Cu Wire Bonding

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Advancing manufacturing technology

Cu Wire Reliability Project Status

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Advancing manufacturing technology

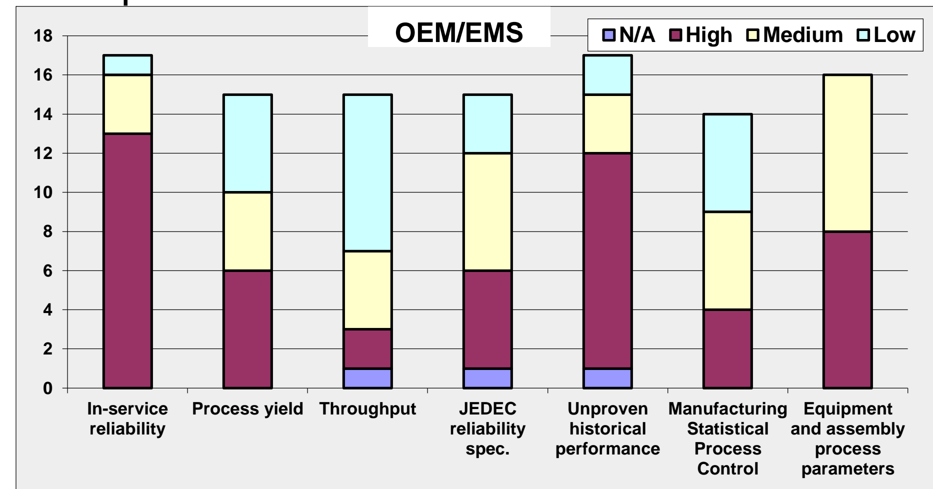
Purpose of Project

- **Design an experimental matrix that includes both leadframe and substrate-based packages.**
- **Perform a series of acceleration tests on components with these material variations.**
- **Perform failure analysis and identify test methods and material properties that impact lifetime during such tests.**
- **Assess the effectiveness of standard reliability test methods and durations on addressing reliability risks of Cu wire bonded devices.**

Cu wire bonding adoption survey (2010):

What are the major concerns with Cu wire bonding?

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



Phase 2 Experiment Plan

Package & material variations

Package Type	Wire type	Wire diameter	EMC	Surface finish
2	3	1	1 for Au, 2 for Cu	3 types
• BGA • QFN	• Au (control) • Bare Cu • Pd-coated Cu	0.8mil	• Material A • Material B • Material C	• Electrolytic NiAu (for Au as control) • ENEP • ENEPIG

Acceleration tests

- **MSL3 260°C**
- **5 Biased-HAST test (extended test duration)**
  - **130°C/85RH**
  - **110°C/85RH**
  - **85°C/85RH**
  - **130°C/55RH**
  - **110°C/55RH**
- **HTS (175°C)**
- **AATC (-55-125°C, 2 cycles /hr)**

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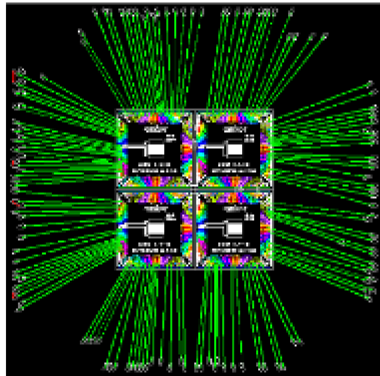
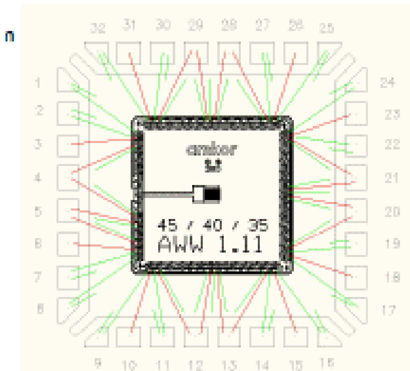
Test Die/ Package Information

