Reliability Testing of CGA/LGA/HDI

(Rev. A)

by

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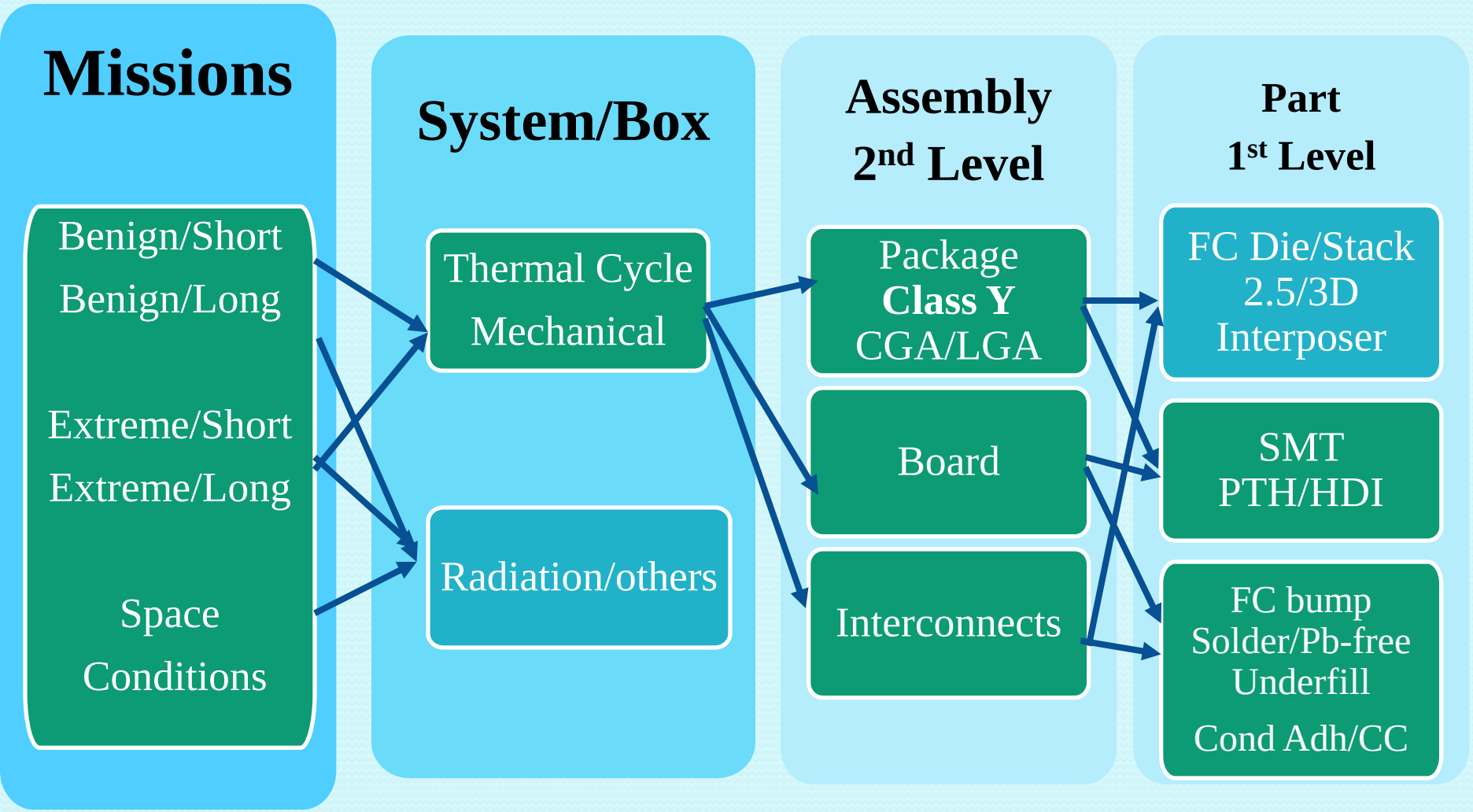
Outline

- NEPP CGA/LGA Reliability
  - Key accomplishment
    - 2nd report released
  - CGAs
- LGA
  - LGA column attach integrity/aging
  - LGA on PCB
- TC Results for Class Y/Hermetic CGAs
  - Key assembly variables
  - Test results/photos after 100/200 TC1
  - Test results/photos after 200 TC2
- Summary

Hierarchy of Reliability



CGA/CGA/HDI Overall Objectives
2nd Report Scope

LGA

- New column pull testing data after isothermal aging
- Brief review of previous CGA (two types) assembly onto PCB
- LGA assembly with no column
- Inspection and quality assurance indicators of LGA

CGA

- Brief review of package/capacitors reliability evaluation
- Brief review of CGA/LGA assemblies, QA indicators
- Results of TC (-55° to 100°C or 125°C) of CGA assemblies

LGA/CGA HDI

- Pad pull test of conventional pad design/Daisy chain
- Example of a CSP on HDI/TC results
- Reliability of LPGA/LGA/CGA package assemble on HDI PCB
- Reliability functional CGA on HDI

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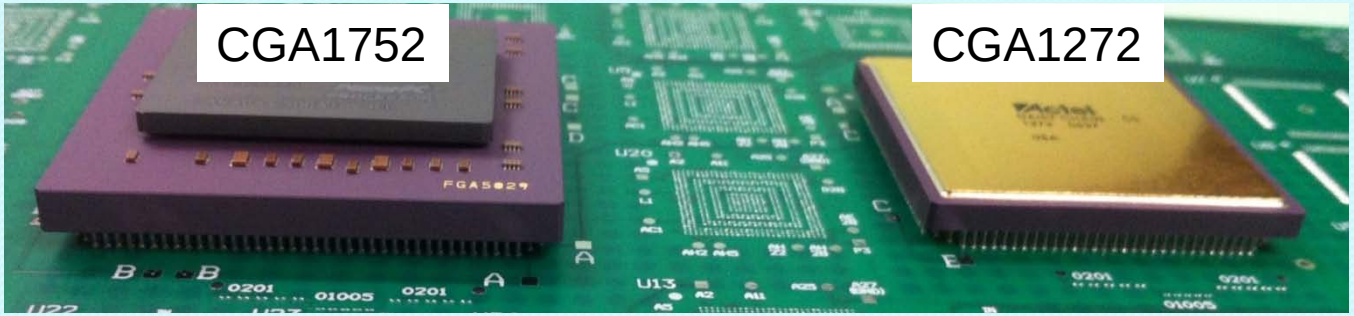
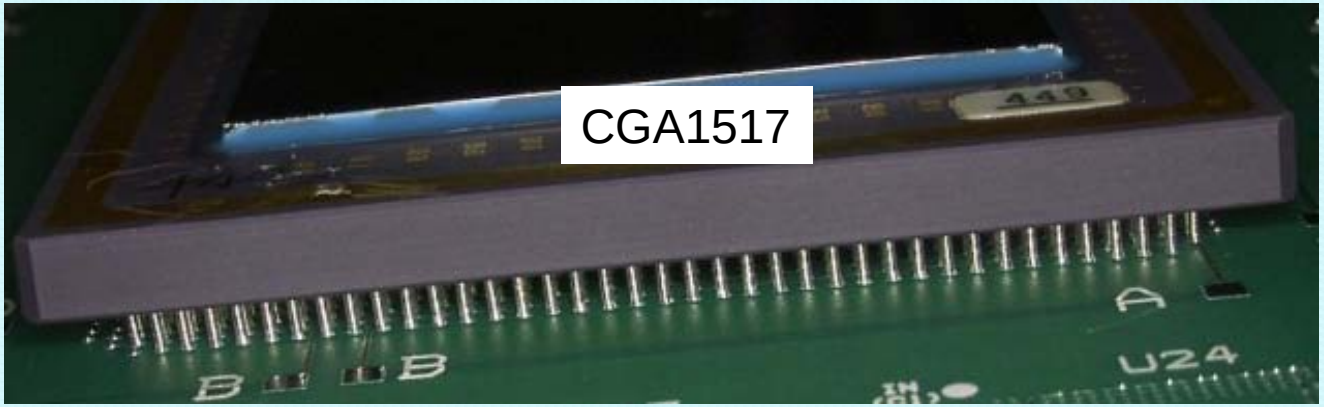
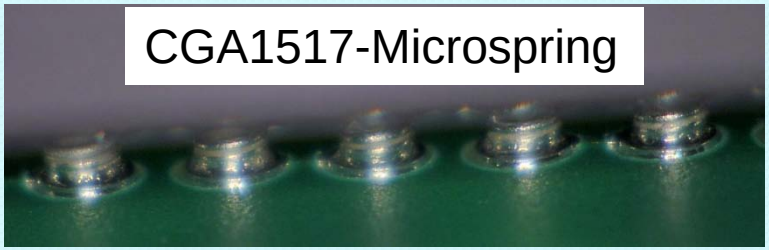
CGA Class Y/Hermetic Packages







