Low-Silver BGA Assembly
Phase I – Reflow Considerations and Joint Homogeneity
Third Report: Comparison of Four Low-Silver Sphere Alloys and Assembly Process Sensitivities

Quyen Chu
Girish Wable
Anthony Babasa
Evan Doxtad
Michael Lapitan
Michael Santos
Josh Solon
Jabil Circuit
San Jose, CA, USA
St. Petersburg, FL, USA

Ken Hubbard
Gnyaneshwar Ramakrishna
Cisco Systems
San Jose, CA USA

Greg Henshall
Hewlett-Packard
Palo Alto, CA USA

Ahmer Syed
Amkor
Chandler, AZ USA

Ranjit Pandher
Cookson Electronics
South Plainfield, NJ, USA

Chrys Shea
Shea Engineering Services
Burlington, NJ USA

Abstract
Some Ball Grid Array suppliers are migrating their sphere alloys from SAC305 (3% Ag) or 405 (4% Ag) to alloys with lower silver contents. There are a numerous perceived benefits to this move in terms of cost and performance, but process compatibility and reliability concerns have yet to be addressed.

Process compatibility concerns stem from the fact that the low-silver SAC replacement alloys have higher melting temperatures than SAC305, approximately 227°C as compared to 221°C. Certain families of electronic assemblies, such as consumer portables, are often heat-sensitive and are reflowed in the low end of the established lead-free peak temperature range, typically 230-235°C. The small temperature difference between the spheres' melting temperature and the peak reflow temperature raises questions about the reliability of the solder joints that are formed under this tight thermal margin. These are similar to the concerns raised with the backward compatibility of SAC305/405 spheres with tin-lead solder processes. Some of the solutions identified in the lead-free ball/tin-lead paste scenario may apply to the low-silver ball/SAC305 paste combination, but they require review for their applicability with this new set of mixed metals.

A study has been undertaken to characterize the influence of alloy type and reflow parameters on low-silver SAC spheres assembled with backward compatible pastes and profiles. The DOE combines low-silver sphere materials with tin-lead and lead-free solders at different combinations of peak temperature and times above liquidus. Solder joint formation and reliability are assessed to provide a basis for developing practical reflow processing guidelines.

Key Words: Lead-free, low silver, BGA, reflow, mixed metals

Introduction
This is the third report of a series that reviews the results of each phase of the experiment. The first phase was split into two parts:

- Phase 1A studied a broad process window with many peak temperature and time above liquidus (TAL) combinations in order to generally characterize joint formation results with respect to mixing levels and homogeneity. It used primarily SAC105 spheres in combination with Sn-Pb and SAC305 solder pastes.
- Phase 1B applied the results of phase 1A to four different low-silver sphere alloys to establish the process cliffs that result in partial mixing or typical process defects. Another goal was to help determine the experimental matrix for the assemblies that will be subjected to thermal cycling in phase 2.

A complete account of the background information, the experimental design and the detailed results are presented in the first two reports[1,2]. They are omitted from this report for purpose of brevity.

Phase 1a Findings:

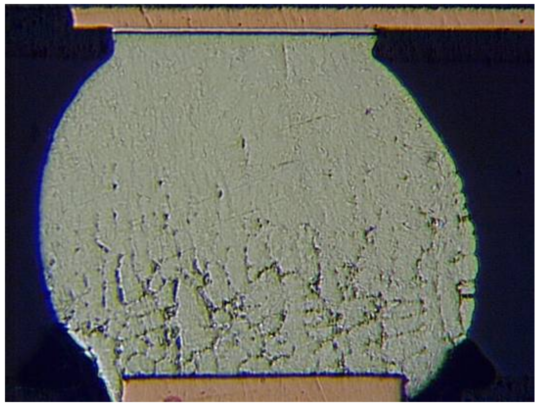


Figure 1. 1.0 mm pitch BGA solder joint with SAC105 sphere and Sn-Pb paste. Reflowed with peak temperature of 215°C and 60 sec TAL. The lead is visible in the microstructure and the mixing level was measured at 32% of the height of the solder joint.

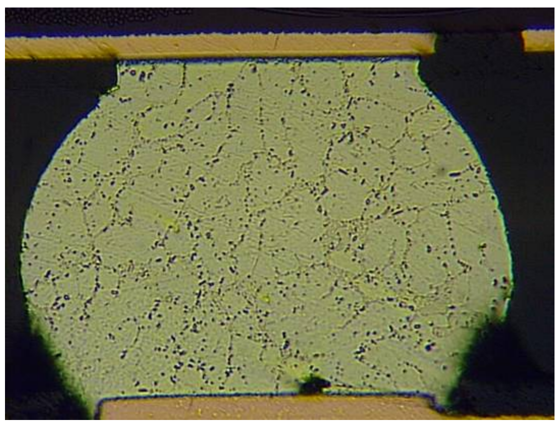


Figure 2. 1.0 mm pitch BGA solder joint with SAC105 sphere and SAC305 solder paste. Reflowed with peak temperature of 220°C and 60 sec TAL. The microstructure appears homogeneous.

It is easy to discern mixing levels when using Sn-Pb solder paste in combination with the low Ag solder spheres, because the lead-containing phase is easy to see in the microstructure of cross-sections using an optical microscope. Figures 1 and 2 show cross sections of BGA joints with low Ag solder spheres and both tin-lead and lead-free solder pastes. The mixing boundary is easy to see on the joint formed with tin-lead solder paste, but indiscernible on the joint formed with SAC305 solder paste. SEM analysis did not provide any more information than optical analysis.

The findings listed herein are based on the observation of the solder joints formed with low Ag SAC spheres and Sn-63Pb solder paste:

- The sphere does not have to reach liquidus temperatures for mixing to begin. Diffusion of the solder paste alloy (tin-lead) into the solder sphere was seen at temperatures as low as 205°C.
- Ball size influences mixing. The larger diameter solder balls have both higher sphere solder volumes and higher sphere:paste solder volume ratios than smaller balls, and do not mix or reach homogeneity as readily as smaller BGA balls.
- Peak temperature had the greatest effect on mixing levels.
- TAL had little effect on mixing levels. In cases of mixed metals, the liquidus temperature referenced is that of the solder alloy; in the case of Sn-Pb solder it is 183°C.

These findings are consistent with those of the iNEMI study[3] that used SAC405 spheres with tin-lead solder paste, but the peak temperatures are 5 to 10°C higher for the SAC105 spheres to attain corresponding levels of mixing.

No conclusions were drawn regarding the combination of low silver SAC spheres with SAC305 solder paste, as the mixing levels could not be determined by visual means. It was noted, however, that full collapse appeared to have taken place during the reflow process and no abnormalities in joint formation we noticed.

Phase 1b Experimental Setup

Phase 1B probed the experimental space that produced partial mixing of SAC105 spheres with tin-lead paste in phase 1A, but did so with four low Ag sphere alloys. Because TAL was not found to have a considerable influence on mixing, it was eliminated from the experimental variables, and all profiles ran TALs of 60 seconds. Elimination of the insignificant variable allowed for more alloy materials to be explored in the same number of runs.

<table>
<tr><th colspan="3">Phase 1B</th></tr>
<tr><th>Paste</th><th>Ball Alloy</th><th>Temp (C)</th></tr>
<tr><td rowspan="11">SnPb</td><td rowspan="3">SACX 0307</td><td>205</td></tr>
<tr><td>210</td></tr>
<tr><td rowspan="4">215</td></tr>
<tr><td>SAC125Ni</td></tr>
<tr><td>SAC 205</td></tr>
<tr><td>SAC 105</td></tr>
<tr><td rowspan="2">SACX 0307</td><td>220</td></tr>
<tr><td rowspan="3">225</td></tr>
<tr><td>SAC125Ni</td></tr>
<tr><td>SAC 205</td></tr>
<tr><td>SACX 0307</td><td>230</td></tr>
<tr><td rowspan="5">SAC305</td><td rowspan="2">SAC 105</td><td>220</td></tr>
<tr><td>225</td></tr>
<tr><td rowspan="2">SACX 0307</td><td>230</td></tr>
<tr><td>235</td></tr>
<tr><td>SAC 105</td><td>225*</td></tr>
<tr><td>WS SnPb</td><td>SAC 105</td><td>215</td></tr>
<tr><td>WS SAC305</td><td>SAC 105</td><td>225</td></tr>
</table>

Table 1. Experimental matrix for phase 1B.

Note that phase 1B also limited the number of lead-free sphere/lead-free paste combinations, as mixing levels could not be determined in phase 1A. It expanded the peak temperature for this combination down as low as 220°C, and included a lead-free leg run under a nitrogen atmosphere (the SA305/105 combination denoted with an * next to the peak temperature)..

Determination of % Mixing

The mixing level of the SAC/Sn-Pb solder joints was determined by comparing the distance between the component and PWB pads with the distance between the border of the lead-containing region and the component pad. The border of the lead-containing region was visually observed at the center of the joint using optical microscopy at 200X magnification. The level of mixing is expressed as a percentage of joint height.

Phase 1b Results:

In concurrence with previous studies of this nature, phase 1B showed that in the cases of SAC spheres with tin-lead paste:

- Mixing occurs at temperatures below the liquidus temperature of the sphere
- Smaller spheres mix more readily (more complete mixing at lower temperatures) than larger spheres.

These results were as expected and documented in the prior reports. Some of the more interesting findings were process-related:

- Temperature differentials (delta T's) across a component of as little as 1.5°C can impact mixing levels by as much as 50%.
- Mixing is not a function of reflow parameters alone. Noise in the print-place portion of the SMT assembly process is also suspected to affect mixing levels.

Delta T's Across Components

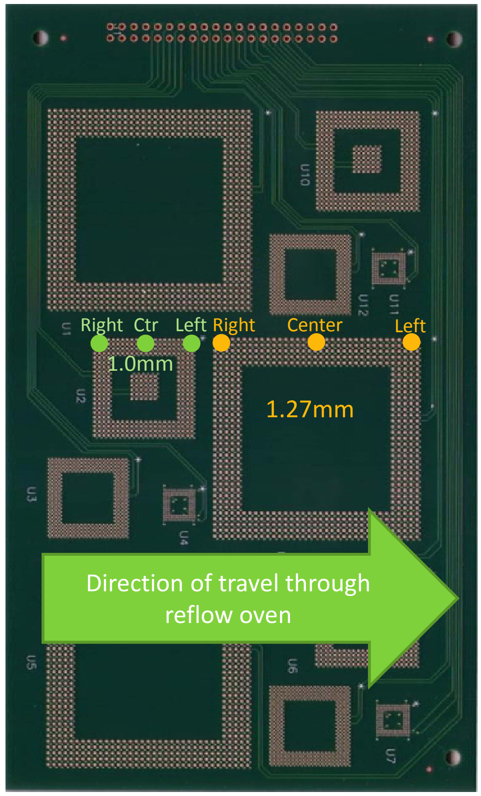
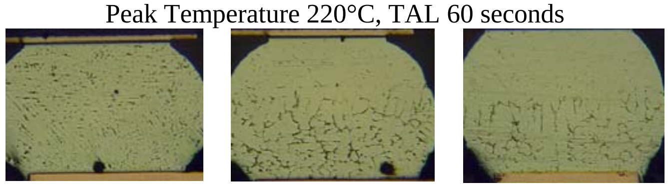


Figure 3. Locations of cross sections on 1.0 and 1.27 mm pitch devices.

Two PWBs were assembled for each parameter set. One was cross sectioned and the other was archived for future reference. Cross sectional analysis was performed at three locations per device. The locations are labeled Left, Center, and Right, and refer to the orientation determined during the sectioning operation. This orientation does not correspond to the direction of flow through the reflow oven, as presented in Figure 3.

After cross sectioning and measuring, photographs were taken of each solder joint and arranged in tabular form, and a trend in mixing levels was noted.

1.27 mm Pitch BGA
Mixing Levels of SAC105 Spheres in Sn-Pb Paste
Peak Temperature 220°C, TAL 60 seconds



Left	Center	Right
100%	62%	49%

Figure 4. Photographs of SAC105 spheres soldered with Sn-Pb paste, their locations on the device, and the different mixing levels observed.

Mixing levels on the 1.27 mm pitch device decreased as the locations of the joints moved from left to right, as seen in Figure 4.

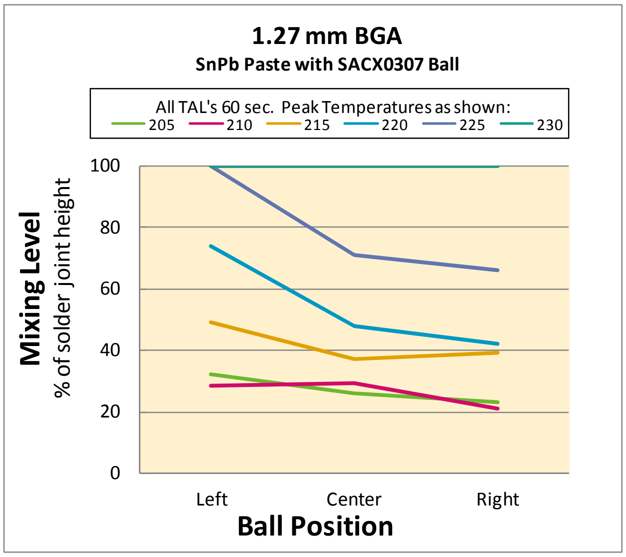


Figure 5. Mixing level trend in 1.27 mm pitch BGA with SACX0307 spheres and Sn-Pb solder paste.

The trend was consistently demonstrated at all peak temperatures, as shown in Figure 5.

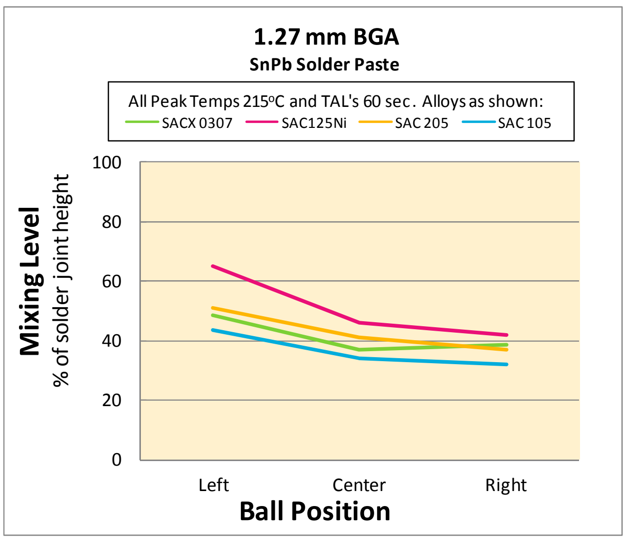


Figure 6. Trend of lower mixing levels toward right side of 1.27 mm pitch device was consistent across all alloys.

The trend was very consistent across all alloys, as shown in Figure 6.

The 1.0 mm pitch device showed a similar trend, but in the opposite direction. Whereas mixing levels decreased when moving from left to right on the 1.27 mm pitch BGA, they increased when moving from left to right on the 1.0 mm pitch BGA.

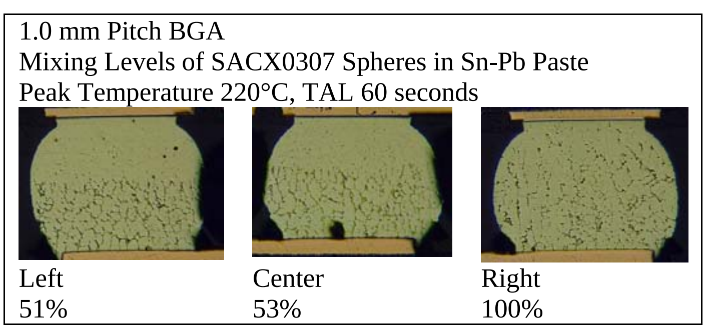


Figure 7. Photographs of SACX0307 spheres soldered with Sn-Pb paste, their locations on the device, and the different mixing levels observed.

