PRODUCT INFORMATION LETTER

PIL APG-AED/10/5912
Notification Date 09/23/2010

L4949E Lead-Free migration to Advanced uPPF frame

Production process involved	L4949ED, L4949EP
Production process details	Generic
Reason for change	Company roadmap
Description	According to PCN APG/08/3923 (November 2008), Lead-free version of L4949ED (SO-8) and L4949EP (SO-20) products will be switched to uPPF frame version. We invite all the Ctms to switch the current orders on the new versions identified by suffix "-E". Please be informed that within December 2010 orders will be switched to new versions automatically.
Forecasted date of implementation	31-Dec-2010
Forecasted date of samples for customer	16-Sep-2010
Forecasted date for **STMicroelectronics** change Qualification Plan results availability	16-Sep-2010
Description of qualification program	See Attached Qualification Plan
Involved ST facilities	ST MUAR Assembly Plant

DOCUMENT APPROVAL

Name	Function
Russo, Alfio	Division Marketing Manager
Parrino, Emanuele	Division Q.A. Manager
Nicoloso, Riccardo	Process Owner

Product Information Letter
L4949E lead-free migration to Advanced uPPF frame

Dear Customer,

According to the PCN APG/08/3923 (notification date: 11/06/2008), STMicroelectronics improved lead-free production of L4949ED (SO-8) and L4949EP (SO-20) introducing advanced uPPF frame.

Today the majority of ST production is already using the new frame option (linked to a dedicated commercial product having the suffix "-E").

With the aim to improve product quality and reliability, we invite you all to switch the current orders on the new L4949E lead-free option. The below table, reporting the old and new commercial, is a helpful guide for correct order insertion:

OLD FRAME Commercial Product	NEW ADVENCED uPPF Commercial Product
L4949ED	L4949ED-E
L4949ED013TR	L4949EDTR-E
L4949EP	L4949EP-E
L4949EP013TR	L4949EPTR-E

We take the chance to inform you that in December 2010 the lead-free orders on older commercial product (without the suffix "-E") will be switched on the newer Commercial Product (suffix "-E") linked to the advanced uPPF frame. Of course, the migration will not impact the order confirmation date.

STMicroelectronics
Automotive Product Group

Date
September 15th, 2010

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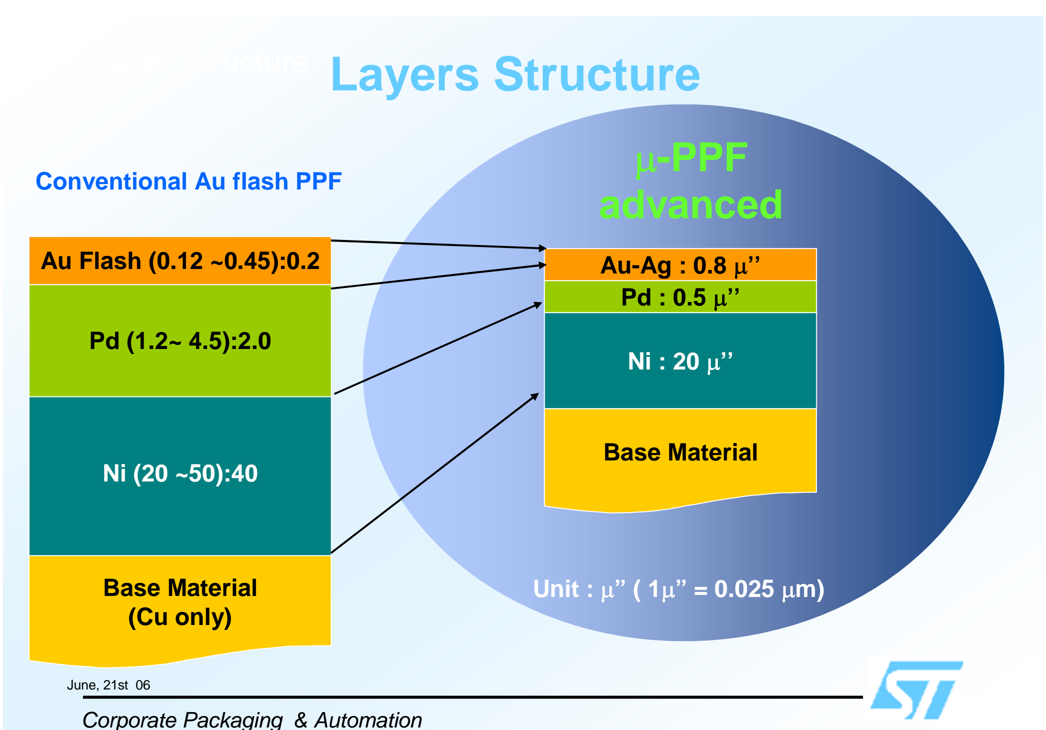
Advanced uPPF and standard PPF frame Comparison

See below layers structures and comparison between standard PPF and uPPF frames .
Reliability evaluation on tet vehicles follows.



ADVANCED μ-PPF FOR Pb-FREE SOIC NARROW, MUAR

RELIABILITY EVALUATION REPORT TEST VEHICLE: W023

Abstract

Aim of the present reliability exercise was to assess the "Advanced Micro-PPF" lead-frame proposed for Pb-free SO-Narrow package in order to increase molding compound adhesion and solderability. The new glue ABLEBOND 8601S-25, replacement of Hitachi EN4900ST10 for workability improvement, has been evaluated too.

Conclusion

On the basis of the results summarized and documented within the present report, the adoption of "Advanced μ-PPF" strongly improves the robustness margin of Pb-free SOIC-Narrow package against thermal fatigue. The new glue ABLEBOND 8601S-25 does not introduce significant variations in the expected reliability performance of the package.

The reliability stress matrix on this test-vehicle has been optimized taking into account the available results on other products, in order to achieve a full AEC-Q100-compliant data collection for the proposed change.

Reliability test conditions and results

TEST NAME	CONDITIONS [SPEC]	U537 REJ./S.S.	NOTES
JL3	24h bake @ 125°C 192h @ 30°C / 60% RH reflow simulation (3 times) at T_{MAX}=260°C [IPC/Jedec J-STD-020C]	0/200	1
JL3 + TCT	Ta=-65/+150°C, 1000 cycles	0/77	1, 2, 3
JL3+THB	Ta=85°C, RH=85%, 1000h Vs=16V Pd=negligible	0/77	-

NOTES:
[1] SAM analysis after JL3 preconditioning shows no significant delamination at the die-molding compound, lead tips and through the die-attach layer. Detail in attachment n. 3.
[2] Wire bonding strength after the stress has been successfully verified through wire-pull test and ball shear test: neither abnormal break loads, nor forbidden failure modes have been detected. Detail in attachment n. 3.
[3] Visual and SEM inspection after the stress test have pointed out no remarkable degradation of silicon passivation, metal interconnects and wire bonds. Detail in attachment n. 3.

Construction note

Technical code :	J5O7*W023FAW
Diffusion process :	BIP
Wafer diameter :	5
Diffusion site :	AMK 5
Die size (mm^2) :	2160x1960
Metal levels :	2,AlSi/AlSiCu
Passivation :	SiN+Polyimide
Back finishing :	CHROMIUM/NICKEL
Package name :	SO 08 .15 JEDEC
Assembly site :	MUAR
Leadframe :	SO 8L 94x125 Du Flo OpC uAdvPPF
Die attach :	ABLEBOND 8601S-25
Wire bonding :	Au 1mils
Molding compound :	NITTO MP8000CH4-2A
Lead finishing :	Ni/Pd/Au
Lot _id :	90830

Attachments

1) Reliability tests description
2) List of stress equipment
3) Physical analysis report
4) Reflow profile

ATTACHMENT 1: RELIABILITY TESTS DESCRIPTION

TEST NAME	DESCRIPTION	PURPOSE
JLn: Jedec Level n surface mounting simulation	The device is submitted to a typical temperature profile used for surface mounting, after a controlled moisture absorption.	As stand-alone test: to investigate the level of moisture sensitivity. As preconditioning before other reliability tests: to verify that the surface mounting stress does not impact on the subsequent reliability performance. The typical failure modes are "pop corn" effect and delamination.
TCT: Temperature Cycles Test	The device is submitted to cycled temperature excursions, between a hot and a cold chamber in air atmosphere.	To investigate failure modes related to the thermo-mechanical stress induced by the different thermal expansion of the materials interacting in the die-package system. Typical failure modes are linked to metal displacement, dielectric cracking, moulding compound delamination, wire-bonds failure, die-attach layer degradation.
THB: Temperature Humidity Bias Test	The device is biased in static configuration minimizing its internal power dissipation, and stored at controlled conditions of ambient temperature and relative humidity.	To investigate failure mechanisms activated in the die-package environment by electrical field and wet conditions. Typical failure mechanisms are electro-chemical corrosion and surface effects related to the moulding compound.

