Green IC packaging: A threath to electronics reliability

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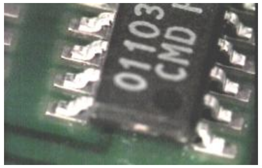
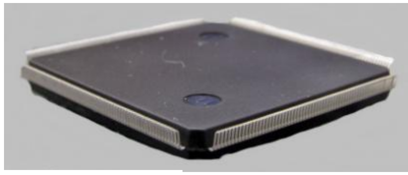
8. Conclusions

1. Plastic packages: molding compound

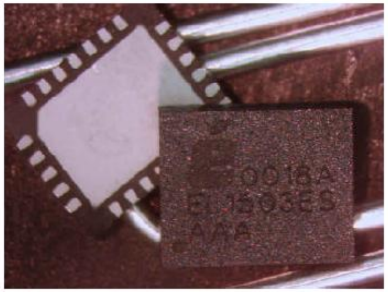
Plastic molding compounds are used to encapsulate the IC/leadframe or IC/substrate assembly in plastic IC packaging:

- Leaded packages: SOIC, QFP, TSOP,...

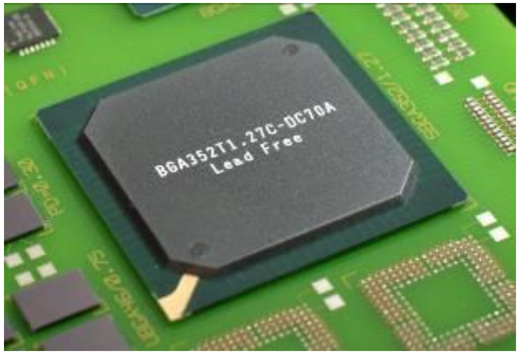




- Leadless packages: QFN, MLF, LPP,...



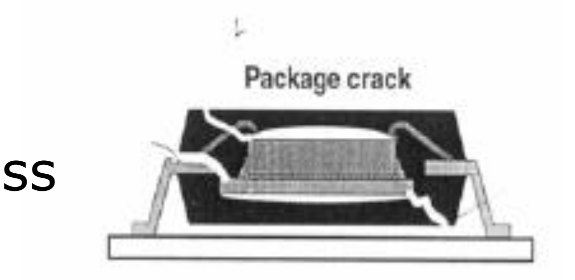
- Area array packages: PBGA



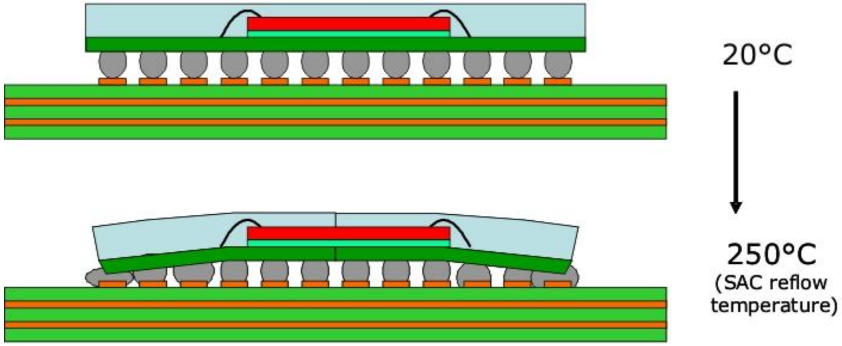
1. Plastic packages: molding compound

Molding compound requirements:

- Compatibility with silicon die & first level interconnect (wire bond, flip chip, die attach)



- Thermal, mechanical, moisture robustness
- Leadframe – substrate matching (warpage)



- Electrical properties
- Thermal conductivity
- Flame retardant
- Manufacturability
- Cost
- ...

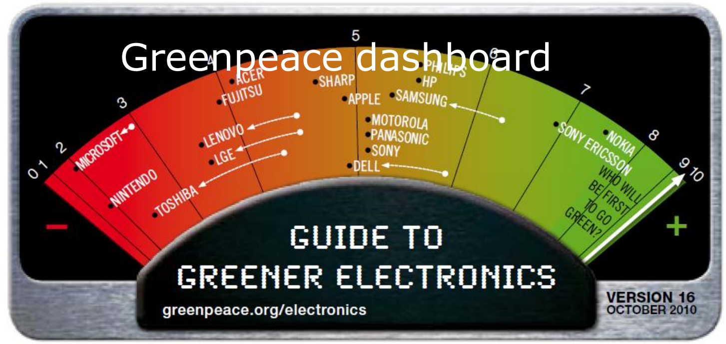
2. Green molding compound

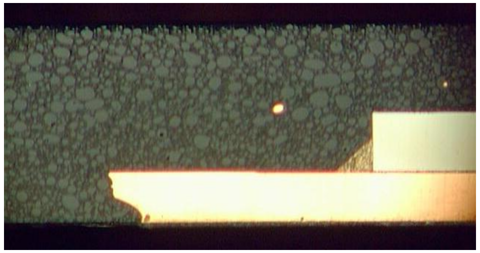
Driven by:

- Need for reduced moisture sensitivity (lead-free)
- "Going Green" trend: Halogen-free plastics
- Die stress: new IC-dielectrics
- Cost

→ Electronic component manufacturers introduced highly SiO_2 filled (85%) "Green mold compounds"

Greenpeace dashboard





February 10, 2010 CN-021010

Customer Notification

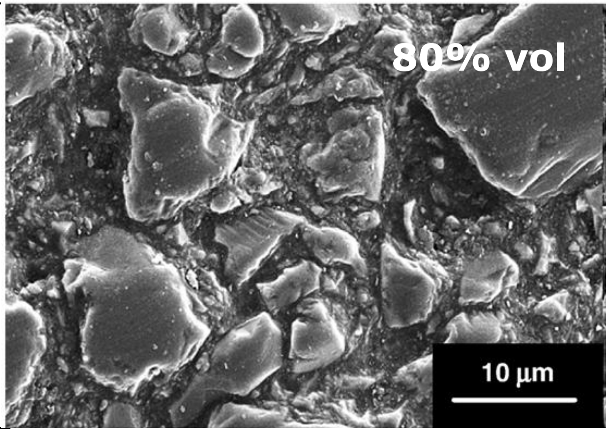
Mold Compound Change

Dear Valued Customer:

This notification is for the purpose of informing you of that our Assembly supplier is converting all mold compounds to green material sets.

Purpose

Due to their worldwide GREEN policy, ASE will transfer all devices which use non-green molding compounds to green molding compounds.



2. Green molding compounds

The change-over took place between 2005-2010

(from a leading semiconductor supplier)

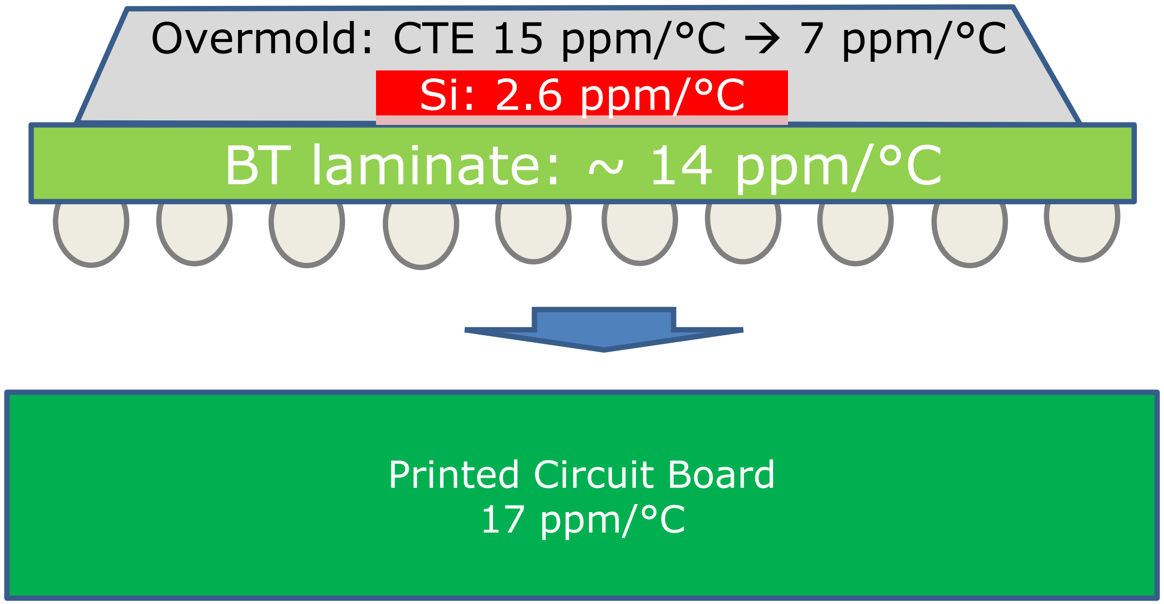
- High penetration level of highly filled GMC

- All plastic components: SOIC, TSOP, QFN, BGA,...
- Customer notification is MISLEADING!
- 2nd level interconnect reliability has not been considered!?

Customer Impact

No customer impact is anticipated with this change; there is no change to form, fit, or function.

3. Impact of Green molding compounds

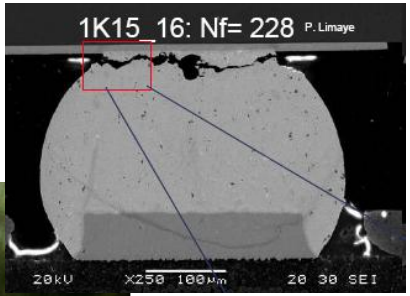


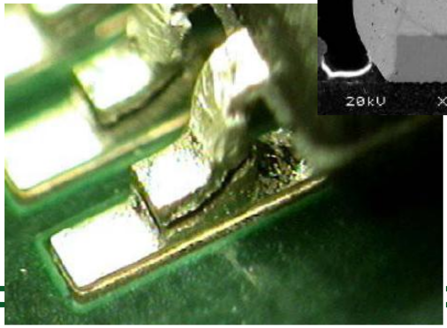
1. Better CTE match with silicon → lower stress in Si die ☺
2. Higher CTE mismatch with BT laminate → more warpage of the package with temperature changes ☹
3. Higher CTE mismatch with PCB → higher stress in the solder connections ☹

3. Impact of Green molding compounds

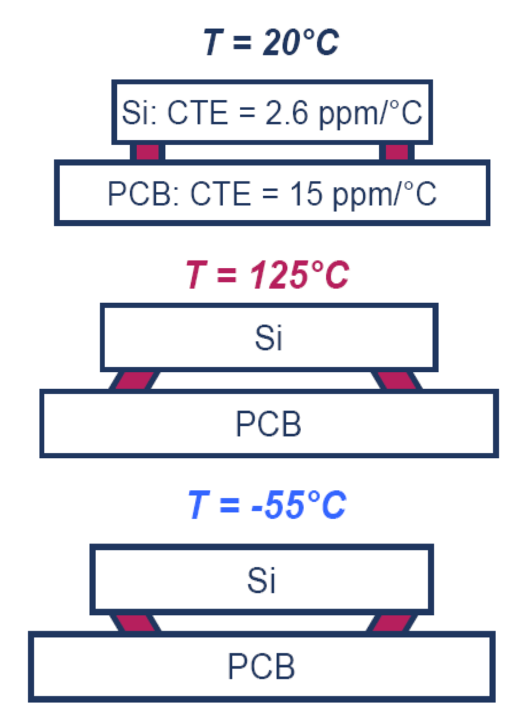
- High SiO_2 filling creates molding compound with very low thermal expansion: 6-10 ppm.
  For reference: CTE Al_2O_3 = 6.7ppm (ex. CBGA)
- In the past it matched the PCB CTE of 15-18ppm
- This creates an upto **tenfold** increase in thermal mismatch between component and PCB.
- Depending on component and PCB details:
  A major increase of thermo-mechanical strain of solder joints and component leads (TSOP).

A major threat to solder joint and interconnect reliability

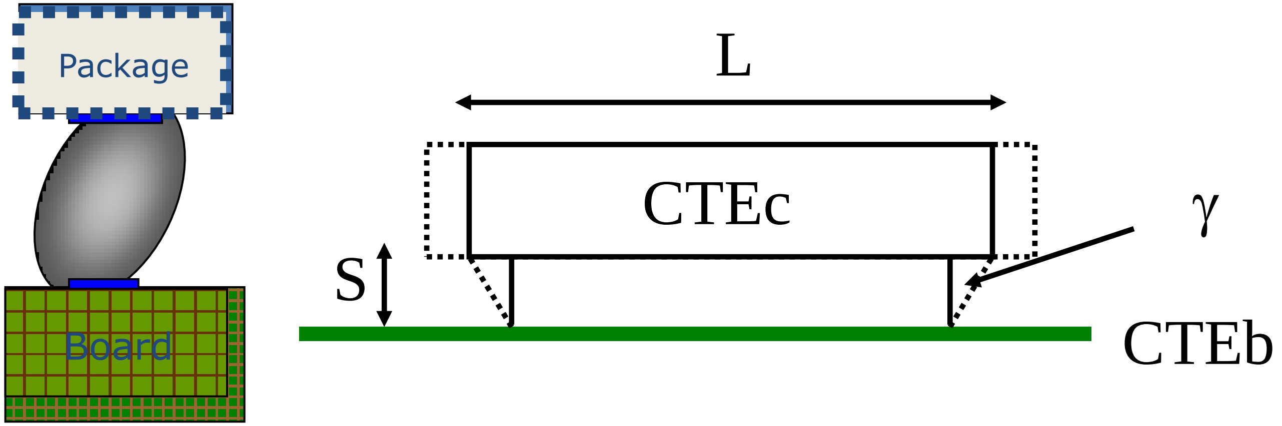




3.1 Solder joint fatigue



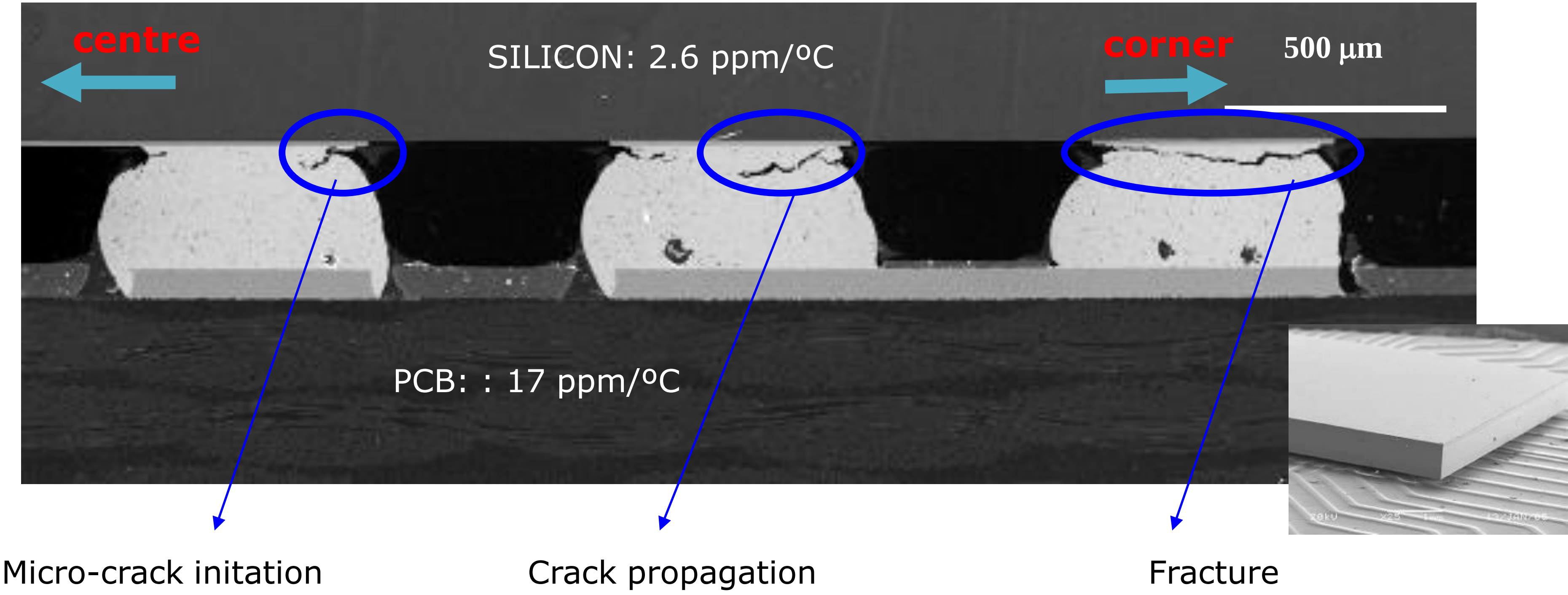
Thermally induced stress-strain



- Joint strain ~ γ ~ $\Delta L/S$ ~$L(CTEc - CTEb)\Delta T/2S$
- Thermo-mechanical strain increases with:
  - increasing thermal mismatch (ceramic, bare silicon, **GREEN MOLD COMPOUND**≈ceramic)
  - increasing component size (**large BGAs**, large dies)
  - decreasing stand-off (**small ball sizes, leadless packages**!)
  - increasing thermal cycling (**outdoor, high power dissipation**)

3.1 Solder joint fatigue

- ***Example***: 10x10 mm² CSP soldered on FR4 PCB after 500 temperature cycles (0 to 100˚C)



3.1 Solder joint fatigue GMC vs. ceramic

- CTE GMC (6-10ppm) comparable to ceramic (Al_2O_3=6.7ppm) CTE
- But elasticity of GMC (E-modulus) is an order of magnitude smaller than that of ceramics→ ten times more flexible.

Consequences

- Package flexibility becomes a dominating factor in the solder joint reliability.
- The simple Engelmaier approach to solder joint reliability of IPC-D-279, cannot be applied to plastic packages.

