
WHISKER TEST REPORT (FINAL REPORT)

General Information

Factory	Amkor Technology Philippines – ATP
Plating Finish	Matte Sn
Package Type	TQFP
Plating Chemistry	ST380
Plating Line	Meco 5
Post Plating Bake	150°C for 1 hour

Report Date : January 3, 2007
Whisker Test Report # : 20060622

Prepared by : Sonny M. Copon
Reliability Engineer

Checked by : Roque Baliwan
Section Manager, Rel/FA

Approved by : Bernard Baylon
Department Manager, Rel/FA

Distribution List :

Bryan Rigg, Henry Carteciano, Greg Gabriel, Sandra Gonzales, Ruth Jacob, Charlie dela Cruz Jr., Eduardo Mertola, Leonida Dapula, Rodrigo Amor, Avelette Tan – ATP GiSong Lee, KwangBok Yang – WW Corp. PIC Gary Hamming – ATI

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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.

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1. Purpose

1.1. Whisker Test on TQFP 44lds (EFTEC64T Base Metal) ST380 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#5, term#2 with 41.90µm;
 – TC with 215°C simulated reflow: comp#2, term#10 with 35.13µm; and
 – TC with 255°C simulated reflow: comp#4, term#14 with 32.17µm.

3.2.3. No whisker was observed in all 3 lots after 4000hrs exposure both at 30°C/60%RH and 55°C/85%RH TH conditions.

3.2.4. Two (2) 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.

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4. Package / Material Description

4.1. Package

Type	TQFP
Body size	10x10 mm
Lead Count	44L
Lead Pitch	0.80 mm
Lead to Lead Gap	0.35 mm

4.2. Material

Lead frame	
Base metal alloy	EFTEC64T
Temper (½ hard, etc.)	½ Hard
Stamped/Etched L/F	Stamped
L/F thickness	0.127 ±0.30 mm
Barrier layer type	Pure Tin Over Copper
Barrier layer thickness	N/A

4.3. Process Dates

	Lot #1	Lot #2	Lot #3
Plating date/time	05/02/06 / 1420H	05/09/06 / 1720H	05/16/06 / 1820H
Post bake date/time	05/02/06 / 1445H	05/09/06 / 1755H	05/16/06 / 1855H
Simulated reflow date	06/13/06	06/13/06	06/13/06
Board assembly date	N/A	N/A	N/A
30°C/60%RH start date	06/13/06	06/13/06	06/13/06
55°C/85%RH start date	06/13/06	06/13/06	06/13/06
-55°C/85°C start date	06/13/06	06/13/06	06/13/06

5. Attachments

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

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5.1. Process Summary

Lot# : LOT-1

PROCESS	MACHINE/ EQUIPMENT	PARAMETERS		MATERIALS	
Plating	Meco 5	Belt Speed Descale <ul style="list-style-type: none"> • Temperature 35°C • Concentration – Salt 72.50 g/li • Concentration – Acid NA Plating <ul style="list-style-type: none"> • Current Density 152.35 ASF • Ampere / cell 200 amps/cell • Concentration – Acid 271.80 ml/li • Concentration – Tin 80.10 g/li • Concentration – Pb N/A • Concentration – Bi N/A • Concentration – Additive (Primary) 70.40 ml/li • Concentration – Additive (Secondary) 3.10 ml/li • Bath Temperature 28°C Impurities <ul style="list-style-type: none"> • Carbon 0.00314 % wt • Pb in deposit (for Matte Sn, Sn/Bi) 4.67 ppm • Cu 3.46 ppm • Fe 24.99 ppm • Ni 6.23 ppm • Sn⁺⁴ 2.25 % 	6.70 m/min	Descale Solution	Actronal 988
Post Plating Bake	Yamato	Hold Temperature	150°C		
		Dwell Time	1 hr		
		Total Cycle Time	1.5 hrs		
Simulated Reflow @ 215°C	Vitronics	Peak Temperature	219°C		
		Dwell Time > 183°C	75 seconds		
Simulated Reflow @ 255°C	Vitronics	Peak Temperature	259°C		
		Dwell Time > 217°C	73 seconds		

