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Lead Free First Article Inspection: The Key to Success

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Process, Process, Process – these words must ring loudly in our ears, and must be at the forefront of lead free implementation. The smaller process windows dictated by lead free alloys are going to put greater demands not only on reflow equipment, but also on first article inspection equipment and procedures. This article will highlight the typical process concerns associated with lead free alloys with respect to proper first article inspection, qualification of a lead free SMT line, and adherence to ISO and Six Sigma Quality Management Philosophies. An effective quality control program is completely dependent on the capability of discovering all possible process problems in order to insure prevention. The enormous financial and reputation costs of warranty failures faced by leading mass production manufacturers can be greatly reduced by improving the first article inspection process.

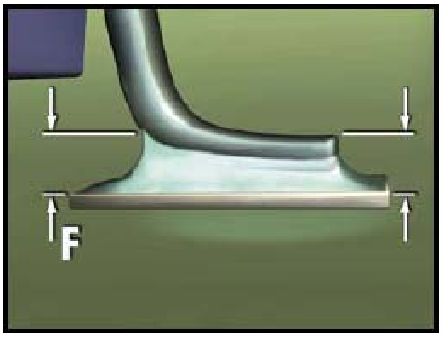
Much has been published concerning the smaller process windows associated with lead free alloys, and their influence on reliability issues. It is suffice to say that the soldering process up until today has been most forgiving to process problems. Lead containing solder pastes have known extended soak ranges from 60 to 120 seconds, as well as broad acceptable peak ranges from 205°C to as high as 255°C. Large temperature deltas in the current soldering process were less problematic for solderability and reliability. Lead free alloys will see much smaller process windows for soak, and a peak range from 230°C to 250°C. Working outside these specified process windows will have a negative impact on solder joint integrity, component safety, and ultimately on reliability.

How this will in practice affect the goal of achieving a stable and reliable process can be seen below. A summary of the most important lead free process concerns, which will directly effect first article inspection and SMT line qualification process, includes:

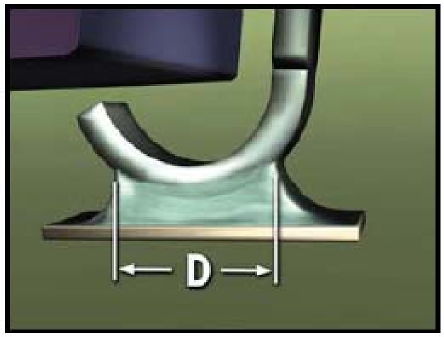
- poor wetting and flow characteristics
- substrate warpage
- higher process temperatures either damaging components or changing the required shape of the solder joint
- striations, also known as the “orange peel” effect, or “freezing lines”, and dendritic crystals make joints appear less shiny, and are more difficult to qualify
- lead free flux residues
- tombstoning
- solder micro balling
- tin whisker formation
- void formation

Understanding the typical characteristics, or better said “problem areas” associated with a lead free soldering process, as listed above, must dictate how a company addresses QA and proper SMT line qualification during the first article inspection process.

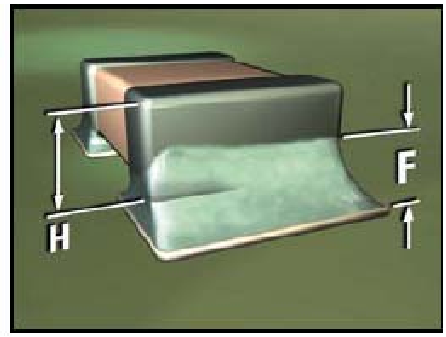
A company’s machinery and chemistry must work together to guarantee a reliable soldering process, and the choices for these must be made with the utmost attention. The performance of the reflow oven will play the most important role in the lead free line. The ultimate key to success, however, is going to be the first article inspection. International soldering standards have been playing an increasingly more important role on a global level over the past 10 years. The IPC 610, excerpt seen in IPC images below (source: **IPC Electronic Workmanship Standard** A-610: Sec. 12.2.5.6; J-STD-001), is today accepted as the most important international workmanship standard with respects to long term reliability. Having such a standard is as important as it ever has been. Inspecting to this standard is a requirement!



IPC Image1



IPC Image 2



IPC Image 3

The miniaturization of components such as 14 mil pitch (0.4mm) TQFPs, 0402 and 0201s, CSP and Flip Chip is making the soldered connection that much smaller, that much more difficult to make, and consequently, that much more difficult to inspect. Standards provide valuable guidelines upon which one must qualify today's SMT process. Inspecting and producing to these standards is paramount for a reliable process. ***Have standards, inspect to standards, and produce to standards!*** It is during the first article inspection process that the integrity of the solder joint must be properly qualified in order to guarantee adherence to such standards.

When we now consider the typical problems associated with a lead free process as noted above, producing to standards will become a much greater challenge. The poor wetting characteristics of SnAgCu alloys will make complete fillet formation more difficult to achieve. Figures 1a & b show a smaller mass TQFP on a medium sized 4 layer PCB and Figure 1c shows the proper toe fillet underneath a PLCC 52. Figure 2a shows a larger mass, high lead count QFP. The test board used a solder paste alloy of SnAg3.8Cu0.7, and was sent through a 4 zone reflow oven. While Figures 1b and c show proper joint formation, Figures 2b & c clearly show wetting and solder flow deficiencies that do not meet prescribed standards.

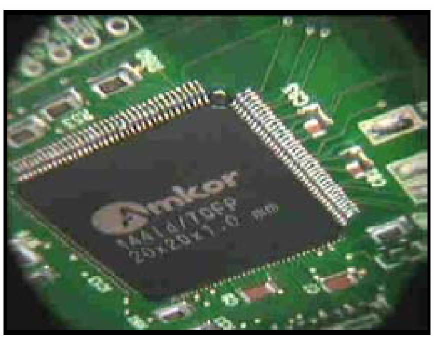


Figure 1a - Small Mass TQFP

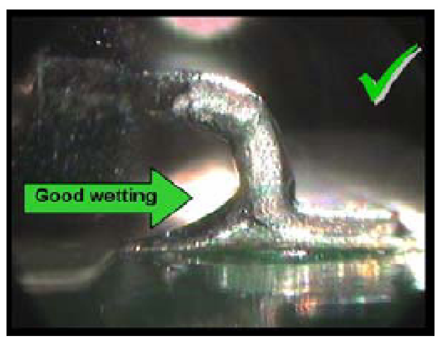


Figure 1b - Proper Joint Formation

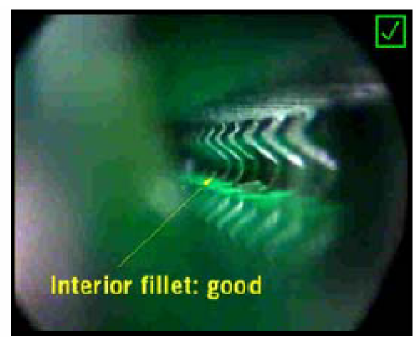


Figure 1c - Proper Toe Fillet Underneath a PLCC 52

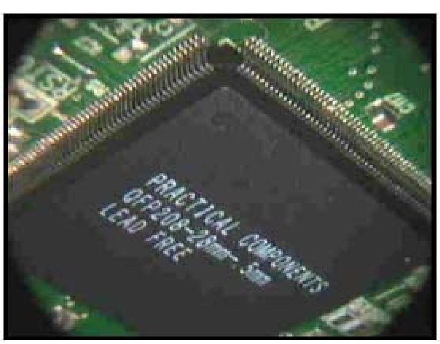


Figure 2a – Larger Mass, High Lead Count QFP

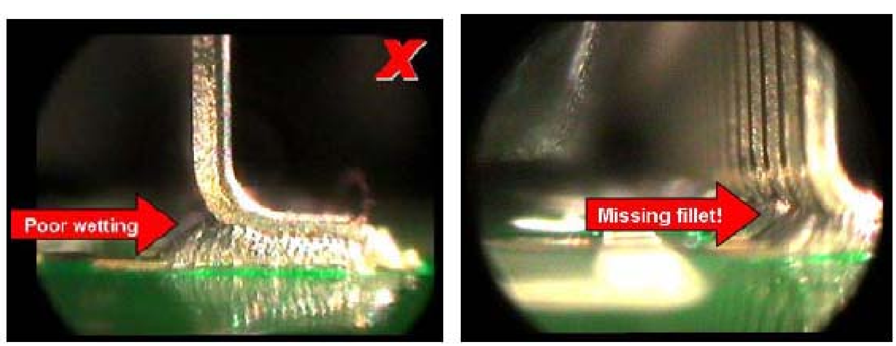


Figure 2b and c – Wetting and Solder Flow Deficiencies

Working outside the specified process window will lead to lead free solderabilty problems. Ultimately, better temperature control and minimizing the Delta T during reflow will be the key to working within the smaller lead free process windows.

The higher process temperatures required for lead free will present new obstacles. As the component body becomes hotter than the PCB during reflow, the molten solder will wick up the component lead, thereby changing the acceptable solder joint shape. Figure 3 shows a cross section of an acceptable joint of a resistor made with a SnPbAg alloy at a proper peak temperature of 215°C. Figure 4 shows a cross section of an acceptable joint of a resistor made with a SnAgCu alloy at a proper peak temperature of 235°C. Figure 5 shows a cross section of an unacceptable joint of a resistor made with a SnAgCu alloy at an unacceptable peak temperature of 260°C. The joint showed in Figure 5 does not meet IPC standard as depicted in Figure 4. Cross sectioning, however, is not a cost effective solution for first article inspection!

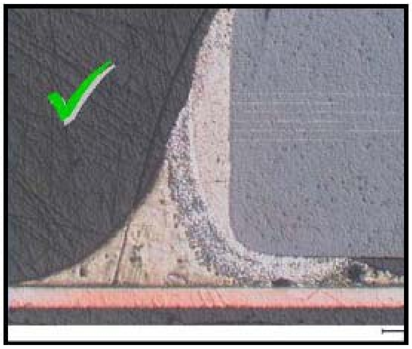


Figure 3 – Cross Section of an Acceptable Joint of a Resistor made with a SnPbAg Alloy at a Proper Peak Temperature of 215°C

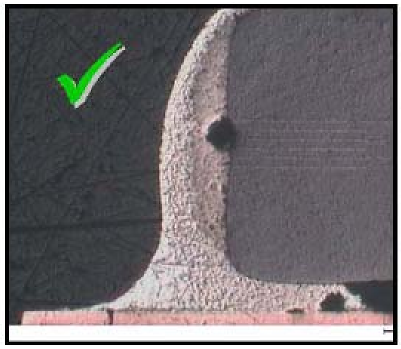


Figure 4 – Cross Section of an Acceptable Joint of a Resistor made with a SnAgCu Alloy at a Proper Peak Temperature of 235°C

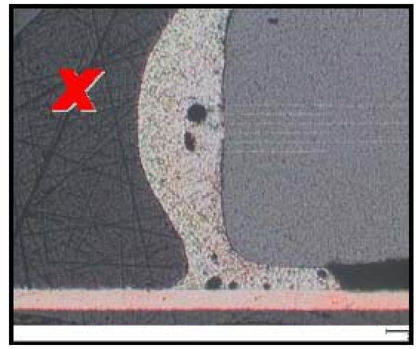


Figure 5 - Cross Section of an Unacceptable Joint of a Resistor made with a SnAgCu Alloy at an Unacceptable Peak Temperature of 260°C

Additionally, higher process temperatures can cause component bulging and substrate warpage. Both of these problems can lead to near opens, as seen in Figure 6a. Exceeding the component's maximum allowable temperature rating can result in fatal pop corning, as seen in Figure 6b, and internal component "meltdown", as seen in Figure 6c.

Figure 6a – Near Opens

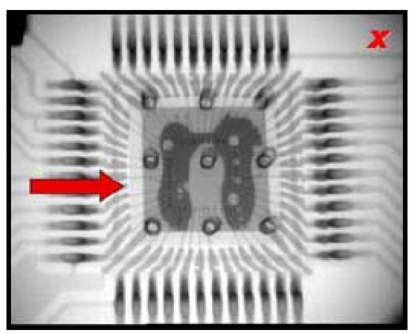


Figure 6b – Fatal Pop Corning

Figure 6c – Internal Component "Meltdown"

It should be clear that the images seen in the previous figures cannot be taken with standard 0°, low magnification inspection equipment such as microscopes being used today for first article inspection. How one inspects the PCB, where one must inspect, and with what equipment, must be time and cost effective for the lead free first article inspection process.

Over the years, operators have successfully used visual indicators to provide information about the integrity of a solder joint. How often have we heard, "if it looks good, it most likely is?" Cold or disturbed joints often appeared dull, matt or grainy. Lead free joints will be characteristically less shiny as seen in Figures 7 and 8. This is a result of striations, "freezing lines" and the "orange peel" effect that occur during the solidification of the lead free alloy. These apparent "defects" are primarily cosmetic in nature and do not necessarily indicate a solderability problem. Higher power magnification must be used to "look between the lines" at the grain structure of the solder joint. Figure 9 reveals a smooth grain structure between the freezing lines which can be a visual indication of a good solder joint.

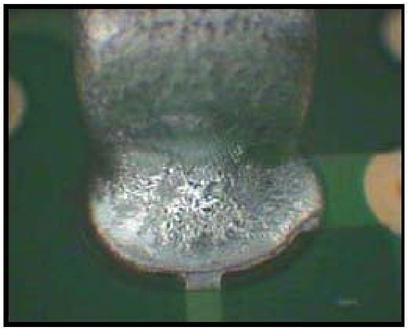


Figure 7 – Lead Free Solder Joint

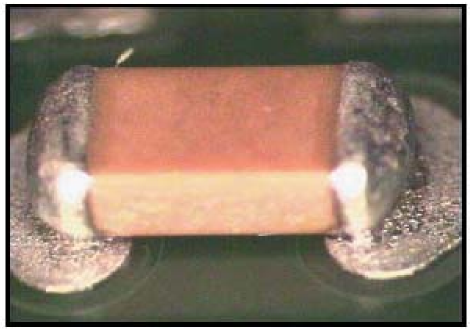


Figure 8 – Lead Free Solder Joint

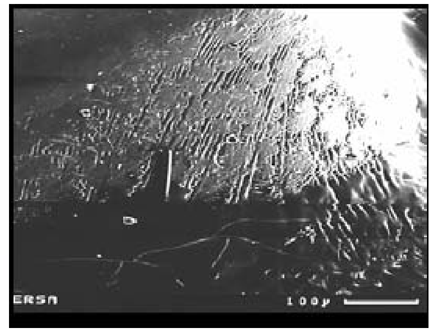


Figure 9 - Smooth Grain Structure between the Freezing Lines

In a lead free wave process, a SnCu or SnAgCu bar alloy will most likely be used. In the bath, copper crystallizes in the form of intermettallic (Cu6Sn5) needles or dendrites. See Figure 10. This is a drawback when using alloys with high tin content: the density of the alloy is lower, causing the needles to settle at the bottom of the solder bath, from where they are circulated and become part of the joint formation. See Figure 11. While this defect is cosmetic in nature only, it does make the joint look less shiny or "disturbed." Operators must be properly equipped and newly trained for the lead free inspection process.

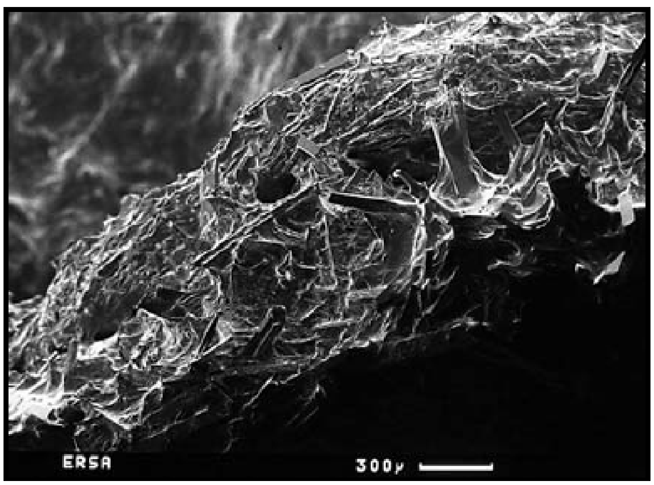


Figure 10 – Cu6Sn5 Needles

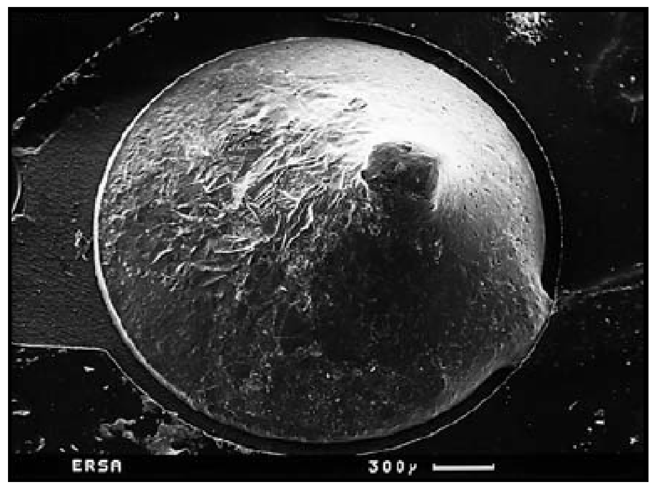


Figure 11 – Cu6Sn5 Needles in a Solder Joint

Additionally, the poor wetting and flow characteristics of lead free solders will make the required PTH hole fill more difficult to achieve in a wave process. Producing high reliability product that meets IPC Class 3 standards will be more difficult using

Additionally, the poor wetting and flow characteristics of lead free solders will make the required PTH hole fill more difficult to achieve in a wave process. Producing high reliability product that meets IPC Class 3 standards will be more difficult using standard wave machines. Strong consideration should be made to implement a lead free selective wave soldering process where at all possible in order to reduce the dpm rates. In any case, first article inspection must be made in a thorough and cost effective manner. The IPC standard noted in Figure 12, will either require costly cross sectioning, see Figure 13, or the use of appropriate optical inspection equipment providing the 90°, board level image as seen in Figure 14.