The cyclic fatigue damage term for leadless SM solder attachments, for which the stresses in the solder joints exceed the solder yield strength and cause plastic yielding of the solder, is

$$\Delta D(\text{leadless}) = \left[\frac{F L_D \, \Delta(\alpha \Delta T)}{h}\right]$$

[Eq. A-3]

3.2 What is required?
Some figures for reference (IPC-9701)

Table 3-1 Product Categories and Worst-Case Use Environments for Surface Mounted Electronics (For Reference Only)

Product Category (Typical Application)	Temperature, °C / °F(1)		Worst-Case Use Environment						
	Storage	Operation	Tmin(2) °C / °F	Tmax(2) °C / °F	ΔT(3) °C / °F	t_D(4) hrs	Cycles/year	Typical years of Service	Approx. Accept. Failure Risk, %
Consumer	-40/85	0/55	0/32	60/140	35/63	12	365	1-3	1
Computers and Peripherals	-40/85	0/55	0/32	60/140	20/36	2	1460	5	0.1
Telecomm	-40/85	-40/85	-40/-40	85/185	35/63	12	365	7-20	0.01
Commercial Aircraft	-40/85	-40/85	-55/-67	95/203	20/36	12	365	20	0.001
Industrial and Automotive - Passenger Compartment	-55/150	-40/85	-55/-67	95/203	20/36 &40/72 &60/108 &80/144	12 12 12 12	185 100 60 20	10-15	0.1
Military (ground and shipboard)	-40/85	-40/85	-55/-67	95/203	40/72 &60/108	12 12	100 265	10-20	0.1
Space leo geo	-40/85	-40/85	-55/-67	95/203	3/5.4 to 100/180	1 12	8760 365	5-30	0.001
Military Aircraft a b c	-55/125	-40/85	-55/-67	125/257	40/72 60/108 80/144	2 2 2	100 100 65	10-20	0.01
Maintenance					&20/36	1	120		
Automotive (under hood)	-55/150	-40/125	-55/-67	125/257	60/108 &100/180 &140/252	1 1 2	1000 300 40	10-15	0.1

& = in addition

1. All categories may be exposed to a process temperature range of 18°C to 260°C [64.4°F to 500°F].
2. Tmin and Tmax are the operational (test) minimum and maximum temperatures, respectively, and do not determine the maximum ΔT.
3. ΔT represents the maximum temperature swing, but does not include power dissipation effects; for power dissipation calculate ΔT; power dissipation can make pure temperature cycling accelerated testing significantly inaccurate. It should be noted that the temperature range, ΔT, is not the difference between Tmin and Tmax ; ΔT is typically significantly less.
4. The dwell time, t_D, is the time available for the creep of the solder joints during each temperature half-cycle.

3.2 What is required? Some figures for reference (IPC-9701)

Computer and peripherals: ΔT=20K, 4cpd, 5y, 0.1%

– N63%(0-100°C) → 1250 cycles/5y

Telecom: ΔT=35K, 1cpd, 7-20y, 0.01%

– N63%(0-100°C) → >2000 cycles/7y…6000 cycles/20y

Industrial/automotive: ΔT=20K(50%)/40K(27%)/60K(16%)/80K(6%), 365cpy, 10-15y, 0.1%

– N63%(0-100°C) → >3000 cycles/10y…4500 cycles/15y

Commercial aircraft: ΔT=20K, 1cpd, 20y, 0.001%

– N63%(0-100°C) → 3500 cycles/20y

Military: ΔT=40K(27%)/60K(73%), 365cpy, 10-20y, 0.1%

– N63%(0-100°C) → 5500 cycles/10y…11000 cycles/20y

Notes:
- Acc. Factor: SnPb Norris-Landzberg eq.
- Weibull slope=6
- No power cycling
- Tmax= max. operation

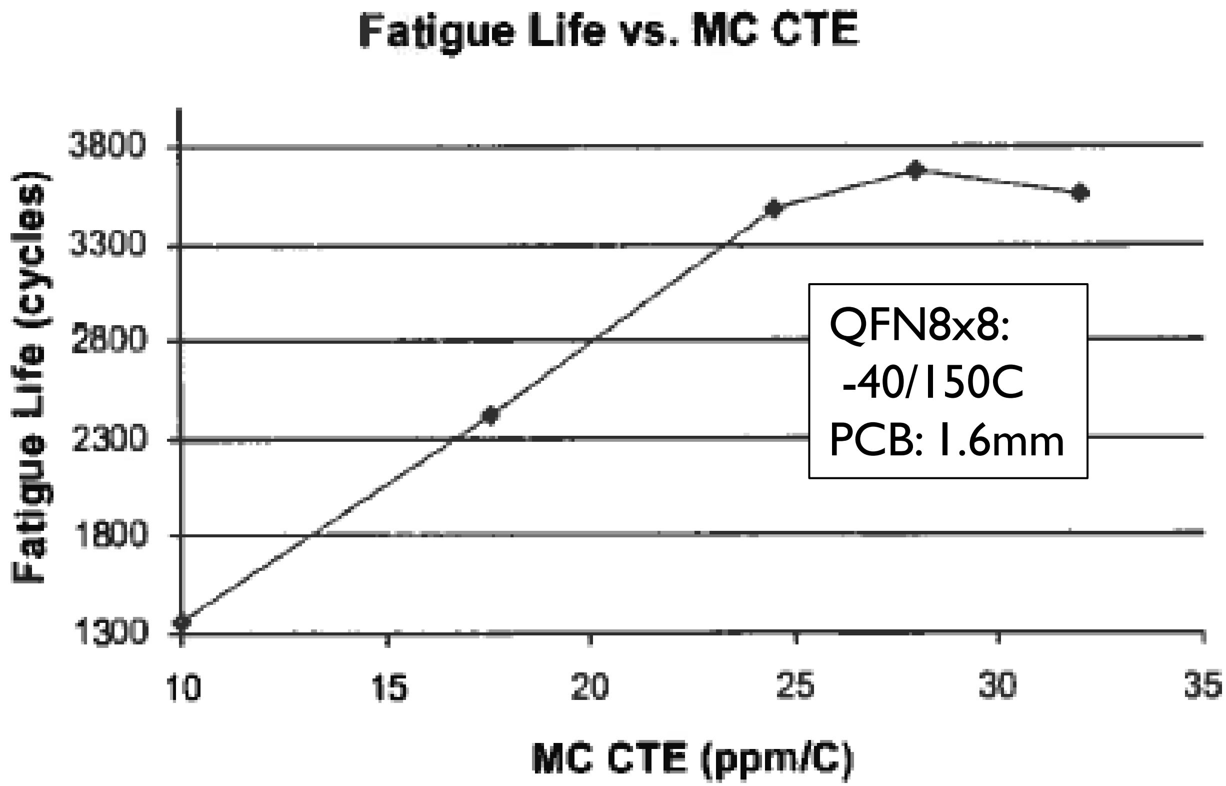
10 year lifetime requires

N63%(0-100°C) **>3000 cycles** (N63%(-40-125°C)>1500 cycles)

3.3 Literature: QFN simulation

- All simulations confirm reduction in lifetime with a factor 1 to 4.
- Higher CTE and lower E is recommended: opposite to GMC

T.Y. Tee et al., 2003



3.3 Literature: QFN simulation

TABLE V

EFFECTS OF MATERIAL PROPERTIES ON SOLDER JOINT

QFN (BLP) -55/125C

	Control	Run 1	[illegible]	[illegible] 3
CTE of Molding Compound (ppm/°C)	8 (EMC 1)	13 (EMC 2)	8 (EMC 1)	13 (EMC 2)
CTE of Leadframe (ppm/°C)	6.4 (Alloy-42)	6.4 (Alloy-42)	16.7 (Copper)	22 (Soft Alloy
Equivalent Creep Strain Range ($\Delta\varepsilon_{crp}$)	0.0300	0.0167	0.0106	0.00538
Fatigue Life based on $\Delta\varepsilon_{crp}$	468	1623	4259	17962
ΔW (MPa)	0.397	0.182	0.0836	0.0428
Fatigue Life based on ΔW	529	1028	1997	3536

2) The EMC 2 which has a high CTE content (13 ppm/°C) offers at least 1.9 fold improvement in fatigue life over the EMC 1 which has a lower CTE content (8 ppm/°C).

X. Zhang et al., 2002

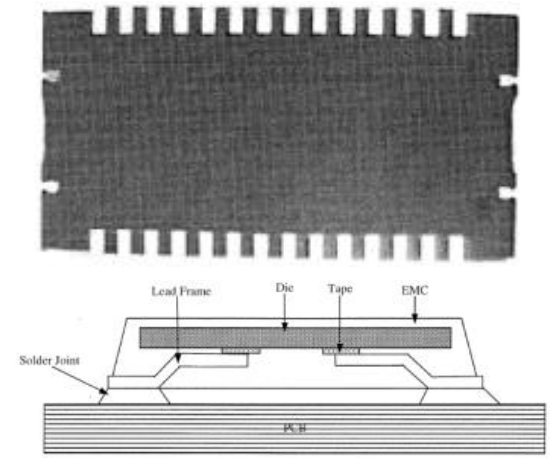


Fig. 2. Schematic diagram of the cross section of a 28-pin BLP package.

TABLE VI

EFFECTS OF SOLDER PAD SIZE AND THE THICKNESS OF THE PCB ON SOLDER JOINT RELIABILITY

CB Land Size (mm x mm)	Thickness of PCB (mm)	Temperature Profile	$\Delta\varepsilon_{crp}$	N ($\Delta\varepsilon_{crp}$)	ΔW (MPa)	N (ΔW)
1.2 x 0.6	0.4	Condition 1	0.021754	926	0.2539	774
1.2 x 0.6	0.4	Condition 2	0.0236735	774	0.1795	1041
1.2 x 0.6	1.2	Condition 1	0.028979	504	0.1975	528
1.2 x 0.6	1.2	Condition 2	0.033951	360	0.2811	710
1.2 x 0.45	0.4	Condition 1	0.0247	707	0.311	651
1.2 x 0.45	0.4	Condition 2	0.0235	786	0.1765	1056

3.3 Literature: BGA simulation

T.Y. Tee et al., 2006

BGA:
-40/125C

TABLE III
SUMMARY OF C²BGA PARAMETRIC STUDIES

Cases	Design Variations	Life (cycles)	% Diff	Warpage (μm)	% Diff
Control	**Control** (see Table 2)	**2238**	-	27	-
C1	Die size=3x3mm	[illegible]	[illegible]	[illegible]	[illegible]
C2	MC thickness=0.6mm, Die thickness=0.225mm	[illegible]	[illegible]	[illegible]	[illegible]
C3	Substrate thickness=0.22mm	[illegible]	[illegible]	[illegible]	[illegible]
C4	Solder ball diameter=0.4mm Solder ball height=0.3mm	[illegible]	[illegible]	[illegible]	[illegible]
C5	Die attach B	2238	0.00	26.7	-1.1
C6	Die attach C	2238	0.00	26	-3.7
C7	Mold compound D	2456	9.74	23.2	-14.1
C8	Mold compound C	1916	-14.4	34.5	27.8
C9	Mold compound B	1689	-24.5	39.9	47.8
C10	Slug attach B	2239	0.04	27	0.0

G. Effect of Mold Compound Material

The fatigue life ranking based on the four mold compound materials is

MC-D > MC-A > MC-C > MC-B.

Mold compound with higher CTE_1 (main effect) and lower modulus is preferred. The thermal cycling temperature range

3.3 Literature: experimental QFN

BOARD LEVEL ASSEMBLY AND RELIABILITY CONSIDERATIONS FOR QFN TYPE PACKAGES

Ahmer Syed and WonJoon Kang
Amkor Technology, Inc.
1900 S. Price Road
Chandler, Arizona

QFN7x7:
-55/125C
PCB: 1.6mm

(a) (b) (c)

Table 1. Mold Compound Material properties (supplier data) and BLR Result Summary

Mold Compound	alpha 1 (ppm/°C)	alpha 2 (ppm/°C)	Tg (°C)	Modulus (kg/mm^2)	Cycles Completed	# of Failures	1st Failure	Mean Life
EMC1	7	25	125	2650	1846	29	649	978
EMC2	7	33	120	2710	4100	29	2166	3150
EMC3	8	35	130	2650	5012	22	1219	2384
EMC4	9	35	150	2800	5012	22	2700	3822
EMC5	10	42	135	2400	5657	12	3747	5320
EMC6	11	45	135	2400	5012	12	3578	4708
EMC7	12	49	130	1900	5012	3	4218	NA
EMC8	14	43	185	1800	5657	24	3684	5090

Comprehensive board-level solder joint reliability modeling and testing of QFN and PowerQFN packages

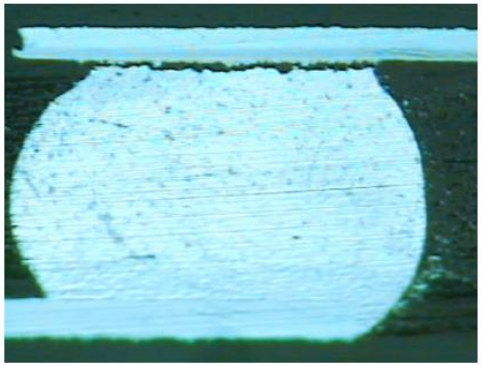
Tong Yan Tee [a,*], Hun Shen Ng [a], Daniel Yap [a], Zhaowei Zhong [b]

T.Y. Tee et al., 2003

Thermal cycling test results

Case	Package	Dominant effect	β (slope)	η (cycles)
1	QFN-4×4	Mold compound CTE = 10 ppm/°C	3.92	3131
2	QFN-4×4	Mold compound CTE = 16 ppm/°C	7.57	4894
3	QFN-4×4	Die thickness = 0.24 mm	5.40	4646
4	QFN-4×4	Die thickness = 0.36 mm	1.66	2743
5	QFN-8×8	75% center pad soldering	4.94	1242
6	QFN-8×8	91% center pad soldering	4.85	1426
7	QFN-8×8	Without solder fillet	8.09	631
8	QFN-8×8	With solder fillet	5.85	871

QFN:
-40/125C
PCB: 1.6mm



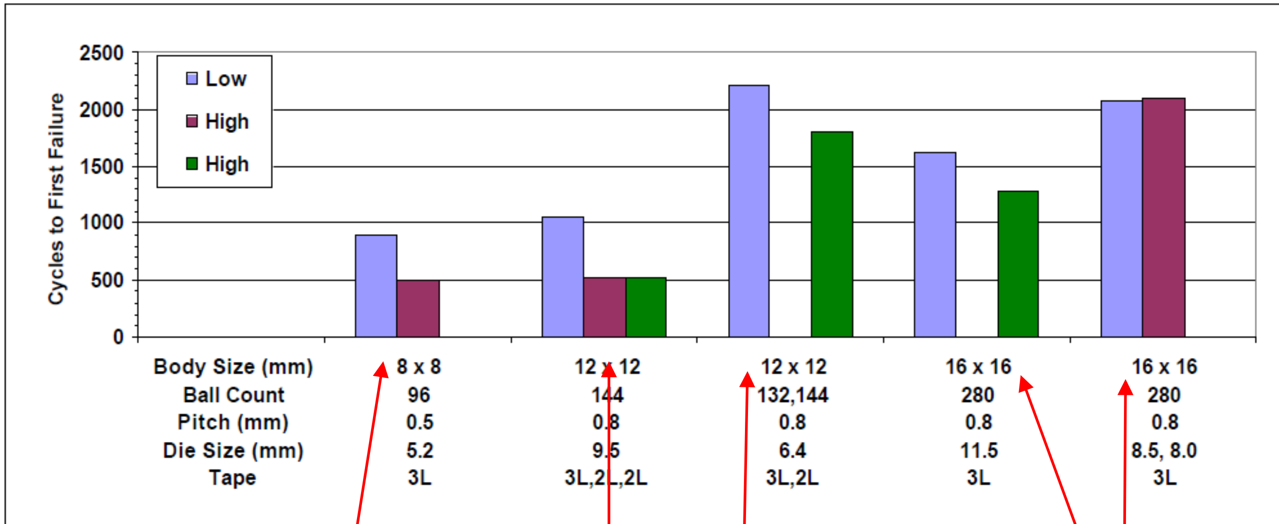
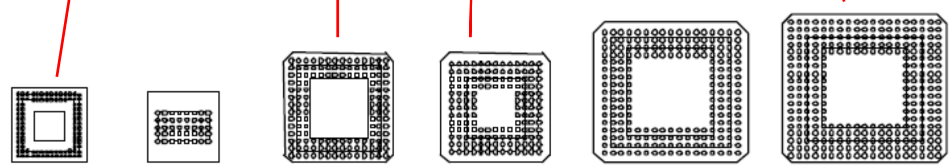


Figure 9. Fatigue life decreases higher filler content mold compound (0.85mm thick test board, –40C ⇔ 125C, 1 cycle/hr).

SOLDER JOINT FATIGUE LIFE OF FINE PITCH BGAs - IMPACT OF DESIGN AND MATERIAL CHOICES

Robert Darveaux[1], Jim Heckman[1], Ahmer Syed[1], and Andrew Mawer[2]

(1999)



8 mm-96	7.5mm-40	12 mm-132	12 mm-144	15mm-208	16mm-280
0.5 mm pitch	0.75 mm pitch	0.8 mm pitch	0.8 mm pitch	0.8 mm pitch	0.8 mm pitch
Die Size:	Die Size:	Die Size:	Die Size:	Die Size:	Die Size:
6.5x6.5 mm	3.5x5.5 mm	9.5x9.5 mm	9.5x9.5 mm	9.5x9.5 mm	8.5x8.5 mm
5.2x5.2 mm		6.4x6.4 mm	6.4x6.4 mm	12.0x12.0 mm	11.5x11.5 mm
3.5x3.5 mm					

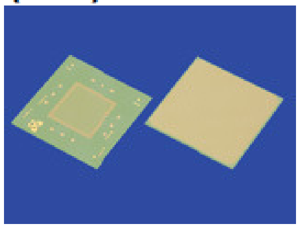
Effect of Mold Compound Filler Content

Shown in Figure 9 are several data sets comparing low and high filler content mold compounds. It is seen that the higher filler content mold compound can cut the fatigue life in half. The effect was less severe for packages with smaller relative die size or a larger ball count.

3.3 A view from the ceramic packaging world

KYOCERA THE NEW VALUE FRONTIER

Ceramic Packages for Large Scale Integration (LSI) Devices



Flip Chip HITCE LTCC BGA Package

Kyocera provides both ceramic and organic packages for Large Scale Integration (LSI) devices. In addition to alumina (Al2O3) ceramics, we produce aluminum nitride (AlN) with high thermal conductivity (150W/mK), as well as Low Temperature Co-Fired Ceramic (LTCC) packages with high (12.3ppm/K) and low (3.4ppm/K) coefficients of thermal expansion.

→ Material Properties

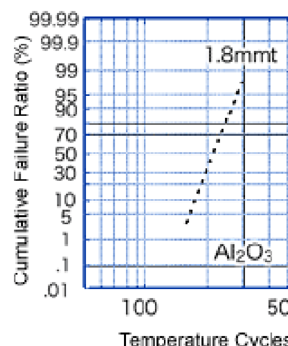
⇨ Organic Packages (KYOCERA SLC Technologies)

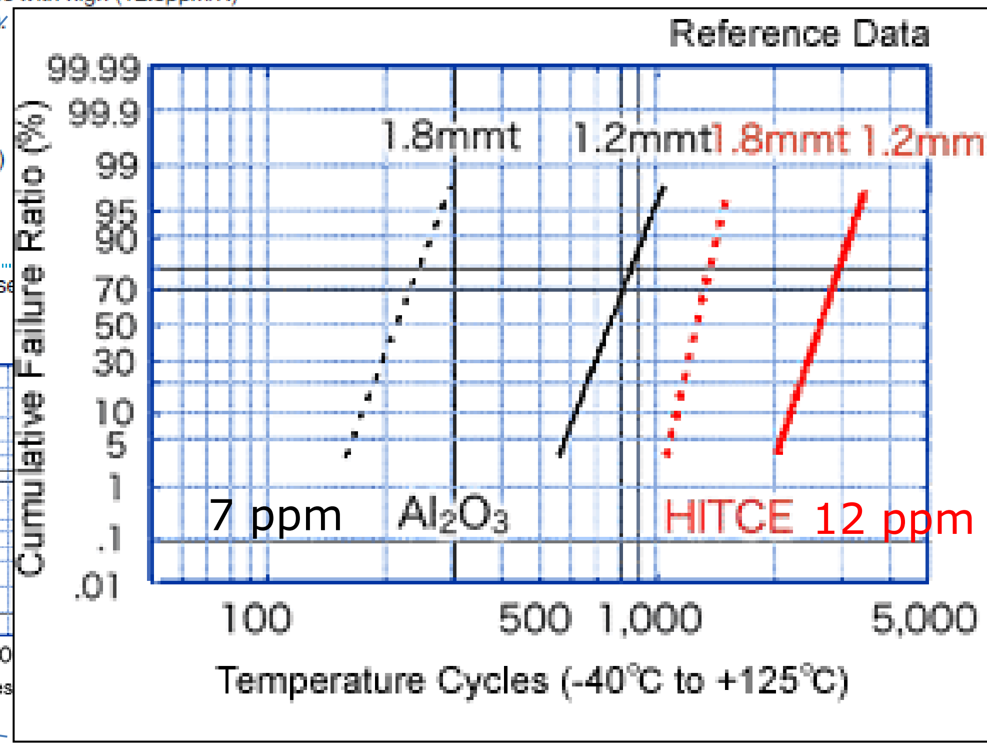
■ High Second Level Reliability

Kyocera's HITCE LTCC material offers a coefficient of thermal expansion (CTE) close boards, providing high reliability in board assembly.