ATTACHMENT 2: LIST OF STRESS EQUIPMENT

EQUIPMENT	TYPE / LOCATION	USED FOR…
MAZZALI THRMAIR	STATIC OVEN / STM Agrate	JL3 (dry bake step)
MAZZALI CLIMATEST	CLIMATIC CHAMBER /STM Agrate	JL3 (moisture soak step)
HERAEUS NOBLELIGHT	REFLOW FURNACE (7 zones) / STM Agrate	JL3 (reflow simulation step)
WEISS TS130	AIR TO AIR SHOCK (2 chambers) / STM Muar	TC 1000
MAZZALI CLIMATEST	CLIMATIC CHAMBER/ STM Agrate	THB 1000h

ATTACHMENT 3: PHYSICAL ANALYSIS REPORT

Technical code : J5O7*W023FAW

Package : SO-8N

Lot_id : 90830

Evaluation subject : SO-8 N advanced µPPF leadframe + new glue

Author : D. Casiraghi

Analysis status: ☐ RUNNING ☒ COMPLETED

ANALYSIS PROGRAM

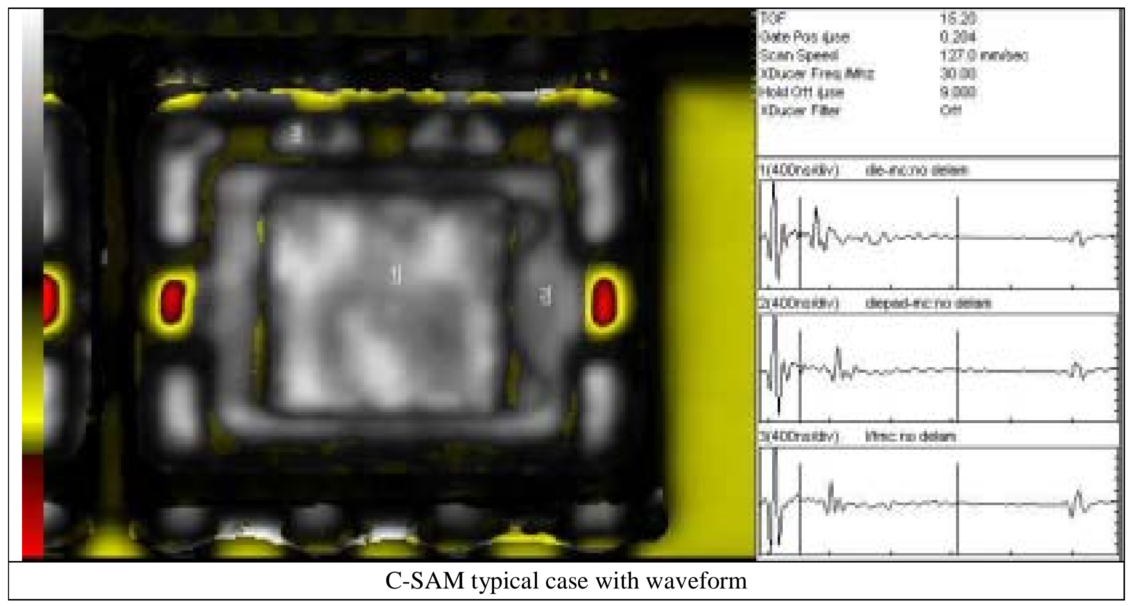
DESTRUCTIVE ITEMS				NON DESTRUCTIVE ITEMS		WHEN
Wire pull test	Ball Shear test	Internal visual	SEM inspection	SAM inspection	Other	
				X		JL3@260°C
X	X	X	X	X		JL3+1000TC

RESULTS SUMMARY

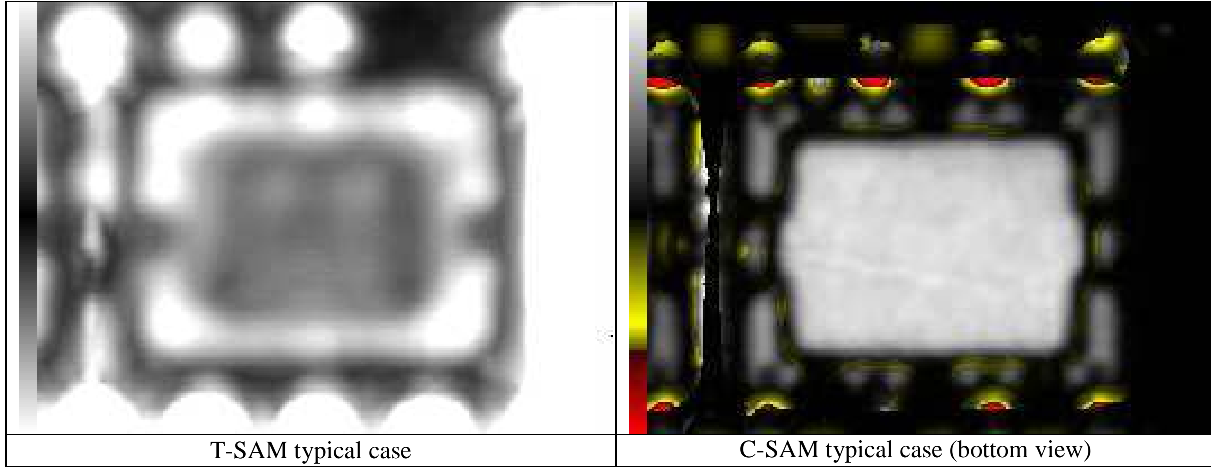
- SAM analysis after JL3 and TC shows no significant delamination at the die-molding compound, lead tips and through the die-attach layer. Uncritical delamination at the die-pad top surface has been observed (no down-bonding present).
- Visual and SEM inspection after JL3+TC showed no significant passivation cracks and no concern in terms of metal and wire bond integrity.
- Wire bonding strength after TC stress has been successfully verified through wire-pull and ball shear tests: neither abnormal break loads, nor forbidden failure modes have been found.

TECHNICAL CODE	PACKAGE	ANALYSIS ITEM	STRESS TEST
J5O7*W023FAW	SO-8 N	SAM inspection	JL3@260°C

TEST EQUIPMENT: SONOSCAN D9000 (Scanning Acoustic Microscope)



C-SAM typical case with waveform



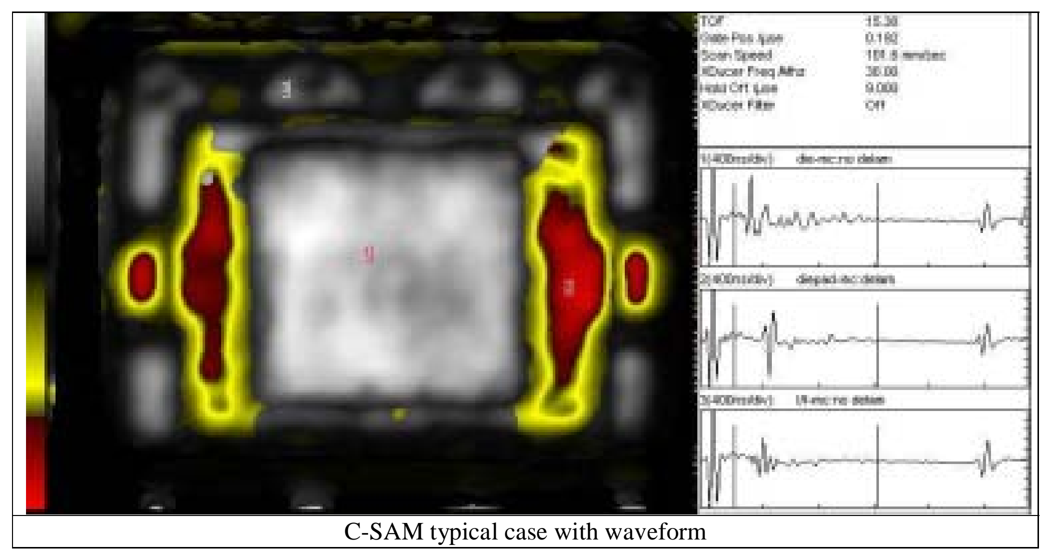
T-SAM typical case

C-SAM typical case (bottom view)

