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Use of Cu Wire in Plastic Encapsulated Microcircuits – Preliminary Data

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Cu Bond Wire Study – Background Info

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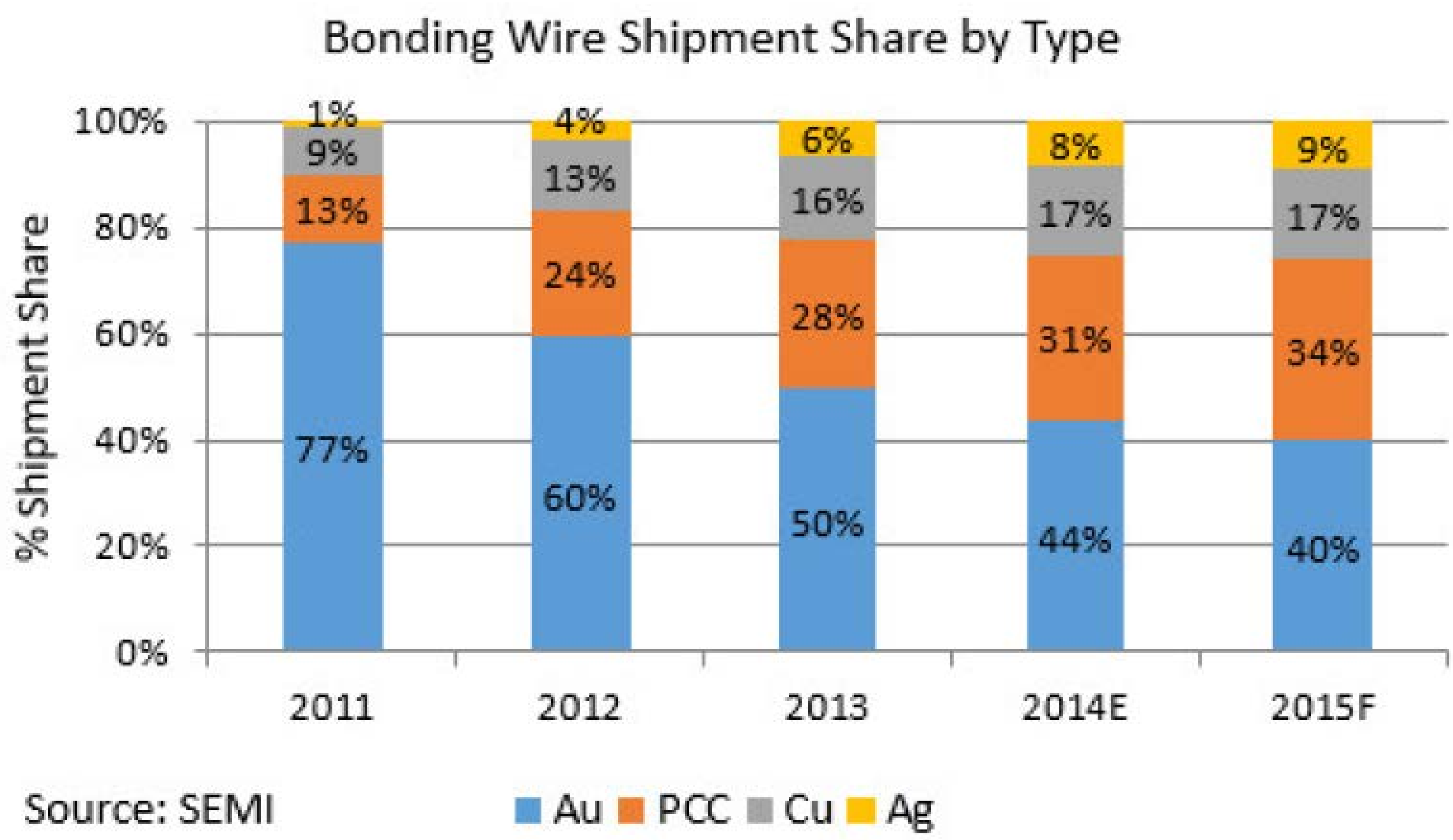
Usage of Cu Wire – Industry Trend



PCC= Palladium-coated Copper

Concerns about Cu Wire in PEMs

INEMI (International Electronics Manufacturing Initiative) Finding

- In-service reliability
- Process yield
- Throughput
- JEDEC reliability spec
- Unproven historical performance
- Manufacturing statistical process control
- Equipment and assembly process parameters

Additional Aerospace and Defense Industry Concerns

- Field failures already observed
- Lack of understanding of physics of failures
- Product Reliability

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Pros

- Cheaper
- Better electrical and thermal properties
- Higher bond break force
- Copper has higher elongation than Gold which means copper can withstand plastic deformation longer

Cons

- **Easily oxides in air – typically requires N2 or special flow of forming gas during mfg.**
- **Cu is harder – bonding process difficult - Requires optimal bonding process otherwise impacts yield and reliability**
- **Quality / Reliability concerns:**
  - **Long term Reliability is a concern and to many it is unknown**
  - **Bond pad aluminum deformation (splash) / Cratering / Cracks under the bond**
  - **Cu ball bond interface corrosion**
  - **IMC (intermetallic dielectric) cracking**
  - **Peeling of the bond pad interface – bond lifting is a major reliability concern**
- **Typically Halogen free special molding compound required for Cu wire products**
  - **Biased humidity failures - corrosion**
  - **Green mold compound with a preferably low Cl content and high pH is recommended**
  - **Lower pH (more acidic) and the higher Cl content are, the poorer the reliability.**

- Industry is starting to use bond pad with
  - NiPd
  - NiPd(Au)
  - CuNiPd
- Some manufacturers are using
  - Palladium Coated Cu Wire

Both solutions are taking care of many of the concerns for Cu. But the above solutions are not universally adopted

Industry is starting to use Pallidum Coated Cu wire or some variant of it

- Advantages
  - Better resistance to pad damage, pad splash and cratering
  - Minimizes die crack
  - Better wire shear
  - Excellent reliability
  - Harder to make than Cu wire

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Palladium Coated Cu Wire

- Advantages
  - Used as an oxidation catalyst
  - 10% harder than platinum, Au but softer than Cu
  - Good adhesion to Cu wire
  - Oxidation free (longer storage/shelf & bonder life)
  - Considered equivalent to Au bonded products.
- Disadvantages
  - Higher price
  - Harder to manufacture than Cu wire

Cu Bond Wire Study at Integra and ASI

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ASI and Integra's Experience

Item	Highlights
Decapsulation & Internal Visual Inspection	• Perform per IAW MIL-STD-1580. • Use custom decap process unique for Cu wire • Inspect and photograph per IAW MIL-STD-883, method 2010, condition A for microcircuits and hybrids / Method 2074 discrete semiconductors • Ball bonds serialized for traceability for ball diameter, pull, and IMC inspection.
Ball Diameter Inspection and Dimension Measurements	• Inspection and photographs of the balls before and after bond pull. • Precision ball dimension measurements
Bond Pull	• Bond pull per IAW MIL-STD-883, method 2011 for microcircuits and hybrids / Method 2037 for discrete semiconductors • Minimum pull at 2x that of Au bond wires of same diameter.
IMC Inspection	• Dissolve the ball away that had undergone bond pull • Photographs and SEM images of the IMC area left after the ball bond is removed from the pad. • Compare to original ball bonds prior to bond pull • Precision ball dimension measurements
Extensive Reliability Evaluation Capability for Cu Wire	• Life Test - Wear out mechanisms • Humidity tests with pre-conditioning • Temp Cycle • High Temp Storage Life • Mechanical stresses • Manufacturing process evaluation • Failure analysis and construction analysis

ASI and Integra's In-House Capabilities

Item	Highlights
Reliability and Physical Analysis	In-House Equipment Includes: • High resolution cameras • Decapsulation stations • Acoustic microscopes • X-Ray • SEM with EDX • Cross sectioning equipment • Full Mil Std 1580 DPA and construction analysis capabilities • Non-destructive screening • Vacuum bake • Bond pull and bond shear equipment including precision gauges • Reliability equipment for life test, high temp storage life, THB, HAST, temp cycle and vacuum bake
Electrical Test	Test all EEE products: Discrete, Passives, Linears, Memory, FPGA, SERDES, Microcontrollers, A/D, D/A, Connectors, Relays, Inductors, Magnetics
Engineering Support	35+ • Product Engineers • Test Engineers • Reliability Engineers