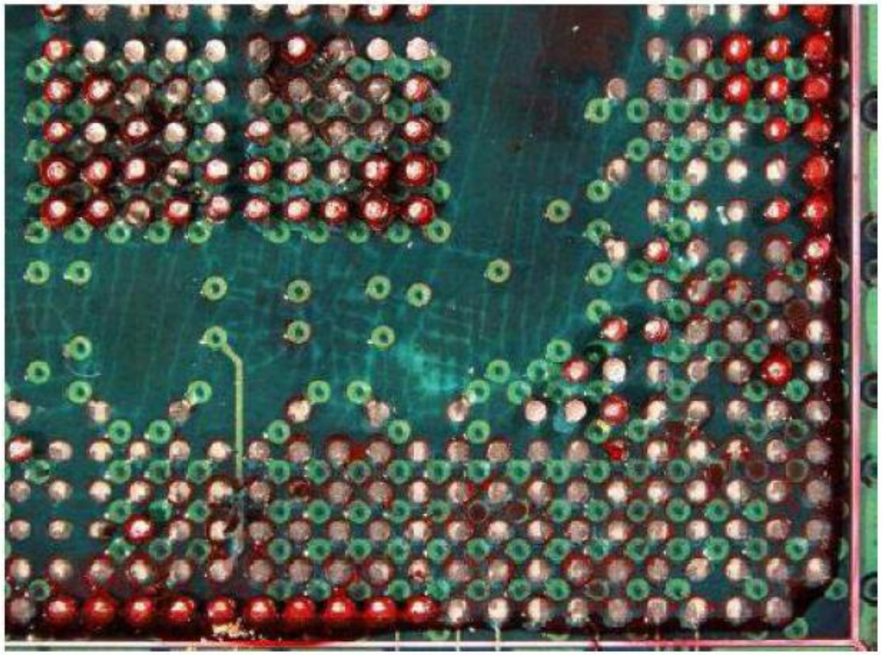
·CTE: 12.3ppm/K (R.T. to 400°C)
·Young's Modulus of Elasticity: 74GPa

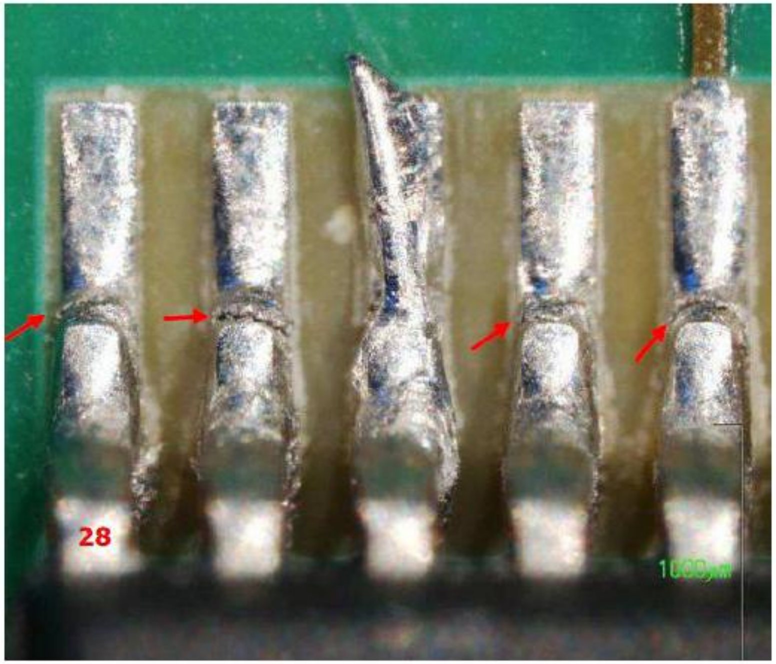
Second Level Reliability Test Samples
Ceramic Package
  Configuration: BGA (1.27mm pitch)
  Materials: Alumina (Al2O3), HITCE LTCC
  Outer Dimension: 33mmSQ
  Thickness: 1.2mm and 1.8mm
Motherboard
  Material: FR-4 (CTE:15ppm/K)
  Outer Dimension: 65mmSQ
  Thickness: 1.6mm





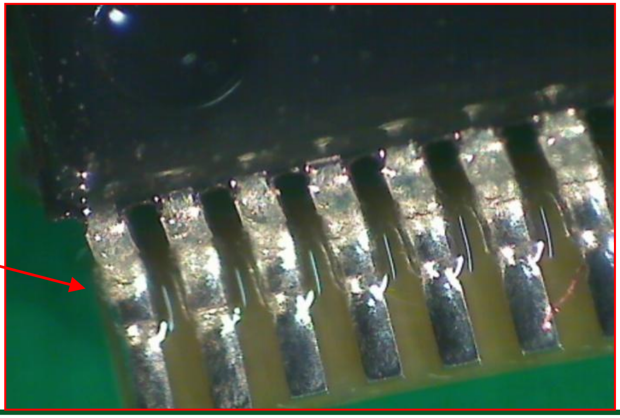
3.4. Experimental results (2)





Solder joint failure: BGA and TSOP II

Lead failure: TSOP I – Cu leadframe!

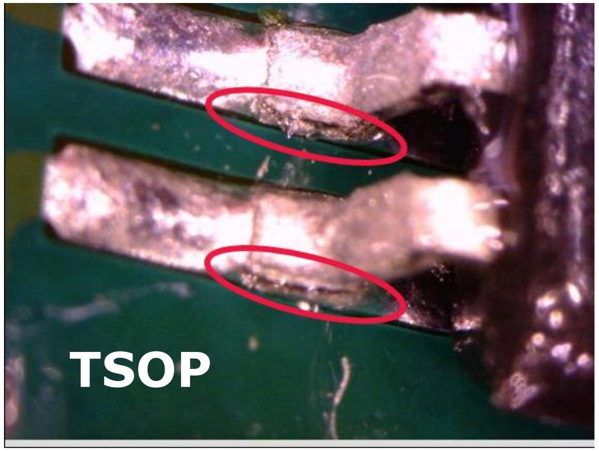


3. Impact of Green molding compounds

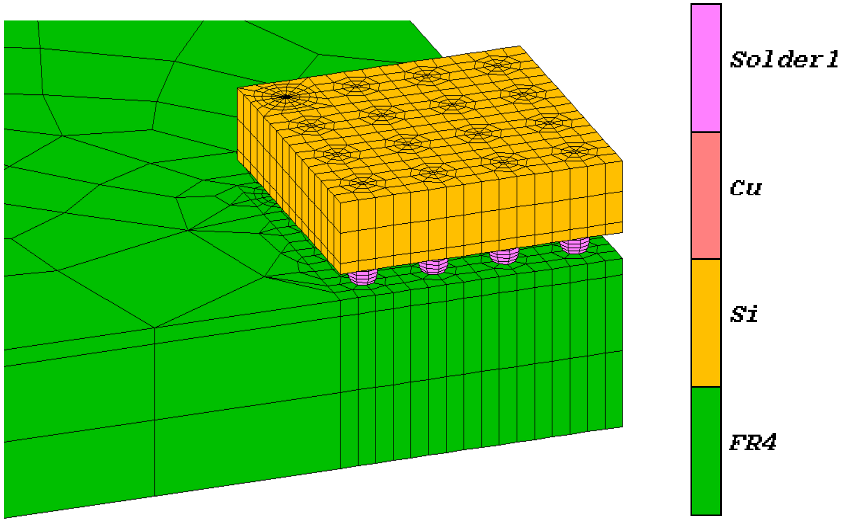
Package Type	Mean life time with non-green compound (CTE ~ 15 - 18 ppm/°C)	Mean life time with green compound (CTE ~ 6-8 ppm/°C)	Life time reduction introducing green compounds
BGA	~ 1100 cycles	~ 500 cycles	~55%
QFN	5090 cycles	978 cycles	~80%

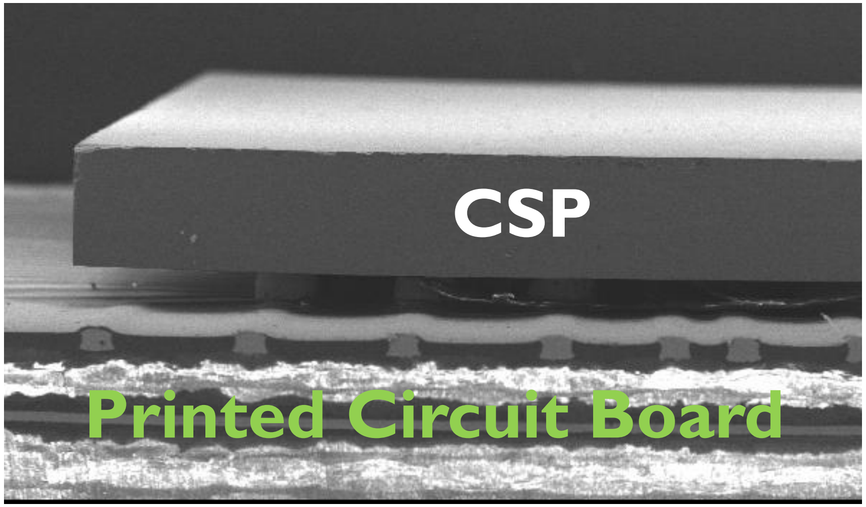
Most critical components:

- Large TSOP
- BGA
  - Partially populated
  - Small pitch
- QFN



Finite Element Model

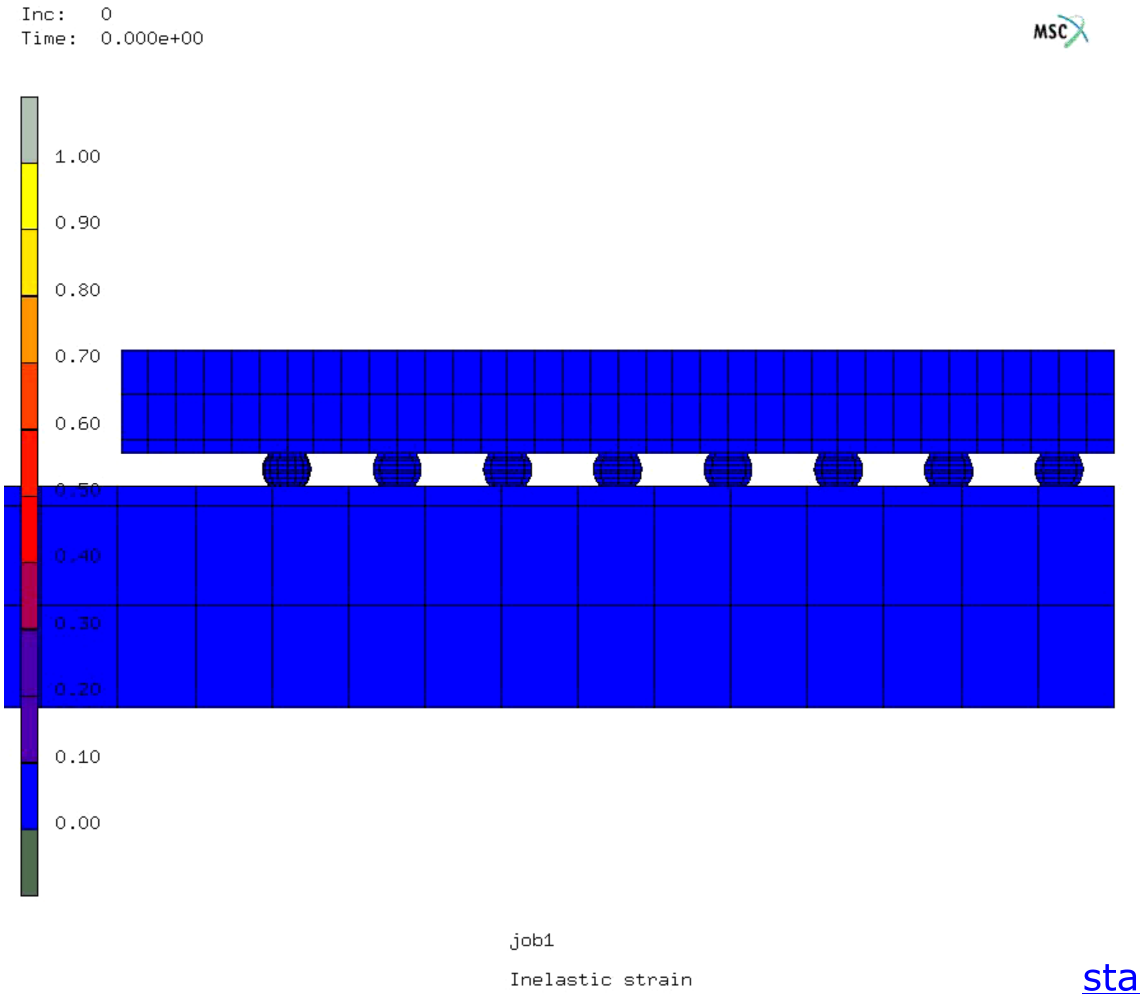




Applied load: temperature cycle

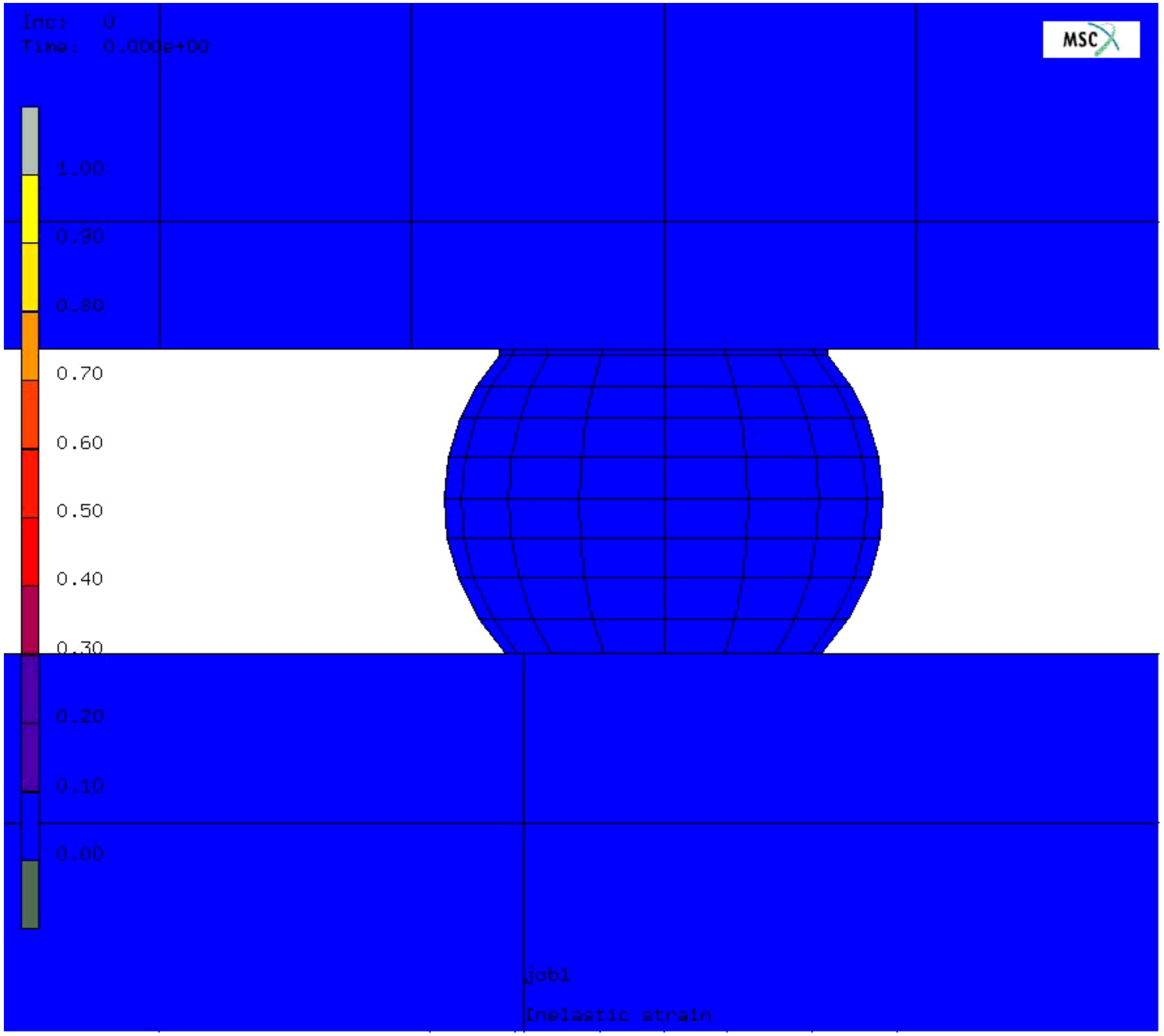
(= externally applied or through internal power dissipation)

