IPC ENGINEERING WEBINAR SERIES

Technical Paper Writing: Industry Best Practices for Conference Manuscripts

- Stanton Rak, PhD; September 28th 2023
- Principal, S.F. Rak Company
- Co-chair of the Technical Program Committee for the *"Electronic Circuits World Convention 16,"* Hosted by IPC at APEX EXPO 2024
- Member of the IPC Thought Leaders Program

Preface

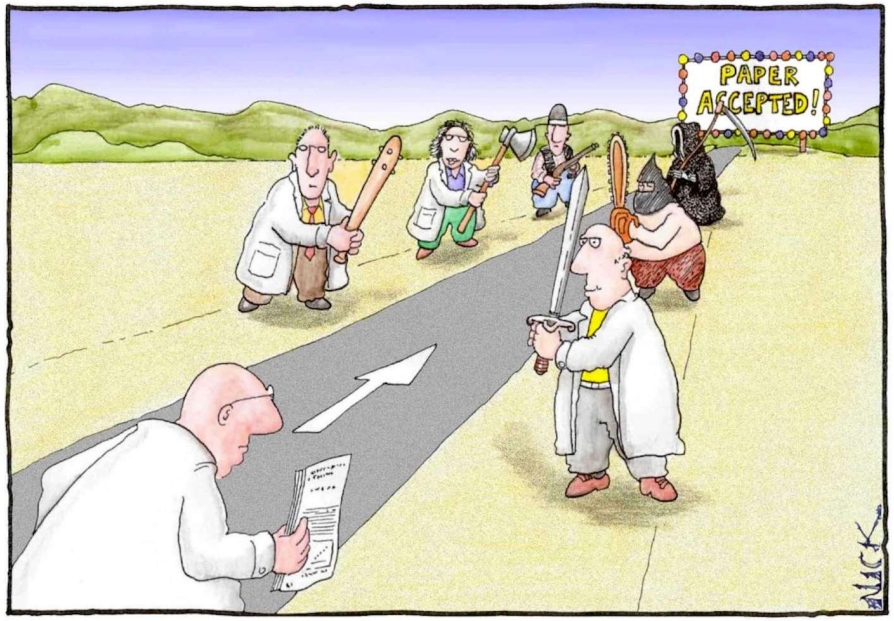
- This webinar will provide an overview of best practices for,
  - Writing a high-quality manuscript suitable for conference presentation and publication
  - Maximizing one's conference experience and effectiveness
  - Strengthening one's technical writing skills having special attention on the electronics industry

- The IPC APEX EXPO Technical Conference will be used as a model for this webinar, including references to the style guideline created for ECWC16 / IPC APEX EXPO 2024, April 9 - 11, 2024

- ****Please note: IPC APEX 2025 is March 18-20, 2025

Outline

- Why and Where to Publish
- Advanced Considerations
- Awareness of the Conference Format and Requirements
- Creating a Manuscript
- Avoiding Common Pitfalls
- Summary Review
- Q & A



Most scientists regarded the new streamlined peer-review process as "quite an improvement."

Why Publish a Technical Paper?

- **Technical marketing**
  - Promote innovation or a solution to an industry need
  - Build awareness, expand one's professional network
- **Strengthens the supply chain**
  - Documented solutions are often adopted by others across the industry
  - Widespread acceptance often leads to reduced costs
- **Improves communication of key results**
  - Peer-reviewed publications can add to information & data credibility
  - Information can be easily referenced & cited in future work

Where to Publish?

- **Refereed Journal Publications**
  - Published by a professional society
  - Specific subject matter
  - Novel content
  - Scientific literature references
  - Technical review process
  - Strict paper formatting rules
- **Industry Trade Journals**
  - Commercial publications
  - Original content not required
  - Product/process photos common
  - Editorial assistance but no formal peer review process
- **Industry Conference Proceedings**

Industry Conference Proceedings

- Associated with participation as a presenter at a technical conference
- Technical content selected by technical committees via abstract submissions; program tracks created
- Submission requires technical paper and presentation
- Original content is usually a requirement
- Technical review process likely
- Travel approval required
- Audience of industry peers, potential clients / collaborators

High-Quality Technical Papers Help to Shape Industry Standards!

Paper + **Presentation** → **Standard, IPC J-STD-004C Requirements for Solder Fluxes**

A Review of Halogen/Halide-Free Test Methods and Classifications for Soldering Materials in the Electronics Industry

Jasbir Bath[1], Gordon Clark[2], Tim Jensen[3], Renee Michalkiewicz[4], Brian Toleno[5]
[1]Christopher Associates Inc./ Koki Solder, Santa Ana, CA; [2]Koki Solder, Scotland; [3]Indium Corporation, Utica, NY; [4]Trace Laboratories Inc., Hunt Valley, MD; [5]Henkel Technologies, Irvine, CA

Abstract
Over the last few years, there has been an increase in the evaluation and use of halogen-free soldering materials. In addition, there has been increased scrutiny into the level of halogens and refinement of the definition and testing of halogen-free soldering materials. The challenge has been that there has been no common standard across the industry in terms of halogen-free definitions and the corresponding test methods to determine these. This has created confusion in the industry as to what end users want and what soldering materials suppliers can actually provide. This paper will review the status of both halogen-free and halide-free in terms of definitions, test methods and the limitations and accuracy of test methods used to determine if a soldering material is halogen/halide-free or not. For halogen-free and halide-free definitions, the paper will review the different industry standards which are currently available and those being drafted, and it will discuss any similarities and differences. It will also cover the origins of some of the definitions mentioned in the standards. The paper will include a review of the accuracy and limitations of several test methods and preparation techniques for halogen and halide determination.

Introduction
In the electronics industry, there is a significant push toward halogen-free products. This movement is due to legislation from various countries, and public outcry from well publicized negative third world recycling practices, as well as non-government organizations (NGOs) testing and publishing information on electronic devices regarding their content of various potentially hazardous materials. Halogen-free products are also being mandated by certain OEMs as a means to lessen potential chemical effects on the environment.