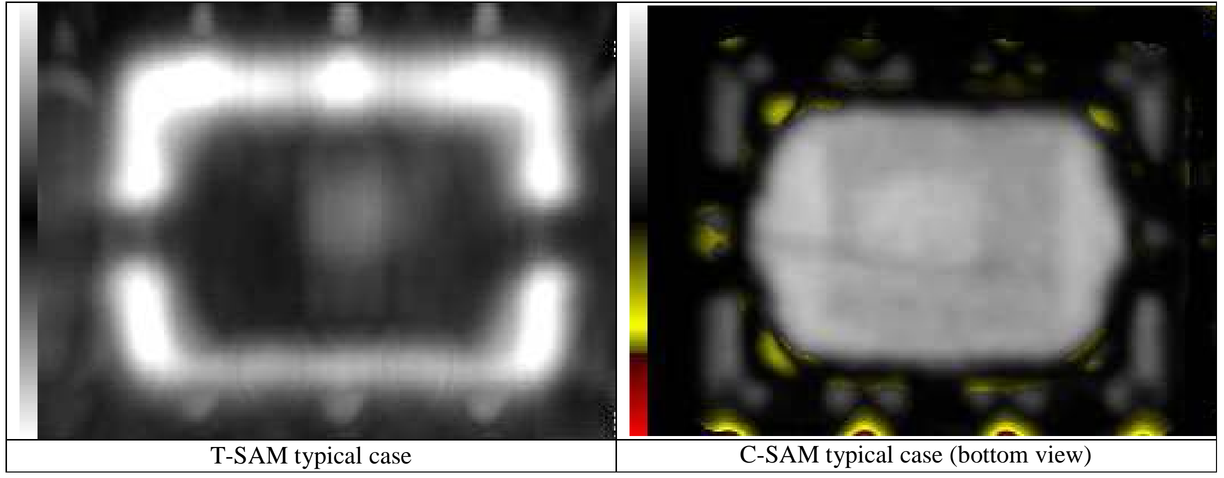
Lot	Sample size	Defective parts (delamination)			
		die-mold (C-scan)	die-attach (T-scan)	l/f-mold (C-scan)	diepad-mold (C-scan)
90830	20	0/20	0/20	0/20	0/20
Transducer frequency (MHz)		30	30	30	30

TECHNICAL CODE	PACKAGE	ANALYSIS ITEM	STRESS TEST
J5O7*W023FAW	SO-8 N	SAM inspection	JL3 + 1000TC (-65/+150°C)

TEST EQUIPMENT: SONOSCAN D9000 (Scanning Acoustic Microscope)



C-SAM typical case with waveform



T-SAM typical case | C-SAM typical case (bottom view)

Lot	Sample size	Defective parts (delamination)			
		die-mold (C-scan)	die-attach (T-scan)	l/f-mold (C-scan)	diepad-mold top(C-scan)
90830	20	0/20	0/20	0/20	20/20*
Transducer frequency (MHz)		30	30	30	30

* uncritical delamination due to absence of wire-bonds on the die-pad.

TECHNICAL CODE	PACKAGE	LOT	ANALYSIS ITEM
J5O7*W023FAW	SO-8 N	90830	Internal visual

ANALYSIS SUMMARY:

WHAT	WHEN	SAMPLE SIZE /LOT	RESULT
Passivation and metal integrity	JL3+1000 TC	5pcs/1	No passivation-cracks / no metal displacement (photo 1-4)

DOCUMENTATION:

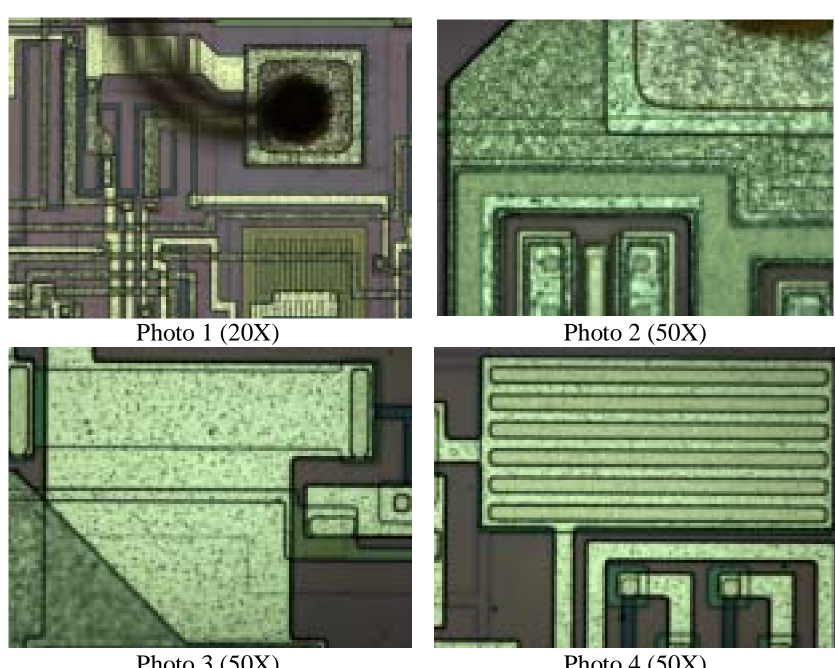


Photo 1 (20X) Photo 2 (50X)

Photo 3 (50X) Photo 4 (50X)

TEST EQUIPMENT: LEICA (Optical Microscope)

TECHNICAL CODE	PACKAGE	LOT	ANALYSIS ITEM
J5O7*W023FAW	SO-8 N	90830	SEM inspection

ANALYSIS SUMMARY:

WHAT	WHEN	SAMPLE	RESULT
Stitch-bond on leads / ball bond	JL3+1000TC	5pcs	No visible defect (photo 1-6)

DOCUMENTATION:

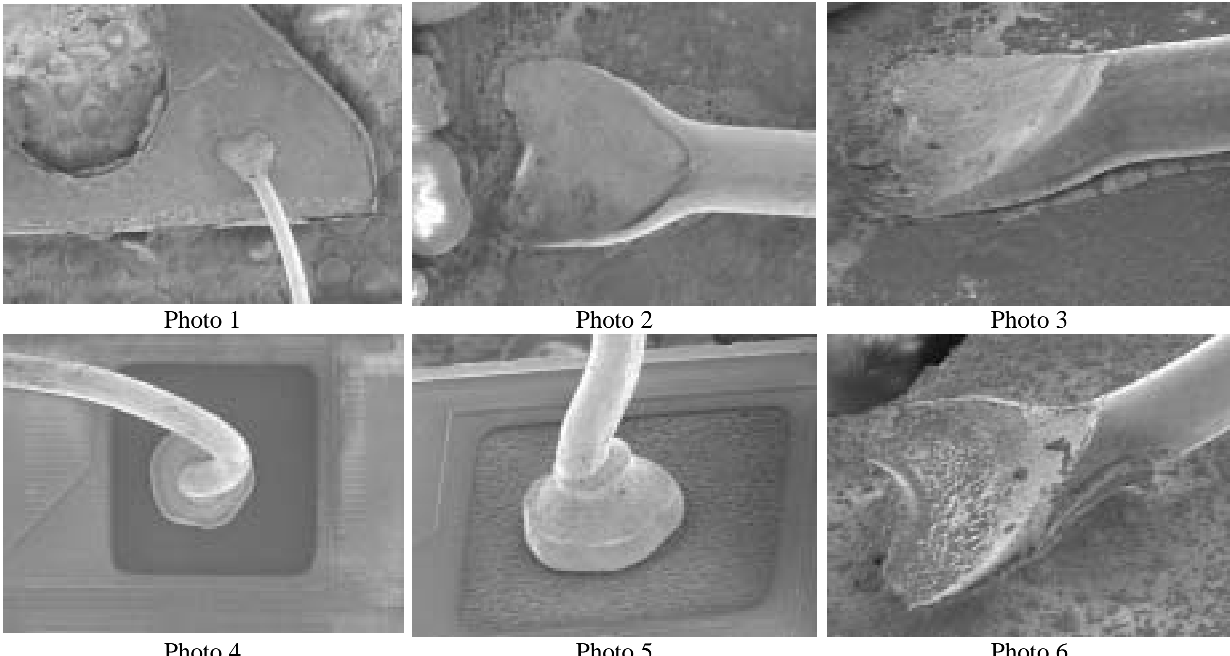


Photo 1 Photo 2 Photo 3
Photo 4 Photo 5 Photo 6

TEST EQUIPMENT: HITACHI (Scanning Electron Microscope)