- **BGA Package**



- **QFN Package**



	BGA 384 i/o	QFN 56L
PKG Size	14 x 14 mm	5 x 5 mm
Die Size	5.1 x 5.1 mm	2.5 x 2.5 mm
Die Thickness	0.02 mm	
Die Pad Opening	0.049 mm	0.038 mm
Die Pad Pitch	0.060 mm	0.045 mm
Wire Diameter	0.020 mm	0.018 mm
Max Wire Length	3.75 mm	1.482 mm
Ball Size/ Pitch	0.04/ 0.65 mm	- / 0.50 mm

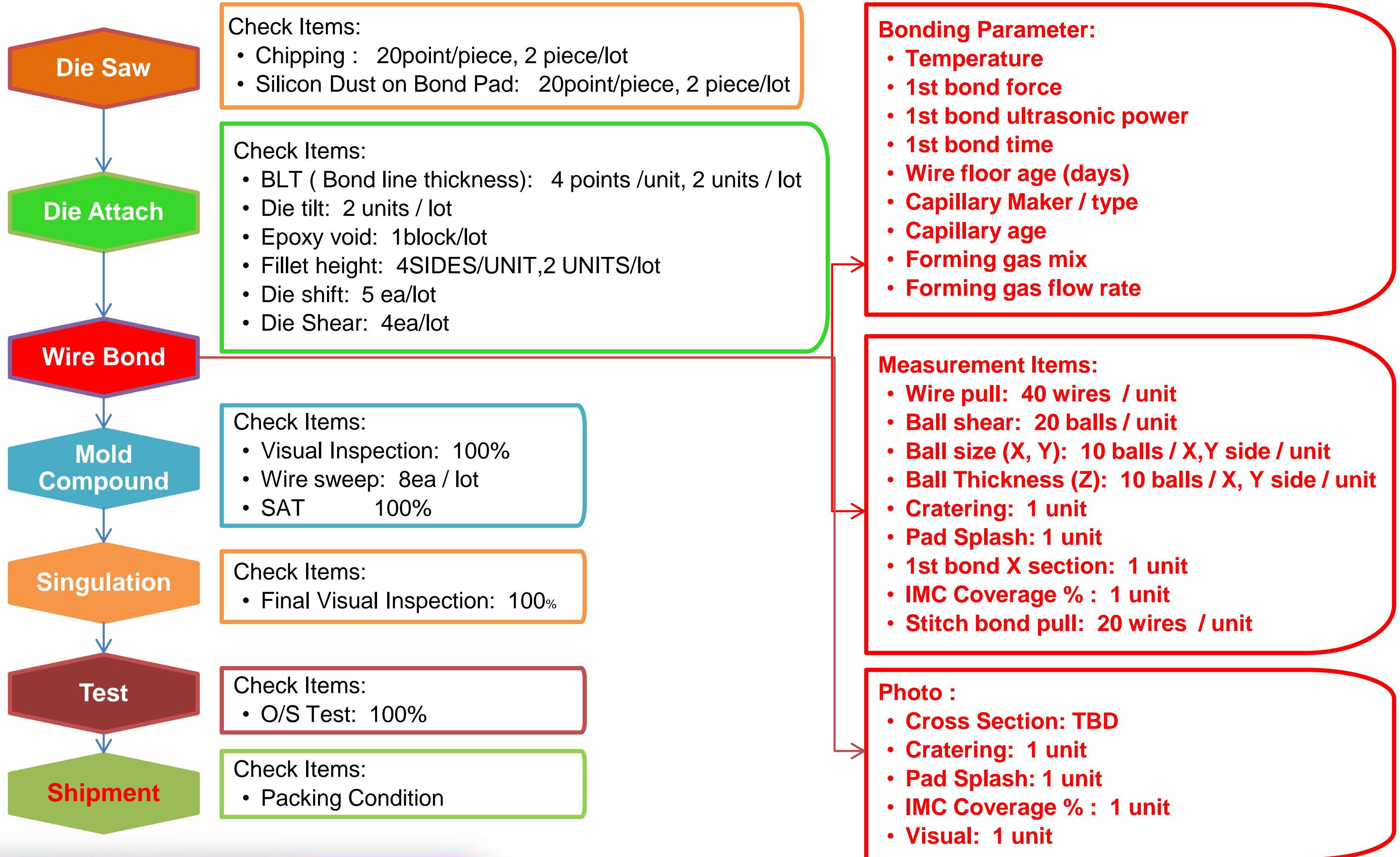
Process Matrix
BGA#

Leg	Wire type	Wire Maker	Mold Compound	Forming gas type	Flow rate (LPM)
BGA1	Au	Co. A	type A	No	No
BGA2	Bare Cu	Co. B	type B	N2H2	0.5
BGA4	Bare Cu	Co. B	type C	N2H2	0.5
BGA7	Cu/Pd	Co. B	type B	N2H2	0.5
BGA3	Cu/Pd	Co. C	type B	N2H2	0.5
BGA5	Cu/Pd	Co. C	type C	N2H2	0.5
BGA6	Cu/Pd	Co. C	type B	N2	0.5