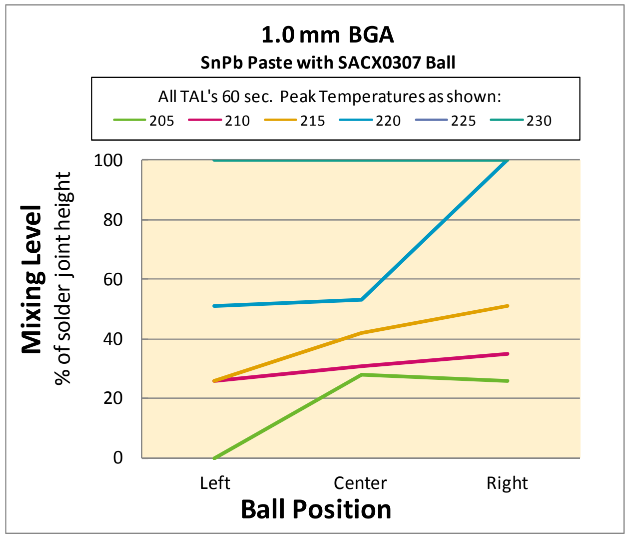


Figure 8. Mixing level trend in 1.0 mm pitch BGA with SACX0307 spheres and Sn-Pb solder paste.

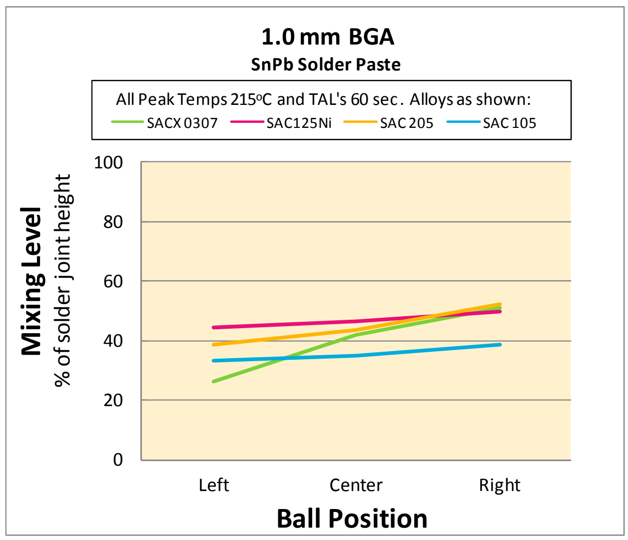


Figure 9. Trend of higher mixing levels toward right side of 1.0 mm pitch device was consistent across all alloys.

Similar to the 1.27 mm pitch device but opposite in direction, the trends demonstrated great consistency across all temperatures and alloys, as shown in Figures 7, 8 and 9.

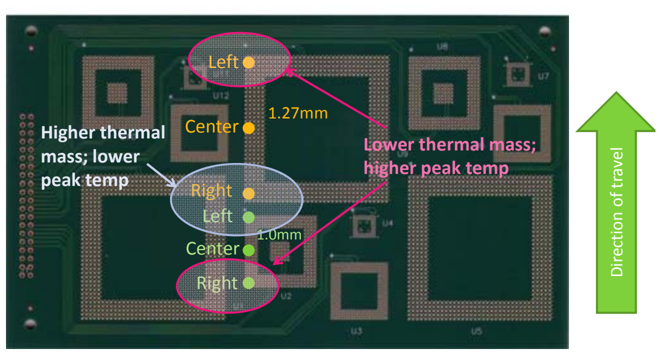


Figure 10. Locations of cross sections for 1.27 and 1.0 mm pitch devices.

Upon reviewing the trends and locations on the PWB layout (figure 10), delta T's were immediately suspected as the source of variation.

The PWBs were reprofiled with the recipes that produced peak temperatures of 220 and 225°C using the same oven and settings as the original experimental build. Thermocouples were located in the joints at all three cross section positions on the 1.27 mm pitch device and on the left and right positions on the 1.0 mm pitch device.

Device		Target Peak Temp	Measured Peak Temp (°C)		Mixing Level		Δ T	Δ Mixing
Device	1.27mm	220	Left	222	Left	74%	7 C	32%
			Center	217	Center	48%		
			Right	215	Right	42%		
		225	Left	225	Left	100%	8 C	34%
			Center	217	Center	71%		
			Right	217	Right	66%		
	1.0mm	220	Left	215.3	Left	51%	1.5 C	49%
			Center	N/A	Center	53%		
			Right	216.8	Right	100%		

Figure 11. Comparison of peak temperature and mixing level differentials across 1.27 and 1.0 mm pitch devices for SACX0307 spheres and Sn-Pb solder paste.

Figure 11 shows the changes in measured peak temperatures and mixing levels. On the 1.27 mm pitch devices, 7 or 8 degree deltas across the component lead to 32-34% differences in mixing levels in the solder joints. On the 1.0 mm pitch devices, a measured 1.5 degree delta across the device is associated with a 49% difference in mixing levels. It should be noted that, to help balance the thermal mass across the PWB, it was designed with 8 layers, and contains 6 ground planes of 1-ounce copper.

Such a seemingly high sensitivity to small thermal differentials was not expected. Experimental error on thermocouple readings is typically considered to be ± 2°C, therefore, the readings taken on the 1.0 mm pitch device cannot be statistically differentiated from each other. Furthermore, normal oven output variation could also reduce the accuracy of the readings. Despite the uncertainty of the actual temperatures to which the joints were exposed, the trends seen in the cross sectional analysis clearly and consistently indicate that the solder joints near the outer edges of the assembly reached higher peak temperatures than those nearer the center, and therefore experienced higher levels of mixing.

After analyzing the trends noticed in phase 1B, the results from phase 1A were revisited, and the information was collated in a similar fashion. The same trend was apparent in joints formed with the SAC105 spheres.

In general, the mixed SAC/Sn-Pb systems showed full mixing across the entire device at the following temperatures:

Device	Temp
0.5mm	210*
0.8mm	215
1.0mm	225
1.27mm	225

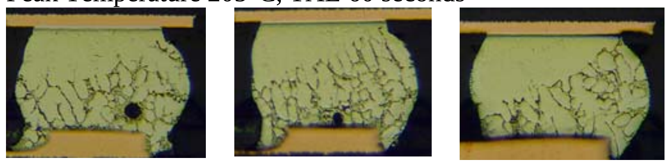
Table 2. Peak temperatures (°C) at which full mixing of the low Ag SAC sphere with the Sn-Pb paste was typically observed.

Notice the * next to the temperature for the 0.5 mm device. In one of the cases observed, the device showed some very interesting results, as discussed below.

Effect of Alignment

Another unexpected finding of phase 1B was the partial mixing found for the first time in the 0.5 mm pitch package, and the form it took on.

0.5 mm PitchBGA
Mixing Levels of SACX0307 Spheres in Sn-Pb Paste
Peak Temperature 205°C, TAL 60 seconds



Left	Center	Right

Figure 12. 0.5 mm pitch BGA device with partial mixing that occurred at an obvious angle and appears similar on all the balls inspected.

Not only did the 0.5 mm pitch solder joints show partial mixing, which did not occur on other similar devices observed in either phase, the mixing boundary appears to lie at an angle with respect to the pads and paste print.

It is hypothesized that misalignment, most likely of the solder paste print but possibly of the BGA placement, is the root cause of this anomaly. During the build for phase 2, several PWBs will be assembled and analyzed to test this theory.

A Noteworthy Process Cliff

1.0 mm Pitch BGA
Mixing Levels of SACX0307 Spheres in Sn-Pb Paste
Peak Temperature 205°C, TAL 60 seconds
Measured Mixing Level & Peak Temp Noted Below Photo

Left	Center	Right
0%	24%	27%
199.5°C	n/a	200.8°C

Figure 13. SACX0307 spheres reflowed on the 205 peak temperature profile. The sphere on the left had a measured peak temperature of 199.5°C, while the sphere on the right had a measured peak temperature of 200.8°C.

Figure 13 illustrates the process sensitivity of low-silver spheres in a tin-lead environment. The profile, designed to average a peak temperature of 205°C across the PWB, produced measured peaks within approximately 5 degrees, which is typically considered acceptable in a standard process.

While the joint on the right that experienced partial mixing would likely be considered reliable (based on previous studies on partially mixed SAC305/SnPb combinations), the joint on the left would not. The measured temperature difference is only 1.3 degrees. Moreover, the interconnection on the left is one which could provide enough electrical continuity to pass a manufacturing test operation but open up intermittently in service.

Further illustrations of the mixing results are provided in the Appendices.

Phase 2 Experimental Design

Phase 2 is the portion of the test that subjects the assemblies to thermal cycling. Two sets of thermal cycles will be performed:

- 0 – 100°C
- -40 – 125°C

The experimental matrix will include:

- Partially and fully mixed low Ag SAC spheres combined with Sn-Pb solder paste.
- Fully mixed low Ag SAC spheres with SAC305 solder paste. Since mixing levels cannot be easily discerned in the SAC105/305 combination, any potential failures with this configuration would be extremely difficult to analyze. The combination of low Ag SAC spheres with SAC305 paste will be processed at a peak temperature of 235°C to ensure full mixing of the alloys.
- Baselines of SAC305/SAC305, SAC305/Sn-Pb, and Sn-Pb/Sn-Pb.

Summary

Mixing levels cannot be easily detected when using SAC solder spheres with SAC solder pastes, so conclusions on partial mixing are limited to combinations of SAC spheres with Sn-Pb paste.

With respect to mixing with tin-lead solder paste, all the low Ag BGA alloys that were tested displayed behavior similar to that of the SAC105 that was tested in phase 1A.

The most influential reflow parameter on mixing is peak temperature. Peak temperature varied by as much as $8^{o}C$ across the largest component, creating variations in mixing levels by up to 35%, and in some cases, by as much as 50%.

Reflow parameters may not be the only process variables that affect mixing. Poor alignment of the solder paste and/or BGA balls with the PWB pads may also create variations in mixing levels, as seen on the 0.5 mm pitch device.

Continuing Work

At the time of this paper's publication, the phase 2 assemblies should be in thermal cycling, which is expected to conclude by December, 2009.

References

[1] "Low-Silver BGA Assembly Phase 1 – Reflow Considerations and Joint Homogeneity Initial Report," Shea, C., et al, Proceedings of APEX 2008.

[2] "Low-Silver BGA Assembly Phase 1 – Reflow Considerations and Joint Homogeneity Second Report: SAC105 Spheres with Tn-Lead Solder Paste," Shea, C., et al, Proceedings of SMTA International 2008.

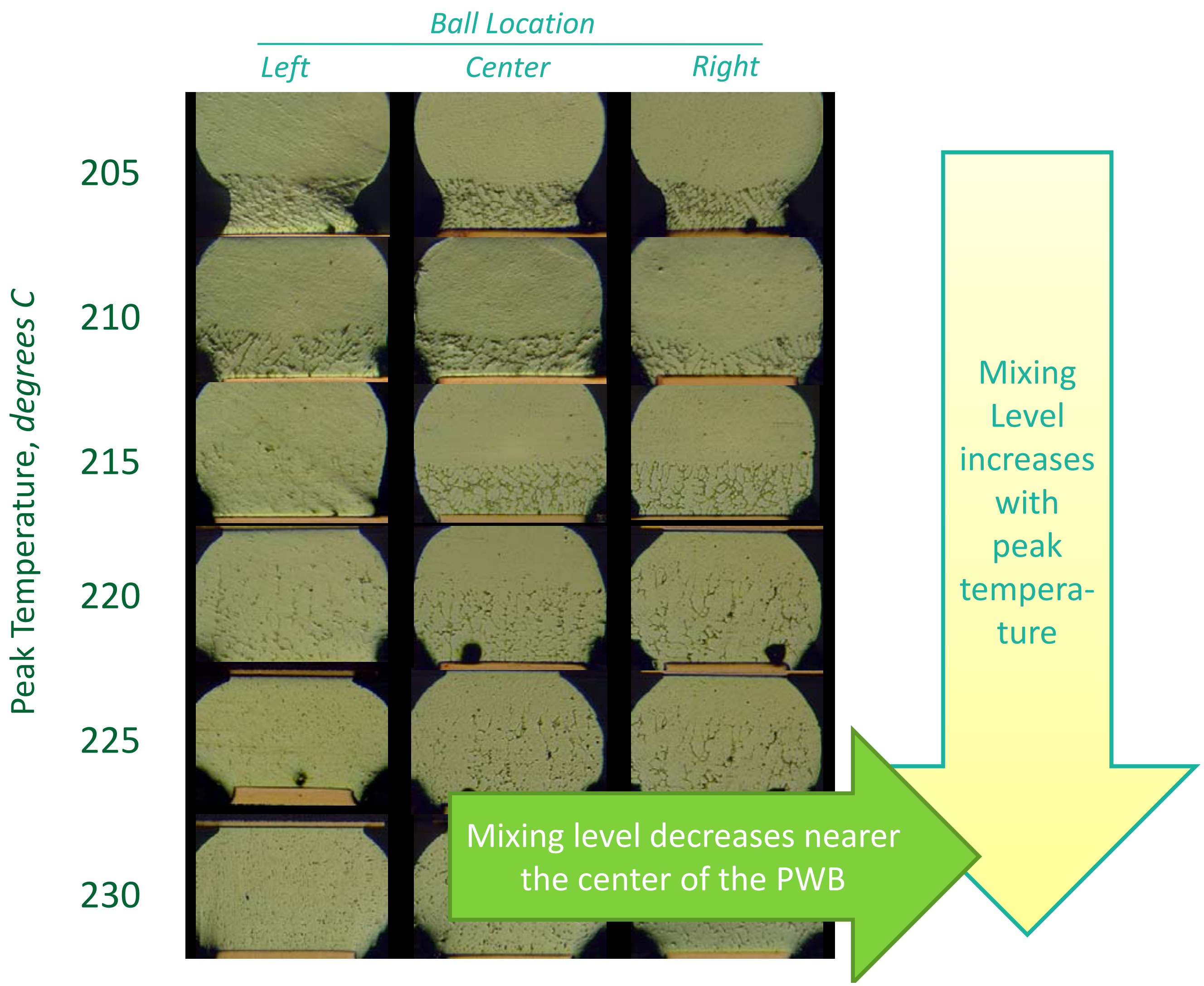
[3] "Solder Joint Reliability of Pb-Free SnAgCu Ball grid Array (BGA) Components in Sn-Pb Assembly Process," Kinyanjui, R., et al, Proceedings of SMTA International, 2007

[4] "Manufacturability and Reliability Impacts of Alternate Pb-Free BGA Ball Alloys," G. Henshall, et al., 2007. Available at:
http://www.inemi.org/cms/projects/ba/Pb-Free_Alloys.html

[5] "A Comprehensive Analysis of the Thermal Fatigue Reliability of SnPb and Pb-Free Plastic Ball grid Arrays (PBGA) Using Backward and Forward Compatible Assembly Processes," Coyle, R., et al, The Journal of Surface Mount Technology, Volume 21, Issue 4, pp33-47.