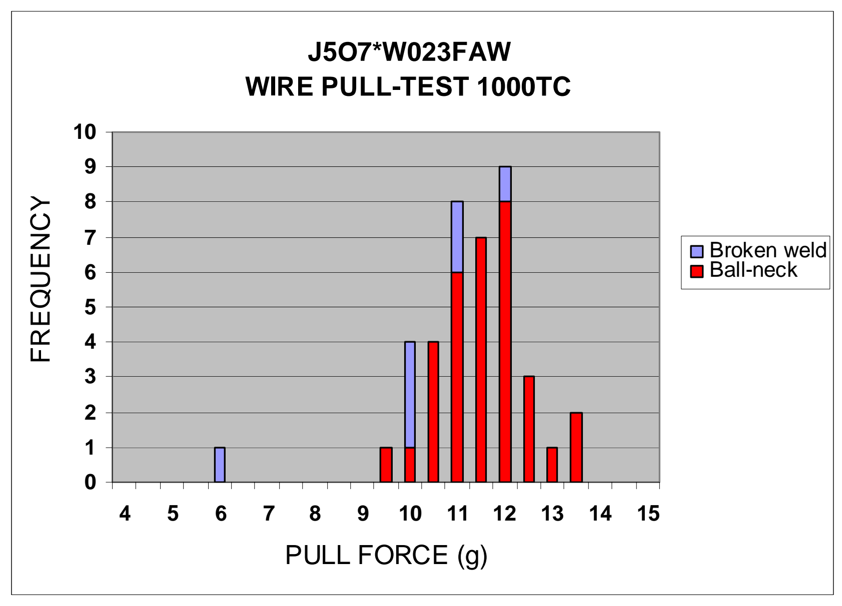
TECHNICAL CODE	PACKAGE	LOT	ANALYSIS ITEM
J5O7*W023FAW	SO-8 N	90830	Wire pull-test

Wire type : Au, 1 mil
LSL (g) : 3.5

Sample size (pcs) : 5
Sample size (wires) : 40

Failure mode		JL3 + 1000 TC
2: BALL NECK	**mean (g)**	11,29
	stdev (g)	0,90
	min (g)	9,15
	max (g)	13,13
	occurrence	83%
4: BROKEN WELD	**mean (g)**	9,81
	stdev (g)	1,88
	min (g)	5,83*
	max (g)	11,78
	occurrence	17%

* low force reading due to lead plating overetch during molding compound removal.



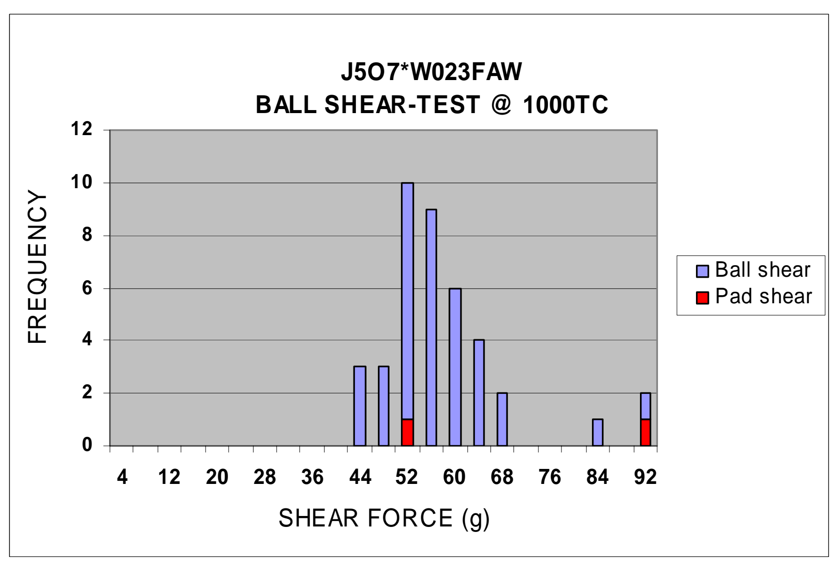
TEST EQUIPMENT: DAGE BT 4000

TECHNICAL CODE	PACKAGE	LOT	ANALYSIS ITEM
J5O7*W023FAW	SO-8 N	90830	Ball shear -test

Wire type : Au, 1 mil
LSL (g) : 12,6

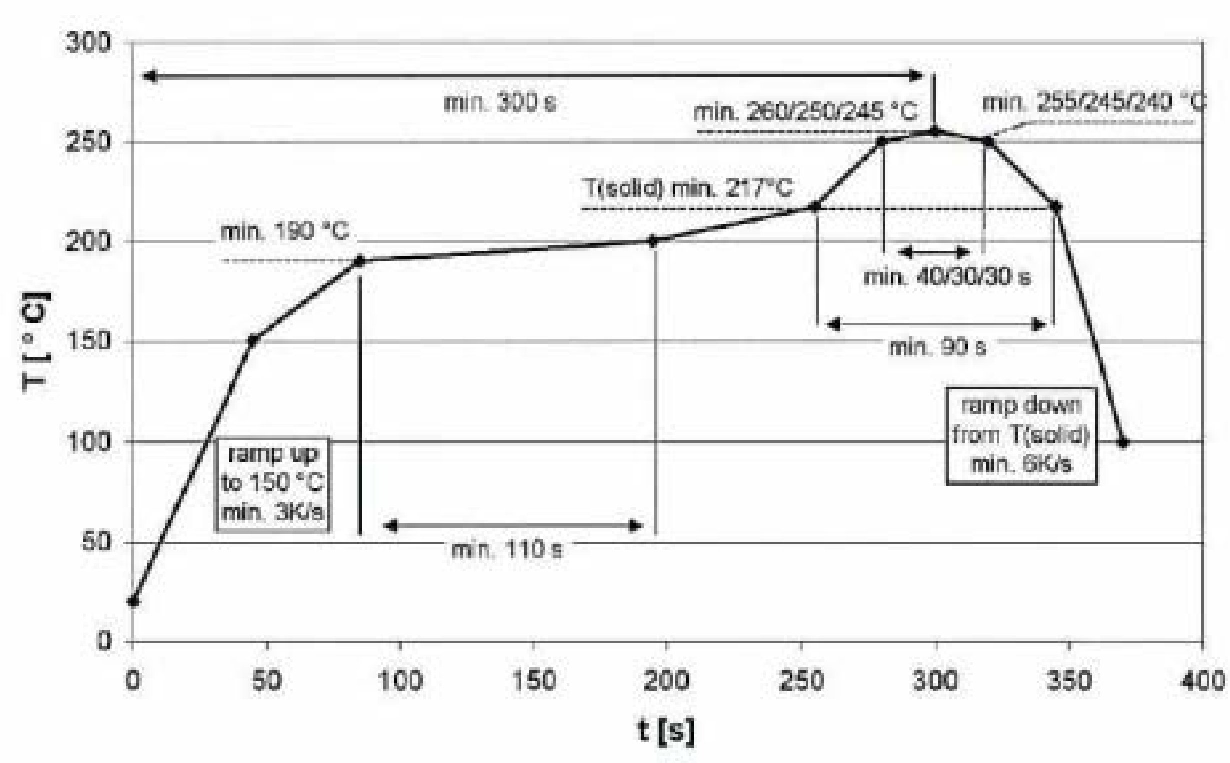
Sample size (pcs) : 5
Sample size (wires) : 40

Failure mode		JL3 + 1000 TC
2: PAD SHEAR	**mean (g)**	70,18
	stdev (g)	30,28
	min (g)	48,77
	max (g)	91,59
	occurrence	5%
3: BALL SHEAR	**mean (g)**	55,46
	stdev (g)	9,29
	min (g)	42,06
	max (g)	88,91
	occurrence	83%



TEST EQUIPMENT: DAGE BT 4000

ATTACHMENT 4: REFLOW PROFILE



Profile Features	Class1 (small)	Class 2 (large)	Class 3 (very large)
preheat			
ramp-up rate to 150 °C	min. 3 K/s (average value over 10 s)		
time from 190°C to 200°C	min. 110 s		
peak			
ramp-up rate from 200°C to T_{peak}	0,5 K/s - 3 K/s (average value over 10 s)		
time above $T_{solidus}$ (min. 217 °C)	min. 90 s		
peak temperature T_{peak}	260 (- 0) °C	250 (- 0) °C	245 (- 0) °C
time above T_{peak} - 5 K	min. 40 s	min. 30 s	min. 30 s
cooling			
ramp-down rate from $T_{solidus}$ (min. 217 °C)	min. 6 K/s (average value over 10 s)		
general			
time 25 °C to T_{peak}	min. 300 s		

ADVANCED μ-PPF FOR Pb-FREE SOIC WIDE, MUAR

RELIABILITY EVALUATION REPORT
TEST VEHICLE: U447

Abstract

Aim of the present reliability exercise was to assess the "Advanced Micro-PPF" lead-frame proposed for Pb-free SO-Wide package in order to improve molding compound adhesion and solderability. The U447 has been selected to verify the integrity of GND down-bonding, performed on a dedicated lead-frame design with anchorage slots on the die-pad.

Conclusion

On the basis of the results summarized and documented within the present report, the adoption of "Advanced μ-PPF" strongly improves the robustness margin of Pb-free SOIC-Wide package against thermal fatigue, also preserving the integrity of GND down-bonds.