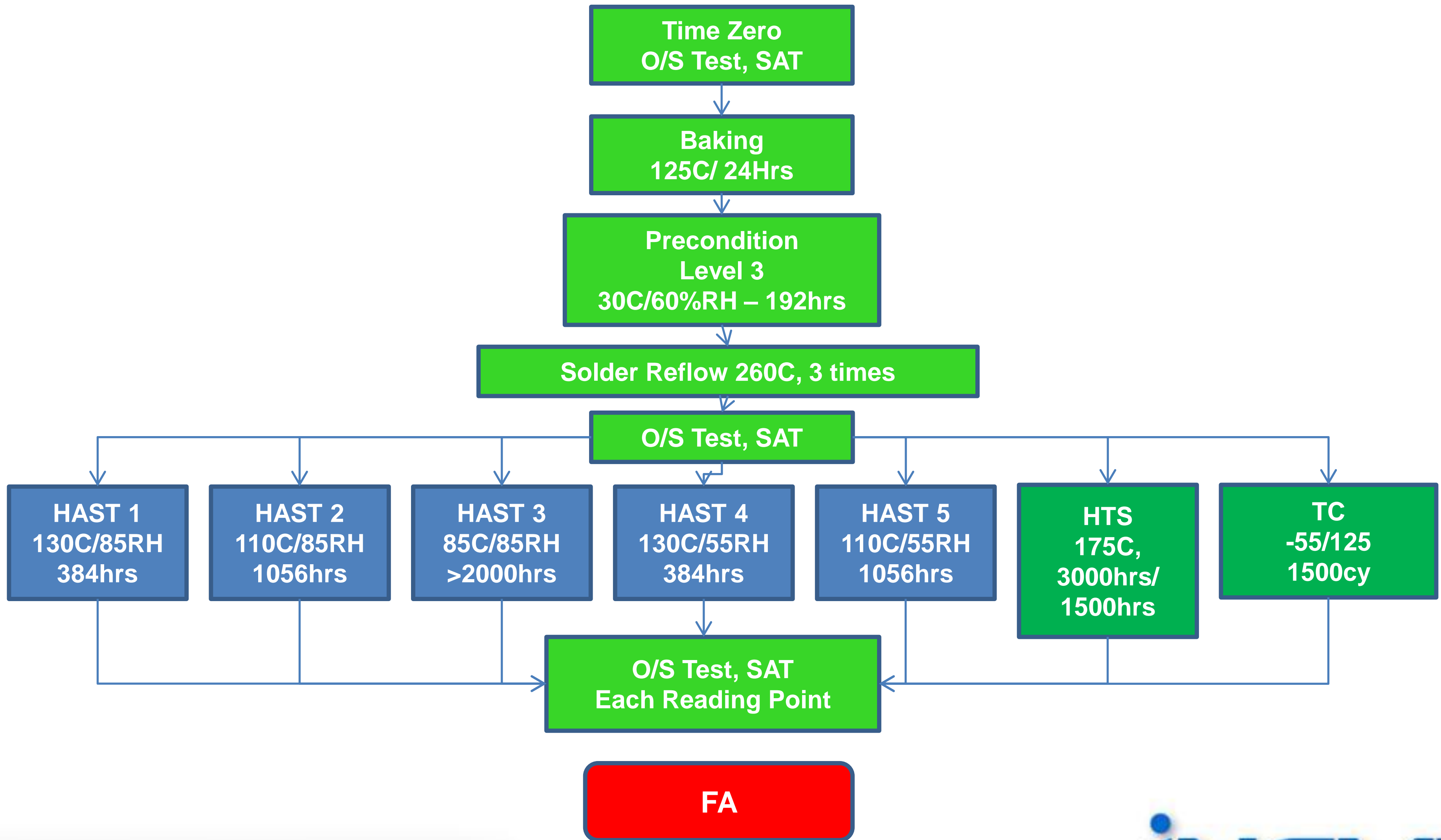
Process Matrix
QFN#

Leg	Wire type	Wire maker	Mold Compound	Forming Gas	Flow rate (LPM)
QFN1	Au	Co. D	Type D	N/A	N/A
QFN2	Bare Cu	Co. B	Type D	N2H2	0.7~0.9
QFN5	Cu/Pd	Co. B	Type D	N2	0.3~0.5
QFN3	Cu/Pd	Co. C	Type D	N2	0.7~0.9
QFN4	Cu/Pd	Co. C	Type D	N2H2	0.7~0.9

Process Monitoring Plan



Reliability Test Flow



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AATC

Leg #	T0	500	1,000	1,500
BGA 1	3/70	1/67	0/66	0/62
BGA 2	0/86	1/86	0/85	0/85
BGA 3	0/86	0/86	0/86	0/86
BGA 4	0/85	1/85	0/84	0/84
BGA 5	0/115	1/115	0/112	0/112
BGA 6	0/85	2/85	0/81	0/81

-55degC/125degC

HTS

Leg #	T0	150	450	950	1,950	3,000
BGA 1	0/30	0/30	0/30	0/30	1/30	0/29
BGA 2	0/30	0/30	0/30	0/30	0/30	0/30
BGA 3	0/24	0/24	0/24	0/24	3/24	9/21
BGA 4	0/27	0/27	0/27	0/27	0/27	2/27
BGA 5	0/30	0/30	0/30	0/30	0/30	2/30
BGA 6	0/25	0/25	0/25	0/25	1/25	0/24

Storage condition: 175degC

HAST – 130/85

Leg #	T1	96H	192H	288H	384H
BGA 1	0/155	0/24	0/24	0/24	0/24
BGA 2	0/205	0/34	0/34	1/34	0/33
BGA 3	1/200	1/34	0/33	0/33	1/33
BGA 4	2/202	0/34	0/34	0/34	2/34
BGA 5	2/200	0/34	0/34	0/34	1/34
BGA 7	5/114	0/96	0/96	0/96	0/96