Figure 12 – A "Standard" Joint

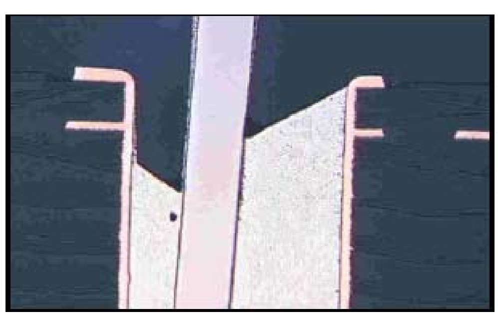


Figure 13 – "Standard" Joint Cross Section

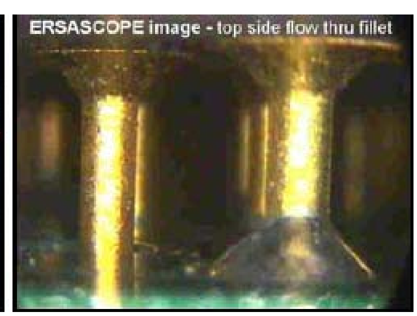


Figure 14 – Board Level Image

Inspection for lead free flux residue on hidden joints, as seen in Figure 16a, will be critical, but impossible to detect with x-ray equipment. Endoscopic BGA optical inspection equipment, as seen in Figure 15, will be required to reveal the defects seen in Figures 16a & b, and Figure 18b.Tin whisker growth seen in Figure 16b will be more prevalent due to the high tin content in the alloy. Tombstoning, as seen in Figure 17, will be more prevalent due to the poorer flow characteristics and stronger surface tension of lead free alloys. Micro solder balling, as seen in Figures 18a and 18b, will occur when working outside of the specified solder paste process window, and will require high magnification inspection equipment with a flexible, 0° to 90° viewing angle. Finally, increased void formation, as seen in Figures 19a, 19b and 19c, will be a result of the higher process temperatures required for lead free, and will require either destructive cross sectioning or x-ray inspection equipment for proper detection.

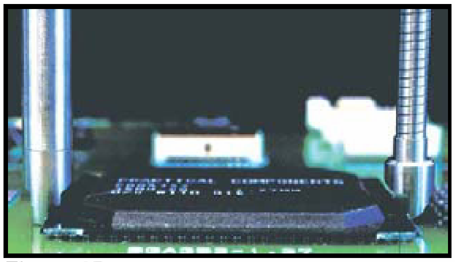


Figure 15 – Inspection Equipment Example

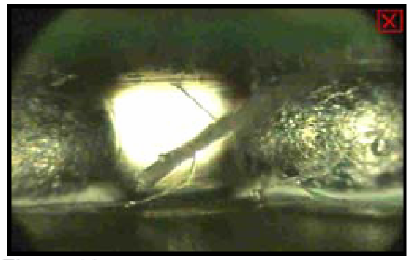


Figure 16a – Solder Defect Example

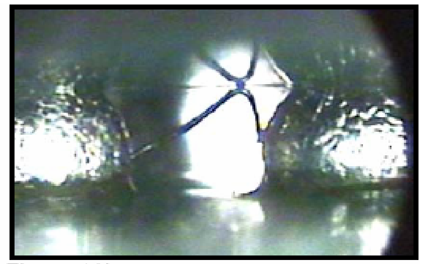


Figure 16b – Tin whisker Growth

Figure 17 - Tombstoning

Figure 18a – Micro Solder Balling

Figure 18b – Micro Solder Balling

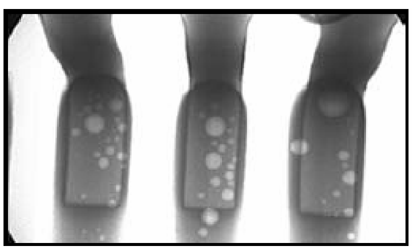


Figure 19a – Void Formation

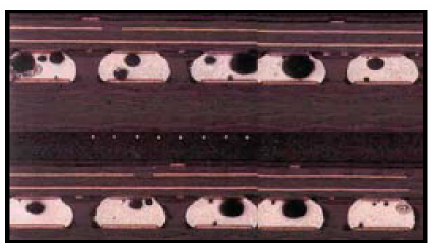


Figure 19b – Void Formation

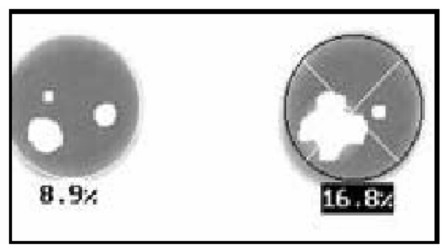


Figure 19c – Void Formation

Lead free BGA, CSP and Flip Chip soldering will have the increased problems associated with smaller process windows, and will require better temperature control. Figures 20, 21 and 22 show the 2 step reflow process, also known as the "double drop", of a BGA package. It is clear to see that the condition shown in Figure 21 if undiscovered will lead to early PCB failure. The temperature delta between a single drop joint in Figure 21 and the double drop joint in Figure 22 can be as low as 5°C in a lead free process!

State of the art AOI and X-ray images, as seen in Figures 23 and 24, while an integral part of both in and off line process control, cannot detect the difference between a single drop and a double drop.

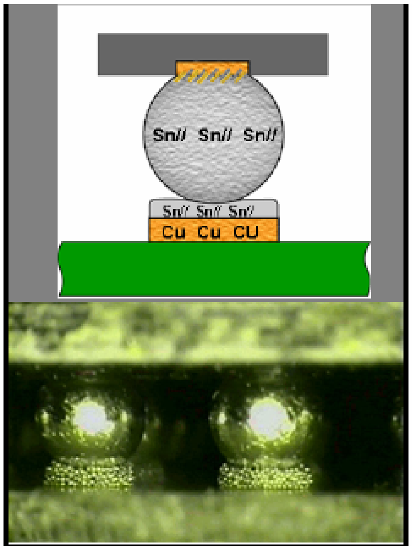


Figure 20 – Reflow Process “Double Drop”

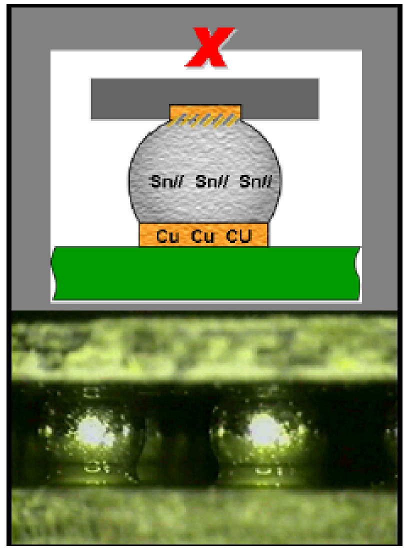


Figure 21 – Delta T for a Single “Drop”

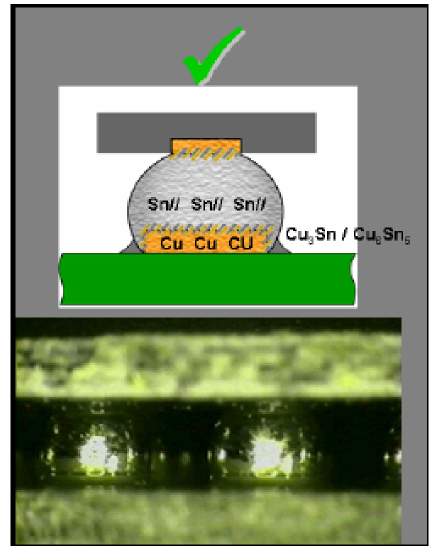


Figure 22 – Delta T for a Double “Drop”

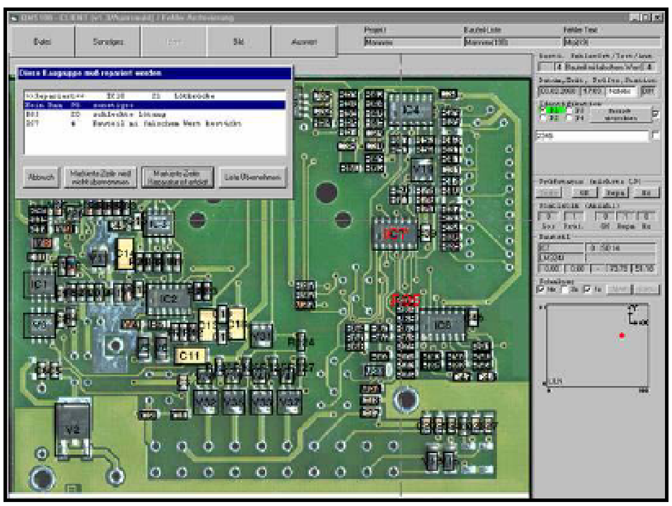


Figure 23 – An AOI Image

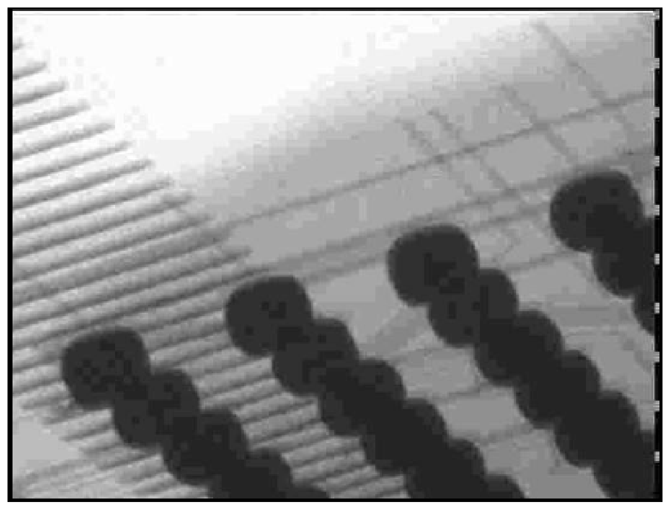


Figure 24 – An X-Ray Image

It will that much more critical to use endoscopic type optical inspection equipment to properly qualify the SMT line in the first article inspection step. The practical consequence of non-use is warranty failures. Mass production manufactures of consumer electronics with BGA, CSP and Flip Chip in their products can confirm the tens of millions of lost capital, not to mention loss of image that can be directly related to warranty failures caused by area array package defects in the field.

Low profile CSP and Flip Chip will require the improved inspection capabilities of a newly engineered Flip Chip optical head. The iris of current endoscopic type or mirror based optical systems sits approximately 0.30 mm from the surface of the PCB. This provides a “look down image,” as seen in Figure 25, of a Flip Chip whose standoff or gap height is only 0.05mm. In Figure 26 the iris is lowered to approximately 0.012mm. This means that it is now possible to “look up,” as seen in Figure 27, at even the top side of the Flip Chip joint.

Figure 28 reveals the importance of this optical innovation by discovering a “disturbed” top side fillet of a Flip Chip with a standoff height of 0.05mm. Additionally, the lower iris now allows for interior joint inspection, as seen in Figure 29, of low profile CSP and Flip Chip components.

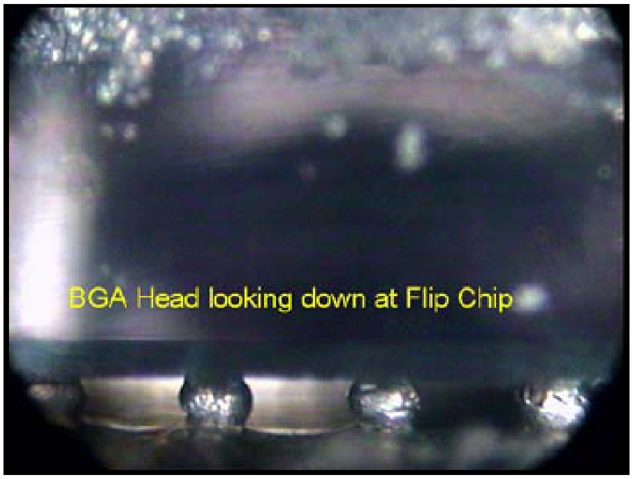


Figure 25 – Current "Look Down" Endoscope Image

Figure 26 - Endoscope with Lower Iris

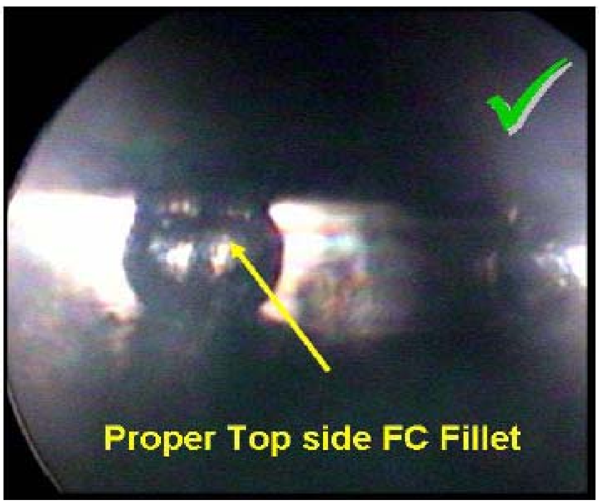


Figure 27 - New "Look Up" Endoscope Image

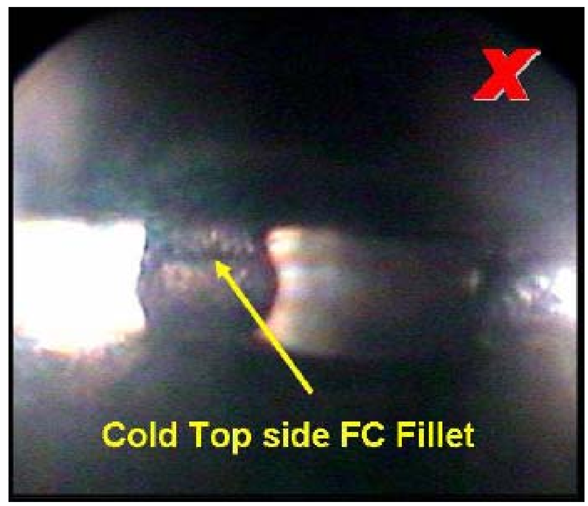


Figure 28 – Disturbed Top Side Flip Chip Fillet

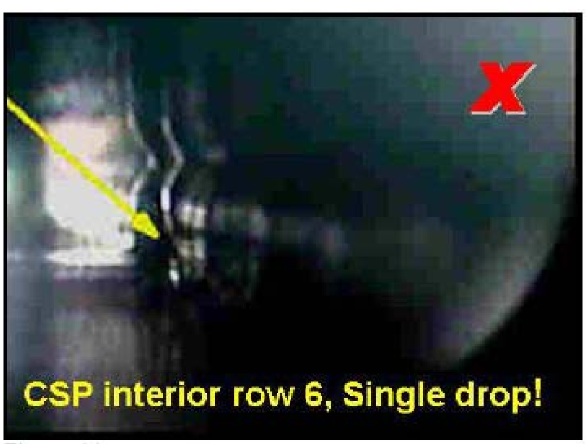


Figure 29 – Interior Solder Joint Inspection for Flip Chip and CSP

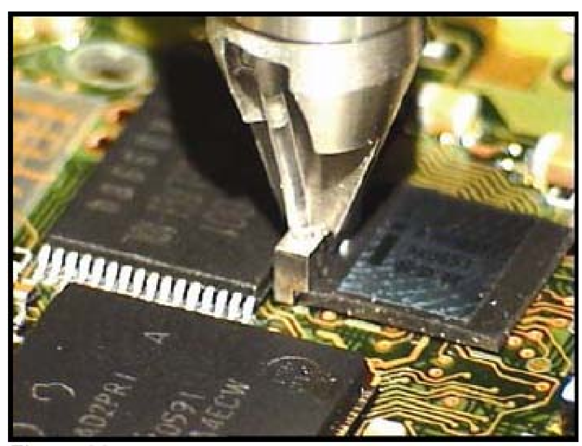


Figure 30 - Inspection of Dense PCBs

The inspection head can be used on densely populated PCBs as seen in Figure 30.

The higher process temperatures required for lead free will pose greater stress on the BGA package. Component shear delamination problems resulting from CTE mismatch problems occurring during the reflow process can be seen in Figures 31 and 32. Such problems will be more prevalent in a lead free process, and will require improved first article inspection to discover this component reliability problem. Based on the prevalence of this specific problem it is strongly recommended to inspect for this component deficiency during first article inspection.

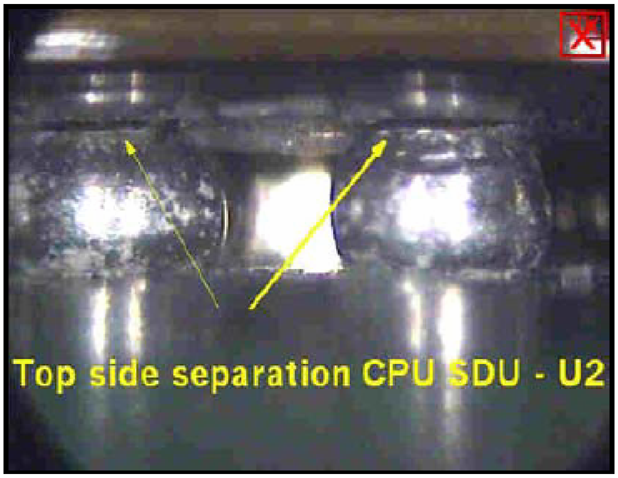


Figure 31 – CTE Mismatch Delamination

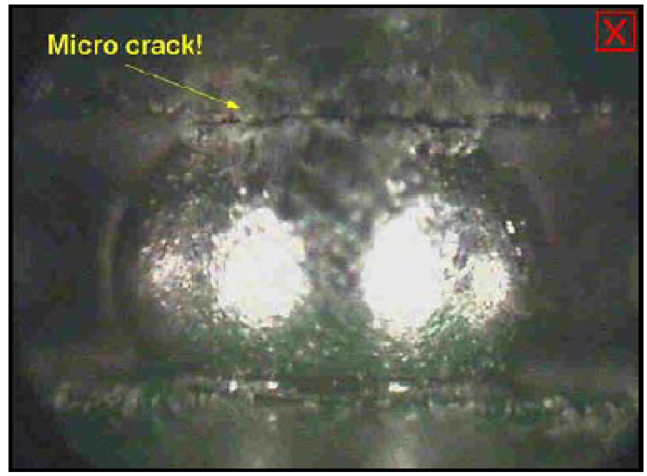


Figure 32 - CTE Mismatch Delamination

The bottom line is: higher process temperatures and smaller process windows associated with lead free will require a much more thorough first article inspection. Manual optical inspection systems will require higher magnification and a flexible viewing angle from 0° to 90°. BGA optical inspection equipment will not only provide the required inspection of hidden BGA, CSP and Flip Chip joints, but also will be an invaluable, high magnification (up to 350x), general inspection tool for lead free applications. All figures shown in this article are real life process defects and concerns, and the majorities have been taken with an endoscopic optical inspection system.

