

IPC/JPCA-2291

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Design Guideline for Printed Electronics

A standard developed by IPC

Association Connecting Electronics Industries



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- 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

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

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Design Guideline for Printed Electronics

Developed by the Printed Electronics Design Subcommittee (D-61) 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 309S
Bannockburn, Illinois
60015-1249
Tel 847 615.7100
Fax 847 615.7105



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Acknowledgment

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Printed Electronics Committee

Chair
Daniel Gamota
Jabil Circuit, Inc.

Printed Electronics Design Subcommittee

Co-Chairs
Daniel Gamota
Jabil Circuit, Inc.

Jie Zhang
Institute of Materials
Research & Engineering (IMRE)

JPCA Printed Electronics Committee

Chair
Dr. Prof. Katsuaki Suganuma
Osaka University, Institute of
Scientific and Industrial Research

Technical Liaison of the IPC Board of Directors

Bob Neves
Microtek (Changzhou) Laboratories

Printed Electronics Design Subcommittee

John Andresakis, Oak-Mitsui, Inc.
Neil Bolding, MacDermid Autotype Inc
Robert Boudreau, Corning Incorporated
Luis Chau, MFLEX
Christine Coapman, C2 Consulting
Daniel Gamota, Jabil Circuit, Inc. (HQ)
Mahendra Gandhi, Northrop Grumman Aerospace Systems
Josh Goldberg, Taiyo America Inc.
Tom Hartmann, Topflight Corporation
Happy Holden, Gentex Corporation
Hirofumi Matsumoto, Nippon Mektron Ltd.

Stephen Meeks, St. Jude Medical
Roger Miedico, Raytheon Company
Richard Morris, Saxby Business Development LLC
Steve Nolan, Lockheed Martin Mission Systems & Training
Debbie Orf, NPES
Gary Schreffler, Lockheed Martin Missile & Fire Control
Dongkai Shangguan, National Center for Advanced Packaging, China
Masato Shishido, JPCA-Japan Electronics Packaging and Circuits Association
Jeffrey Shubrooks, Raytheon Company

David Sommervold, The Bergquist Company, Prescott
Katsuaki Suganuma, Osaka University
Kunio Takahara, JPCA-Japan Electronics Packaging and Circuits Association
Diane Williams, Corning Incorporated
Yukihiro Yoshida, Mitsubishi Plastics, Inc.
Jie Zhang, Institute of Materials Research & Engineering (IMRE)



Documents

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DESIGN GUIDELINES FOR PRINTED ELECTRONICS

1 SCOPE

This guideline provides an overview of the design process flow for printed electronics based devices, modules and units, and final products.

1.1 Purpose The purpose is to present the framework of the design process flow for individuals to manufacture printed electronics based devices, modules and units, and final products.

1.2 Intent The intent of IPC/JPCA-2291 is to establish a design process flow that will facilitate and improve the practice of printed electronics design. IPC/JPCA-2291 identifies documents such as standards that can be used to assist during the design process flow. In general IPC/JPCA-2291 contains generic information that is sufficient for printed electronics design by the product designer.

The subcommittee members that developed IPC/JPCA-2291 acknowledge that individual companies may require additional information than that reported within this document. Therefore, IPC/JPCA-2291 and documents specified within it may only reflect a subset of those required by members of the supply chain.

IPC/JPCA-2291 is “generic” because it specifies only information which forms the basis for further specific declarations. It is therefore intended to be used in conjunction with other documents as needed. Also, part of the intent is to provide mechanisms for securing the integrity of the information exchanged between supply chain members.

1.3 Printed Electronics Document Hierarchy The IPC/JPCA printed electronics standards development subcommittees have established a hierarchy as presented in Figure 1-1 based on the existing initiatives. It was structured to enable the greatest flexibility for the emerging field of printed electronics. The subcommittees plan to revisit it frequently and modify it as necessary during the growth of the field and technologies transition from R&D to commercialization.