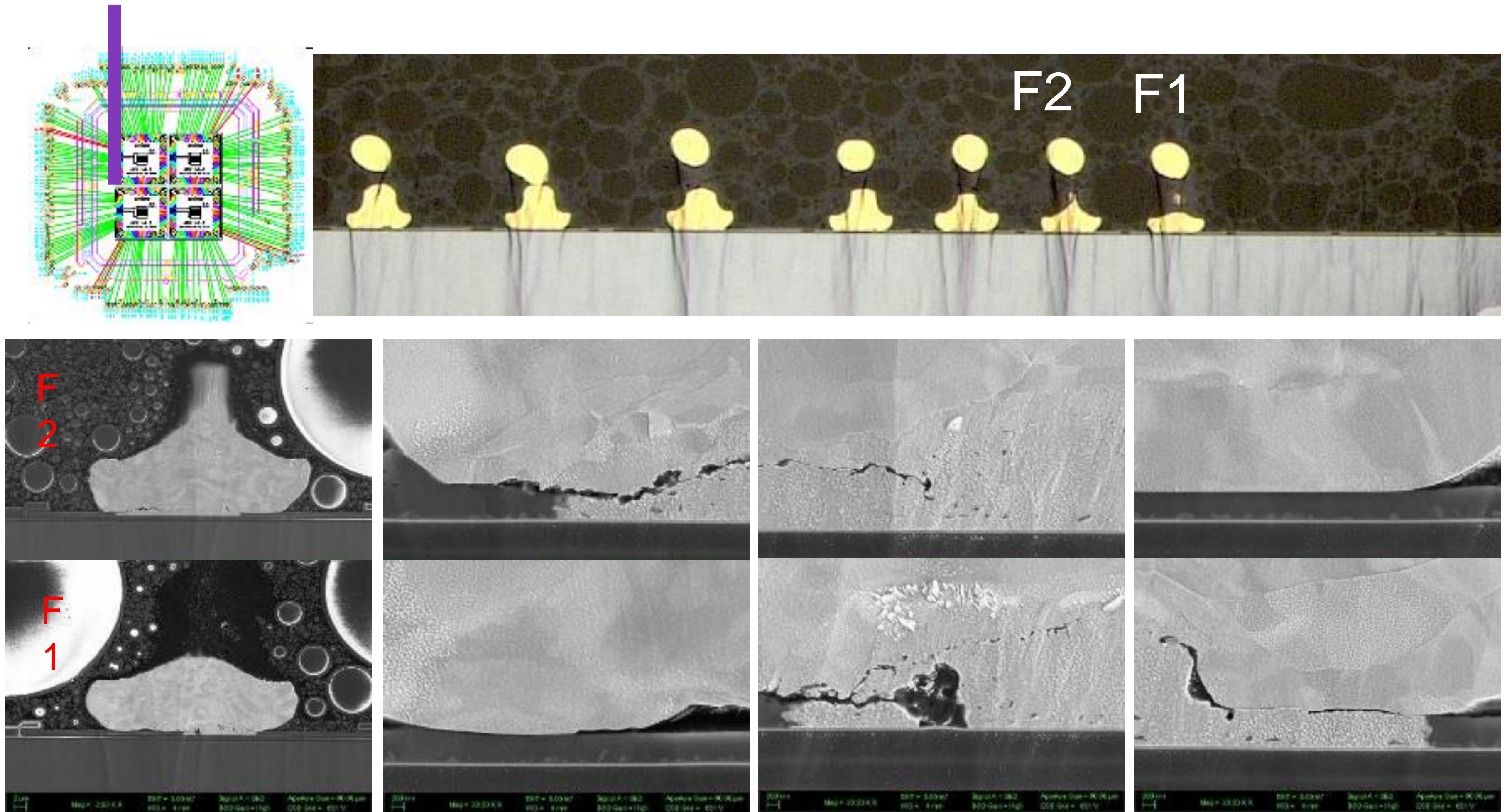
HAST – 110/85

Leg #	264H	528H	792H	1056H
BGA 1	0/22	0/22	0/22	0/22
BGA 2	0/32	0/32	0/32	0/32
BGA 3	0/32	0/32	0/32	0/32
BGA 4	0/32	0/32	0/32	0/32
BGA 5	0/32	0/32	0/32	0/32
BGA 6	0/32	0/32	0/32	0/32

HAST – 130/55

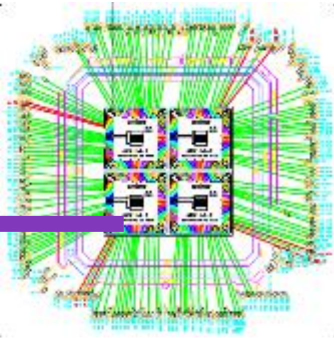
Leg #	94H	192H	288H	384H
BGA 1	0/22	0/22	0/22	0/22
BGA 2	0/33	0/22	0/22	0/22
BGA 3	0/34	0/22	0/22	0/22
BGA 4	0/34	0/22	1/22	0/21
BGA 5	0/34	0/22	0/22	0/22
BGA 6	0/21	0/22	0/22	0/22