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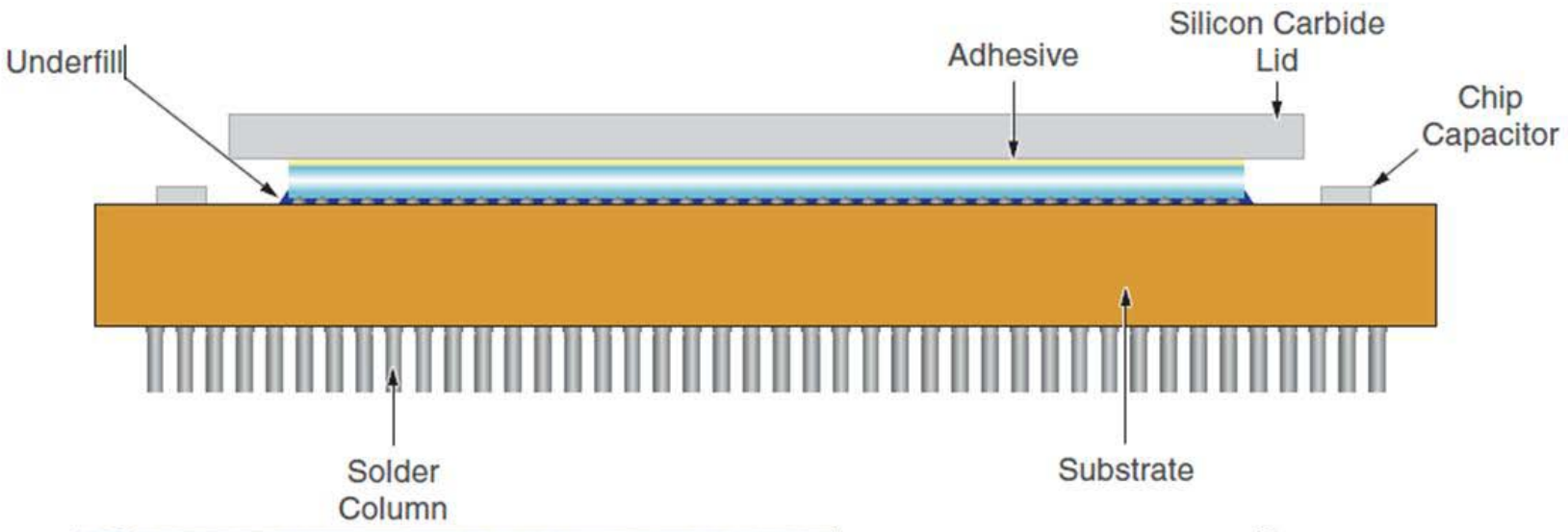
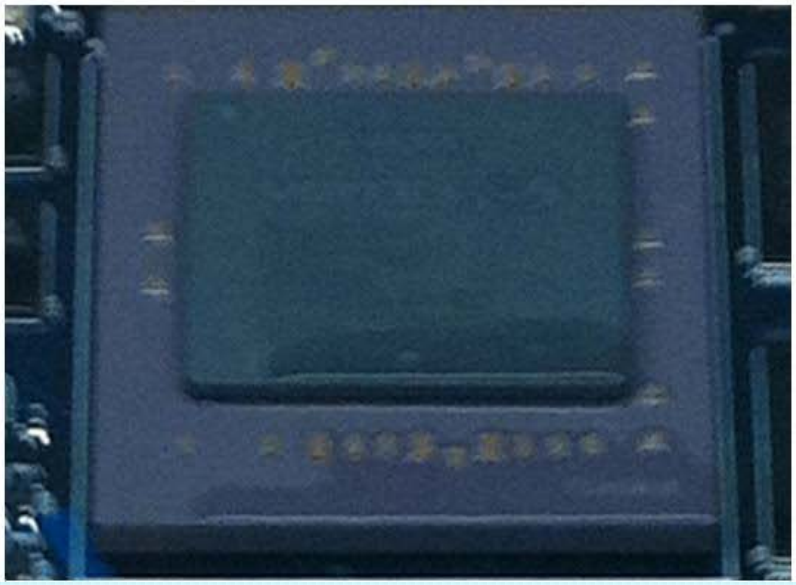
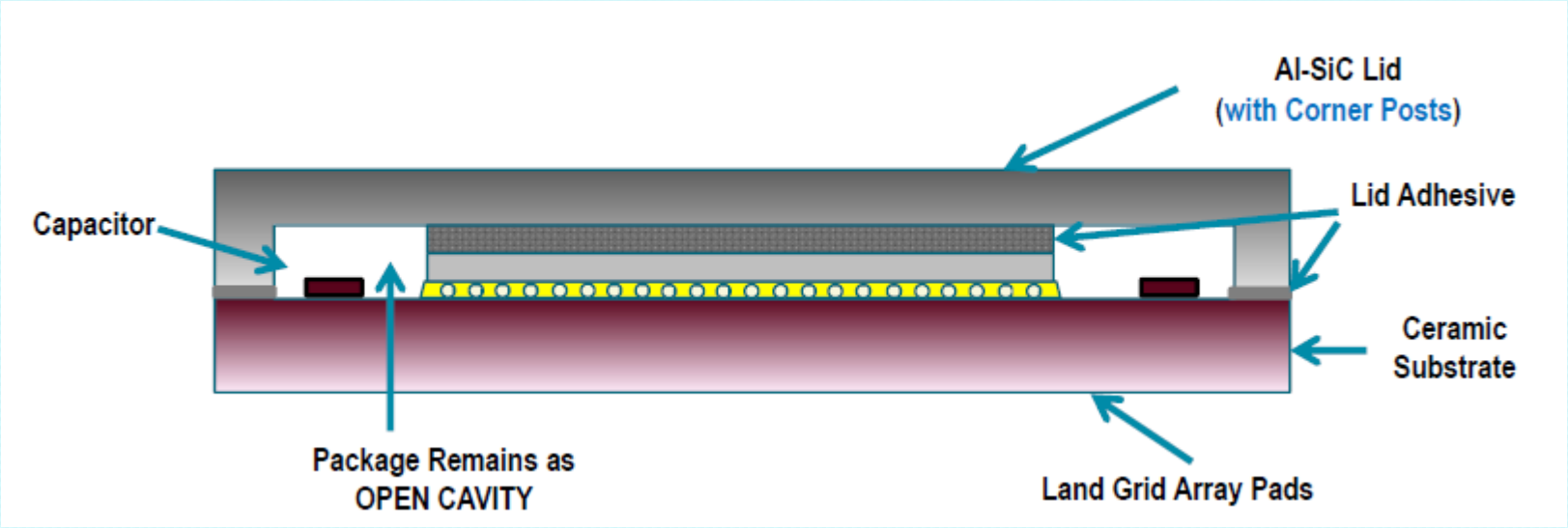
CGA Before Moves to CN (LGA)





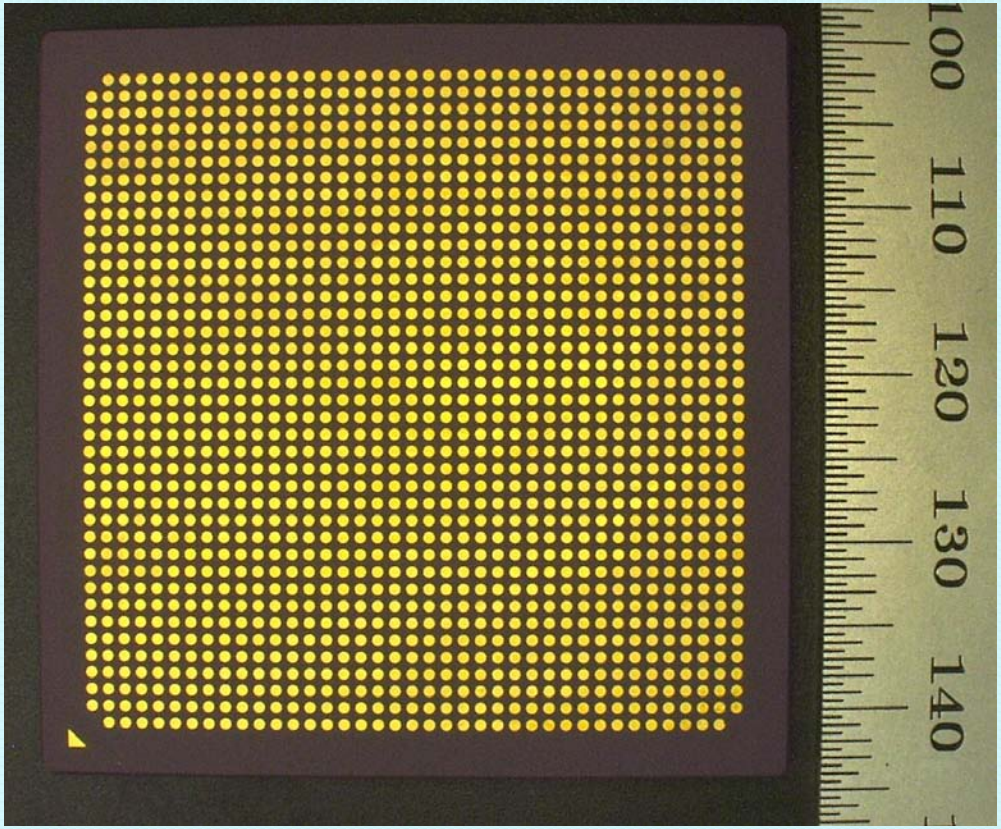
New CN (LGA) Package



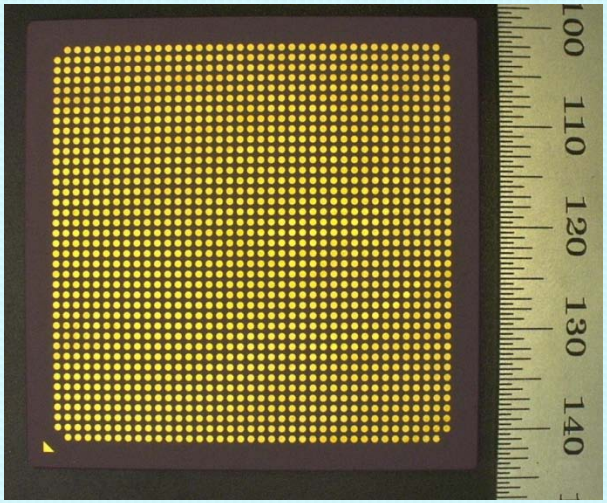
- Build facility changed
- CGA to LGA - pad solder coating
- Flip-chip bump now eutectic
- Lid to Al-SiC
- Underfill changed
- Heat sink now covers caps

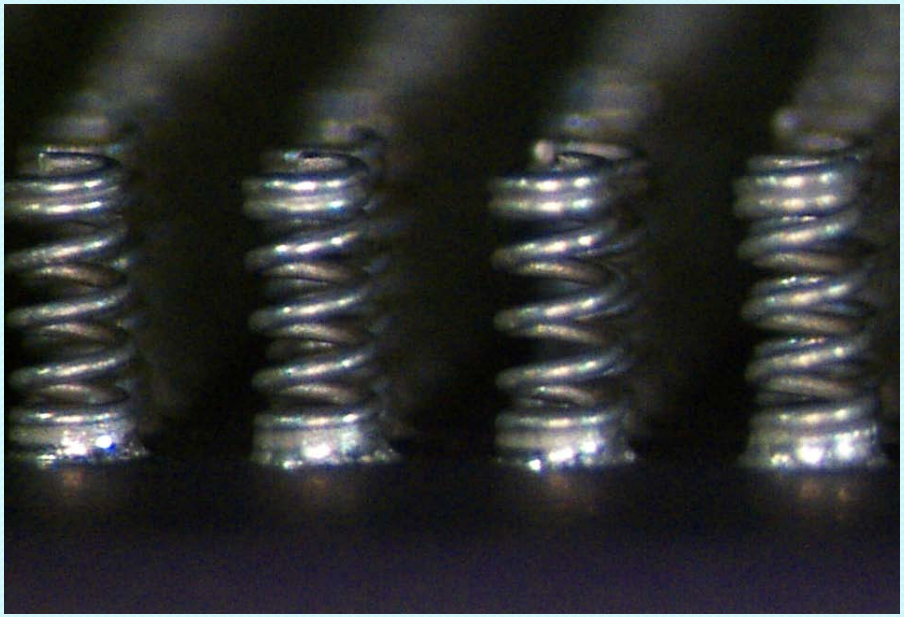
LGA Reliability Testing Methods

- Column attach: Two types
  - Pull test/Age-pull test
- CGA versions assemble onto PCB
- LGA version/bumped/assembled onto PCB



LGA Column/Micro-spring Attachment

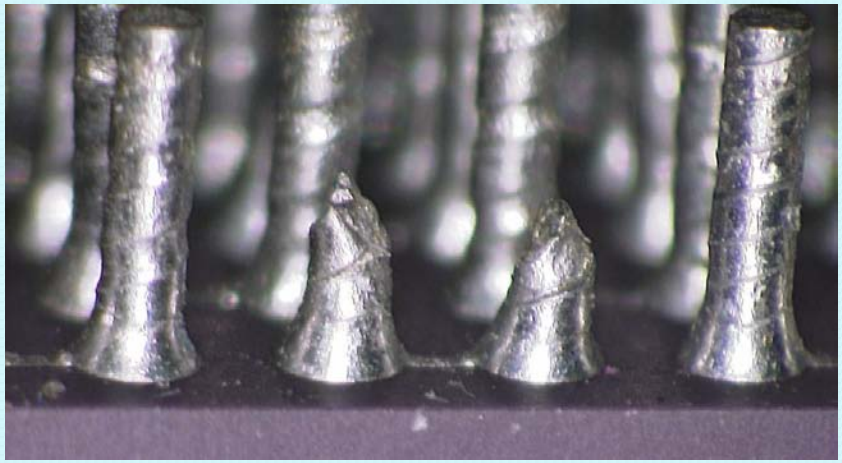




Pull Strength Column/CGA560

Pull Peak Force = 1340 g
Standard Deviation= 137
Failure- Column (mode 1)

Literature:
Strength 20/80 Tin-Lead
33-51 Mpa, 4785-7395 Psi
Diameter =0.022”
Load = **825-1275g**
>**1350g** for eutectic



Column Pull Test

Background:
Column pull test is a method used to determine the strength of the attached column interconnects and the corresponding failure mode. This test yields quantifiable data that pertains to the quality and consistency of the solder column, fillet, and pad. Column pull is a destructive test.