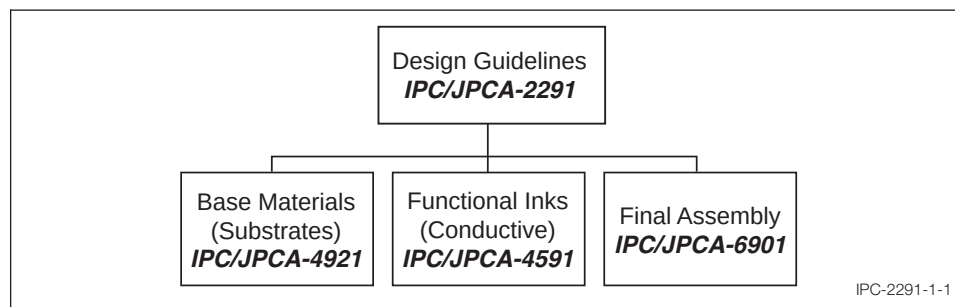


Figure 1-1 Hierarchy for IPC/JPCA Printed Electronics Documents

As the documents listed in Figure 1-1 are completed, new standards projects may be undertaken by the subcommittees. Proposed projects will be listed as shown in Figure 1-2; a project was proposed that addresses manufacturing processes and platforms. In addition to initiating new project topics, subcommittees may also be actively preparing a revision of a previously approved standard based on recent subcommittee member comments as well as general industry trends.

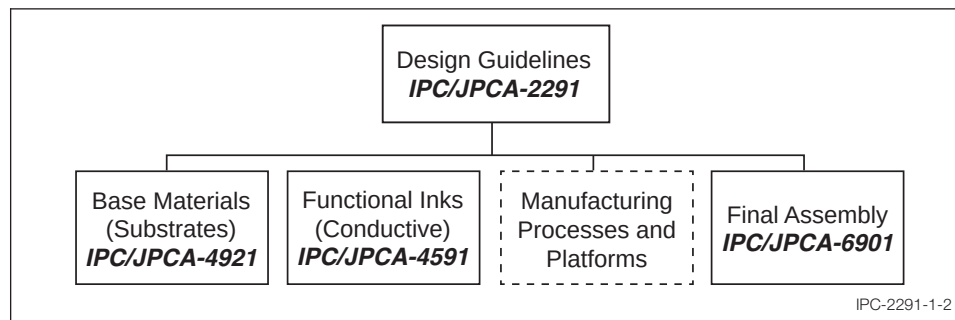


Figure 1-2 Future Hierarchy for IPC/JPCA Printed Electronics Documents

IPC/JPCA-2291 will continue to serve as the primary document which should be consulted when individuals are interested in practicing printed electronics. Review of IPC/JPCA-2291 will provide the reader with a strong appreciation for the technology and identify the supporting documentation to practice the technology in R&D as well as in volume manufacturing.

1.4 Qualification The aggregate of the discrete printed electronics elements (e.g., base materials, functional inks, processes, equipment) necessary for design and manufacture of printed electronics based products **shall** be considered qualified if they independently meet the requirements of the standard for the discrete element.

1.5 Procurement Documentation The documentation **shall** provide sufficient information to the supplier so that the supplier can fabricate the printed electronics elements. The procurement documentation should specify the requirements that can be selected from within the standard for the discrete element.

1.6 As Agreed Upon Between User and Supplier (AABUS) The term AABUS indicates additional or alternate requirements to be decided between the user and the supplier in the procurement documentation. Examples include contractual requirements, modifications to purchase documentation, and information on the drawing. Agreements can be used to define test methods, conditions, frequencies, categories or acceptance criteria within a test, if not already established.

1.7 Interpretation The emphatic form of the verb “**shall**” is used throughout this standard whenever a requirement is intended to express a provision that is mandatory. Deviation from a “**shall**” requirement may be considered if sufficient data is supplied to justify the exception.

The words “should” and “may” are used whenever it is necessary to express nonmandatory provisions. “Will” is used to express a declaration of purpose. To assist the reader, the word “**shall**” is presented in bold characters.

1.8 Presentation All dimensions and tolerances in this specification are expressed in hard SI (metric) units and parenthetical soft imperial (inch) units. Users of this specification are expected to use metric dimensions. All dimensions greater than or equal to 1.0 mm [0.0394 in] will be expressed in millimeters and inches. All dimensions less than 1.0 mm [0.0394 in] will be expressed in micrometers and microinches.

2 APPLICABLE DOCUMENTS

The following documents of the issue currently in effect form a part of this standard to the extent specified herein.