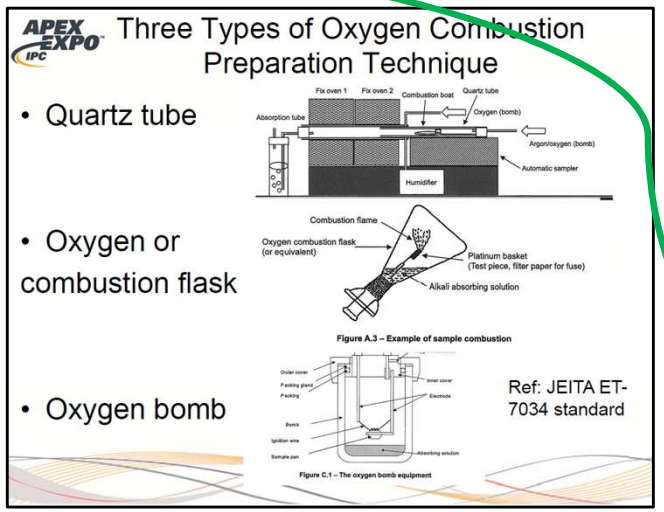
In electronics assemblies, halogens can be found in the plastics for cables and housings, board laminate materials, components, and soldering fluxes and pastes. In solder pastes and fluxes, the halogenated compounds are used as activators that remove oxides to promote solder wetting. Eliminating the halogenated compounds can have a significant negative effect on the board assembly process. Process assembly challenges are not the only issues electronics assemblers face as they become halogen-free. The use of proper test methodologies to determine that the soldering products are actually halogen-free is currently not well defined as there are a variety of test methods and standards in the industry.

Halide content has been measured either qualitatively or quantitatively with halide testing being specified for more than fifty years with standards such as the United States Federal Specification QQ-S-571 standard [1] followed by MIL-F-14256 [2] and IPC-SF-818[3] standards and currently in standards such as IPC J-STD-004[4]. The specifications have listed requirements for the halide content of flux-containing soldering materials.

The terms halogen and halide have caused confusion in the electronics industry with definitions to try and clear up the confusion provided by standards such as JEITA ET-7304[5] and IPC-J-STD-004[4]. The term halogen refers to all halogen family elements and halogen compounds including those which are present in nature. The JEITA ET-7304 standard [5] specifically targets the halogen families of chlorine (Cl), bromine (Br) and Fluorine (F) used as the activators for soldering materials. The term halide is defined as the halide ion or halide salt compound having an ionic character (e.g. Cl^-, Br^-, F^-).

Covalently bonded halogens do not disassociate in water, and therefore the chloride, bromide and fluoride are still attached (covalently bound) to other species (typically organic), and will not be detected by techniques such as ion chromatography or titration. Ionically bonded halogens do disassociate in water into the negatively charged halide ion (Cl^-, Br^- F^-, etc.) and the positively charged species (H^+, Na^+ etc.). Test methods used to look for ionic species, such as ion chromatography, will only detect halides.

A better understanding of the test methods, what they are capable of detecting in terms of halides and halogens, and how they relate to the various halogen-free definitions and standards is required. A variety of these test methods and standards will be discussed in the following sections as well as some test preparation techniques.



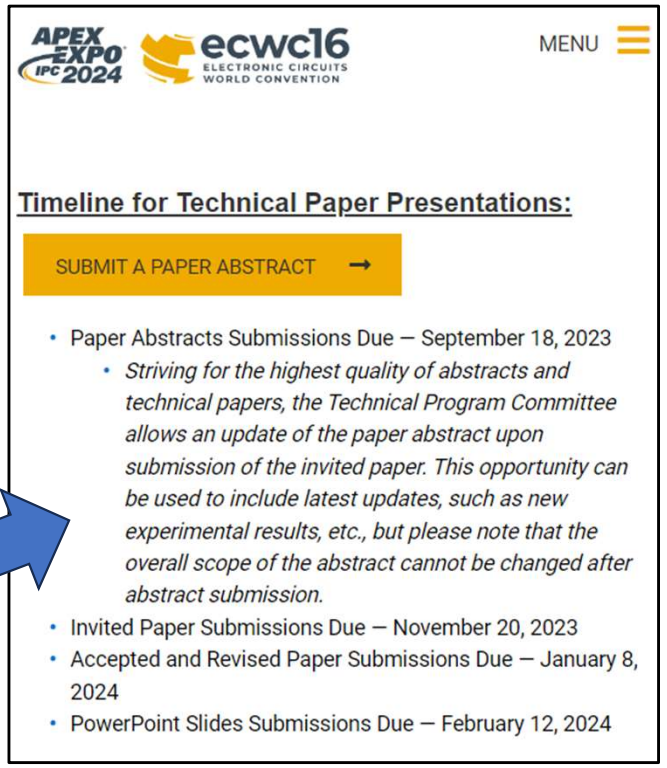
B-10 Halide versus Halogen Content IPC-TM-650, Method 2.3.28.1, is intended for the detection of ionic halides. Ionic halide content is not to be confused with halogen content. Halogen content should be tested per EN 14582 or AABUS. An Oxygen Bomb is utilized to dissociate the covalently bound halide and this product is dissolved and analyzed via ion chromatography. For additional information see *A Review of Test Methods* and *Classifications for Halogen-Free Soldering Materials* by Jasbir Bath, Gordon Clark, Tim Jensen, Renee Michalkiewicz and Brian Toleno published in the 2011 IPC APEX conference proceedings.

