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OCTOBER 25 - 29, 2026
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Please take a moment to review the contents of this speaker kit, which includes everything you need to prepare for the conference:

- Speaker & Conference Information
- Speaker Checklist & Responsibilities
- Travel Details
- Speaker Forms

POINT OF CONTACT



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SPEAKER CHECKLIST & DUE DATES

Stay on track with this planner

Friday, September 18



- Copyright & Permission to Post Form
- Technical Paper*
- Presentation Slide Deck

**Papers not submitted by this date will be removed from the conference unless pre-approved for an extension.*

Friday, September 18



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Friday, July 10

- Agreement Form
- Biography Form*
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**if not submitted with abstract*



Friday, September 18

Early Registration Rates Expire

Purchasing a discounted speaker registration is required for conference participation.

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View event information, templates, submission forms, and find information to help you prepare for the conference!

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EVENT & TRAVEL DETAILS

DATES

Conference: October 25- 29, 2026

Exposition: October 27-29, 2026

LOCATION

Donald E. Stephens Convention Center
5555 N River Rd, Rosemont, IL 60018

EXPO

The expo will be held October 27-29. We encourage you to visit the expo. Please let us know if your company is interested in exhibiting or sponsorship to increase your exposure. More information may be found online, [EXHIBITS | SPONSORSHIPS](#)

Exhibition Hours

Tuesday, October 27: 4:00PM - 7:00PM

Wednesday, October 28: 10:00AM - 5:00PM

Thursday, October 29: 10:00AM - 2:00PM

PROGRAM

All presentations will be in-person. We ask that you promote the conference, expo and courses to your contacts as well. All content is required to be strictly technical. Please refer to the Non-Commercialism Policy included in this speaker kit.

PROCEEDINGS

Instructions on how to access the proceedings will be sent electronically to your email that is tied to your conference registration. The link to access technical papers and presentations will be emailed following the conclusion of the conference.

PARKING

Public parking is available in the William St. Garage and East Parking Garage (\$15.00 for 24 hours).

HOTEL ACCOMMODATIONS

All participants are responsible for arranging their own travel arrangements. Hotel reservations can be made via the special group rate weblink. Hotel rooms may sell out so **BOOK YOUR HOTEL** in advance.

Deadline to book: September 18, 2026

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Reservations should be made using the reservation link below or calling the hotel directly and referencing the SMTA International Conference. We do not use a housing company. Please be aware of any individuals or companies that contact you to book your hotel reservations or offers a reduced rate as it is unauthorized and fraudulent. The SMTA is not responsible for housing issues that result from booking accommodations independently of the SMTA room block offered through the website.

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International visitors may need a Visa to enter the United States. Because of world events, Visa applications are subject to a greater degree of scrutiny than in the past. The greater scrutiny means a longer waiting period; therefore, the State Department recommends that you begin your Visa application process well in advance of your travel dates.

*If you need a Visa support letter, please contact **smtai@smta.org** with your request.

SPEAKER ROLES & RESPONSIBILITIES

TECHNICAL PAPERS (REQUIRED)

All papers must be submitted by September 15. **Any delinquent papers will be removed from the technical program unless pre-approved for an extension.** A technical paper for the conference proceedings is required for all accepted abstracts and scheduled for a presentation in the technical program.

Papers should describe significant results from experiments, emphasize new techniques, and contain technical, economic, or appropriate test data. **Materials must be original, unpublished, and non-commercial in nature.** All papers and presentations are reviewed by SMTA for compliance with the non-commercialism policy and format requirements. Final papers may be returned to the author for corrections if necessary. Please review/apply SMTA Paper Format Requirements to layout your final paper correctly.

REASONS FOR NON-ACCEPTANCE

- Commercialism or non-objectivity that cannot be corrected with editing
- Previously published paper or similarity to previously published paper
- Inadequate technical content; lacks supportive test data
- Comparisons to products produced by competing companies
- Subject not related to the interests of the SMTA International audience

NON-COMMERCIALISM POLICY

Technical papers and presentation slides perceived as sales presentations will not be accepted by the SMTAI Technical Committee or the Session Chairs.

- Avoid commercialism and limit company logos, website, slogans, etc. to the title page only
- Do NOT use a company name or a specific trade name in the paper title
- Use generic names (Product A/Company B), not specific companies/model numbers, to identify equipment, products, or processes
- Limit Trademarks and © (Copyrights) to references and endnotes

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A presentation is also required for each session and is limited to 30 minutes including Q & A. Presentation Format Requirements and SMTAI template are also available on the SMTA International speaker portal.

REQUIRED FORMS AND DELIVERABLES

- Speaker forms: agreement, biography, copyright
- Technical paper
- Technical presentation

SPEAKER ROLES & RESPONSIBILITIES

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- **Check off your Speaker Checklist.** Be sure you have turned in all required forms before the conference.
- **Register for the conference.** All speakers are required to register for the conference at the discounted rate.

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- **Check-in to the SMTA Office (59/60).** You will receive your conference badge, speaker gift, instructions for proceedings access and other important information.
- **Attend the speaker breakfast the morning of your presentation.** A hot breakfast will be provided. It is important that you attend as this is where you will be able to meet with your session chair. Confirm that your session chair has reviewed your presentation and your bio form.
- **Visit the Speaker Prep Room.** This room is provided to you to test and prepare your presentation. A private room with a screen and projector is available.