4. Basics of solder joint failure modeling



start

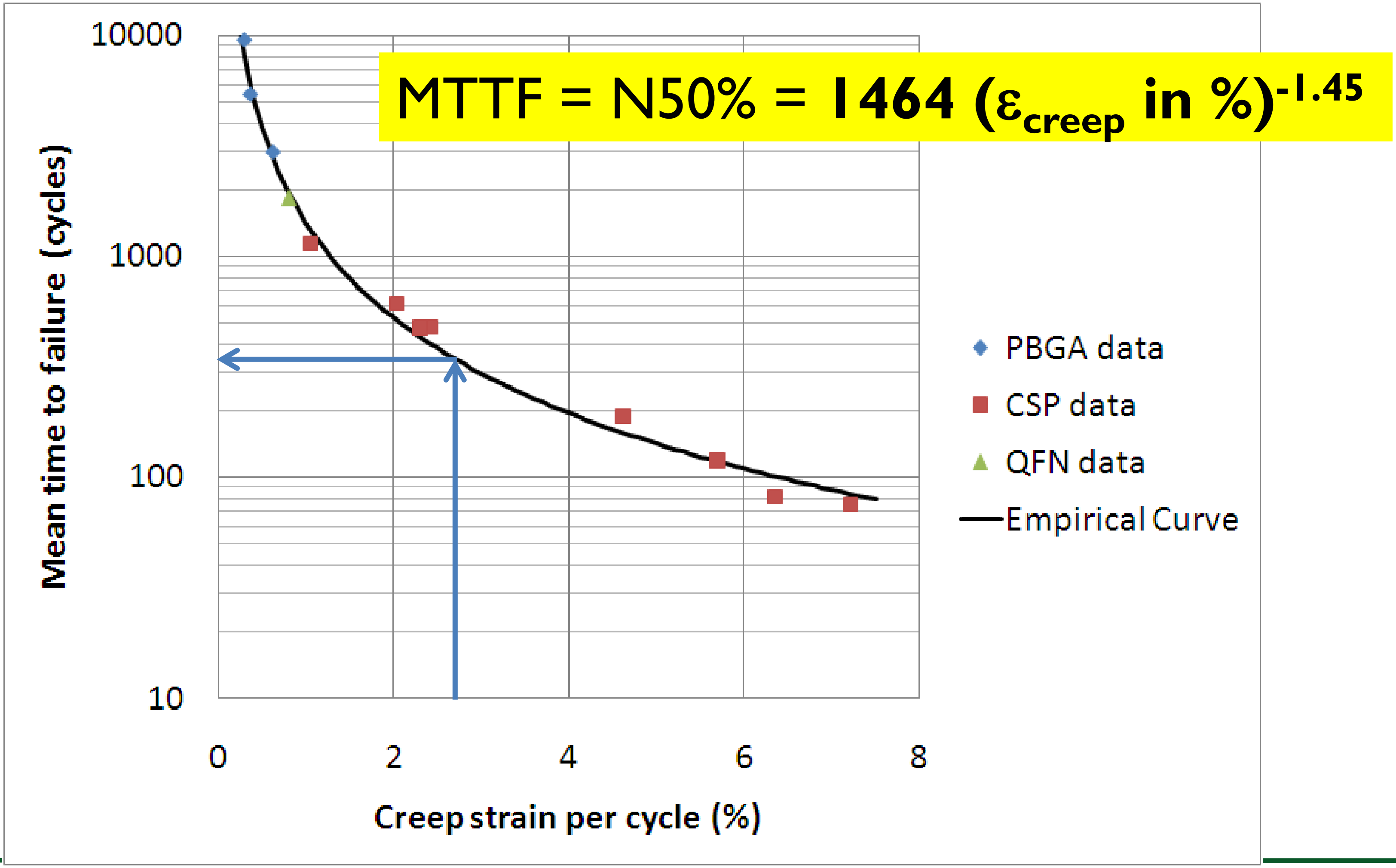
4. Basics of solder joint failure modeling



start

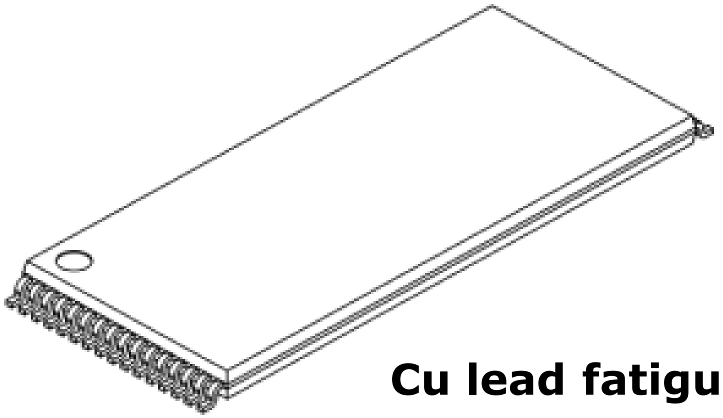
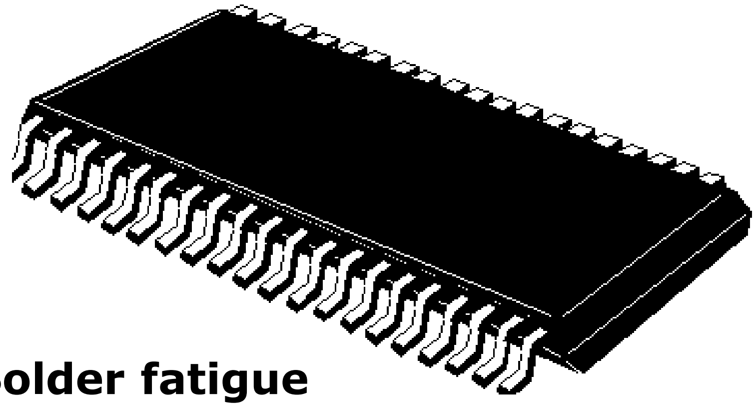
4. Basics of solder joint failure modeling

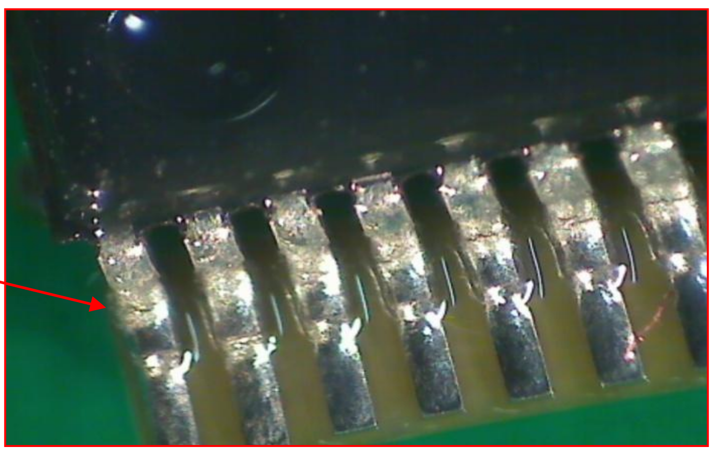
Empirical curve for Sn-Ag-Cu solder materials

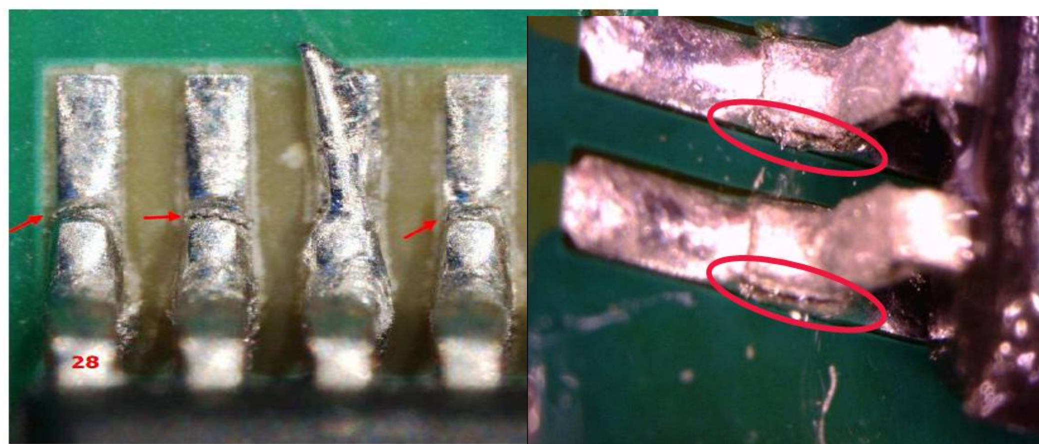


5. Reliability of TSOPI & TSOPII

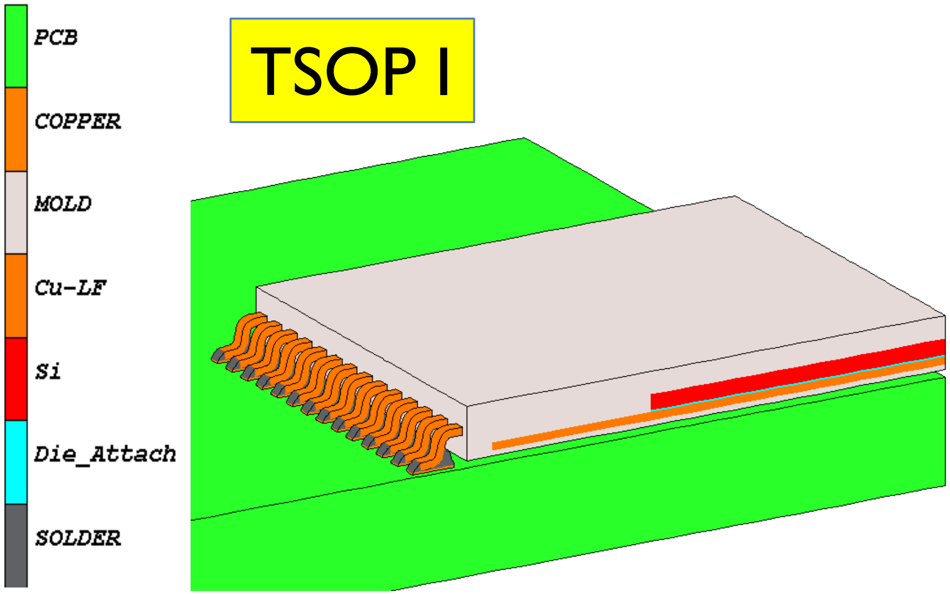
Package size: ~ 20 X 14 mm^2

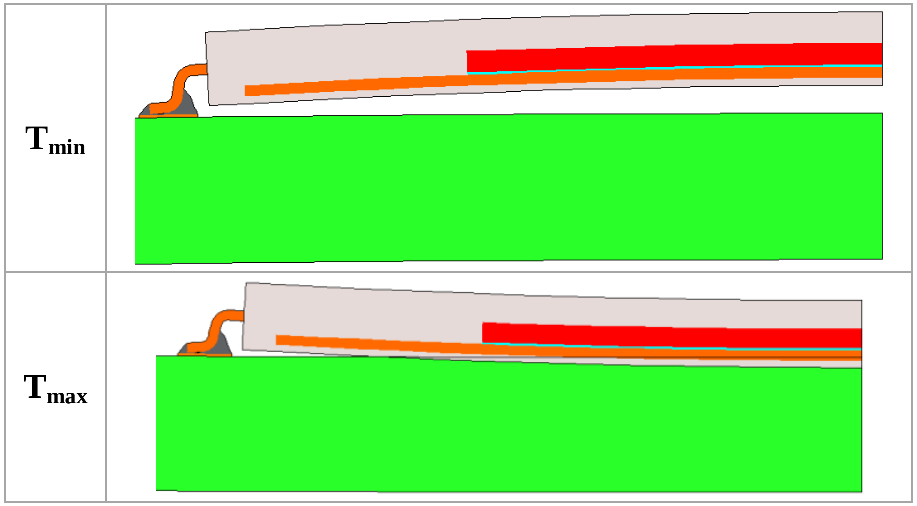
TSOP I (56 pins)	TSOP II (54 pins)
 **Cu lead fatigue**	 **Solder fatigue**

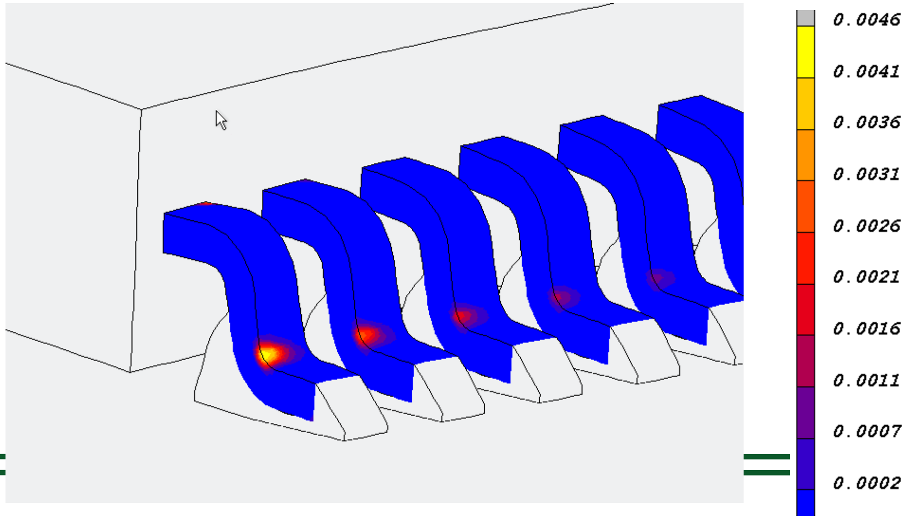




5. Reliability of TSOPI



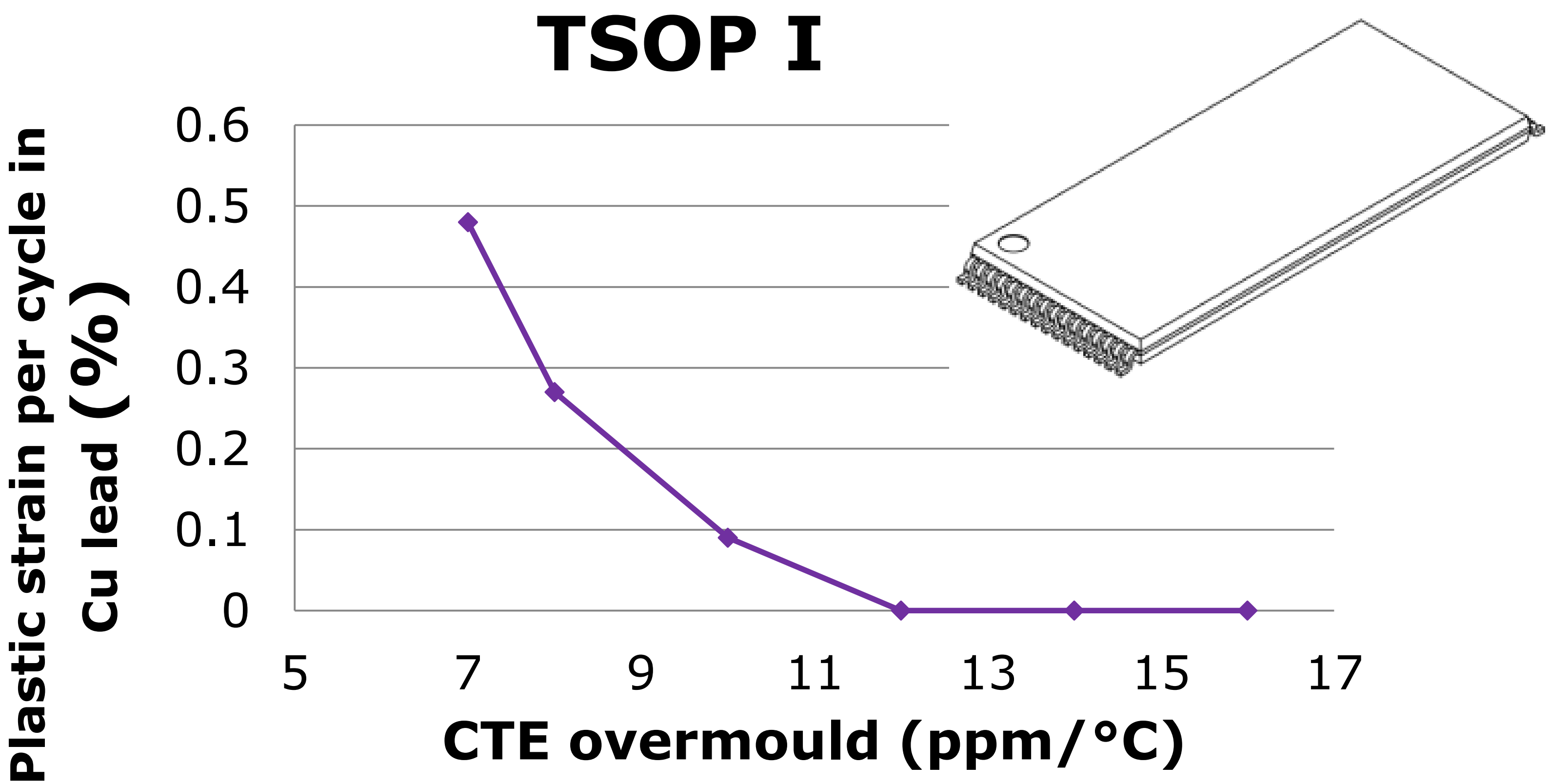




Plastic deformation in Cu leads

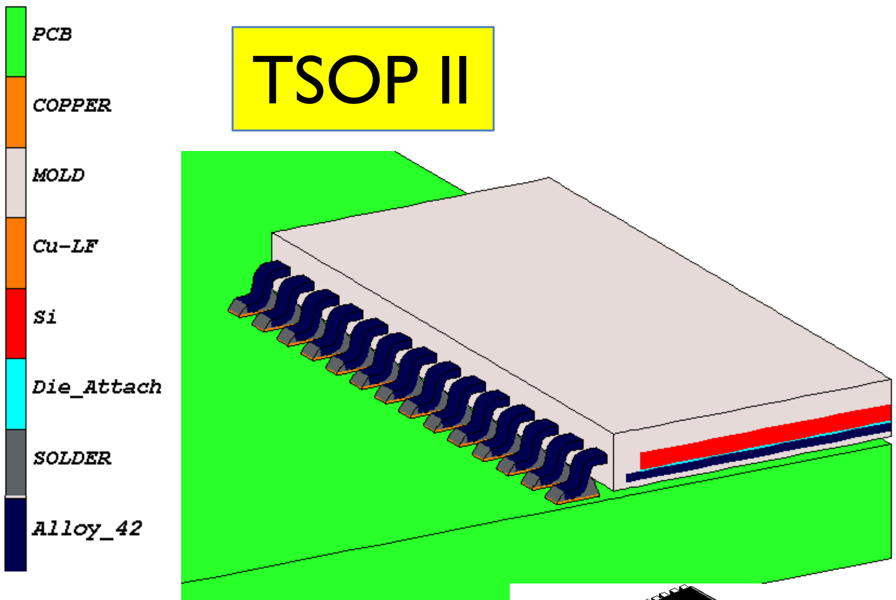
B. Vandevelde, M. Lofrano, G. Willems:
Green Mold Compounds: Impact on Second Level Interconnect Reliability
EPTC, Singapore, 12/2011