Failure Modes:

Mode 1 Column Failure – Failure through the core of the wire, leaving the copper wire spiraling out away from the fractured core (see Figure 1).

Mode 2 Joint to Pad Failure – Failure of the column attach joint on the device side. Non-solder colored material must be visible on the device side of the fracture. Probable causes: pad contamination, pad corrosion or excessive intermetallic growth.

Mode 3 Pad Failure – Pad is lifted off from the device substrate.

Mode 4 Fixture Failure – Failure is through or at the fixture attach joint.

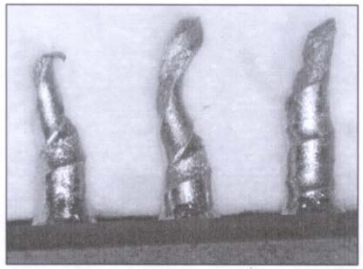


Figure 1. Failure mode 1 for reinforced column.

Measurement #	Peak Force (g)	Failure Mode
1 (periphery)	1380	1
2 (periphery)	1384	1
3 (periphery)	1301	1
4 (periphery)	1140	1
5 (periphery)	1148	1
6 (periphery)	1375	1
7 (periphery)	1298	1
8 (periphery)	1646	1
9 (periphery)	1097	1
10 (periphery)	1411	1
1 center	1345	1
2 center	1343	1
3 center	1441	1
4 center	1439	1
5 center	1345	1

Average Peak Force: 1340
Standard Deviation: 137

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Pull Strength Column/CGA1517

Column Pull Test

Background:

Column pull test is a method used to determine the strength of the attached column interconnects and the corresponding failure mode. This test yields quantifiable data that pertains to the quality and consistency of the solder column, fillet, and pad. Column pull is a destructive test.

Failure Modes:

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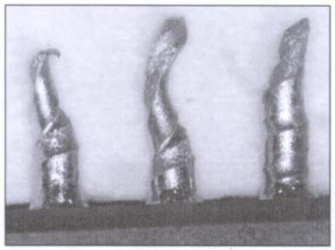

Figure 1. Failure mode 1 for reinforced column.

Measurement #	Peak Force (g)	Failure Mode
1 (periphery)	879	Column Failure
2 (periphery)	974	Column Failure
3 (periphery)	961	Column Failure
4 (periphery)	901	Column Failure
5 (periphery)	973	Column Failure
6 (periphery)	857	Column Failure
7 (periphery)	927	Column Failure
8 (periphery)	962	Column Failure
9 (periphery)	863	Column Failure
10 (periphery)	971	Column Failure
11 (center)	873	Column Failure
12 (center)	940	Column Failure
13 (center)	975	Column Failure
14 (center)	901	Column Failure
15 (center)	945	Column Failure

Column Diameter = 0.015”
Pull Peak Force = 975 g
Average Force = 927 g
Standard Deviation = 44 g
Failure- Column (mode 1)

Literature

Strength 20/80 SnPb

33-51 Mpa, 4,785-7,395 Psi

Diameter =0.015”

Load = **436-674 g**

>1350 g for eutectic SnPb

1.81 x106 grams force/ square inch

Mil-STD-883/Method 2038			
1.81E+06	0.00038	688 gr f	22 mils
1.81E+06	0.00017	320 gr f	15 mils

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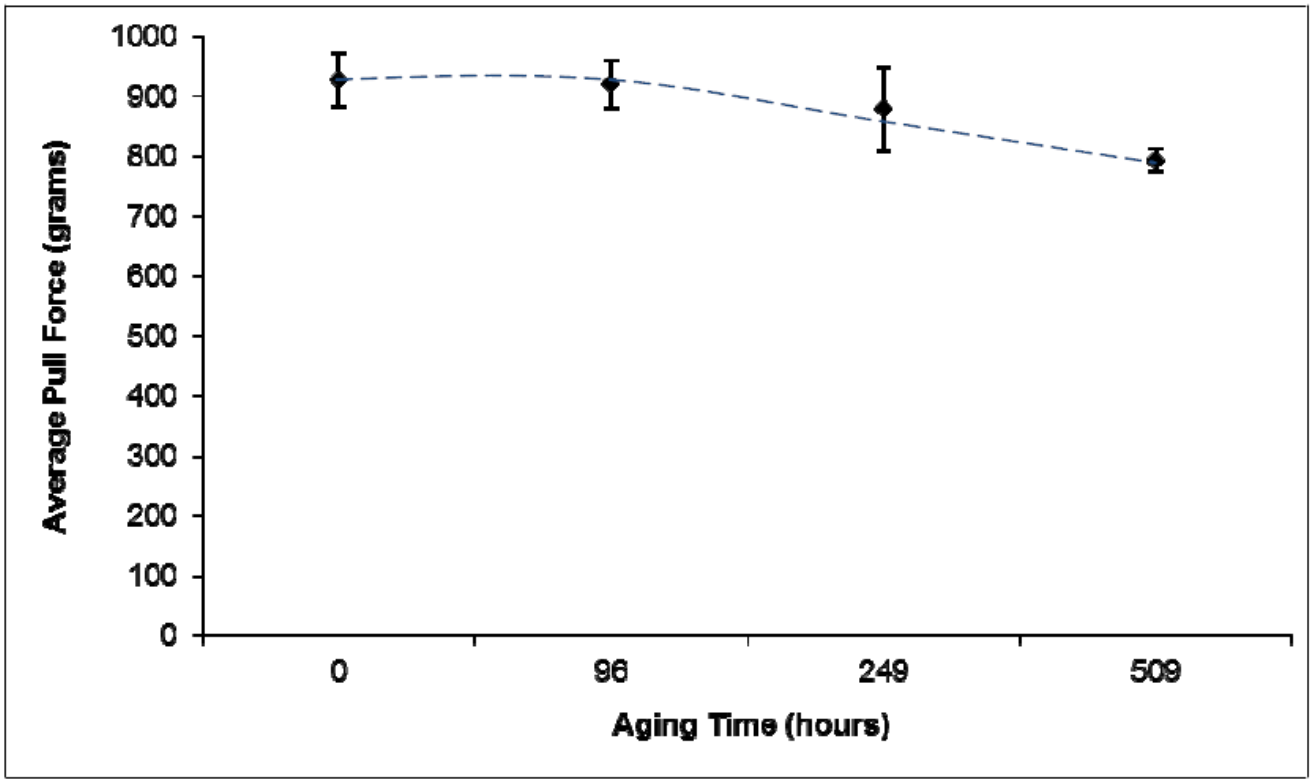
Pull Strength vs Aging at 125°C



Aging Time (hours)	Average Pull Force (grams)	Standard Deviation (grams)
0	927	44
96	920	40
249	878	70
509	793	19

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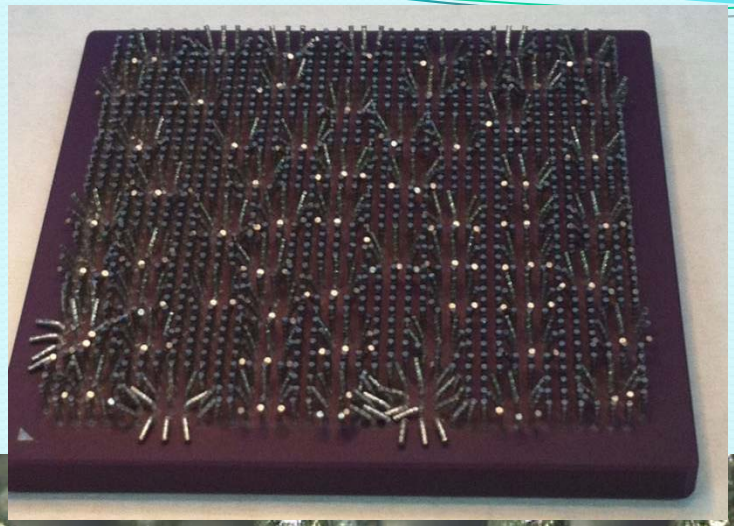
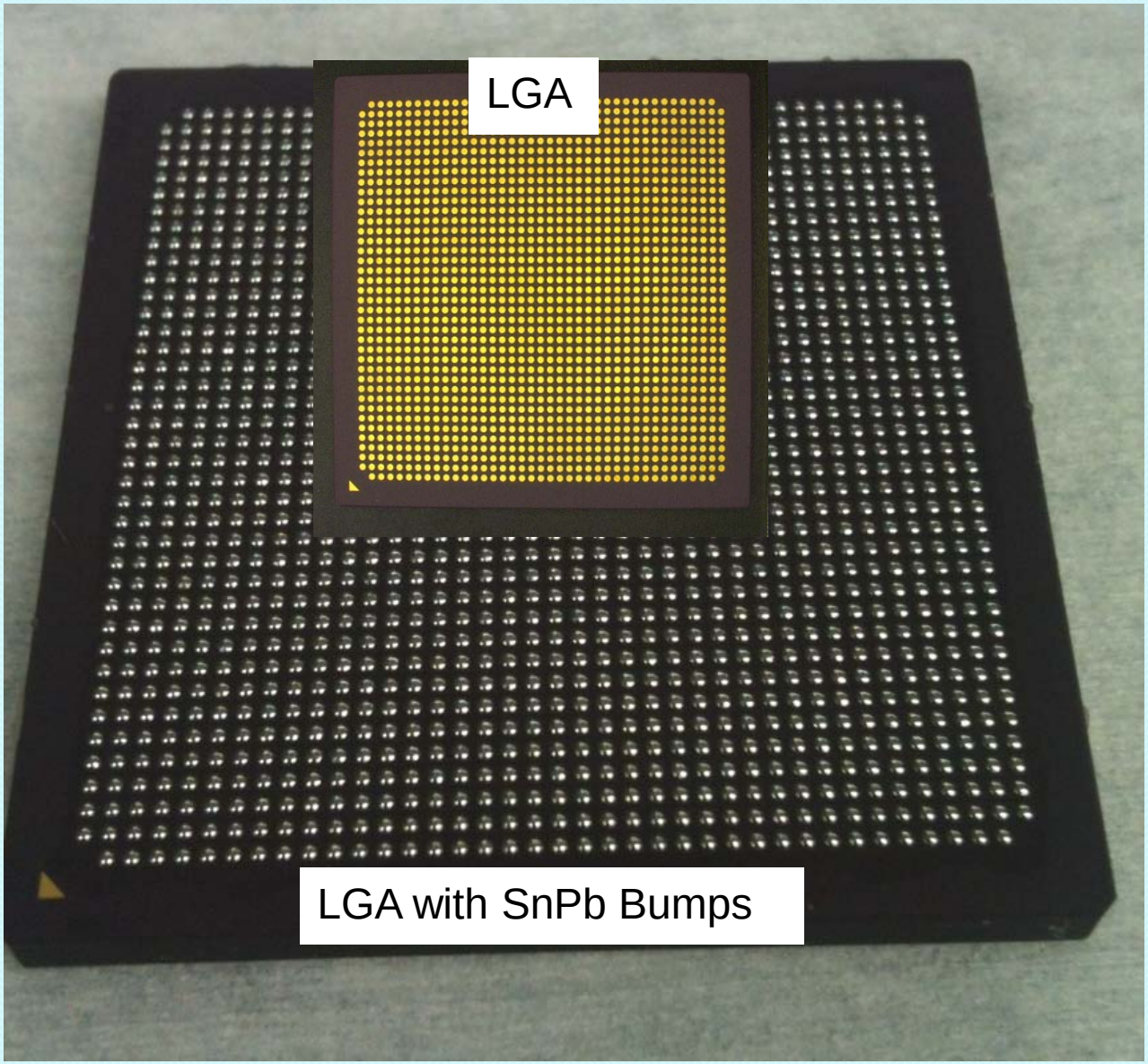
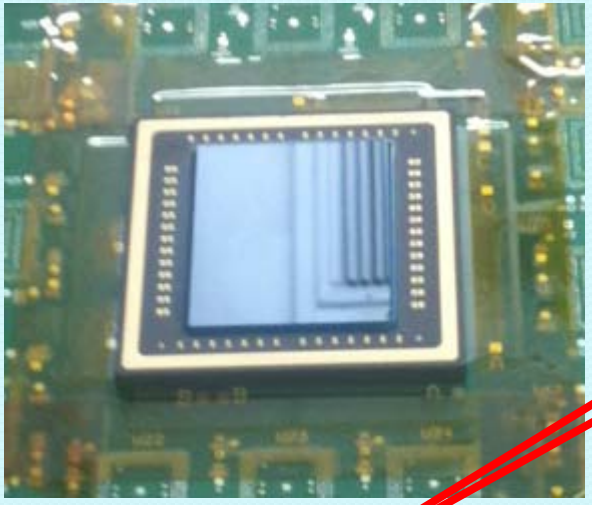
Column Pull Failure- CGA1517

