2	Comp # 3 / Term # 61	none	none	none	none	none
Lot-3	Comp # 6 / Term # 7	none	none	none	none	none

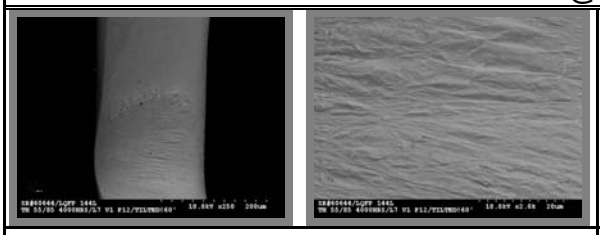
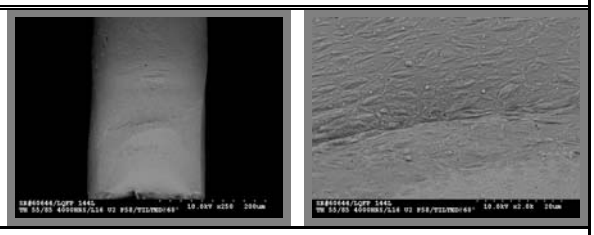
SEM Photo @ Post 4000 hr	
	
Lot-1: No whisker observed	Lot-2: No whisker observed

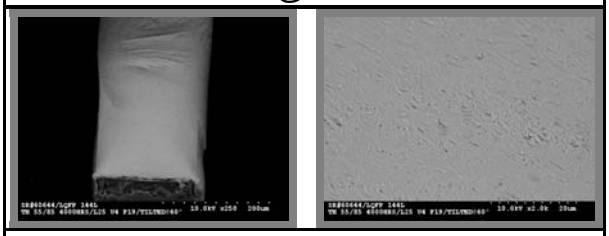
SEM Photo @ Post 4000 hr	
	
Lot-3: No whisker observed	

WHISKER TEST REPORT
(FINAL REPORT)

5.3.7. High Temperature/Humidity (55°C/85%RH) post 255°C simulated reflow

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3216 hr	4000 hr
Lot-1	Comp # 1 / Term # 12	none	none	none	none	none
Lot-2	Comp # 2 / Term # 58	none	none	none	none	none
Lot-3	Comp # 4 / Term # 19	none	none	none	none	none

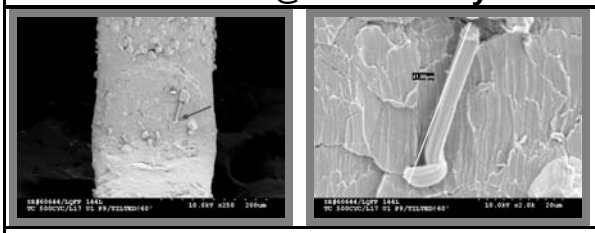
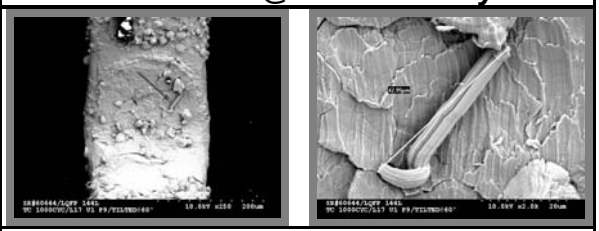
SEM Photo @ Post 4000 hr	
	
Lot-1: No whisker observed	Lot-2: No whisker observed

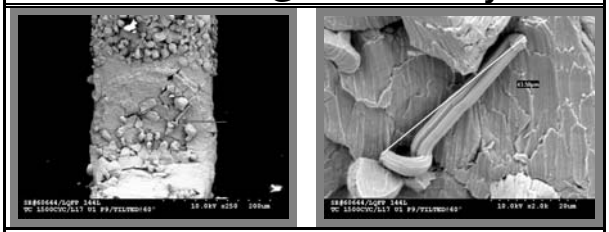
SEM Photo @ Post 4000 hr	
	
Lot-3: No whisker observed	

WHISKER TEST REPORT
(FINAL REPORT)