In conclusion, some words of wisdom to contemplate:
A wise man said, "If it's not broken, don't fix it."
A wiser man asked, "If I can't see what's broken, how do I know what needs to be fixed!"

To See is to Survive – Only by being capable of seeing all potential problems in your lead free process, will you be able to react, in order to correct those problems, assure quality, and guarantee adherence to reliability standards!

Following a Six Sigma quality philosophy, for example, only then makes sense and truly brings an added value when all possible defects can be detected at their point of occurrence. The final step to achieving "Zero Defect" was limited up until now by the tremendous associated costs and the non-existence of capable and efficient defect detection equipment. Integrating optical inspection equipment into the quality security chain is not only affordable, but also makes plain good sense.

Lead free first article inspection must be taken very, very seriously. The times of giving the key process engineers the role of singing only the chorus part are over. QS managers and process engineers must have a stronger voice! Quality Management following the ISO philosophy is a corporate leadership task from the top down. There is a very practical reason behind the decision that ISO 9001:2000 has now targeted core and supporting process steps, which include production, in the newly specified audit programs.

The bottom line, however, has less to do with a stamp of approval, and more to do with dollars and "sense": a properly qualified lead free SMT process will ultimately reduce the tremendous costs associated with soldering related process problems, rework, scrap and warranty failures. Mass production manufacturers know the true financial and image loss costs of warranty failures caused by the inability to detect all possible process related problems in their lines. And who seriously believes that with the implementation of lead free these problems will go away? On the contrary, all indications point to an increase to process problems! Having, inspecting and producing to accepted soldering standards has always been a requirement, but one that companies have been able to do with a questionable level of thoroughness. Honestly, how many companies producing to IPC Class 2 and 3 are inspecting the hidden PLCC toe fillets, the difficult to see TQFP heel fillets, not to mention the double drop on their BGAs? Implementation of lead free will require manufacturers to seriously reexamine their QA procedures. The industry must properly equip and train operators in order to successfully accomplish Lead Free First Article Inspection: The Key to Success. Non compliance can result in a company paying the ultimate price!

References

Figure source information:

1. Figures 3, 4, and 5: Zollner
2. Figures 6a and 6c: Philips
3. Figures 12, 17 and 18a: IPC
4. Figure 13: Frauenhofer Institute ISIT
5. Figure 15: Multicore
6. Figures 19a, 19c and 24: Phoenix
7. Figure 19b: Solectron

Lead Free First Article Inspection:

The Key to Successful Lead Free Implementation

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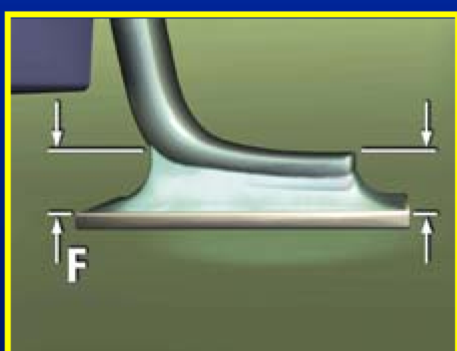
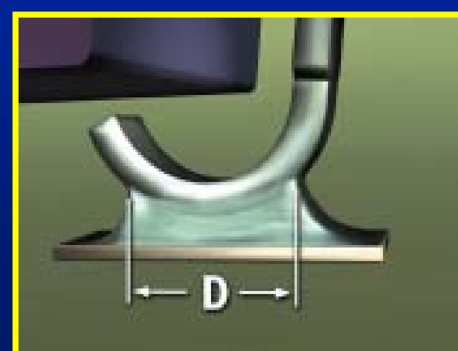
ERSA GmbH

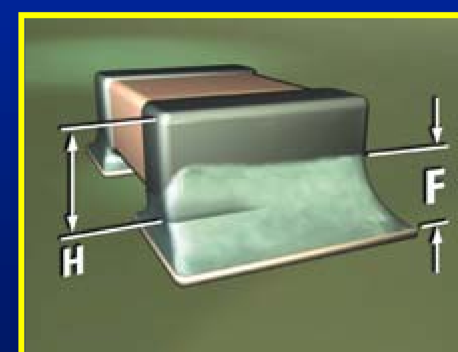
IPC APEXPO 2004 Technical Conference
February 24th, 2004

Lead Free Soldering:

Meeting International Standards must be a primary concern!

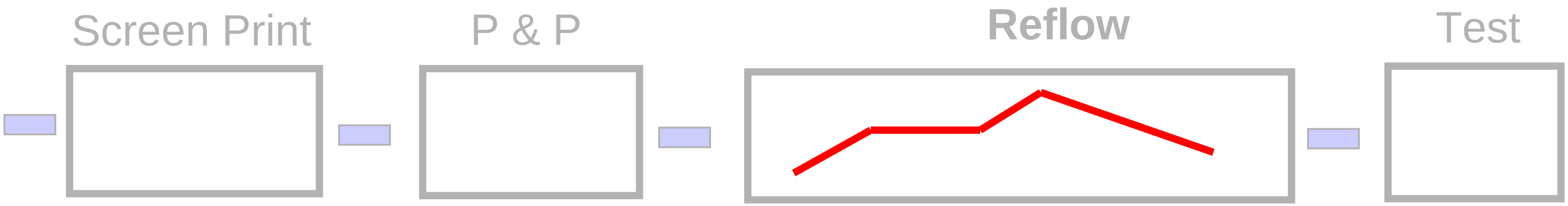




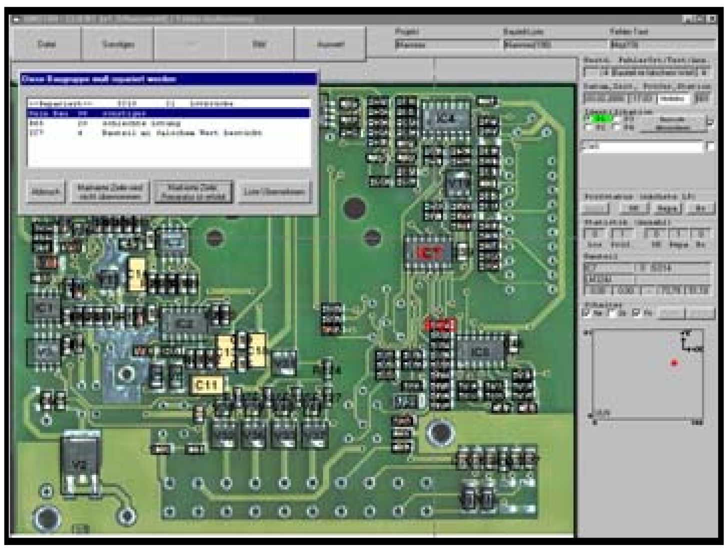


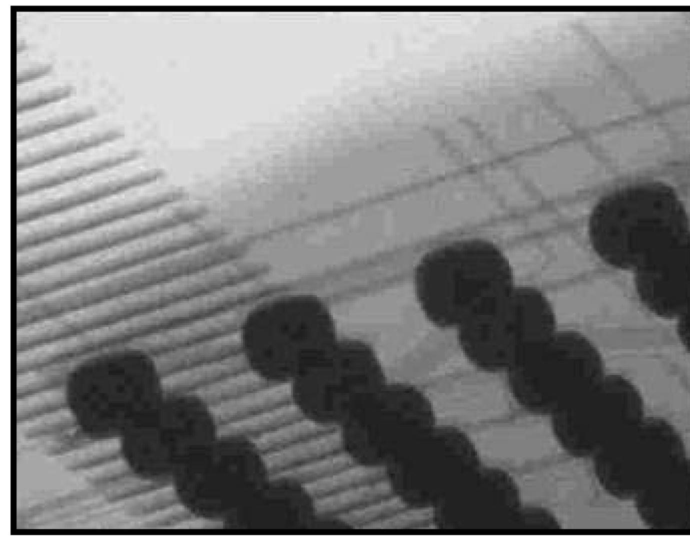
Source: IPC Electronic Workmanship Standard A-610: Sec. 12.2.5.6; J-STD-001

Where to invest most in the SMT QA process?



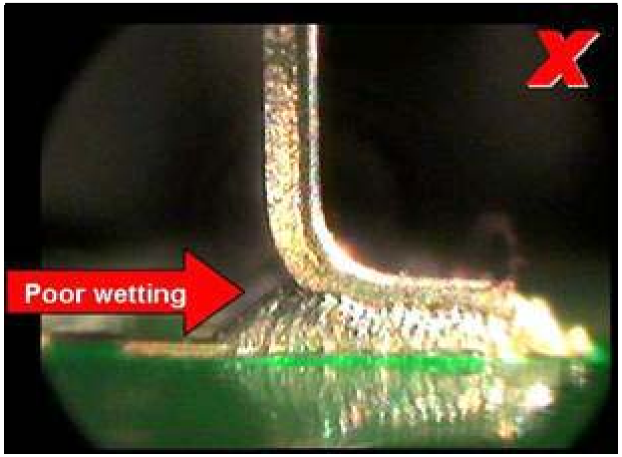
AOI and X ray are in-line, but cannot detect all defects!

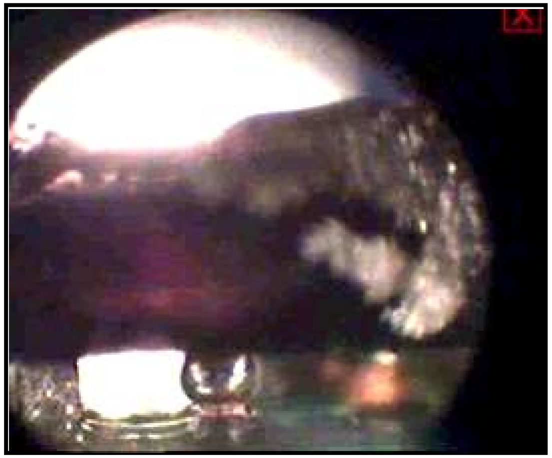




Only one undetected cold solder joint is all takes to cause a mis-qualification of the SMT line

Solder defects resulting from a poor reflow process





Not detected from AOI, Xray or ICT !!!!

The cost of producing and/or not detecting defects is too high!!!

ERSA GmbH Pictures: ERSA

A Kurtz Company

Lead Free Reflow First Article Inspection

How does Lead Free change my inspection process?

Lead Free Production Soldering:

Higher process temperatures, smaller process windows, poor wetting, and different surface appearance

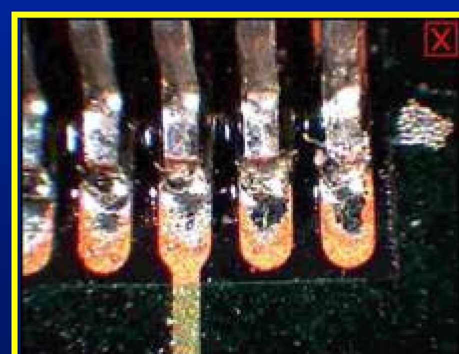
Require new training & procedures, higher magnification inspection & flexible viewing angles from 0° to 90°!

Critical Areas of Interest for Lead Free Inspection

1. Poor wetting and flow characteristics
2. Substrate warpage
3. Higher process temperatures either damaging components or changing the required shape of the solder joint
4. Striations, “orange peel” effect, “freezing lines”, and dendritic crystals make joints appear less shiny
5. Lead free flux residues
6. Tombstoning
7. Solder micro balling
8. Tin whisker formation
9. Void formation

Lead Free Soldering:

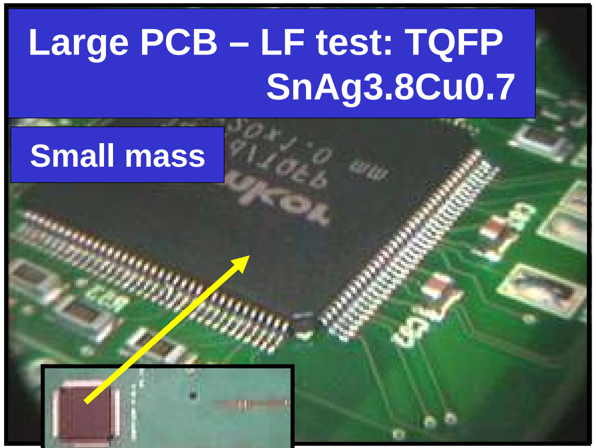
Poor wetting and flow characteriszics!

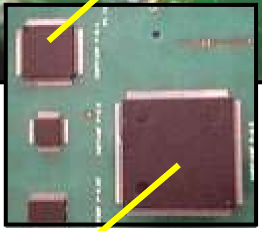


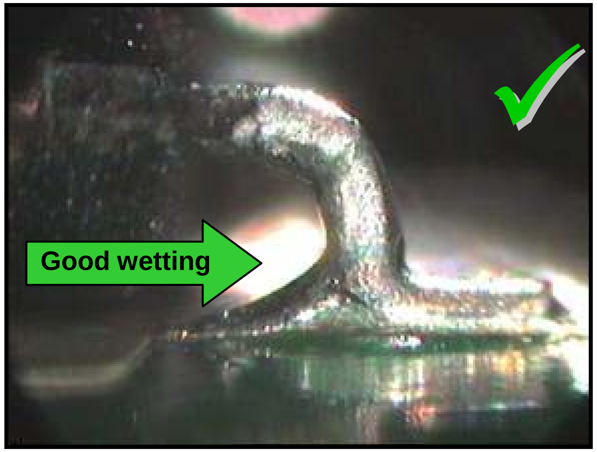
Source: ERSA, Frauenhofer

Lead Free will require improved inspection for IPC 610!

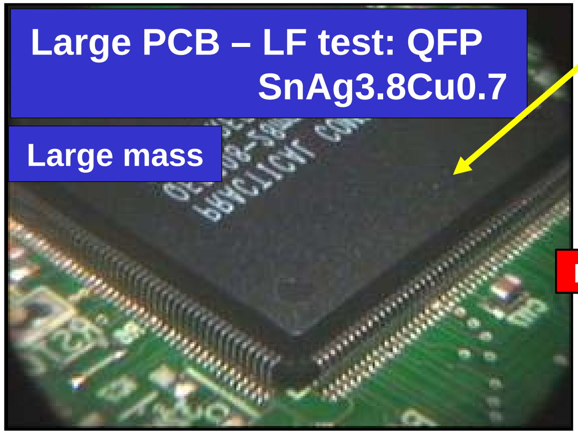
IPC Electronic Workmanship Standard
A-610: Sec. 12.2.5.6; J-STD-001

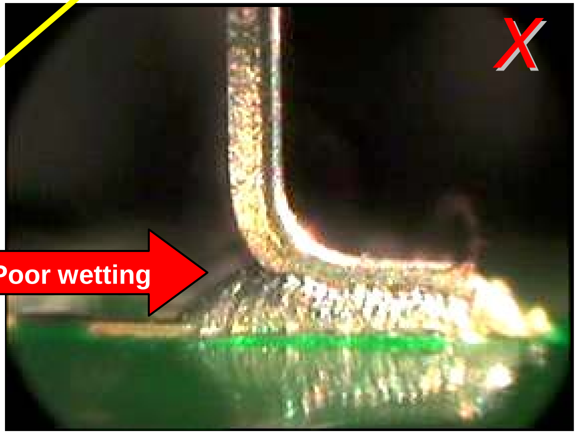


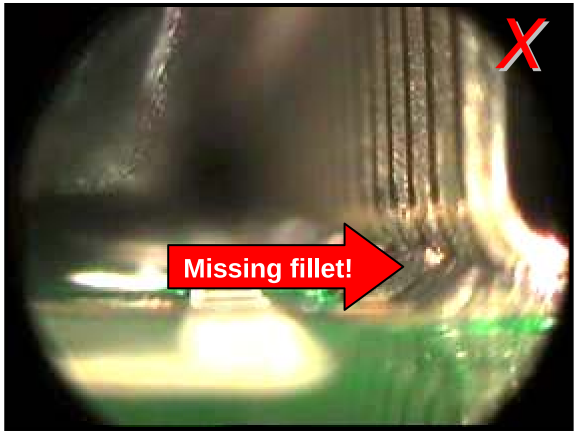




Required inspection of heal fillets!