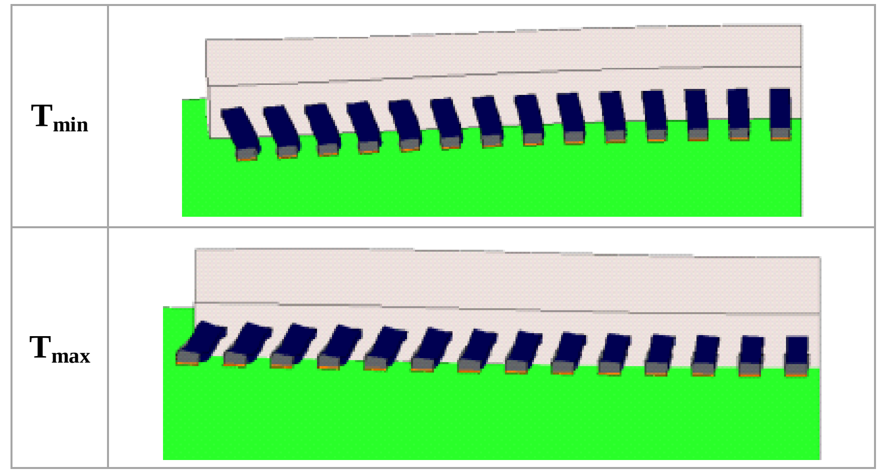
5. Reliability of TSOPI

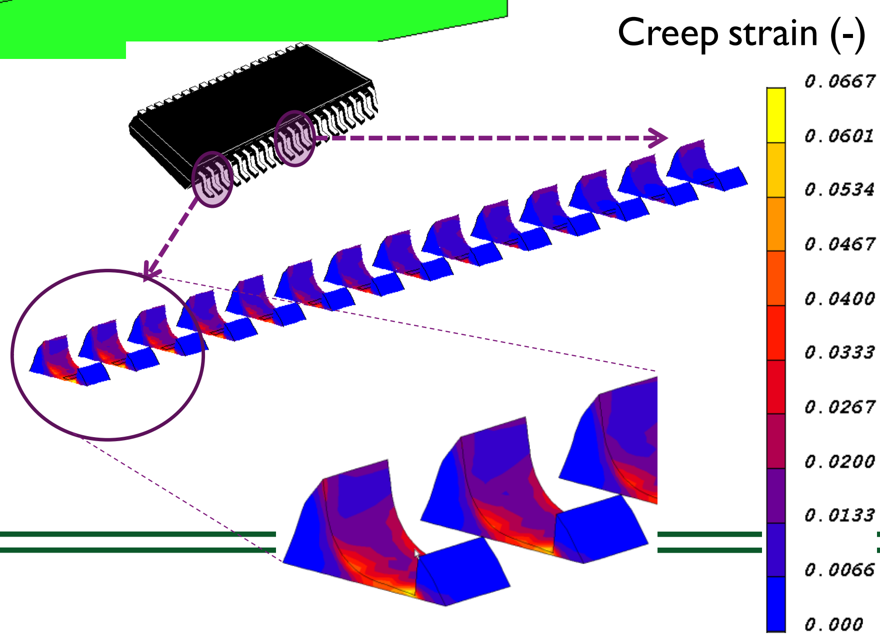


Bart Vandevelde et al. EPTC 2012

5. Reliability of TSOPII





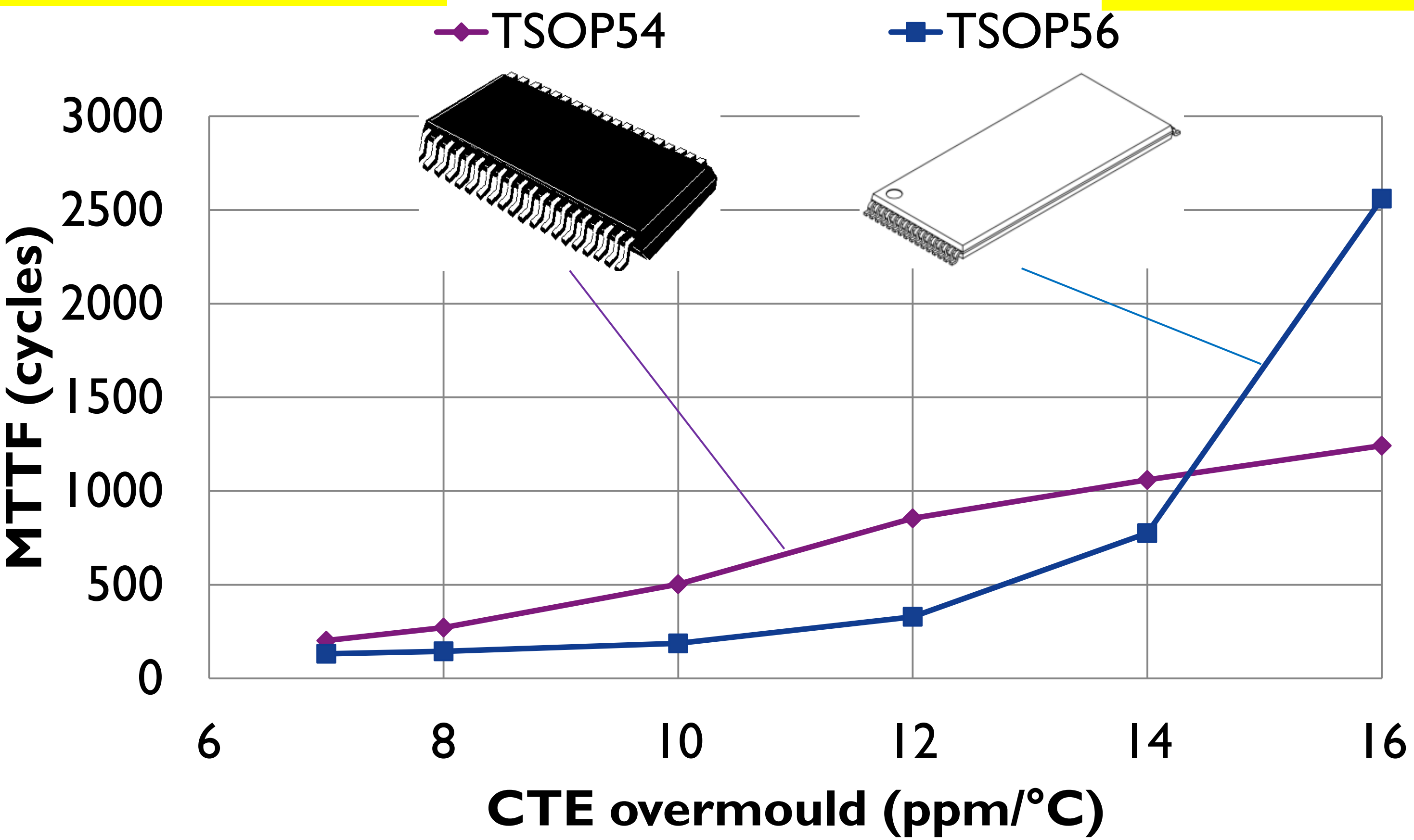


Bart Vandevelde et al.
EPTC 2012

5. Reliability of TSOP with Cu leadframe

85% reduction!

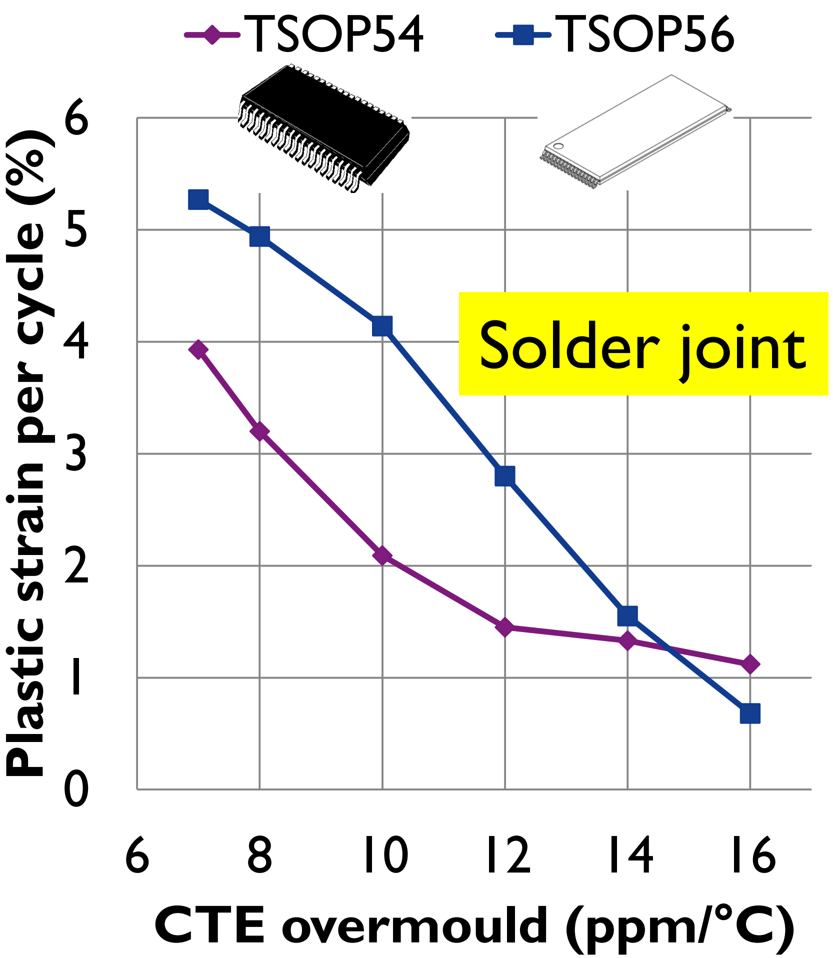
95% reduction!

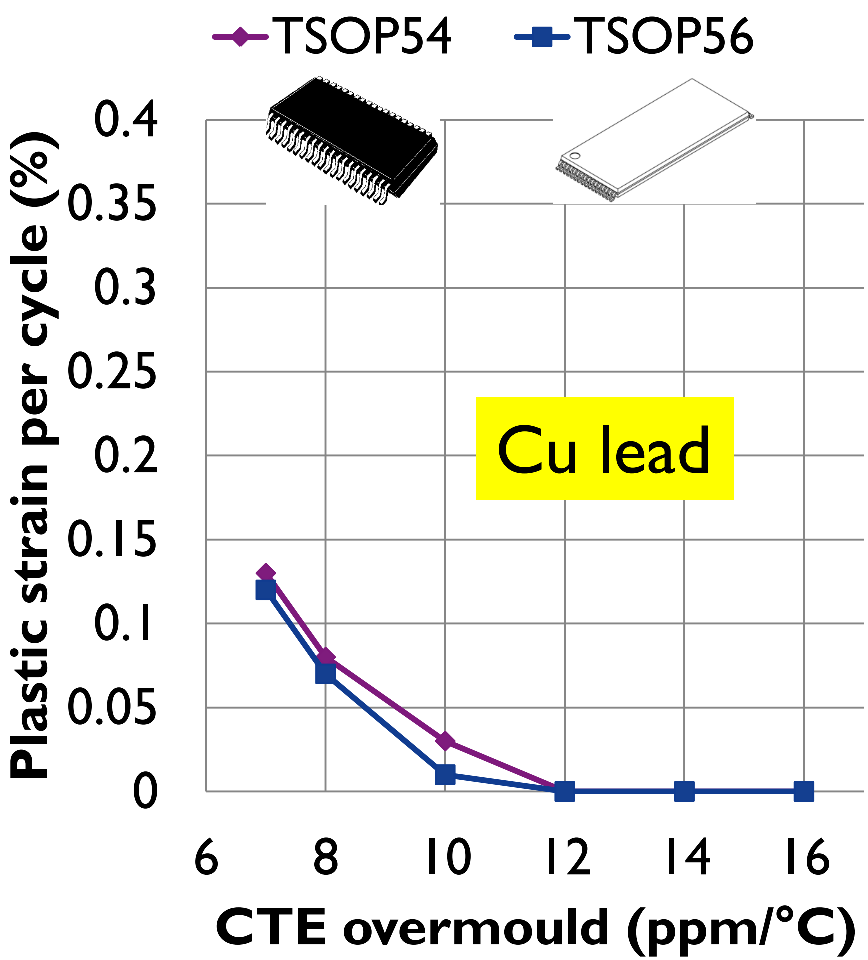


(Temperature cycles: 0 to 100˚C)

Bart Vandevelde et al. EPTC 2012

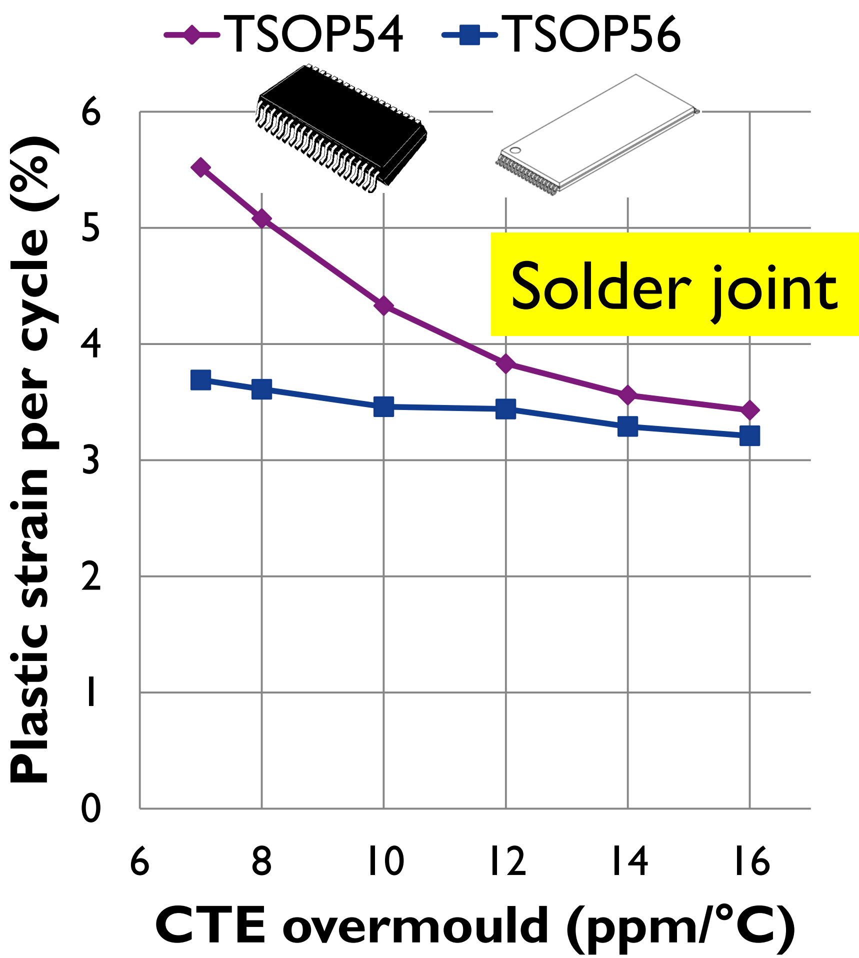
5. Reliability of TSOP with Cu leadframe

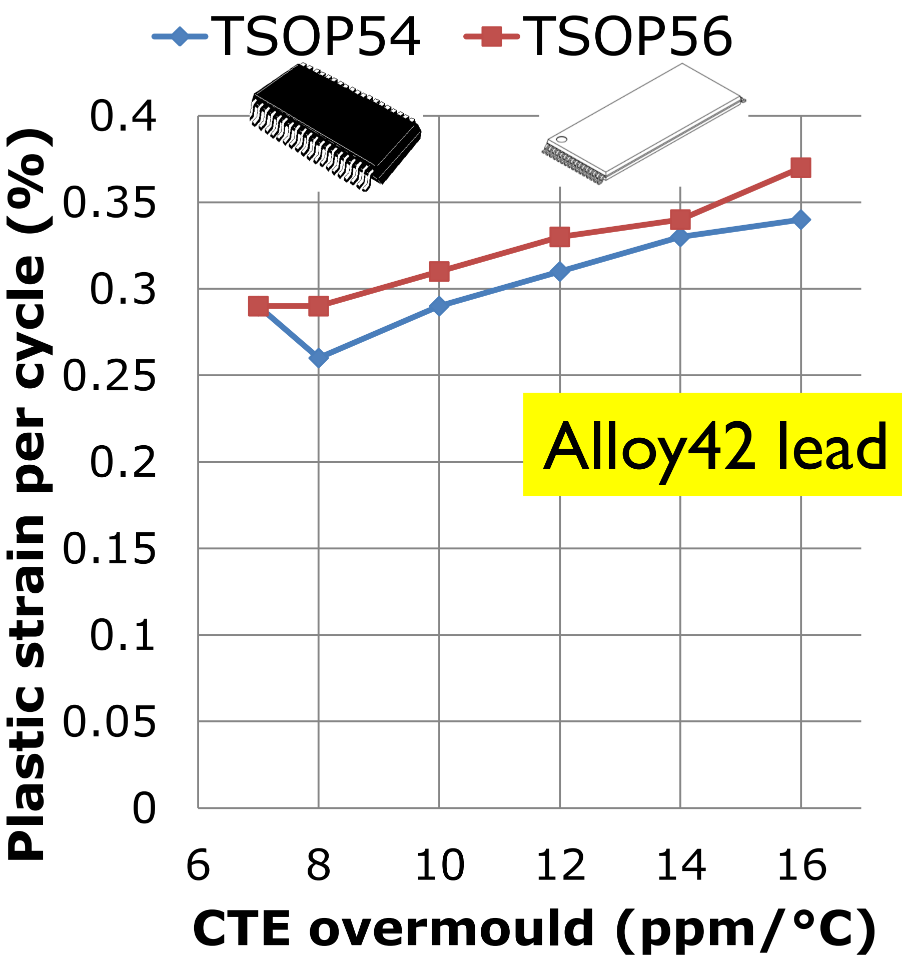




Bart Vandevelde - imec

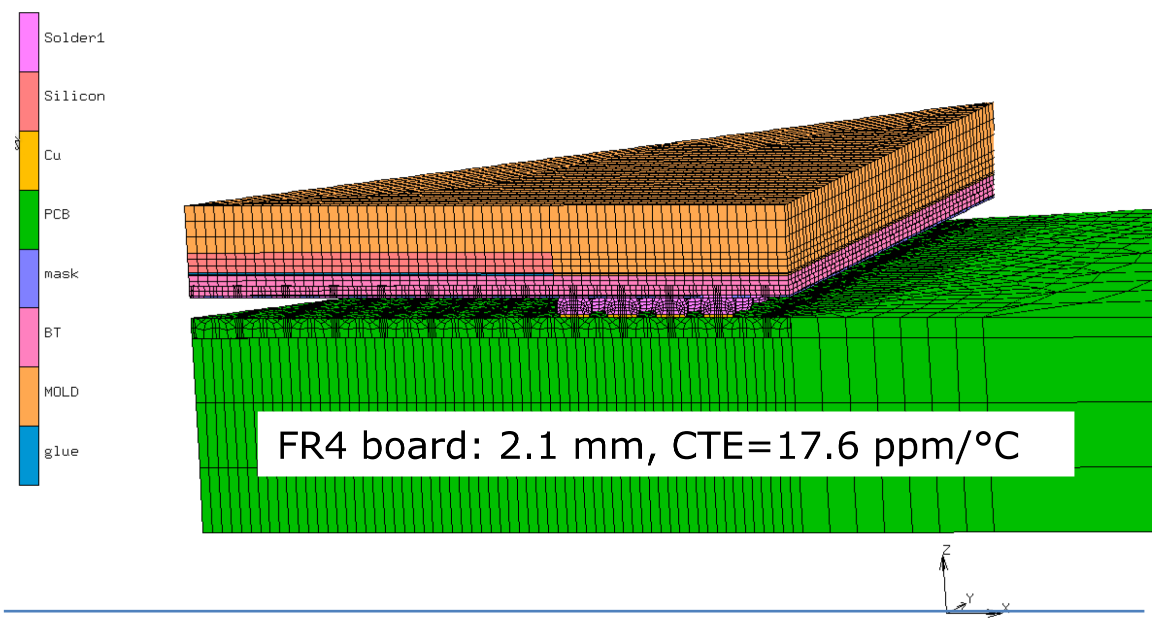
5. Reliability of TSOP with Alloy42 leadframe