5.3.8. Thermal Cycling (-55/85°C) post 215°C simulated reflow

Lot No.	Component # / Termination #	Readpoints			
		0 cyc	500 cyc	1000 cyc	1500 cyc
Lot-1	Comp # 2 / Term # 9	none	22.41µm	27.18µm	30.40µm
	Comp # 4 / Term # 6	none	20.82µm	-	-
	Comp # 4 / Term # 14	none	-	23.71µm	-
	Comp # 4 / Term # 18	none	-	-	30.49µm
Lot-2	Comp # 1 / Term # 9	none	41.00µm	42.95µm	43.50µm
	Comp # 6 / Term # 41	none	13.55µm	-	-
	Comp # 6 / Term # 6	none	-	21.91µm	25.55µm
Lot-3	Comp # 2 / Term # 6	none	17.93µm	25.58µm	26.06µm
	Comp # 3 / Term # 30	none	26.67µm	26.75µm	27.02µm

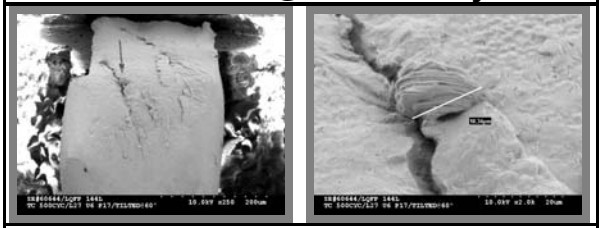
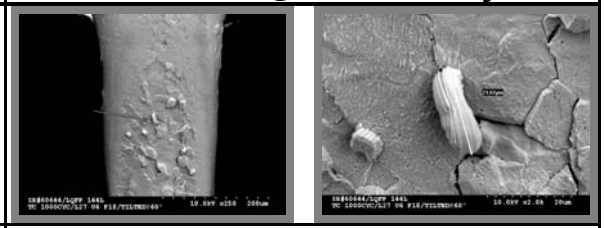
SEM Photo @ Post 500 cyc	SEM Photo @ Post 1000 cyc
	
Longest whisker growth of 41.00µm	Longest whisker growth of 42.95µm

SEM Photo @ Post 1500 cyc

Longest whisker growth of 43.50µm

WHISKER TEST REPORT
(FINAL REPORT)

5.3.9. Thermal Cycling (-55/85°C) post 255°C simulated reflow

Lot No.	Component # / Termination #	Readpoints			
		0 cyc	500 cyc	1000 cyc	1500 cyc
Lot-1	Comp # 3 / Term # 43	none	11.21µm	18.60µm	-
	Comp # 6 / Term # 14	none	14.03µm	-	-
	Comp # 6 / Term # 6	none	-	18.83µm	20.46µm
	Comp # 3 / Term # 47	none	-	-	25.08µm
Lot-2	Comp # 1 / Term # 4	none	14.21µm	-	-
	Comp # 4 / Term # 6	none	14.87µm	16.71µm	-
	Comp # 1 / Term # 1	none	-	16.25µm	27.12µm
	Comp # 1 / Term # 9	none	-	-	18.36µm
Lot-3	Comp # 4 / Term # 9	none	16.25µm	20.50µm	-
	Comp # 6 / Term # 17	none	18.34µm	-	-
	Comp # 6 / Term # 18	none	-	21.97µm	24.76µm
	Comp # 4 / Term # 19	none	-	-	23.85µm

SEM Photo @ Post 500 cyc	SEM Photo @ Post 1000 cyc
	
Longest whisker growth of 18.34µm	Longest whisker growth of 21.97µm

SEM Photo @ Post 1500 cyc

Longest whisker growth of 27.12µm

WHISKER TEST REPORT
(FINAL REPORT)