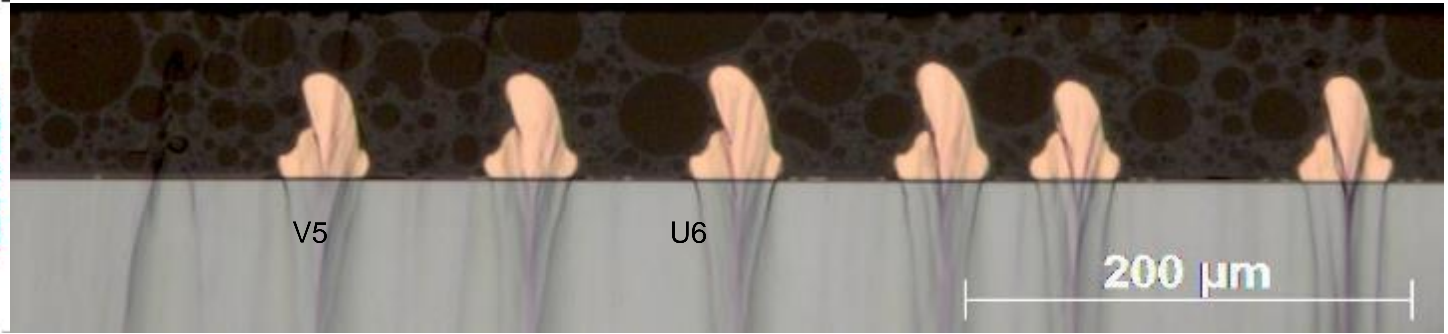
Leg#1: Au Wire

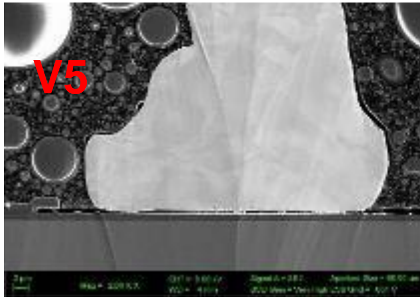


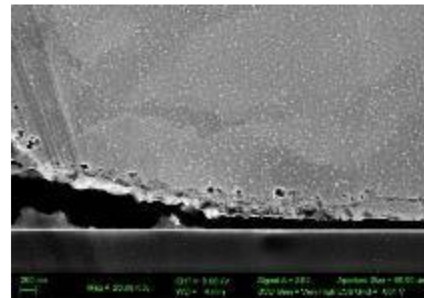
Crack is observed in Au-Al IMC.