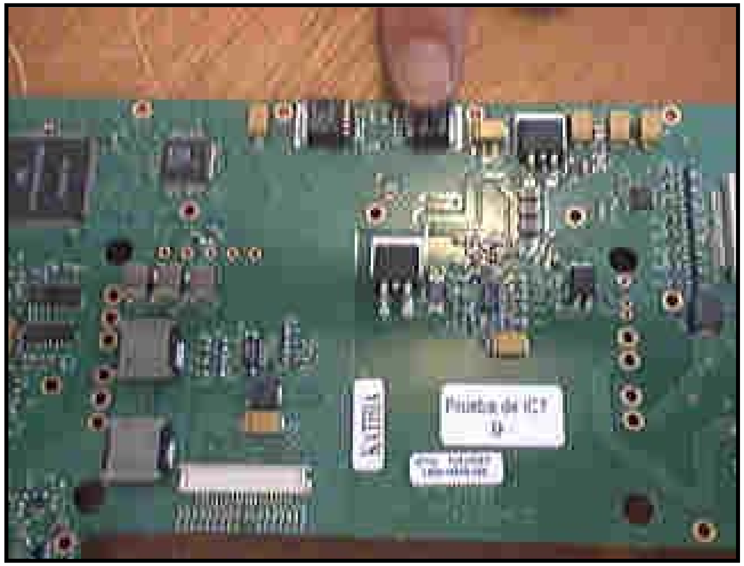


ERSA GmbH Pictures: ERSA

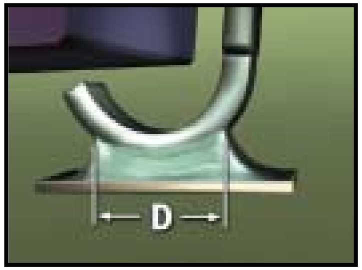
A Kurtz Company

Lead Free reflow will require improved for SMT inspection!

Lead Free solder has Wetting problems!!!



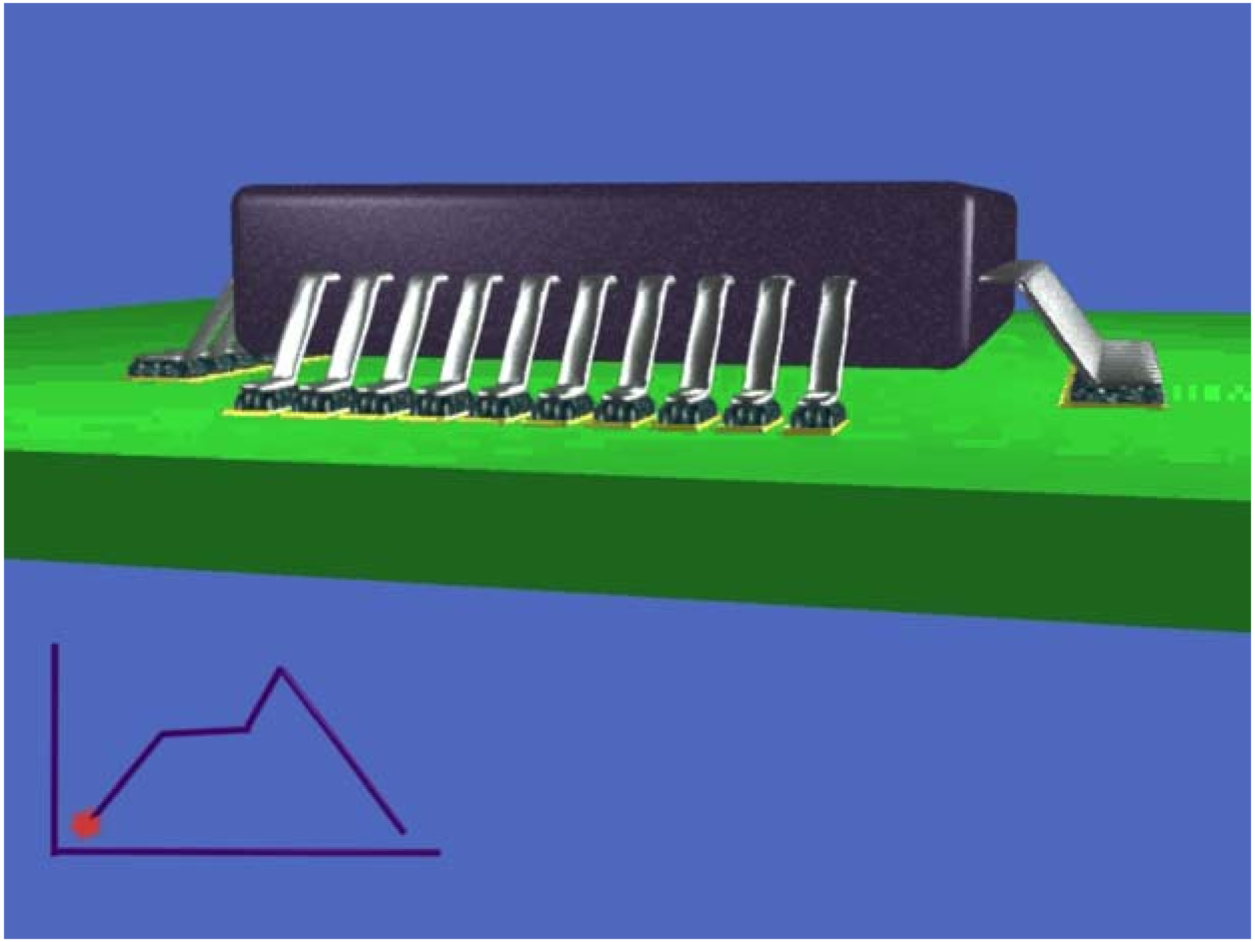
Initial Lead Free Reflow Solder Test:
LF Solder paste: SnAg3.8Cu0.7



ERSA GmbH

Pictures: ERSA, IPC

Lead Free Reflow Process Concerns: Board warpage



Caused from high temperature & unefficient center support

Lead Free Reflow Process Concerns: Open or Near Open Joints

Result of board warpage and component bulging due to high temperature

High magnification and optimal viewing angle required!

ERSA GmbH Picture: Philips

A Kurtz Company

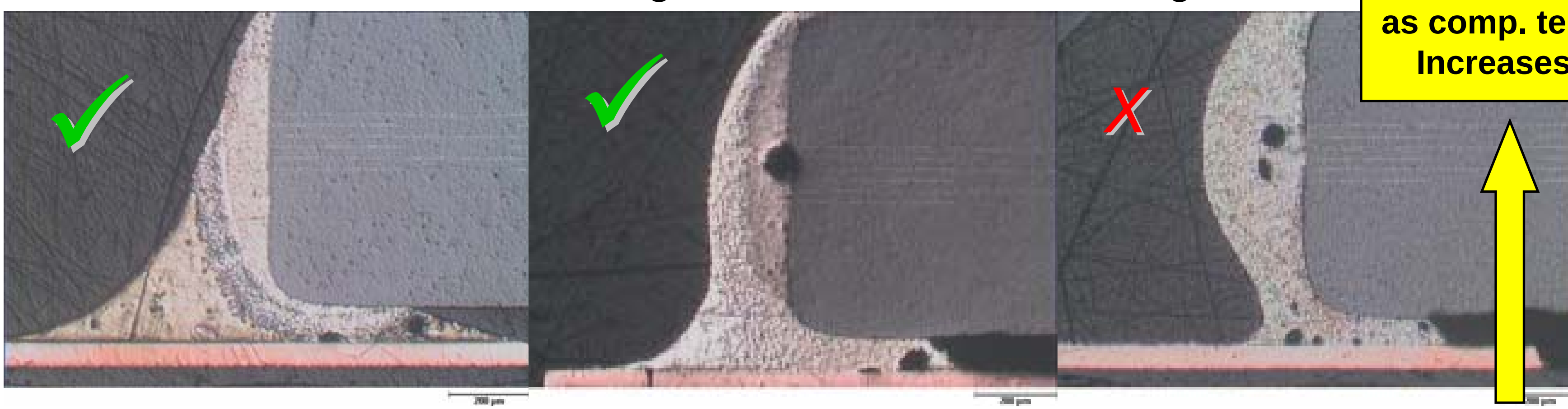
High Temperature Profiles for lead free reflow soldering

High temperature reflow profiles, with peak temperatures up to 250 °C, are often recommended to solder lead free assemblies.

This extreme high temperatures may damage components, PCB laminate and influence solder joint reliability and shape.

SnPb **SnAgCu** **SnAgCu**

Solder moves to hotter area as comp. temp Increases!

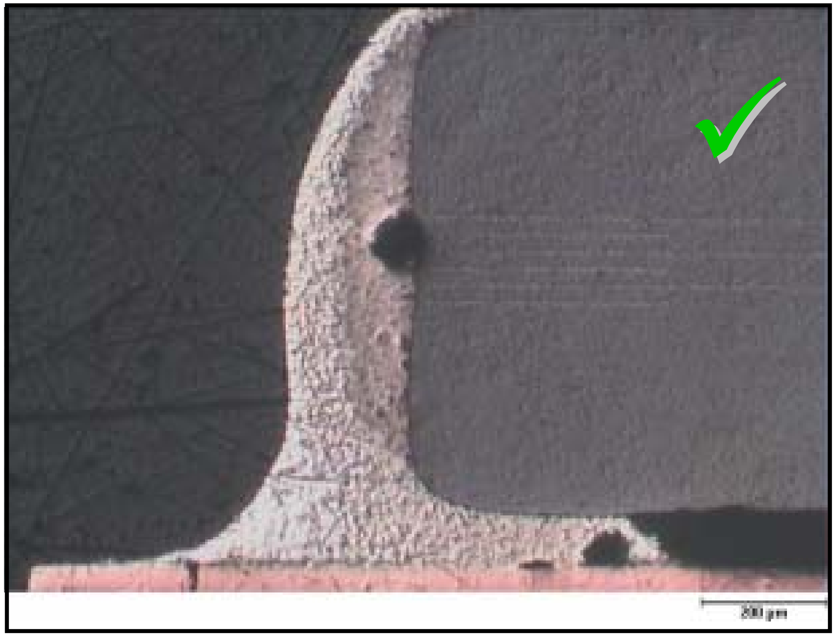


T_{max} 215°C **T_{max} 235°C** **T_{max} 260°C**

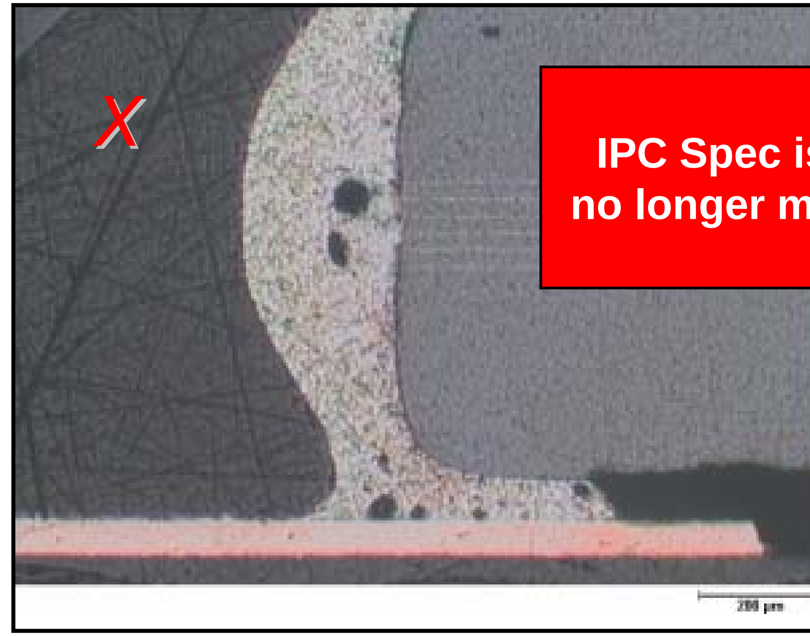
Component: Chip C 1206 AgPd
Board: NiAu

Pictures: Zollner, Zandt

High temperatures will influence solder joint reliability and shape.

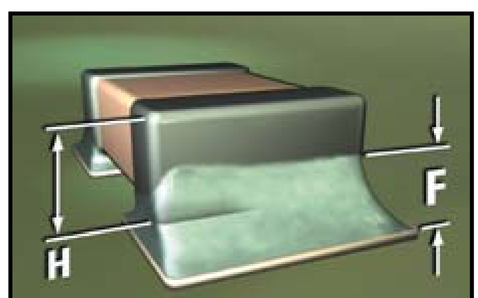


T_{max} 235°C



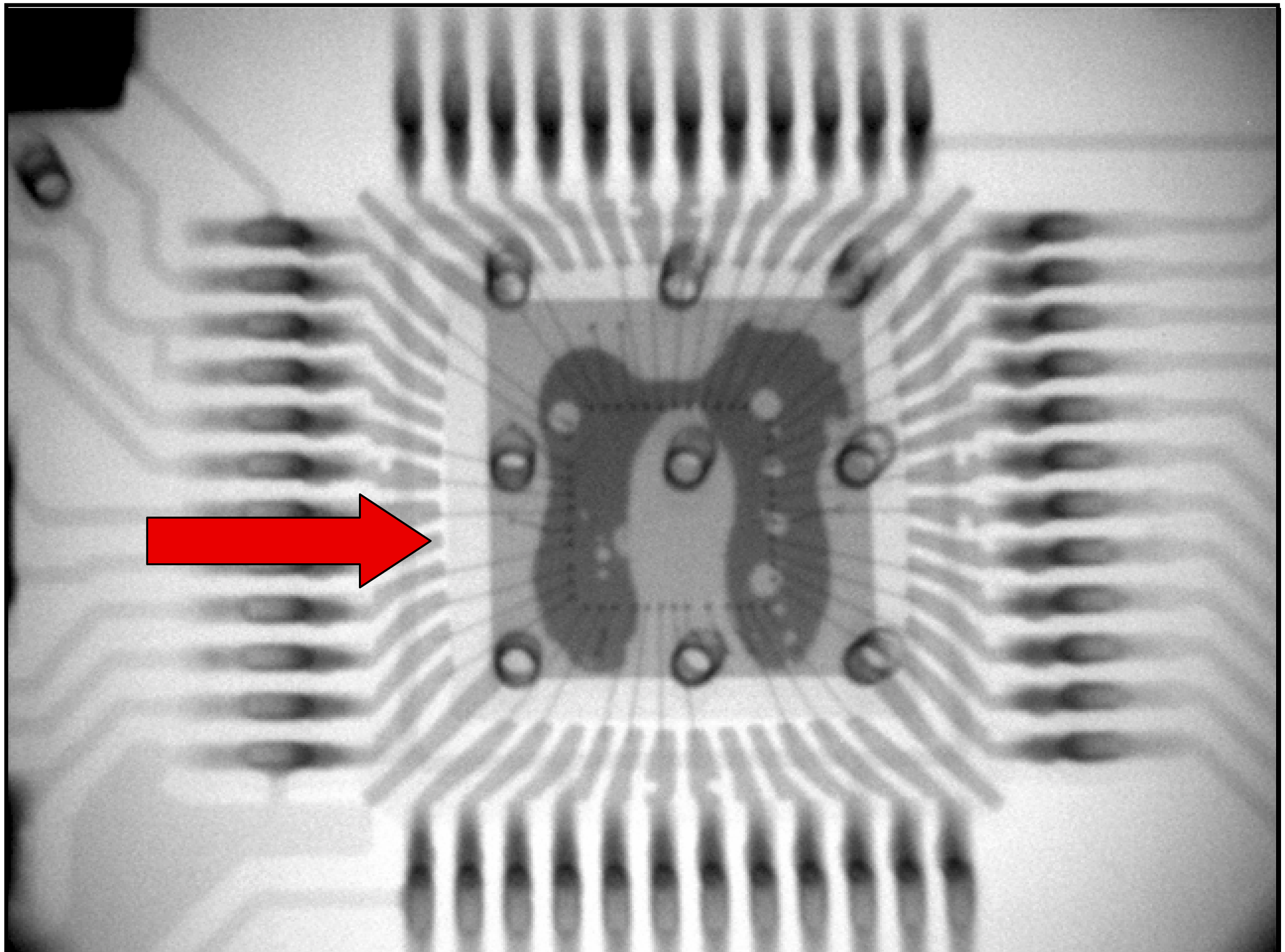
IPC Spec is no longer met!

T_{max} 260°C



IPC Electronic Workmanship Standard
A-610: Sec. 12.2.5.6; J-STD-001

Heading Conditions for Component Safety:



Picture: ERSA

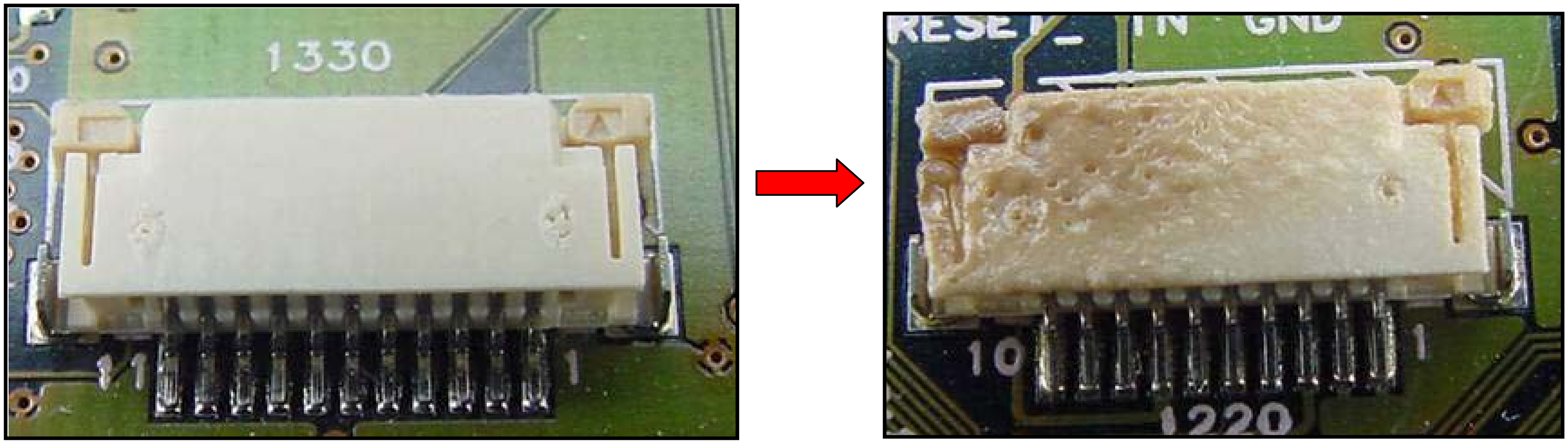
For Component Safety:

1.Heat Ramp rate must not exceed 3°C/sec. Max

2. Maximum Die Temp must not exceed 260°C

If these critcal process conditions are not met, than the die wire bond can break!