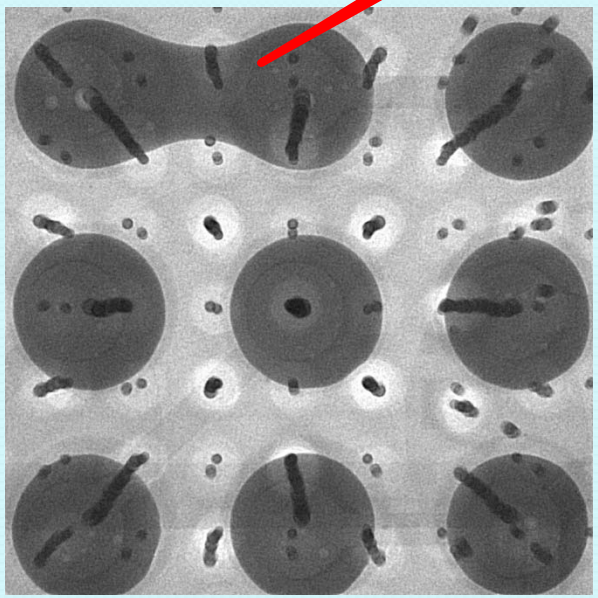


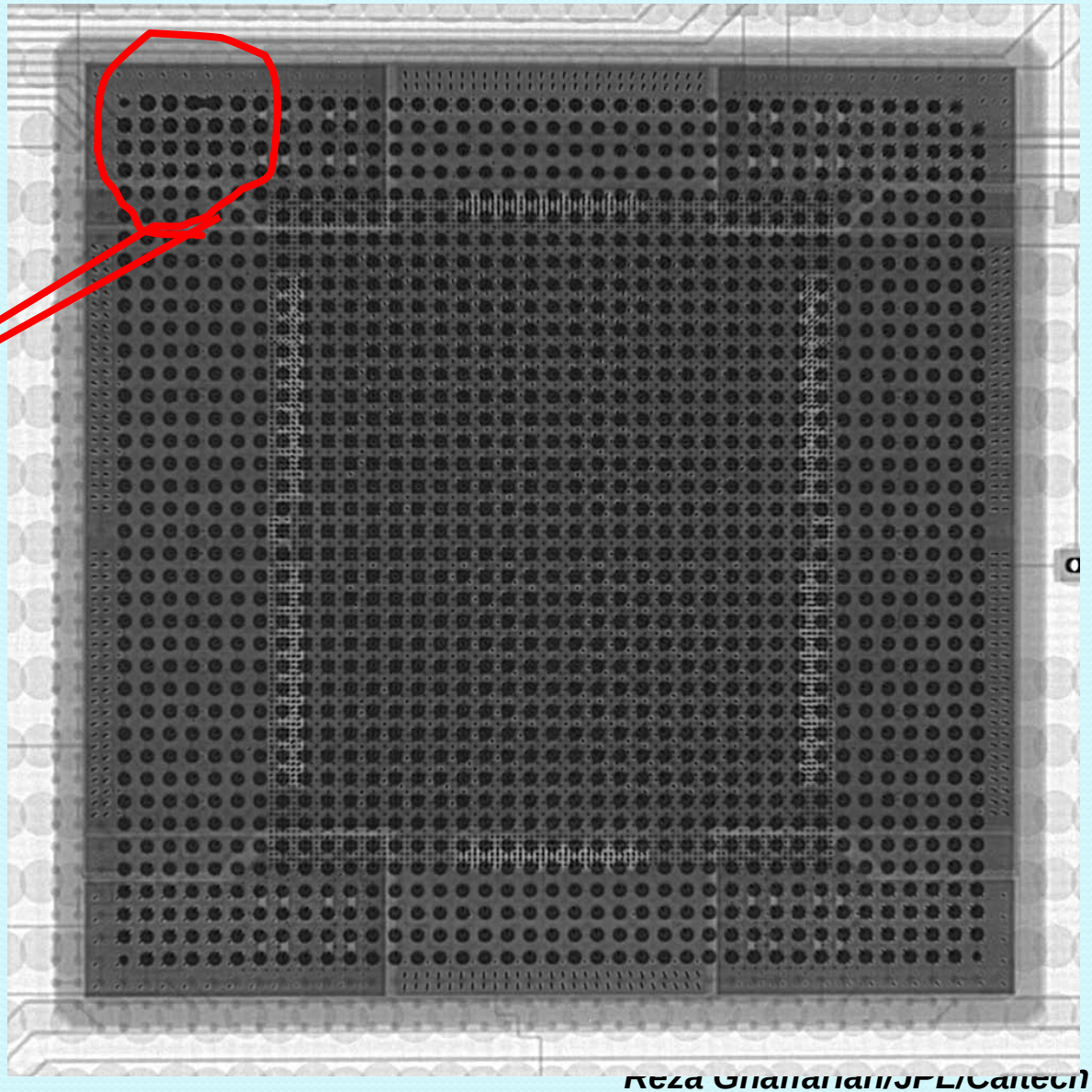
Successful Solder Bumping of LGA



X-ray of LGA Assembly



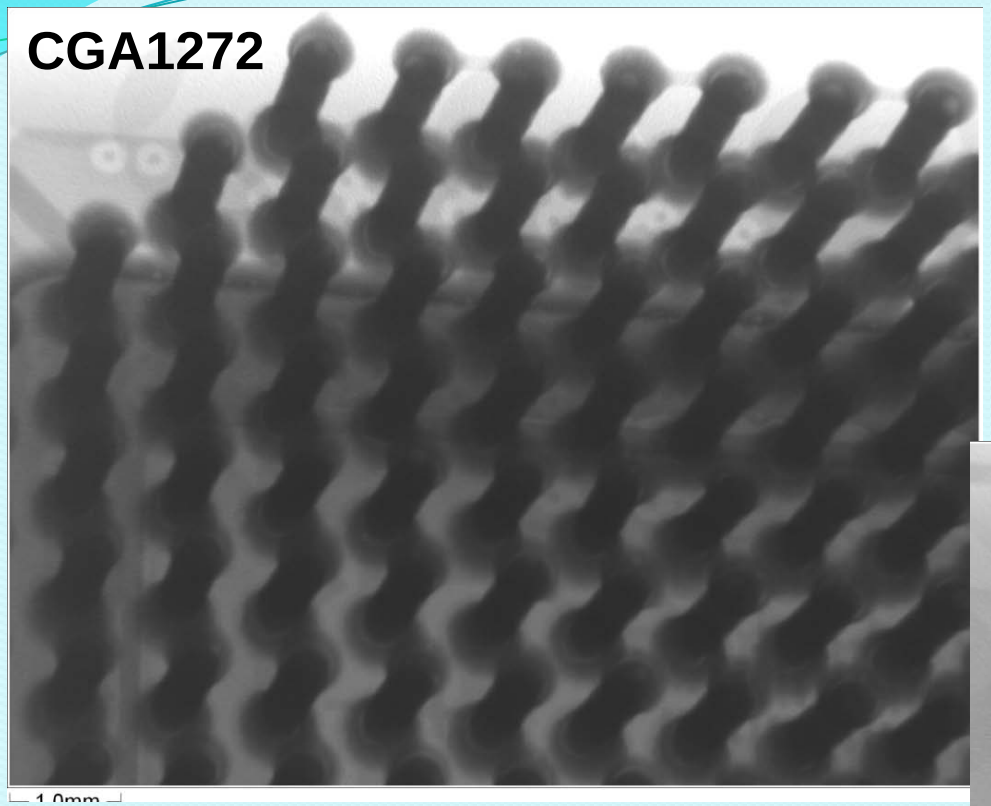


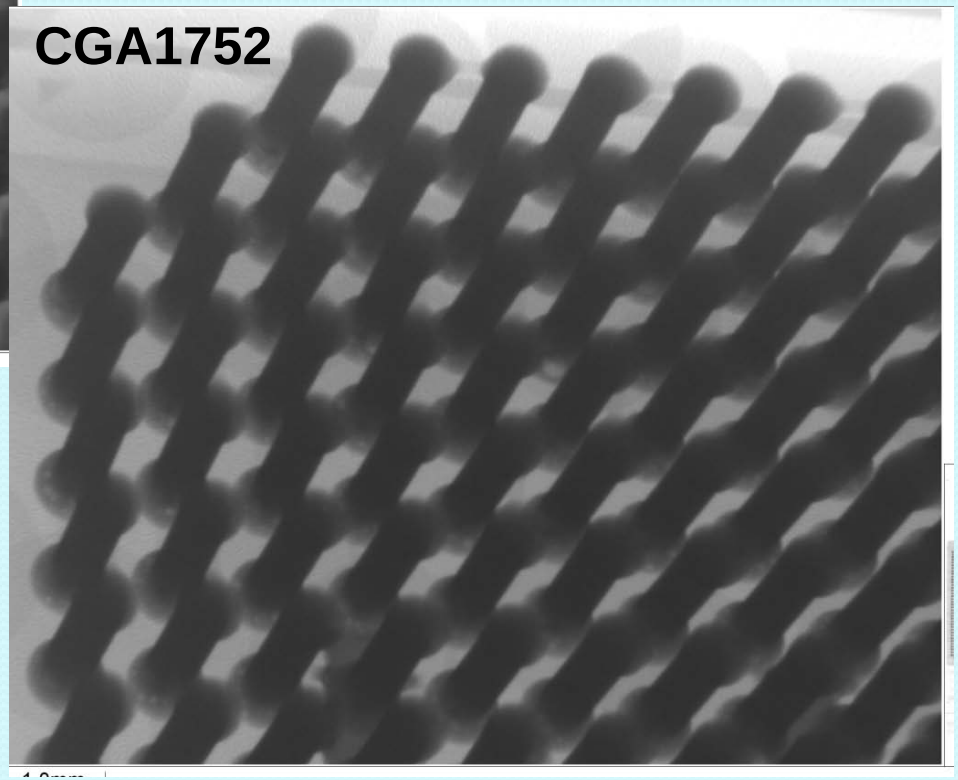


Build Numerous CGAs Key Assembly Variables

- CGA1752
  - 1.0-mm pitch, 42.5-mm
- CGA1272
  - 1.0-mm pitch, 37.5-mm
- PCB
  - High Tg FR-4, 0.093”, HASL
- Solder paste
  - RMA, Type III/IV/V
- Stencil
  - 6-mil-thick or mini-stencil