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- **Presentations are 30 minutes,** including time at the end for Q&A. The session chair will have signs with alerts for 10-minutes/5-minutes remaining.
- **Utilize the podium and lapel microphones.** Even if you feel you are able to project loudly, we often receive feedback that the audience is unable to hear due to ambient room noise.

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- **Power Point Presentations will be posted online in PDF format and available for three months.**
- **Speaker Scores / Summary** will be compiled and sent to you approximately one month after the conference.
- **Conference awards will be announced in December 2026.** Conference awards will be presented at the 2027 SMTA International Conference.
- **Save the Date!** The Technical Committee would like to invite you to submit an abstract for 2027 (October 24 – October 28). Abstracts will be due April 2027.

PRESENTATION TIPS

We understand many of you are seasoned speakers and have your own proven methods of preparation and delivery. The suggestions below may help you to increase or improve your speaker ratings.

SLIDE DECK GUIDELINES

- Provide an agenda
- Make sure slides are readable. Use a light color background and one font
- Underscore key points in your presentation with copy, photographs or charts
- Limit usage of red vs. green on the same slide for those that may be colorblind
- An effective 25-minute presentation includes 30-35 slides
- Provide a summary of key points to close
- Practice presentation for delivery and timing

PRESENTATION

- Presentations should be technical and not perceived as sales presentations
- Keep presentations strictly technical and educational
- Encourage audience participation
- Do not read slide by slide
- Provide insight on how audience can transfer information to their job jobs and organizations
- Leave time for questions, Repeat questions

CONFERENCE AWARDS

BEST OF CONFERENCE AWARDS

The SMTA International Technical Conference Awards recognize outstanding achievements in electronics manufacturing, honoring individuals and teams who have demonstrated exceptional innovation, leadership, and contribution to the field.

Best of Proceedings" Paper Award

*Selected by the SMTA International Technical Program Committee.

Best Practical and Applications Based Knowledge Award

*Selected by the SMTA International Technical Program Committee.

NON-COMMERCIALISM

POLICY
Rev Date March.2021
Ref Section: 8.4

COMMERCIALISM DEFINED

Commercialism is the inclusion in a paper and/or presentation of written or visual references to any company or organization for the promotion or commercial advantage of the presenting company or the commercial disadvantage of a competing company.

NON-COMMERCIALISM RULES APPLY TO THE FOLLOWING

Technical Papers, Presentations and Professional Development Courses

Company Names and Logos: Excessive use of the presenting company's name or logo is prohibited. The names or logos of any company supplying goods or services or any competing company is also prohibited. Paper and presentation templates provided by SMTA shall be used for papers and presentations.

Names: Use of brand names, product names, trade names, or trademarks is prohibited. Use of industry accepted generic descriptions or neutral designations such as Type A, Type B, Type C, etc. is acceptable.

Products and Services: Discussions of the presenting company's products and/or services are prohibited unless they pertain to the data or information being published. Any discussion of a competitor's products and/or services is prohibited.

Comparisons: General comparisons of products and services are prohibited. Generic comparisons that are supported by data may be allowed.

Graphics: Any graphic that promotes a product and/or service is prohibited.

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Authors will be asked to correct papers and/or presentations that violate these rules as defined above. SMTA reserves the right to reject any paper and/or presentation for violating these rules.

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TECHNICAL PAPERS

Papers must be a minimum of 4 pages (including text, photos, tables, charts, references etc.) and include the following:

- Abstract / Introduction
- Conclusion
- 2-6 Key words
- Acknowledgements
- Discussion of methodology
- References
- Results of the data

FORMAT

(You can find a template in .doc format on the Speaker Portal)

Title and Author Information:

- Center Paper Title in all Title Case - Use 14pt bold TIMES NEW ROMAN
- Center Author(s) Company, ST, Country, Email (one is required) Use 12pt Times New Roman
- Include a list of 3 to 4 key words after abstract to facilitate an electronic search of papers

Margins and Spacing:

- Use single line spacing
- 0.75" margins on all 4 sides of paper. (If using A4 sized paper, leave a 1.5" bottom margin)
- 2 column format with a 0.25" spacing between columns

Text:

- All body text - 10pt. Times New Roman or equivalent 'serif font'
- Justify / block text - no indents for paragraphs
- HEADINGS - flush left; all capital letters; bold 10pt. **Times New Roman**
- Subheadings - flush left; capitalize the First Letter of Each Word; use bold 10pt. **Times New Roman**
- No line spacing between headings, subheadings and body text
- When using British-American units of measure, give metric equivalent (in parentheses)
- Do NOT number pages. They will be numbered for the Table of Contents in the Proceedings
- Illustrations and tables may be placed in the body of text or at the end of your paper
- References must appear as a separate section at the end of the paper. In the body text, reference information should be indicated by a numeral in square brackets, i.e. [1] or in superscript² numbers.