Lead Free Reflow Process Concerns: Component Damage

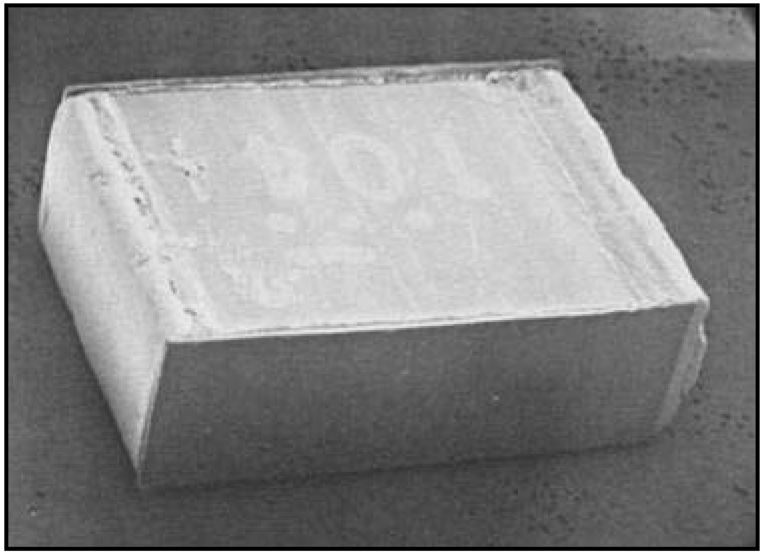


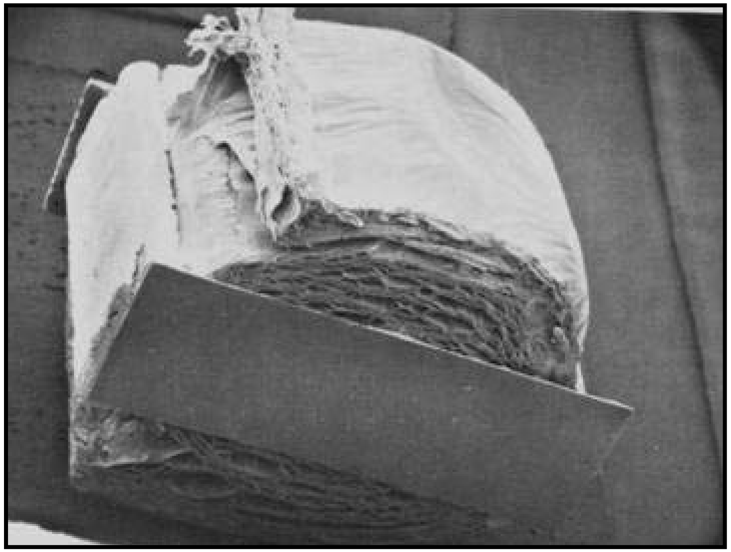
240 ºC

270 ºC

Deformation of thermo-plastic component bodies

Lead Free Reflow Process Concerns : Component Damage





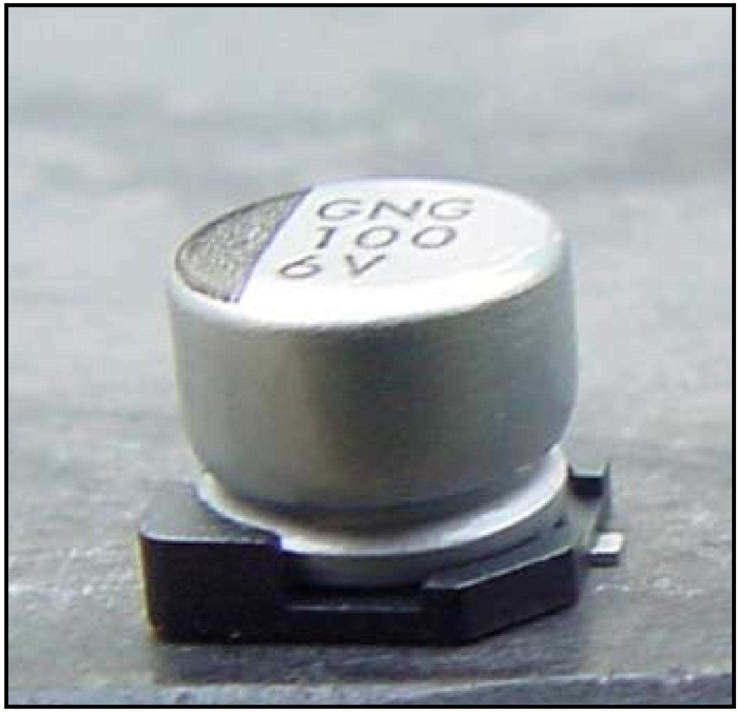
225 ºC

255 ºC

ERSA GmbH Pictures: Philips

A Kurtz Company

Lead Free Reflow Process Concerns: Component Damage



225 ºC

250 ºC

Vapor pressure in ELCO

ERSA GmbH Pictures: Philips

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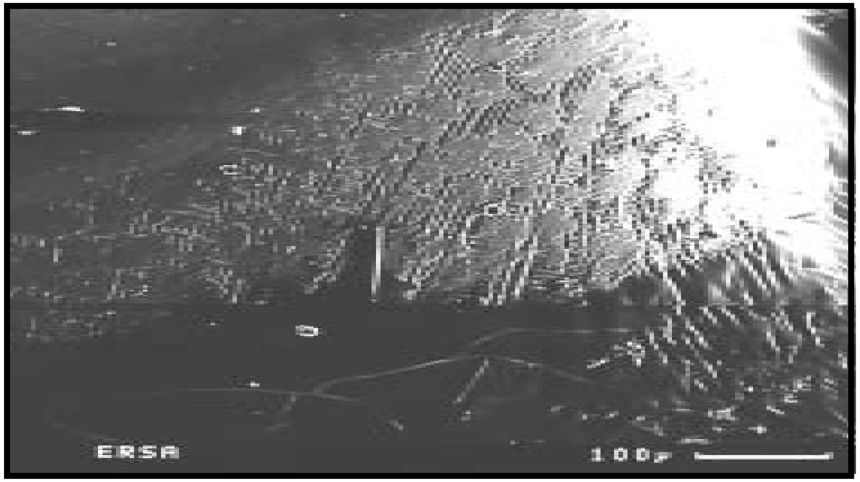
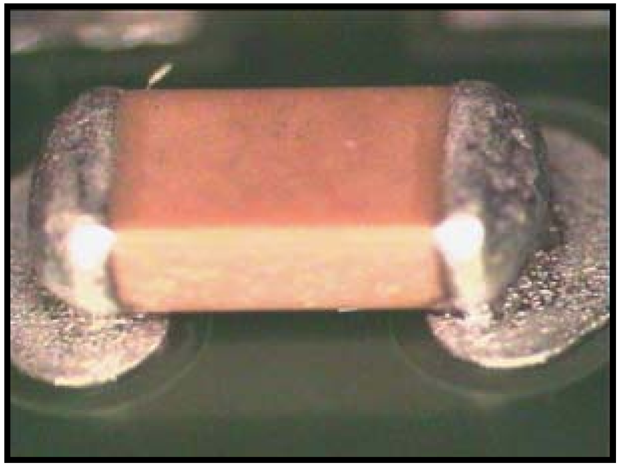
Lead Free Solder Joint Inspection is more difficult!





The solder joint surface looks more grainy, due to the primary dendritic solidification of the lead free solder.

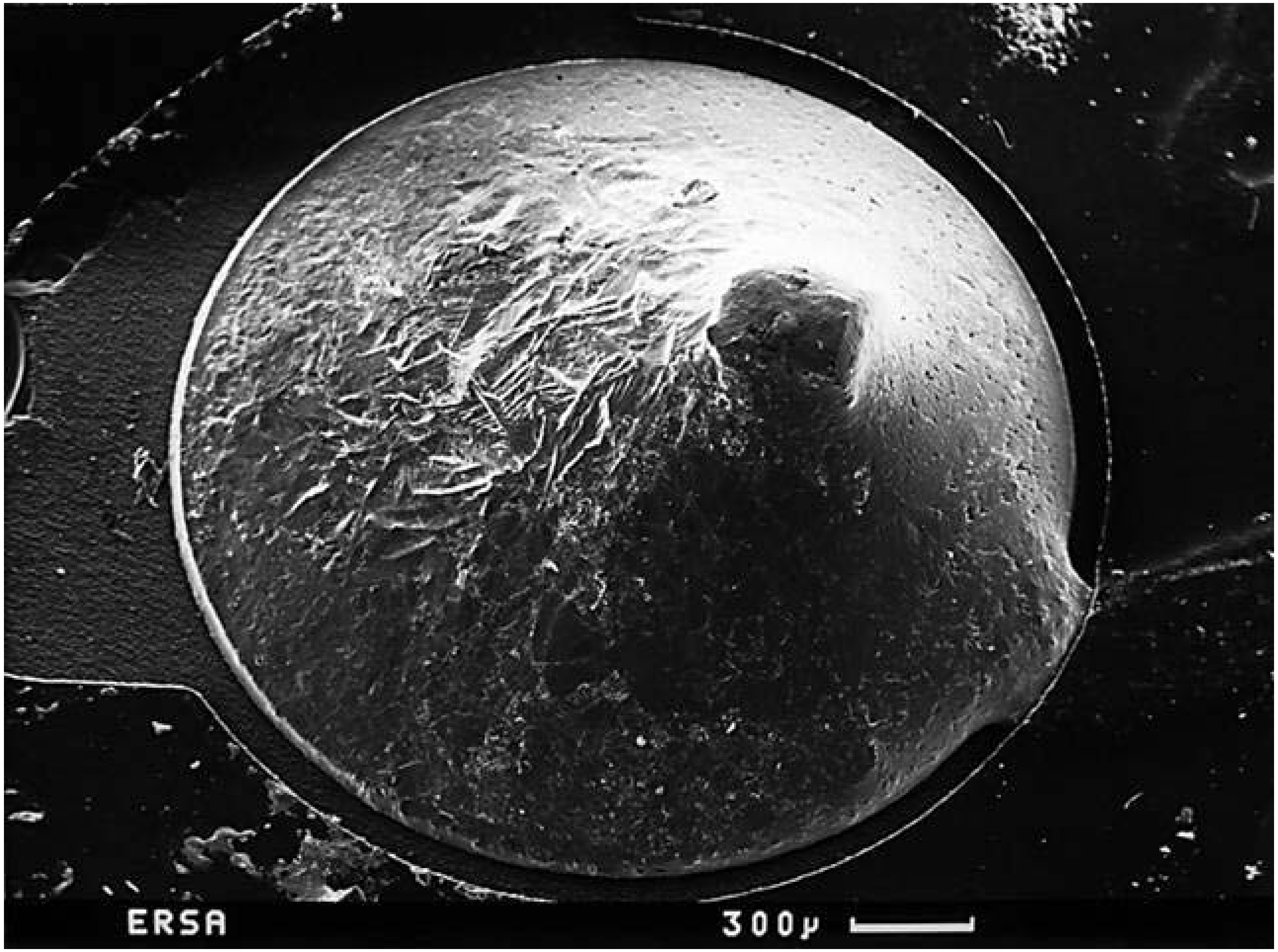
“Freezing lines“ or “orange peel effect“ are cosmetic in nature and do not indicate a poor joint!

Highest magnification is required!

ERSA GmbH Pictures: ERSA

A Kurtz Company

Lead free wave solder joint with embedded Cu needles



Cosmetic defect only!

ERSA GmbH Picture: ERSA

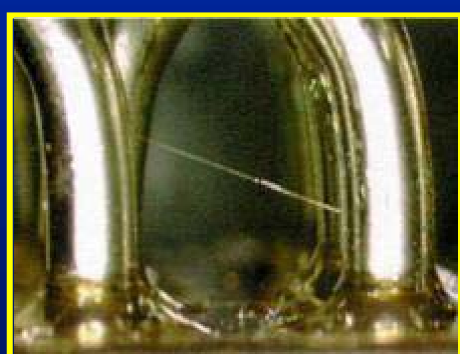
Lead Free Soldering:

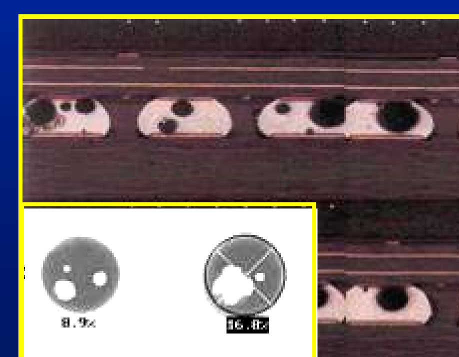
Flux residue, tombstoning, micro-balling!

Source: ERSA, Frauenhofer ISIT

Lead Free Soldering:

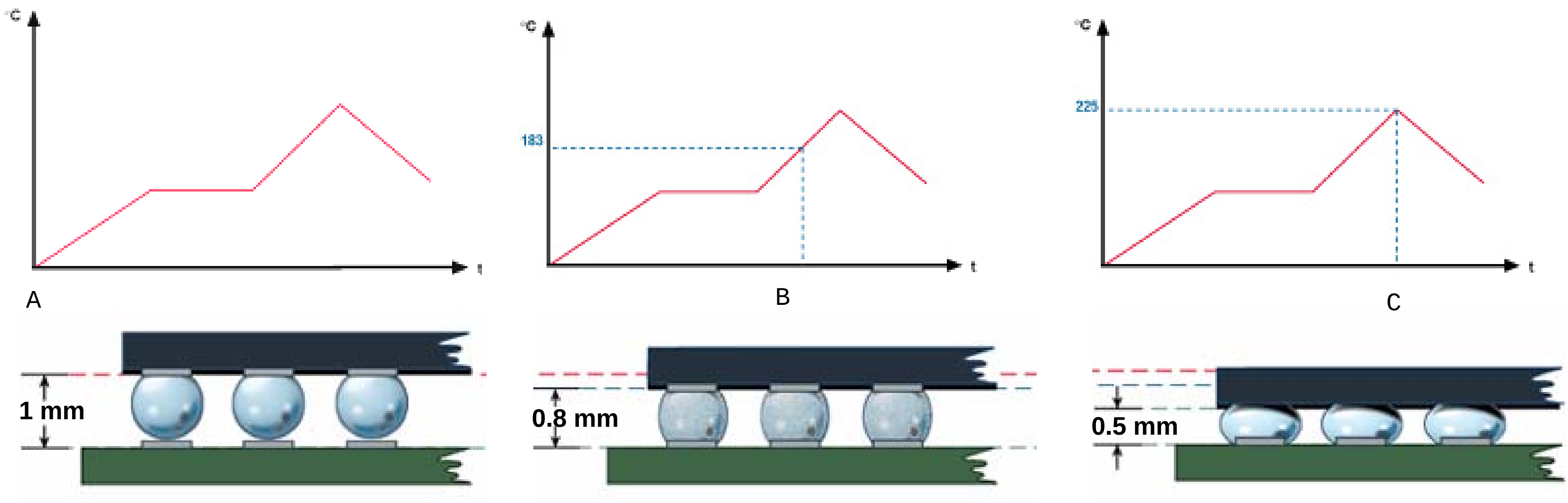
Tin whisker and increased void formation!





Source: Frauenhofer, Phoenix, Solectron

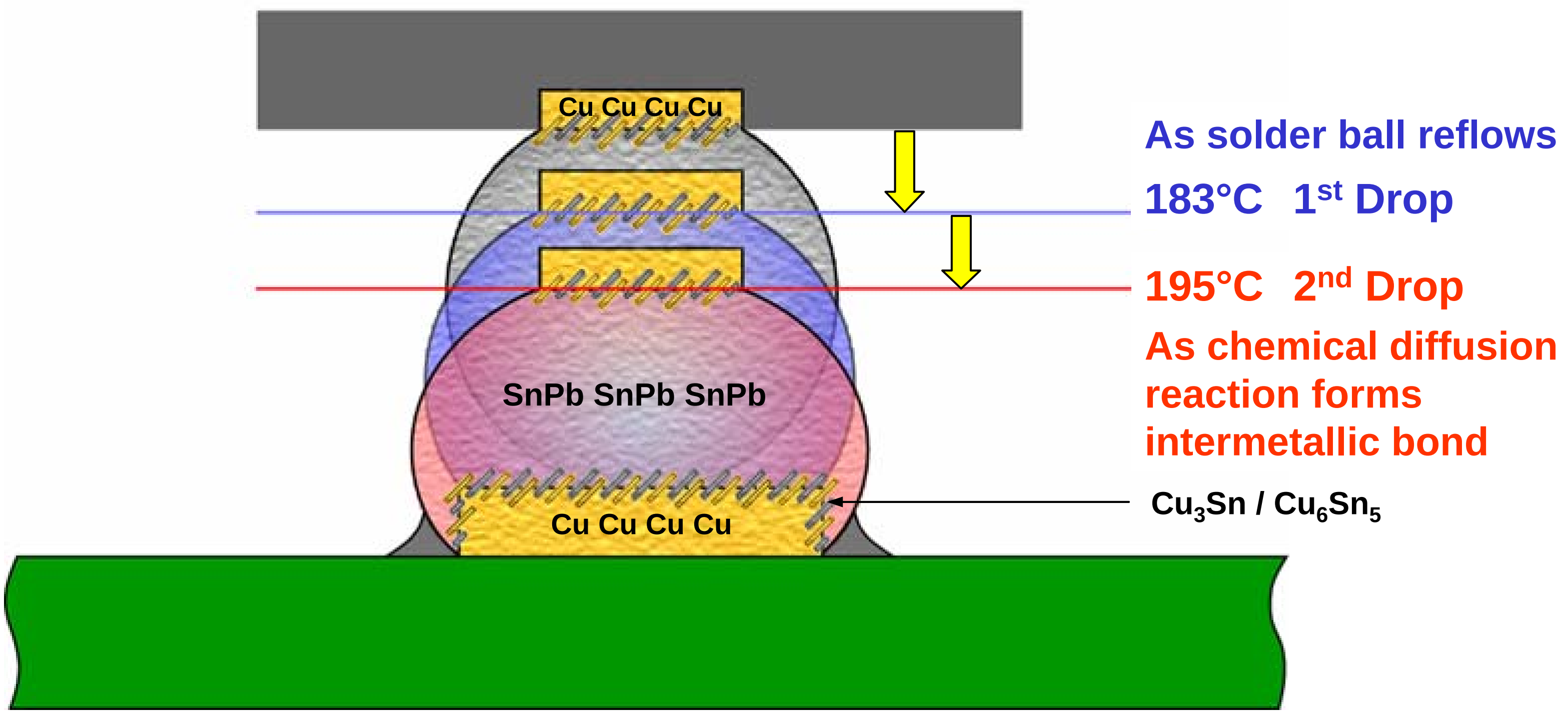
BGA Production –
Typical Physical Effects during a BGA Reflow Process



Condition A	Condition B	Condition C
Before Reflow Begins	*At Solder Melt Point*	*At Proper Peak Temperature*

The physical effects during reflow of a PBGA collapsible package are graphically shown in the figures with regards to the stand-off height, the collapse and wetting angle.