Advanced Considerations: Prior to Submitting to a Conference

- Topic alignment with conference scope
- Management support
- Travel approval / cost estimate
- Abstract, paper, and presentation submission timeline
- External publication approval process at one's Company
- Confidentiality and IP protection

Building Awareness, Conference Format & Requirements

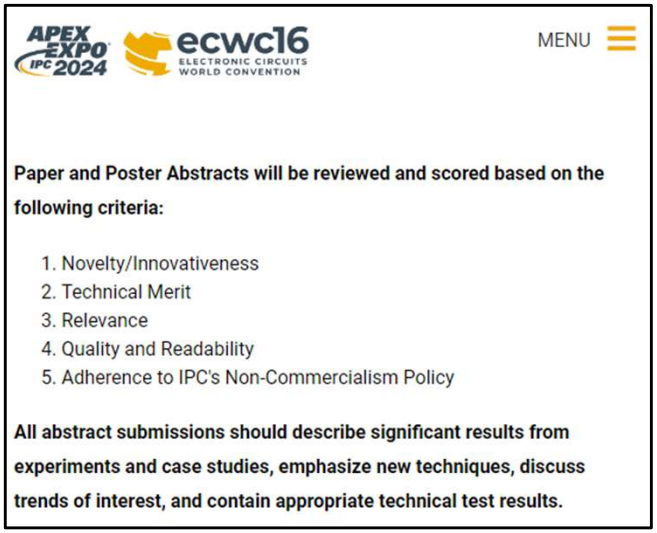
1. Know the primary Conference contact and how to reach them
   Julia Flynn JuliaFlynn@ipc.org, IPC's Professional Development and Events Manager
2. Novel content required
   – Can be extension of previous work
   – Please ask Conference contact about any concerns
3. Note the abstract, paper, and presentation submission due dates



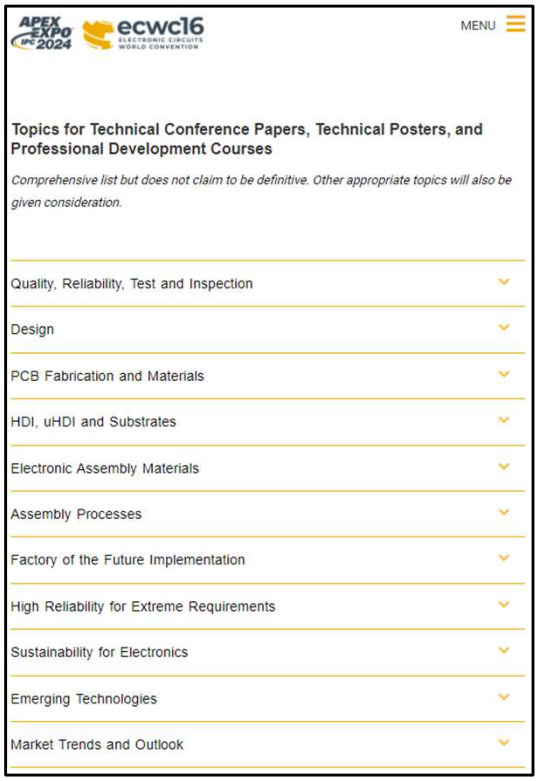
Building Awareness, Conference Format & Requirements Cont.'

4. Be aware of any paper peer review process & acceptance criteria
   - Used by Technical Program Committee for abstract acceptance and Best-of-Conference determination
5. Be prepared to classify your topic into a subject category
   - Helps with review & target audience

Review Criteria



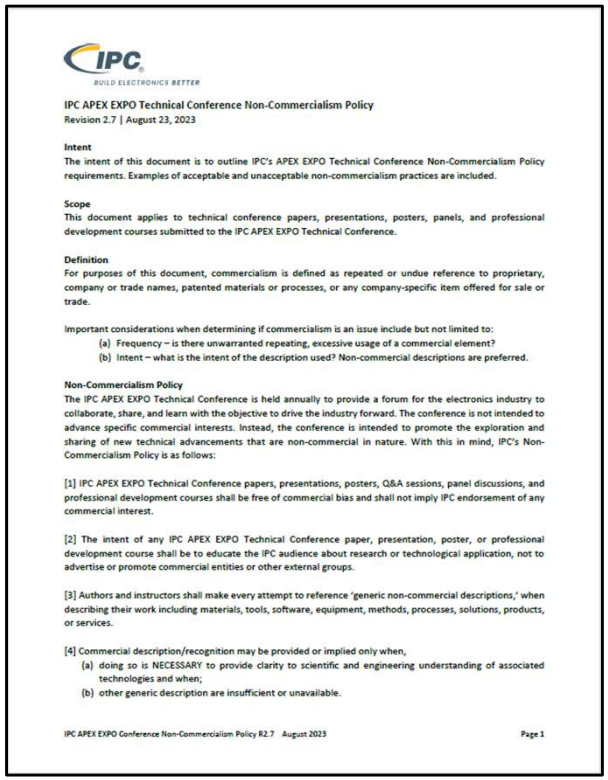
Subject Categories



Building Awareness, Conference Format & Requirements Cont.'

6. Read and respect any required non-commercialism policies
   - See link in CfP
   - Examples provided within!
7. Review any paper and presentation guidelines
   - Author & speaker Guidebook made available upon abstract acceptance
   - Paper & presentation templates provided

IPC APEX EXPO Technical Conference Non-Commercialism Policy



IPC
BUILD ELECTRONICS BETTER

IPC APEX EXPO Technical Conference Non-Commercialism Policy
Revision 2.7 | August 23, 2023

Intent
The intent of this document is to outline IPC's APEX EXPO Technical Conference Non-Commercialism Policy requirements. Examples of acceptable and unacceptable non-commercialism practices are included.

Scope
This document applies to technical conference papers, presentations, posters, panels, and professional development courses submitted to the IPC APEX EXPO Technical Conference.

Definition
For purposes of this document, commercialism is defined as repeated or undue reference to proprietary, company or trade names, patented materials or processes, or any company-specific item offered for sale or trade.

Important considerations when determining if commercialism is an issue include but not limited to:
(a) Frequency – is there unwarranted repeating, excessive usage of a commercial element?
(b) Intent – what is the intent of the description used? Non-commercial descriptions are preferred.