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Lot# : LOT-2

PROCESS	MACHINE/ EQUIPMENT	PARAMETERS		MATERIALS	
Plating	Meco 5	Belt Speed Descalce <ul style="list-style-type: none"> • Temperature • Concentration – Salt • Concentration – Acid Plating <ul style="list-style-type: none"> • Current Density • Ampere / cell • Concentration – Acid • Concentration – Tin • Concentration – Pb • Concentration – Bi • Concentration – Additive (Primary) • Concentration – Additive (Secondary) • Bath Temperature Impurities <ul style="list-style-type: none"> • Carbon • Pb in deposit (for Matte Sn, Sn/Bi) • Cu • Fe • Ni • Sn⁺⁴ 	6.70 m/min 35°C 72.60 g/li NA 152.35 ASF 200 amps/cell 269.00 ml/li 80.80 g/li N/A N/A 73.40 ml/li 3.00 ml/li 28°C 0.00415 % wt 5.06 ppm 3.88 ppm 8.73 ppm 14.16 ppm 2.25 %	Descalce Solution	Actronal 988
Post Plating Bake	Yamato	Hold Temperature Dwell Time Total Cycle Time	150°C 1 hr 1.5 hrs		
Simulated Reflow @ 215°C	Vitronics	Peak Temperature Dwell Time > 183°C	219°C 75 seconds		
Simulated Reflow @ 255°C	Vitronics	Peak Temperature Dwell Time > 217°C	259°C 73 seconds		

WHISKER TEST REPORT (FINAL REPORT)

Lot# : LOT-3

PROCESS	MACHINE/ EQUIPMENT	PARAMETERS		MATERIALS	
Plating	Meco 5	Belt Speed Descale <ul style="list-style-type: none"> • Temperature • Concentration – Salt • Concentration – Acid Plating <ul style="list-style-type: none"> • Current Density • Ampere / cell • Concentration – Acid • Concentration – Tin • Concentration – Pb • Concentration – Bi • Concentration – Additive (Primary) • Concentration – Additive (Secondary) • Bath Temperature Impurities <ul style="list-style-type: none"> • Carbon • Pb in deposit (for Matte Sn, Sn/Bi) • Cu • Fe • Ni • Sn⁺⁴ 	6.70 m/min 35°C 69.40 g/li NA 152.35 ASF 200 amps/cell 269.80 ml/li 80.10 g/li N/A N/A 70.50 ml/li 3.20 ml/li 28°C 0.00415 % wt 4.37 ppm 3.88 ppm 8.73 ppm 14.16 ppm 4.12 %	Descale Solution	Actronal 988
Post Plating Bake	Yamato	Hold Temperature Dwell Time Total Cycle Time	150 °C 1 hr 1.5 hrs		
Simulated Reflow @ 215°C	Vitronics	Peak Temperature Dwell Time > 183°C	219°C 75 seconds		
Simulated Reflow @ 255°C	Vitronics	Peak Temperature Dwell Time > 217°C	259°C 73 seconds		

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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	0/116	N/A	N/A	N/A	PASSED
001-0522-2571	Plating thickness	400 – 700µ” (10 – 17.50µm)	0/5 rdgs	578.80	510.40	552.80	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	2.86	1.81	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	0/116	N/A	N/A	N/A	PASSED
001-0522-2571	Plating thickness	400 – 700µ” (10 – 17.50µm)	0/5 rdgs	576.80	519.80	549.40	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	2.45	1.81	2.21	

Lot# : LOT-3

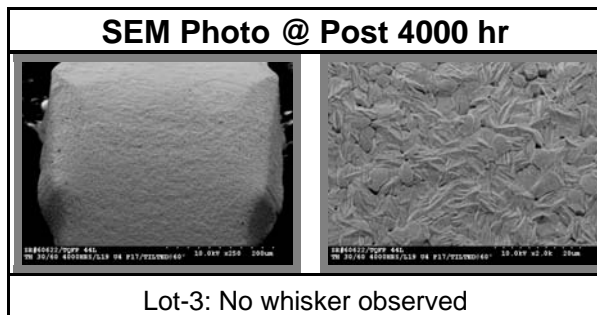
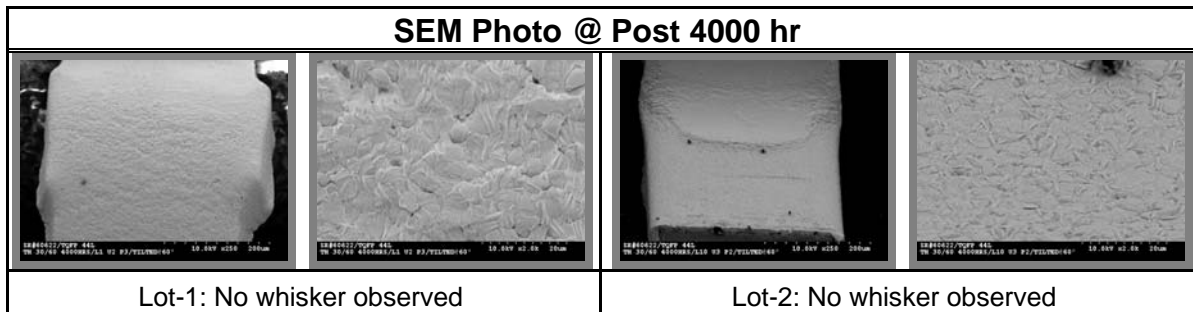
Process / SPEC No.	Test Item	SPEC # or Criteria	# Failure / S. Size	Test Data			Result
				MAX	MIN	AVG	
001-0530-2011	Visual	001-0322-2595	0/116	N/A	N/A	N/A	PASSED
001-0522-2571	Plating thickness	400 – 700µ” (10 – 17.50µm)	0/5 rdgs	572.40	514.60	548.90	PASSED
001-0522-2571	Deposit composition	100% Sn	N/A	N/A	N/A	N/A	100% Sn
Surface of Deposit	Grain size range	N/A	N/A	2.86	2.36	2.59	