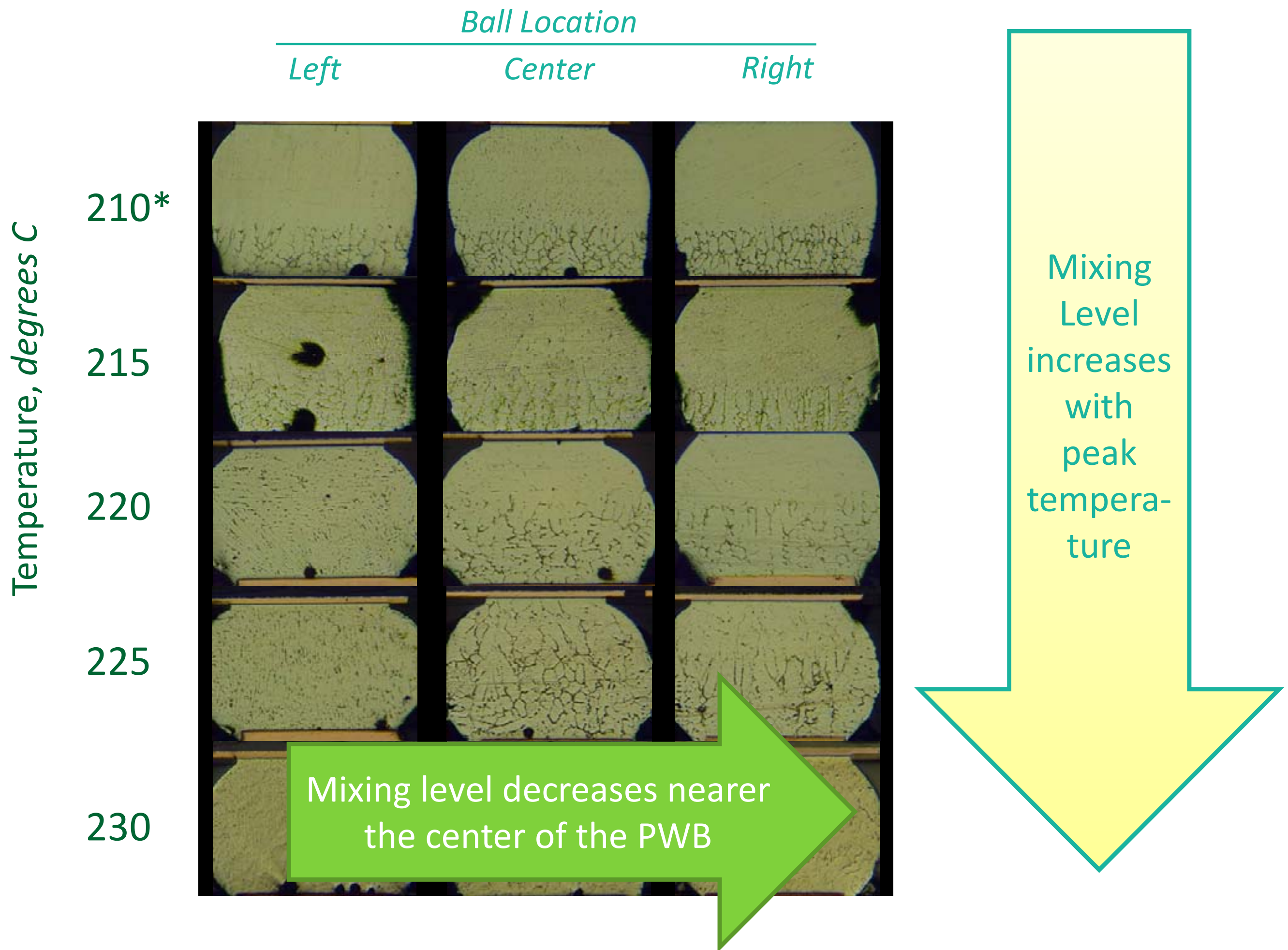
Appendix A

1.27mm BGA Tin-Lead Solder Paste, Phase 1B SACX0307 Ball



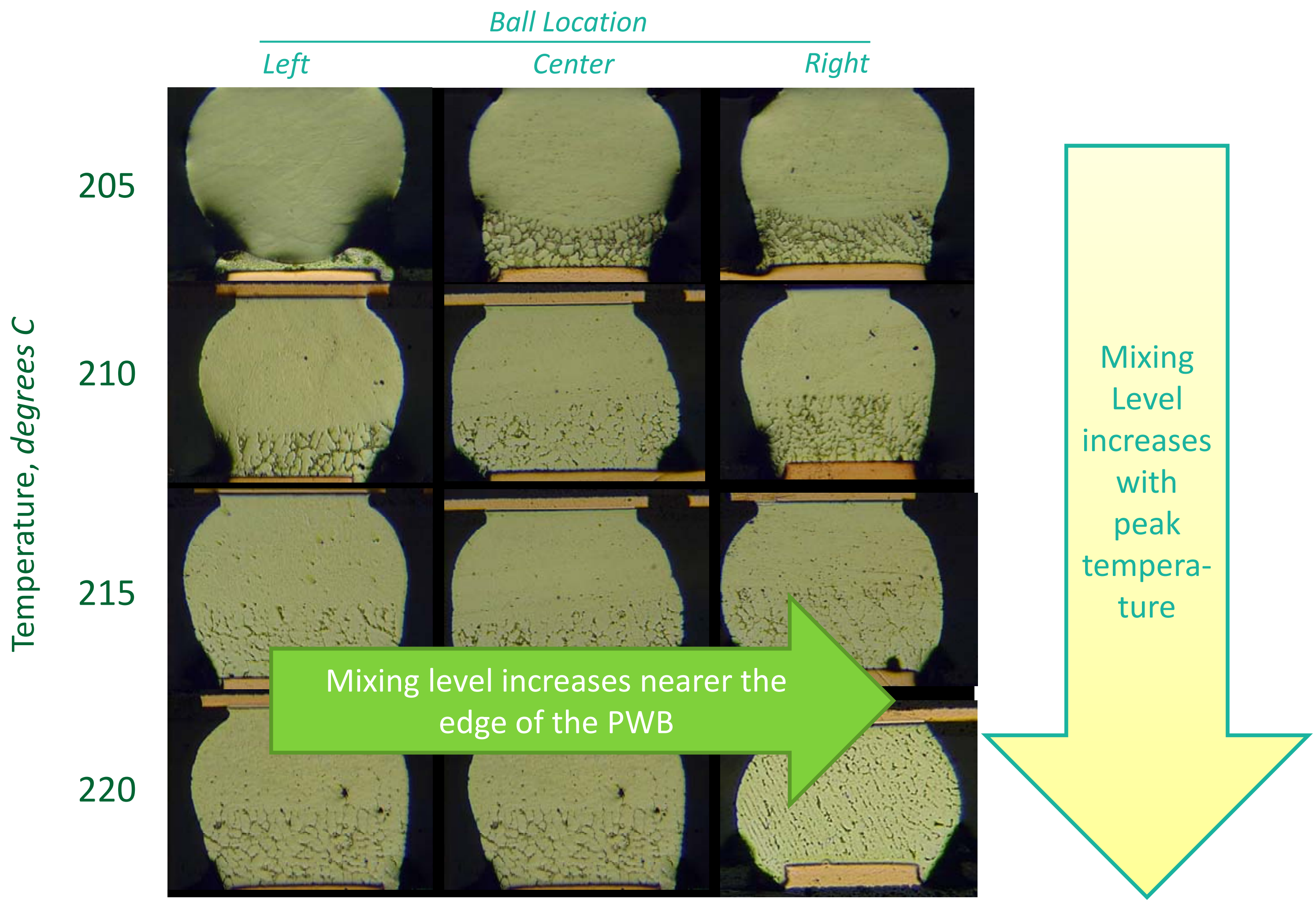
Appendix B

1.27mm BGA Tin-Lead Solder Paste, *Phase 1A SAC105* Ball



* Profile with peak temp of 210C had 120 sec TAL

1.0mm BGA Tin-Lead Solder Paste, Phase 1B SACX0307 Ball



Appendix D

1.0mm BGA Tin-Lead Solder Paste, *Phase 1A SAC105* Ball

Ball Location

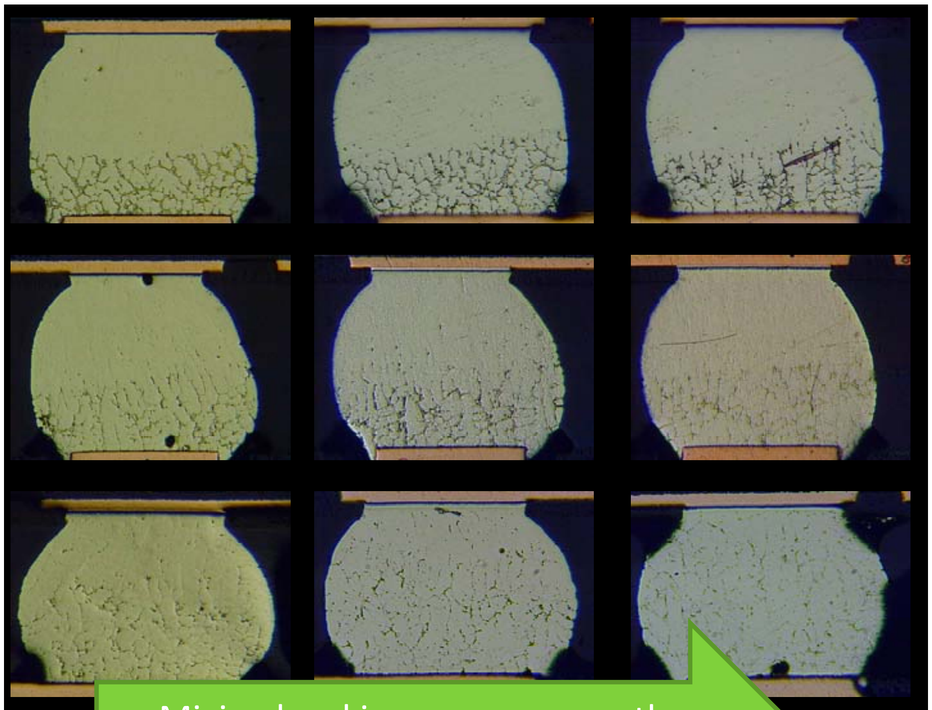
Left *Center* *Right*

Temperature, *degrees C*

210*

215

220

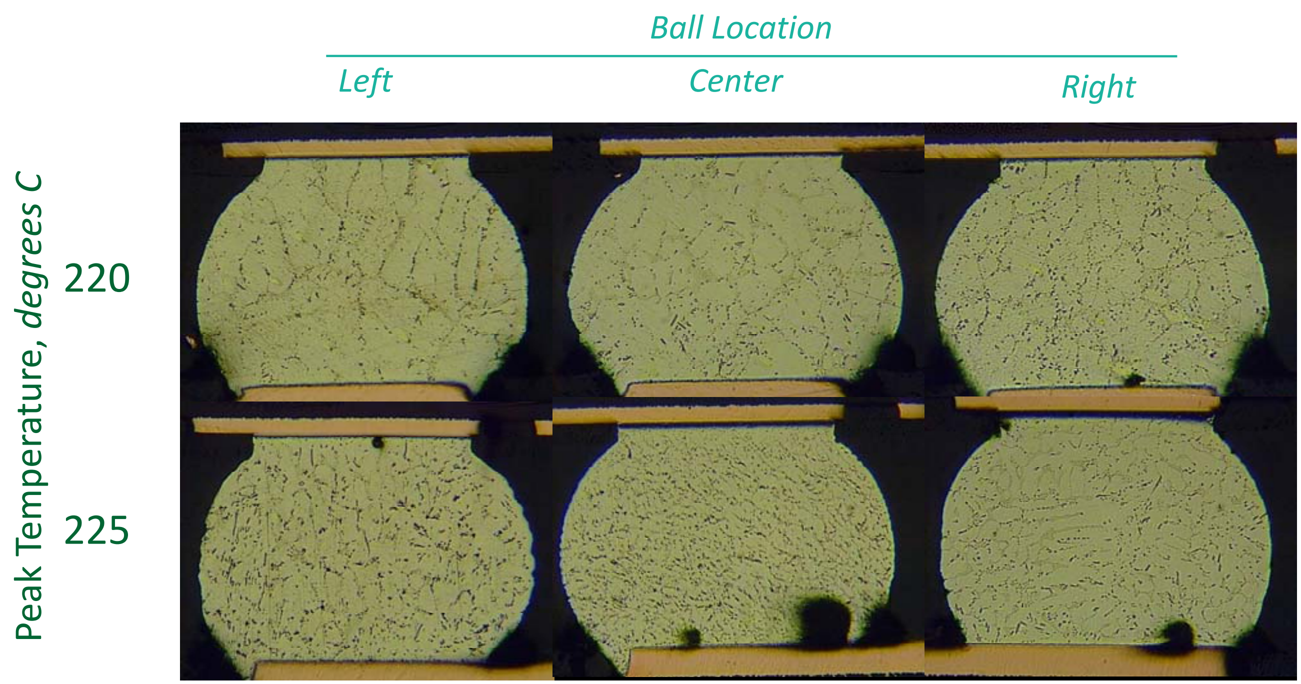


Mixing level increases nearer the edge of the PWB

Mixing Level increases with peak tempera-ture

* Profile with peak temp of 210C had 120 sec TAL

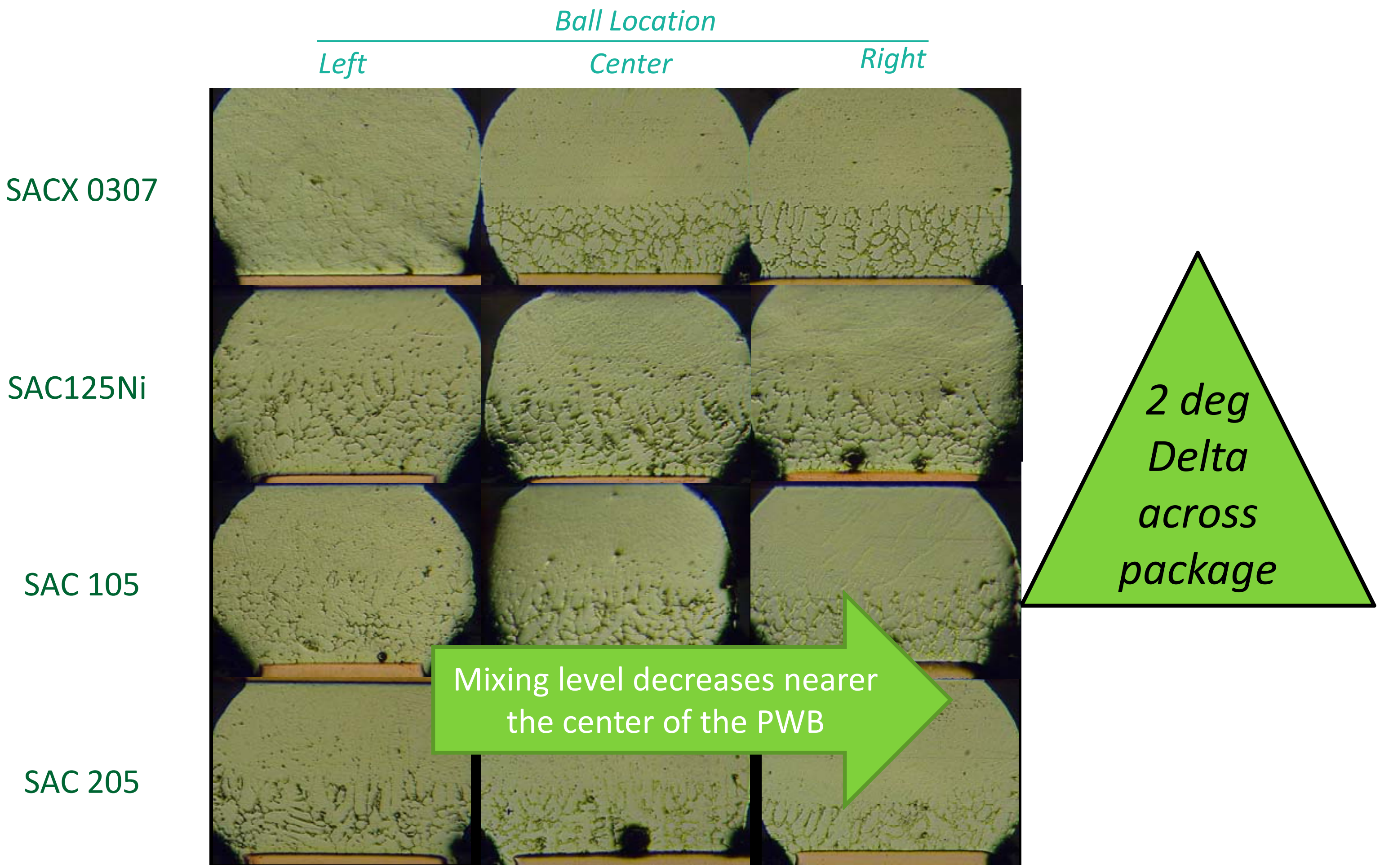
1.0mm BGA Lead-Free Solder Paste, *Phase 1B SAC105* Ball



All spheres showed good collapse
No mixing boundaries could be identified.