Upload Your Final Technical Paper:

- By the required deadline of September 18, 2026
- Using SMTA Format Requirements
- In a Word document (**required**)
- On the ftp Speaker Portal website - www.smtai.org/speaker-portal

TECHNICAL PAPER FORMAT

REFERENCE SECTION – UPDATED AS OF SEPTEMBER 1, 2018

[33] S.K. Kang, Paul Lauro, Da-Yuan Shih, Donald W. Henderson, Timothy Gosselin, Jay Bartelo, Steve R. Cain, Charles Goldsmith, Karl J. Puttlitz, and Tae-Kyung Hwang, "Evaluation of Thermal Fatigue Life and Failure Mechanisms of Sn-Ag-Cu Solder Joints with Reduced Ag Contents," Proceedings of Electronic Components and Technology Conference, 661-667, Las Vegas, NV, 2004.

FORMAT

Reference number

[33] - in [brackets]

Author Names

S.K. Kang - author first name or first initial and last name (author names as they appear in the original citation)

Paper Title

"Evaluation of Thermal Fatigue Life and Failure Mechanisms of Sn-Ag-Cu Solder Joints with Reduced Ag Contents," - "paper title in parentheses"

Conference Proceedings Title

Proceedings of Electronic Components and Technology Conference, title in italics (optional formats Proceedings of 54th ECTC; Proceedings of 54th Electronic Components and Technology Conference)

Page Number Range

661-667, - page number range (pp. 661-667 is an optional format)

Conference Location (Optional)

Las Vegas, NV

Date

2004 (June 1-4, 2004 date and month optional if available)

Outline of SMTA Format Required

(Please see the *SAMPLE* technical paper that follows for a visual reference)

Enter Paper Title – Title Case – 14PT Times New Roman; Centered & Bold

Insert 1 blank line

Authors Name(s)

Company

State Abbreviation (XX), Country

Email (no hyperlink) (minimum of one contact is required)

(12 point Times New Roman - no bold)

Insert 2 blank lines

Margins:

Top, bottom & sides 0.75 inches

If using A4 paper – leave a 1.50 inch margin on bottom

Two-column format; 0.25 inch space between columns

Text:

10 point Times Roman font; single-spaced

Text fully justified (no ragged right edge)

Block paragraphs (no indents)

Omit page numbers - they will be inserted electronically

Key words:

2 to 6 keywords after abstract (no bold)

HEADINGS: ALL CAPS (bold and left-justified)

Subheadings:

First Letter of Each Word in Caps; bold and left-justified.

No line spacing under any headings.

Single line spacing between paragraphs

Tables/Figures/Photos/Graphics Titles (see examples):

Use **BOLD**, 10 point Times New Roman; flush left. Illustrations and tables may appear in the body of text or be placed at the end of your paper. PLEASE NOTE: For the best possible reproduction of your paper on the Proceedings flashdrive, **embed your color figures and color graphics/photos** directly into your word document.

Use only white backgrounds for text and figures for good contrast/readability. (Proceedings flashdrive is in color)

REFERENCES:

Use superscript numbers¹ or brackets [2] for references in text. **Do NOT use hyperlinks in text to link to References.** Place references at end of the paper.

Fully justify REFERENCES – Do NOT include hyperlinks to websites or publications. See *SAMPLE* paper.

Our goal for the Proceedings is to have the flashdrive appear as if it were created and edited as a uniform publication. Minor deviations won't be noticed but a uniform appearance contributes to the professionalism of authors and the conference.

Example of table or graphic and caption in a paper:

Table 1. Cu Dissolution DOE Matrix

		Contact Time Replicates (secs)					
Exp. #	ALLOY	1	2	3	4	5	6
1-1	Sn-Pb	30	30	30	30	30	30
		50	50	50	50	50	50
1-2	SAC405	30	30	30	30	30	30
		50	50	50	50	50	50
1-3	SAC305	30	30	30	30	30	30
		50	50	50	50	50	50
1-4	Sn-Cu + Ni (1)	30	30	30	30	30	30
		50	50	50	50	50	50
2-1	Sn-Ag-Cu + Bi	30	30	30	30	30	30
		50	50	50	50	50	50
2-2	Sn-Ag-Cu + Sb	30	30	30	30	30	30
		50	50	50	50	50	50
2-3	Sn-Cu + X/Y	30	30	30	30	30	30
		50	50	50	50	50	50
2-4	Sn-Cu + Ni (2)	30	30	30	30	30	30
		50	50	50	50	50	50
DOE RUNS		16	16	16	16	16	16
TOTAL DOE RUNS		96					

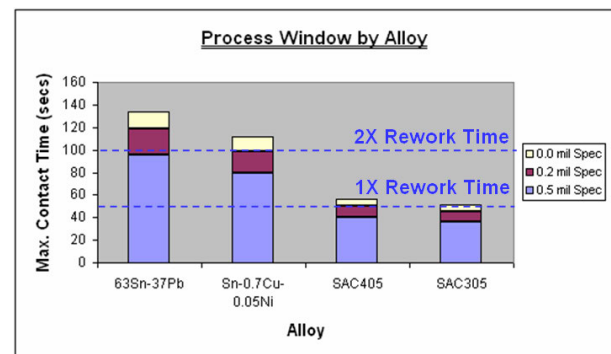


Figure 1. PTH Process Window by Alloy

EXAMPLE of placement of a table (or graphic) that will not fit in one column.