Double Drop Effect by BGA / CSP / Flip Chip components

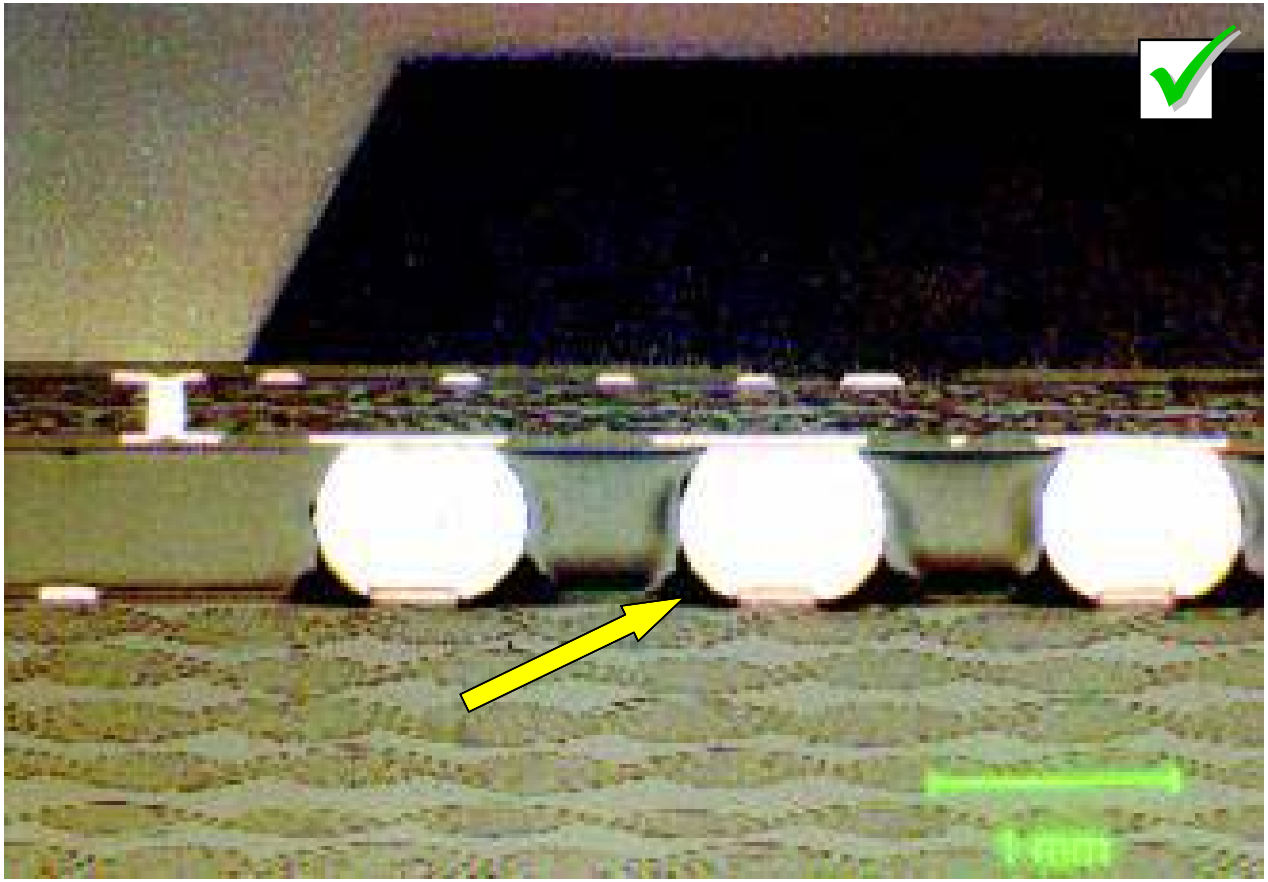


Graphic depicts a non-solder mask defined (NSMD) pad

Life cycle test results show that NSMD pad on both board and package give superior performance to when solder mask defined (SMD) pads are used.

Source:Reliability of BGA Packages in an Automotive Environment, Roger Rörgren, Per-Erik Tegehall and Per Carlsson, IVF - The Swedish Institute of Production Engineering Research, www.ivf.se

Cross-section –
of Double Drop PBGA on an NSMD Pad



Note: Complete wetting to the pad and proper wetting angle of the flux residue fillet.

ERSA GmbH Picture: ERSA

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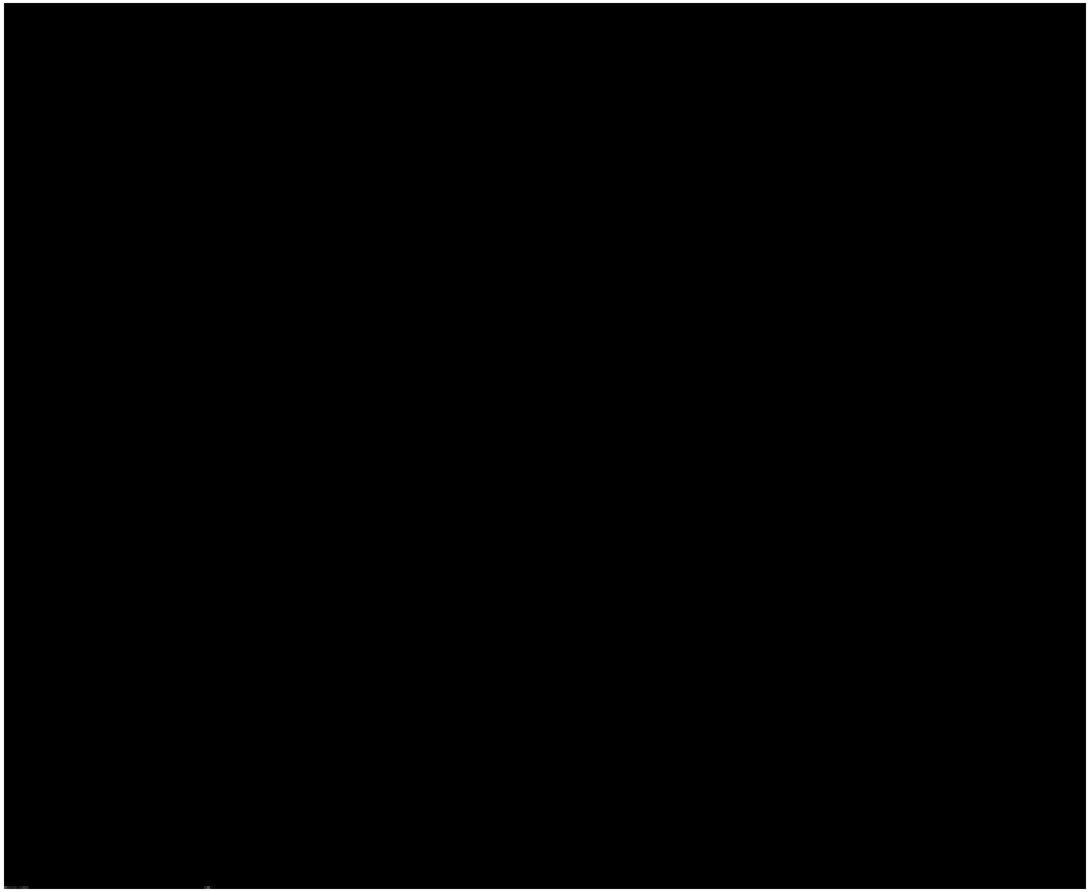
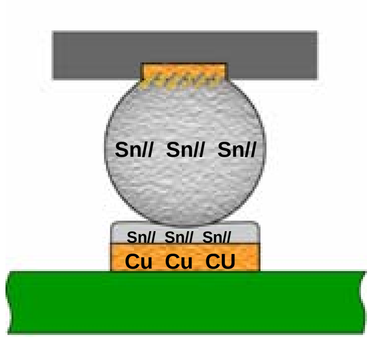
BGA Double Drop Effect
documented by Philips CFT

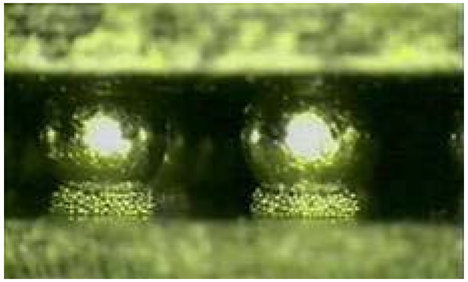
Video clip of BGA joint formation revealing the double drop effect.
The video was generated using a BGA Optical Inspection System.



Source: BGA Joint Formation, Jan Kolsters, Philips CFT, Eindhoven, Netherlands, May 2000

The importance of temperature control in an SMD/BGA Line





At room temperature

25° C

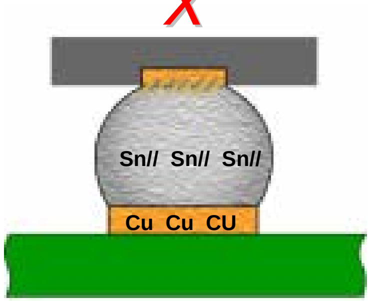
(All materials are solid)

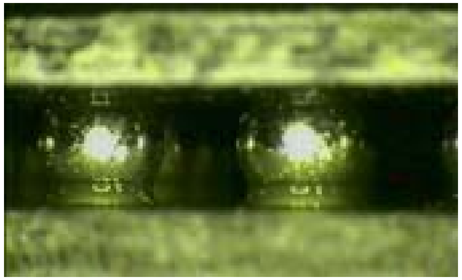
No bond between pin, solder and pad:

Function Test - *GOOD!

Joint Reliability - BAD!

X





At solder melt temperature

SnPb:185° C or SnCuAg:225°C

(The liquid solder flows)

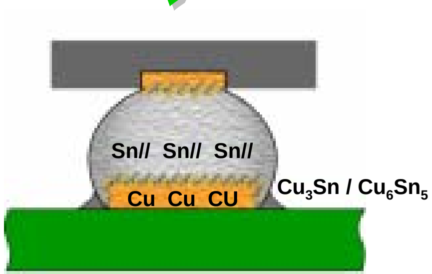
Surface tension bond between pin and pad:

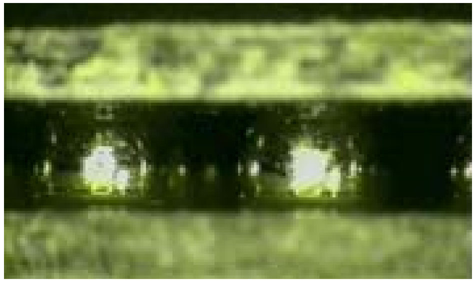
Function Test – *GOOD!

ICT / X-Ray – *GOOD!

Joint Reliabilty - BAD!

X





At proper "wetting" temperature

SnPb:195/205 ° C or SnCuAg:230/235°C

(Intermetallic bond is formed)

Intermetallic bond between pin and pad:

Function Test – *GOOD!

ICT / X-Ray – *GOOD!

Joint Reliabilty – GOOD!

Pictures: ERSA

ERSA GmbH

***Proper Test & Inspection results depend on equipment and techniques**

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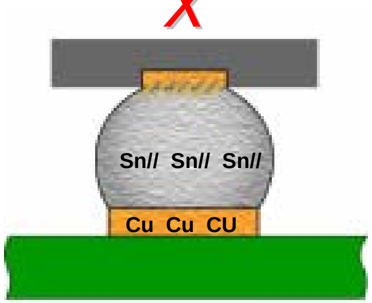
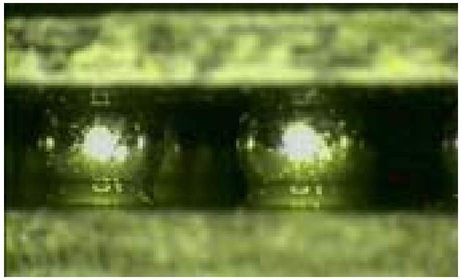
Producing an Unknown ΔT will lead to Unknown Results

X





At solder melt temperature
SnPb:185° C or SnAgCu:225°C
(The liquid solder flows)

Surface tension bond between pin and pad:

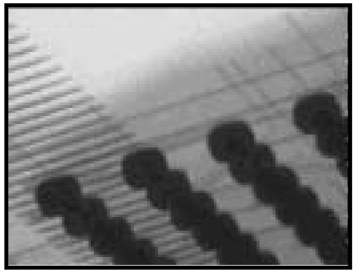
Function Test – *GOOD!

ICT / X-Ray – *GOOD!

Joint Reliabilty - BAD!

X

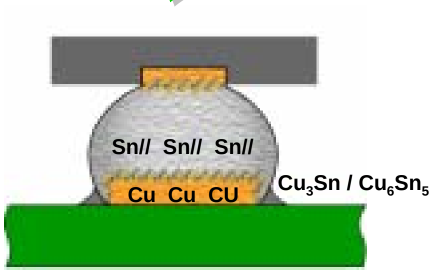
? ? ? ? ?

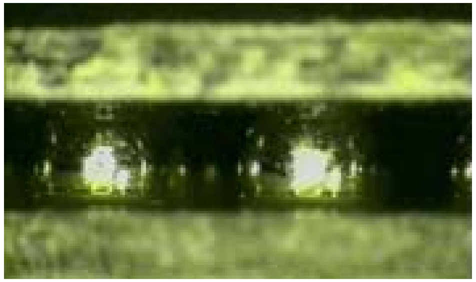


Less than 5°C ΔT can make the difference between Bad and Good Reliability!

? ? ? ? ?

✓





At proper “wetting” temperature
SnPb:195/205 ° C or SnAgCu:230/235°C
(Intermetallic bond is formed)

Intermetallic bond between pin and pad:

Function Test – *GOOD!

ICT / X-Ray – *GOOD!

Joint Reliabilty – GOOD!

✓

ERSA GmbH

Pictures: ERSA

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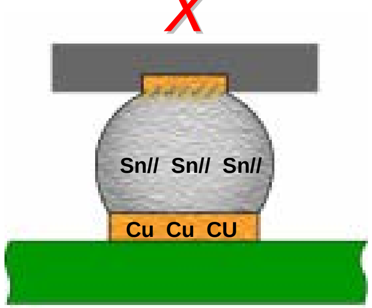
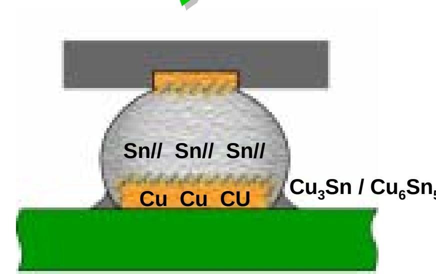
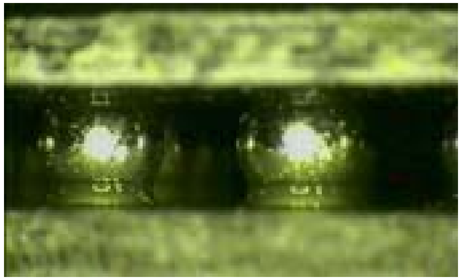
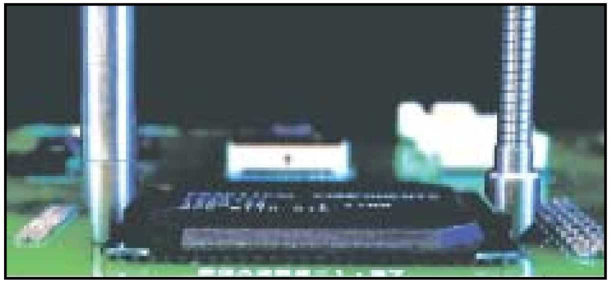
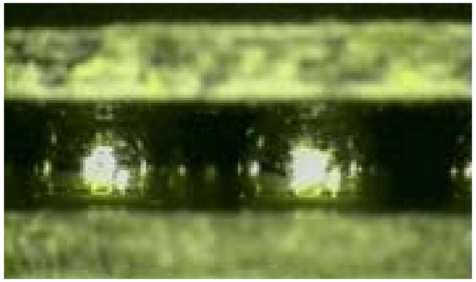
BGA Optical Inspection Detects the Critical Difference











At solder melt temperature
SnPb:185° C or SnAgCu:225°C
(The liquid solder flows)

Surface tension bond between pin and pad:

Function Test – *GOOD!

ICT / X-Ray – *GOOD!

Joint Reliabilty - BAD!

At proper "wetting" temperature
SnPb:195/205 ° C or SnAgCu:230/235°C
(Intermetallic bond is formed)

Intermetallic bond between pin and pad:

Function Test – *GOOD!

ICT / X-Ray – *GOOD!

Joint Reliabilty – GOOD!

