IPC-6902

2021 - February

Qualification and Performance Specification for Printed Electronics on Flexible Substrates

An international standard developed by IPC

BUILD ELECTRONICS **BETTER**

The Principles of Standardization

In May 1995 the IPC's Technical Activities Executive Committee (TAEC) adopted Principles of Standardization as a guiding principle of IPC's standardization efforts.

Standards Should:

- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

Standards Should Not:

- Inhibit innovation
- Increase time-to-market
- Keep people out
- Increase cycle time
- Tell you how to make something
- Contain anything that cannot be defended with data

Notice

IPC Standards and Publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such Standards and Publications shall not in any respect preclude any member or nonmember of IPC from manufacturing or selling products not conforming to such Standards and Publication, nor shall the existence of such Standards and Publications preclude their voluntary use by those other than IPC members, whether the standard is to be used either domestically or internationally.

Recommended Standards and Publications are adopted by IPC without regard to whether their adoption may involve patents on articles, materials, or processes. By such action, IPC does not assume any liability to any patent owner, nor do they assume any obligation whatever to parties adopting the Recommended Standard or Publication. Users are also wholly responsible for protecting themselves against all claims of liabilities for patent infringement.

IPC Position Statement on Specification Revision Change

It is the position of IPC's Technical Activities Executive Committee that the use and implementation of IPC publications is voluntary and is part of a relationship entered into by customer and supplier. When an IPC publication is updated and a new revision is published, it is the opinion of the TAEC that the use of the new revision as part of an existing relationship is not automatic unless required by the contract. The TAEC recommends the use of the latest revision. Adopted October 6, 1998

Why is there a charge for this document?

Your purchase of this document contributes to the ongoing development of new and updated industry standards and publications. Standards allow manufacturers, customers, and suppliers to understand one another better. Standards allow manufacturers greater efficiencies when they can set up their processes to meet industry standards, allowing them to offer their customers lower costs.

IPC spends hundreds of thousands of dollars annually to support IPC's volunteers in the standards and publications development process. There are many rounds of drafts sent out for review and the committees spend hundreds of hours in review and development. IPC's staff attends and participates in committee activities, typesets and circulates document drafts, and follows all necessary procedures to qualify for ANSI approval.

IPC's membership dues have been kept low to allow as many companies as possible to participate. Therefore, the standards and publications revenue is necessary to complement dues revenue. The price schedule offers a 50% discount to IPC members. If your company buys IPC standards and publications, why not take advantage of this and the many other benefits of IPC membership as well? For more information on membership in IPC, please visit www.ipc.org or call 847/597-2809.

Thank you for your continued support.

IPC-6902

Qualification and Performance Specification for Printed Electronics on Flexible Substrates

Developed by the Printed Electronics Final Assembly Subcommittee (D-64) of the Printed Electronics Committee (D-60) of IPC

Users of this publication are encouraged to participate in the development of future revisions.

Contact:

IPC
3000 Lakeside Drive, Suite 105N
Bannockburn, Illinois
60015-1249
Tel 847 615.7100
Fax 847 615.7105

This Page Intentionally Left Blank

Acknowledgment

Any document involving a complex technology draws material from a vast number of sources across many continents. While the principal members of the Printed Electronics Final Assembly Subcommittee (D-64) of the Printed Electronics Committee (D-60) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of IPC extend their gratitude.

Printed Electronics Committee

Chair
Neil Bolding
MacDermid Alpha Electronics Solutions

Vice Chair
Jeff Shubrooks
Raytheon

Printed Electronics Final Assembly Subcommittee

Co-Chairs
Michael Jawitz
Raytheon

Jeff Shubrooks
Raytheon

Technical Liaison of the IPC Board of Directors

Bob Neves
Microtek (Changzhou) Laboratories

Printed Electronics Final Assembly Subcommittee

Evan Albertson, TTM Technologies, Inc.

Zainab Ali, Honda Research & Development, Inc.

Leonard Allison, Engineered Materials Systems, Inc.

Sai Avuthu, Jabil Circuit, Inc.

Andy Behr, Panasonic Industrial Devices Sales Company of America (PIDSA)

Neil Bolding, MacDermid Alpha Automotive

Alan Burk, ALMAX

Maarten Cauwe, imec-CMST

Stephen Chavez, UTC Aerospace Systems

Zhiman Chen, ZHUZHOU CRRC TIMES ELECTRIC CO., LTD.

Christopher Clark, L3Harris

Ross Dillman, ACI Technologies, Inc.

Jeffrey Fitzgerald, BAE Systems

Francois-Xavier Fortier, Ecole de Technologie Superieure

Mahendra Gandhi, Northrop Grumman Space Systems

Mary Herndon, Raytheon Company

Robert Hopkins, Yuasa System CO., LTD.