(You may also place all large tables and graphics as an APPENDIX at end of the paper after your REFERENCES)

The third development stage was to build the actual notebook or desktop production motherboard in a lead-free configuration and perform the full battery of board level and system level testing. One notable discovery in this stage was that torsion testing of a notebook motherboard could result in PCB pad cratering due to strain from the high modulus SAC alloy; this was consistent with work from others [6]. As a result some BGA components on notebook products required partial underfilling (or edge glue) to prevent such failures. Such techniques are now fairly common for lead-free assemblies [7]. Without getting into great detail, it can be said that in the course of this extensive two year effort many lead-free issues were discovered and each was resolved prior to launching of the consumer lead-free products.

business products that may be exposed to such harsh environments (this would include server products).

DISCUSSION OF CHALLENGES

All of this previous experience with converting notebook and desktop products to lead-free was leveraged in taking the next step of converting the complex and challenging class A server products to lead-free. An effective way to start with implementation of any major product or manufacturing change is to consider all the differences from what was previously known and the impact these differences may have on the final product. In this case the primary gaps in transitioning from a lead-free consumer product to a lead-free server are shown in Table 1.

Table 1. Differences in a lead-free server compared to transitioning lead-free client products.

Change/Challenge	Risk	Action
PCB thickness increase (from 0.062" to 0.092 or greater)	Incomplete hole fill in wave	Improve wetting with flux, alloy choice, and/or increase temp
		Ensure PTH components can survive increased temp
	Increased thermal stress on PTHs	Reduce z-axis CTE and/or increase Cu thickness.
1-3 additional processor sockets are required per board.	More thermal energy needed to achieve consistent solder joints can cause heat damage.	Ensure surface finish has good solderability and PCB can handle added heat stress.
All boards require 2 side SMT + wave solder.	Solderability of PTH degrades with 2 nd side reflow	Ensure a robust surface finish that remains solderable after 2 heat cycles.
In circuit test strain limits could be larger with thicker boards.	ICT stress must be minimal to prevent BGA fracture	Ensure low contact resistance on test points.
Immersion silver surface finish eliminated due to corrosion risk	Alternative finish must meet ICT and solderability requirements	Investigate several alternatives (OSP, ImSn, ENIG, and LF HASL)
PCB laminate may change from what was used on DT and NB products.	Thermal cycle life of the BGA components can change	Build test vehicle and run thermal cycle testing
Larger and heavier assemblies	Shock/vibration differences	Test final assemblies using shock/vibration/HALT
PTH rework time is longer	Cu dissolution can reduce knee thickness below specification.	Select rework alloy and optimize process to reduce copper dissolution

Since 2005 many tens of millions of lead-free products have been produced and field results show the reliability to be as good (and in many cases better) than the leaded products they replaced. However, one issue did escape this qualification process. Over time it was discovered by Dell [8] and others [9, 10, 14] that the immersion silver surface finish selected for lead-free PCBs had the susceptibility to creep corrode when used in high sulfur and high humidity environments. An IPC investigation is currently underway to develop test methods to better predict sulfur based corrosive environments, while silver manufacturers are actively working to improve their ImAg surface finishes. However, until such time that ImAg is proven to not creep corrode, Dell will not employ this surface finish for critical

It is also helpful to understand any constraints that may exist. Some constraints at Dell's EMs include the fact that nitrogen reflow was not widely available and no-clean solder flux was required. Without a nitrogen blanket one can expect heavier oxidation of the surfaces to be soldered. In addition, the no-clean fluxes are not as active as the water soluble fluxes, therefore reducing the oxides is more difficult. Another constraint is to ensure that all IPC 610D solder joint inspection criteria are met (some papers have been written that suggest that hole fill requirements could be reduced while still maintaining sufficient reliability [11] but there is insufficient data at this time to support such a change in specifications). A further constraint is that components with ball pitch as low as 0.8 mm and peripheral

Have High Cu Dissolution Rates of Sac305/405 Alloys Forced A Change in the Lead-Free Alloy Used During Pth Processes?

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[Note yellow highlighting for format reference]

ABSTRACT

To date, the majority of the Electronics Manufacturing industry has implemented either SAC305 or 405 alloys to manufacture Pb-free (E.U. RoHS, compliant) products, for both the SMT and PTH card assembly processes. This original alloy composition choice, dating back to 1999, was based on early research into the metallurgy and reliability of the alloy/s and agreement amongst top companies involved in iNEMI, JEITA and within the European Union. A recent shift towards SAC305 has recently been observed within the industry due to its lower cost when compared to SAC405, based on lower silver content. Historically, reliability assessment efforts have focused on SMT solder joint connections as PTH solder joint connections were not typically a reliability concern due to their construction. Conceptually, it is easier from a process and supply chain point of view to use a single Pb-free alloy for both the SMT and PTH attach process. However, issues relating to high rates of copper (Cu) dissolution occurring during the PTH rework process using either SAC305 or 405 alloys may force a change in this concept.

The high Cu dissolution rates experienced when using SAC305/405 may dictate a change in the Pb-free alloy used during the PTH rework process, in order for typical methods of rework (i.e. solder fountain) to continue to be used. However, making a change in the Pb-free alloy used for only the PTH rework process itself creates new questions which would need to be answered. For instance, what is the impact of reworking a SAC305/405 assembled connector using an alternate Pb-free alloy? Is changing the Pb-free alloy used within the primary attach process to match the PTH rework alloy the right solution? This leads to further questions relating to process controls and reliability of a final “mixed” Pb-free joint as well as the “pure” alternative Pb-free alloy selected which would need to be addressed.