- Reflow vapor phase
  - Placement by rework station

As Assembled X-ray





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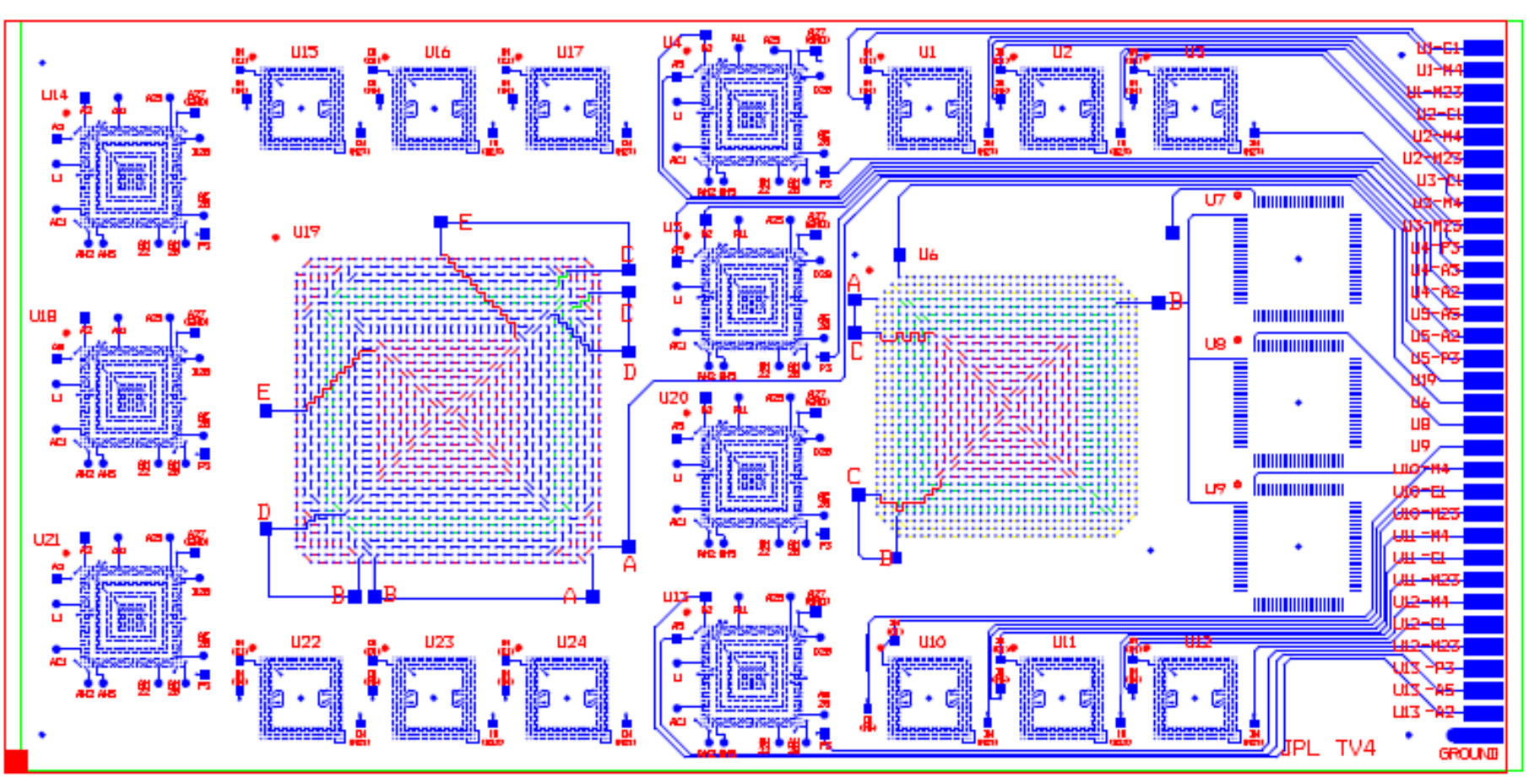
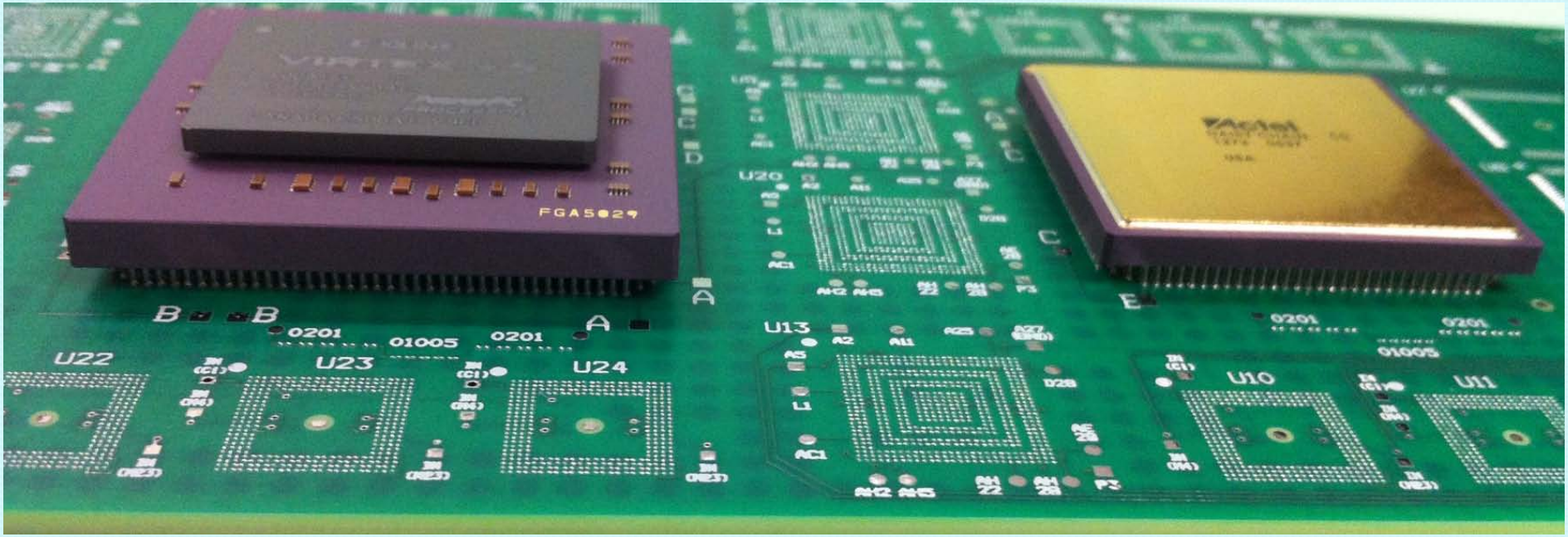
Test Vehicle Design



CGA1752 5 Daisy Chains **CGA1272 3 Daisy Chains**

Two CGA Assemblies



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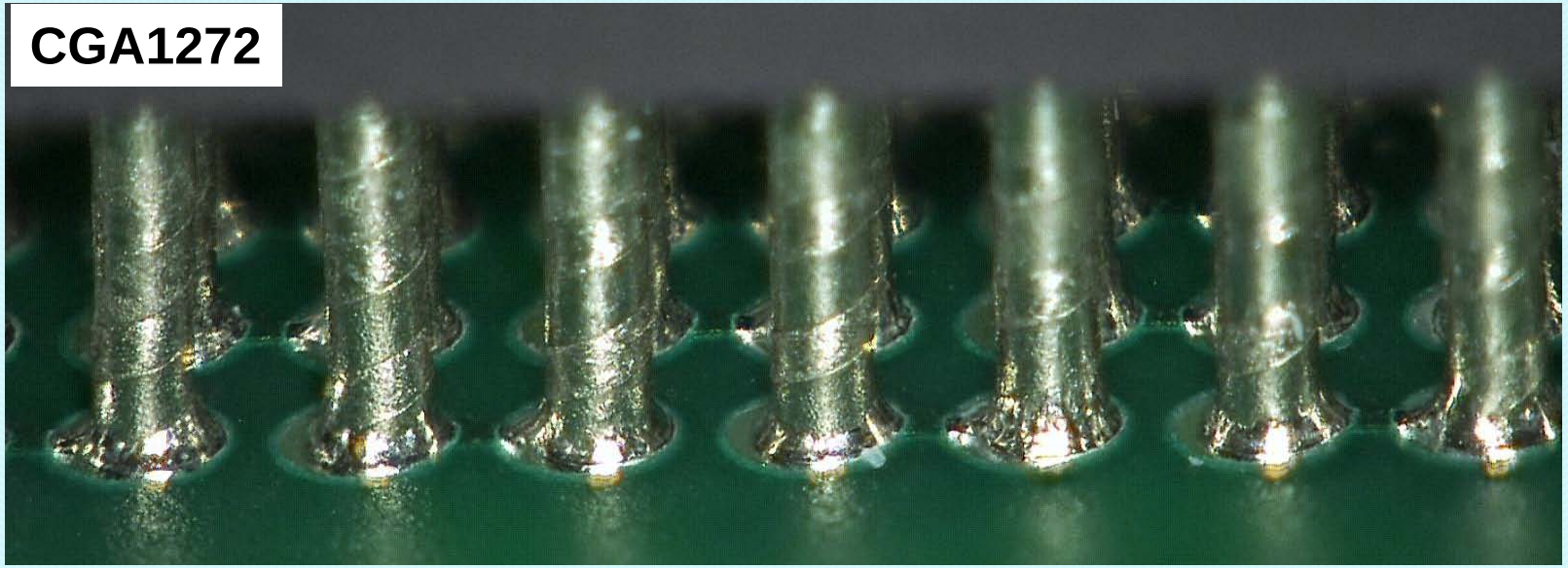
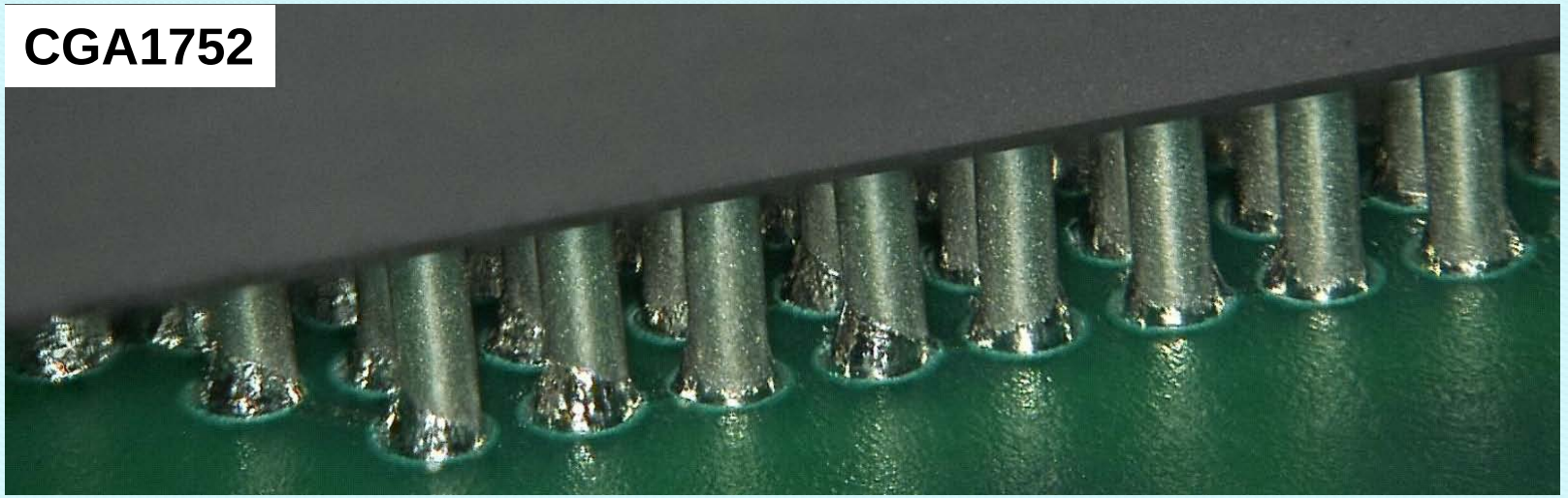
Assembly Solder Joint Quality