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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	3000 hr	4000 hr
Lot-1	Comp # <u>2</u> / Term # <u>3</u>	none	none	none	none	none
Lot-2	Comp # <u>3</u> / Term # <u>2</u>	none	none	none	none	none
Lot-3	Comp # <u>4</u> / Term # <u>17</u>	none	none	none	none	none

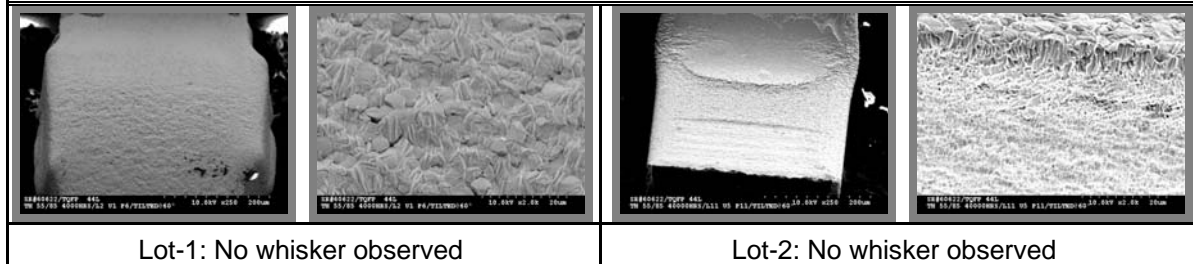


WHISKER TEST REPORT (FINAL REPORT)

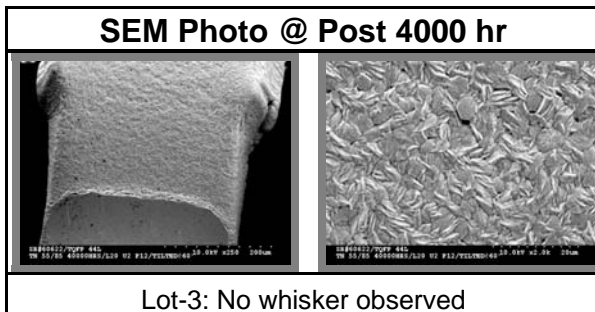
5.3.2. High Temperature/Humidity (55°C/85%RH)

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3178 hr	4000 hr
Lot-1	Comp # <u>1</u> / Term # <u>6</u>	none	none	none	none	none
Lot-2	Comp # <u>5</u> / Term # <u>11</u>	none	none	none	none	none
Lot-3	Comp # <u>2</u> / Term # <u>12</u>	none	none	none	none	none

SEM Photo @ Post 4000 hr



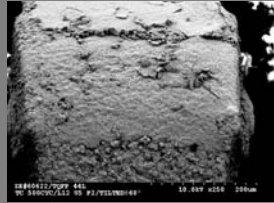
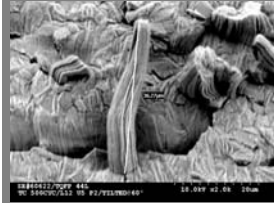
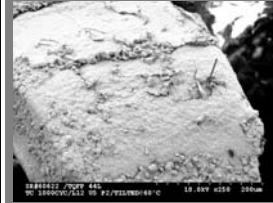

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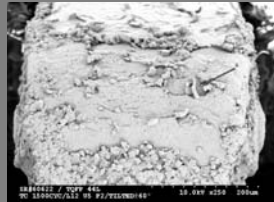
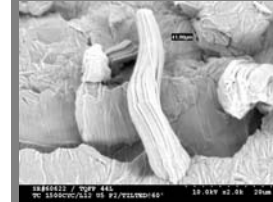


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5.3.3. Thermal Cycling (-55/85°C)