The reliability stress matrix has been successfully enlarged with wet environmental tests (ES and THB) in order to exclude any potential drawback in the new lead-frame implementation and contribute to a full AEC-Q100-compliant data collection for the proposed change (other SOIC-Wide test-vehicle have been tested in this perspective).

Released by: ALBERTO MANCALEONI
APG Back-end Q&R – Reliability Manager

Reliability test conditions and results

TEST NAME	CONDITIONS [SPEC]	U447 REJ./S.S.	NOTES
JL3	24h bake @ 125°C 192h @ 30°C / 60% RH reflow simulation (3 times) at T_{MAX}=260°C [IPC/Jedec J-STD-020C]	0/291	1, 5
JL3 + TCT	Ta=-50/+150°C, 1000 cycles	0/77	2, 3, 4
JL3+ES	100 TC (-50/+150°C) + 96h PPT (2atm, 121°C)	0/77	2, 3
JL3+THB	Ta=85°C, RH=85%, 1000h V_1=45V ; P_D negligible	0/87	-

NOTES:

[1] SAM analysis after preconditioning shows no significant delamination at the die-molding compound, lead tips, die-pad interfaces and through the die-attach layer. Detail in attachment n. 3.

[2] Wire bonding strength after the stress has been successfully verified through wire-pull test and ball shear test: neither abnormal break loads, nor forbidden failure modes have been detected. Detail in attachment n. 3.

[3] Visual and SEM inspection after the stress test have pointed out no remarkable degradation of silicon passivation and metal interconnects. Stitch bonds integrity on internal lead-tips and die-pad has been carefully checked after TC. Detail in attachment n. 3.

[4] SAM analysis after TC shows no significant delamination at the die-molding compound and lead tips interfaces; minor delaminations at the die-pad interfaces and through the die-attach layer have been observed on very limited areas. Detail in attachment n. 3.

[5] Reflow profile according to Bosch specification (see attachment #4) performed in Reutlingen.

Construction note

Technical code	**:**	J6Z7*U447CA6
Diffusion process	**:**	BCD3
Wafer diameter	**:**	6”
Diffusion site	**:**	ANG-MO-KIO
Die size (mm^2)	**:**	4.12x2.51
Metal levels	**:**	2, Al/Si/Cu
Passivation	**:**	USG-PSG-SiON-PIX
Back finishing	**:**	Lapped Silicon
Package name	**:**	SO-20L
Assembly site	**:**	MUAR
Leadframe	**:**	SO 20L 195x250 MtBtw16+2+2 uAdvPPF
Die attach	**:**	HITACHI EN4900 ST12
Wire bonding	**:**	Au, 1.5 mils
Molding compound	**:**	SUMITOMO EME7026
Lead finishing	**:**	Ni/Pd/Au PPF
Lot _id	**:**	99804

Attachments

1) Reliability tests description
2) List of stress equipment
3) Physical analysis report
4) Reflow profile

ATTACHMENT 1: RELIABILITY TESTS DESCRIPTION

TEST NAME	DESCRIPTION	PURPOSE
JLn: Jedec Level n surface mounting simulation	The device is submitted to a typical temperature profile used for surface mounting, after a controlled moisture absorption.	As stand-alone test: to investigate the level of moisture sensitivity. As preconditioning before other reliability tests: to verify that the surface mounting stress does not impact on the subsequent reliability performance. The typical failure modes are "pop corn" effect and delamination.
TCT: Temperature Cycles Test	The device is submitted to cycled temperature excursions, between a hot and a cold chamber in air atmosphere.	To investigate failure modes related to the thermo-mechanical stress induced by the different thermal expansion of the materials interacting in the die-package system. Typical failure modes are linked to metal displacement, dielectric cracking, moulding compound delamination, wire-bonds failure, die-attach layer degradation.
ES: Environmental Sequence	The device is submitted in sequence to TCT and PPT, sometimes preceded by JLn preconditioning.	To simulate the actual combination of environmental stresses interacting in the field application. The typical failure modes are those reported for JLn, TCT and PPT.
THB: Temperature Humidity Bias Test	The device is biased in static configuration minimizing its internal power dissipation, and stored at controlled conditions of ambient temperature and relative humidity.	To investigate failure mechanisms activated in the die-package environment by electrical field and wet conditions. Typical failure mechanisms are electro-chemical corrosion and surface effects related to the moulding compound.

ATTACHMENT 2: LIST OF STRESS EQUIPMENT

EQUIPMENT	TYPE / LOCATION	USED FOR…
BINDER FE115	STATIC OVEN / RB Reutlingen	JL3 (dry bake step)
CTS C+10/200	CLIMATIC CHAMBER / RB Reutlingen	JL3 (moisture soak step)
REHM V8	REFLOW FURNACE / RB Reutlingen	JL3 (reflow simulation step)
WEISS TS130	AIR TO AIR SHOCK (2 chambers) / STM Muar	TC, ES (100 TC step)
MAZZALI CLIMATEST	CLIMATIC CHAMBER/ STM Agrate	THB
MAZZALI	PRESSURE POT/ STM Muar	ES (96h PPT step)

ATTACHMENT 3: PHYSICAL ANALYSIS REPORT

Technical code : J6Z7*U447CA6

Package : SO-20L

Lot_id : 99804

Evaluation subject : SO-20L advanced µPPF Leadframe

Author : D. Casiraghi

Analysis status: ☐ RUNNING ☒ COMPLETED

ANALYSIS PROGRAM

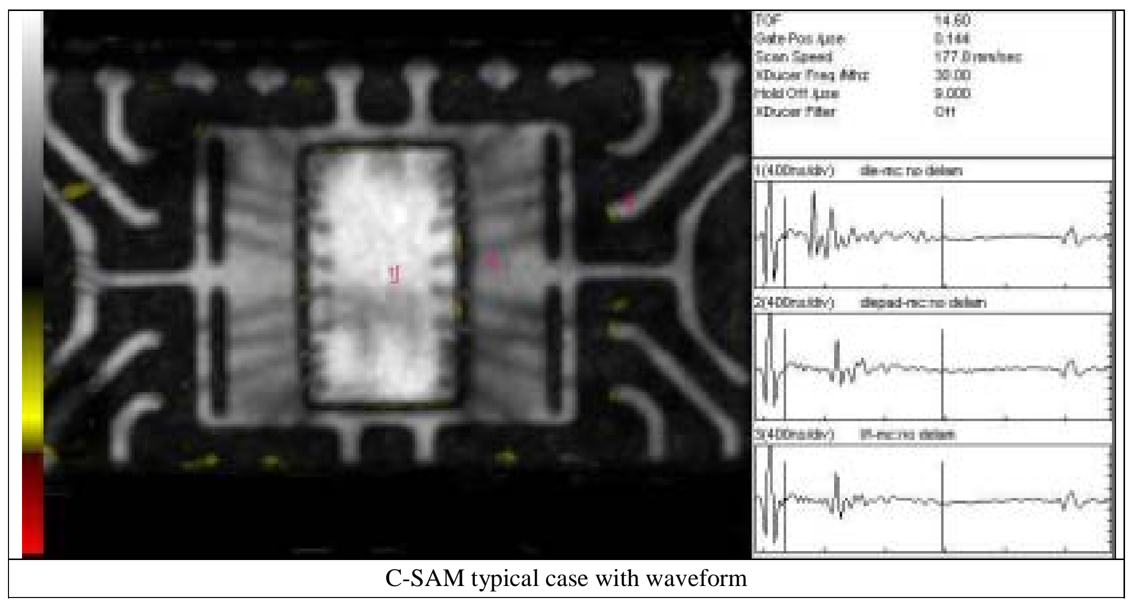
DESTRUCTIVE ITEMS				NON DESTRUCTIVE ITEMS		WHEN
Wire pull test	Ball Shear test	Internal visual	SEM inspection	SAM inspection	Other	
				X		JL3@260°C
X	X	X	X	X		JL3+1000TC
X		X				JL3+ES (100TC+96hAC)