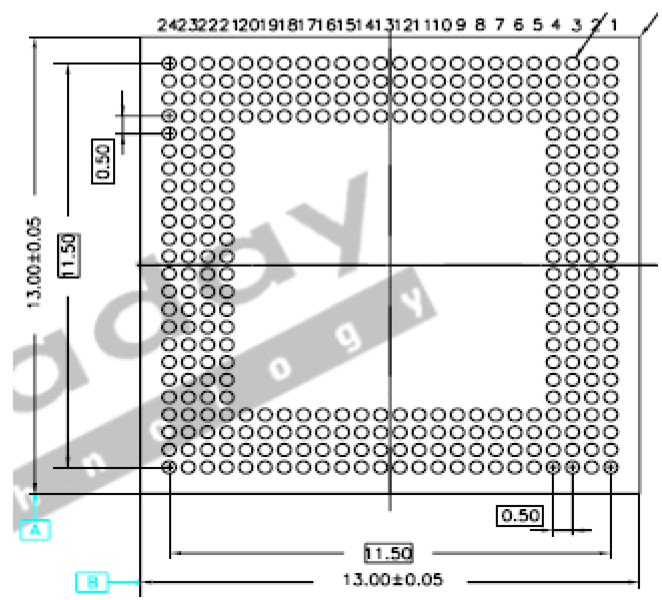




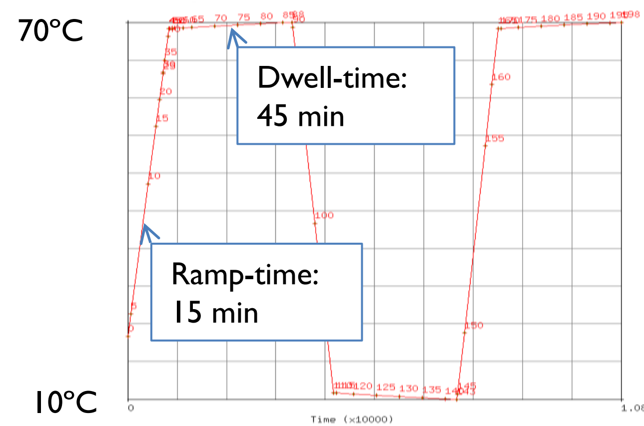
Bart Vandevelde - imec

6. Reliability of BGA
0.5mm partially populated PBGA



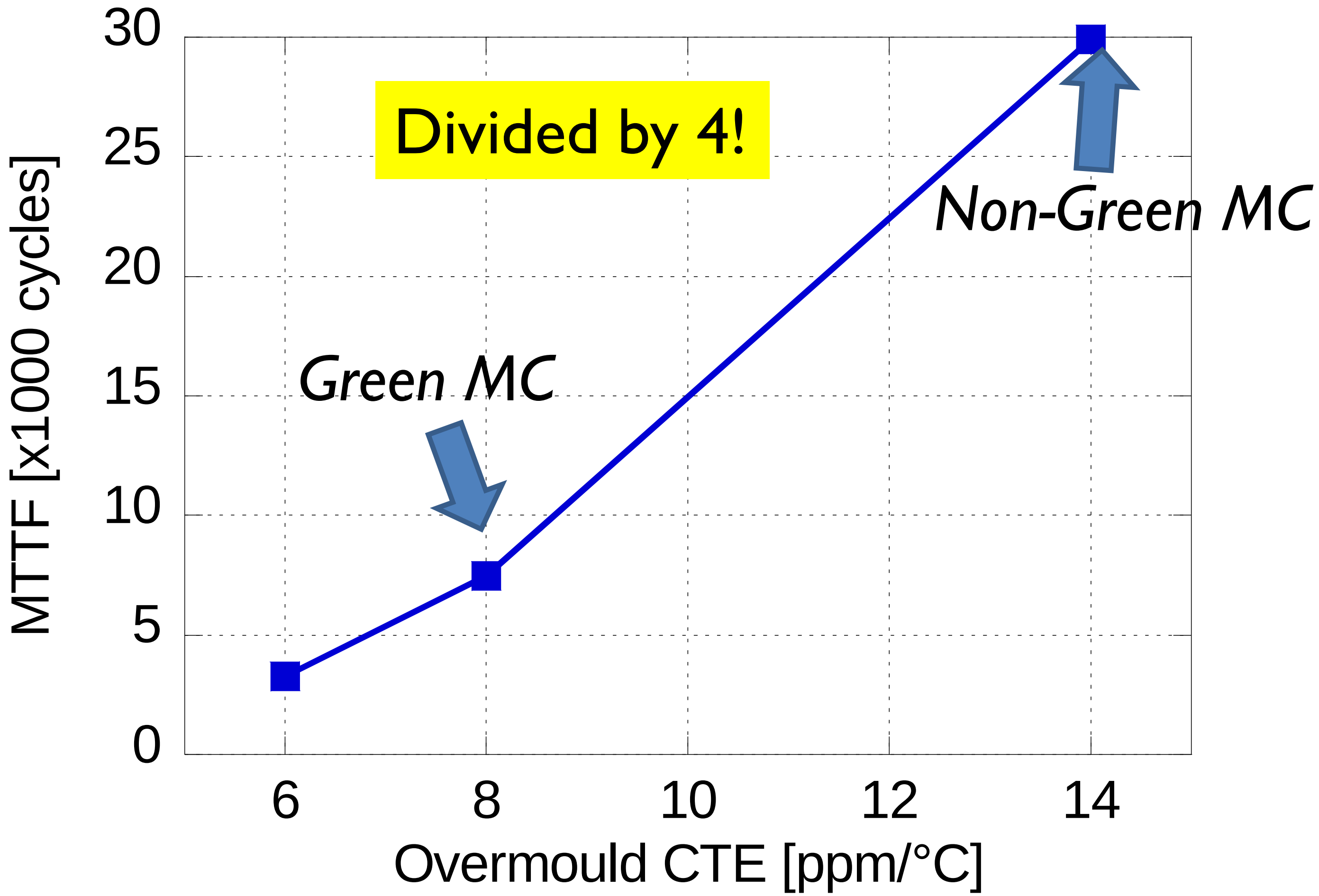


Ball size	0.3 mm
Ball pitch	0.5 mm
Size	13x13 mm^2
Array size	24x24 (4 rows – 320 balls)
Overmould CTE	8 ppm/°C

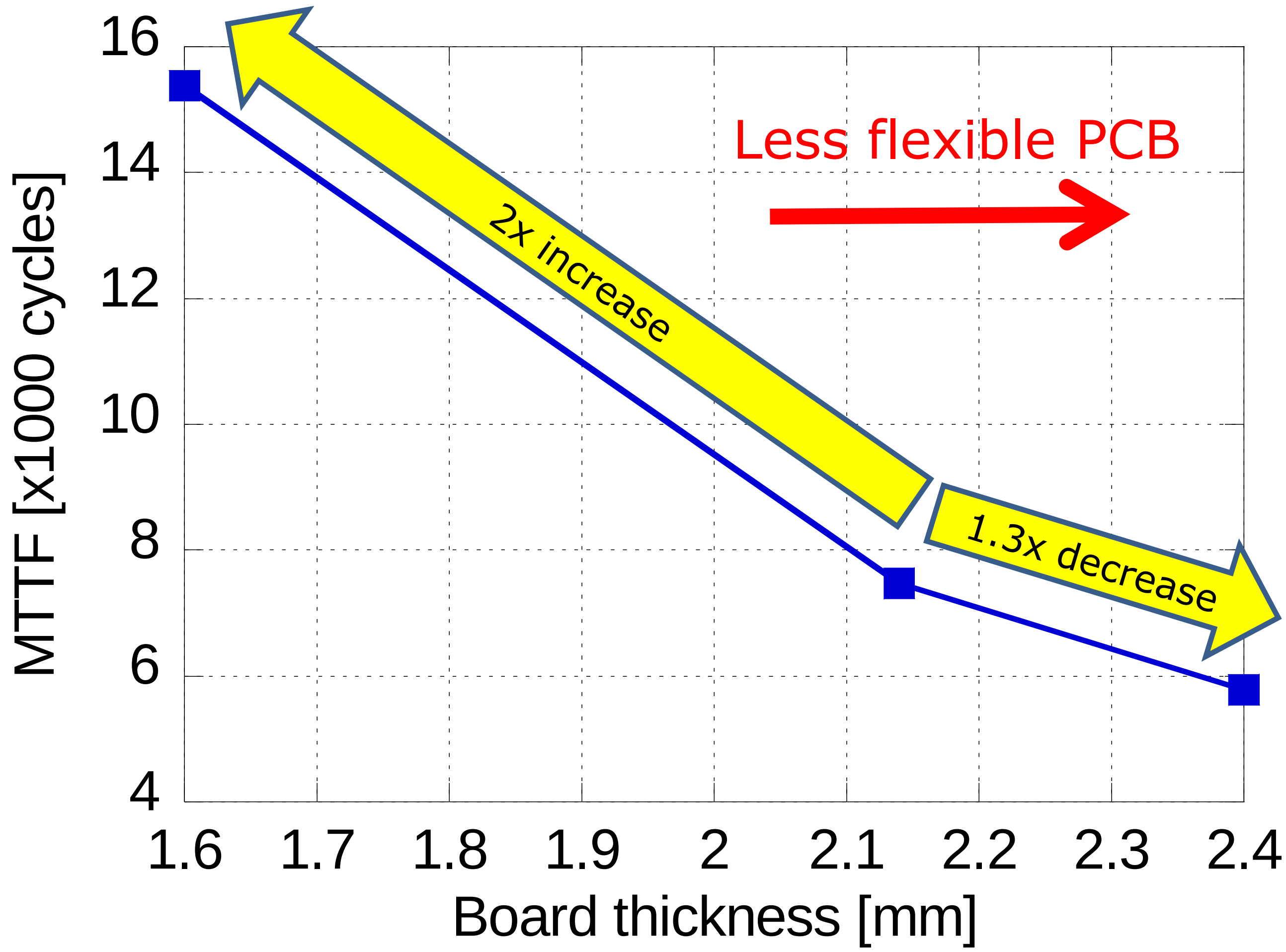


6. Reliability of BGA
Moulding compound CTE dependency

SAC solder joints

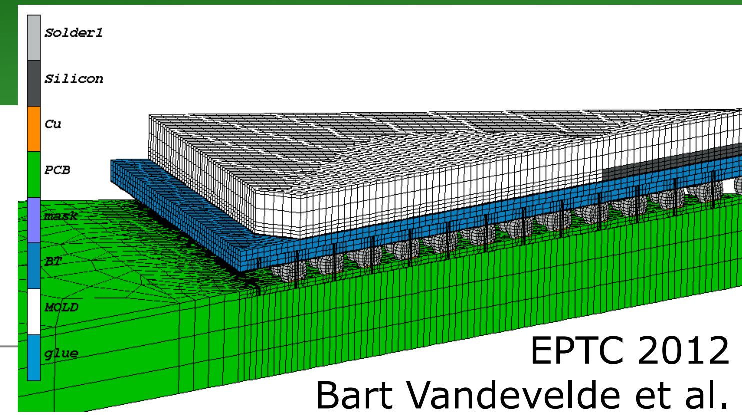


6. Reliability of BGA
Impact of board thickness

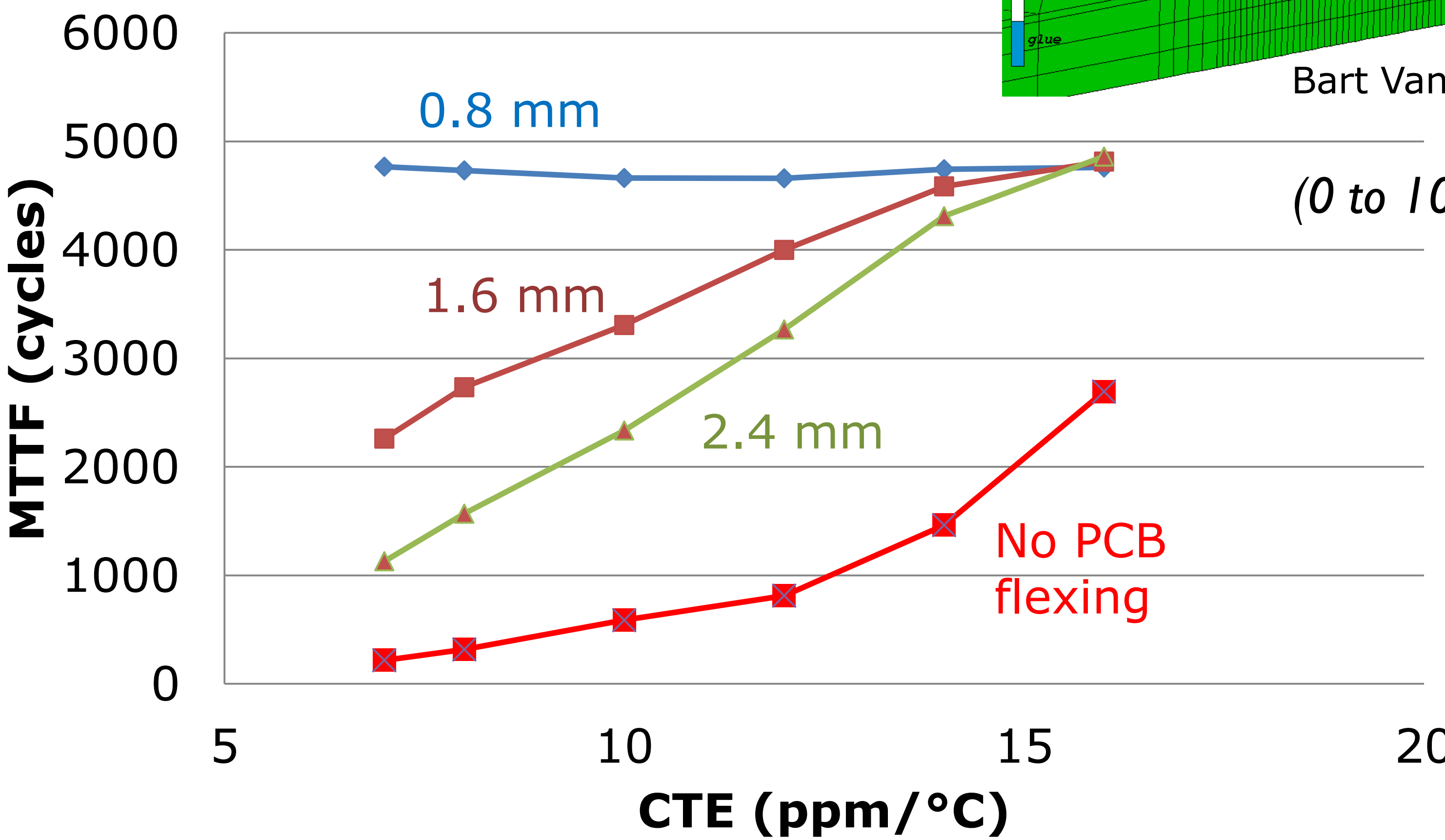


6. Reliability of BGA
Impact of board thickness

PBGA 27x27 area array
1.27mm pitch



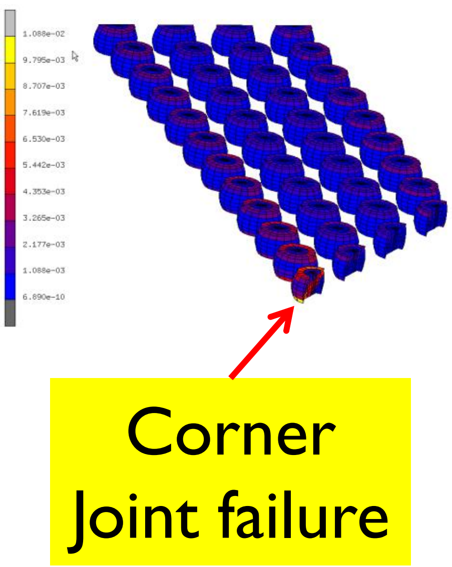
EPTC 2012
Bart Vandevelde et al.