Phase 1

- Perform evaluation of Cu Wire without bias stresses
- Intended to gather some basic information
- Stresses utilized were unbiased and were common for typical qualifications for package changes

Phase 2

- Perform evaluation of Cu Wire with bias stress
- Utilizes biased HAST to more rapidly age the intermetallic bond.
- Temp Cycle utilized to stress the bonds and accelerate the process of work hardening and intermetallic bond issues.
- Increased Sample size

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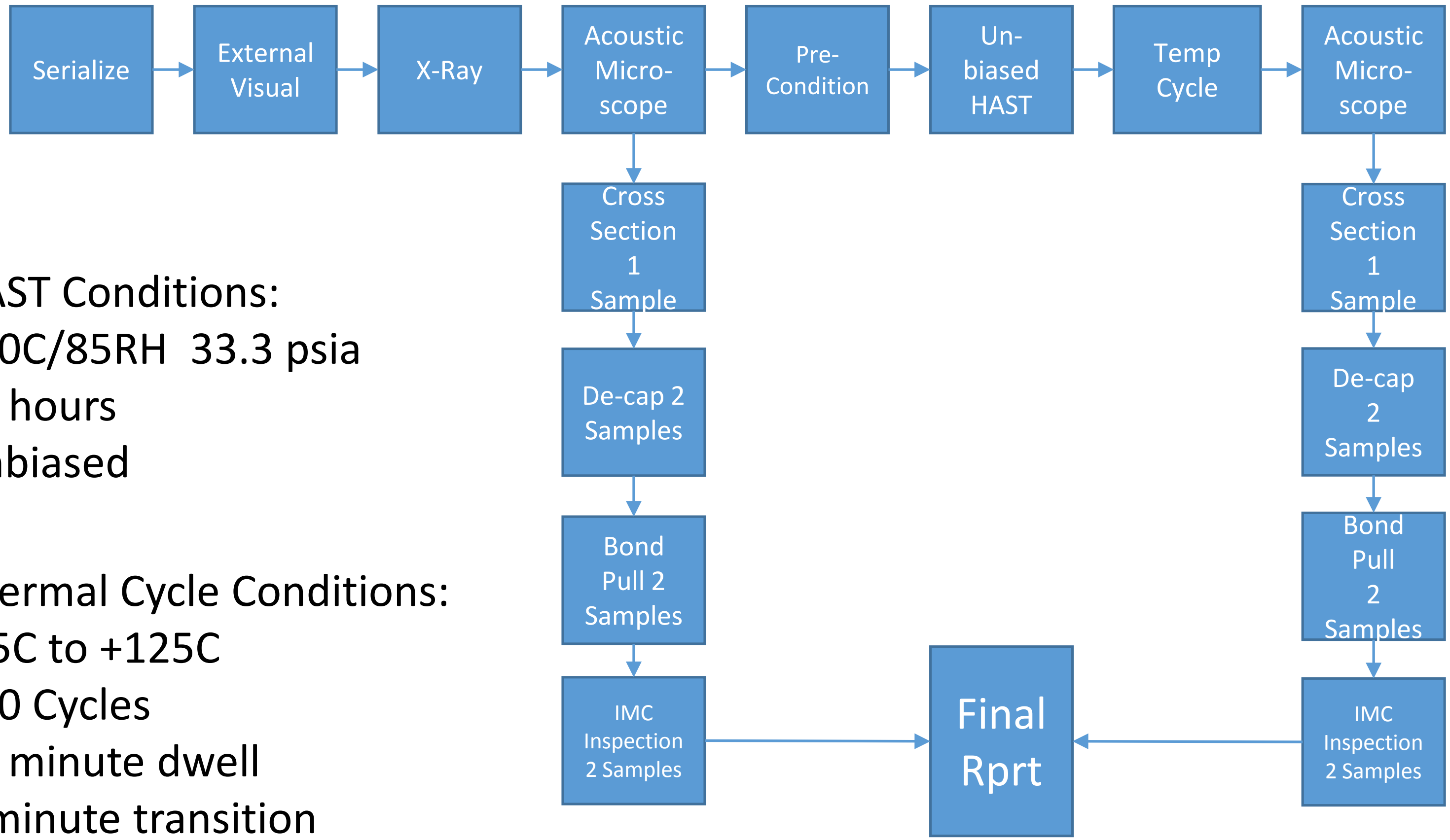
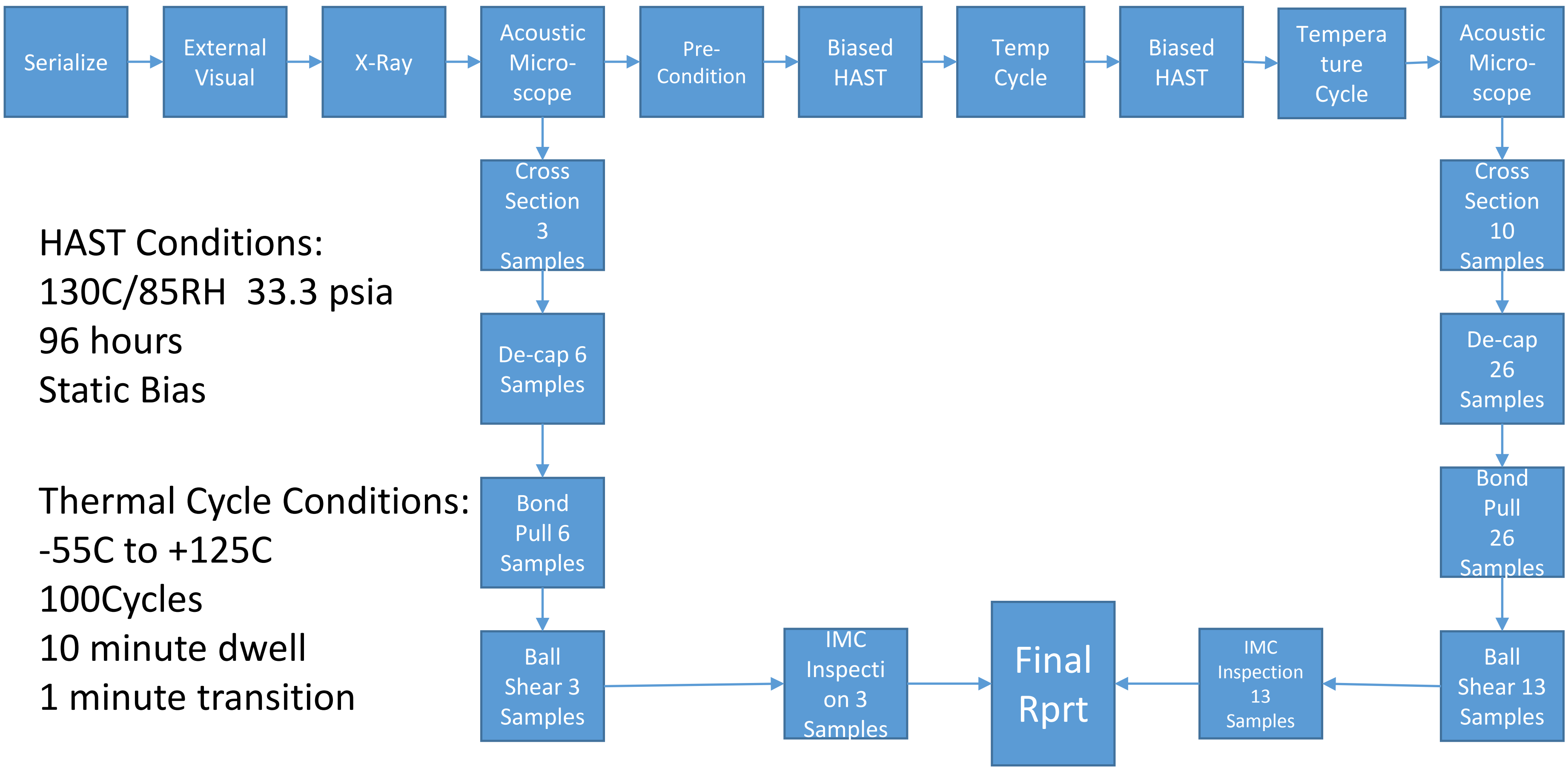
Process Flow for Phase 1