RESULTS SUMMARY

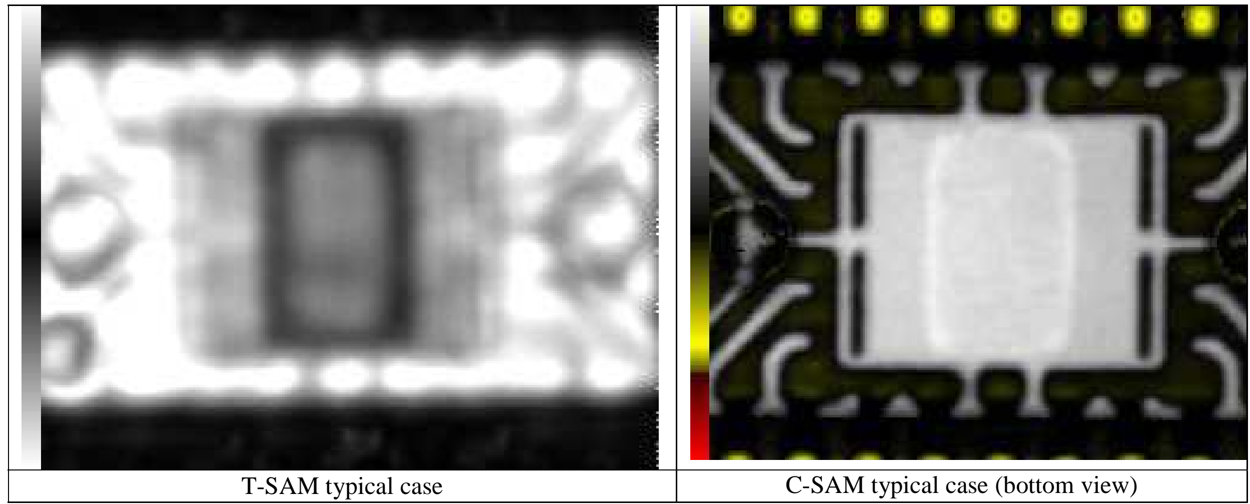
- SAM analysis after JL3 preconditioning shows no significant delamination at the die-molding compound, lead tips, die-pad interfaces and through the die-attach layer.
- SAM analysis after TC shows no significant delamination at the die-molding compound and lead tips interfaces; minor delaminations at the die-pad interfaces and through the die-attach layer have been observed on very limited areas.
- Visual and SEM inspection after JL3+TC showed minor and physiological passivation cracks and no concern in terms of metal and wire bond integrity.
- Visual inspection after ES stress test did not show any remarkable defect in terms of metal corrosion and oxidation.
- Wire bonding strength after TC and ES stress has been successfully verified through wire-pull test and ball shear test: neither abnormal break loads, nor forbidden failure modes have been found**.** With particular focus on 2nd bond (main reason for advanced µPPF adoption) no degradation trend has been observed until 1000 cycles on both standard bonds and down-bonds.

TECHNICAL CODE	PACKAGE	ANALYSIS ITEM	STRESS TEST
J6Z7*U447CA6	SO 20	SAM inspection	JL3@260°C

TEST EQUIPMENT: SONOSCAN D9000 (Scanning Acoustic Microscope)



C-SAM typical case with waveform

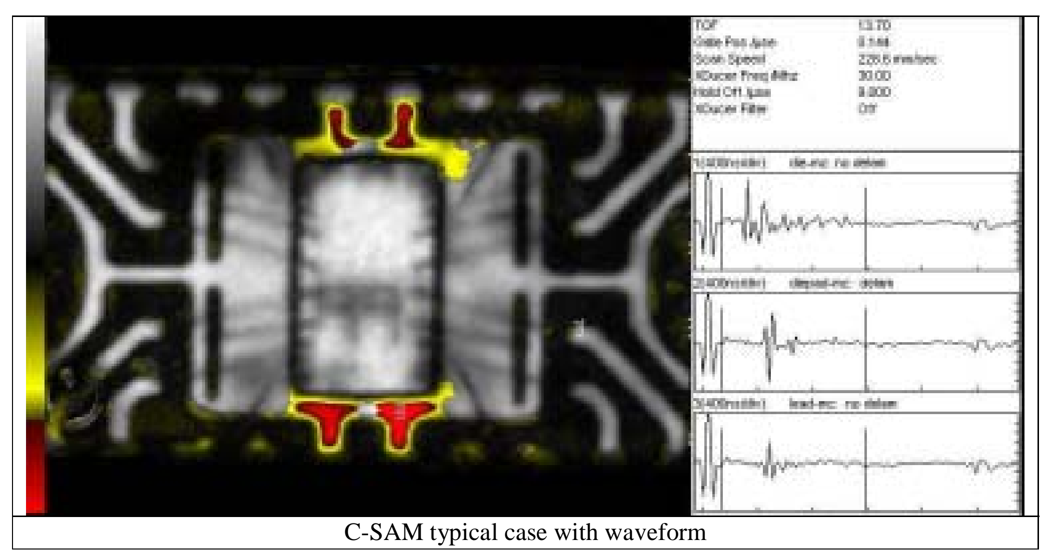


T-SAM typical case | C-SAM typical case (bottom view)

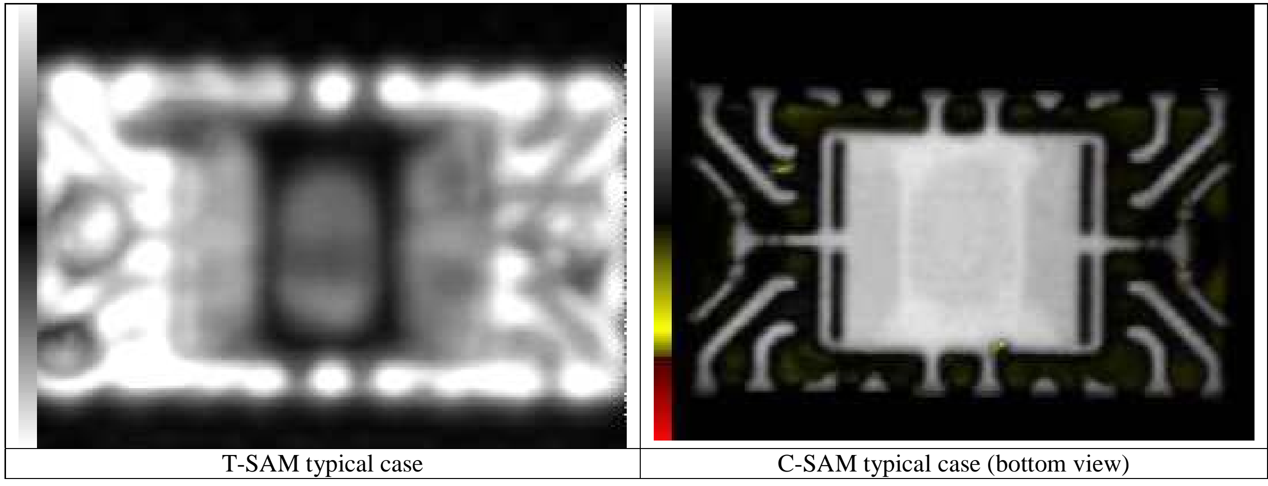
Lot	Sample size	Defective parts (delamination)			
		die-mold (C-scan)	die-attach (T-scan)	l/f-mold (C-scan)	diepad-mold (C-scan)
99804	20	0/20	0/20	0/20	0/20
Transducer frequency (MHz)		30	30	30	30

TECHNICAL CODE	PACKAGE	ANALYSIS ITEM	STRESS TEST
J6Z7*U447CA6	SO 20	SAM inspection	JL3@260°C + 1000TC (-50/+150°C)

TEST EQUIPMENT: SONOSCAN D9000 (Scanning Acoustic Microscope)



C-SAM typical case with waveform



T-SAM typical case | C-SAM typical case (bottom view)

Lot	Sample size	Defective parts (delamination)			
		die-mold (C-scan)	die-attach (T-scan)	l/f-mold (C-scan)	diepad-mold (C-scan)
99804	20	0/20	0/20*	0/20*	0/20
Transducer frequency (MHz)		30	30	30	30

*minor delamination on top side (batwing leads) , and die-attach perimeter.