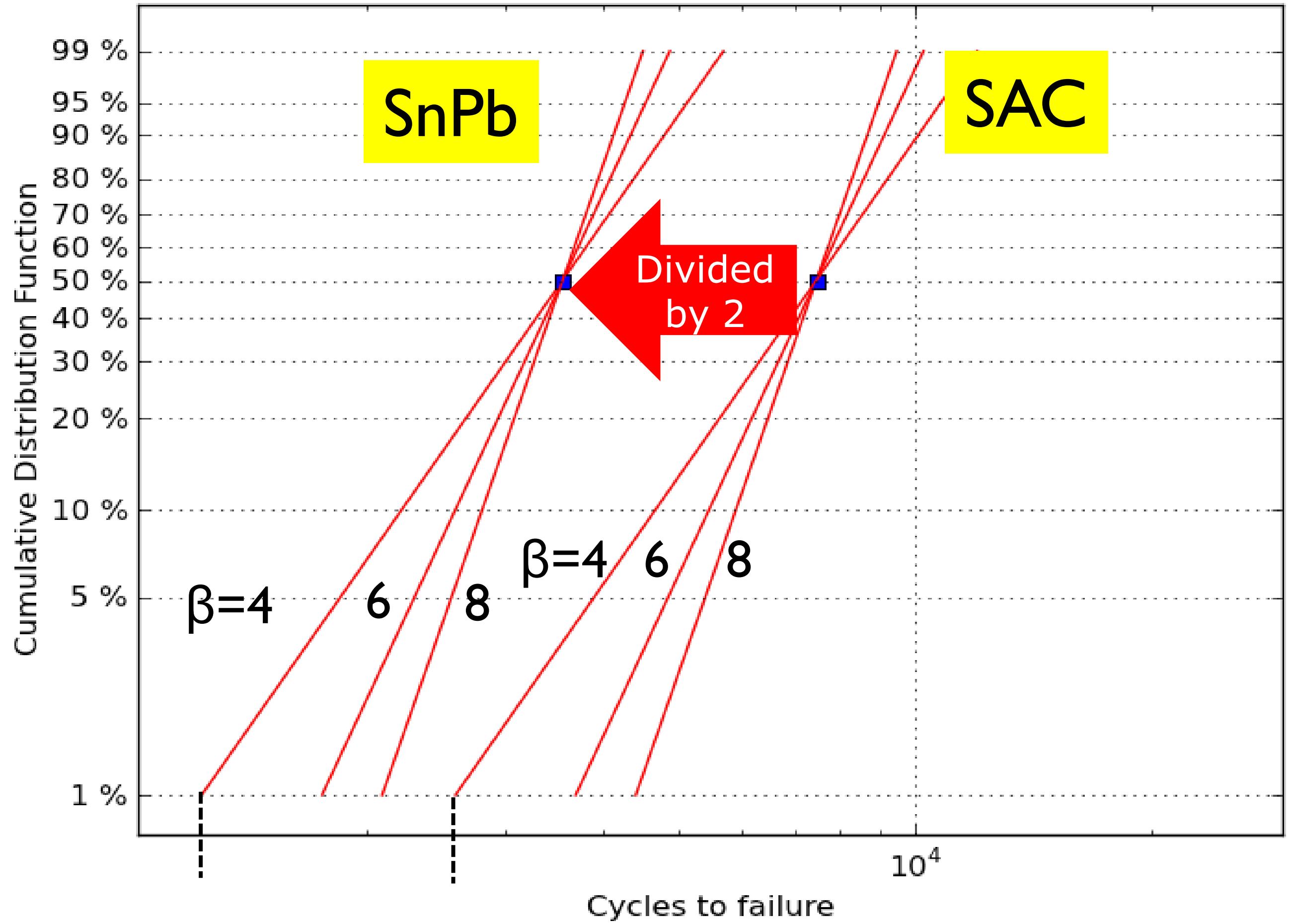


(0 to 100°C cycling)

6. Reliability of BGA
SnPb versus SAC

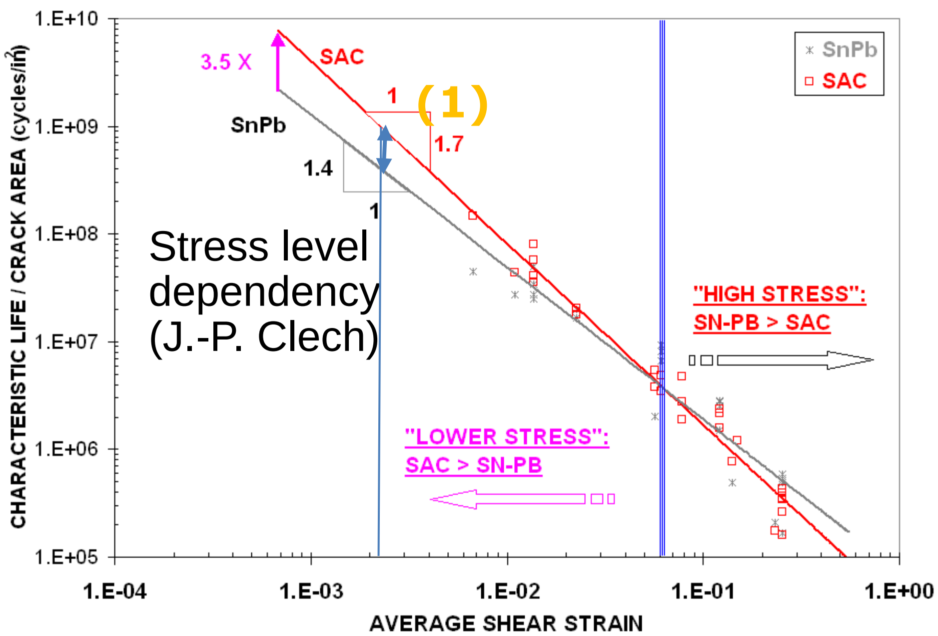
SnPb is significantly worse than lead-free!





6. Reliability of BGA SnPb versus SAC

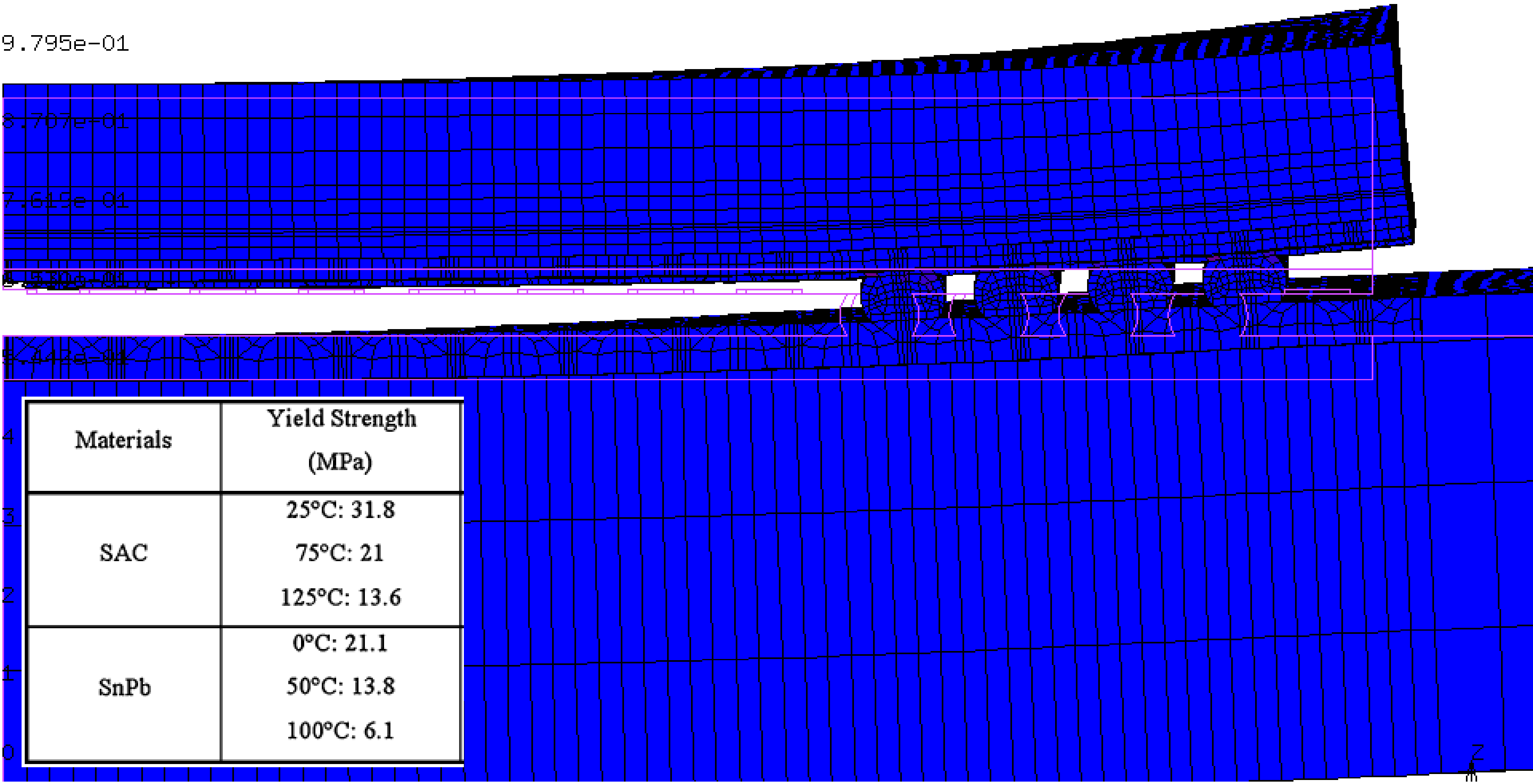
Why is SnPb version worse than SAC?



1. Under low stress conditions lifetime of SAC is higher than that of SnPb.
2. Strain itself depends on the solder alloy.

   SAC is stronger than SnPb. Therefore SAC solder joints of flexible components on flexible PCBs will deform less than SnPb solder joints under the same conditions of thermal cycling.

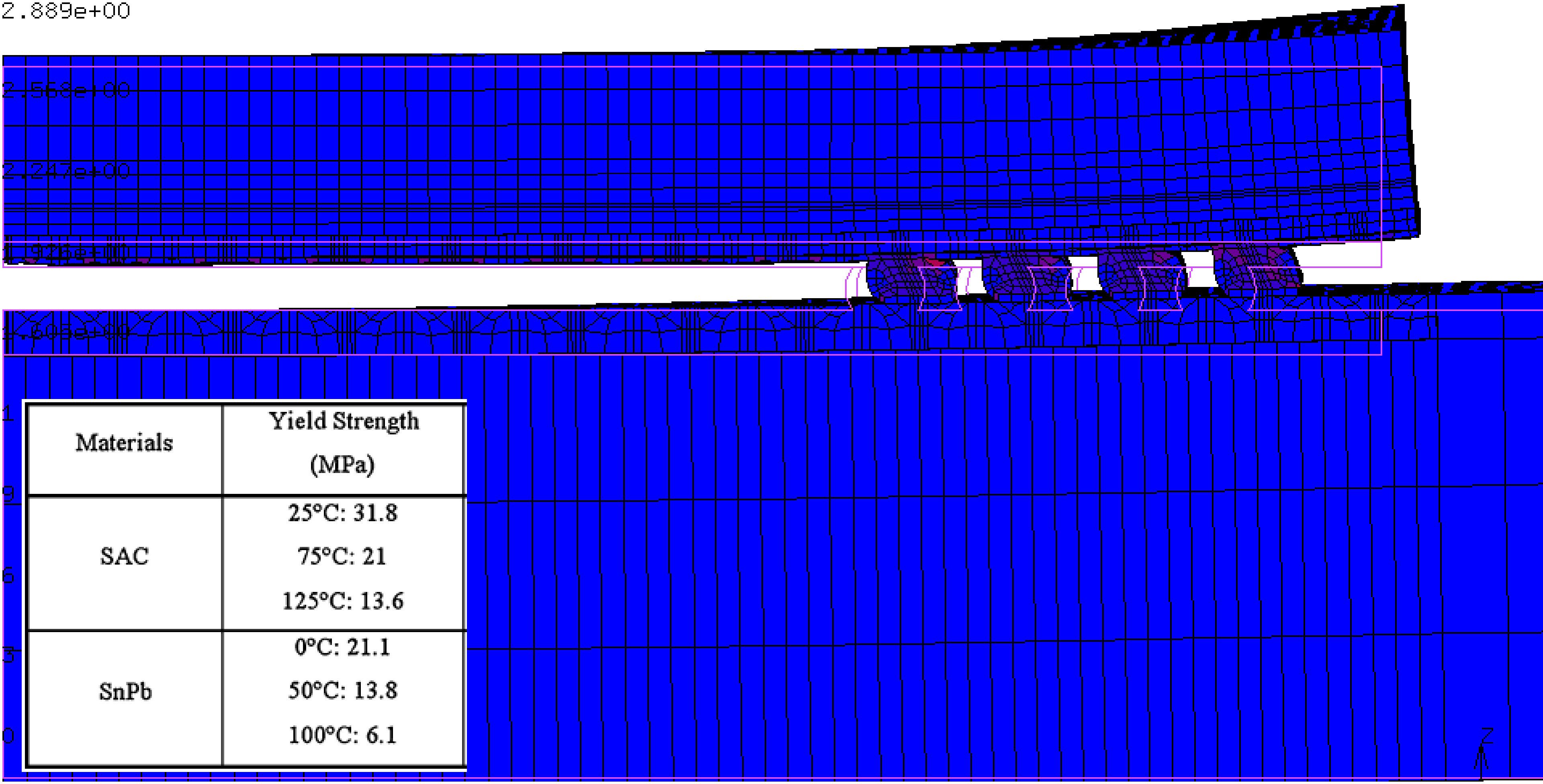
6. Reliability of BGA
SAC



Materials	Yield Strength (MPa)
SAC	25°C: 31.8 75°C: 21 125°C: 13.6
SnPb	0°C: 21.1 50°C: 13.8 100°C: 6.1

Stronger connections: more bending of both board and package.
Less strain/deformation of solder balls

6. Reliability of BGA SnPb

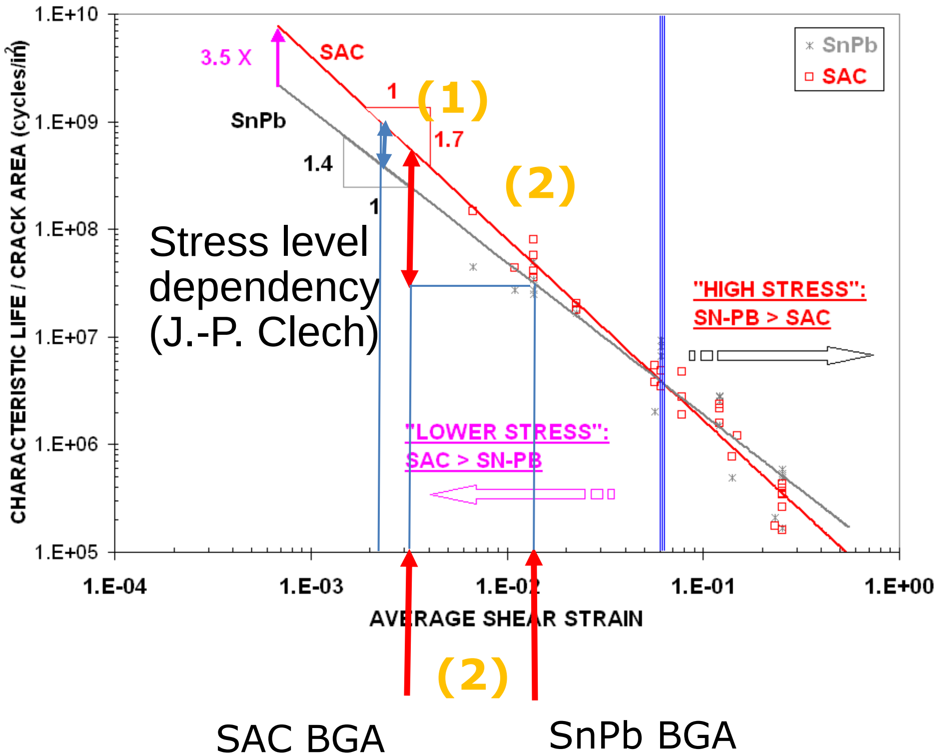


Materials	Yield Strength (MPa)
SAC	25°C: 31.8 75°C: 21 125°C: 13.6
SnPb	0°C: 21.1 50°C: 13.8 100°C: 6.1

Weaker connections: limited board bending because solder balls start to shear (more solder joint deformation)

6. Reliability of BGA SnPb versus SAC

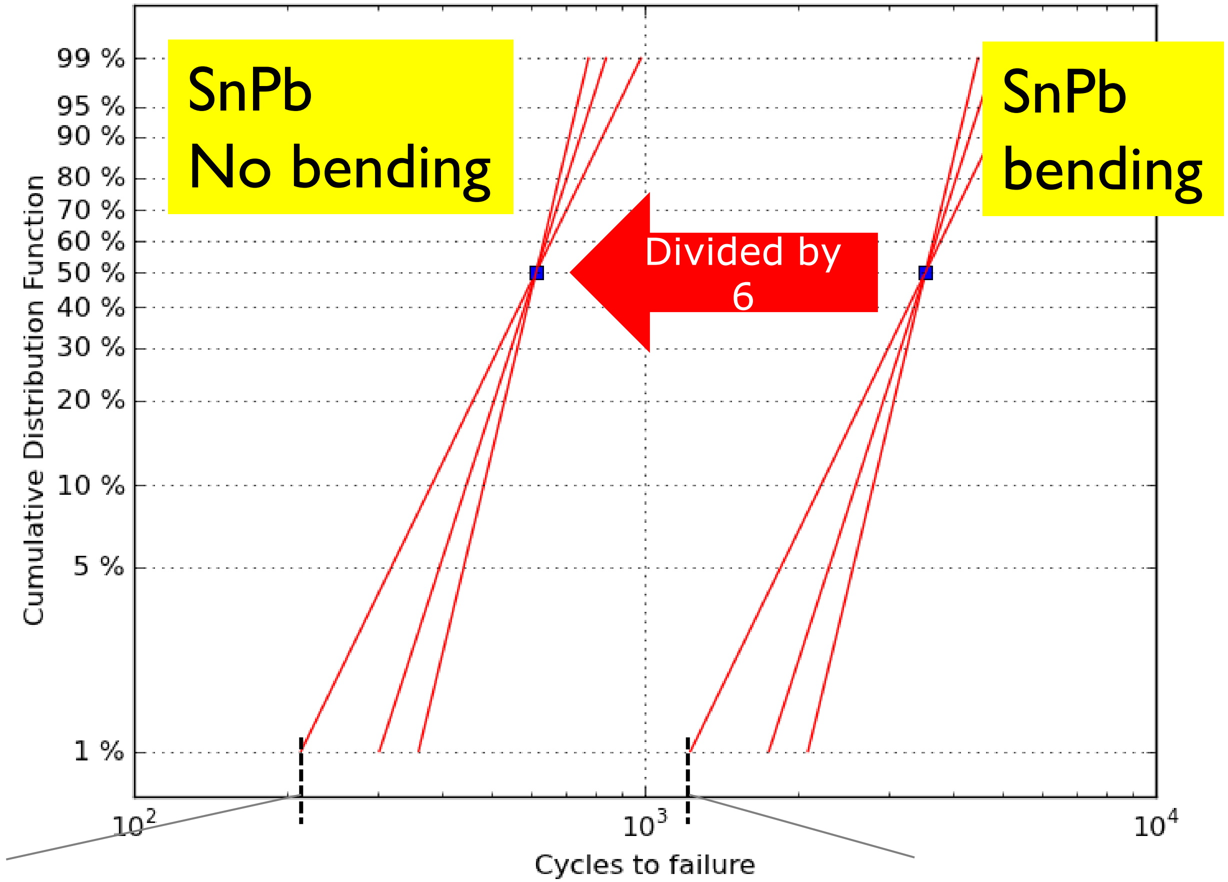
Why is SnPb version worse than SAC?



1. Under low stress conditions lifetime of SAC is higher than that of SnPb.
2. Strain itself depends on the solder alloy.

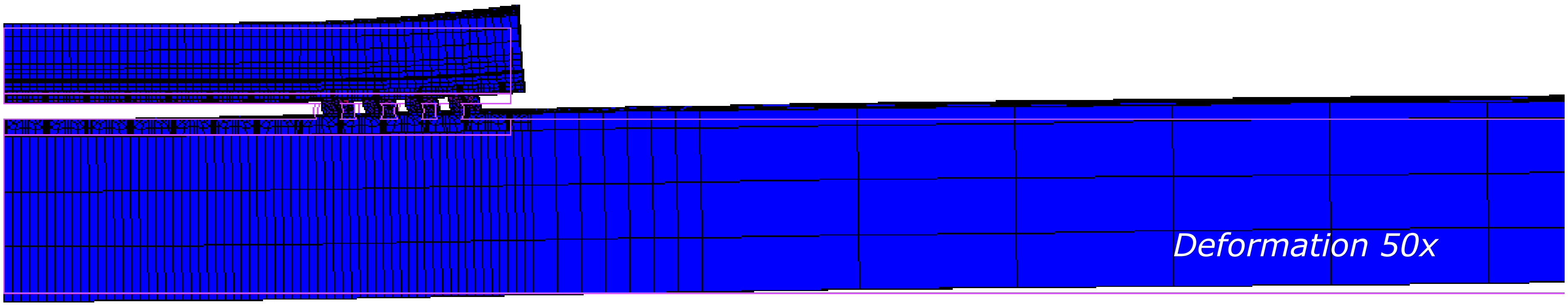
   SAC is stronger than SnPb. Therefore SAC solder joints of flexible components on flexible PCBs will deform less than SnPb solder joints under the same conditions of thermal cycling.