5.4. Appendix

5.4.1. Inspection Equipment

5.4.1.1. Optical Microscope

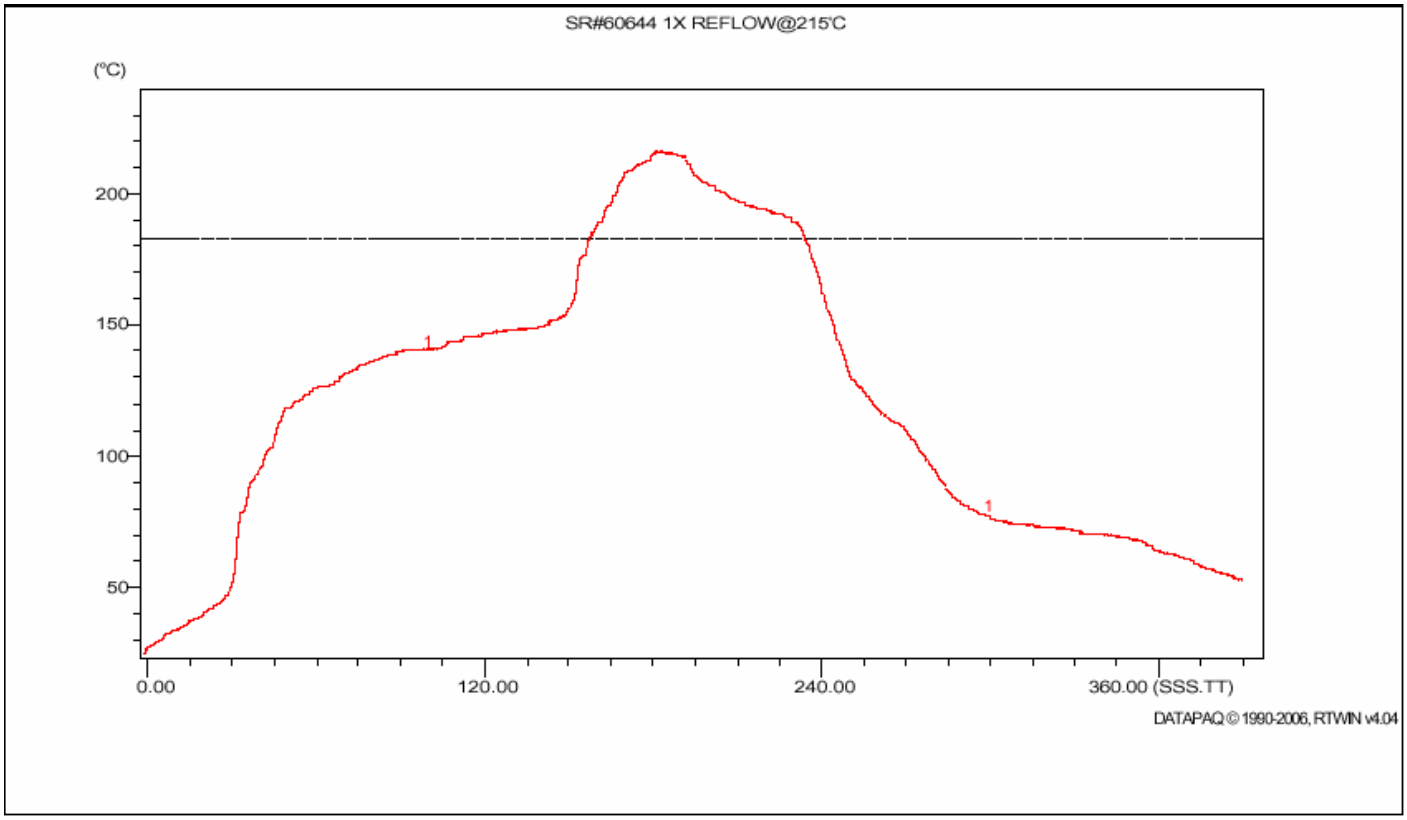
Instrument maker	:	Olympus
Model number	:	SZ40
Magnification	:	40-60x