Non-Commercialism Policy
The IPC APEX EXPO Technical Conference is held annually to provide a forum for the electronics industry to collaborate, share, and learn with the objective to drive the industry forward. The conference is not intended to advance specific commercial interests. Instead, the conference is intended to promote the exploration and sharing of new technical advancements that are non-commercial in nature. With this in mind, IPC's Non-Commercialism Policy is as follows:

[1] IPC APEX EXPO Technical Conference papers, presentations, posters, Q&A sessions, panel discussions, and professional development courses shall be free of commercial bias and shall not imply IPC endorsement of any commercial interest.

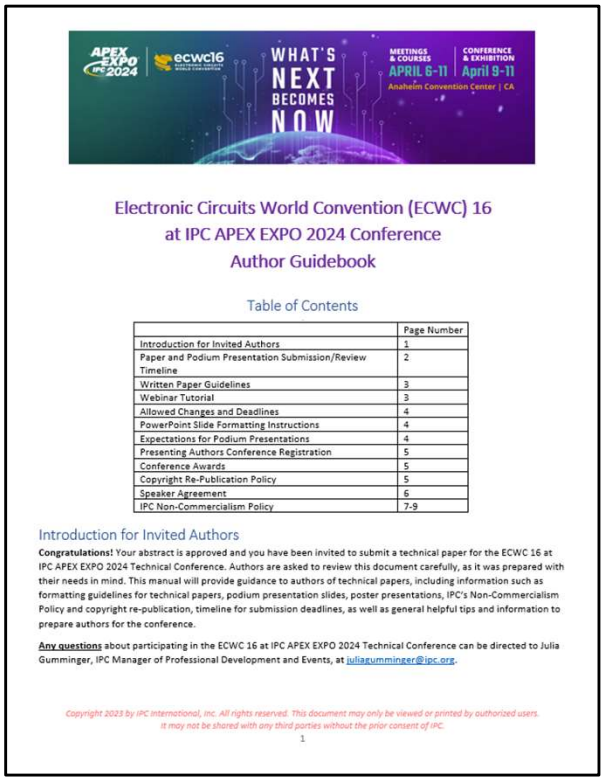
[2] The intent of any IPC APEX EXPO Technical Conference paper, presentation, poster, or professional development course shall be to educate the IPC audience about research or technological application, not to advertise or promote commercial entities or other external groups.

[3] Authors and instructors shall make every attempt to reference 'generic non-commercial descriptions,' when describing their work including materials, tools, software, equipment, methods, processes, solutions, products, or services.

[4] Commercial description/recognition may be provided or implied only when,
(a) doing so is NECESSARY to provide clarity to scientific and engineering understanding of associated technologies and when;
(b) other generic description are insufficient or unavailable.

IPC APEX EXPO Conference Non-Commercialism Policy R2.7 August 2023 Page 1

IPC APEX EXPO Technical Conference Author & Speaker Guidebook



Electronic Circuits World Convention (ECWC) 16
at IPC APEX EXPO 2024 Conference
Author Guidebook

Table of Contents

Introduction for Invited Authors

Congratulations! Your abstract is approved and you have been invited to submit a technical paper for the ECWC 16 at IPC APEX EXPO 2024 Technical Conference. Authors are asked to review this document carefully, as it was prepared with their needs in mind. This manual will provide guidance to authors of technical papers, including information such as formatting guidelines for technical papers, podium presentation slides, poster presentations, IPC's Non-Commercialism Policy and copyright re-publication, timeline for submission deadlines, as well as general helpful tips and information to prepare authors for the conference.

Any questions about participating in the ECWC 16 at IPC APEX EXPO 2024 Technical Conference can be directed to Julia Gumminger, IPC Manager of Professional Development and Events, at juliagumminger@ipc.org.

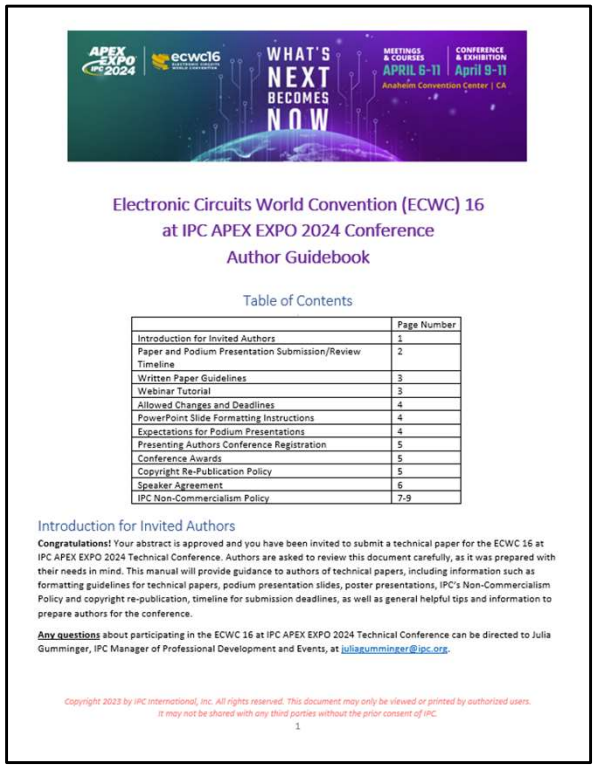
1

Building Awareness, Conference Format & Requirements Cont.'