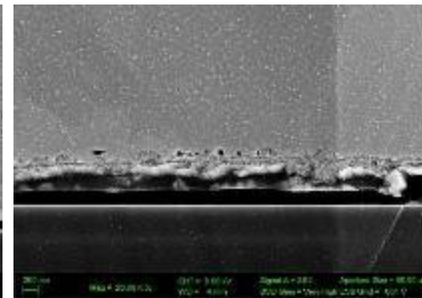
Leg#2 : Bare Cu

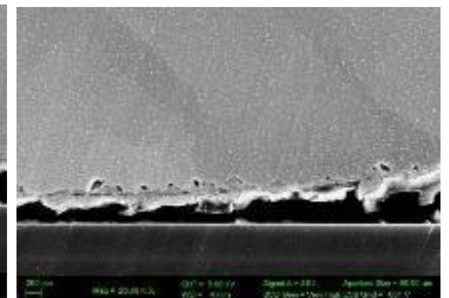


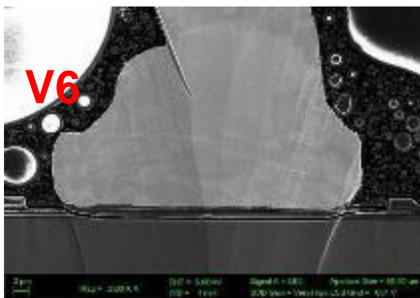


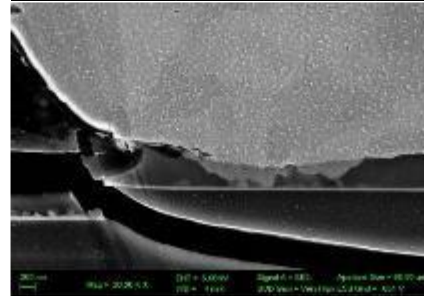


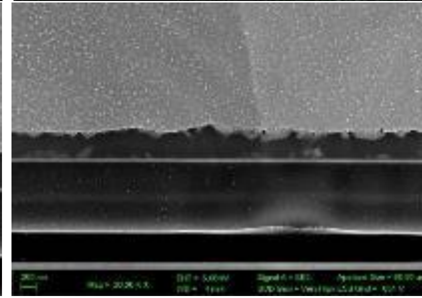


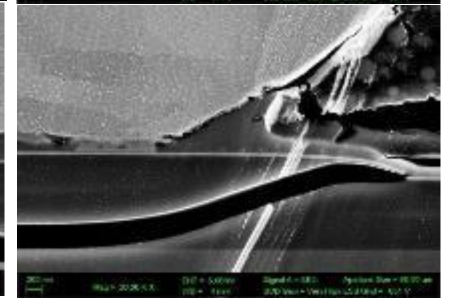