1.27mm BGA Tin-Lead Solder Paste

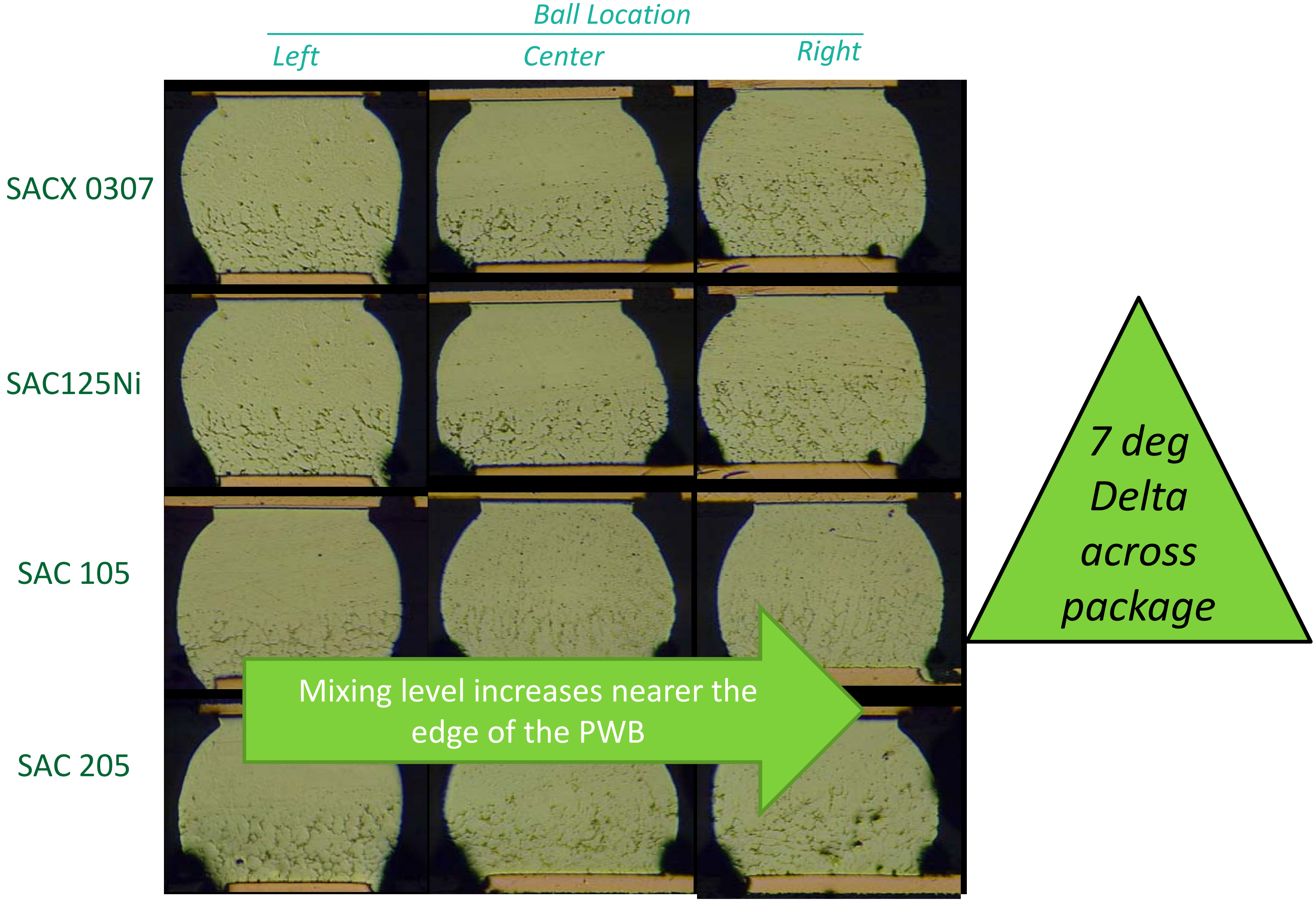
Peak Temp 215°C, TAL 60 Seconds



Appendix G

1 mm BGA Tin-Lead Solder Paste

Peak Temp 215°C, TAL 60 Seconds



Low Silver BGA Sphere Metallurgy Project

COMPARISON OF FOUR LOW-SILVER SPHERE ALLOYS AND ASSEMBLY PROCESS SENSITIVITIES

Quyen Chu, Anthony Babasa, Evan Doxtad, Michael Lapitan, Michael Santos, Josh Solon, Girish Wable, Jabil

Greg Henshall, Hewlett-Packard

Ranjit Pandher, Cookson Electronics

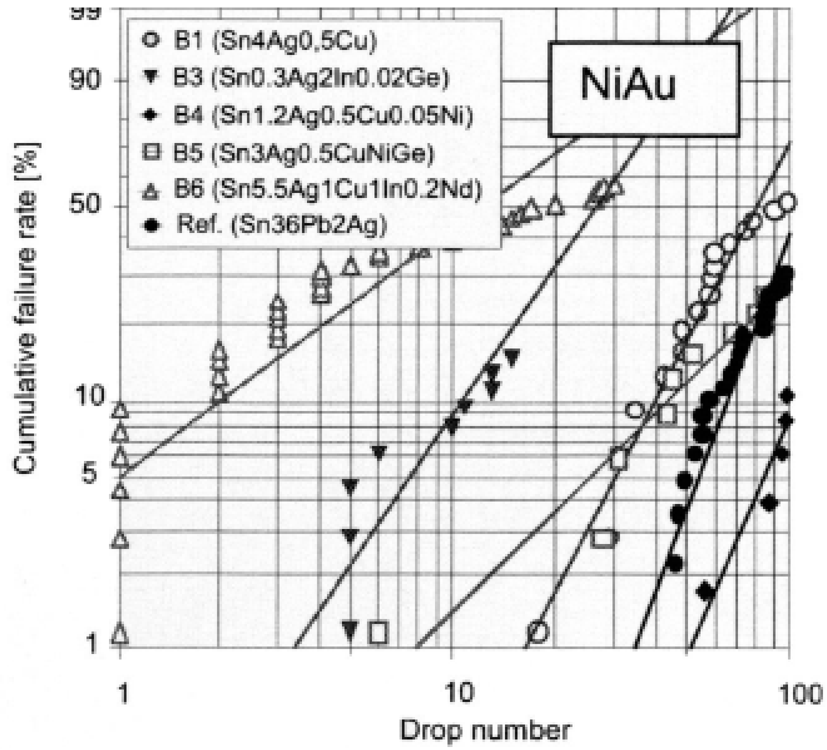
Ahmer Syed, Amkor

Ken Hubbard & Gnyaneshwar Ramakrishna, Cisco

Chrys Shea, Shea Engineering Services

Low Ag BGA Assembly Background

- Some BGA suppliers are migrating to low silver solder alloys as replacement to SAC 305 (3% Ag) or 405 (4% Ag)
- Benefits *(limited data)*
  - Improved performance against drop and shock
  - Suppression of Sn oxidation and improved wetting
  - Potentially lower price due to use of less silver
  - Exotic dopants lower copper dissolution in SMT joints
    - Slower intermetallic growth under aging
  - Less surface roughness
  - Reduced intermetallic, occurrence of silver tin platelets
  - Eliminate the need of under filling in some cases



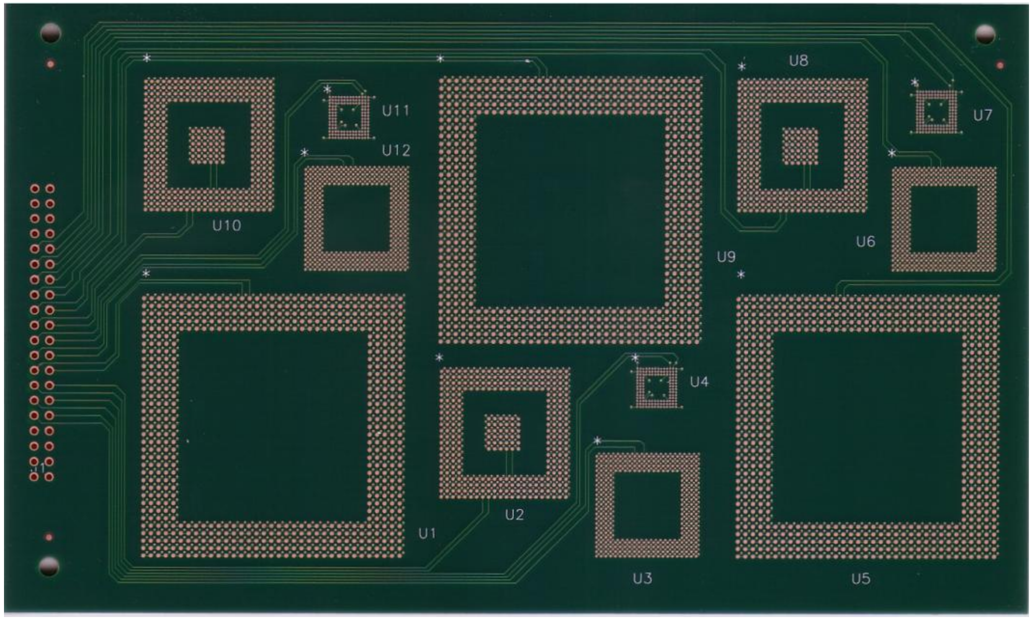
BGA Manufactures	*Low Silver Solder Alloy Proposed*
ST Micro	SACN
Samsung Electronics	SAC 105
Xilinx	SACN
Micron	Sn1.0Ag0.5Cu
Qualcomm	SAC 105
Philips Semiconductor	Sn1Ag0.1CuXNiXdopants
Intel	SAC 105
Infineon	Sn1.2Ag0.5Cu0.005Ni
National Semiconductor	LF35

The Thermal Pinch

- SAC305/405 spheres reach full liquidus at approx 221C
- Low Ag spheres reach full liquidus at approx 227C
- Thin, light assemblies peak out at approx 230-235C
- Extremely small thermal margin for error due to oven loading, thermocouple placement, sphere location on device
- Hotter reflow temperatures bring risk of warpage of PWB and device; complications at final assembly
- Processing window is dangerously narrow

Test Vehicle PCB Design

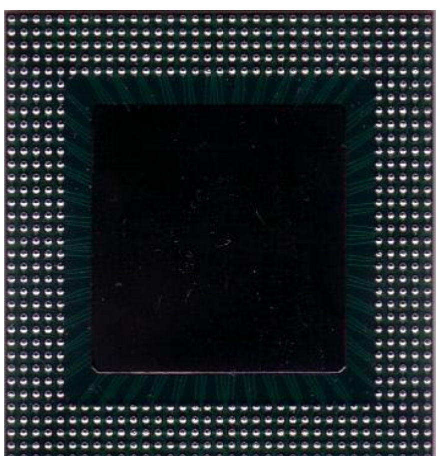
- PCB Dimensions:
  - 6.800” x 4.075” x 0.093”
- Finish
  - Copper OSP
  - Electrolytic NiAu
- Number of Layers
  - 8 Internal board Layers
  - 2 Ground [1 oz.] Layers,
  - 6 Signal Layers
- Tg = 170C
- Td = 340C



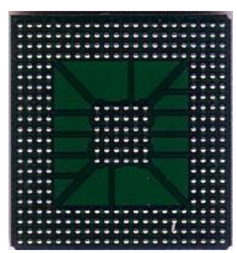
Bare Test Board
Designed by iNEMI Mixed MetalsProject

Test Vehicle - Components

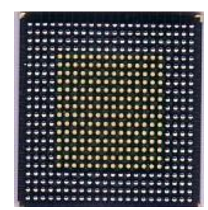
Component Part #	I/O Count	Ball Pitch (mm)	Package Size (mm)	Ball Dia. - As Rec'd (mm)	Ball Diameter (mm)	Ball Height (mm)	Ball Volume (mm^3)	Qty Per Brd
A-SBGA600-1.27mm-45mm	600	1.27	45	0.76	0.62	0.52	0.2298	3
A-PBGA324-1.0mm-23mm	324	1	23	0.63	0.45	0.55	0.1309	3
A-CABGA288-.8mm-19mm	288	0.8	19	0.46	0.48	0.36	0.0510	3
A-CTBGA132-0.5mm-8mm	132	0.5	8	0.3	0.32	0.19	0.0141	3



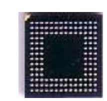
1.27mm
SBGA600



1.0mm
PBGA324



0.8mm
CABGA



0.5mm
CTBGA132

Largest sphere volume; slowest to mix

Two Segments of Process Development Phase

Phase 1a

- Assembled 36 test vehicles with SAC105 spheres and SAC305 & SnPb pastes
- Used a variety of peak temps and TALs
- Found that main influencers on mixing are peak temp and sphere size
- TAL did not have a considerable effect on mixing
- Could not determine mixing levels of SAC105/SAC305 combinations – only SAC105/SnPb

Phase 1b

- Assembled 36 test vehicles with SAC105, SAC205, SACX and SAC125Ni with SAC305 & SnPb pastes
- Used a variety of peak temps with constant 60 sec TALs
- Cross sectional analysis to define peak temps that result in partial mixing for each sphere size
- Determined processing conditions for Phase 2 – Thermal Cycling

Phase 1b Assembly Matrix

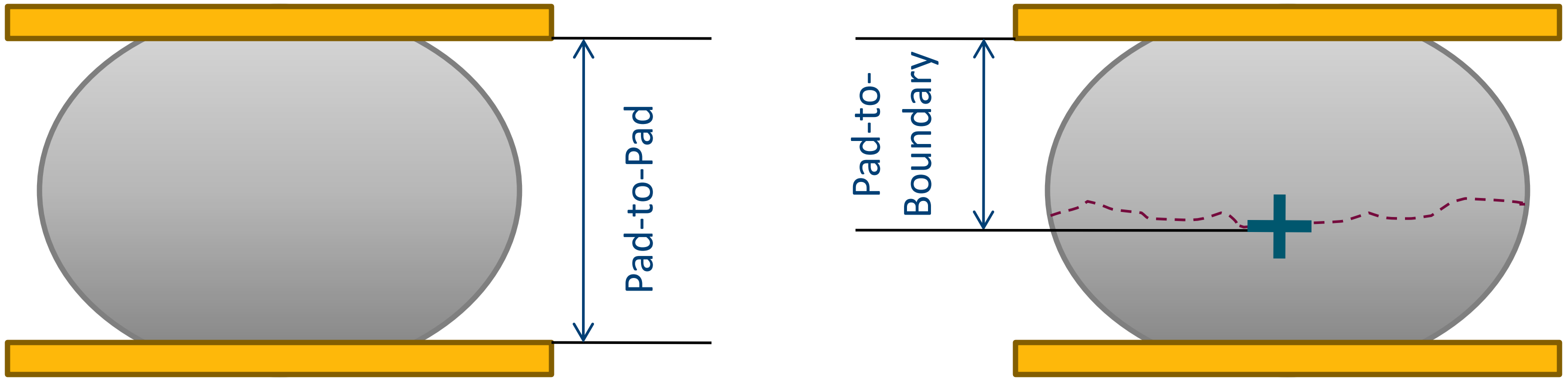
Phase 1B		
Paste	**Ball Alloy**	**Temp (C)**
SnPb	SACX 0307	205
		210
	SAC125Ni	215
	SAC 205	
	SAC 105	
	SACX 0307	220
	SAC125Ni	225
	SAC 205	
	SACX 0307	230
SAC305	SAC 105	220
		225
	SACX 0307	230
		235
	SAC 105	225*
WS SnPb	SAC 105	215
WS SAC305	SAC 105	225