HAST Conditions:
130C/85RH 33.3 psia
96 hours
Unbiased

Thermal Cycle Conditions:
-55C to +125C
100 Cycles
10 minute dwell
1 minute transition

Process Flow for Phase 2



HAST Conditions:
130C/85RH 33.3 psia
96 hours
Static Bias

Thermal Cycle Conditions:
-55C to +125C
100Cycles
10 minute dwell
1 minute transition

Data for Phase 1

Sample Devices

Part Number	Manufacturer	Date Code	Bond Material	Bond Pad Material
74FCT162245ATPVG	IDT	1402	Cu	Al
TPS51116RGET	Texas Instruments	1038	Cu	Cu/Ni/Pd
M74VHC1GT50DFT1G	On Semiconductor	1421	Cu	Al
BAS70-04LT1G	On Semiconductor	1448	Cu	Al

It has been observed during analysis that PCN data is not always accurate for determining when parts actually transition to copper. Because of this, all devices were chosen base on historical analysis data indicating that the manufacturer had transitioned their product to copper.

Two additional devices were candidates, however, the date codes received were prior to the manufacturer's transition to copper.

Phase 1 Inspection Criteria

Tests	Qty	Test Conditions	Purpose	Accept Reject Criteria	Notes:
External Visual	10	MIL-STD-883 Method 2009	Determine pre-existing condition of parts.		
Pre Stress - X-Ray	10	MIL-STD-883 Method 2012	General Construction		
Pre Stress - SAM	10	IPC/JEDEC J-STD-035	General Material Continuity and Baseline	C/JEDEC J-STD-020 paragraph 6.1-6.2.	
Pre Stress – Cross Section	1	Internal Process	Metal stack of bond interface with measurement of IMC and confirmation of Cu wire bonds		
Pre Stress – De-encapsulation and Internal Visual	2	MIL-STD-883 Method 2010	Examination for device quality. Examination of de-encapsulation quality.		De-encapsulation process is proprietary and is optimized to minimize attack on Cu wire
Pre Stress – Bond Pull	2	MIL-STD-883 Method 2011	Primarily looking for week IMC.	2 X gold wire limit for specific size wire.	Investigate any bond lifts for IMC or Cratering issues.
Pre Stress - IMC Inspection	2	Company Proprietary	Ball Bond and IMC area by location.		This is a proprietary process and optimized to minimize attack on the IMC.

Phase 1 Inspection Criteria (continued)

Tests	Qty	Test Conditions	Purpose	Accept Reject Criteria	Notes:
Pre-Conditioning	7	JESD-22-A113F Devices were treated as MSL 3	Initial conditioning of parts to simulate PWB attachment.		
Unbiased HAST	7	JESD22-A118 Condition A	Accelerated Aging and moisture loading.		
Temp Cycle	7	JESD22-A104E Condition B	Mechanical stress of bond wires and wire interfaces.		
SAM	7	IPC/JEDEC J-STD-035	Compare to baseline.	IPC/JEDEC J-STD-020 paragraph 6.1-6.2.	
Post Stress – Cross Section	1	Internal Process			
Post Stress – De-encapsulation and Internal Visual	2	MIL-STD-883 Method 2010	Examination for device Induced issues. Examination of de-encapsulation quality.		De-encapsulation process is proprietary and is optimized to minimize attack on Cu wire
Post Stress – Bond Pull	2	MIL-STD-883 Method 2011	Primarily looking for week IMC.	2 X gold wire limit for specific size wire.	Investigate any bond lifts for IMC or Cratering issues.
Post Stress - IMC Inspection	2	Company Proprietary			This is a proprietary process and optimized to minimize attack on the IMC.

Summary of Results on all 4 lots

Lot Numbers	Ext. Vis	Pre- X-ray	Pre-SAM	Pre-Bond Pull	Pre-IMC	Post-SAM	Post Bond Pull	Post-IMC	Comparative Analysis
74FCT162245AT PVG	Pass	Pass	Pass	*	Pass	Pass	*	Pass	No significant degradation or growth of IMC.
TPS51116RGET	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	No significant degradation or growth of IMC.
M74VHC1GT50D FT1G	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	No significant degradation or growth of IMC.
BAS70-04LT1G	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	No significant degradation or growth of IMC.

Bond lifts were identified for part number 74FCT162245ATPVG. One pre-stress and one post-stress device exhibited bond lifts on pins 12 and 15. Minor cratering was seen.

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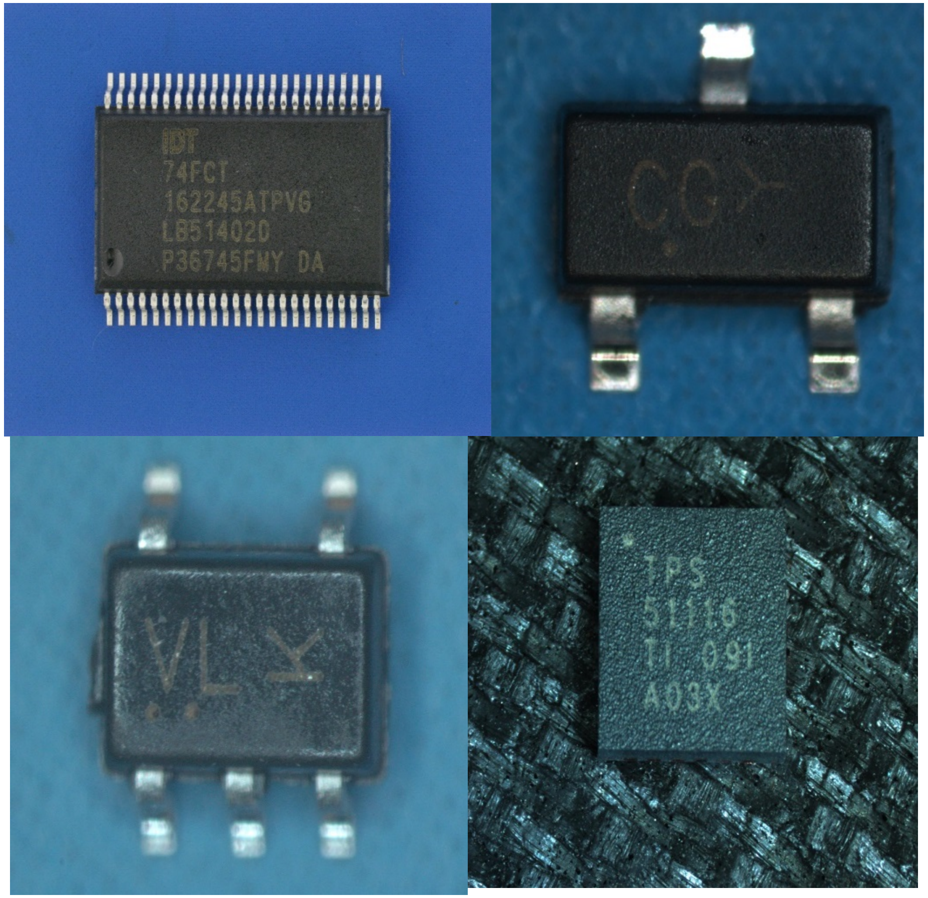
Initial Conditions of the Parts



- Devices were purchased from Authorized distributor.
- All devices were inspected and found to be in good condition.
- No indication of improper storage that might effect reliability study.
- Minor oxidation was seen on the leads post stress.
- No cracks or package related defects were noted post stress.