No PCB bending yields even more strain

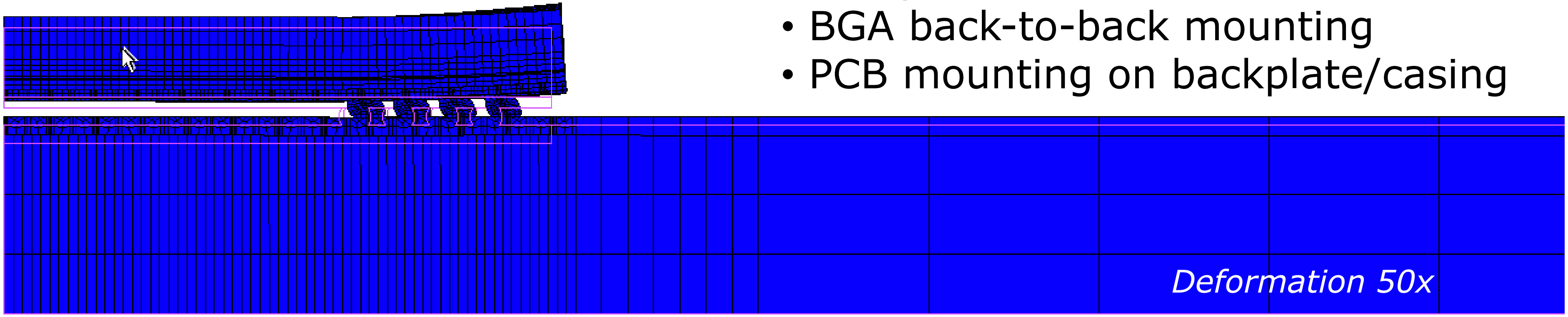


6. Reliability of BGA
Increasing strain: no PCB bending

- Board bending allowed



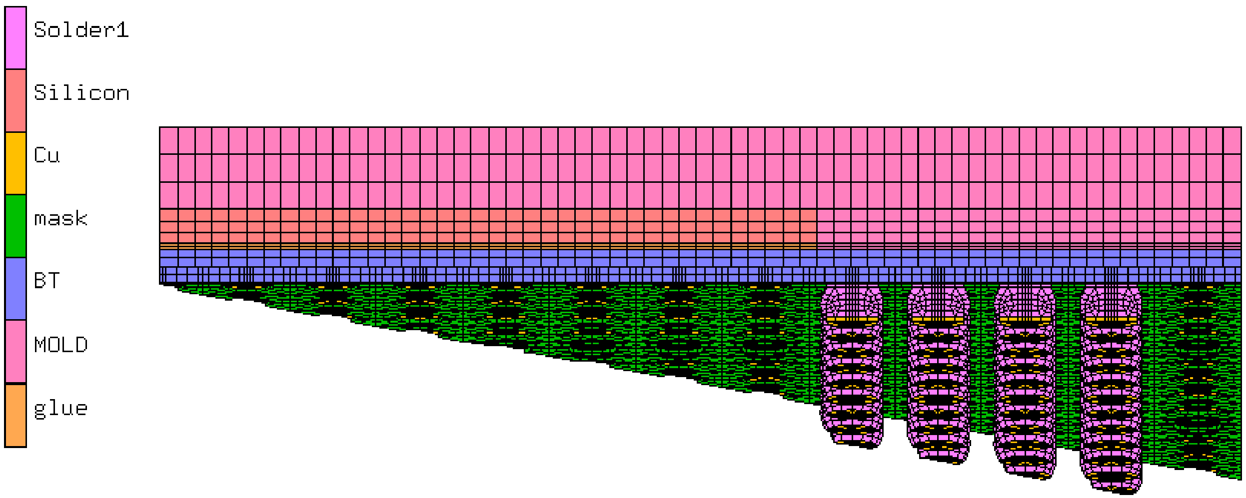
- No board bending allowed



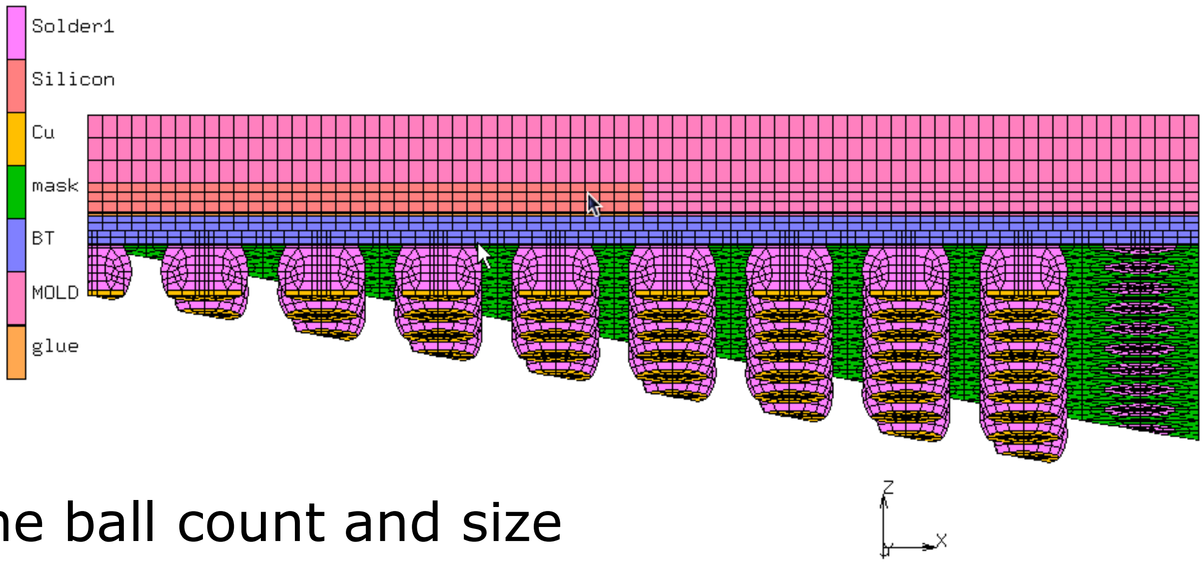
- PCB stiffners on backside
- Components on backside
- BGA back-to-back mounting
- PCB mounting on backplate/casing

6. Reliability of BGA
Impact package type

Partly populated area array
0.5mm pitch
Ball size 0.3mm



Fully populated area array
0.8mm pitch
Ball size 0.5mm



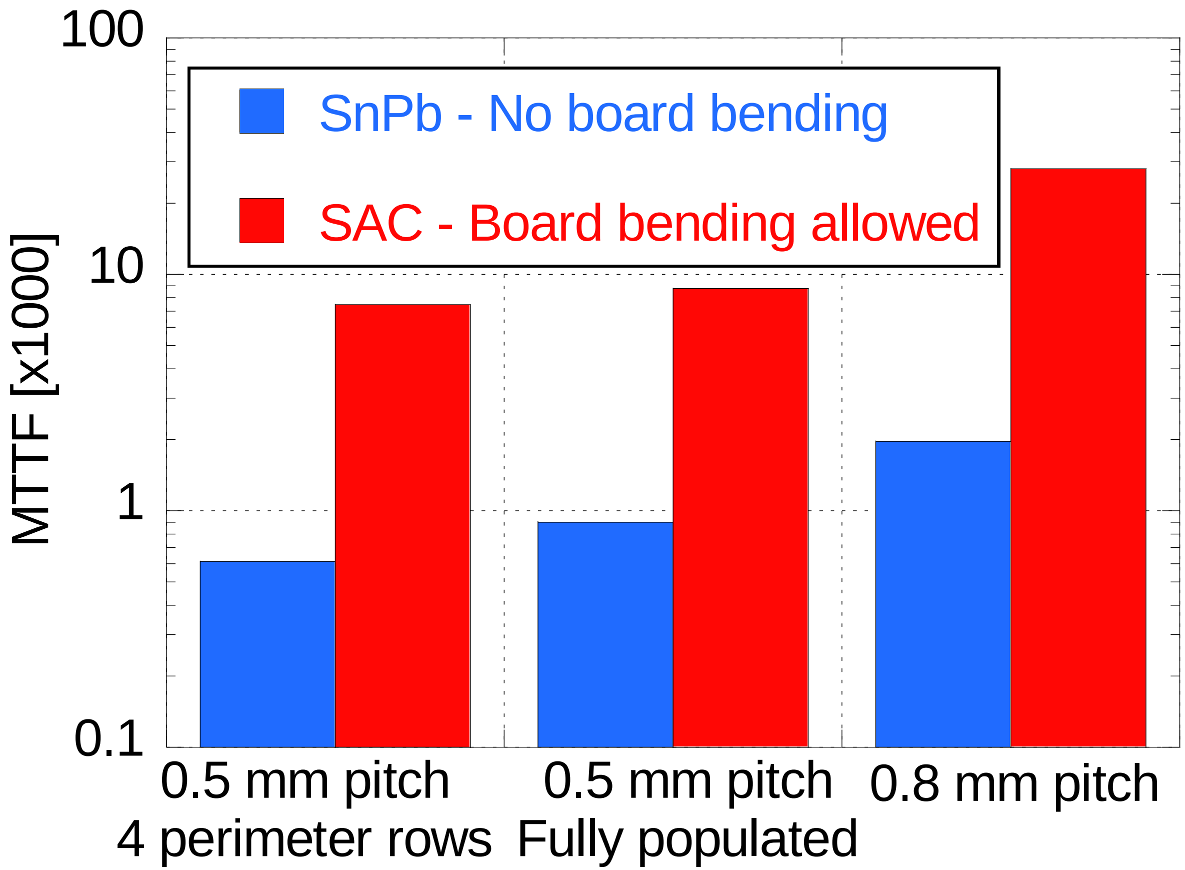
Approximately same ball count and size

6. Reliability of BGA
Impact package type

Changing package type can improve lifetime up to 4x

Reliability improves:

- Higher CTE of molding compound
- SAC i.s.o. SnPb
- Larger balls/pitch
- Fully populated



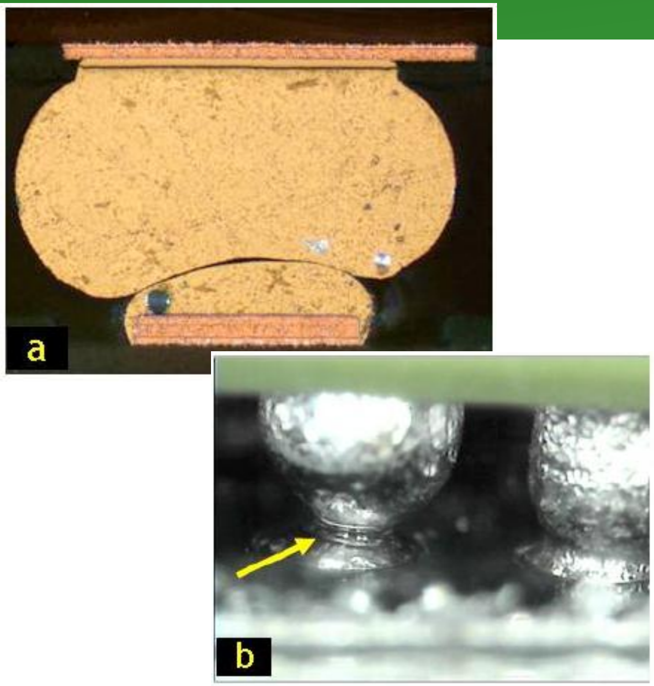
7. There is more: Head-in-Pillow

What:

Head-in-Pillow BGA Defects
Karl Seelig
AIM
Cranston, Rhode Island, USA

Head-in-pillow (HiP), also known as ball-and-socket, is a solder joint defect where the solder paste deposit wets the pad, but does not fully wet the ball. This results in a solder joint with enough of a connection to have electrical integrity, but lacking sufficient mechanical strength. Due to the lack of solder joint strength, these components may fail with very little mechanical or thermal stress. This potentially costly defect is not usually detected in functional testing, and only shows up as a failure in the field after the assembly has been exposed to some physical or thermal stress.

Head-in-pillow defects have become more prevalent since BGA components have been converted to lead-free alloys. The defect can possibly be attributed to chain reaction of



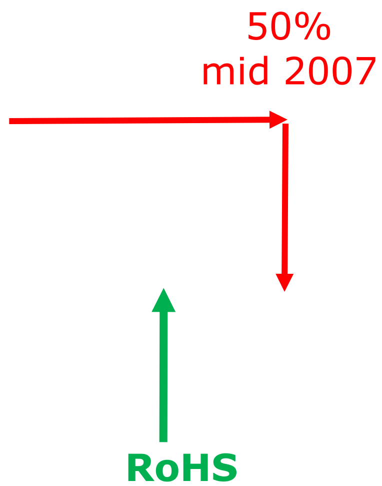
- Associated to lead-free soldering?
- But:
  - Became more and more prevalent 1-2 years after 1/7/2006
  - Occurs recently also with SnPb soldering.
  - HiP unheard of in SnPb soldering prior to 2008?!

References

1. "Pb-free: Fact or Fiction?", http://www.circuitsassembly.com/cms/news/6458, April 18, 2008.
2. Karl Seelig, "HIP Defects in BGAs", Circuits Assembly, pp 28-31, December 2008.
3. Tim Jenson, "The Graping Phenomenon: Improving Pb-Free Solder Coalescence through Process Optimization and Materials" Proceedings of APEX 2008, Las Vegas.
4. Chrys Shea, "Step the HOP", p 33, Circuits Assembly, August 2008.
5. Chrys Shea, "HOP-ing Mad", Circuits Assembly, pp 72-73, July 2008.
6. "Koki No-clean Lead Free Solder Paste Anti-Pillow Defect S3X58-M406-3 series Product information", version 42016e, August 29, 2006, www.ko-ki.co.jp
7. Rick Lathrop, "BGA Coplanarity Reduction During the Ball Attach Process", Capital SMTA meeting, June 5, 2007.
8. JESD22B-112, "High Temperature Package Warpage Measurement Methodology", August 2005.
9. IEC 601191-6-19 (draft), "Measurement methods of package warpage at elevated temperature and the maximum permissible warpage"

7. There is more: Head-in-Pillow

- Major root cause of Head-in-Pillow is component warpage.
- More warpage when temperature is higher → lead-free
- But:
  - Is now also being reported for SnPb soldering of BGA
  - Seems to have become an issue well after the introduction of lead-free soldering.
- Lower mold compound CTE will increase/alter the warpage behaviour of PBGA.
- Look at the GMC introduction→



Conclusion seems to be:
GMC most likely root cause
of "HiP-epidemic".

7. There is more: wire bond fatigue

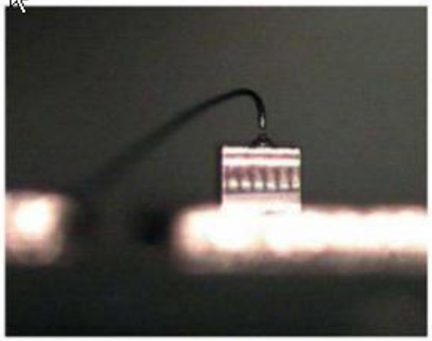


Figure 9: SN1
After chemical decapsulation, optical image presented neck broken wire.

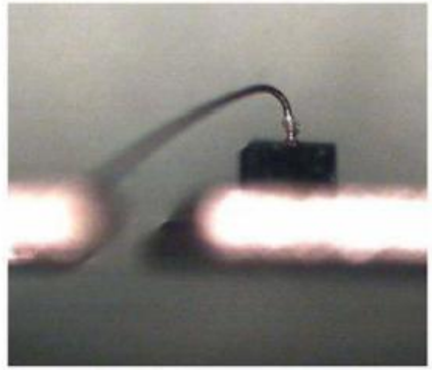


Figure 10: SN2
After chemical decapsulation, optical image presented wire defect.

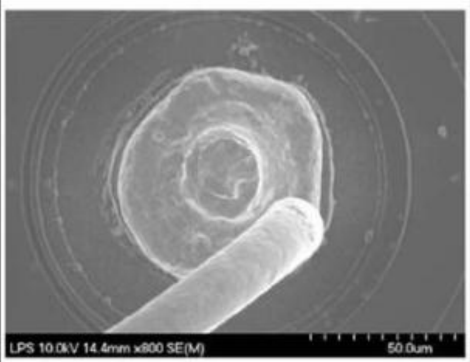


Figure 11: SN1
After chemical decapsulation, SEM image found neck broken wire.

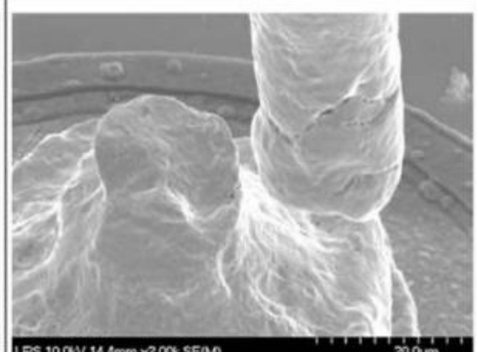


Figure 12: SN1
After chemical decapsulation, SEM image found neck broken wire.

Low cost trends:

- Green Molding Comp.
  Reduction in CTE
- Au → Cu wire
  Increase in CTE

Larger CTE mismatch

→ Increased risk of wire bond fatigue!

Cu Wire Neck Fatigue Fracturing Elimination

Song Xiaoqing, Wei Haili, Zhao Hongbin
Leshan Phoenix Semiconductor Co. Ltd
289 West People Road Leshan, Sichuan, 614000 China
Email: xiaoqing.song@onsemi.com

8. Conclusions

Green, low CTE molding compounds increase the thermal mismatch between "plastic" packages and the PCB upto tenfold!

This creates major issues:

- Reduction in lifetime below acceptable level due to **solder joint failure** of "plastic" packages especially TSOP, BGA, QFN. Complex dependency on package and PCB flexibility.
- Reduction in lifetime below acceptable level due to **Cu lead failure** of TSOP type I components.
- Assembly **yield reduction** due to Head-in-Pillow of BGA solder joints.
- Increased risk of **"Early Failure"** due to electrically undetected HiP BGA solder joints.
- Increased risk of **wire bond failure**.
- Very limited (and costly) workarounds: underfill (?)

8. Electronics reliability

Green molding compounds constitute a bigger threath to electronics reliability than the switch to lead-free solder ever was!

- “Is SAC more or less (10%...x2) reliable than SnPb” vs. increasing solder joint strain upto ten times.
- Introduced into (qualified!) products without OEM’s being aware of it!
- Especially dangerous for products using SnPb solder, i.e., high reliability products like telecom, automotive, avionics, industrial, safety, medical...

Dank U voor uw aandacht
Vragen?

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Met steun van het IWT