- 18 legs (combinations)
- 2 boards per leg
- 36 assemblies in total

** Denotes assembly reflowed in Nitrogen environment (<300 ppm). FYI, no discernable differences in mixing were noted.*

Measurement Technique

- Cross sections were ground and polished at the approximate center of the spheres
- They were observed under optical microscopy at 200X magnification
- Measurements were taken at the center of the joint, as shown
- Mixing level of the SAC/Sn-Pb solder joints was determined by comparing the distance between the component and PWB pads with the distance between the border of the lead-containing region and the component pad.



$$\text{Mixing level (\%)} = \frac{(P2P - P2B)}{P2P} * 100$$

Results

SAC-SAC Systems

1.0mm BGA Lead-Free Solder Paste, *Phase 1B SAC105* Ball

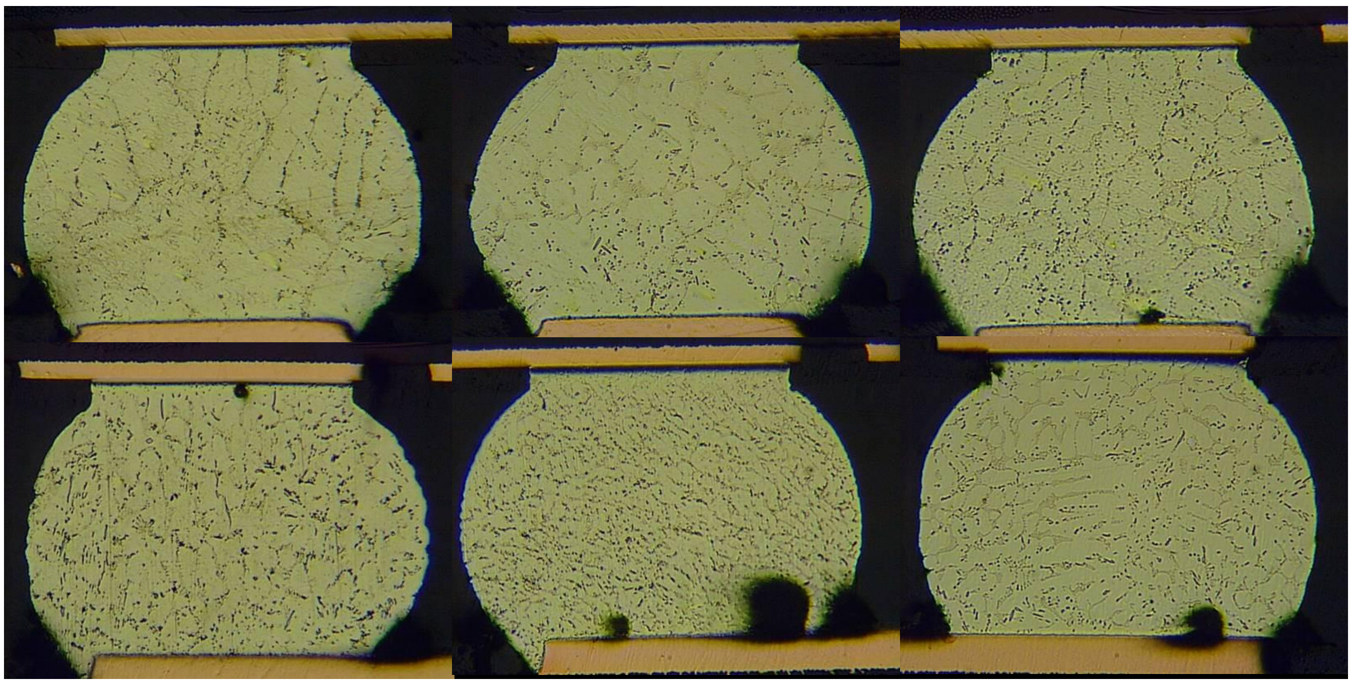
Ball Location

Left *Center* *Right*

Peak Temperature, *degrees C*

220

225



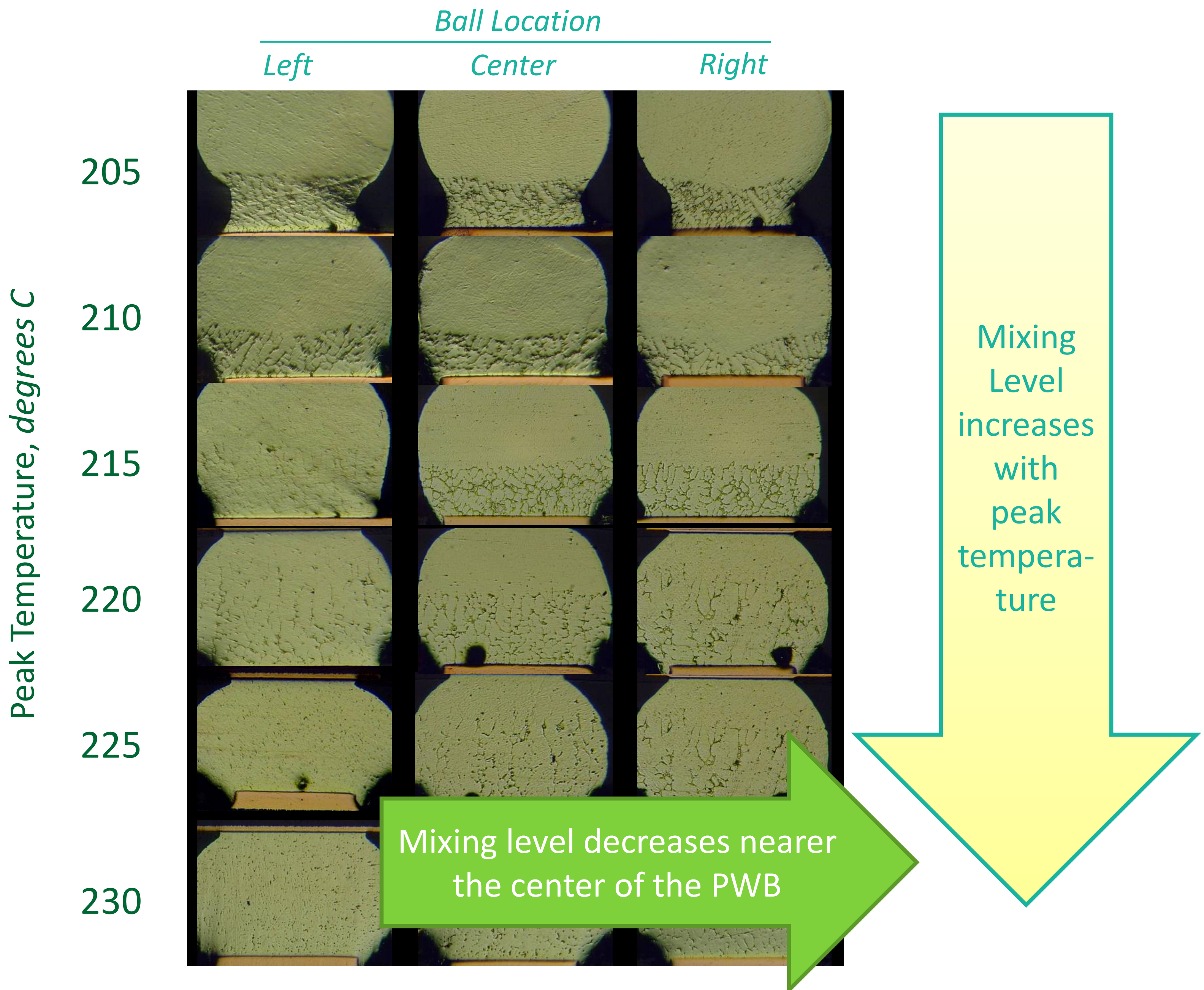
All spheres showed good collapse

No mixing boundaries could be identified

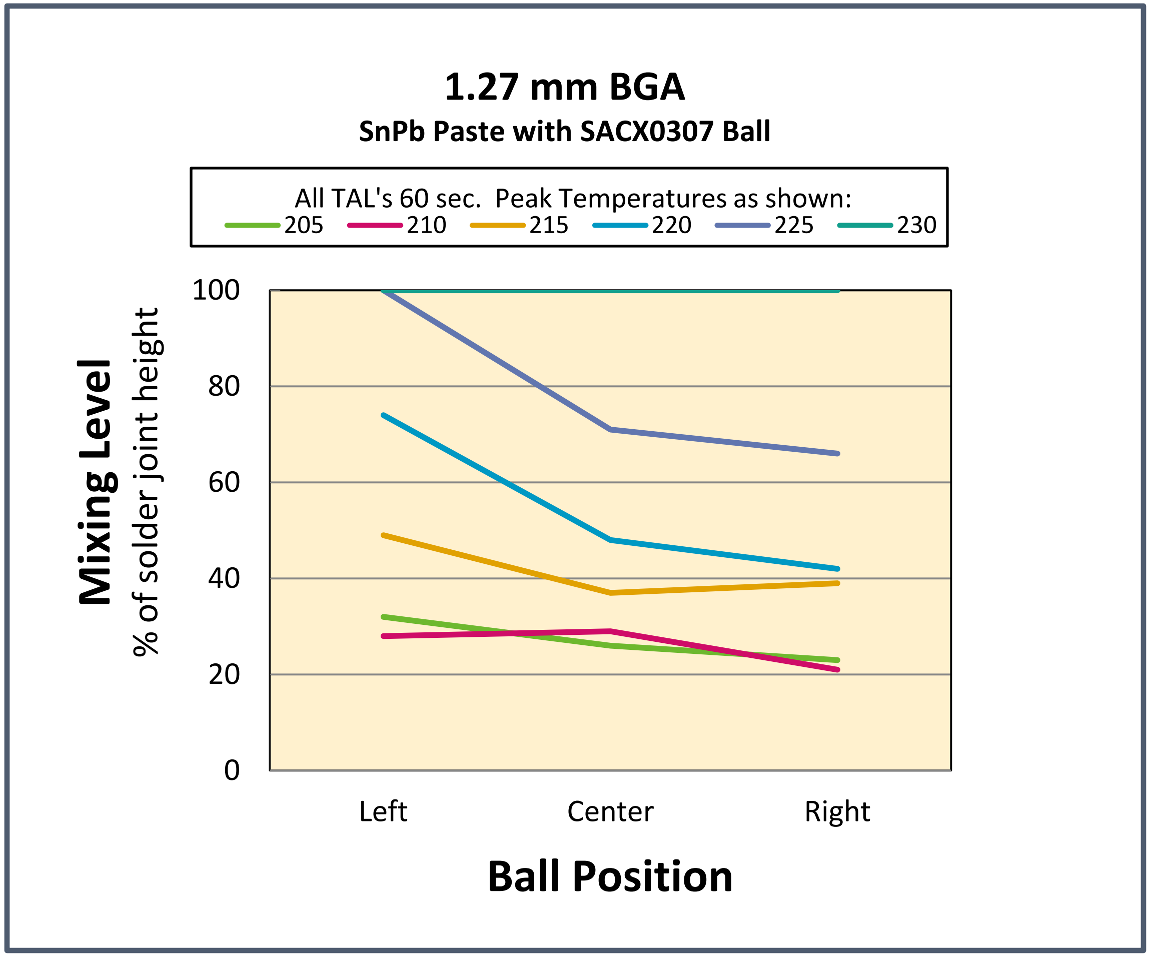
SAC-SnPb Systems

This is where it gets interesting…

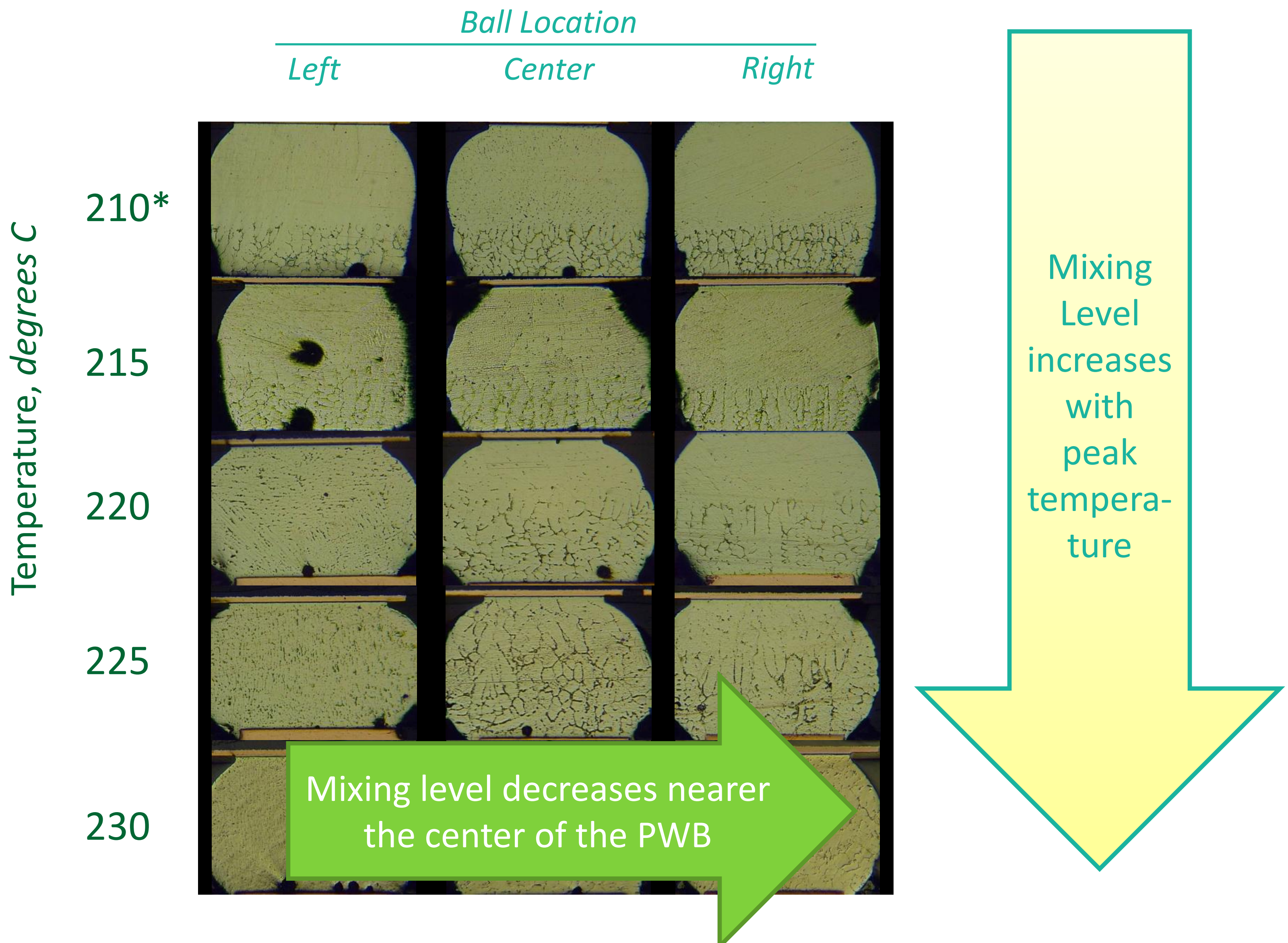
1.27mm BGA Tin-Lead Solder Paste, Phase 1B SACX0307 Ball