Lot No.	Component # / Termination #	Readpoints			
		0 cyc	500 cyc	1000 cyc	1500 cyc
Lot-1	Comp # <u>1</u> / Term # <u>21</u>	none	19.93µm	24.58µm	27.36µm
	Comp # <u>2</u> / Term # <u>20</u>	none	24.08µm	24.13µm	24.79µm
Lot-2	Comp # <u>1</u> / Term # <u>20</u>	none	25.35µm	40.30µm	40.32µm
	Comp # <u>5</u> / Term # <u>2</u>	none	36.27µm	41.89µm	41.90µm
Lot-3	Comp # <u>4</u> / Term # <u>22</u>	none	23.16µm	23.48µm	-
	Comp # <u>5</u> / Term # <u>1</u>	none	20.45µm	28.29µm	-
	Comp # <u>4</u> / Term # <u>21</u>	none	-	-	31.65µm
	Comp # <u>5</u> / Term # <u>11</u>	none	-	-	30.08µm

SEM Photo @ Post 500 cyc		SEM Photo @ Post 1000 cyc	
			
Longest whisker growth of 36.27µm		Longest whisker growth of 41.89µm	

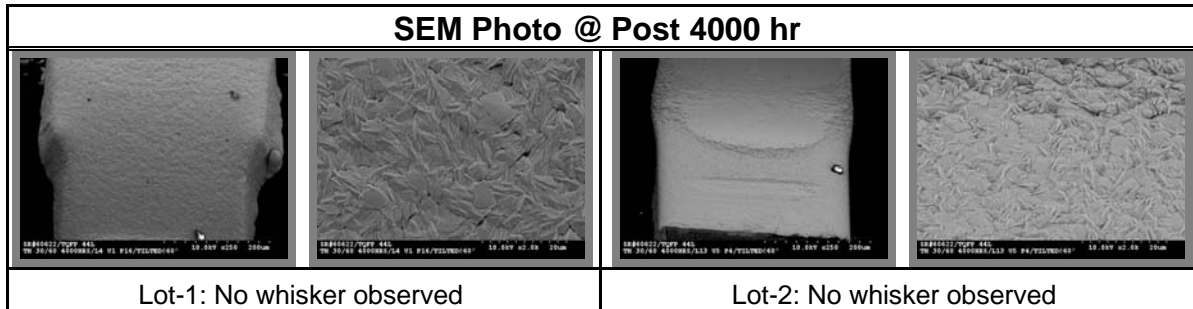
SEM Photo @ Post 1500 cyc	
	
Longest whisker growth of 41.90µm	

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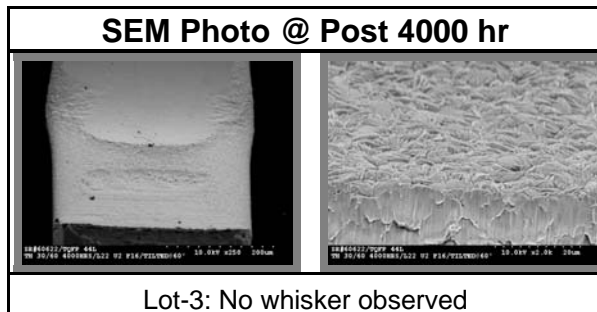
5.3.4. Ambient Temperature/Humidity (30°C/60%RH) post 215°C simulated reflow

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3000 hr	4000 hr
Lot-1	Comp # <u>1</u> / Term # <u>16</u>	none	none	none	none	none
Lot-2	Comp # <u>5</u> / Term # <u>4</u>	none	none	none	none	none
Lot-3	Comp # <u>2</u> / Term # <u>16</u>	none	none	none	none	none

SEM Photo @ Post 4000 hr



SEM Photo @ Post 4000 hr

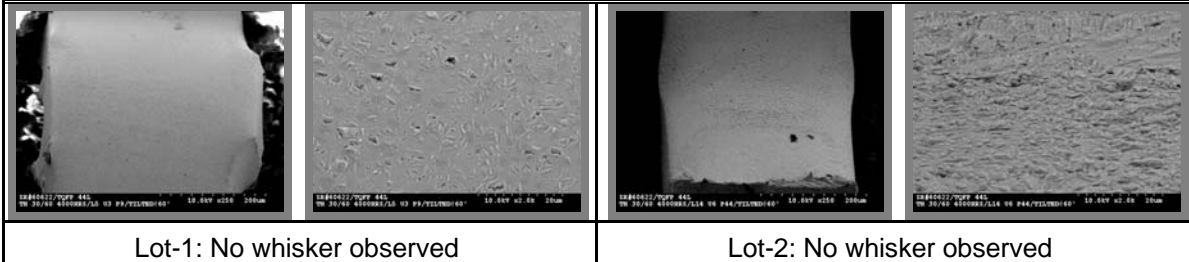


WHISKER TEST REPORT (FINAL REPORT)