This paper discusses the work performed studying and comparing the Cu dissolution rates of various Pb-free alloys available on the market today. Although the use of a PCB with a nickel plated layer can reduce the occurrence of Cu dissolution, all experiments in this study were performed on

an OSP finished board. Finishes such as OSP which do not have a nickel later represent the worst case scenario with respect to Cu dissolution. An OEM server product was used as the test vehicle throughout this study. A total of six Pb-free alloys and a eutectic tin/lead (Sn-Pb) control alloy were included in the evaluation. Specifically, two binary eutectic and four ternary “near eutectic” Pb-free alloys were included. Each of the “alternative Pb-free alloys” studied include varying levels of certain elemental additives. Common additives included in some of these alloys are, nickel (Ni), germanium (Ge), bismuth (Bi) and antimony (Sb). This paper also includes a brief metallurgical analysis into the effects of adding each of these above additives. In addition, both time zero analysis and ATC (0-100°C) thermal reliability analysis of the Sn-Cu + Ni solder vs. SAC405 will also be discussed. Finally, the manufacturing impact when altering the Pb-free PTH alloy will be briefly discussed, including process control, contamination, cost and supply chain considerations.

There is enough data to indicate that several alternative Pb-free alloys available on the market today are suitable replacements to SAC305/405 for PTH solder fountain rework, allowing up to a 2X rework process. In addition, the cost of these alloys warrants further study into also replacing the wave solder alloy as a cost reduction to SAC305/405.

Key words: Cu dissolution, Pb-free, process window, PTH rework, PTH primary attach

INTRODUCTION

There is no doubt that any EMS company who has made the transition over to Pb-free assembly, and has attempted to rework PTH connectors using conventional equipment with either SAC305 or 405 alloys would have experienced some degree of Cu dissolution. Depending on the size and complexity of the connector and PCB itself, the extent of dissolution would have ranged from either a slight loss of the barrel knee and annular ring edges to a complete loss of the pad surface, barrel knee and portions of the barrel wall on numerous barrel locations of the reworked connector.

This occurrence of Cu dissolution during PTH rework is not a new phenomenon. In some cases, high degrees of Cu dissolution occurred under Sn-Pb conditions when reworking larger, more thermally massive PCBs which required longer contact times (i.e. server type product). In some instances, a “low-melt” alloy was incorporated into the Sn-Pb process in order to allow the longer contact times required for 2X rework^{1,2}. This however, was only required on an extremely small percentage of card types. The majority of PTH reworks were capable of using the one alloy type (i.e. eutectic 63Sn-37Pb). However, now with having to use Pb-free alloys such as SAC305 or 405 this issue relates to the majority of product types – regardless of size and complexity. The main reasons for this increase in Cu dissolution using SAC305/405 are due to the increased operating temperatures, along with the change in the alloy composition itself. Primarily, it is the increase in tin content (%Sn) which causes higher rates of Cu dissolution. Aside from incorporating other techniques to attempt to reduce the degree of Cu dissolution, such as methods of reducing contact time using barrel cleaning techniques as well as methods of reducing flow rates, it is clear that a change in Pb-free alloy is the main solution required in order to establish a safe PTH rework process window, which the industry has been accustomed to when using Sn-Pb alloy.

There are a handful of alternative Pb-free alloys available on the market today, which are variations of Sn-Ag-Cu or Sn-Cu based alloys which have varying degrees of elemental additives such as nickel (Ni), germanium (Ge), bismuth (Bi), antimony (Sb) + others. These additives add certain properties which help in controlling the grain structure which acts to reduce the degree of Cu dissolution as well as offer other soldering benefits. The specific alloys included in this study, along with their respective melting ranges are listed in Table 1. The impact of these additives from a metallurgical point of view will be briefly discussed.

Table 1. Alloy Composition and Melting Range

ALLOYS		MELTING RANGE
63Sn-37Pb	(Sn-Pb)	183°C
95.5Sn-3.8Ag-0.7Cu	(SAC405)	217° to 220°C
96.5Sn-3.0Ag-0.5Cu	(SAC305)	217° to 224°C
99.1Sn-0.7Cu-0.05Ni-(≤0.01)Ge ¹	(Sn-Cu + Ni)	227°C
98.6Sn-0.3Ag-0.7Cu-Bi-X-Y ²	(Sn-Ag-Cu + Bi)	217° to 228°C
96.0Sn-2.5Ag-0.8Cu-0.5Sb	(Sn-Ag-Cu + Sb)	217° to 219°C
99.1Sn-0.7Cu-X-Y	(Sn-Cu + X)	227°C

1. U.S. Patent # 6180055

2. Patent # PCT/GB2005/004609

BACKGROUND

To date, previous studies on the phenomenon of Cu dissolution have resulted in several key outcomes. Firstly, the industry will likely be forced to move away from using SAC305/405 alloys during PTH processes^{3,4}. The main reason for this is based on the high Cu dissolution rates of these alloys, having a direct impact during the PTH rework process. This is a concern, especially for high reliability, long life products which may require multiple reworks during their lifetime. It has been shown that both SAC305

and 405 alloys have Cu dissolution rates which are 2X higher when compared to a Sn-Cu + Ni doped alloy and a conventional Sn-Pb eutectic alloy. The calculated Cu dissolution rates are directly correlated to the allowable PTH rework process window. It can be seen that significant improvements to the allowable process window are made when using an alternative Pb-free alloy which offers lower rates of Cu dissolution as shown in Figure 1.