Represented Graphically,

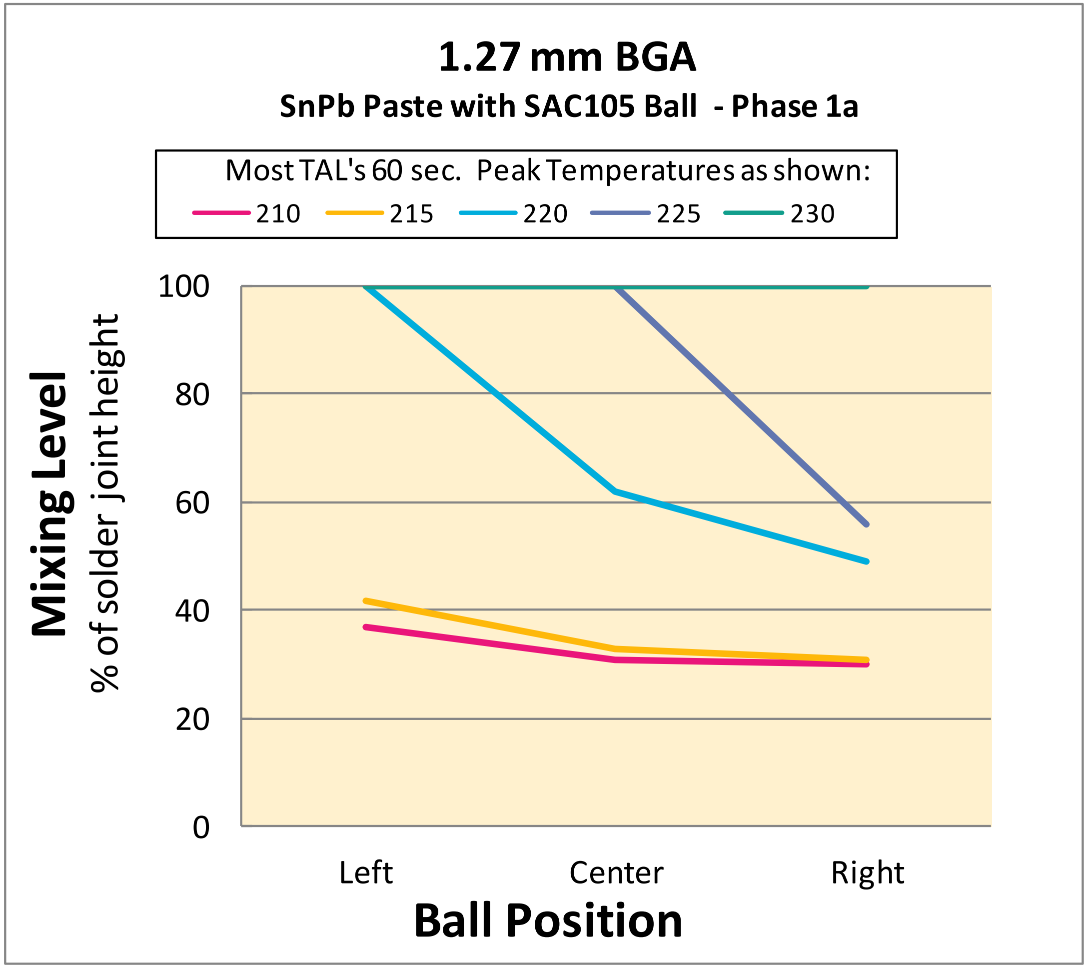


1.27mm BGA Tin-Lead Solder Paste, *Phase 1A SAC105* Ball



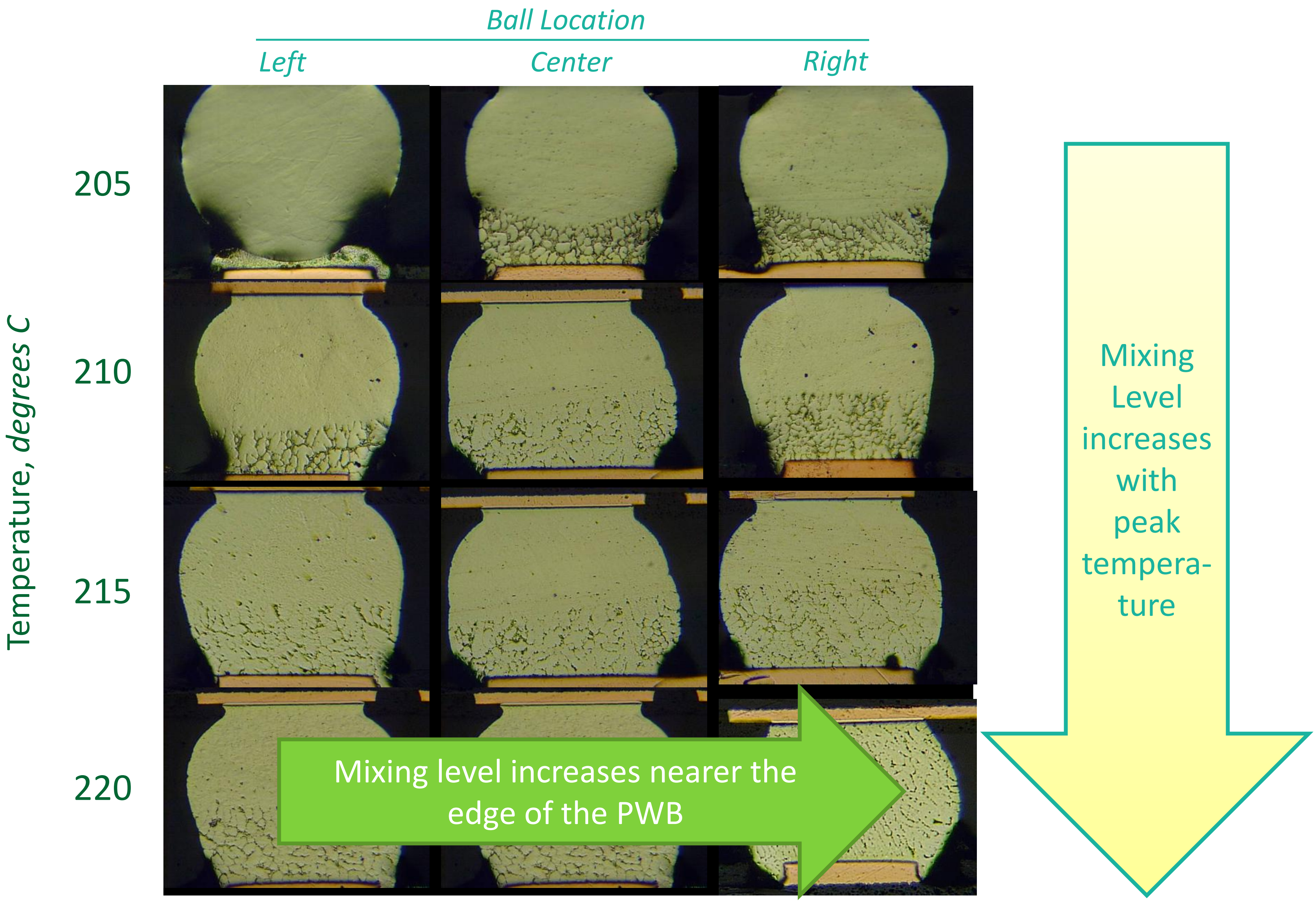
* Profile with peak temp of 210C had 120 sec TAL