8. Be mindful of presentation time and paper length requirements
   - In-person presentations only!
   - Presentations, 25 min. maximum plus 5 min. for Q&A; 30 min. hard stop
   - Technical papers, 6 pages minimum
9. Ask any questions about the facilities and what to expect
   - E.g., audio / visual capabilities; file control
10. Become familiar with the Conference software submission tools
    - Oxford Abstracts used for IPC APEX
11. Understand the Conference registration requirements and if any discounts apply
    - E.g., Speakers receive complementary, day-of passes and significant discounts on conference packages
    - For international travelers, invitation letters are possible during online registration process or in advance, juliaflynn@ipc.org

Creating your Manuscript

- Abstract
  - What to include and avoid
- Paper requirements
  - Word template; follow the flow
  - Section explanations
  - Format highlights
- Author Guidebook
  - Contains comprehensive information that an author should know about the manuscript process and the Conference



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The Abstract, Best Practices

- Abstracts are reviewed by a technical committee to select papers
- Abstracts are often 250 words or less describing,
  - Problem statement
  - Background or legacy work
  - Experimental design (high level)
  - Key insights gained by the new work
- Good abstracts are short and very clear on what the paper will cover
- Avoid commercialism, acronyms, and abbreviations
- Be mindful of English & grammar; avoid use of 1st person, e.g., I, me, we, our
- Incorporate feedback from the Reviewers

Temperature Behavior of FR4 Substrates when Processing during Laser Depaneling

Patrick Stockbruegger
LPKF Laser & Electronics AG
Garbsen, Lower Saxony, Germany

Stephan Schmidt
LPKF Laser & Electronics Inc.
Tualatin, Oregon, United States

Abstract
The use of modern laser systems for depaneling printed circuit boards can present many advantages as well as some challenges for the production engineer compared to conventional mechanical singulation methods. It is particularly important to properly understand the effects of the laser energy to the substrate material in order to take advantage of the technology without creating unintended side effects. The temperature response of the substrate is of central importance for many factors such as the distance of components from the cutting channel or the degree of carbonization. This paper presents an in-depth analysis of the temperature behavior of FR4 material for different laser powers and wavelengths. The temperature measurement was carried out by using Type-K thermocouples applicated in non-plated through holes. These have been positioned at distances with a regular interval to the cutting channel. Thereby the temperature was measured three times for each distance during the ablation process. The result is information on the heat input in 100 µm steps distance from the cutting contour during the laser ablation process through copper layers and PCB base material. Based on the regular measurements, a temperature behavior model can be derived from the data using statistical methods. This paper is examining if the temperatures of all systems measured are considerably below the melting points of tin/silver/copper alloy, even at the smallest intervals. In addition, the authors are investigating the possible correlation between different laser wavelengths, pulse durations, laser power and cutting strategies and its impact on temperature level measured on the substrate material.

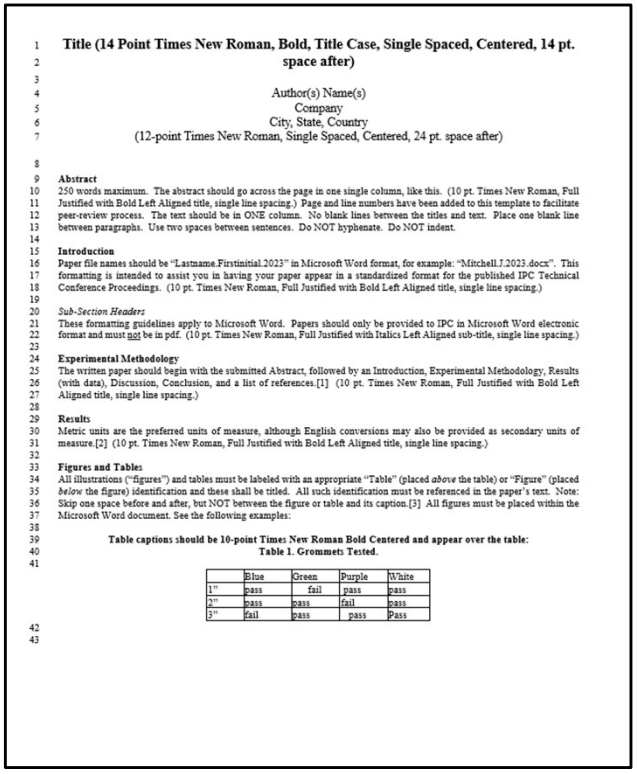
> **NextGen Best Paper**
"Temperature Behavior of FR4 Substrates When Processing During Laser Depaneling"
Patrick Stockbruegger, LPKF Laser & Electronics AG
co-author: Stephan Schmidt, LPKF Laser & Electronics Inc.

The Manuscript, Follow the Flow!

Manuscript Sections

1. Abstract
2. Introduction
3. Experimental Methodology
4. Results
5. Discussion
6. Conclusions
7. Acknowledgements
8. References

WORD Template



Title (14 Point Times New Roman, Bold, Title Case, Single Spaced, Centered, 14 pt. space after)

Author(s) Name(s)
Company
City, State, Country
(12-point Times New Roman, Single Spaced, Centered, 24 pt. space after)

Abstract
250 words maximum. The abstract should go across the page in one single column, like this. (10 pt. Times New Roman, Full Justified with Bold Left Aligned title, single line spacing.) Page and line numbers have been added to this template to facilitate peer-review process. The text should be in ONE column. No blank lines between the titles and text. Place one blank line between paragraphs. Use two spaces between sentences. Do NOT hyphenate. Do NOT indent.

Introduction
Paper file names should be "Lastname.Firstinitial.2023" in Microsoft Word format, for example: "Mitchell.J.2023.docx". This formatting is intended to assist you in having your paper appear in a standardized format for the published IPC Technical Conference Proceedings. (10 pt. Times New Roman, Full Justified with Bold Left Aligned title, single line spacing.)

Sub-Section Headers
These formatting guidelines apply to Microsoft Word. Papers should only be provided to IPC in Microsoft Word electronic format and must not be in pdf. (10 pt. Times New Roman, Full Justified with Italics Left Aligned sub-title, single line spacing.)

Experimental Methodology
The written paper should begin with the submitted Abstract, followed by an Introduction, Experimental Methodology, Results (with data), Discussion, Conclusion, and a list of references.[1] (10 pt. Times New Roman, Full Justified with Bold Left Aligned title, single line spacing.)