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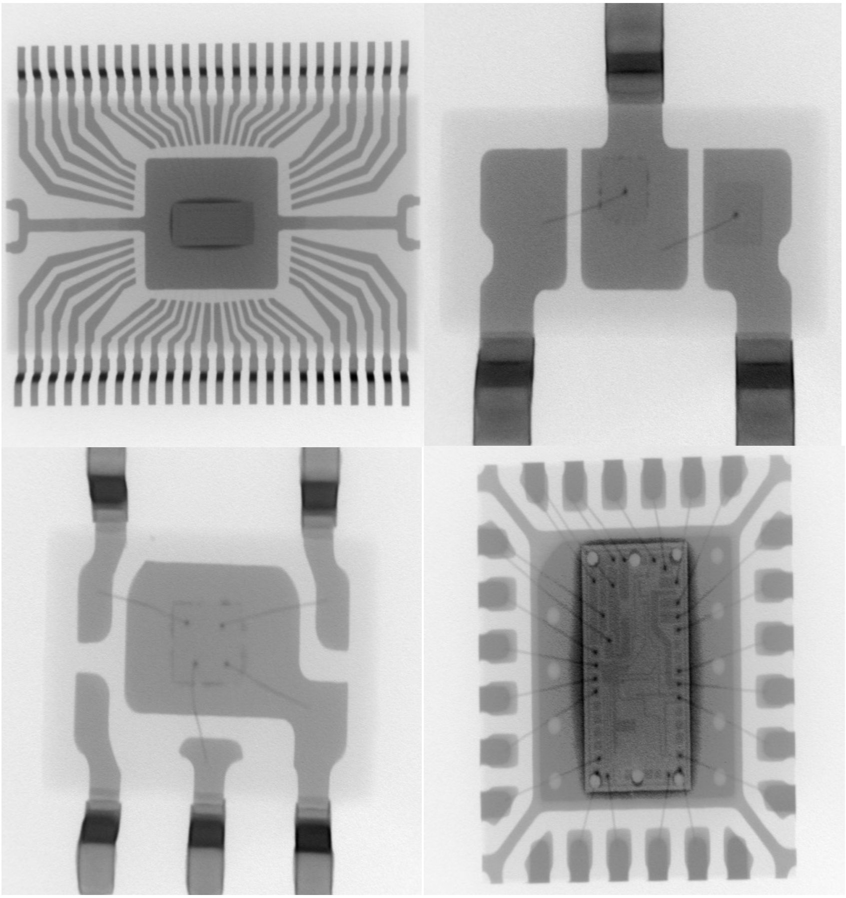
External Visual Inspection Results – Pre-Stress

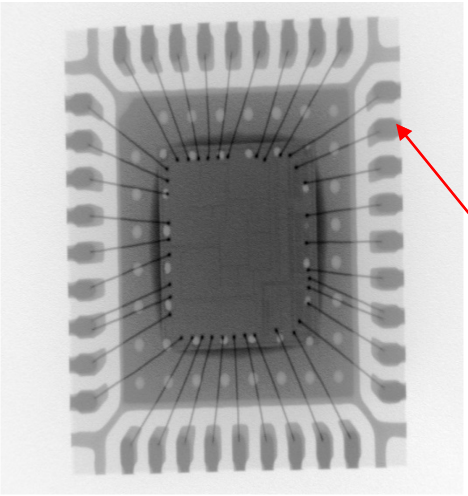
	M74LVHC1GT50DFT1G		BAS70-04LT1G2		74FCT162245ATPVG		TPS51116RGET	
	QTY In	QTY Out	QTY In	QTY Out	QTY In	QTY Out	QTY In	QTY Out
Foreign Material	10	10	10	10	10	10	10	10
Construction Defects	10	10	10	10	10	10	10	10
Leads	10	10	10	10	10	10	10	10
Package Body	10	10	10	10	10	10	10	10
Lot Disposition	Pass		Pass		Pass		Pass	

X-Ray Results



- All devices were inspected and found to be acceptable.
- Copper wire bonds were noted in X-Ray and confirmed in cross section

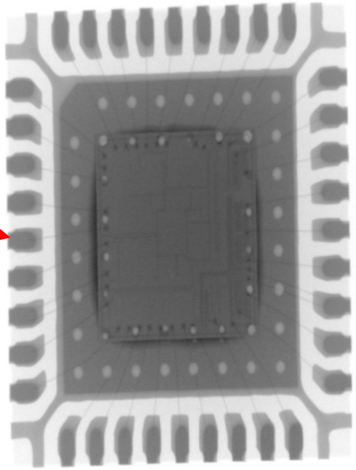
X-Ray (Gold Copper Comparison)



Gold Wire bonds
Gold has higher radio density making it darker when viewed in X-Ray.

- Image to the left shows copper vs gold wire bond comparison. Both parts are TPS40140RHH. Top part has gold bond wires and was built in the 5th month of 2011. Bottom part is copper wire bonded built in the 9th month of 2013.

Copper Wire Bonds
Copper has lower radio density making is lighter when viewed in X-Ray.



X-Ray Results Pre-Stress

	M74LVHC1G T50DFT1G		BAS70-04LT1G2		74FCT1622 45ATPVG		TPS51116R GET	
	QTY In	QTY Out	QTY In	QTY Out	QTY In	QTY Out	QTY In	QTY Out
Extraneous Material	10	10	10	10	10	10	10	10
Element Condition	10	10	10	10	10	10	10	10
Wire Bonding	10	10	10	10	10	10	10	10
Wire Sweep	10	10	10	10	10	10	10	10
Lot Disposition	Pass		Pass		Pass		Pass	

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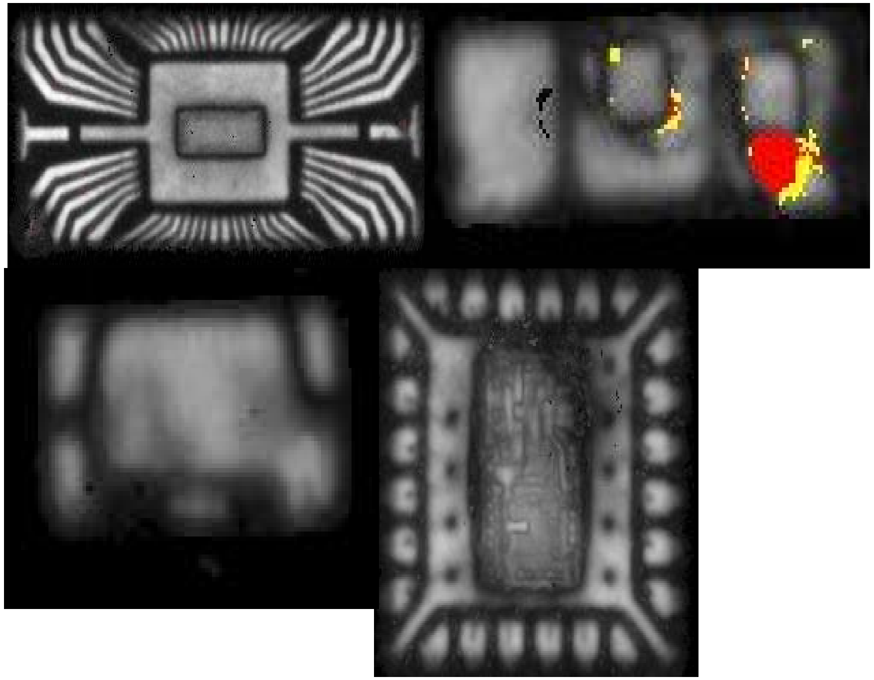
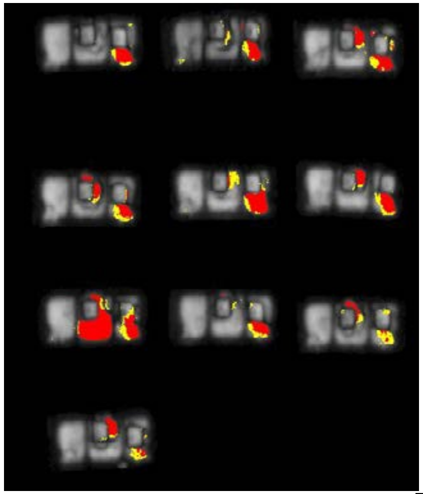
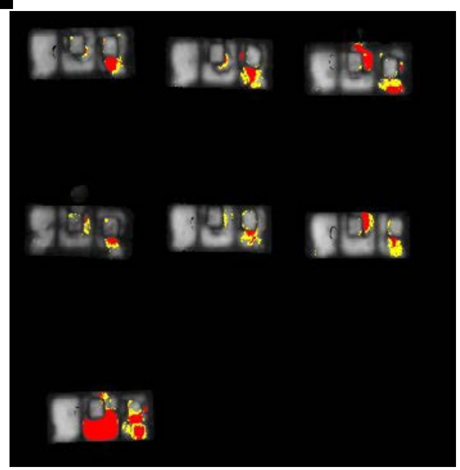


- Molding compound to lead frame showed some areas of delamination which is consistent with what was noted on previous lots.
- No delamination was noted on the active surface of the die.
- Delamination was worse after stress as expected. No cracks in the molding compound were identified.