CGA1272



CGA1752



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CGA1272/1517/1752 TCs
See NEPP's 2nd Report

ID	Paste Type & Process	A-1752	B-1752	C-1752	D-1752	E-1752	A-1272	B-1272	C-1272
TV5-001	Type5 Tin-Lead Paste, Vapor Phase, Daisy Chain CGA1752 & CGA1272	7.61	10.71	10.61	11.50	12.02	1.92	2.53	2.15
	100 Cycles (-55 °C to 125 °C)	***7.78***	***10.92***	***10.82***	***11.72***	***12.25***	***2.01***	***2.62***	***2.24***
	200 Cycles (-55 °C to 125 °C)	***7.67***	***10.77***	***10.68***	***11.55***	***12.1***	***1.99***	***2.61***	***2.23***
TV5-002	Type3 Tin-Lead Paste, Vapor Phase, Daisy Chain CGA1752 & CGA1272	7.18	10.10	9.97	10.79	11.26	1.88	2.46	2.07
	100 Cycles (-55 °C to 125 °C)	***7.36***	***10.32***	***10.19***	***11.04***	***11.52***	***1.95***	***2.57***	***2.15***
	200 Cycles (-55 °C to 125 °C)	***7.25***	***10.16***	***10.04***	***10.88***	***11.34***	***1.94***	***2.54***	***2.14***
TV5-003	Type4 Tin-Lead Paste, Vapor Phase, Daisy Chain CGA1752 & CGA1272	7.61	10.74	10.63	11.48	12.01	1.88	2.50	2.11
	100 Cycles (-55 °C to 125 °C)	***7.81***	***11***	***10.8***	***11.75***	***12.26***	***1.99***	***2.61***	***2.23***
	200 Cycles (-55 °C to 125 °C)	***7.66***	***10.79***	***10.69***	***11.55***	***12.07***	***1.97***	***2.59***	***2.2***
TV5-004	Type4 Tin-Lead Paste, Vapor Phase, Daisy Chain CGA1752 & CGA1272	7.1	10.05	9.91	10.74	11.16	1.89	2.47	2.09
	100 Cycles (-55 °C to 100 °C)	***7.16***	***10.09***	***9.95***	***10.78***	***11.21***	***1.95***	***2.54***	***2.16***
	200 Cycles (-55 °C to 100 °C)	***7.16***	***10.1***	***9.95***	***10.77***	***11.22***	***1.95***	***2.54***	***2.15***
TV5-005	Type4 Tin-Lead Paste, Vapor Phase, Daisy Chain CGA1752 & CGA1272	7.19	10.1	9.95	10.81	11.34	1.83	2.18	2.06
	100 Cycles (-55 °C to 100 °C)	***7.24***	***10.17***	***10.03***	***10.88***	***11.43***	***1.89***	***2.25***	***2.16***
	200 Cycles (-55 °C to 100 °C)	***7.27***	***10.18***	***10.01***	***10.88***	***11.42***	***1.91***	***2.27***	***2.17***

ID	Paste Type & Process	CGA	A-1272	B-1272	C-1272
TV5-011	Type5 Tin-Lead Paste, Vapor Phase, CGA1517 MicroSpring and CGA1272 DC	**1517**	1.89	2.49	2.15
	100 Cycles (-55 °C to 100 °C)		1.99	2.57	2.49
	200 Cycles (-55 °C to 100 °C)		1.96	2.57	2.53
TV5-014	Type4 Tin-Lead Paste, Vapor Phase, CGA1517 MicroSpring and CGA1272 DC	**1517**	1.85	2.42	2.04
	100 Cycles (-55 °C to 100 °C)		*1.91*	*2.5*	*2.11*
	200 Cycles (-55 °C to 100 °C)		*1.91*	*2.5*	*2.12*
TV5-017	Type4 Tin-Lead Paste, Vapor Phase/Stencil 5, CGA1517 Cu Column and CGA1272 DC	**1517**	1.82	2.39	2.07
	100 Cycles (-55 °C to 100 °C)		*1.9*	*2.48*	*2.11*
	200 Cycles (-55 °C to 100 °C)		*1.87*	*2.45*	*2.1*
TV4-021	Type5 Tin-Lead Paste, Vapor Phase, CGA1517 Cu Column and No CGA1272 DC	**1517**	NA	NA	NA
	100 Cycles (-55 °C to 100 °C)		NA	NA	NA
	200 Cycles (-55 °C to 100 °C)		NA	NA	NA
TV5-032	Type5 Tin-Lead Paste, Vapor Phase, CGA1509 90/10 Column and CGA1272 Rework Station	**1509**	1.67	open	0.43
	100 Cycles (-55 °C to 100 °C)		*1.7*	*open*	*0.46*
	200 Cycles (-55 °C to 100 °C)		*1.73*	*open*	*0.47*

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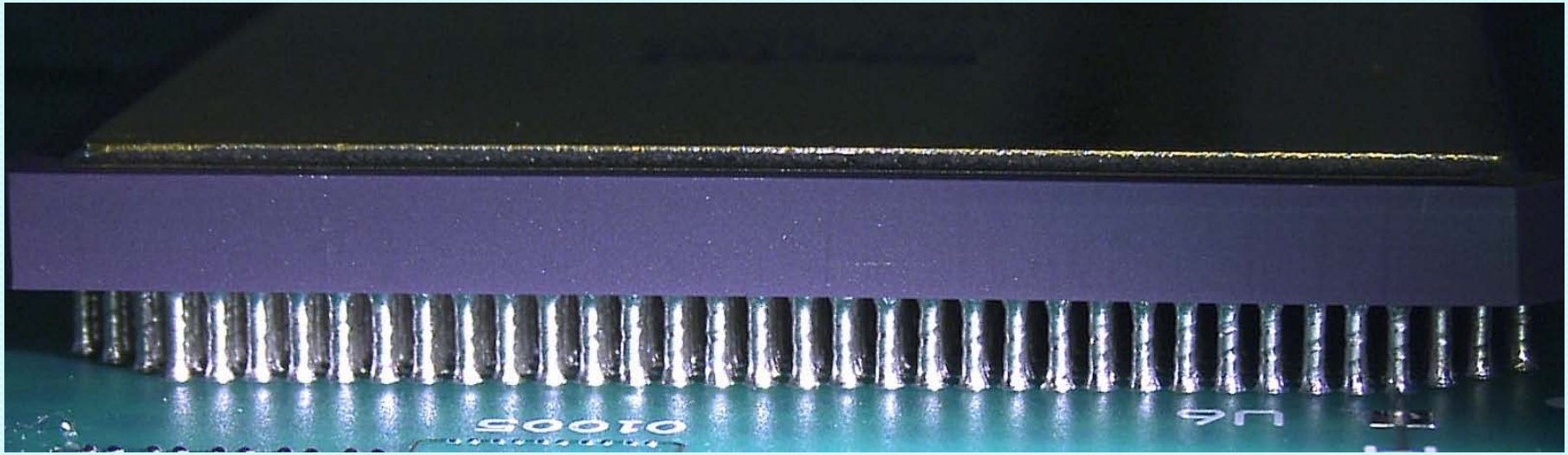
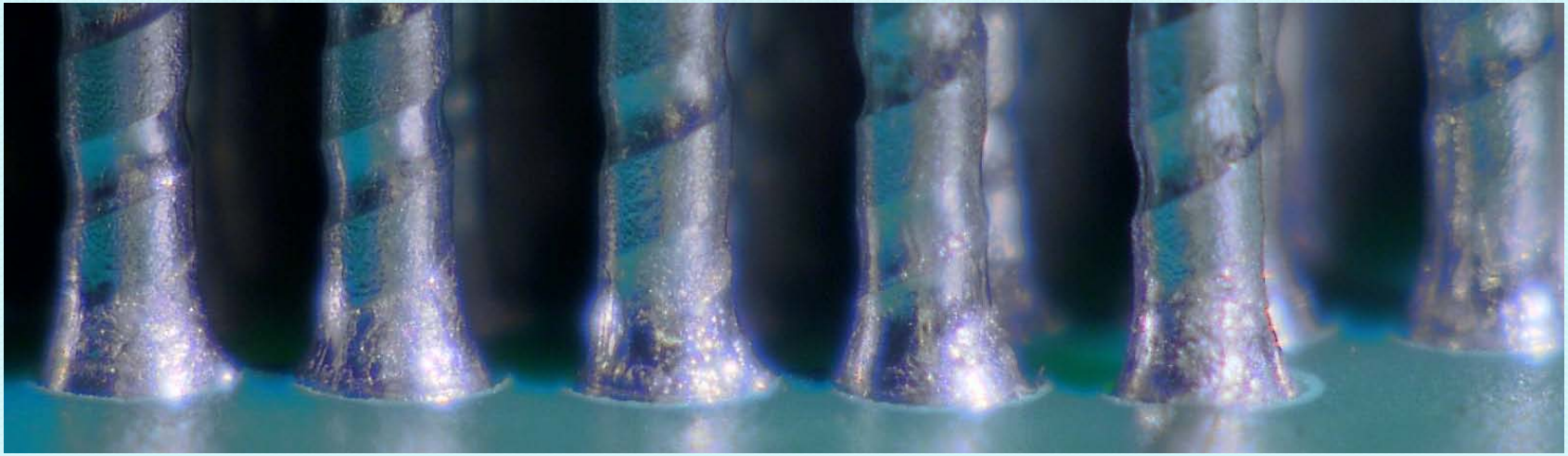
SN05-1272-100 TC (-55/100°C)