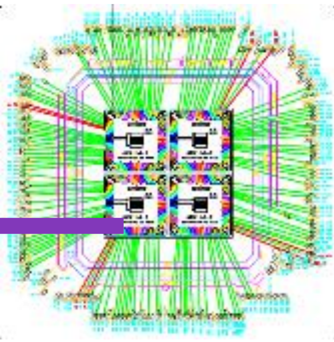


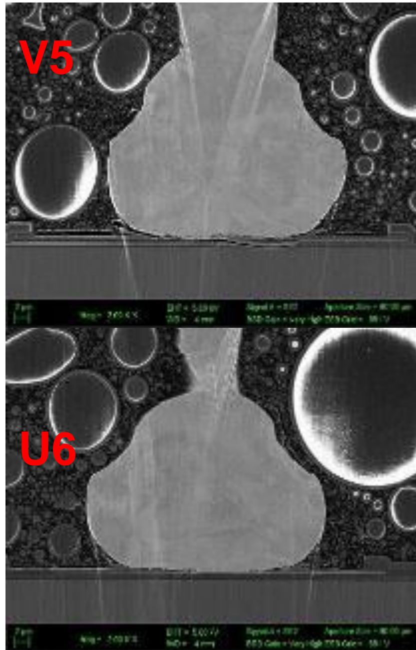


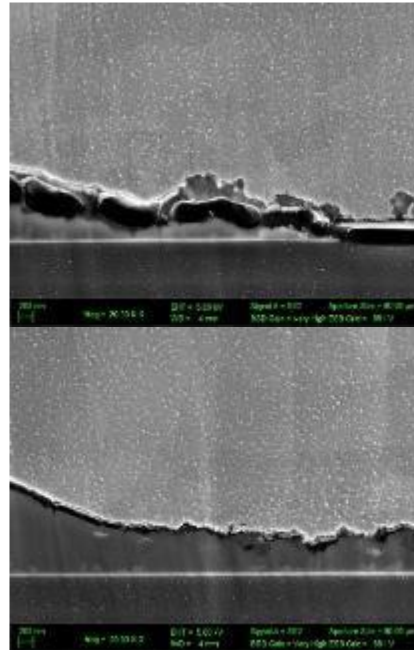


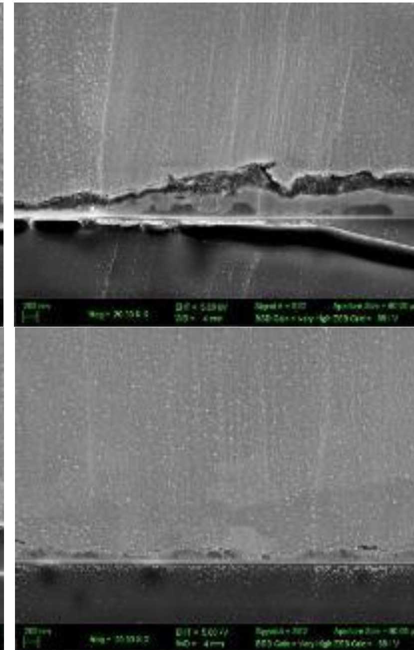


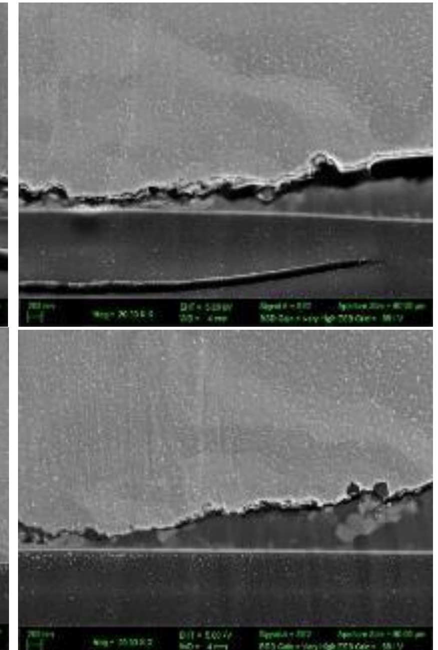
Leg#3: Cu/Pd Wire











SiOx layer was damaged on V5.