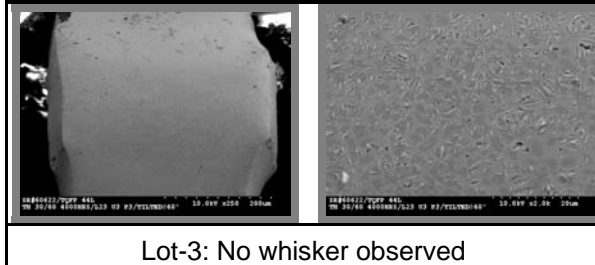
5.3.5. Ambient Temperature/Humidity (30°C/60%RH) post 255°C simulated reflow

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3000 hr	4000 hr
Lot-1	Comp # <u>3</u> / Term # <u>9</u>	none	none	none	none	none
Lot-2	Comp # <u>6</u> / Term # <u>44</u>	none	none	none	none	none
Lot-3	Comp # <u>3</u> / Term # <u>3</u>	none	none	none	none	none

SEM Photo @ Post 4000 hr



SEM Photo @ Post 4000 hr

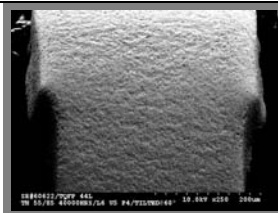
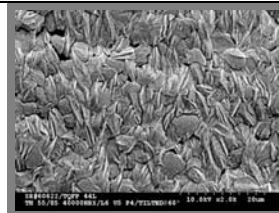
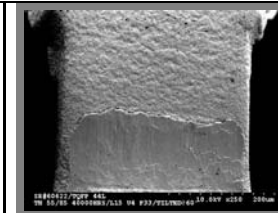
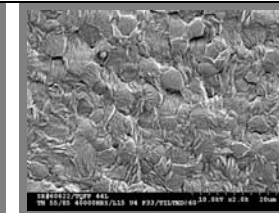


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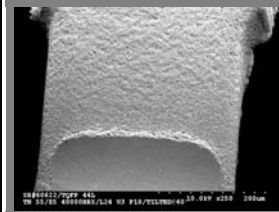
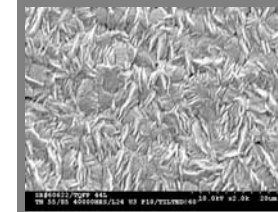
5.3.6. High Temperature/Humidity (55°C/85%RH) post 215°C simulated reflow

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3178 hr	4000 hr
Lot-1	Comp # <u>5</u> / Term # <u>4</u>	none	none	none	none	none
Lot-2	Comp # <u>4</u> / Term # <u>33</u>	none	none	none	none	none
Lot-3	Comp # <u>3</u> / Term # <u>10</u>	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

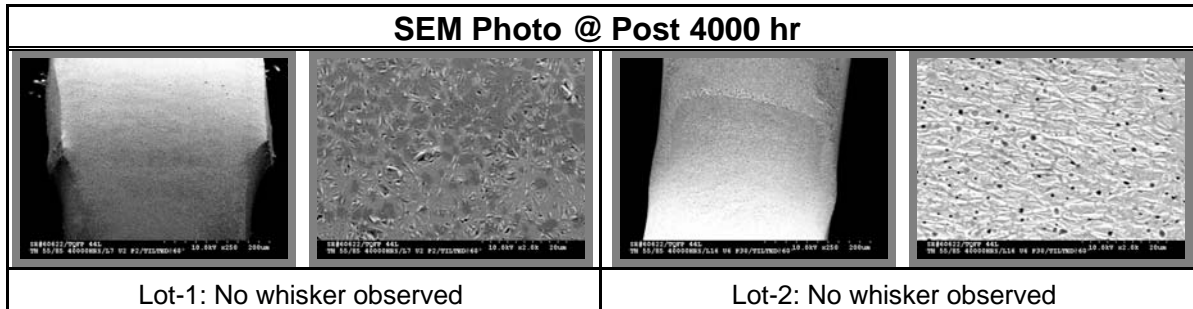
	
Lot-3: No whisker observed	

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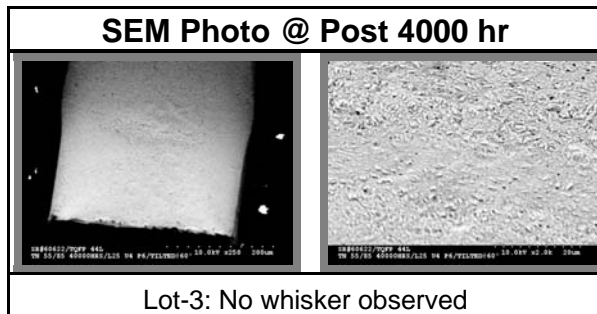
5.3.7. High Temperature/Humidity (55°C/85%RH) post 255°C simulated reflow