TECHNICAL CODE	PACKAGE	LOT	ANALYSIS ITEM
J6Z7*U447CA6	SO 20	99804	Internal visual

ANALYSIS SUMMARY:

WHAT	WHEN	SAMPLE SIZE /LOT	RESULT
Metal corrosion and oxidation	JL3 +ES	5pcs/1	No remarkable defect (photo 1-3)
Passivation and metal integrity	JL3+1000 TC	5pcs/1	Minor passivation-cracks / no metal displacement (photo 4-6)

DOCUMENTATION:

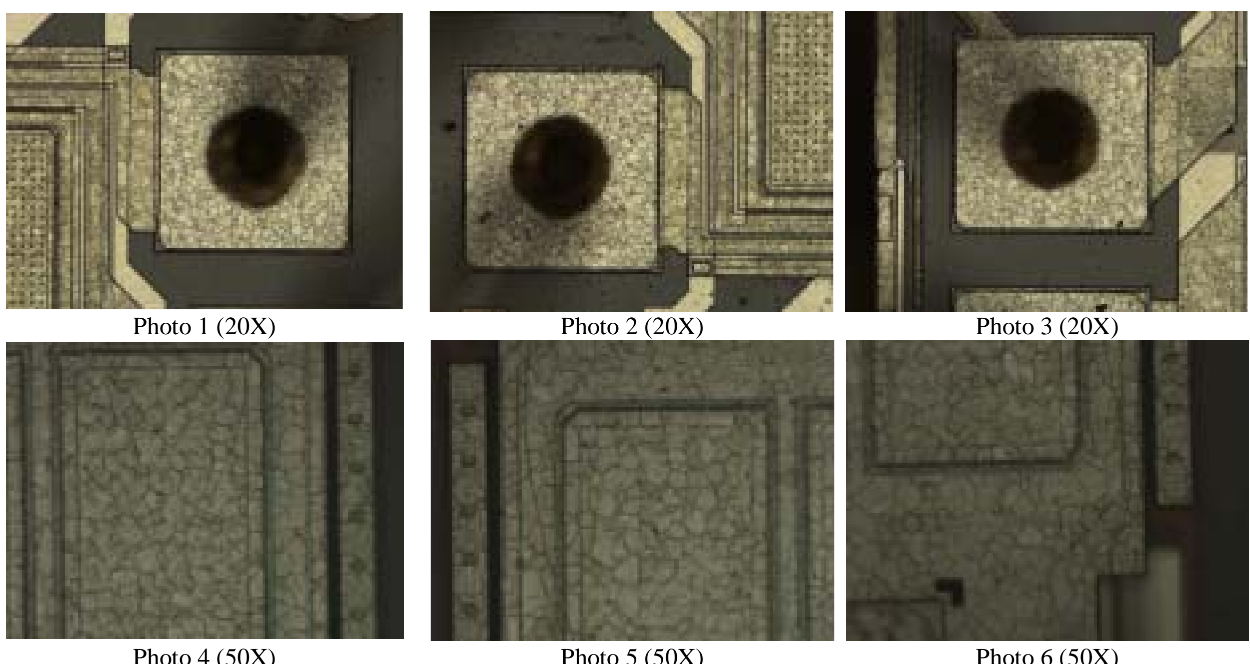


Photo 1 (20X) Photo 2 (20X) Photo 3 (20X)

Photo 4 (50X) Photo 5 (50X) Photo 6 (50X)

TEST EQUIPMENT: LEICA (Optical Microscope)

TECHNICAL CODE	PACKAGE	LOTS	ANALYSIS ITEM
J6Z7*U447CA6	SO 20	99804	SEM inspection

ANALYSIS SUMMARY:

WHAT	WHEN	SAMPLE	RESULT
Stitch-bond / ball bond / down-bonds	JL3@260°C+1000TC	5pcs	No visible defect (photo 1-6)

DOCUMENTATION:

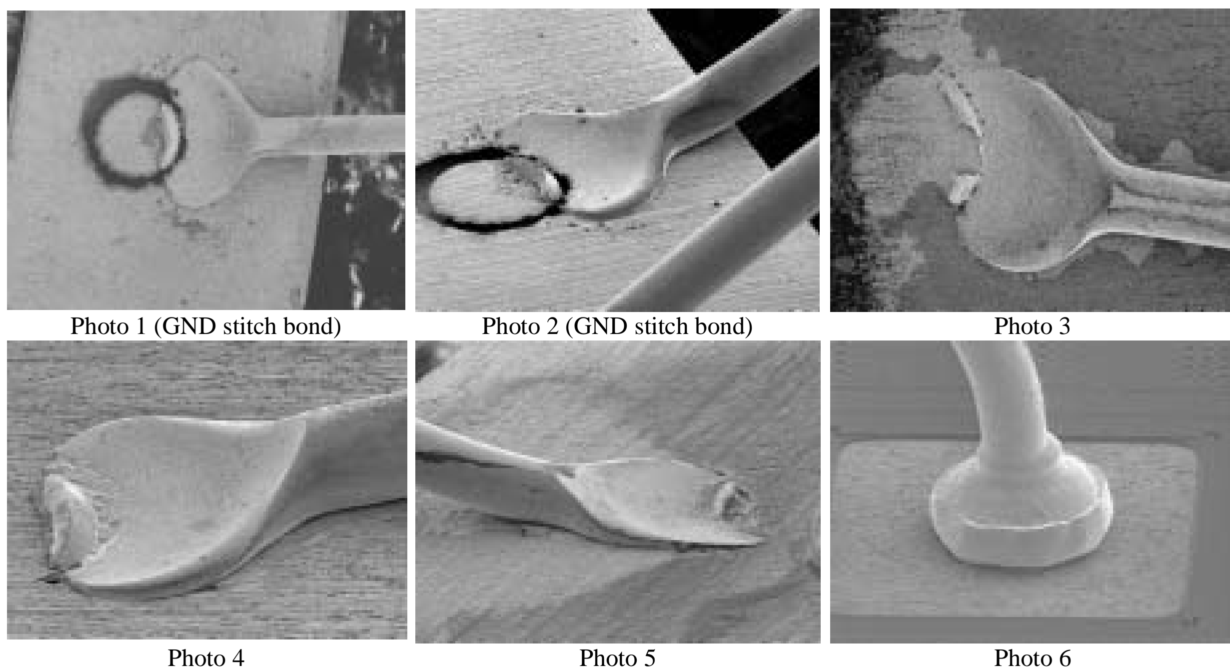
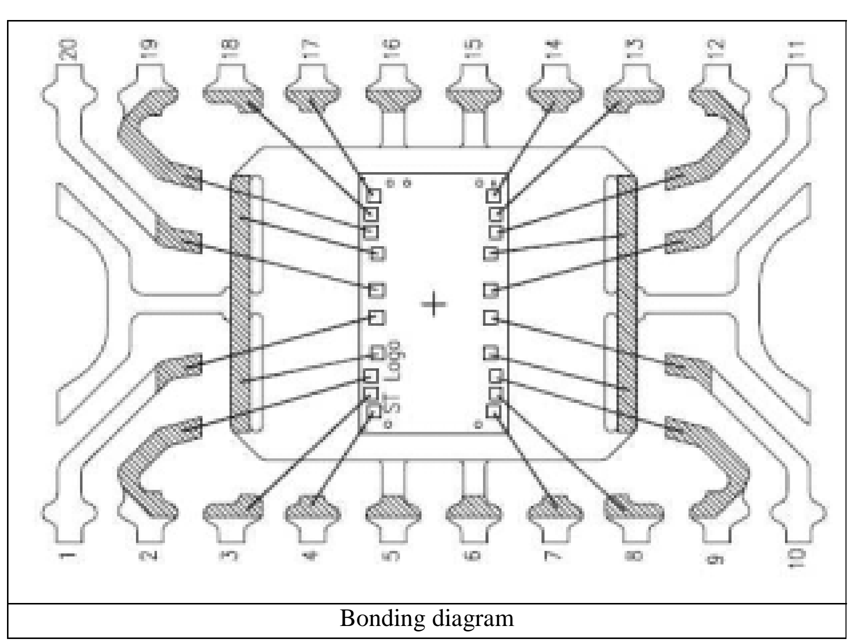


Photo 1 (GND stitch bond) Photo 2 (GND stitch bond) Photo 3

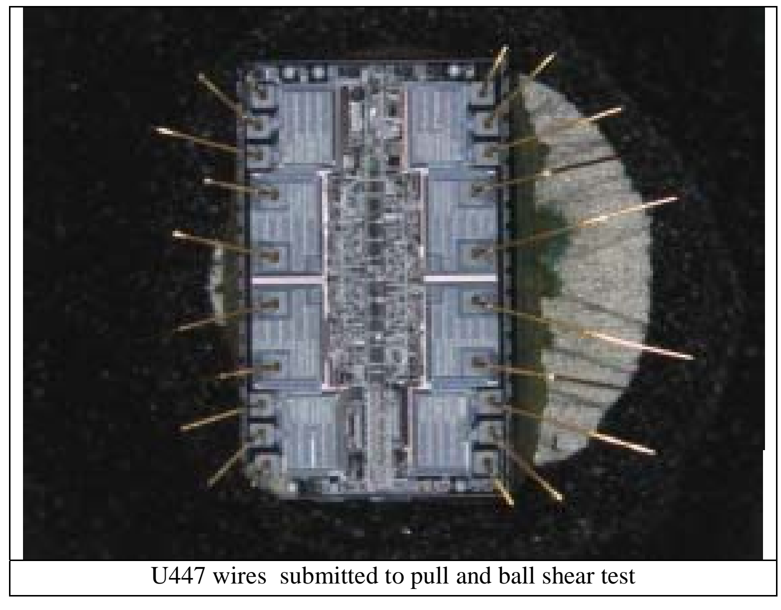
Photo 4 Photo 5 Photo 6

TEST EQUIPMENT: HITACHI (Scanning Electron Microscope)