Results
Metric units are the preferred units of measure, although English conversions may also be provided as secondary units of measure.[2] (10 pt. Times New Roman, Full Justified with Bold Left Aligned title, single line spacing.)

Figures and Tables
All illustrations ("figures") and tables must be labeled with an appropriate "Table" (placed *above* the table) or "Figure" (placed *below* the figure) identification and these shall be titled. All such identification must be referenced in the paper's text. Note: Skip one space before and after, but NOT between the figure or table and its caption.[3] All figures must be placed within the Microsoft Word document. See the following examples:

Table captions should be 10-point Times New Roman Bold Centered and appear over the table:
Table 1. Grommets Tested.

	Blue	Green	Purple	White
1"	pass	fail	pass	pass
2"	pass	pass	fail	pass
3"	fail	pass	pass	Pass

Pre-formatted!

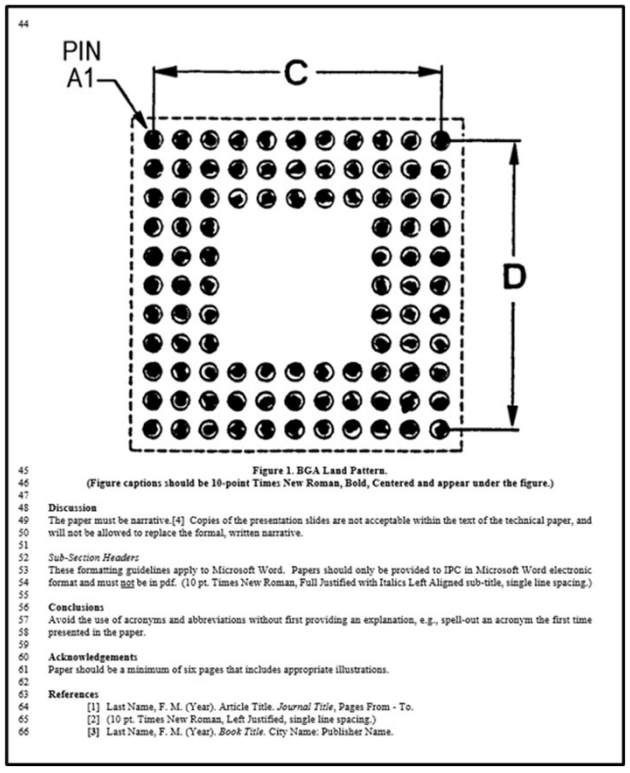


Figure 1. BGA Land Pattern.
(Figure captions should be 10-point Times New Roman, Bold, Centered and appear under the figure.)

Discussion
The paper must be narrative.[4] Copies of the presentation slides are not acceptable within the text of the technical paper, and will not be allowed to replace the formal, written narrative.

Sub-Section Headers
These formatting guidelines apply to Microsoft Word. Papers should only be provided to IPC in Microsoft Word electronic format and must not be in pdf. (10 pt. Times New Roman, Full Justified with Italics Left Aligned sub-title, single line spacing.)

Conclusions
Avoid the use of acronyms and abbreviations without first providing an explanation, e.g., spell-out an acronym the first time presented in the paper.

Acknowledgements
Paper should be a minimum of six pages that includes appropriate illustrations.

References
[1] Last Name, F. M. (Year). Article Title. *Journal Title*, Pages From - To.
[2] (10 pt. Times New Roman, Left Justified, single line spacing.)
[3] Last Name, F. M. (Year). *Book Title*. City Name: Publisher Name.

The Manuscript, Follow the Flow, Cont.'

Manuscript Sections

1. Abstract (reviewed)
2. Introduction, elaborate on,
   a. Reasons for work
   b. Relevant background
      – Include references
      – Include figures
   c. Benefits of new work
   d. Scope of work / paper
3. Experimental Methodology, describe, e.g.,
   a. Design / Process parameters
   b. Equipment / Software
   c. Test method / DOE
   d. Materials

3. Experimental – Equipment & design parameters

Development of a Custom Build Plate for Printing on PCBs

A custom build plate was machined from aluminum-2024 having a milled recess or cavity for positioning and retaining the SIR Test PCB, see Figure 9. The aluminum metal also acts to transfer heat to the PCB surface to aid in filament wetting and improving adhesion to the PCB substrate. A thermal interface material may also be placed between the milled recess and the PCB to assist in heat transfer to the PCB substrate, if desired. The aluminum build plate could be directly inserted into the commercial 3D printer. Aluminum-2024 is thermally stable and not prone to warpage. The aluminum plate was compatible with the active leveling program of the 3D printer, even after 10 cycles. Figure 10 shows the SIR Test PCB positioned in the recess of the build plate. The 1.6 mm thick PCB's surface is flush with the surface of the aluminum build plate. The 3D-printer's "g-code" (described below in *Equipment and Materials Used*) was modified with the assistance of the equipment supplier to allow the build plated to remain heated between prints and to bypass the leveling routine. Heating of the aluminum build plate to 120ºC required 20 min. plus an additional 5 min. to perform the leveling routine. It was possible to bypass heating and leveling in-between prints and reduce downtime when printing on multiple PCBs.

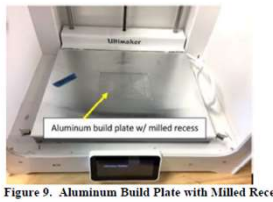


Figure 9. Aluminum Build Plate with Milled Recess

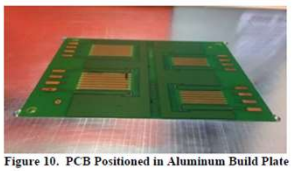


Figure 10. PCB Positioned in Aluminum Build Plate

A similar design approach to reduce thermal stress was applied to generate the retention walls capable of retaining a liquid encapsulant. In the 3D model shown in Figure 1, the retaining walls surround the perimeter of the SIR comb test pattern so that liquid encapsulant can easily fill the enclosed area. The dimensions (in mm; see Figures 13 & 14) represent a typical area and height that a liquid encapsulant may be required to provide protection for a component or circuit. The wall thickness selected for this case study was 4 mm with the tapering angle 56° from the horizontal. The corners were rounded with a radius of 2 mm to reduce stress on the retaining walls, prevent warping, and improve adhesion of the printed structure to the PCB.