Constantin Hudon, Varitron Technologies Inc.

Werner Huegel, Robert Bosch GmbH

Bruce Hughes, Nvidia Corporation

Michael Jawitz, Raytheon Company

Suriyakan Kleitz, Schlumberger Well Services

Rebekah Kovarik, Lockheed Martin

Zhe (Jacky) Liu, ZTE Corporation

Tony Ma, Adlink Technology Inc.

Mike Mastropietro, ACI Materials

Mauricio Mendez, Plexus Manufacturing Solutions - Guadalajara

Michael Miller, NSWC Crane

Michael Pomfret, Washington Clean Energy Testbeds

Mike Ramsay, Lubrizol

Erika Rebrosova, SunChemical

Outi Rusanen, Tactotek

Haridoss Sarma, GO 2 Scout 4 R&T

Michael Schleicher, Semikron Elektronik GmbH Co. KG

Paul Shaw, In2Tec

Wu-Sheng Shih, Brewer Science, Inc.

Jeff Shubrooks, Raytheon Company

Timm Smith, Voormi

Xing Tong, SAIC

Steve Vetter, NSWC Crane

Martin Wickham, National Physical Laboratory

Koko Wright, SIGMADESIGN, Inc.

Special Recognition

IPC recognizes the following group of people who showed exceptional leadership and effort in the development of IPC-6902. Their efforts accelerated the process of publishing this much needed standard.

Andy Behr, Panasonic Industrial Devices Sales Company of America (PIDSA)

Alan Burk, ALMAX

Mary Herndon, Raytheon Company

Michael Jawitz, Raytheon Company

Mike Mastropietro, AC Materials

Jeff Shubrooks, Raytheon Company

This Page Intentionally Left Blank

Table of Contents

1 SCOPE 1
1.1 Purpose 1
1.2 Classification 1
1.3 Measurement Units 1
1.4 Definition of Requirements 1
1.5 Process Control Requirements 1
1.6 Order of Precedence 2
1.6.1 Conflict 2
1.6.2 Clause References 2
1.6.3 Appendices 2
1.7 Use of "Lead" 2
1.8 Abbreviations and Acronyms 2
1.9 Terms and Definitions 2
1.9.1 Crease 2
1.9.2 Via 2
1.9.3 Foreign Object Debris (FOD) 2
1.10 Printed Electronics Types 2
1.11 Standard Printed Electronic Design 3
1.12 Selection for Procurement 3
1.12.1 Production Master and Database 3
1.12.2 Deviations and Waivers 4
1.12.3 Selection (Default) 4

2 APPLICABLE DOCUMENTS 4
2.1 IPC 4
2.2 ASTM International 5
2.3 JEDEC 5

3 REQUIREMENTS 6
3.1 General 6
3.2 Materials 6
3.2.1 Flexible Base Materials 6
3.2.2 External Bonding Materials 6
3.2.3 Printed Dielectric Materials 6
3.2.4 Printed Conductive Materials 6
3.2.5 Printed Passive Materials 6
3.2.6 Marking Inks 6
3.2.7 Final Finishes, Coatings and Platings (Metallic and Nonmetallic) 6
3.3 Visual Examination 6
3.3.1 Visual Imperfections 7
3.3.2 Registration 8
3.3.3 Dielectric Wetting 8
3.3.4 Adhesion 8
3.3.5 Marking 8
3.3.6 Defects in Printed Materials 9
3.3.7 Workmanship 9
3.4 Dimensional Requirements 9
3.4.1 Pattern Feature Accuracy 10
3.4.2 Bow and Twist (Rigid Areas) 10
3.4.3 Flex (Nonrigid Areas) 10
3.5 Printed Materials Mechanical Requirements 10
3.6 Nonprinted Solderable Surfaces 10
3.7 Structural Integrity 10
3.7.1 Requirements for Coupons or Flexible Printed Electronic Devices after Thermal Stressing 10
3.8 Electrical Requirements 11
3.8.1 Dielectric Withstanding Voltage 11
3.8.2 Electrical Continuity and Isolation Resistance 12
3.8.3 Moisture and Insulation Resistance (MIR) 12
3.9 Special Requirements 13
3.9.1 Outgassing 13
3.9.2 Fungus Resistance 13
3.9.3 Vibration 13
3.9.4 Mechanical Shock 13
3.9.5 Impedance Testing 13
3.9.6 Coefficient of Thermal Expansion (CTE) 13
3.9.7 Thermal Shock 13
3.9.8 Surface Insulation Resistance (As Received) 13
3.9.9 Ultraviolet (UV) Resistance 13
3.9.10 Material Removal or Replacement 14
3.9.11 Simulation for Component Assembly and Rework 14
3.9.12 Flexibility Endurance 14
3.9.13 Adhesion 14
3.9.14 Destructive Physical Analysis (DPA) 14
3.9.15 Solderability 14
3.9.16 Abrasion Resistance 14
3.9.17 Accelerated Aging 14
3.9.18 Silver Migration 14
3.9.19 Current Carrying Capacity 14
3.9.20 Repair 14
3.9.21 Rework 14