BONDING DIAGRAM



Bonding diagram



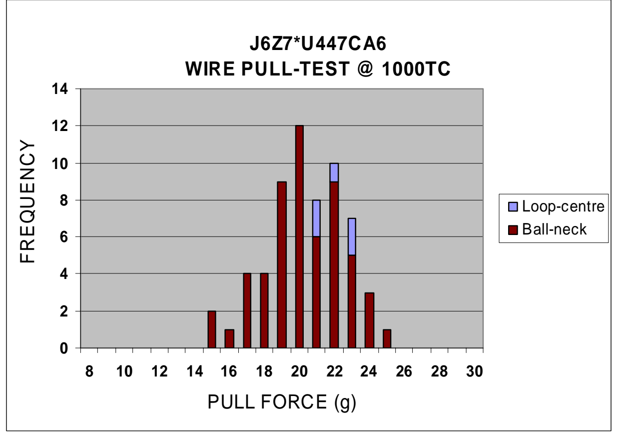
U447 wires submitted to pull and ball shear test

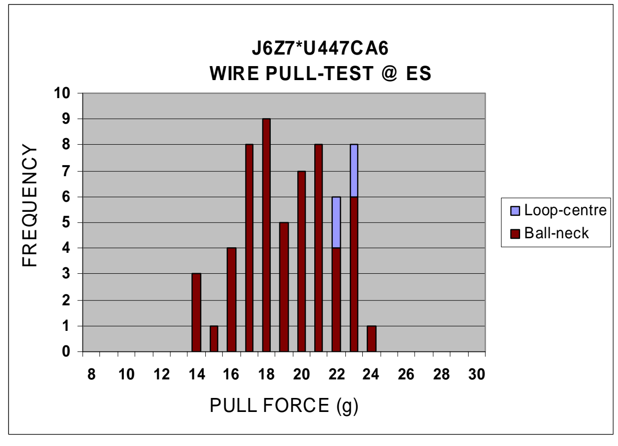
TECHNICAL CODE	PACKAGE	LOT	ANALYSIS ITEM
J6Z7*U447CA6	SO-20L	99804	Wire pull-test

Wire type : Au, 1,5 mil
LSL (g) : 7.5

Sample size (pcs) : 5
Sample size (wires) : 60

Failure mode		JL3 + 1000 TC	JL3 + ES
2: BALL NECK	**mean (g)**	19.68	18.72
	stdev (g)	2.18	2.54
	min (g)	14.80	13.63
	max (g)	24.03	23.52
	occurrence	92%	93%
3: LOOP CENTRE	**mean (g)**	21.55	22.09
	stdev (g)	1.04	0.46
	min (g)	20.44	21.58
	max (g)	22.89	22.49
	occurrence	8%	7%



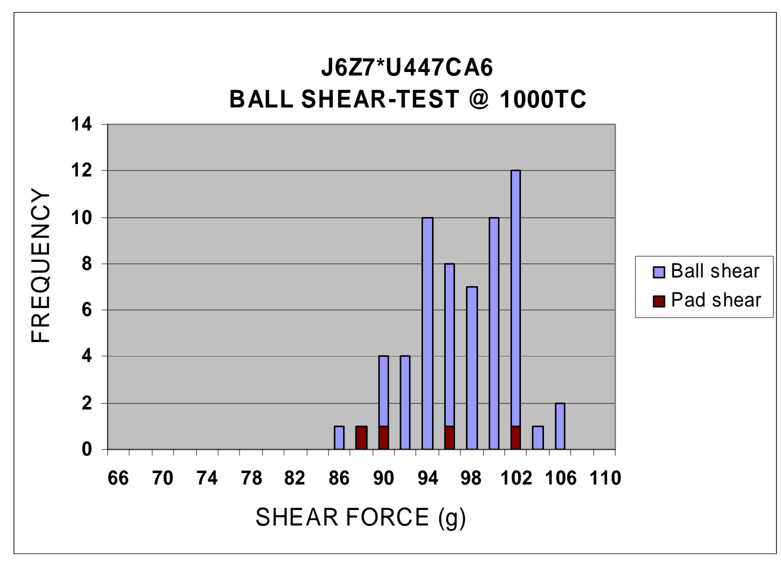


TECHNICAL CODE	PACKAGE	LOT	ANALYSIS ITEM
J6Z7*U447CA6	SO 20	99804	Ball shear test

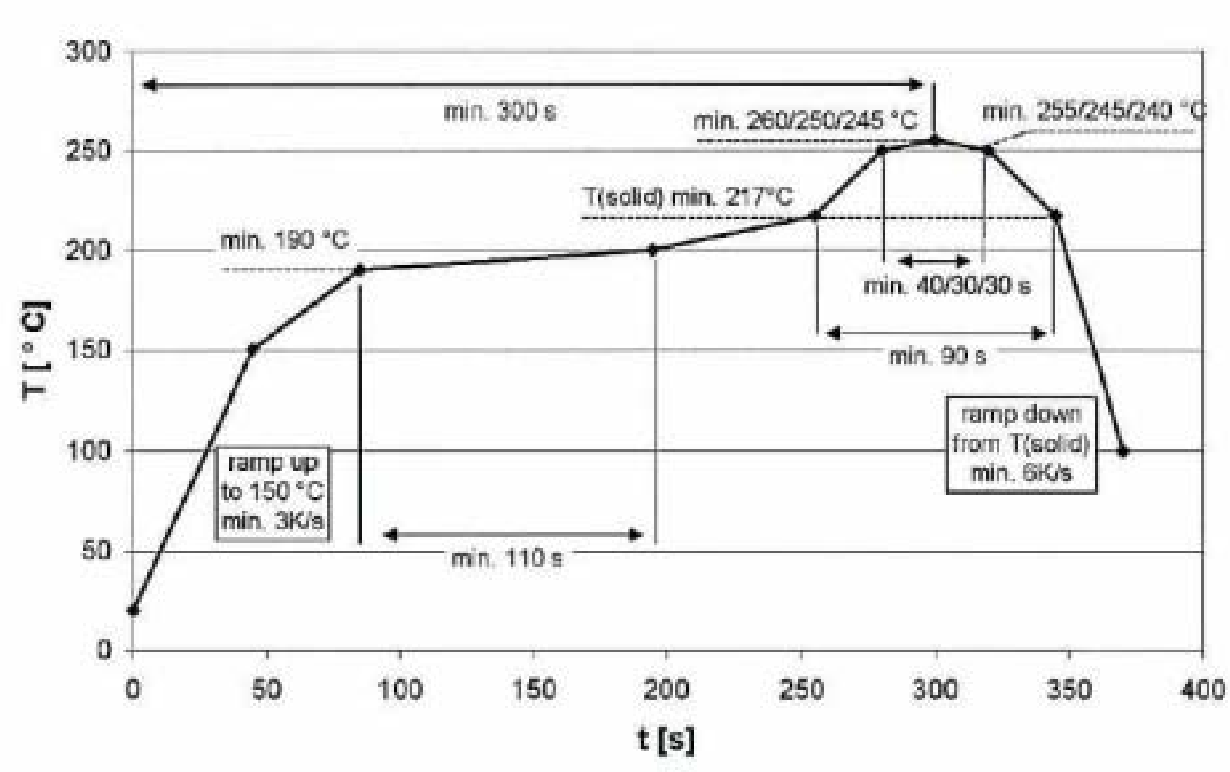
Wire type : Au, 1,5 mil
LSL (g) : 45

Sample size (pcs) : 5
Sample size (wires) : 60

Failure mode		JL3 + 1000 TC
2: PAD SHEAR	**mean (g)**	92.88
	stdev (g)	6.59
	min (g)	87.33
	max (g)	101.36
	occurrence	7%
3: BALL SHEAR	**mean (g)**	96.49
	stdev (g)	4.22
	min (g)	85.46
	max (g)	105.66
	occurrence	93%



ATTACHMENT 4: REFLOW PROFILE



Profile Features	Class1 (small)	Class 2 (large)	Class 3 (very large)
preheat			
ramp-up rate to 150 °C	min. 3 K/s (average value over 10 s)		
time from 190°C to 200°C	min. 110 s		
peak			
ramp-up rate from 200°C to T_{peak}	0,5 K/s - 3 K/s (average value over 10 s)		
time above $T_{solidus}$ (min. 217 °C)	min. 90 s		
peak temperature T_{peak}	260 (- 0) °C	250 (- 0) °C	245 (- 0) °C
time above T_{peak} - 5 K	min. 40 s	min. 30 s	min. 30 s
cooling			
ramp-down rate from $T_{solidus}$ (min. 217 °C)	min. 6 K/s (average value over 10 s)		
general			
time 25 °C to T_{peak}	min. 300 s		

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