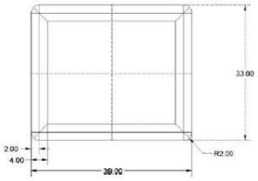


Figure 13. Top View of Retaining Wall Dimensions

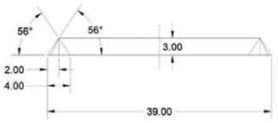


Figure 14. Side View of Retaining Wall Dimensions

3. Experimental – Materials, software, & process settings

Equipment and Materials Used

The FFF 3D printer used for this investigation was a professional desktop Ultimaker S5 open-source printer which is compatible with 3rd-party plastic filaments. Please note that this work is not a specific endorsement of any one, 3D-printer manufacturer. The methodologies described within this paper are generic and adaptable to various 3D-printing equipment. The filaments and their corresponding printing temperature parameters are listed in Table 1. Each material was dried at its respective baking temperature for 4 hr. before printing. Three different filaments types were selected based on different needs including acceptance in the automotive manufacturing environment, ESD (electrostatic discharge) capability, and temperature stability. The x,y,z-resolution of the 3D printer is specified at 6.9, 6.9, and 2.5 µm respectively. Layer resolution for the 0.8 mm nozzle is 20 - 600 µm.

Table 1. Filament Information

Filament Details			Printing Temperature		Baking Temperature (°C)
Type	Manufacturer	Product	Nozzle Temp (°C)	Bed Temp (°C)	
PLA	Ultimaker	Tough PLA	220	60	55
ABS	3DXTECH	ESD ABS	240	110	80
PCTG	Ultimaker	CPE+	260	110	80

The open-sourced software "Cura" was used to adjust print settings and to slice models. The slicing software slices the object "STL" file (drawing file) to contain the information needed to create a 3D print.[17] The slicing software automatically converts an STL file to g-code. G-code is a widely used computer numerical control programming language in industry and is the language that the printer uses to physically print the 3D object. The g-code language was modified with the assistance of the printer manufacturer for certain functional aspects described in this work. Table 2 lists two sets of parameters which were used for the prints. The main difference is the diameter size of the nozzle, which directly influences the amount of extruded material. Although there are many settings to consider, the listed settings focus on the condition of the initial layer. The initial layer is critical to establish adhesion or "anchoring" and will be highlighted in the Results section below.

Table 1. Printer Settings

	Printer Settings	
Nozzle Type	CC 0.6 mm	AA 0.8 mm
Layer Height	0.25 mm	0.4 mm
Line Width	0.525	0.7
Initial Line Width Multiplier	120%	120%
Infill	50%	50%
Initial Layer Speed	10 mm/s	10 mm/s
Layer Speed	30 mm/s	30 mm/s
Z – Offset	-0.1 mm	-0.1 mm
Print Time	~6 min	~4 min (< 2 min optimized)

The Manuscript, Follow the Flow, Cont.'

Manuscript Sections

4. Results
   a. Show findings / progression
   b. List / graph data
   c. Use Figures, Tables
   d. Display work outcome
5. Discussion
   a. Describe how the methodological approach, i.e., design / process parameters, equipment / software, test method / DOE, and / or material each impacted the results & findings
   b. Summarize the data and findings; explain how the data support the work outcome
   c. Describe the effectiveness and benefits of the new approach

4. Results – Show findings, Figures

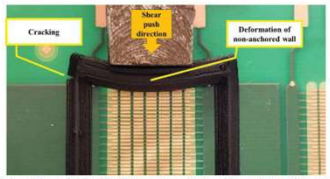


Figure 24. Deformation and Cracking of ABS Wall Structure during Shear due to Superior Mechanical Anchoring of Filled 0.8 mm Grooves. Specimen Printed using 0.8 mm Diameter Extrusion Nozzle.

Inspection of the removed retaining wall structure shown in Figure 25 revealed that the PCB grooves had filled completely when using the 0.8 mm diameter extrusion nozzle along with the same z-offset and print speed as used for the 0.6 mm nozzle. Thus, matching the nozzle diameter with the PCB groove width is an important design-for-print parameter for creating robust PCB composite structures. The variance observed in the shear data for the 0.6 mm diameter nozzle was no longer observed with the 0.8 mm nozzle, thus confirming that the complete filling of the grooves with plastic is important to establish consistent anchoring strength. The 0.8 mm width PCB groove / 0.8 mm diameter extrusion nozzle, along with the process parameters listed in Table 2, and the wall design features described in Figures 13 and 14, yielded a 3D-printed, ABS retaining wall / PCB composite structure that could be securely handled for additional processing and testing.

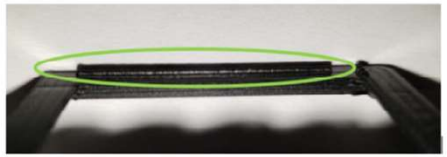


Figure 25. Removed Wall Structure showing Full ABS Filling of 0.8 mm PCB Grooves using 0.8 mm Diameter Extrusion Nozzle and Parameters in Table 2

4. Results – List data, Tables

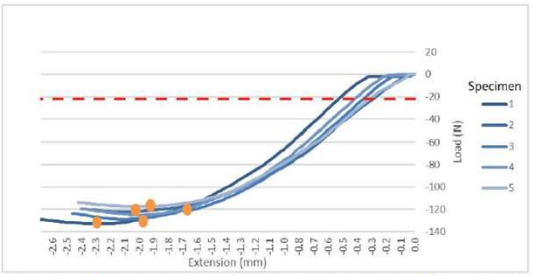


Figure 32. Shear Force of PCTG Wall Structure with PCB Grooves; 0.8 mm Dia. Nozzle; Exposure to 100°C for 1 hr.