5.4.1.2. SEM

Instrument maker	:	Hitachi
Model number	:	S3000N
Magnification	:	500kx

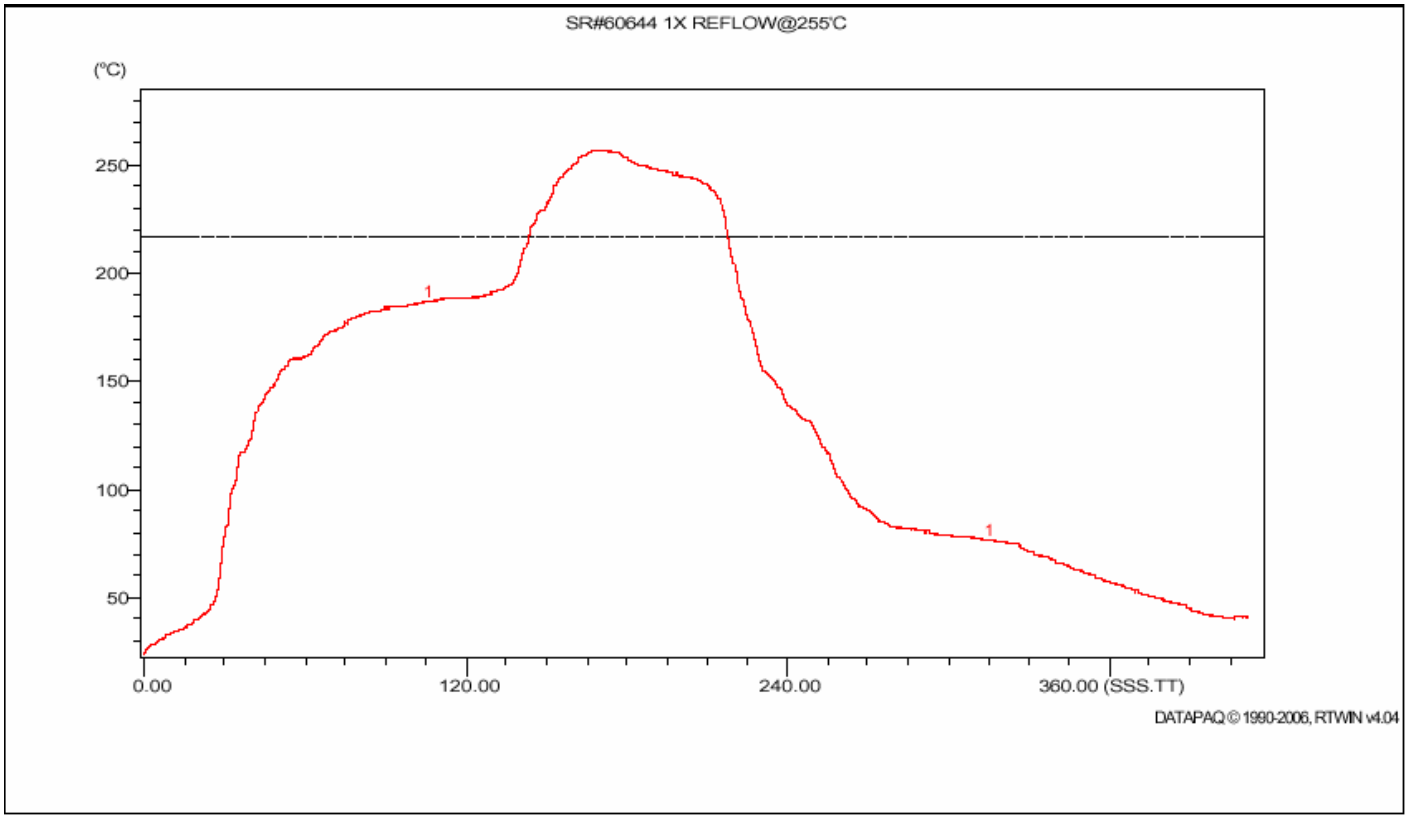
5.4.2. Reflow Profiles

5.4.2.1. Simulated 215°C Reflow



WHISKER TEST REPORT
(FINAL REPORT)

5.4.2.2. Simulated 255°C Reflow



WHISKER TEST REPORT
(FINAL REPORT)