Scanning Acoustic Microscopy (continued)





- Worst case was BAS70-04LT1G.
- Delamination indications were present pre and post stress.
- Delamination change was less than 5% from pre-to-post.
- Pre-stress upper left image. Post-stress lower right. S/N 8-10 were used for pre-stress cross section, bond pull, internal visual inspection and IMC Inspection.

SAM Inspection Results

M74LVHC1GT50DFT1G

S/N	Inspection Results	PASS / FAIL	S/N	Inspection Results	PASS / FAIL	% Change
1	C5	Pass	1	C5	Pass	1%
2	C5	Pass	2	C5	Pass	1%
3	C5	Pass	3	C5	Pass	1%
4	C5	Pass	4	C5	Pass	3%
5	C5	Pass	5	C5	Pass	1%
6	C5	Pass	6	C5	Pass	5%
7	C5	Pass	7	C5	Pass	1%
8	C5	Pass				
9	C5	Pass				
10	C5	Pass				

BAS70-04LT1G2

S/N	Inspection Results	PASS / FAIL	S/N	Inspection Results	PASS / FAIL	% Change
1	C5	Pass	1	C5	Pass	0%
2	C5	Pass	2	C5	Pass	1%
3	C5	Pass	3	C5	Pass	2%
4	C5	Pass	4	C5	Pass	1%
5	C5	Pass	5	C5	Pass	1%
6	C5	Pass	6	C5	Pass	1%
7	C5	Pass	7	C5	Pass	1%
8	C5	Pass				
9	C5	Pass				
10	C5	Pass				

74FCT162245ATPVG

S/N	Inspection Results	PASS / FAIL	S/N	Inspection Results	PASS / FAIL	% Change
1	A	Pass	1	A	Pass	0%
2	A	Pass	2	A	Pass	0%
3	A	Pass	3	A	Pass	0%
4	A	Pass	4	A	Pass	0%
5	A	Pass	5	A	Pass	0%
6	A	Pass	6	A	Pass	0%
7	A	Pass	7	A	Pass	0%
8	A	Pass				
9	A	Pass				
10	A	Pass				

TPS51116RGET

S/N	Inspection Results	PASS / FAIL	S/N	Inspection Results	PASS / FAIL	% Change
1	A	Pass	1	A	Pass	0%
2	A	Pass	2	A	Pass	0%
3	A	Pass	3	A	Pass	0%
4	A	Pass	4	A	Pass	0%
5	A	Pass	5	A	Pass	0%
6	A	Pass	6	A	Pass	0%
7	A	Pass	7	A	Pass	0%
8	A	Pass				
9	A	Pass				
10	A	Pass				

SAM Inspection Criteria

A. No Anomalies

B. JEDEC J-STD-020D Failure Criteria

1. Internal Crack that intersects a bond wire, ball bond, or wedge bond.
2. Internal Crack extending from any lead finger to any other internal feature.
3. Internal crack extending more than 2/3 the distance from any feature to the outside of the package

C. JEDEC J-STD-020D Criteria Requiring Further Evaluation Metal Lead Frame Construction

1. Delamination on Active Surface of the die.
2. Delamination on any wire bonding surface.
3. Delamination change >10% along any polymeric film bridging any metallic features that is designed to be isolated
4. Delamination/cracking >50% of the die attach area in thermally enhanced packages or devices that require electrical contact to the backside of the die.
5. Surface-breaking feature delaminated over its entire length.

D. JEDEC J-STD-020D Criteria Requiring Further Evaluation Substrate Based Package

1. Delamination on the active side of the die
2. Delamination on any wire bonding surface.
3. Delamination change >10% along the polymer potting or molding compound/laminate interface
4. Delamination change >10% along the solder mask/laminate resin interface
5. Delamination change >10% within the laminate
6. Delamination/cracking change >10% through the die attach region
7. Delamination/cracking between under fill resin and chip or under fill resin and substrate/solder mask
8. Surface-breaking feature delaminated over its entire length.

E. MIL-STD-883/2030 Failure Criteria

1. Contact area voids > 50 percent of the total intended contact area
2. A single void which exceeds 15% percent of the intended contact area, or a single corner void in excess of 10 % of the total intended contact area
3. When the image is divided into four equal quadrants by bisecting both pairs of opposite edges, any quadrant exhibiting contact area voids in excess of 70% of the intended quadrant contact area

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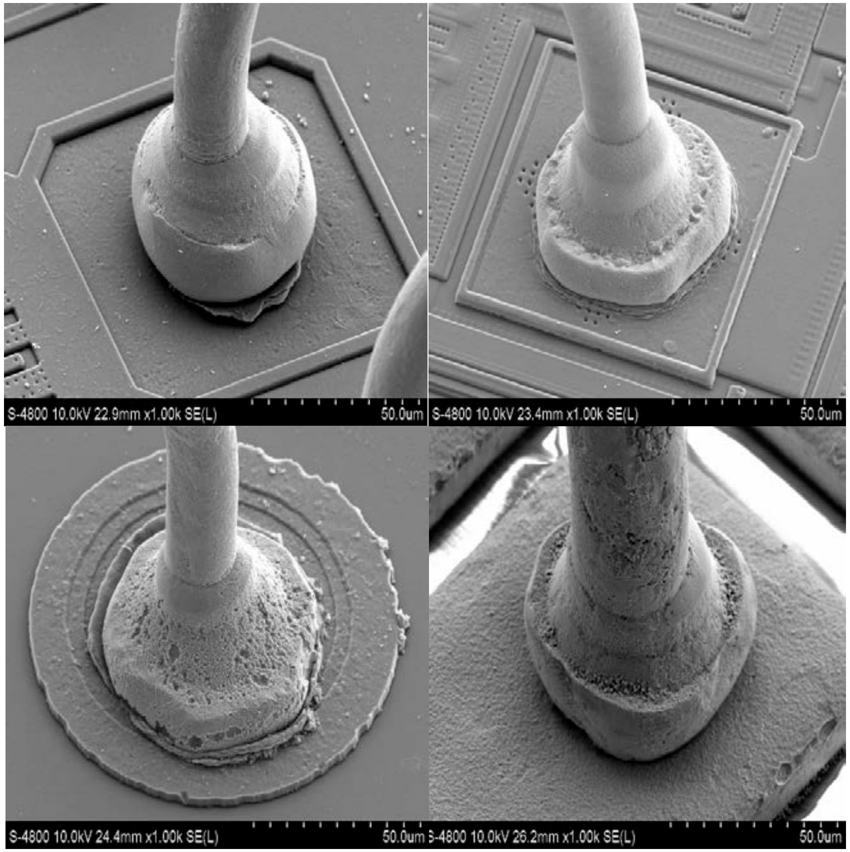
De-Capsulation



- No single method is best when de-encapsulating copper wire bonded parts.
- Analytical Solutions utilizes several methods based on observations seen in cross section.
- Some degradation of the copper wire bond is expected during de-encapsulation. This degradation must be minimal to properly evaluate bonding.