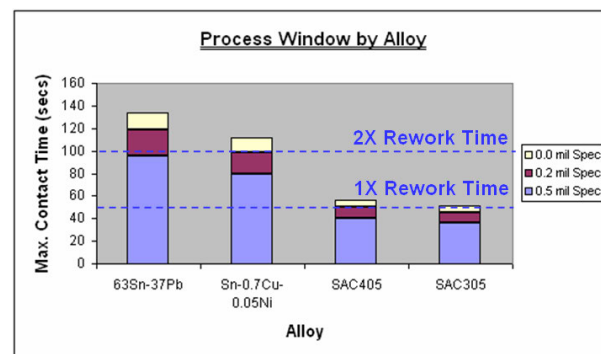


Figure 1. PTH Process Window by Alloy

The second conclusion was that Cu dissolution rates will vary from barrel-to-barrel across a connector and will even vary within a single barrel based on geometry (Figure 2 a,b). Specifically, the knee of the PTH barrel will dissolve at a faster rate as compared to the annular ring and/or barrel wall⁵. This is explained by atomic diffusion theory correlating the effects of surface geometry on the rate of atomic diffusion, as well as proximity to the solder flow. The main reason for the variance across a connector has been linked to flow rate. Typical flow-well design utilizes a single central opening through which solder can flow. This design point often results in higher dissolution rates within center barrels of a connector rework location. Center pins are often subjected to turbulent solder flow, while edge pins are subjected to laminar flow. Modifications in flow-well design have proven effective in reducing solder turbulence, resulting in reduced Cu dissolution rates during solder fountain rework⁶.

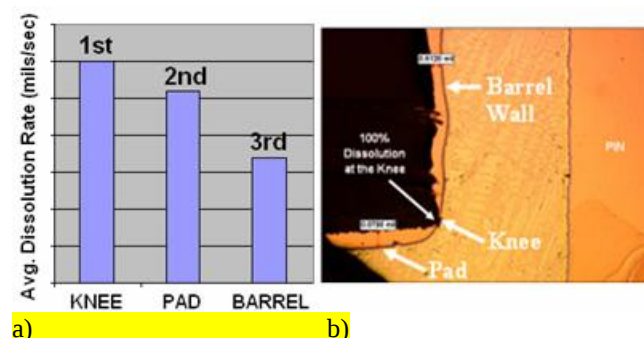


Figure 2. a) Cu dissolution rates by barrel geometry ; b) X-section showing 100% Cu dissolution at the knee location.

METALLURGICAL THEORY

All of the “alternative Pb-free alloys” included in this study are primarily Sn-Ag-Cu or Sn-Cu based alloys with some controlled levels of additives. It is the addition of these

additives which help to control the final grain structure thus improving final joint appearance, wetting, and flow characteristics. Resultant effects include improved barrel fill and reduced Cu dissolution. The type, wt% and combination of the base elements and additives all have an impact on controlling the above properties. This section will provide a summary on the impact of each of the common additives, specifically on effecting Cu dissolution from a metallurgical point of view.

Kinetics of Cu Dissolution

Before being able to discuss the impact of each of the additives on Cu dissolution, the basic mechanisms behind how Cu dissolution occurs need to be explained.

The Cu dissolution process itself can be considered as occurring by the following mechanisms⁷:

- (1) Departure of atoms of the solid surface and
- (2) Diffusion into the solder melt.

Diffusion controlled processes result in a uniform attack while interface controlled reactions may be recognized by preferential etching of grain boundaries. In this study smooth copper/intermetallic interface without any signs of grain boundary attack was detected. The mechanisms themselves occur in series and the slowest one determines the overall kinetics of the process. The most general dissolution rate equation is shown below⁸:

$$C = C_s(1 - \exp(-K(A/V)t))$$

Where C is the solute concentration at time t , K is the solution rate constant and V is the volume of liquid. This equation can be applied for diffusion controlled or interface controlled processes. The solution rate constant K is D/δ for the case of diffusion control, where D is the diffusion coefficient in liquid and δ is the thickness of the effective concentration boundary layer. In general, the boundary layer thickness is less than 0.1mm. This boundary layer is a layer of liquid existing immediately adjacent to the solid copper (Cu) interface/intermetallic layer (Figure 3). The Cu concentration gradient exists within this layer. During the diffusion controlled process the liquid boundary layer which is formed during the solder fountain rework is an important feature of Cu dissolution.