Lot No.	Component # / Termination #	Readpoints				
		0 hr	1000 hr	2000 hr	3178 hr	4000 hr
Lot-1	Comp # <u>2</u> / Term # <u>2</u>	none	none	none	none	none
Lot-2	Comp # <u>6</u> / Term # <u>30</u>	none	none	none	none	none
Lot-3	Comp # <u>4</u> / Term # <u>6</u>	none	none	none	none	none

SEM Photo @ Post 4000 hr



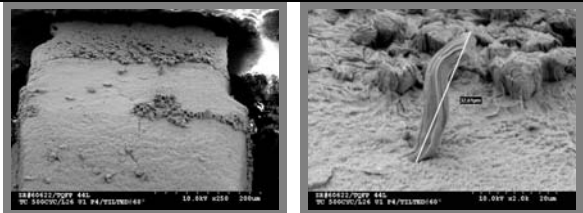
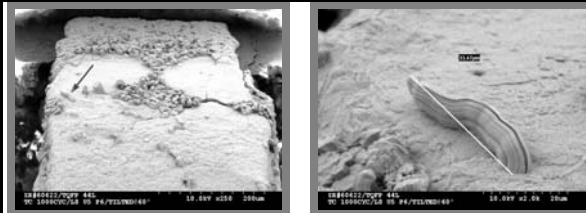
SEM Photo @ Post 4000 hr

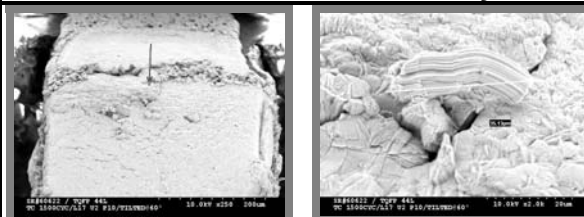


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5.3.8. Thermal Cycling (-55/85°C) post 215°C simulated reflow

Lot No.	Component # / Termination #	Readpoints			
		0 cyc	500 cyc	1000 cyc	1500 cyc
Lot-1	Comp # <u>3</u> / Term # <u>10</u>	none	24.41µm	26.10µm	31.55µm
	Comp # <u>5</u> / Term # <u>6</u>	none	27.27µm	33.47µm	33.64µm
Lot-2	Comp # <u>2</u> / Term # <u>10</u>	none	26.10µm	30.09µm	35.13µm
	Comp # <u>4</u> / Term # <u>3</u>	none	26.30µm	30.99µm	33.69µm
Lot-3	Comp # <u>1</u> / Term # <u>4</u>	none	32.61µm	32.79µm	33.08µm
	Comp # <u>6</u> / Term # <u>18</u>	none	25.32µm	22.83µm	-
	Comp # <u>6</u> / Term # <u>14</u>	none	-	-	31.41µm

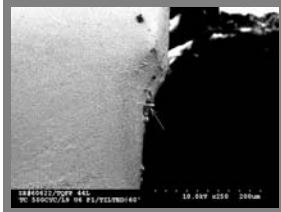


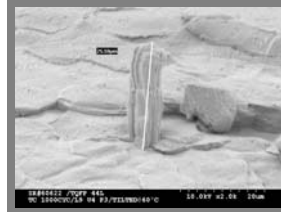
SEM Photo @ Post 500 cyc	SEM Photo @ Post 1000 cyc
 <p>Longest whisker growth of 32.61µm</p>	 <p>Longest whisker growth of 33.47µm</p>

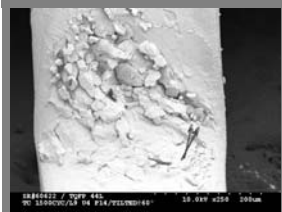
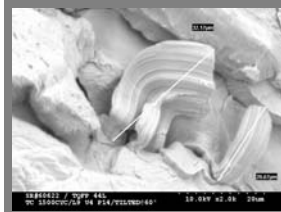
SEM Photo @ Post 1500 cyc
 <p>Longest whisker growth of 35.13µm</p>