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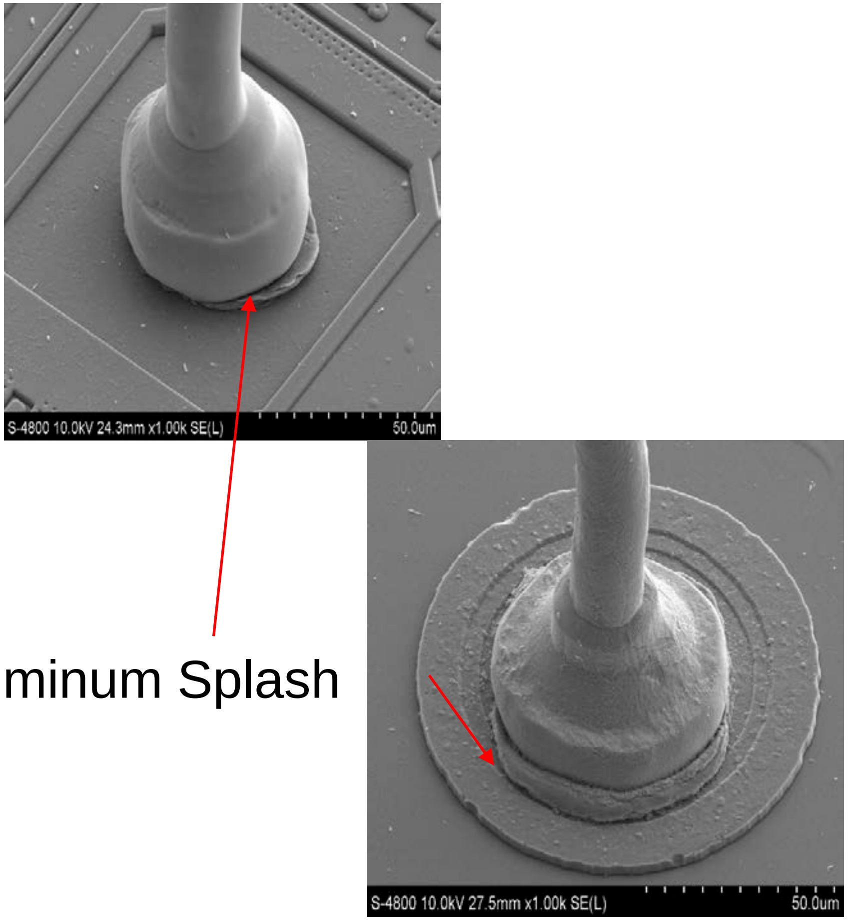

Aluminum Splash

- No device exhibited quality issues.
- No differences visually identified pre-to-post stress.
- Bonds remained relatively in tact. Some minor attack was noted.
- Aluminum splash was seen on all devices with copper-to-aluminum interface. See left image.

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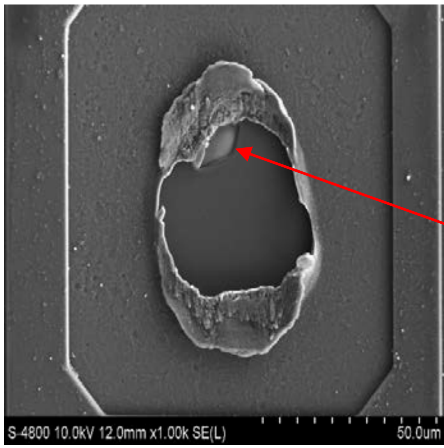
Internal Visual Results

Pre/Post Stress	M74LVHC1GT50DFT1G		BAS70-04LT1G2		74FCT162245ATPVG		TPS51116RGET	
	QTY In	QTY Out	QTY In	QTY Out	QTY In	QTY Out	QTY In	QTY Out
Die Condition	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2
Bond Condition	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2
De-encapsulation Quality	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2
Internal Wires	2/2	2/2	2/2	2/2	2/2	2/2	2/2	2/2
Lot Disposition	Pass		Pass		Pass		Pass	

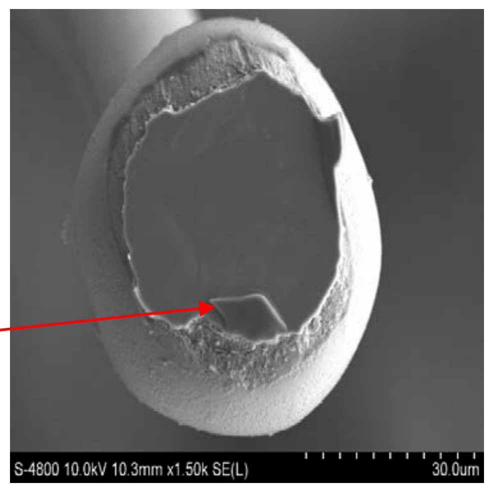
Bond Pull Data

M74LVHC1GT50DFT1G				BAS70-04LT1G2				74FCT162245ATPVG				TPS51116RGET			
Pre		Post		Pre		Post		Pre		Post		Pre		Post	
Min	9.9077	Min	9.1773	Min	10.0604	Min	7.9913	Min	4.38	Min	4.6416	Min	18.4135	Min	18.2446
Max	11.1957	Max	12.468	Max	11.588	Max	9.4953	Max	9.88	Max	9.6367	Max	29.3736	Max	33.6069
Mean	10.31854	Mean	11.11228	Mean	10.85465	Mean	8.871925	Mean	7.706979	Mean	8.613078	Mean	23.03589	Mean	25.98575
STDev	0.38173	STDev	1.116476	STDev	0.63974	STDev	0.563751	STDev	1.362938	STDev	0.816796	STDev	3.01775	STDev	3.261812
Number of bonds	8	Number of bonds	8	Number of bonds	4	Number of bonds	4	Number of Bonds	96	Number of Bonds	96	Number of Bonds	50	Number of Bonds	50
Bond Lifts	No	Bond Lifts	No	Bond Lifts	No	Bond Lifts	No	Bond Lifts	Yes	Bond Lifts	Yes	Bond Lifts	No	Bond Lifts	No

Bond lifts occurred on 74FCT162245ATPVG on S/N 9 pre stress and S/N 2 post stress. Bond locations were 12 and 15 on both devices. Bond pull limit for Gold is 1.5 grams. 2 X Failure criteria for copper would be 3 grams.



Cratering



Residual Silicon

- Worst Case bond lift from with minor cratering. Bond 15 from S/N 2.
- This device type exhibited the worst aluminum splash during internal visual inspection and cross section inspection.
- Failure was between aluminum pad and silicon.

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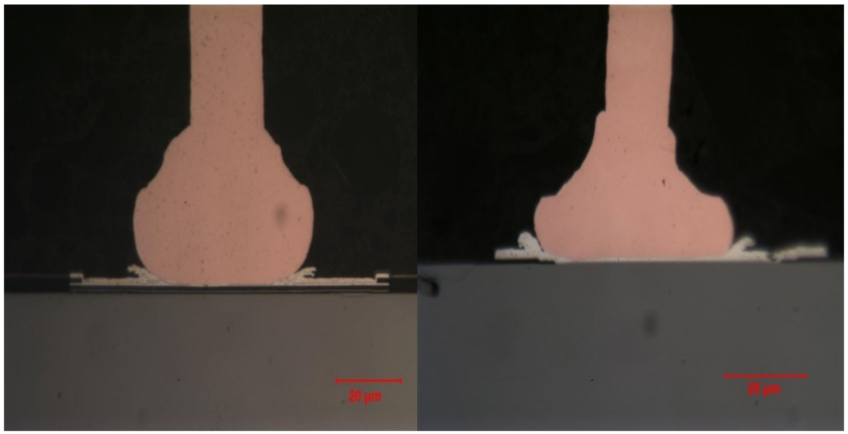
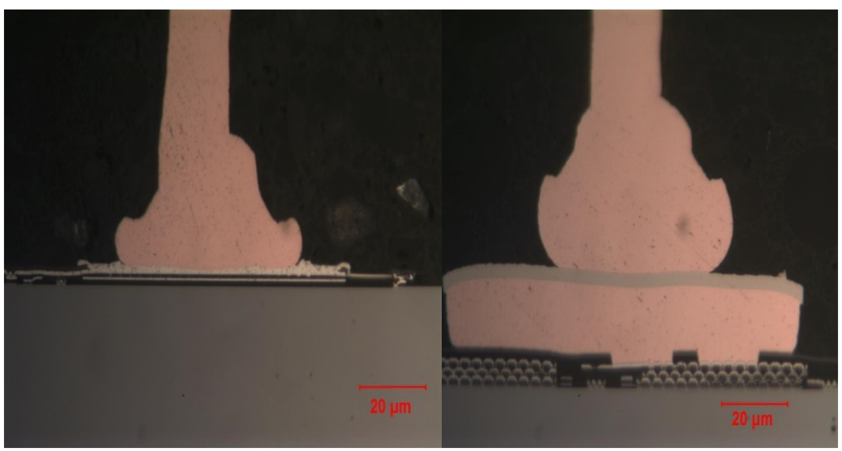
Comparison of Pull Data for Bond Lifts

74FCT162245ATPVG				
	Pre	Cratering ?	Post	Cratering?
Location 12	4.48	No	4.64	No
Location 15	8.29	No	8.83	Yes

- While not every device showed a location dependency there does seem to be a dependency on this device type.
- With the larger sample size in phase 2 and the addition of ball shear these site dependencies can be better documented and explained.
- Pre data is from S/N 9 and Post data is from S/N 2
- No other bond lifts were noted.