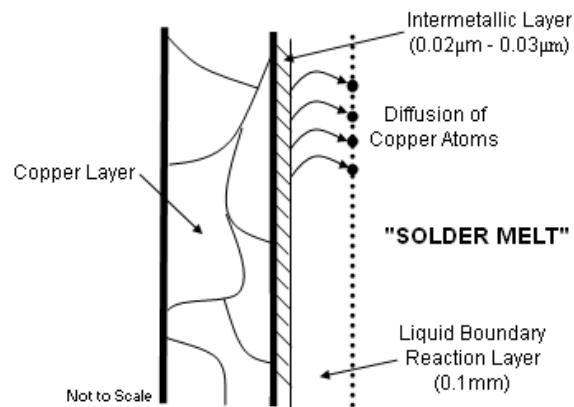


Figure 3. Departure and Diffusion of Cu Atoms into Solder Melt (Kinetics of Cu Dissolution)

The thickness of this liquid diffusion boundary layer is a function of the physical properties, the velocity of the solution and the diffusion coefficient. The dissolution rate increases with increasing peripheral velocity, which is relevant to the fountain rework situation. Other influences in reducing Cu dissolution would be based on the type of additive present in the bulk solder. The exact influence of each will be discussed below.

Sn-Pb and Sn-Ag-Cu and Sn-Cu Based Alloys

It has been found that it is the Sn component of most solders that reacts with the copper substrate⁹. In the case of Sn-Pb solders, only the Sn components react, since Cu is nearly insoluble in liquid Pb at soldering temperatures and forms no intermetallic compounds with it. Therefore, the Sn-rich solders dissolve more Cu than eutectic Sn-Pb solder.

With increasing copper concentration in the solder the rate of dissolution decreases because of the concentration gradient reduction. Thus, solders with 0.7% Cu remove less copper from the plating layer than solders with 0.5% Cu. Therefore, based on this, the Cu dissolution rates of the SAC305 alloy (0.5%Cu) should be greater than that of the SAC405 alloy (0.7%Cu). This will be further illustrated in the results section.

Effect of Additives

An effect of a reactive third and fourth component within a binary and ternary based alloy respectively is not properly understood yet and cannot be predicted without experimentation under different conditions. Below is brief summary of the expected reaction of common additives specifically with respect to controlling Cu dissolution.

1. Some components such as Sb and Bi may dilute the Sn-rich solder and reduce Cu dissolution in molten solder. Typically these elements improve solder grain structure, strength and/or ductility. However they are prone to defects such as fillet lifting and contamination issues.

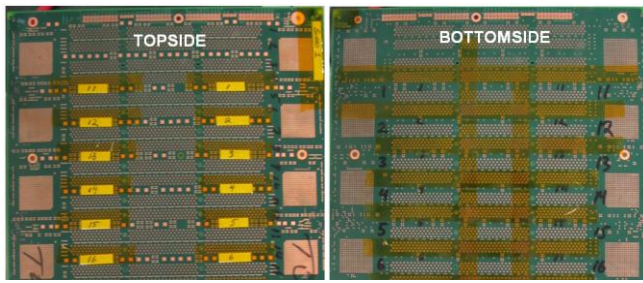


Figure 5. Sample Preparation

Each DOE sample was cross-sectioned along the entire length of the sample at a middle row and Cu thickness measurements taken. Cu thickness measurements were focused solely at the knee location (Figure 6). In absence of a current IPC industry specification for remaining Cu plating thickness after rework, an OEM specification of 0.5 mils of remaining Cu plating was used¹⁴.

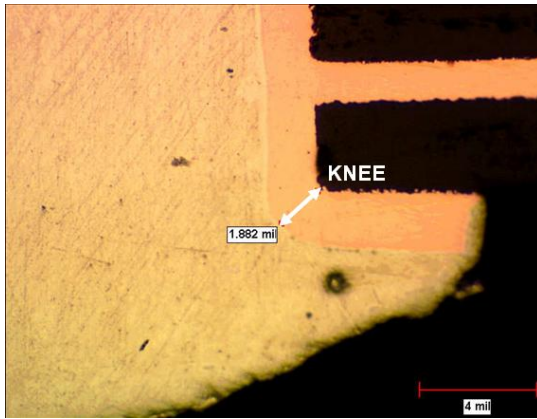


Figure 6. Cu Thickness Measurement Locations

EXPERIMENTAL RESULTS

The statistical results indicate that both contact time as well as alloy type have a significant impact on the rate of Cu dissolution (Table 4).

Table 4. ANOVA Statistical Results Showing Significance of Contact Time and Alloy

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Contact Time (secs)	1	1.70428	1.61816	1.61816	28.10	0.000
Alloy Coded	6	6.08388	5.98639	0.99773	17.33	0.000
Contact Time (secs)*Alloy Coded	6	0.56246	0.56246	0.09374	1.63	0.164
Error	41	2.36102	2.36102	0.05759		
Total	54	10.71163				

The interaction plot (Figure 7), illustrates the Cu dissolution results of each alloy at both 30 and 50 second exposure times. The values on the y-axis are the measured remaining Cu thickness of the knee plating after a 30 and 50 second exposure to molten solder (x-axis). The alternative Pb-free alloys have been coded (Alloy A, B, C and D) with the results of SAC305, 405 as well as the Sn-Pb control cell identified in the chart.