Represented Graphically

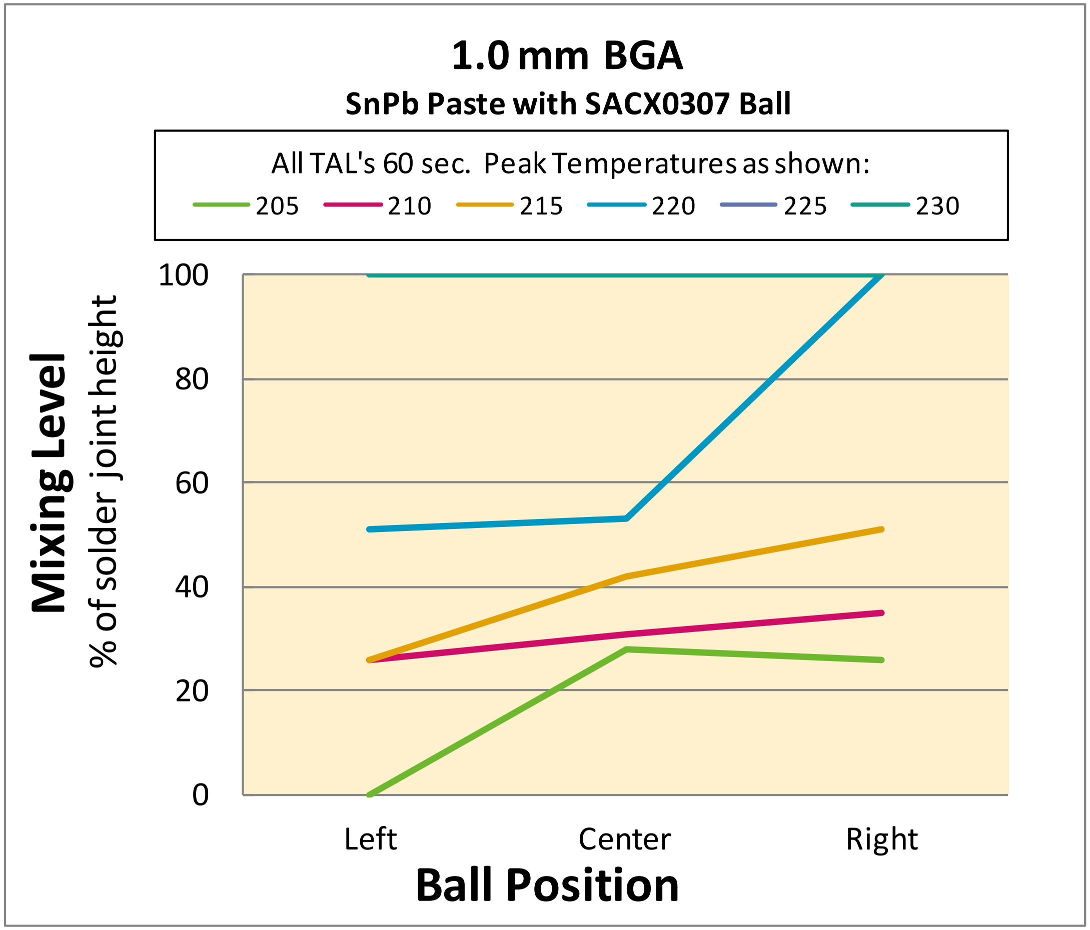


* Profile with peak temp of 210C had 120 sec TAL

1.0mm BGA Tin-Lead Solder Paste, Phase 1B SACX0307 Ball



Represented Graphically



1.0mm BGA Tin-Lead Solder Paste, *Phase 1A SAC105* Ball

Ball Location

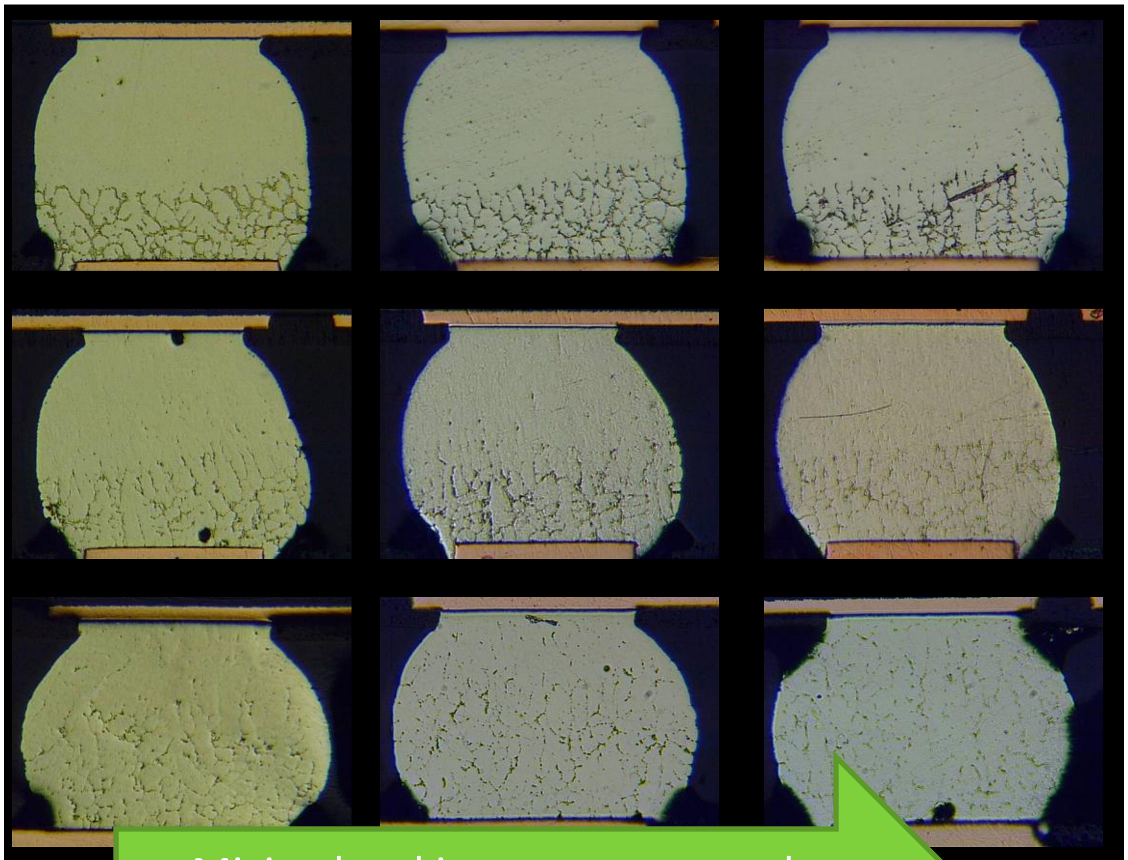
Left *Center* *Right*

Temperature, *degrees C*

210*

215

220

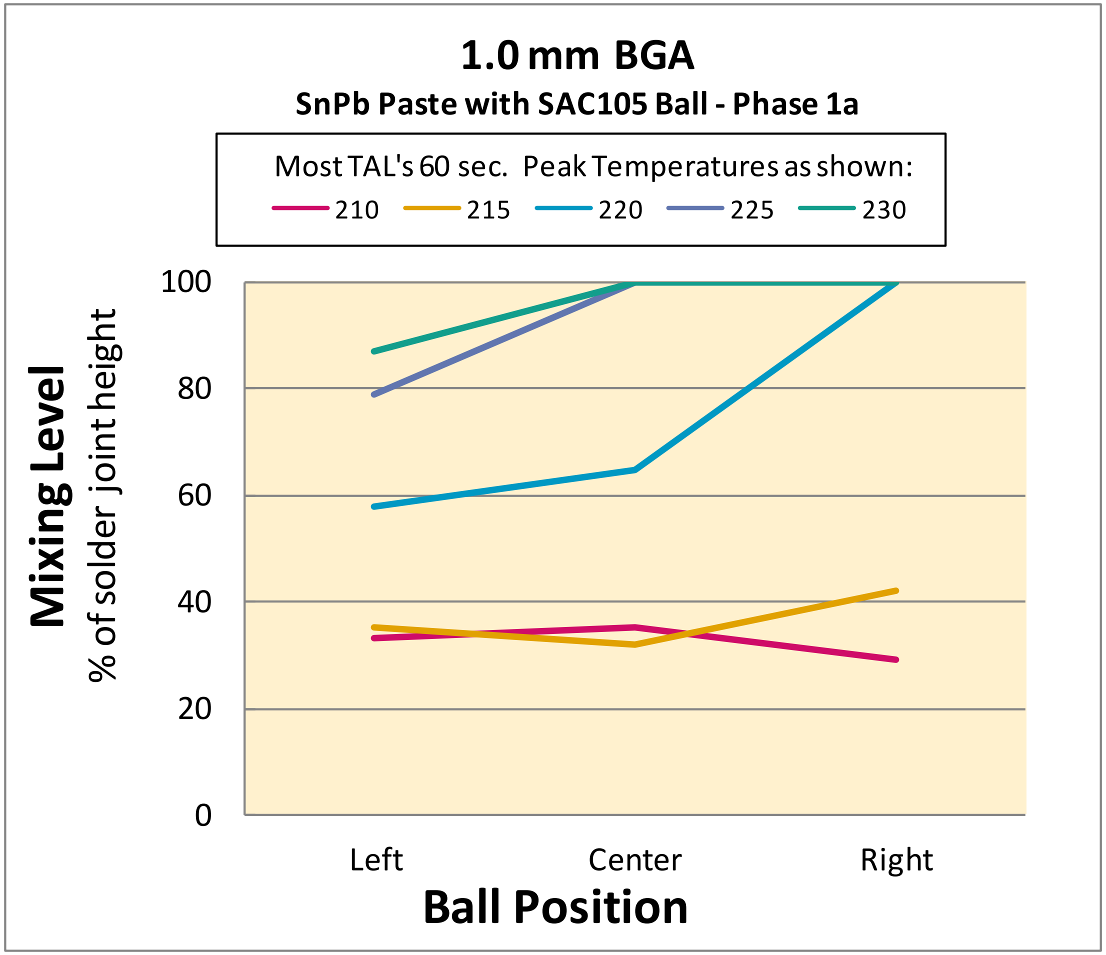


Mixing level increases nearer the edge of the PWB

Mixing Level increases with peak tempera-ture

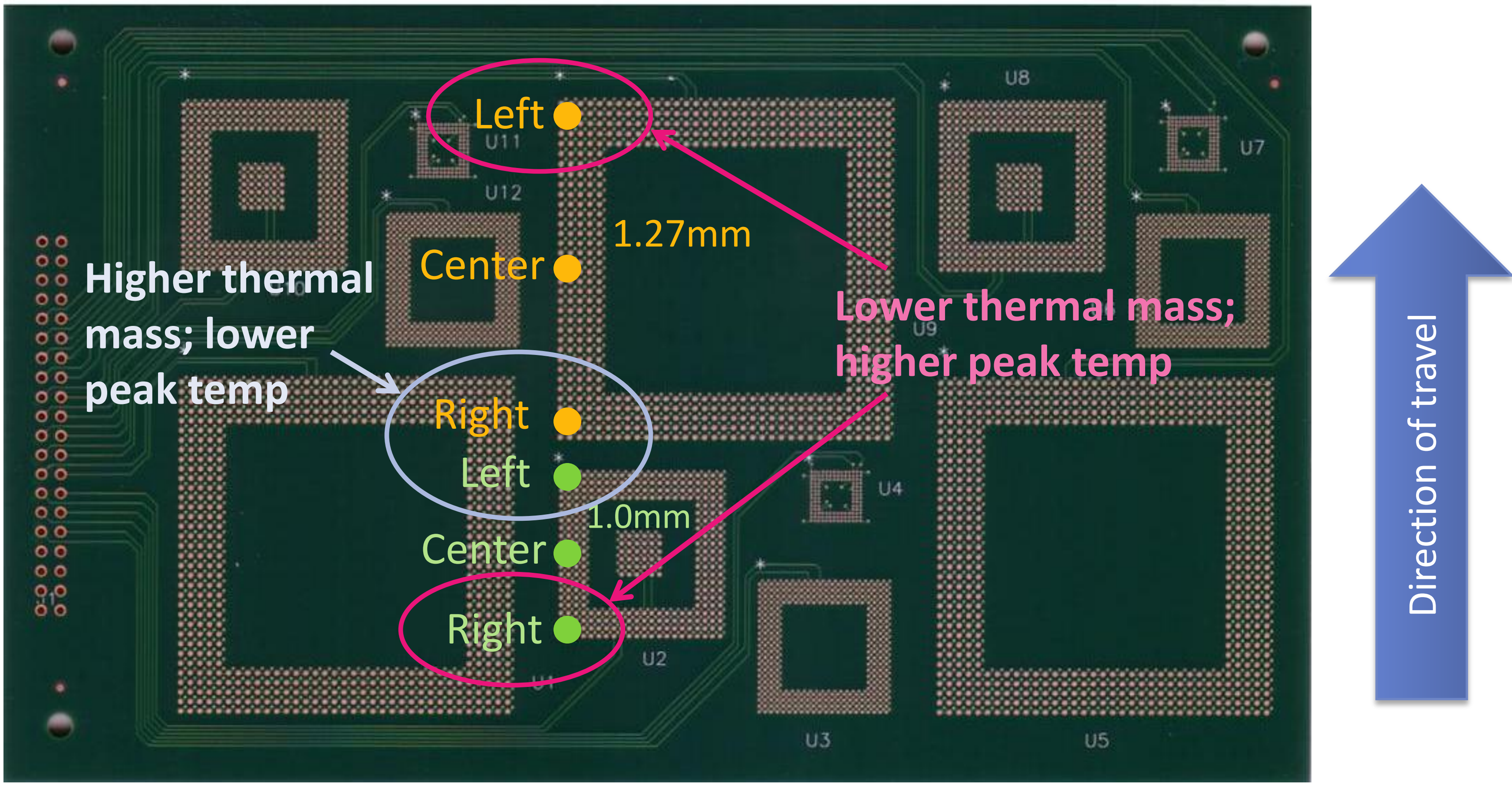
* Profile with peak temp of 210C had 120 sec TAL

Represented Graphically

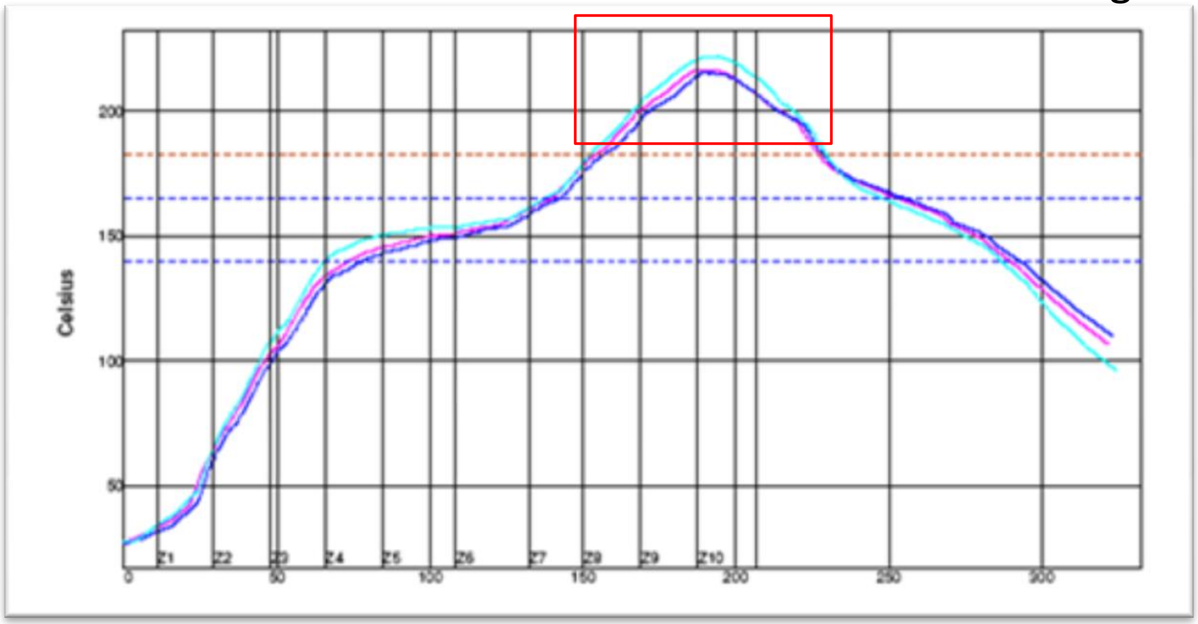


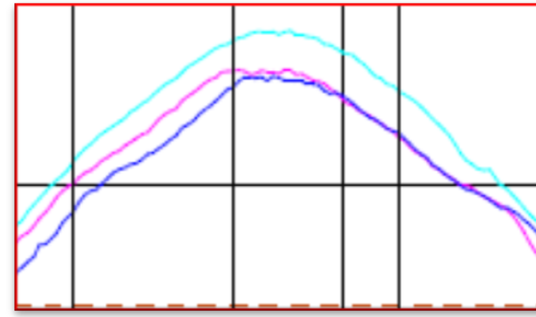
* Profile with peak temp of 210C had 120 sec TAL

Test Vehicle



1.27mm Thermal Profile Low Ag **220**C

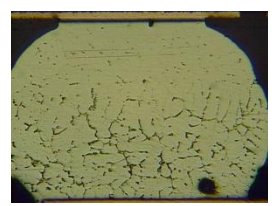




Left
Center
Right

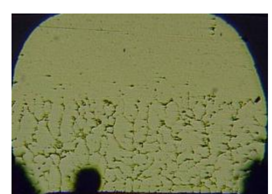
	Left	*Center*	*Right*
Peak Temperature	222.39	216.63	215.60
Time Above Liquidus	76.82	72.51	71.19

1.27mm BGA SAC105

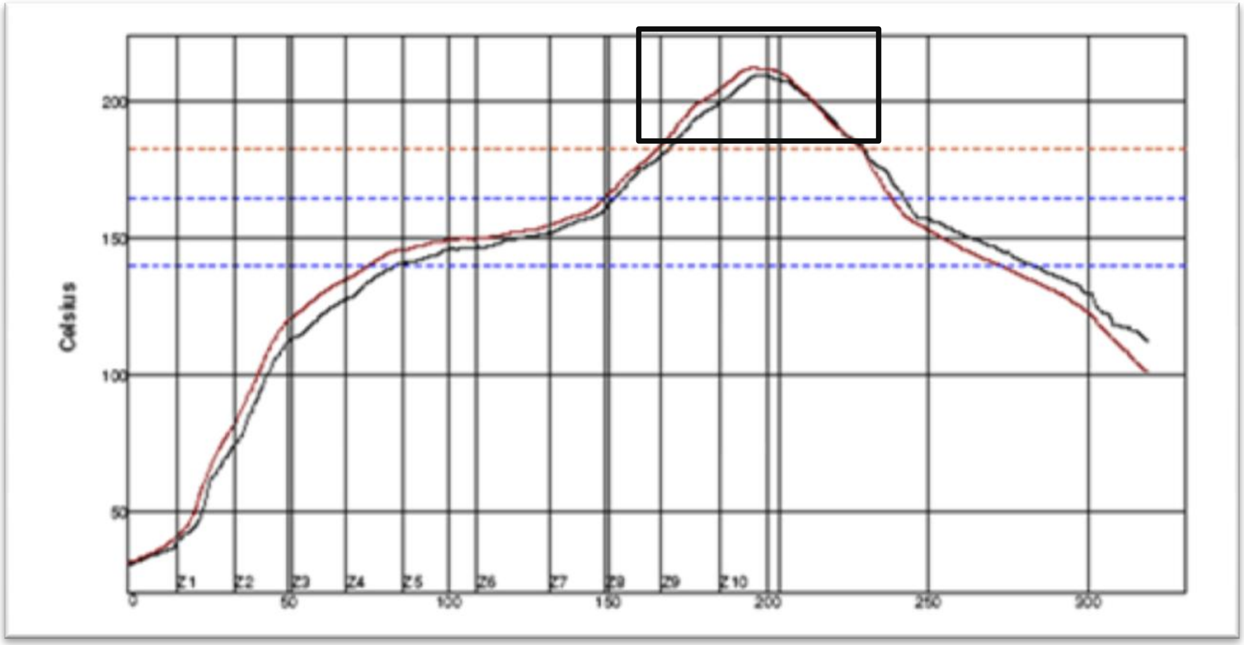
Mixing Level	100%	62%	49%

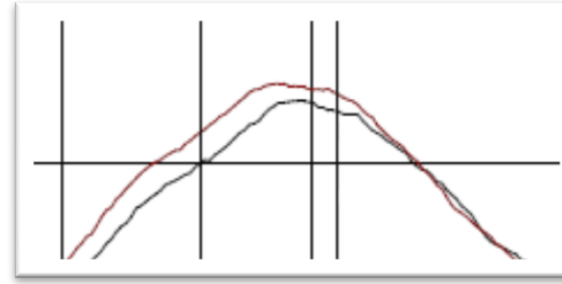
1.27mm BGA SACX

Mixing Level	74%	48%	42%

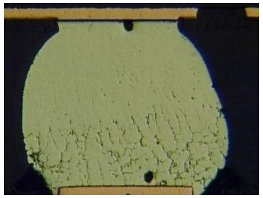
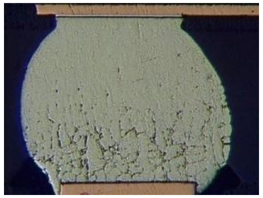
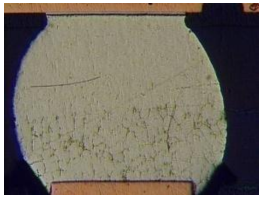
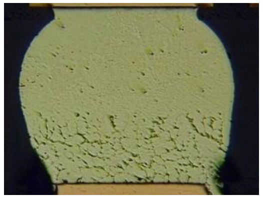
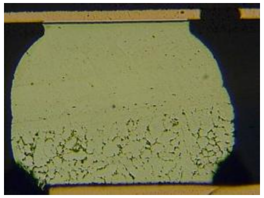
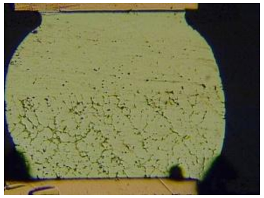
1.0mm Thermal Profile Low Ag **215**C