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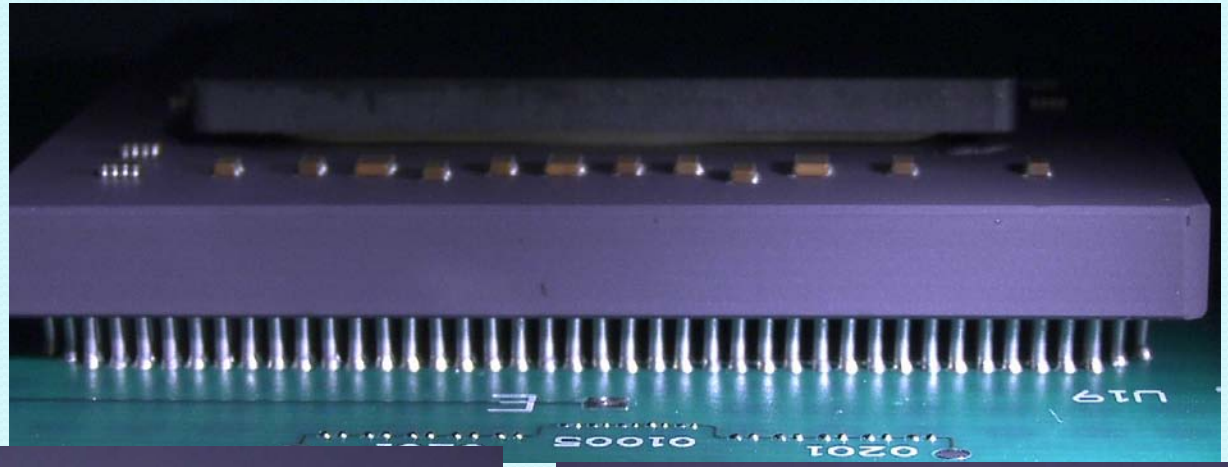
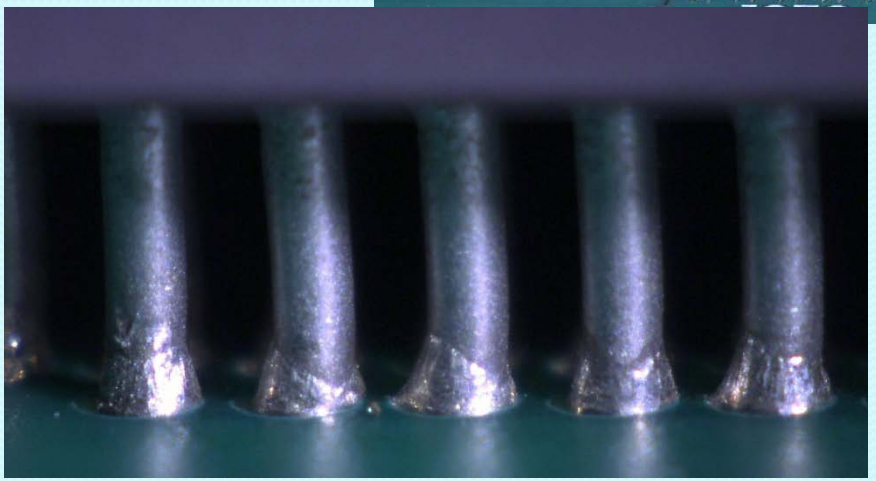
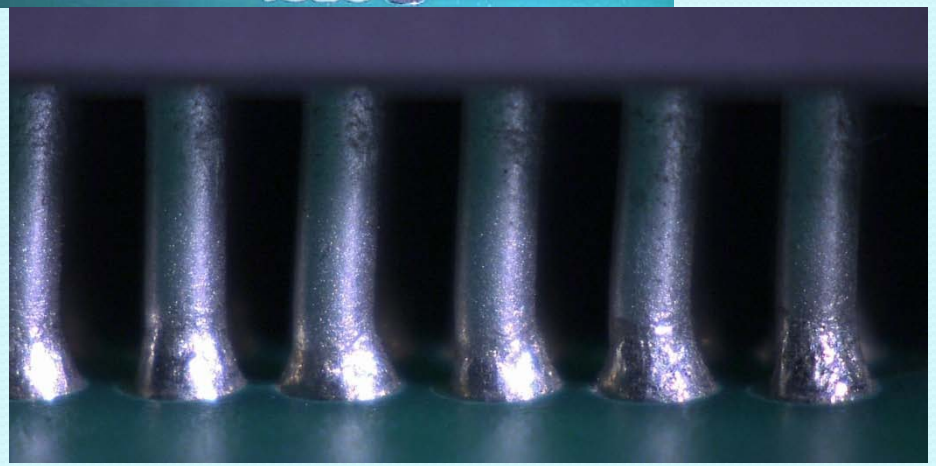
SN04-1752 100 TC (-55/100°C)







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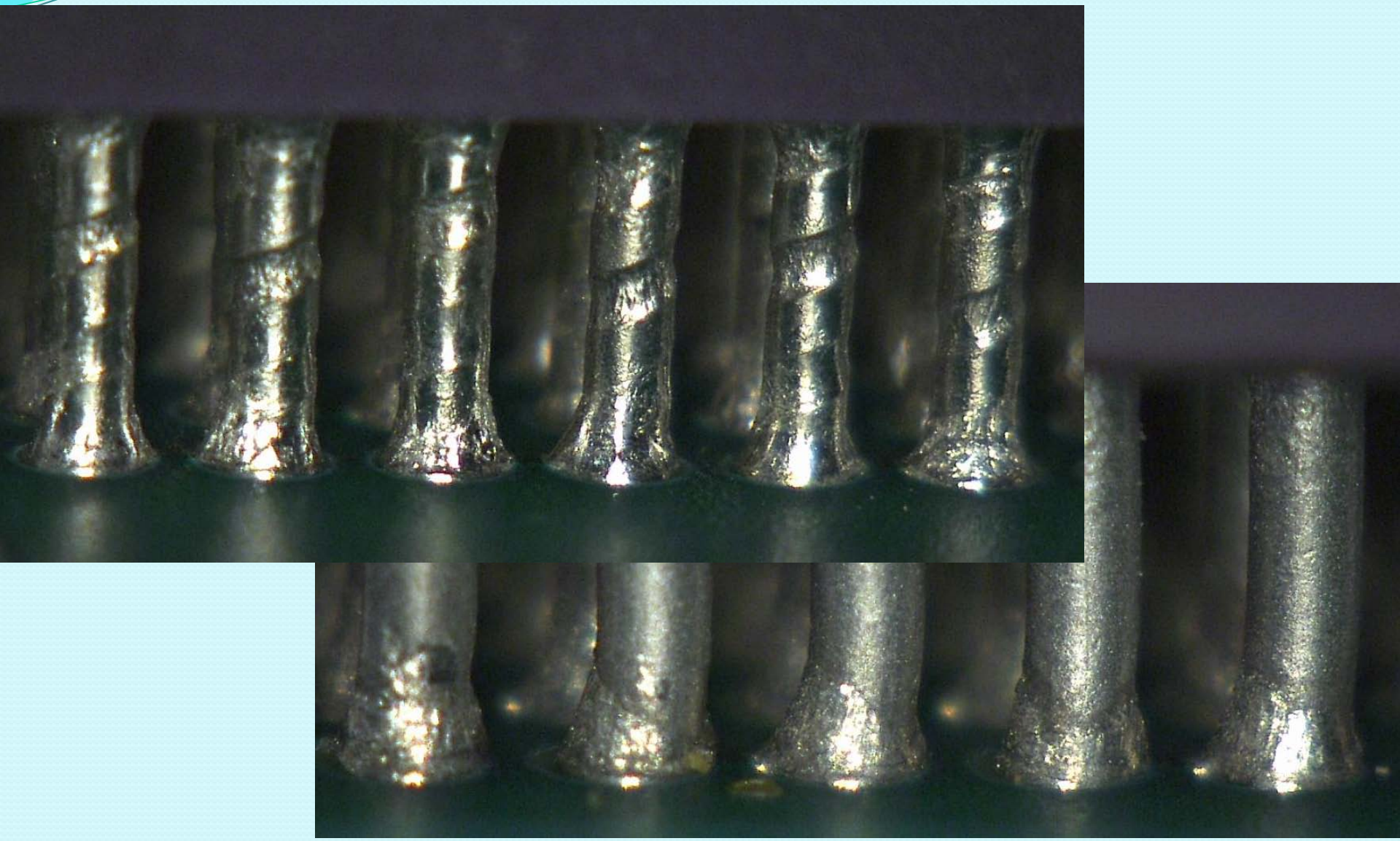
SN05-1272, SN04/1752-200TC



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TVs TC (-55/125°C)
See NEPP's 2nd Report