The shear force adhesion data reported above are summarized and compared in Table 3. It is important to note that printing into the milled, thin grooves of the PCB substrate provided excellent anchoring of the 3D retaining wall structure for the three types of plastic filaments evaluated -- ABS, PLA, and PCTG. The plastic materials themselves cracked or deformed before the retaining wall structure detached from the PCB. The printed retaining wall / PCB composite structures could be handled normally during dispense and cure operations with no separation of the retaining wall structures from the PCBs.

Table 3: Summary of Retaining Wall Structure Shear Test Results Based on Different Factors. "Green" Color is Considered Acceptable, "Yellow" is Questionable, "Red" is Unsatisfactory.

(FFF) Plastic Filament type	PCB Preparation Method / 3D-Print Extruder Nozzle	Average Maximum Shear Force (N)
ABS	No surface preparation (reference) / CC 0.6 mm nozzle	< 22 (separated with contact)
ABS	ABS + Acetone deposited film / CC 0.6 mm nozzle	49 (separation in shear)
ABS	PCB Grooves / CC 0.6 mm nozzle	111 (separation in shear)
ABS	PCB Grooves / AA 0.8 mm nozzle	> 142 (cracked in shear)
PLA	PCB Grooves / AA 0.8 mm nozzle	> 165 (deformed in shear)
PCTG	PCB Grooves / AA 0.8 mm nozzle	> 116 (deformed in shear)
PCTG	PCB Grooves / AA 0.8 mm nozzle; Thermal aged, 1 hr. @ 100°C, after 3D printing	> 125 (deformed in shear)

The Manuscript, Follow the Flow, Cont.'

Manuscript Sections

6. Conclusions
   a. Briefly summarize the key elements & findings of the work. Data should support Conclusions.
   b. Concisely reiterate what is "new" and how a problem has been solved or a new avenue created
7. Acknowledgements
   a. Recognize individuals for direct contributions to the work described
8. References
   a. A common challenge!
      I. [#] in text after period
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Conclusions
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Paper should be a minimum of six pages that includes appropriate illustrations.

References

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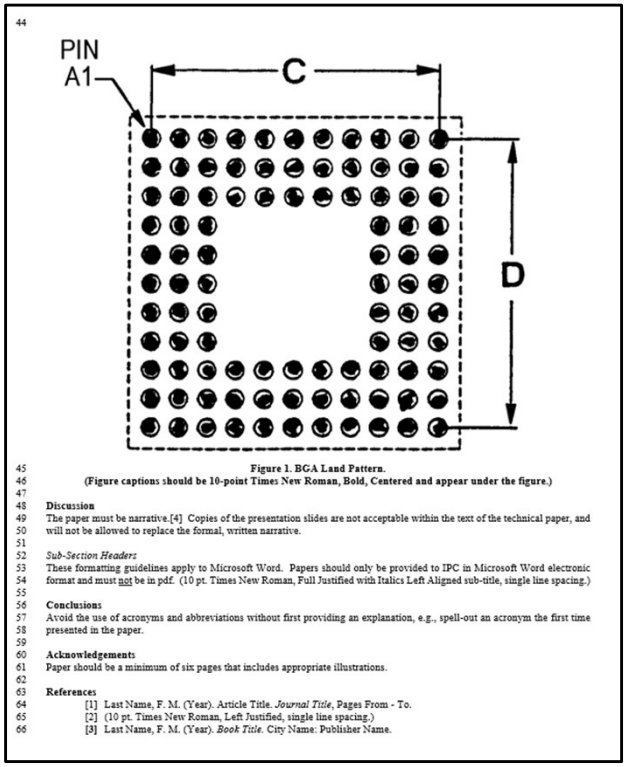

Figure 1. BGA Land Pattern.
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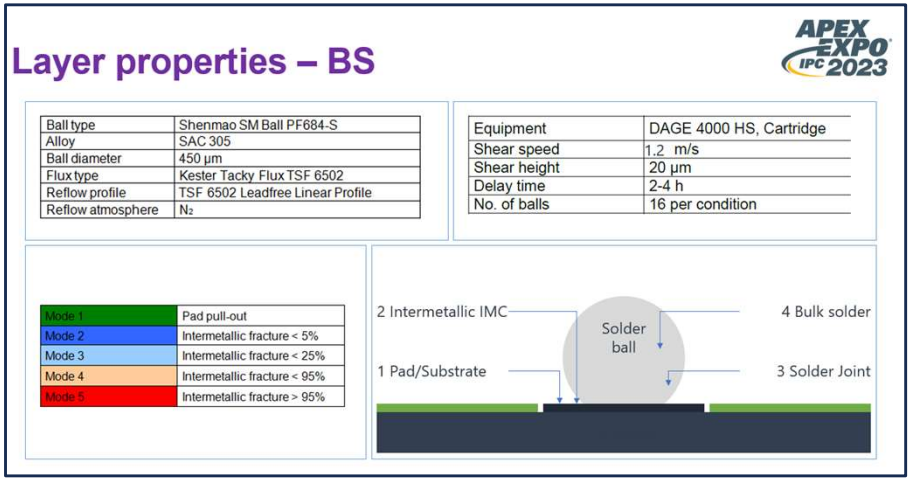

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  - Manuscript sections, “Abstract → References;” Format highlights
- Pitfalls to avoid,
  - Commercialism and time extensions

Acknowledgements

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- IPC APEX EXPO Technical Program Committee

Thank you! / Q & A?

Stanton Rak, PhD
Principal, S.F. Rak Company
stanton@sfrak.com

Co-chair, IPC APEX EXPO 2024 / ECWC16 Technical Program Committee