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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 # <u>4</u> / Term # <u>16</u>	none	17.94µm	-	-
	Comp # <u>6</u> / Term # <u>1</u>	none	21.69µm	-	-
	Comp # <u>4</u> / Term # <u>3</u>	none	-	25.59µm	-
	Comp # <u>6</u> / Term # <u>33</u>	none	-	23.00µm	-
	Comp # <u>4</u> / Term # <u>14</u>	none	-	-	32.17µm
	Comp # <u>6</u> / Term # <u>31</u>	none	-	-	29.25µm
Lot-2	Comp # <u>1</u> / Term # <u>10</u>	none	10.93µm	-	-
	Comp # <u>6</u> / Term # <u>11</u>	none	15.15µm	24.23µm	29.38µm
	Comp # <u>1</u> / Term # <u>4</u>	none	-	19.24µm	-
	Comp # <u>1</u> / Term # <u>6</u>	none	-	-	24.16µm
Lot-3	Comp # <u>2</u> / Term # <u>3</u>	none	16.10µm	20.07µm	20.79µm
	Comp # <u>4</u> / Term # <u>15</u>	none	15.16µm	-	-
	Comp # <u>4</u> / Term # <u>19</u>	none	-	25.19µm	31.94µm

SEM Photo @ Post 500 cyc		SEM Photo @ Post 1000 cyc	
			
Longest whisker growth of 21.69µm		Longest whisker growth of 25.59µm	

SEM Photo @ Post 1500 cyc	
	
Longest whisker growth of 32.17µm	

WHISKER TEST REPORT (FINAL REPORT)

5.4. Appendix

5.4.1. Inspection Equipment

5.4.1.1. Optical Microscope

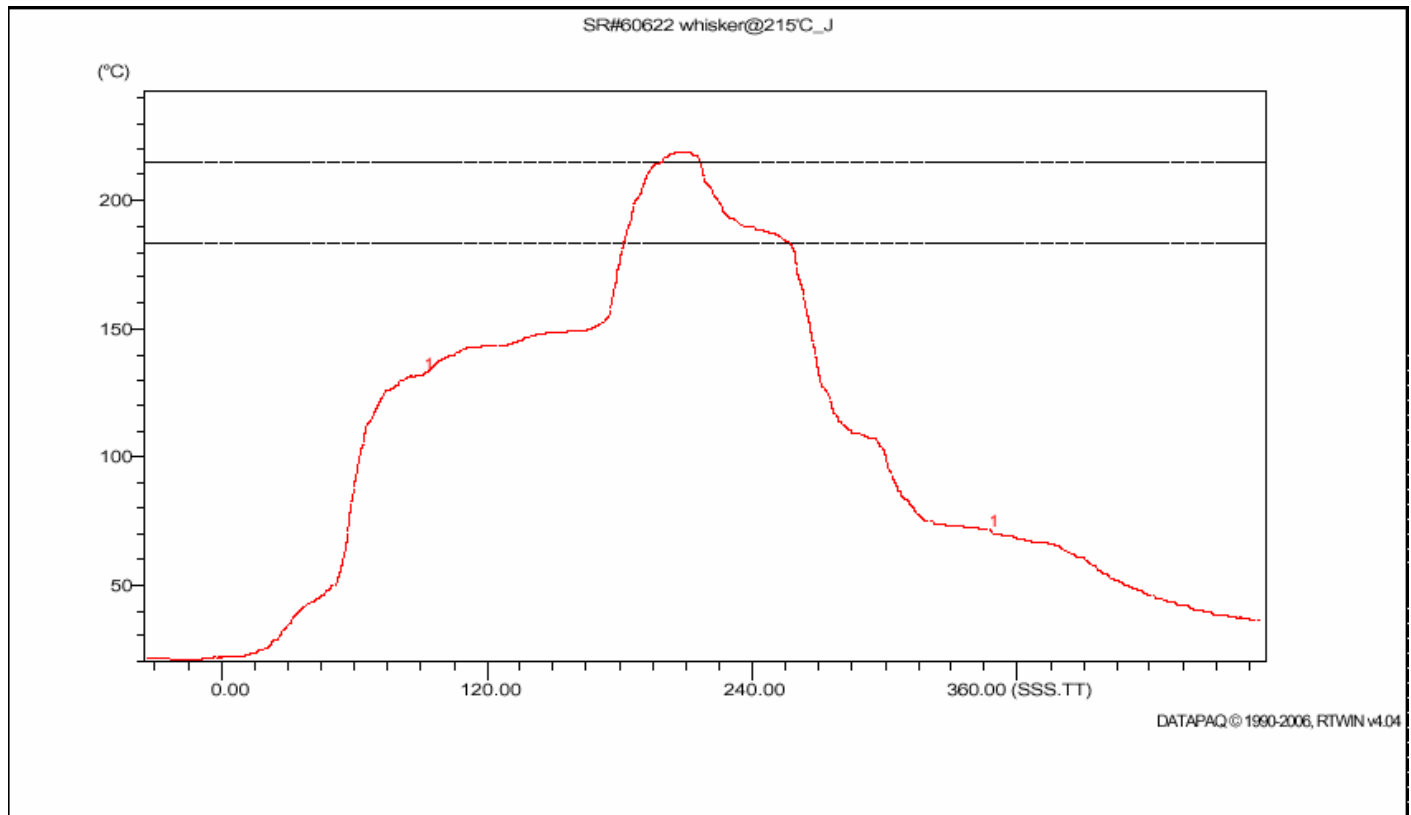
Instrument maker : Olympus
Model number : SZ40
Magnification : 40-60x