BGA Optical Inspection Allows for Proper SMT Qualification

ERSA GmbH Pictures: ERSA

*Proper Test & Inspection results depend on equipment and techniques

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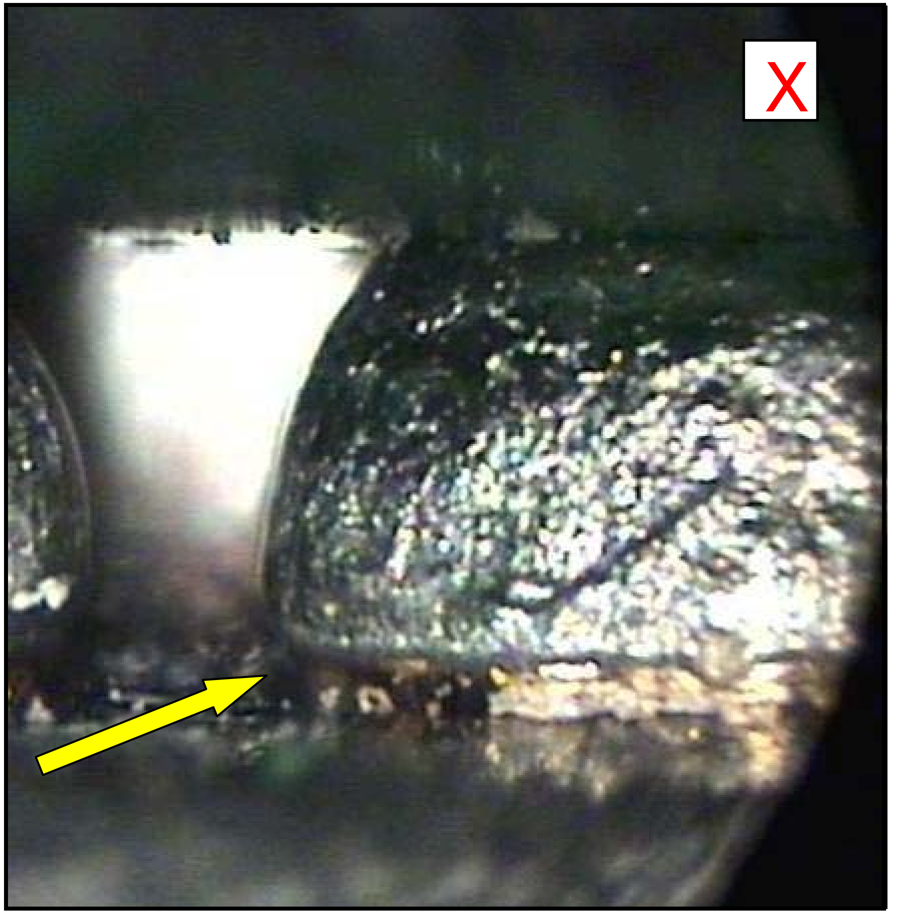
BGA Optical Inspection System & Image

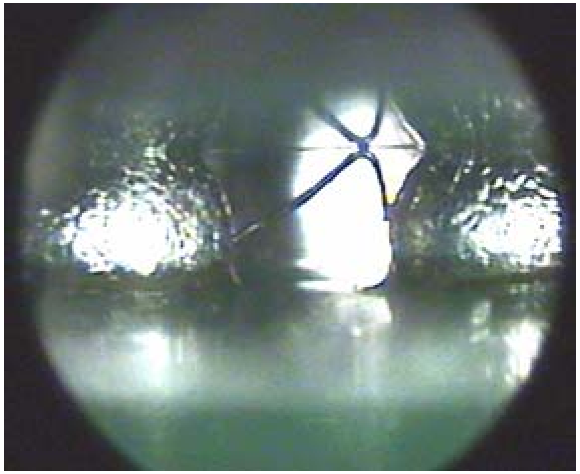


Single drop PBGA; no wetting to pad: Aerospace Industry – real life example

ERSA GmbH Pictures: ERSA

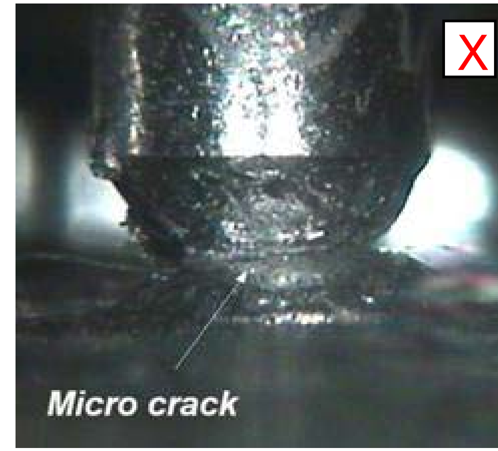
A Kurtz Company

BGA Optical Inspection –
Typical BGA Problems where X-Ray alone might fail!

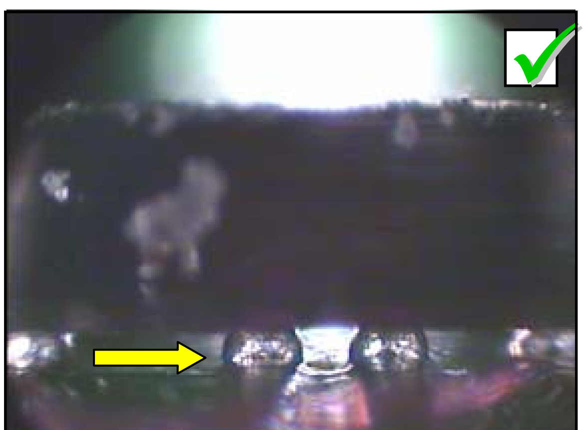


Tin Whisker formation causes short

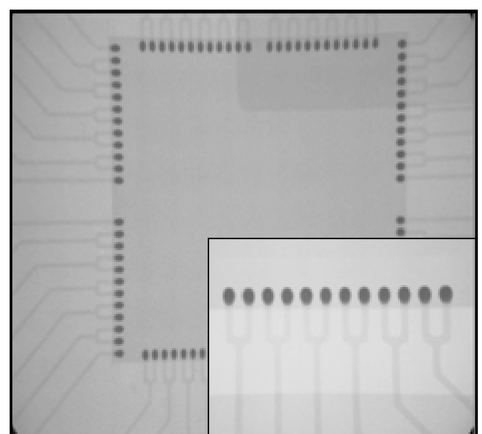
Delamination difficult to detect with x-ray



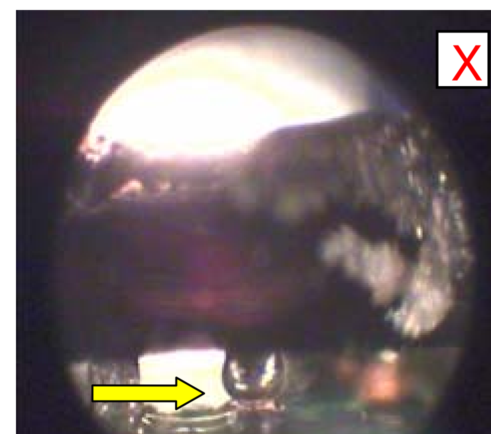
Micro crack difficult to detect with x-ray



Optical image of good Flip Chip solder joint, 2 mils; good drop



X-ray Image of Flip Chip 96 after Soldering – difficult to detect the true quality of the solder joints

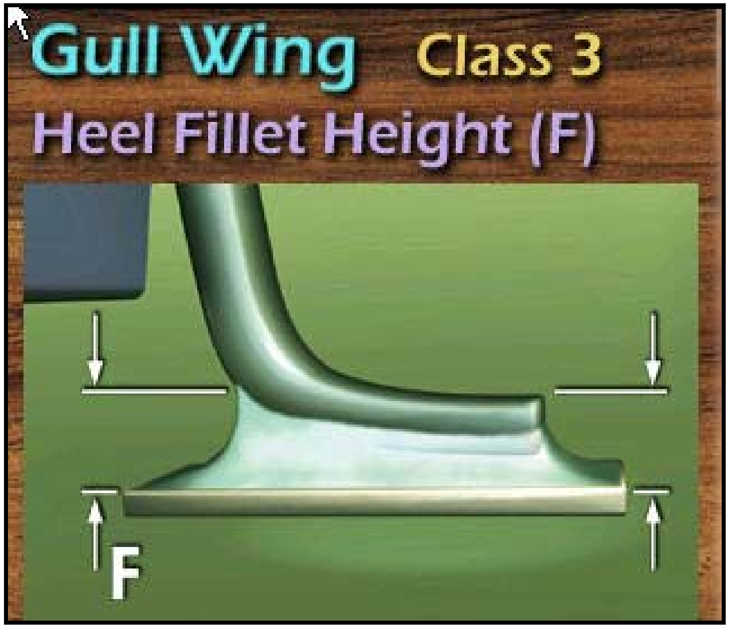


Optical image of bad Flip Chip solder joint; no drop

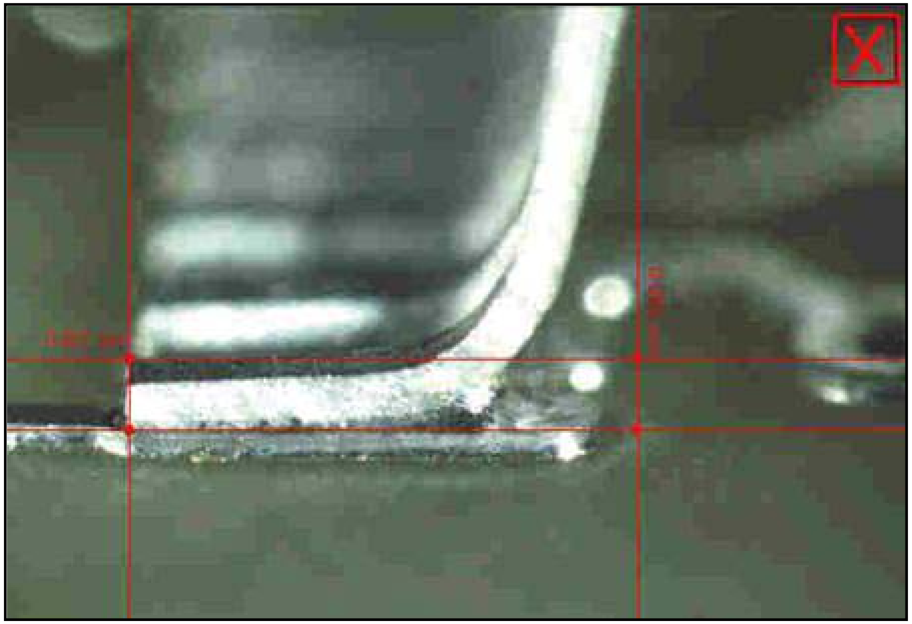
ERSA GmbH Pictures: ERSA

A Kurtz Company

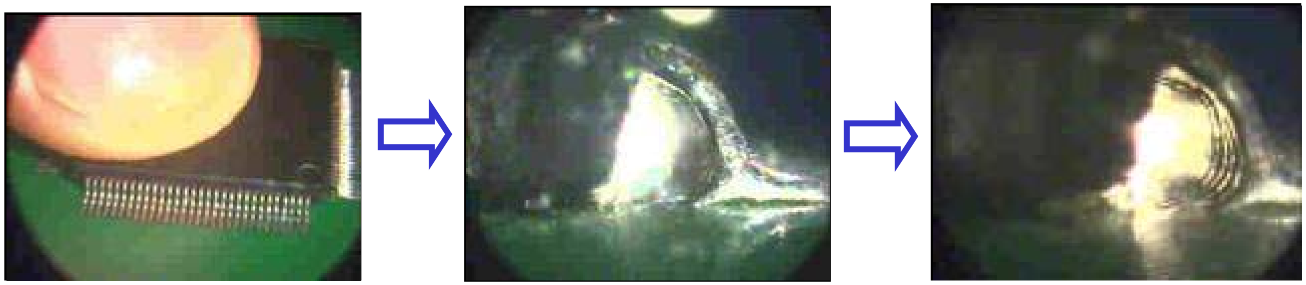
Have Standards, Inspect to Standards, Produce to Standards!



IPC Electronic Workmanship Standard
A-610: Sec. 12.2.5.6; J-STD-001



Inspect and measure heal fillet



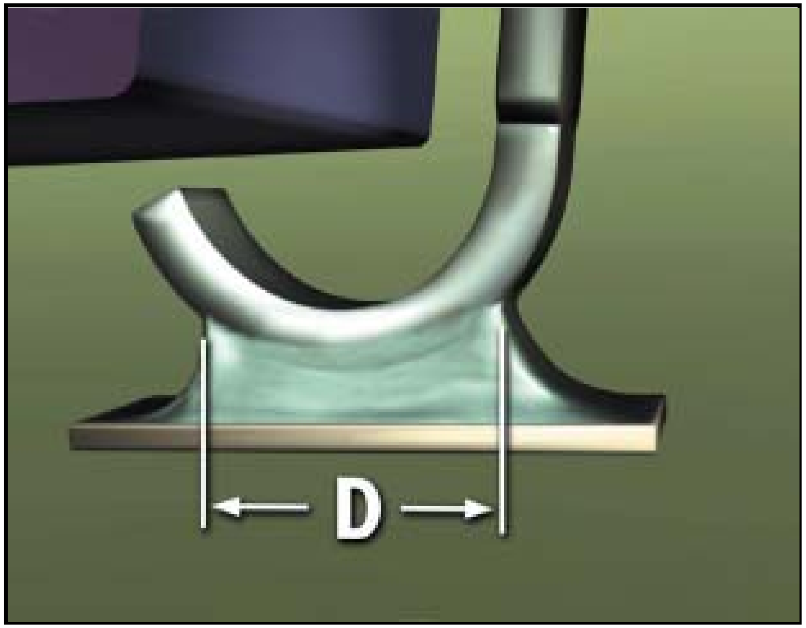
16 Mil Pitch (.4mm) TQFP Heel Inspection

ERSA GmbH

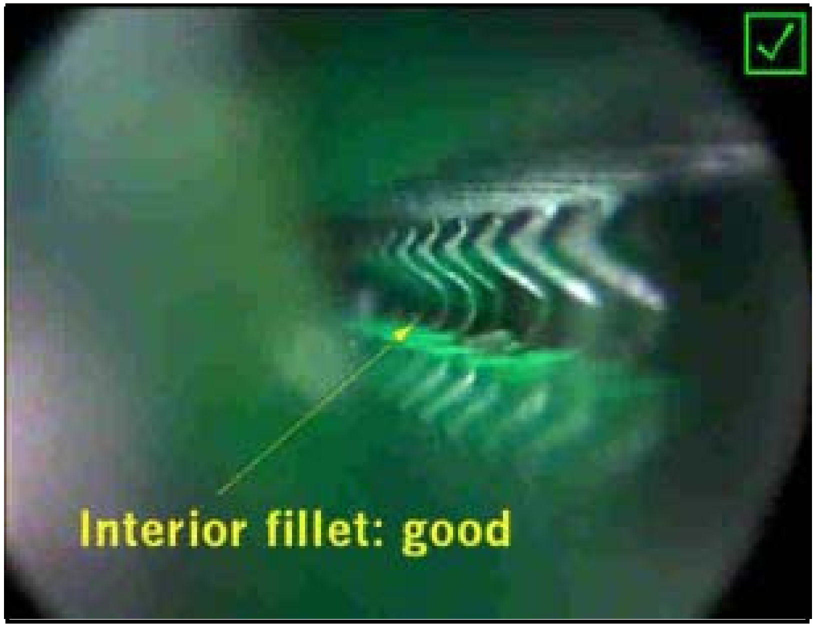
Pictures: ERSA

A Kurtz Company

Have Standards, Inspect to Standards, Produce to Standards!



IPC Electronic Workmanship Standard
A-610: Sec. 12.2.5.6; J-STD-001

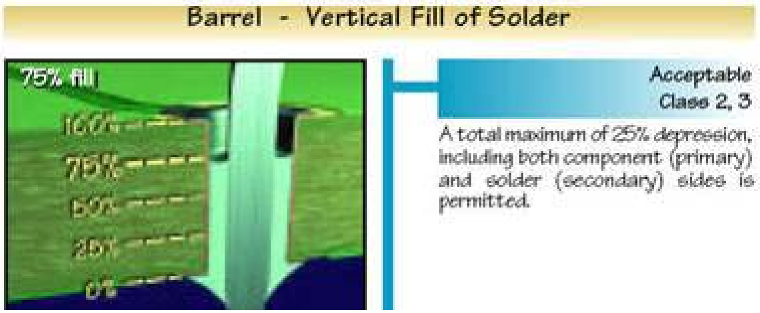


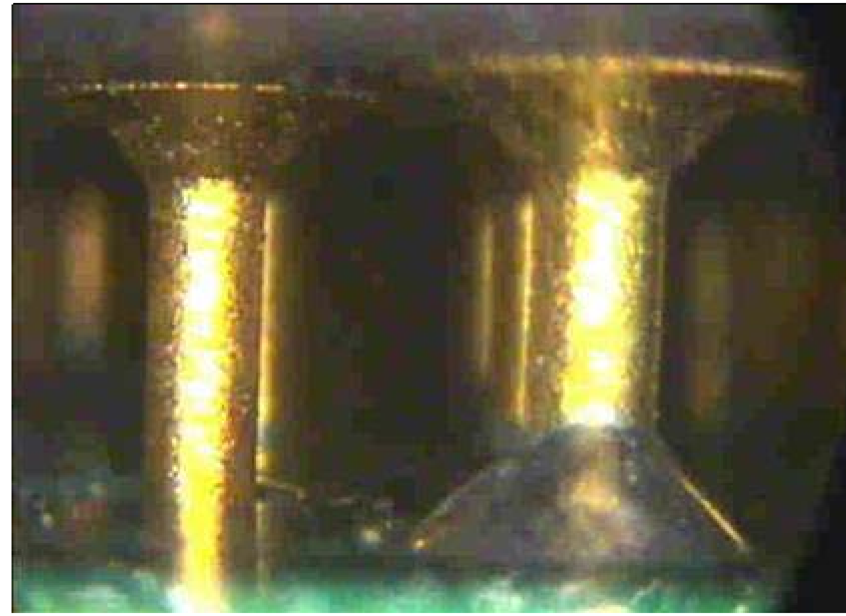
Inspection of PLCC toe fillet

ERSA GmbH Pictures: ERSA

A Kurtz Company

Have Standards, Inspect to Standards, Produce to Standards!