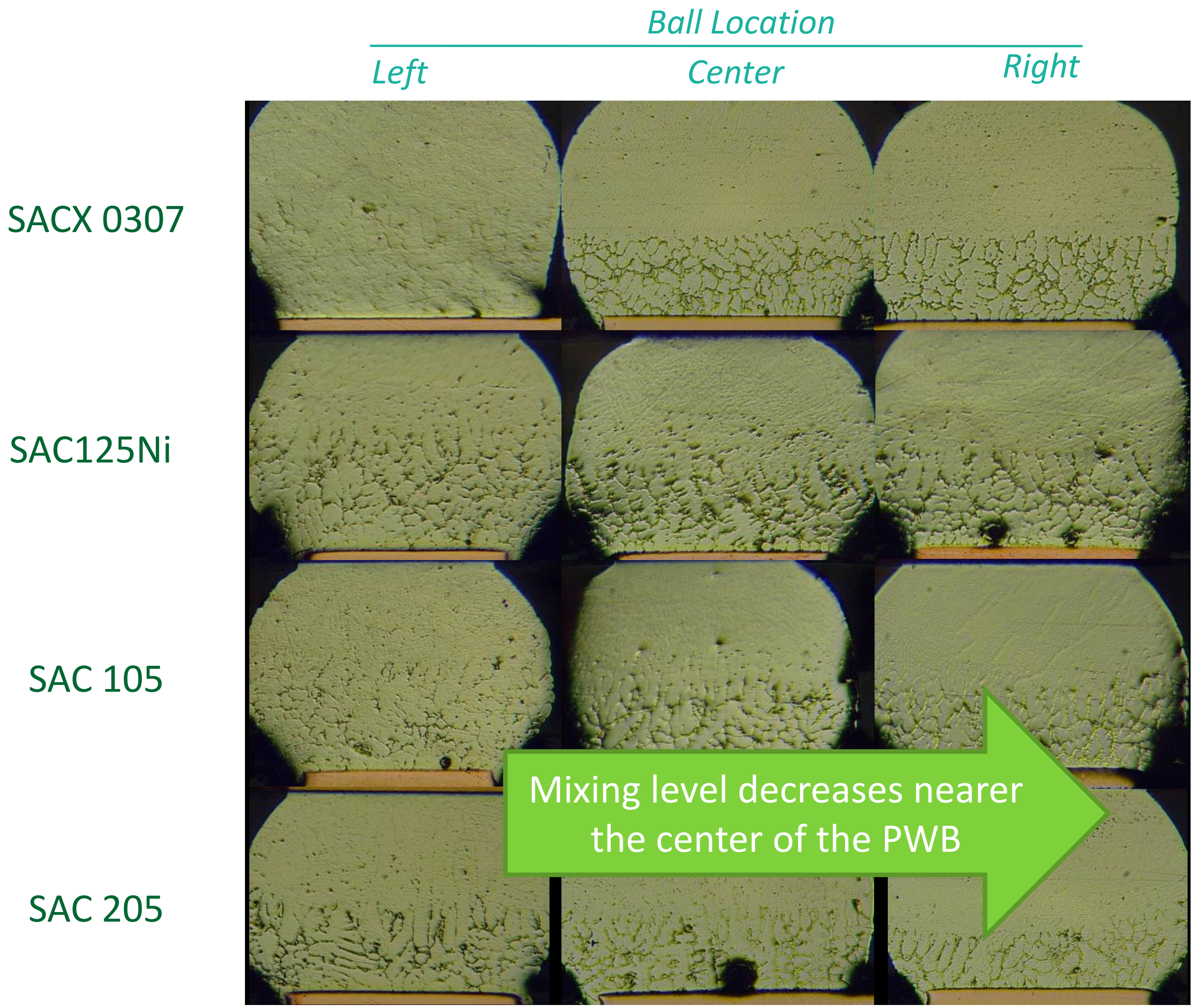
Right

Left

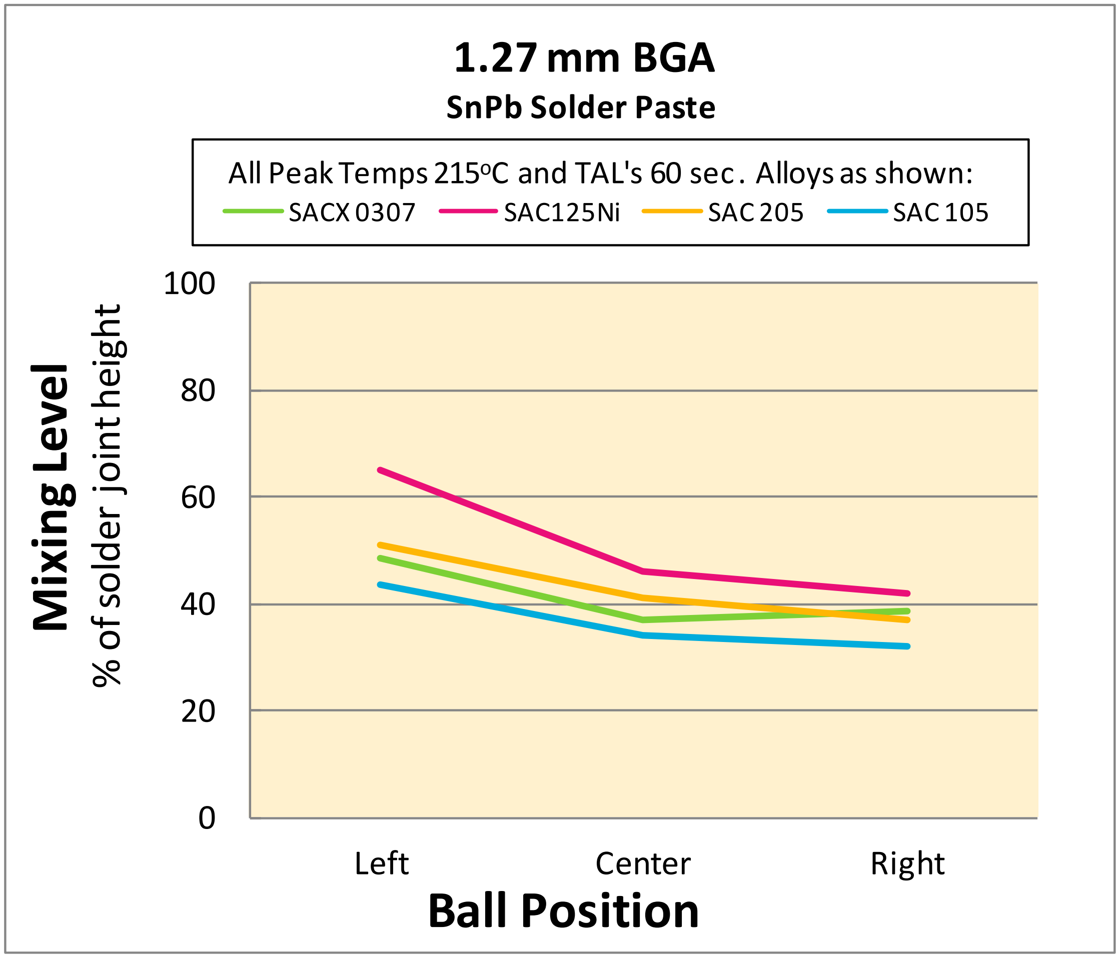
	Left	*Center*	*Right*
1mm BGA SAC105			
Mixing Level	35%	32%	42%
1mm BGA SACX			
Peak Temperature	210.03	N/A	212.67
Time Above Liquidus	61.12	N/A	63.51
Mixing Level	26%	42%	51%

1.27mm BGA Tin-Lead Solder Paste

Peak Temp 215ºC, TAL 60 Seconds

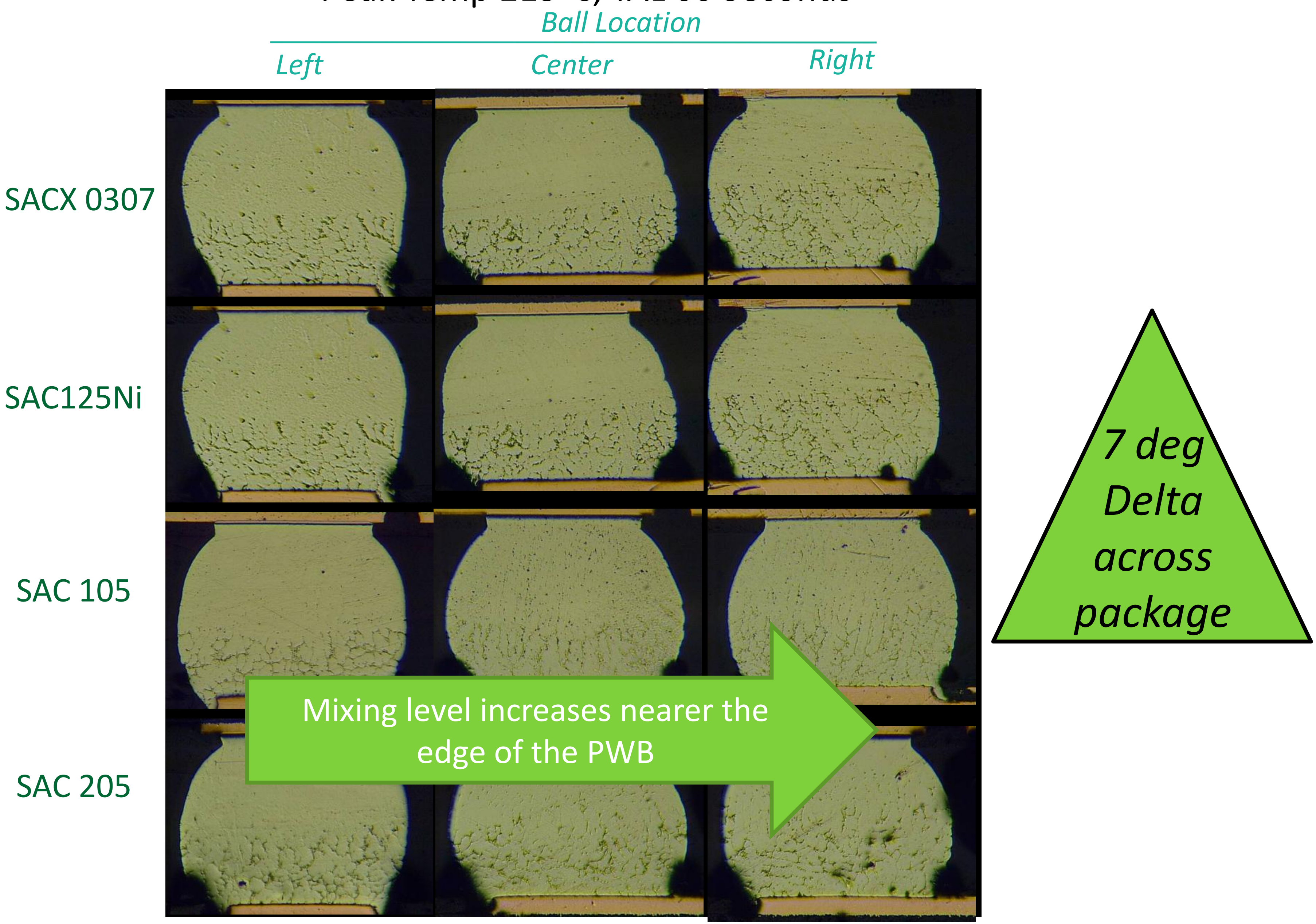


Represented Graphically

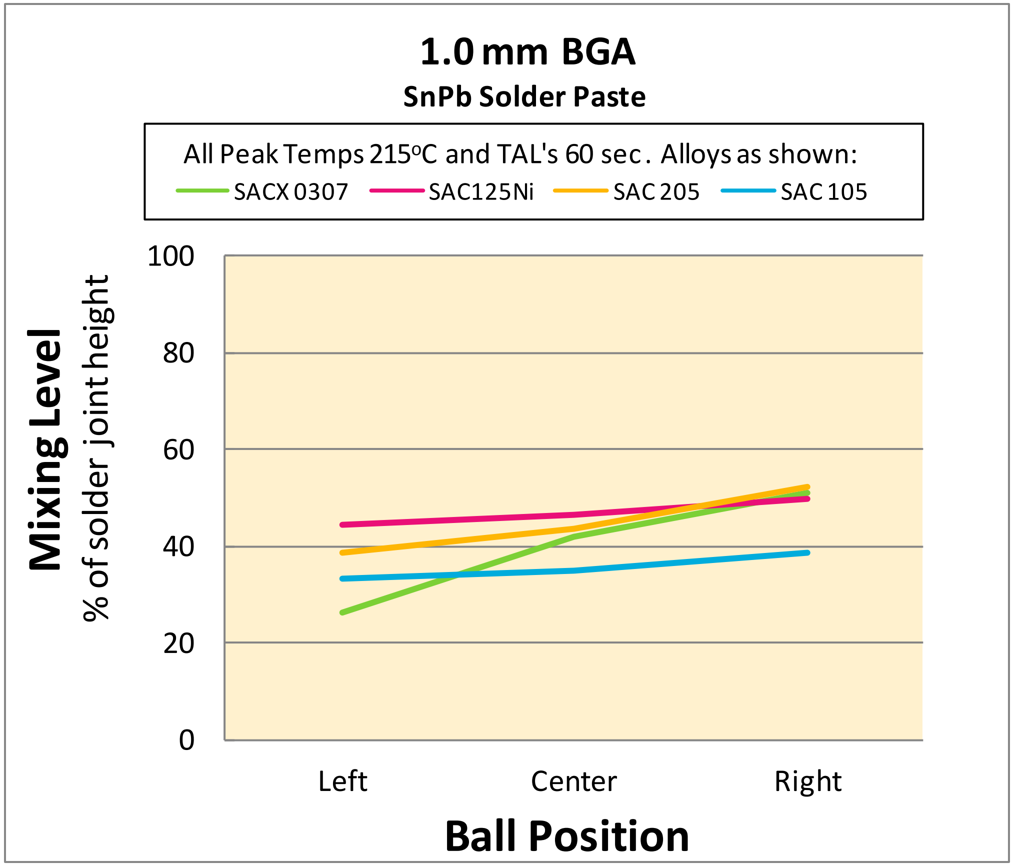


1 mm BGA Tin-Lead Solder Paste

Peak Temp 215°C, TAL 60 Seconds



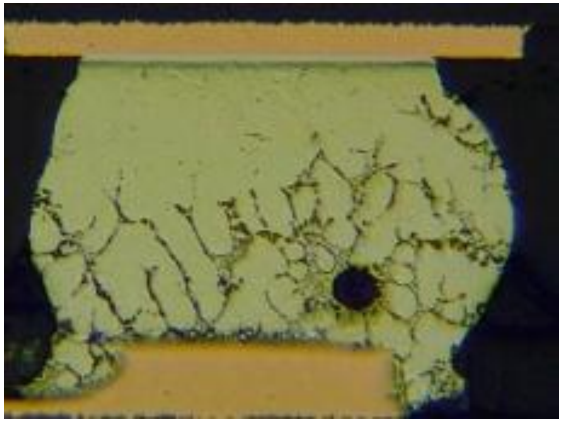
Represented Graphically

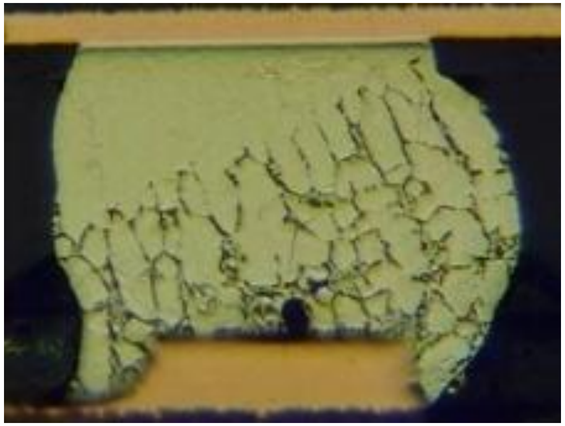


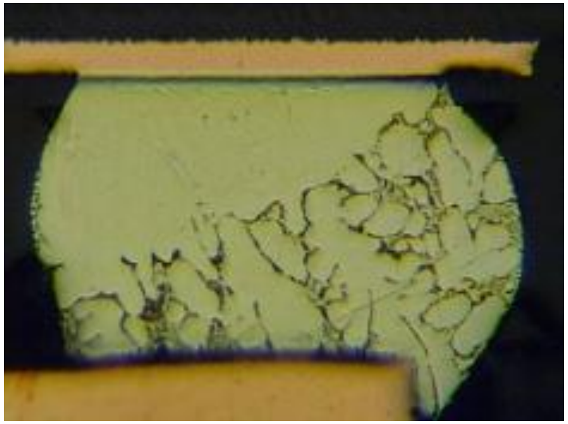
Really Interesting Find:

0.5mm Pitch BGA

Peak Temperature 205° C, TAL 60 seconds







Check out these mixing boundaries!

Conclusions

- Can’t visually quantify mixing levels of SAC-SAC systems
- Can visually quantify SAC-SnPb systems
- Spheres don’t have to melt for mixing to occur
- Sphere size and peak temperature are significant factors in mixing. TAL is not.
- Small differences in peak temperature –as small as 2 degrees – can make considerable differences in mixing levels
- Process noise is suspected to play a larger role than originally thought in mixing behaviors

Many, Many Thanks

Profiling, Assembling, and Cross Sectioning was performed by:

- Anthony Babasa
- Evan Doxtad
- Michael Lapitan
- Michael Santos
- Josh Solon

The End

Questions?