5.4.1.2. SEM

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

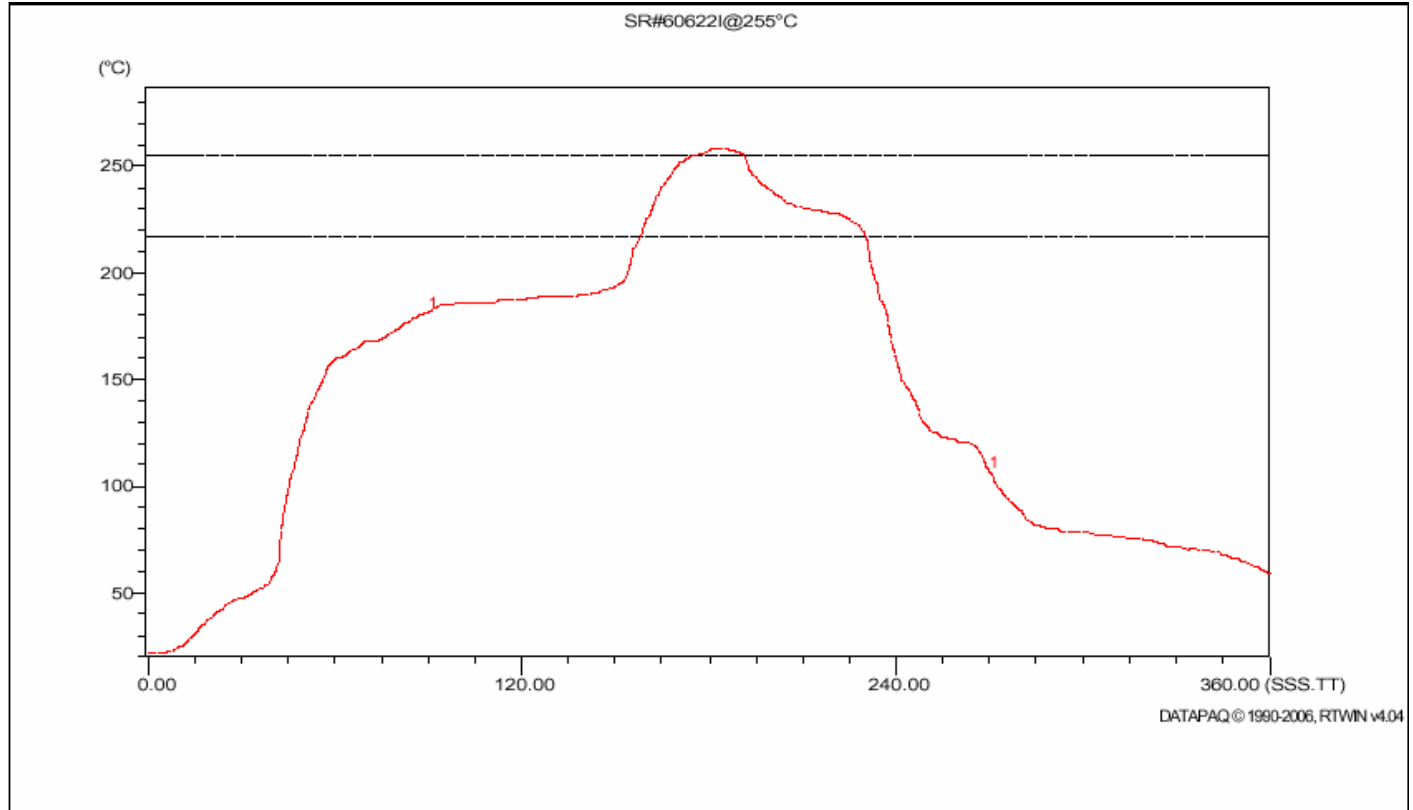
5.4.2. Reflow Profiles

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)