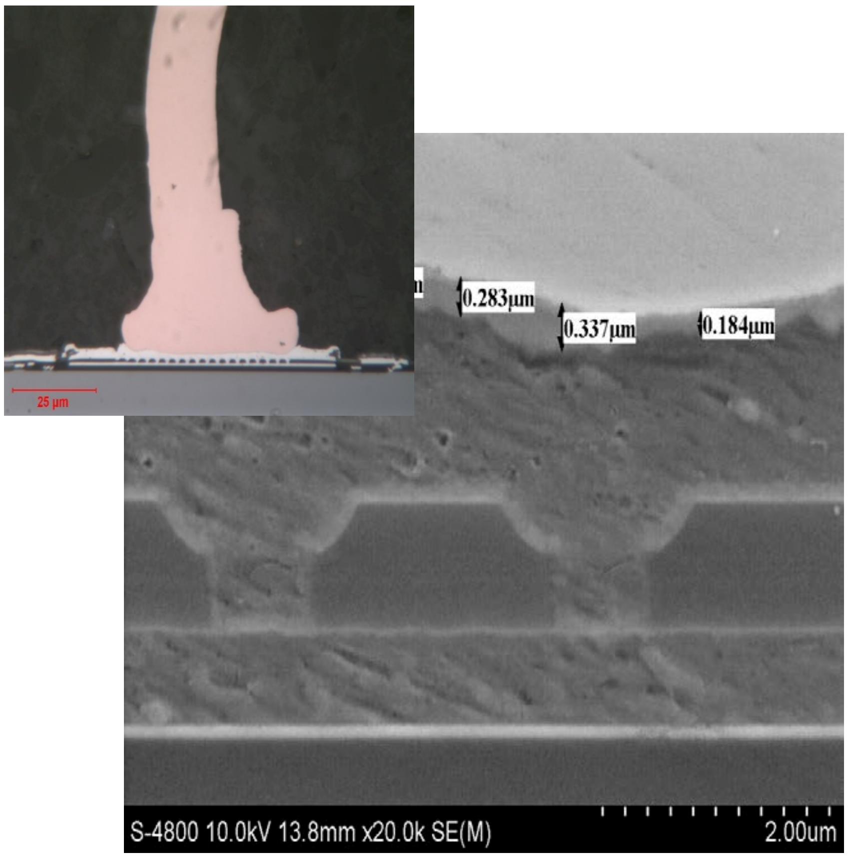
Cross Section





- Cross section was performed to obtain the following:
  - Confirm use of copper wire bonds
  - Determine the metal stack up
  - Measure the intermetallic pre and post stress
  - Identify any additional concerns about the devices that might affect the outcome of the experiment.
- No cratering was present
- Bonds were well formed
- Aluminum splash was present but appeared to be acceptable.
- No visible change from pre-to-post at this magnification.

IMC Inspection Cross Section



- Cross Section and measurement of IMC.
- No cracking or voiding of IMC was observed on any device.
- IMC growth was observed with Cu/Al interface but was not observed on Cu/Pd interface.
- IMC was not able to be measured on Cu/Pd interface.
- Only 1 bond per device was analyzed. Additional samples will be analyzed in Phase 2.

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IMC Inspection Cross Section Data

M74LVHC1GT50DFT1G				BAS70-04LT1G2			
Pre	um	Post	um	Pre	um	Post	um
Average	0.0873	Average	0.2284	Average	0.15	Average	0.1776

74FCT162245ATPVG				TPS51116RGET			
Pre	um	Post	um	Pre	um	Post	um
Average	0.1431	Average	0.126	Average	0	Average	0

- Au/Pd intermetallic on the TPS51116RGET was not measurable due to thickness and slow diffusion with this metal stack.
- While there appeared to be an increase with the On Semiconductor parts there appears to be a decrease with the IDT device.
- Larger sample sizes are required to obtain a statistically significant indicator of rate of growth. This will be accomplished in phase 2.

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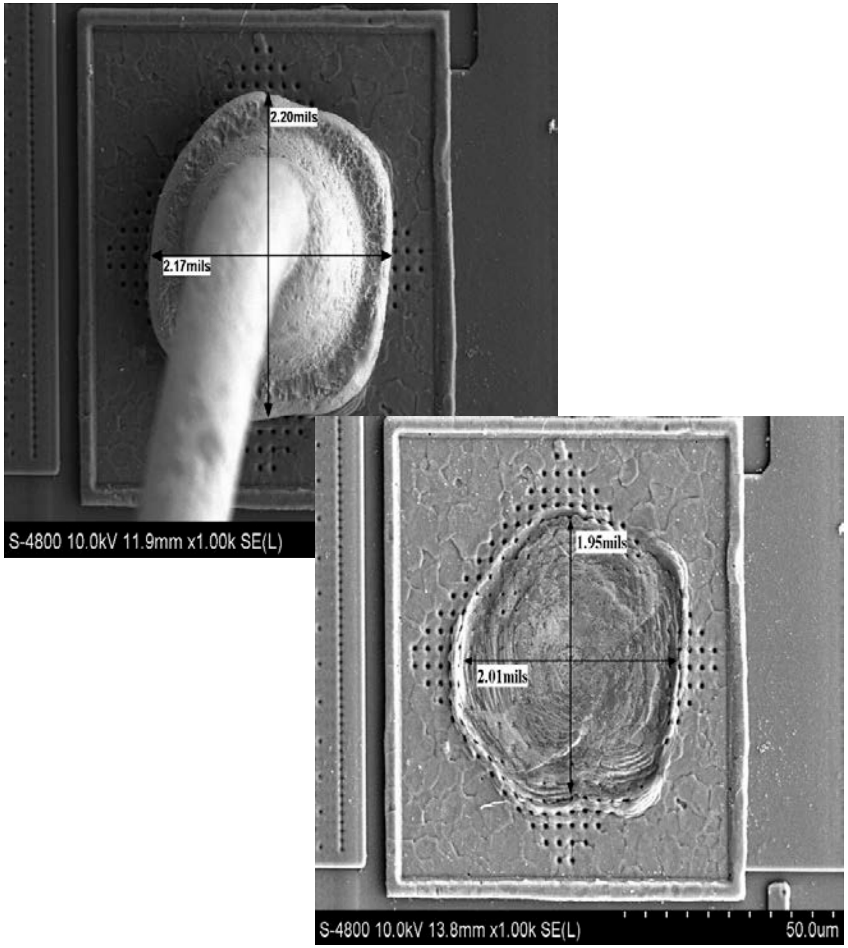
IMC Inspection Etched



- Method used to remove copper wire bonds was a proprietary process developed at Analytical Solutions.
- Exposure time of the etch varied between 1 and 5 seconds.
- Not all bonds were removed but greater than 80% of bonds removed from each device.
- Area of intermetallic in relation to the ball bond was compared between pre and post stress and was determined to be between 2% and 6% greater on post stress devices.