4 QUALITY ASSURANCE PROVISIONS 14
4.1 Responsibility for Inspection 14
4.1.1 Test Equipment and Inspection Facilities 14

4.1.2 Contract Services 15
4.2 Materials Inspection 15
4.3 Quality Conformance Inspection 15
4.3.1 Inspection of Product for Delivery 15
4.3.2 Quality Conformance 15
4.4 Reliability Test and Evaluation 18
4.4.1 Noncompliance 18
4.5 Qualification 18
4.5.1 Sample Test Coupons 18
4.6 Acceptance Testing and Frequency 18
4.6.1 C=0 Zero Acceptance Number Sampling Plan 19
4.6.2 Additional Test Coupons for Suspected Isolated Defects 19

5 NOTES 19
5.1 Ordering Data 19

APPENDIX A Index of Acronyms and Abbreviations 20

Figures

Figure 1-1 Example of Printed Electronic Using Every Standard Printed Electronic Design (SPED) Type in One Device 3
Figure 3-1 Surface Mount Land Defects 7
Figure 3-2 Foreign Object Debris (FOD) 8
Figure 3-3 Conductor Overlap 8
Figure 3-4 Variation in Conductor Height and Width 9
Figure 3-5 Voids in Printed Dielectric Between Printed Conductors 9
Figure 3-6 Conductive Hole Fill Class 2 and 3 11
Figure 3-7 Conductive Hole Fill Class 1 11
Figure 3-8 Resistive Continuity Test Illustrations (Network Resistance) 12

Tables

Table 1-1 Default Requirements 4
Table 3-1 Dielectric Withstanding Test Voltages 12
Table 3-2 Insulation Resistance 12
Table 3-3 Surface Insulation Resistance 13
Table 4-1 Qualification Testing and Acceptance Testing Frequency 15
Table 4-2 C=0 Sampling Plan Per Lot Size 19

Qualification and Performance Specification for Printed Electronics on Flexible Substrates

1 SCOPE

This standard establishes and defines the qualification and performance requirements for printed electronics and their forms of component mounting and interconnecting structures on flexible substrates. Flexible substrates, as pertain to this standard, are materials or devices which have some amount of flexibility or bendability but are not considered to be stretchable (e.g., fabrics, textiles, stretchable polymers, etc.). The substrate can be conductive, semiconductive or nonconductive.

1.1 Purpose The purpose of this specification is to provide requirements for qualification and performance of flexible printed electronics designed to IPC-2292.

1.2 Classification IPC standards recognize that electrical and electronic assemblies are subject to classifications by intended end-item use. Three general end-product classes have been established to reflect differences in manufacturability, complexity, functional performance requirements, and verification (inspection/test) frequency. It should be recognized that there may be overlaps of equipment between classes.

CLASS 1 General Electronic Products

Includes products suitable for applications where the major requirement is function of the completed assembly.

CLASS 2 Dedicated Service Electronic Products

Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end-use environment would not cause failures.

CLASS 3 High Performance/Harsh Environment Electronic Products

Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support or other critical systems.

1.3 Measurement Units All dimensions and tolerances in this specification are expressed in hard SI (metric) units. Users of this specification are expected to use metric dimensions. All dimensions ≥ 1 mm will be expressed in millimeters. All dimensions < 1 mm will be expressed in micrometers.

1.4 Definition of Requirements The words **shall** or **shall not** are used in the text of this document wherever there is a requirement for materials, preparation, process control or acceptance.

The word ‘‘should’’ reflects recommendations and is used to reflect general industry practices and procedures for guidance only.

Line drawings and illustrations are depicted herein to assist in the interpretation of the written requirements of this Standard. The text takes precedence over the figures.

1.5 Process Control Requirements The primary goal of process control is to continually reduce variation in the processes, products, or services to provide products or processes meeting or exceeding User requirements. Process control tools such as IPC-9191, JEDEC JESD 557 or other User-approved system may be used as guidelines for implementing process control.

Manufacturers of Class 3 products **shall** develop and implement a documented process control system.

A documented process control system, if established, **shall** define process control and corrective action limits.

This may or may not be a statistical process control system. The use of ‘‘statistical process control’’ (SPC) is optional and should be based on factors such as design stability, lot size, production quantities, and the needs of the Manufacturer.