5.4.3. Verification Results of Terminations with Surface Corrosion

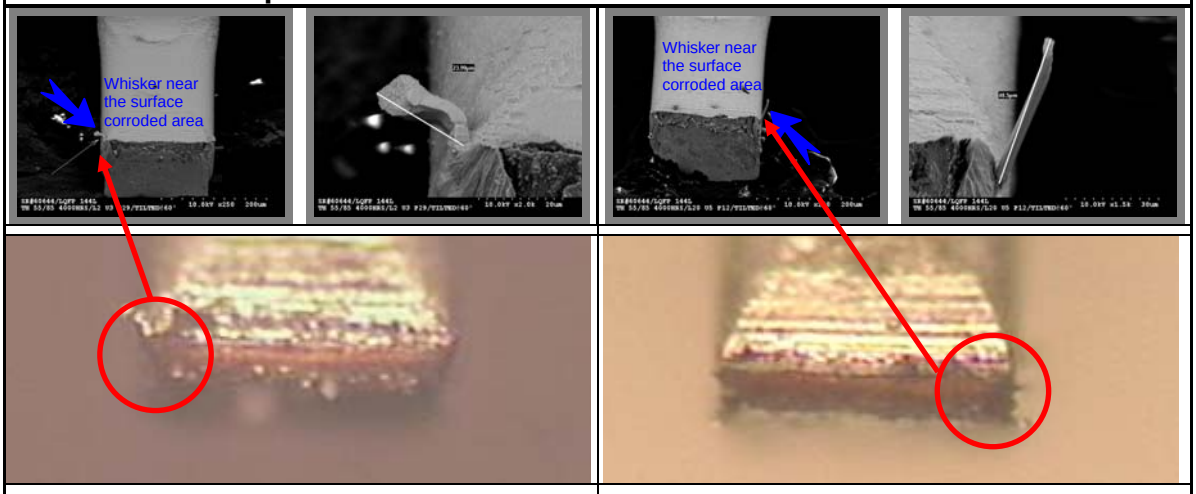
5.4.3.1. Surface Corrosion Definition from JEDEC Standard JESD201

Surface Corrosion: A localized change to a silver-colored Sn surface finish appearing in an optical microscope as non-reflective dark spots ranging in size from about 25 micrometers on the longest dimension to the entire termination.

5.4.3.2. Verification of Surface Corrosion at different High Temperature/Humidity Conditions

5.4.3.2.1. High Temperature/Humidity (55°C/85%RH)

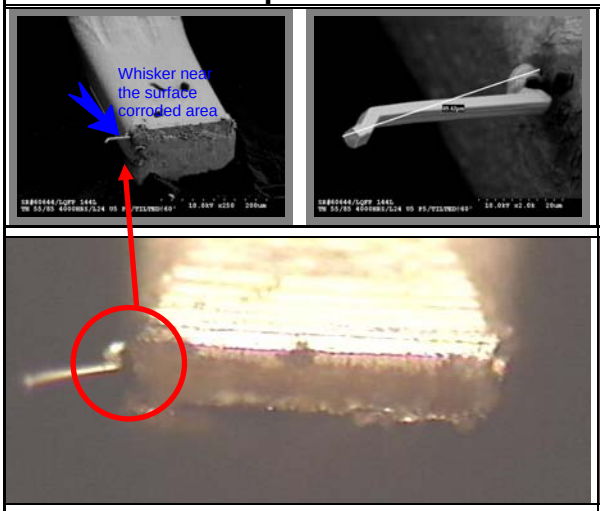
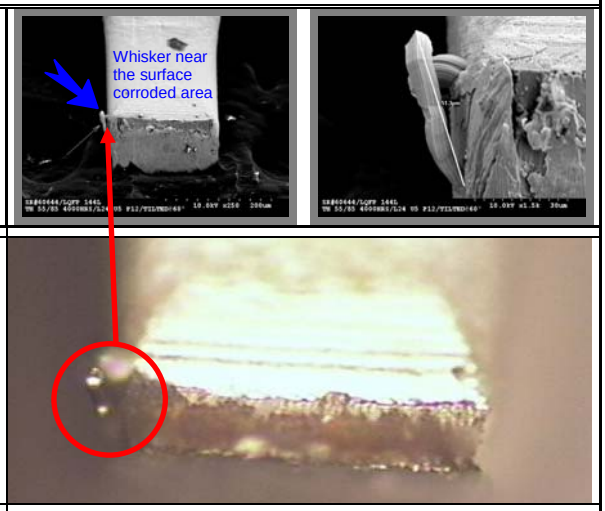
Example of Whiskers near the Surface Corroded Areas



Whisker growth of 23.99µm	Whisker growth of 17.08µm

WHISKER TEST REPORT
(FINAL REPORT)

5.4.3.2.2. High Temperature/Humidity (55°C/85%RH) post 215°C simulated reflow

Example of Whiskers near the Surface Corroded Areas	
	
Whisker growth of 49.42µm	Whisker growth of 51.30µm