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Statistical Analysis of IMC Area Pre-to-Post

M74LVHC1GT50DFT1G (Ball)				M74LVHC1GT50DFT1G (IMC)				BAS70-04LT1G2 (Ball)				BAS70-04LT1G2 (IMC)			
Pre		**Post**		**Pre**		**Post**		**Pre**		**Post**		**Pre**		**Post**	
Min	2.10	Min	2.17	Min	2.00	Min	1.95	Min	2.43	Min	2.41	Min	2.35	Min	2.29
Max	2.40	Max	2.38	Max	2.24	Max	2.29	Max	2.57	Max	2.58	Max	2.49	Max	2.52
Mean	2.29	Mean	2.26	Mean	2.11	Mean	2.13	Mean	2.50	Mean	2.50	Average	2.41	Average	2.45
STDev	0.08	STDev	0.06	STDev	0.07	STDev	0.10	STDev	0.05	STDev	0.06	Stdev	0.05	Stdev	0.07
Number of bonds	8	Number of bonds	8	Number of bonds	8	Number of bonds	8	Number of Bonds	4	Number of Bonds	4	Number of Bonds	4	Number of Bonds	4
Average Area	4.11	Average Area	4.02	Average Area	3.51	Average Area	3.50	Average Area	4.91	Average Area	4.92	Average Area	4.55	Average Area	4.70
						% IMC area Change Pre-to-Post	2%							% IMC area Change Pre-to-Post	2%

TPS51116RGET (Ball)				TPS51116RGET (IMC)				74FCT162245ATPVG (Ball)				74FCT162245ATPVG(IMC)			
Pre		**Post**		**Pre**		**Post**		**Pre**		**Post**		**Pre**		**Post**	
Min	2.45	Min	2.43	Min	1.88	Min	1.93	Min	2.04	Min	2.06	Min	0.18	Min	1.50
Max	2.82	Max	2.89	Max	2.57	Max	2.90	Max	2.36	Max	2.34	Max	2.00	Max	2.07
Mean	2.65	Mean	2.63	Mean	2.19	Mean	2.24	Mean	2.17	Mean	2.18	Average	1.70	Average	1.77
STDev	0.08	STDev	0.08	STDev	0.14	STDev	0.21	STDev	0.05	STDev	0.05	Stdev	0.16	Stdev	0.10
Number of bonds	50	Number of bonds	50	Number of bonds	48	Number of bonds	49	Number of Bonds	96	Number of Bonds	96	Number of Bonds	93	Number of Bonds	94
Average Area	5.59	Average Area	5.44	Average Area	3.77	Average Area	3.94	Average Area	3.68	Average Area	3.74	Average Area	2.27	Average Area	2.46
						% IMC area Change Pre-to-Post	4%							% IMC area Change Pre-to-Post	6%

With limited data on sample sizes and stress level:

1. IMC was found to be 6% greater pre to post stress
2. Aluminum Splash was observed
3. Bond lifting was observed with location dependency
4. IMC
   a. Au/Pd IMC was much thinner than Au/Al – IMC was not measurable due to thickness and slow diffusion with this metal stack
   a. IMC seen on all other devices

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Summary

Lot Numbers	Discussion of Results
74FCT162245ATPVG	• More work needs to be done to identify the cause of the bond lifts. Since these appear to be location dependent, it is recommended that phase 2 specifically look at those locations in cross section. • Because we have location dependent bond lifts this part is a prime candidate for phase 2. The identification of weaker bond interfaces combined with additional stresses may well yield outlier data to be used for future selection of parts. • IMC was found to be 6% greater pre to post stress with no cracking or voiding detected. Aluminum splash was seen during internal visual inspection and cross section inspection. • During Phase 2 sample sizes will increase for cross section and IMC inspection allowing better insight into the cause of bond lifts and provide more quantifiable date to support cause identification..
TPS51116RGET	• Au/Pd IMC was much thinner than Au/Al IMC seen on all other devices. • While the area did change from the pre-to-post stressed parts the sample size was too small to make any assumptions about the parts. • Phase 2 sample sizes have increased and will provide statistically significant sample sizes.
M74VHC1GT50DFT1G	• No indications of bond quality issues were noted. • This part will be eliminated from phase 2 as it exhibits the same formation as the other On Semiconductor device.
BAS70-04LT1G	• No indications of bond quality issues were noted. • Phase 2 sample sizes will increase to provide a more statistically significant sample size and additional aging.

Phase 2 Qual Work Has Started

- Phase 2 Sample Size increased to 45 pieces per device type

- Parts will follow the phase 2 flow from slide 4. Major differences include.
  - Increased sample size for cross section and Post IMC inspection.
    - Specifically look at bond issues seen in phase 1 as well as inclusion of more bond analysis.
  - Ball shear added
    - Ball Shear directly relates to the IMC strength where bond pull will only capture gross defects.
  - Increased HAST and T/C with included Bias for HAST.
    - Biased HAST is necessary to accelerate the galvanic reaction the parts will see during normal operation.

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Phase 2 Schedule

- **Non-Destructive Testing Completion:** 5/29/2015
- **Preconditioning Completion:** 6/05/2015
- **First Biased HAST:** 6/12/2015
- **First Temperature Cycle:** 6/16/2015
- **Virgin Destructive Analysis and IMC inspection:** 6/19/2015
- **Second Biased HAST:** 6/22/2015
- **Second Temperature Cycle:** 6/28/2015
- **Final Destructive Analysis and IMC inspection:** 8/7/2015
- **Data Release:** 8/14/2015

Phase 2 Schedule

Tests	Qty	Test Conditions	Purpose	Accept Reject Criteria	Notes:
External Visual	40	MIL-STD-883 Method 2009	Determine pre-existing condition of parts.		
Pre Stress - X-Ray	40	MIL-STD-883 Method 2012	General Construction		
Pre Stress - SAM	40	IPC/JEDEC J-STD-035	General Material Continuity and Baseline	C/JEDEC J-STD-020 paragraph 6.1-6.2.	
Pre Stress – Cross Section	3	Internal Process	Metal stack of bond interface with measurement of IMC and confirmation of Cu wire bonds		
Pre Stress – De-encapsulation and Internal Visual	6	MIL-STD-883 Method 2010	Examination for device quality. Examination of de-encapsulation quality.		De-encapsulation process is proprietary and is optimized to minimize attack on Cu wire
Pre Stress – Bond Pull	6	MIL-STD-883 Method 2011	Primarily looking for week IMC.	2 X gold wire limit for specific size wire.	Investigate any bond lifts for IMC or Cratering issues.
Pre Stress- Ball Shear	3	JESD22-B116A			Look for location dependencies.
Pre Stress - IMC Inspection	3	Company Proprietary	Ball Bond and IMC area by location.		This is a proprietary process and optimized to minimize attack on the IMC.

Phase 2 Schedule (continued)

Tests	Qty	Test Conditions	Purpose	Accept Reject Criteria	Notes:
Pre-Conditioning	31	JESD-22-A113F Devices were treated as MSL 3	Initial conditioning of parts to simulate PWB attachment.		
Biased HAST	31	JESD22-A110D Condition A	Accelerated Aging and moisture loading.		
Temp Cycle	31	JESD22-A104E Condition B	Mechanical stress of bond wires and wire interfaces.		
Biased HAST	31	JESD22-A110D Condition A	Accelerated Aging and moisture loading.		
Temp Cycle	31	JESD22-A104E Condition B	Mechanical stress of bond wires and wire interfaces.		
SAM	31	IPC/JEDEC J-STD-035	Compare to baseline.	IPC/JEDEC J-STD-020 paragraph 6.1-6.2.	
Post Stress – Cross Section	10	Internal Process			
Post Stress – De-encapsulation and Internal Visual	21	MIL-STD-883 Method 2010	Examination for device Induced issues. Examination of de-encapsulation quality.		De-encapsulation process is proprietary and is optimized to minimize attack on Cu wire
Post Stress – Bond Pull	21	MIL-STD-883 Method 2011	Primarily looking for week IMC.	2 X gold wire limit for specific size wire.	Investigate any bond lifts for IMC or Cratering issues.
Pre Stress- Ball Shear	10	JESD22-B116A			Look for location dependencies.
Post Stress - IMC Inspection	11	Company Proprietary			This is a proprietary process and optimized to minimize attack on the IMC.

Integra Technologies Thanks You

Thank you from the Employee Owners of Integra Technologies!!

Integra Technologies LLC, along with the recently acquired Analytical Solutions, has been providing one of the broadest ranges of test and evaluation services in our industry for over 30 years. Our services include:

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Wafer Probe
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Failure Analysis
Counterfeit Detection
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Assembly/Repackaging (outsourced to qualified partners)
MIL-STD 883 and 750 Testing
Volume Production Test
Destructive Physical Analysis
Obsolescence Management

We are approved by DLA for MIL-STD-883 & 750 processing, ITAR, ISO 9001, AS9100 and DMEA Category 1 “Trusted”

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