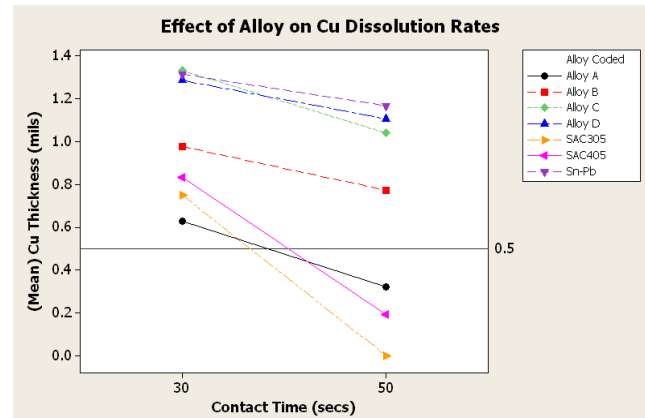


Figure 7. Interaction Plot Results – Effect of Alloy on Cu Dissolution Rates

The results show that two of the alternative Pb-free alloys performed the best with respect to the rate of Cu dissolution occurring. Specifically, Alloy C and D results are comparable to those of the Sn-Pb control cell. In addition, Alloy B's result also showed a statistically significant difference from the performance of SAC305/405 alloys and although showing poorer results, it had no statistical difference compared to Alloys C, D and the Sn-Pb cell. Although it had a similar slope to the other alternative Pb-free alloys, Alloy A showed a slightly higher occurrence of Cu dissolution at the exposure times of 30 and 50 seconds. Alloy A has a statistically similar rate of dissolution compared to the SAC305/405 alloys. It can be seen from Figure 7 that Alloy A's results drops below the specification limit of 0.5 mils of remaining Cu plating at approximately 40 seconds, which is a concern.

As the Pb-free PTH process window is strongly dependant on total cumulative exposure to solder, the final Cu dissolution rates calculated can be correlated to a maximum expected allowable process window for each alloy studied. Figure 8 illustrates each alloy's process window using three different specification limits of remaining Cu plating thickness for comparison sake. Also illustrated on the graph is the total time required to 1X (50 seconds) and 2X (100 seconds) rework the DIMM connector assembled on the same test vehicle. Based on this, it can be seen that both Alloy C and D are capable of performing up to a 2X rework using any of the three specification limits listed. Alloy B is capable of performing a 1X rework using any of the three specification limits, however falls short of being able to complete a 2X rework. Finally, Alloy A along with SAC305 and 405 are capable of performing a 1X rework, however, only when using a specification limit of 0.2mils of remaining Cu or less. All three are incapable of completing a 2X PTH rework.

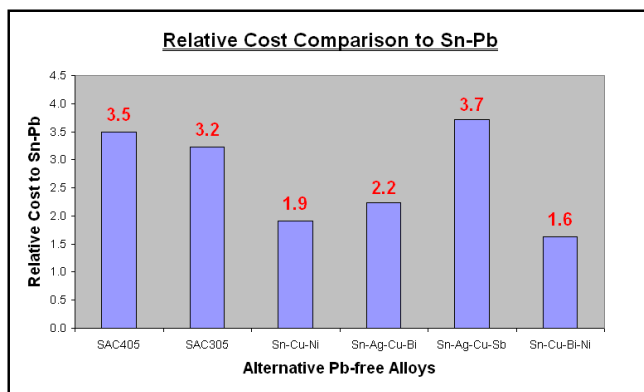


Figure 16. Relative Cost of Alloy Compared to Sn-Pb

CONCLUSIONS

The high Cu dissolution rates of SAC305/405 alloys are indeed the main driving factor in the requirement to change the Pb-free alloy used within the solder fountain rework process. This change could also potentially drive a change in the alloy used within the wave solder attach process in order to simplify the manufacturing process and reduce the degree of pot contamination during PTH rework. However, the push to replace SAC305/405 alloy with an alternative Pb-free alloy within the wave soldering process could easily be justified from a financial perspective in addition to technical justifications. Some of the alternative Pb-free alloys offer a 50% reduction in cost compared to SAC305/405 alloys, which can be quite significant if this saving is shared amongst multiple wave soldering machines.

This study indicated that there are three "alternative Pb-free alloys" (B, C and D) which could be used as potential replacements for the SAC305/405 alloy based on their Cu dissolution rate results. Each of the three alloys showed statistically similar dissolution rates to that of the Sn-Pb alloy. There are however, other considerations aside from Cu dissolution rates which need to be considered before selecting an appropriate alternative alloy. These include, the final joint quality produced as well as the reliability. In addition, supply chain considerations, logistics and costs are important factors in selecting a replacement Pb-free alloy.

FUTURE WORK

Future work will include performing forced PTH reworks (1X and 2X) and reliability studies including ATC and mechanical testing to further understand the impact of Cu dissolution on PCB reliability. This will include both pure and mixed Pb-free conditions using the top three alternative Pb-free alloys from this study. There is a large amount of data available on solder joint reliability using SAC305/405 alloy, but further testing will be required if an alternative Pb-free alloy is chosen for PTH processes, especially primary attach. Provide recommendations to include specific IPC specifications relating to remaining Cu plating due to Cu dissolution post PTH rework. In addition, steps required to implement an alternative Pb-free alloy into the

manufacturing process will be taken such as performing initial validation by applying the development findings to controlled volume manufacturing conditions.

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