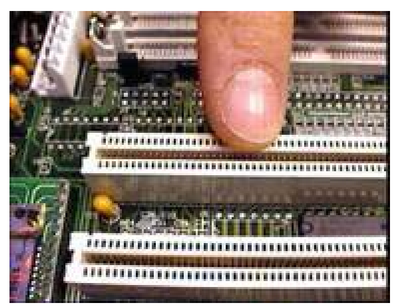


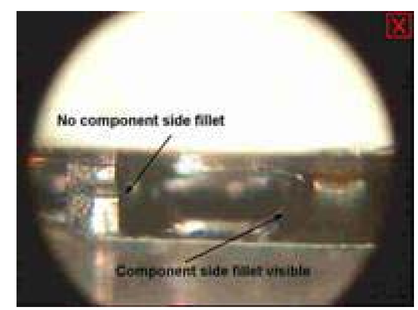
IPC Electronic Workmanship Standard
A-610: 6.3, Table 6-2; J-STD-001C: 9.2.5.1

ERSASCOPE: Inspect top side flow thru fillet

CLASS II: 50% PTH Hole Fill

CLASS III: 75% PTH Hole Fill





ERSA GmbH Pictures: ERSA

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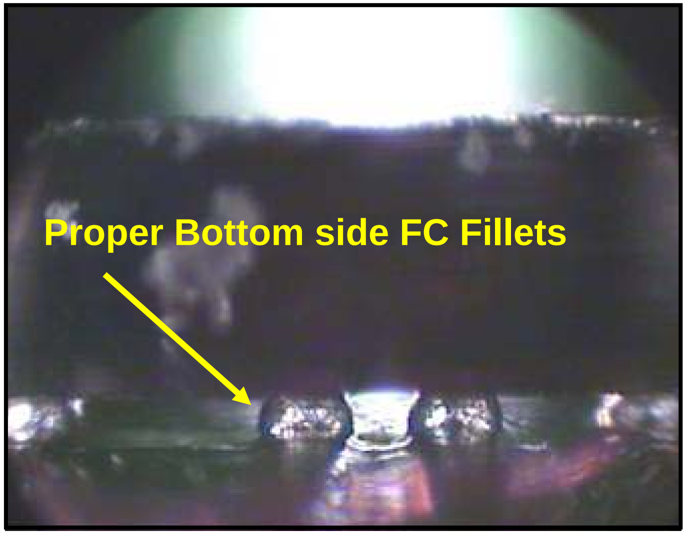
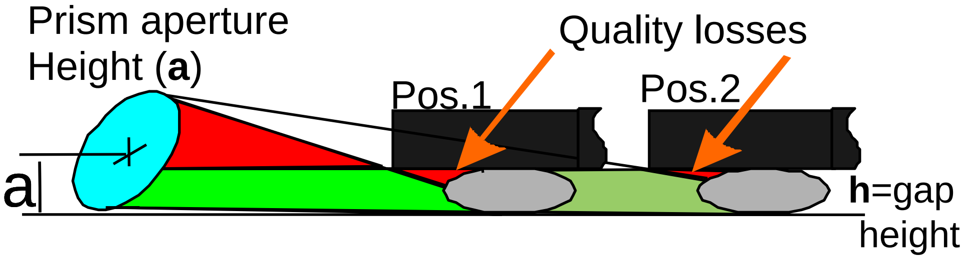
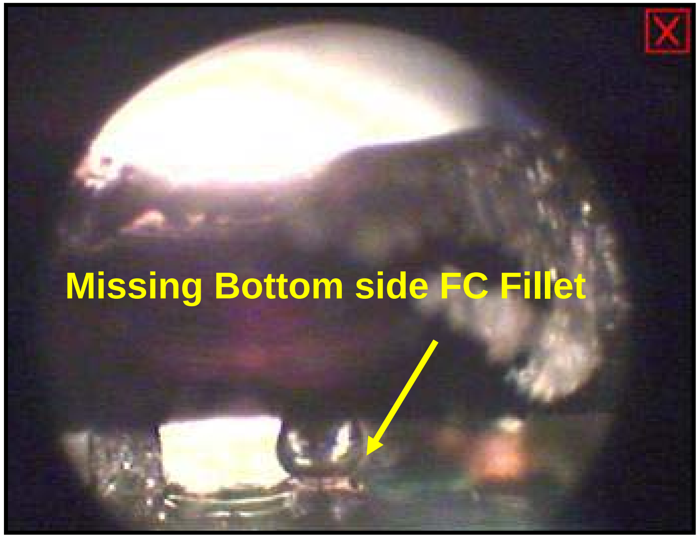
Original Optical Flip Chip Inspection: Looks down



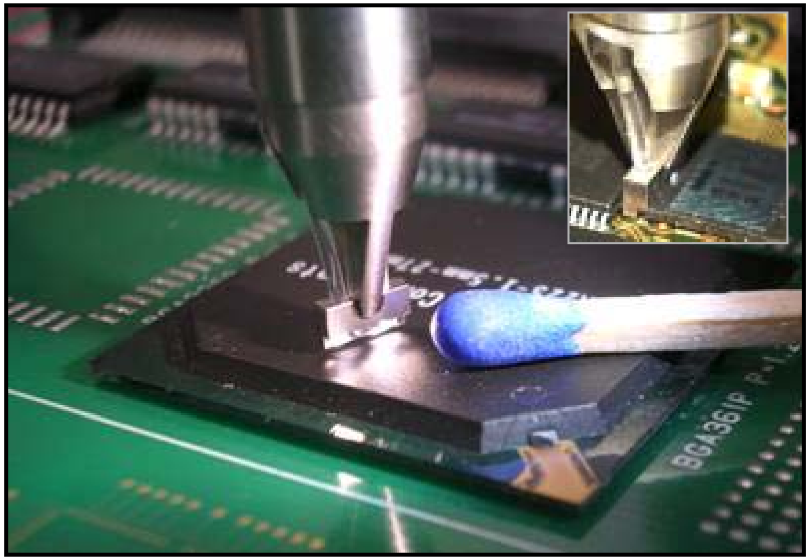


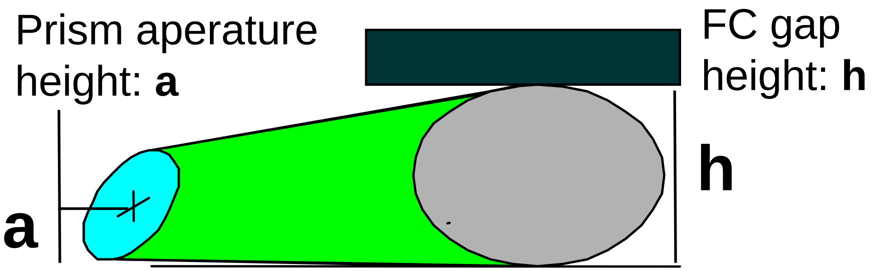


Optical Head 1: a = 0.300 mm
Flip Chip: h= 0.050 mm

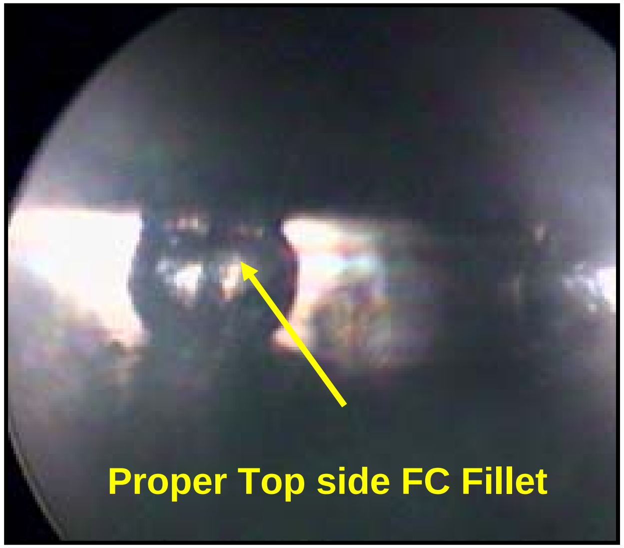
ERSA GmbH Pictures: ERSA

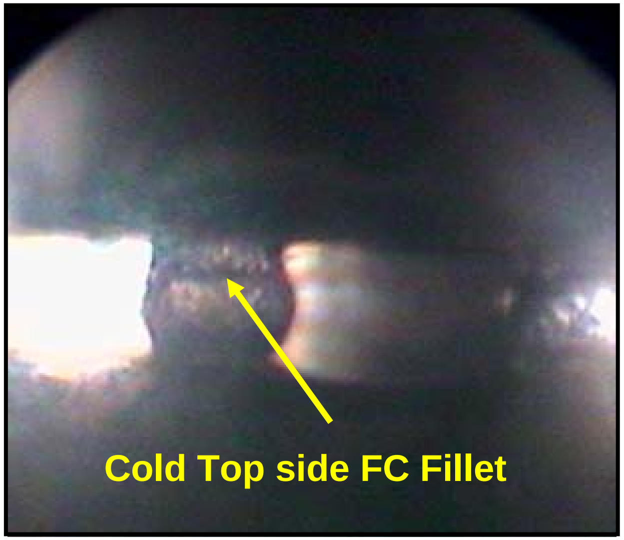
New Flip Chip Inspection Head: Looks Up!





Optical Head 2: a = 0.012 mm
Flip Chip: h= 0.050 mm





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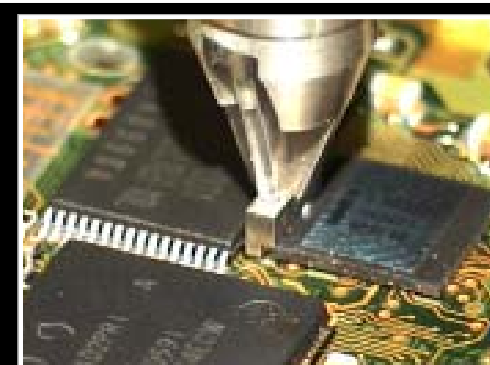
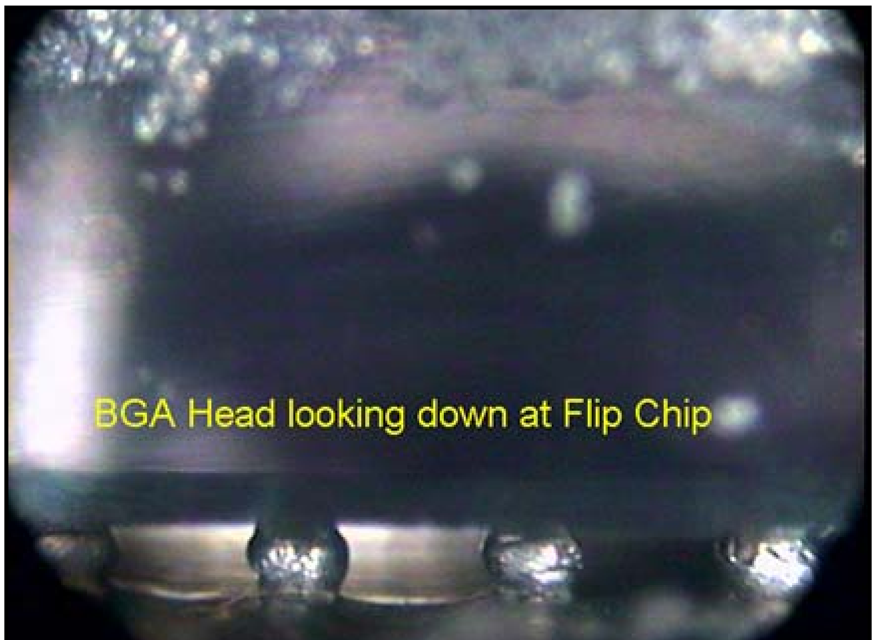
Pictures: ERSA A Kurtz Company

Flip Chip Inspection: Original vs. New Optical System

Original Optical Head



New Flip Chip Head



Low Profile CSP (below 0.10mm) Internal Inspection

ERSA GmbH Picture: ERSA

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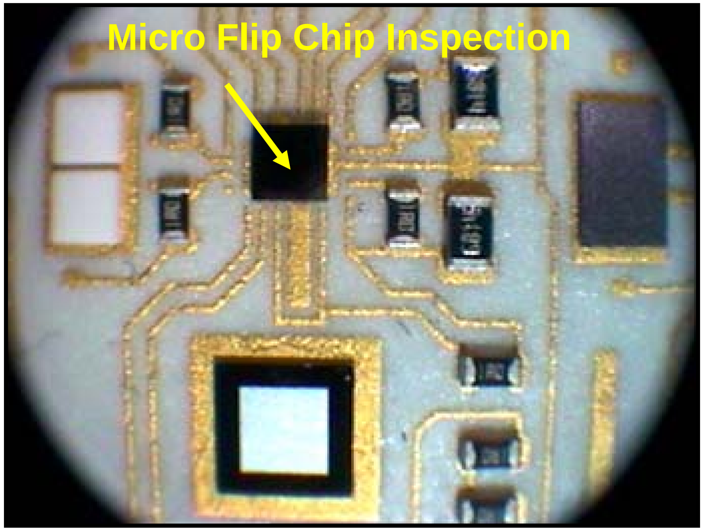
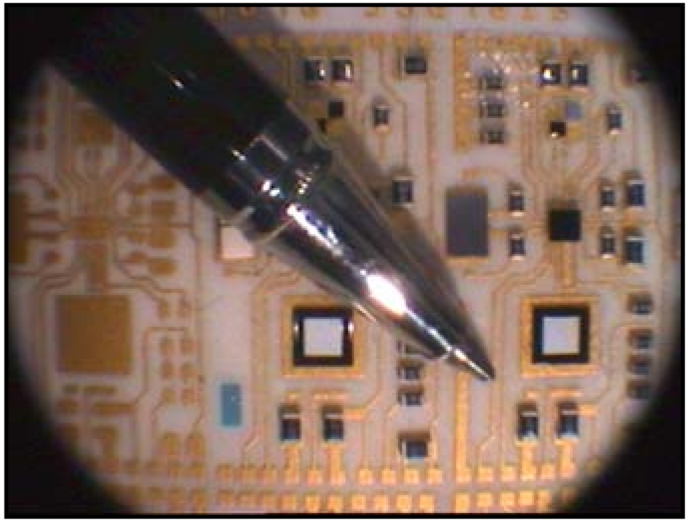
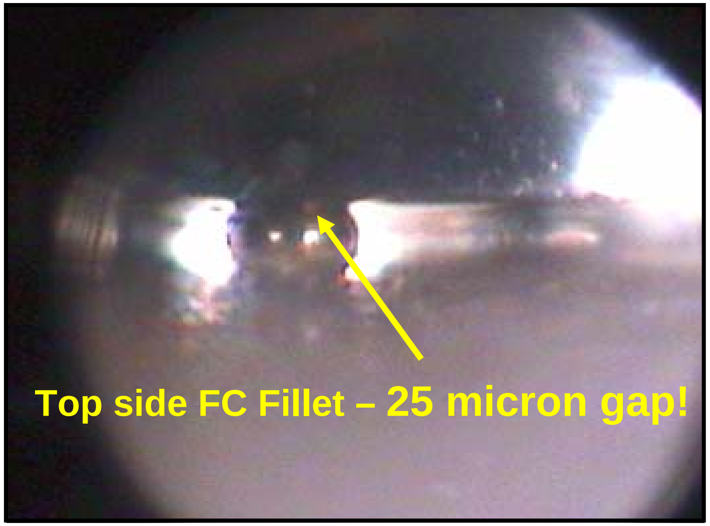
New Optical Micro Flip Chip Inspection







ERSA GmbH Pictures: ERSA

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So what's the bottom real line for lead free implementation with respect to my first artcle inspection process?

Lead Free Production Soldering:

Higher process temperatures, smaller process windows, poor wetting, and different surface appearance

Require new training & procedures, higher magnification inspection & flexible viewing angles from 0° to 90°!

Look Closely at Your Inspection Process!

Having, inspecting and producing to accepted soldering standards has always been a requirement, but one that companies have been able to do with a questionable level of thoroughness.

Honestly, how many companies producing to IPC Class 2 and 3 are inspecting the hidden PLCC toe fillets, the difficult to see TQFP heel fillets, not to mention the double drop on their BGAs?

ERSA GmbH

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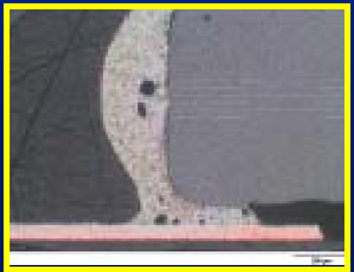
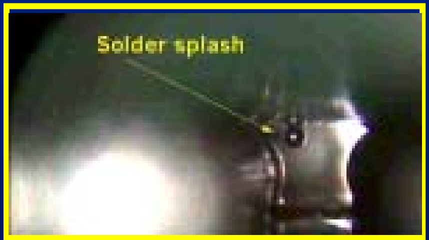
What are the True Costs of Quality Problems????

Mass production manufacturers know the true financial and image loss costs of warranty failures caused by the inability to detect all possible process related problems in their lines.

And who seriously believes that with the implementation of lead free these problems will go away? On the contrary, all indications point to an increase to process problems!





Some Words of Wisdom that can Help!

A wise man said, "If it's not broken, don't fix it."

A wiser man asked, "If I can't see what's broken, how do I know what needs to be fixed!"

To See is to Survive – Only by being capable of seeing all potential problems in your process, will you be able to react, in order to correct those problems and assure quality!

Lead Free will require a more thorough First Article Inspection Process!