ID	Paste Type & Process	CGA	A-1272	B-1272	C-1272
TV5-012	Type4 Tin-Lead Paste, Vapor Phase, CGA1517 MicroSpring and CGA1272 DC	**1517**	1.88	2.48	2.1
	100 Cycles (-55 °C to 125 °C)		*1.95*	*2.57*	*2.18*
	200 Cycles (-55 °C to 125 °C)		*1.92*	*2.53*	*2.15*
TV5-013	Type4 Tin-Lead Paste, Vapor Phase, CGA1517 MicroSpring and CGA1272 DC	**1517**	1.87	2.45	2.09
	100 Cycles (-55 °C to 125 °C)		*1.92*	*2.53*	*2.17*
	200 Cycles (-55 °C to 125 °C)		*1.91*	*2.52*	*2.15*
TV5-015	Type4 Tin-Lead Paste, Vapor Phase/Stencil 4, CGA1517 Cu Column and CGA1272 DC	**1517**	1.88	2.48	2.11
	100 Cycles (-55 °C to 125 °C)		*1.97*	*2.57*	*2.19*
	200 Cycles (-55 °C to 125 °C)		*1.97*	*2.55*	*2.19*
TV5-016	Type4 Tin-Lead Paste, Vapor Phase/Stencil 5, CGA1517 Cu Column and No CGA1272 DC	**1517**	1.86	2.45	2.07
	100 Cycles (-55 °C to 125 °C)		*1.9*	*2.51*	*2.14*
	200 Cycles (-55 °C to 125 °C)		*1.89*	*2.51*	*2.13*
TV4-022	Type4 Tin-Lead Paste/Stencil4, Vapor Phase, CGA1517 Cu Column and CGA1272 DC	**1517**	1.94	2.53	2.11
	100 Cycles (-55 °C to 125 °C)		*1.98*	*2.57*	*2.18*
	200 Cycles (-55 °C to 125 °C)		*1.98*	*2.57*	*2.16*
TV4-023	Type4 Tin-Lead Paste/Stencil4, Vapor Phase, CGA1517 Cu Column and CGA1272 DC-Ink Defect	**1517**	1.98	2.57	2.16
	100 Cycles (-55 °C to 125 °C)		*2.05*	*2.65*	*2.23*
	200 Cycles (-55 °C to 125 °C)		*2.02*	*2.63*	*2.21*
TV4-024	Type4 Tin-Lead Paste/Stencil4, Vapor Phase, CGA1517 Cu Column and CGA1272 DC-Kapton Defect	**1517**	Open	2.54	2.11
	100 Cycles (-55 °C to 125 °C)		*Open*	*2.62*	*2.19*
	200 Cycles (-55 °C to 125 °C)		*Open*	*2.61*	*2.19*
TV5-031	Type4 Tin-Lead Paste, Vapor Phase, CGA1509 90/10 Column and CGA1272 DC	**1509**	1.92	2.52	2.14
	100 Cycles (-55 °C to 125 °C)		*1.95*	*2.54*	*2.17*
	200 Cycles (-55 °C to 125 °C)		*2*	*2.59*	*2.21*
TV5-035	Type5 Tin-Lead Paste, Vapor Phase, CGA1509 90/10 Column and CGA1272 DC	**1509**	1.95	2.77	2.39
	100 Cycles (-55 °C to 125 °C)		*2.01*	*278*	*2.41*
	200 Cycles (-55 °C to 125 °C)		*1.8*	*2.75*	*2.4*
TV5-036	Type5 Tin-Lead Paste, Vapor Phase, CGA1509 90/10 Column and CGA1272 DC	**1509**	2	2.61	2.21
	100 Cycles (-55 °C to 125 °C)		*1.92*	*2.53*	*2.16*
	200 Cycles (-55 °C to 125 °C)		*1.95*	*2.56*	*2.18*

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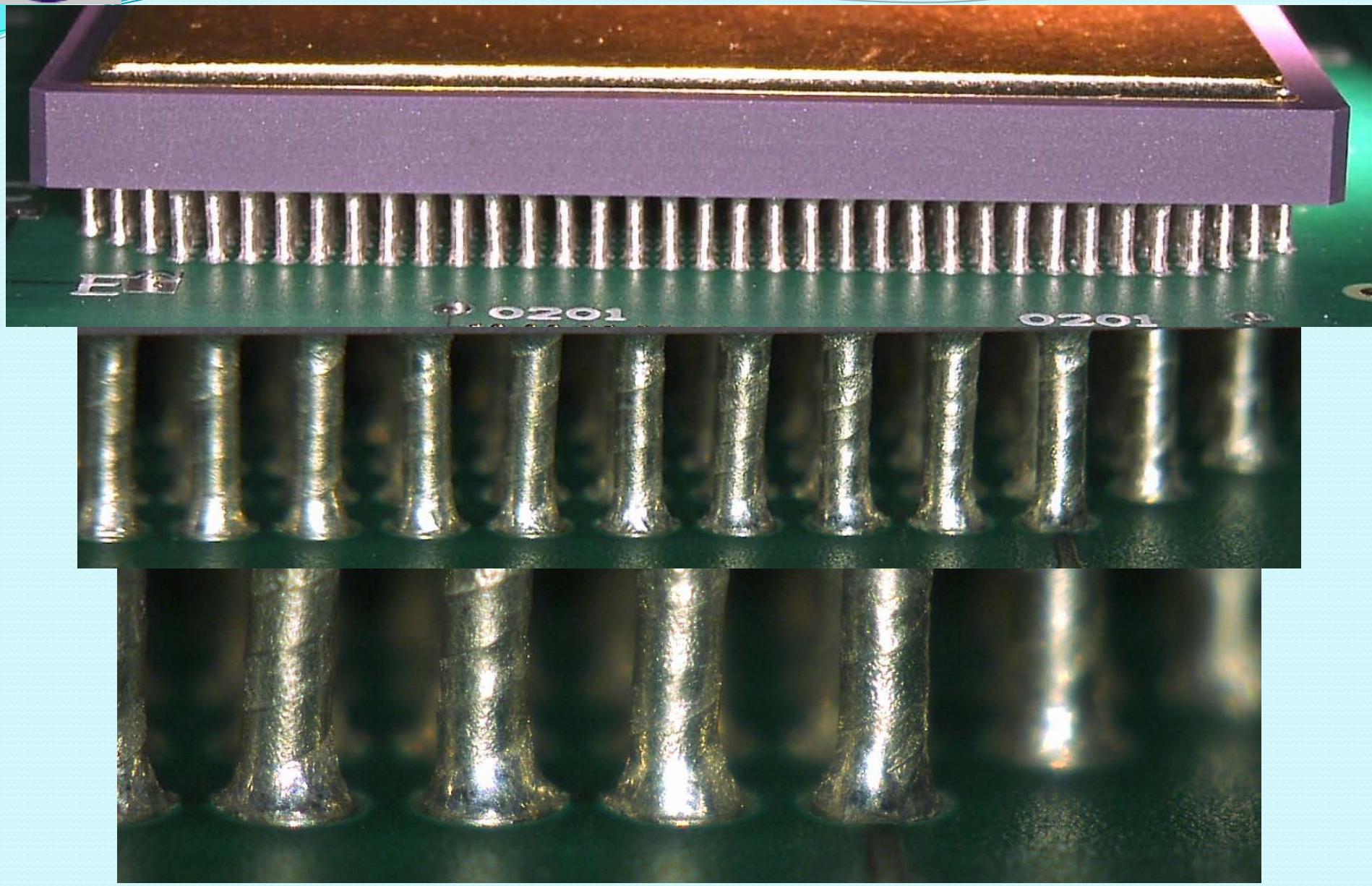
SN01-1272-200TC (-55/125°C)



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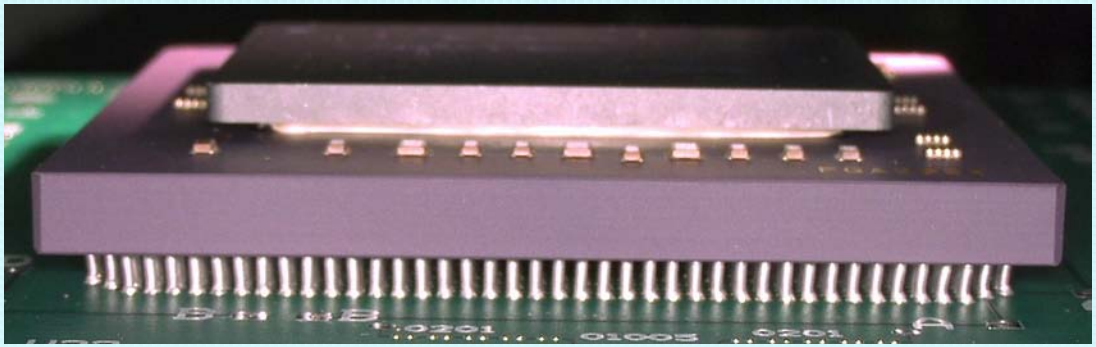
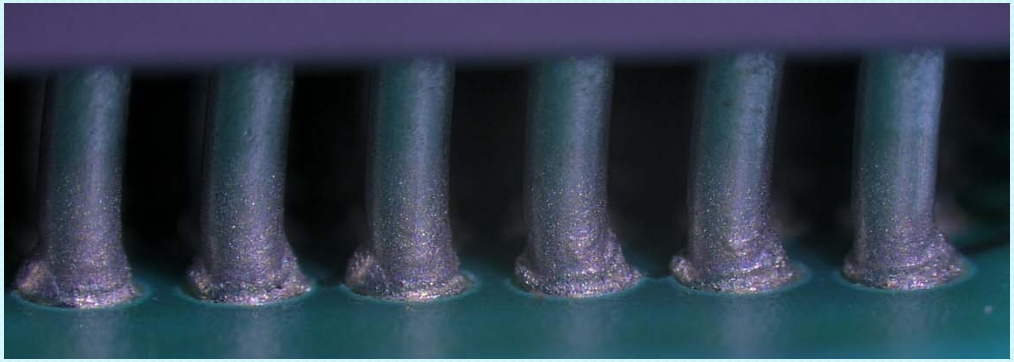
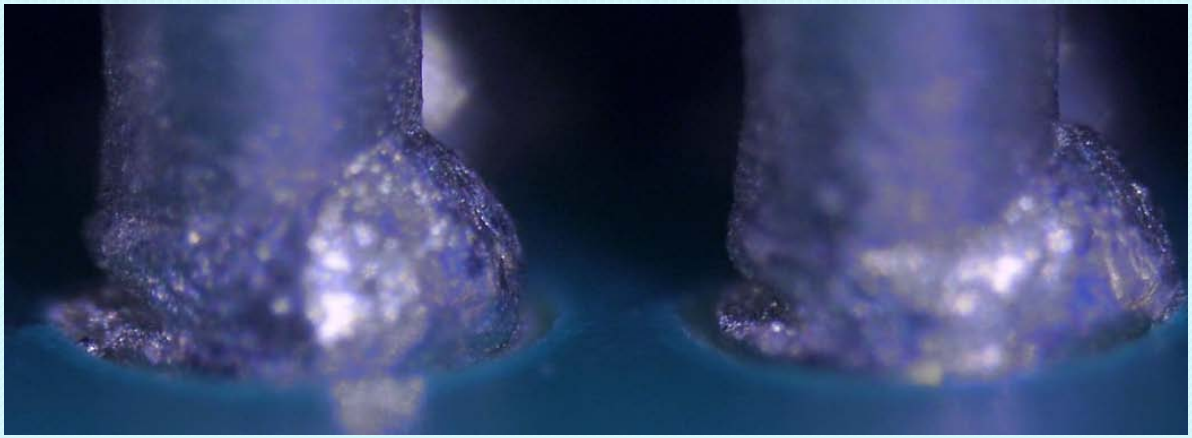
SN01-1752-200 TC (-55/125°C)







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Summary

- LGA column attachment
  - Success on Cu wrap column attach
    - Column pull for 22 mil dia.
    - Pull tests/aging at 125°C/500 hr.
    - Pull for 15 mil dia. /aging at 125°C/500 hr.
  - Success on Micro-coil spring column attach
    - Minimum signs of damage after 200 TCs
- Success on Assembly (Vapor Phase)
  - CGA 1272/1509/1517/1752
    - Several variables
    - Visual inspection
    - X-ray

Reliability & Future Activities

- Reliability TC Results
  - CGAs, 5 different types/2TVs
  - 2nd report- See NEPP website
  - TC test result 200 cycle (-55/100°C)
  - TC test result 200 cycle (-55/125°C)
  - Damage monitoring and NDE/SEM evaluation
- PCB with HDI (microvia)
  - HDI assembly/optimize process
  - Reliability testing
- Active die, HDI, Reliability
  - Use lessons learned for efficient resource utilization
  - Release report

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References

http://NEPP.nasa.gov