Summary

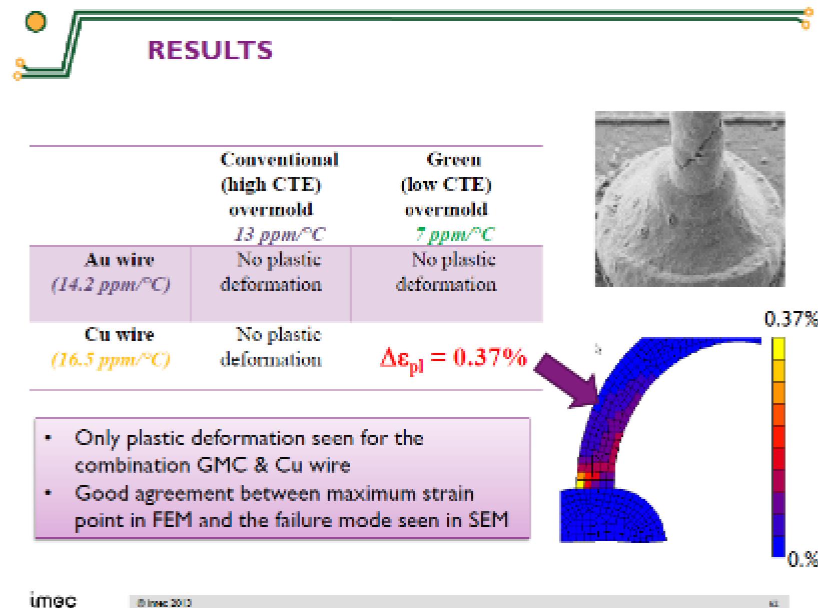
- Process Characterization:
  - Bare Cu and Pd coated Cu Wires are bonded on the 1st and 2nd bond side on both BGA and QFN.
  - Process monitoring shows all measurement data are all within the current defined specification values.
- BGA Reliability Test:
  - Temp Cycling: All Legs except leg#3 are failed at early hours (500hrs)
  - HTS: All legs except leg#2 are failed.
  - HAST 130/85: Leg# 2, 3, 4, 5 are failed.
    - FA study shows all failures are come from pad damaged layer.

Leg	Wire type	Wire Maker	Mold Compound	Forming gas type	Flow rate (LPM)	TC -55/ 125 1500hrs	HTS 175C 3000hrs	HAST 130C/ 85RH% 384hrs
BGA1	Au	Co. A	type A	No	No	Fail	Fail	OK
BGA2	Bare Cu	Co. B	type B	N2H2	0.5	Fail	OK	Fail
BGA3	Cu/Pd	Co. C	type B	N2H2	0.5	OK	Fail	Fail
BGA4	Bare Cu	Co. B	type C	N2H2	0.5	Fail	Fail	Fail
BGA5	Cu/Pd	Co. C	type C	N2H2	0.5	Fail	Fail	Fail
BGA6	Cu/Pd	Co. C	type B	N2	0.5	Fail	Fail	-
BGA7	Cu/Pd	Co. B	type B	N2H2	0.5	-	-	OK

Next Step

- **Complete Reliability Testing and Failure Analysis**
- **Access the Reliability Test Method vs. Test Condition**

- **Next project to assess the Green Mold Compound Affection to Cu wire Bonding Reliability**



	Conventional (high CTE) overmold 13 ppm/°C	Green (low CTE) overmold 7 ppm/°C
Au wire (14.2 ppm/°C)	No plastic deformation	No plastic deformation
Cu wire (16.5 ppm/°C)	No plastic deformation	$\Delta\varepsilon_{pl} = 0.37\%$

Source: Imec

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