2.1 IPC¹

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC-TM-650 Test Methods Manual²

IPC/JPCA-4591 Requirements for Printed Electronics Functional Conductive Materials

IPC/JPCA-4921 Requirements for Printed Electronics Base Materials

IPC-9191 General Requirements for Implementation of Statistical Process Control

J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies Training and Certification Program

J-STD-004 Requirements for Soldering Fluxes

2.2 NCSL International³

ANSI/NCSL Z540.3-2006 Requirements for the Calibration of Measuring and Test Equipment

2.3 ISO⁴

ISO 10012 Measurement management systems—Requirements for measurement processes and measuring equipment

1. www.ipc.org

2. Current and revised IPC Test Methods are available on the IPC Web site (www.ipc.org/html/testmethods.htm)

3. www.ncsli.org

4. www.iso.org

3 TERMS AND DEFINITIONS

The definition of all terms **shall** be in accordance with IPC-T-50 and the following terms. An asterisk (*) by the term indicates that it is a reproduction from IPC-T-50 to assist the reader in interpretation of this standard.

3.1 base material* The insulating material upon which a conductive pattern may be formed.

3.2 barrier A material or a composite of materials that inhibits the passage of radiation (particles or waves) or diffusion of materials (gases, liquids, or solids).

3.3 fiducial mark A printed electronics artwork feature (or features) that provide(s) a common measurable point for processing and assembly with respect to a pre-determined pattern. Fiducials are reference marks on the printed electronics base materials for aligning the base material and the deposition hardware when using a vision system to manufacture printed electronics assemblies. A local fiducial is a reference mark used to locate the position of a specific (discrete) pattern on a printed electronics base material. A global fiducial is a reference mark used to locate the position of a group of patterns on a printed electronics base material.

3.4 functional biologically active material A biological material or material composite comprised of a biological component or components that have intrinsic material properties that enable the control of shape, structure, or biological properties. These materials can assemble into highly organized structures of interacting parts that can adaptively change in response to their biological environment. The change in structure can be interrogated using an electrical, mechanical, or optical sensing system to indicate a positive or negative response as recorded by single use medical device sensors.

3.5 functional chemically active material A material or material composite comprised of a reactive component or components that have intrinsic material properties that enable the control of shape, structure, or chemical properties. These materials can change their mechanical or chemical properties, color, or assemble into highly organized structures of interacting parts that can adaptively change in response to their chemical environment. The change in mechanical or chemical properties, or structure can be interrogated using an electrical or optical sensing system to indicate a positive or negative response as recorded by pH for water salinity sensors or % moisture for humidity sensors.

3.6 functional conductive material A material or material composite comprised of a component or components that have intrinsic material properties providing electrical conductivity to the final (post-processed) printed structure (thin or thick film). The components could be metal or metal oxide particles/fibers, metal or metal oxide precursors, allotropes of carbon, inherently conductive organic small molecules or polymers dissolved or dispersed in a vehicle, etc.

3.7 functional dielectric material A material or material composite comprised of a component or components that have intrinsic material properties providing electrical insulation to the final (post-processed) printed structure (thin or thick film). The components could be ceramic particles/fibers, ceramic precursors, allotropes of carbon, inherently dielectric organic small molecules or polymers dissolved or dispersed in a vehicle, etc.

3.8 functional material A material or material composite comprised of a component or components that have intrinsic material properties providing electrical, optical, or thermal attributes to the final (post-processed) printed structure (thin or thick film). The components could be metal or ceramic particles/fibers, metal or ceramic precursors, allotropes of carbon, organic small molecules or polymers dissolved or dispersed in a vehicle, etc.

3.9 functional optically active material A material or material composite comprised of a reactive component or components that have intrinsic material properties that enable the control of shape, structure, or optical properties. These materials can change their structural properties that result in an optical property change or can assemble into highly organized structures of interacting parts that can adaptively change in response to their optical environment. Example functional optically active materials are: organic light emitting, electrochromic, electrophoretic, liquid crystals, etc.

3.10 functional semiconductive material A material or material composite comprised of a component or components that have intrinsic material properties providing electrical semiconductivity to the final (post-processed) printed structure (thin or thick film). The components could be metal oxide particles/fibers, metal oxide or organic small molecule precursors, allotropes of carbon, inherently semiconductive organic small molecule or polymers dissolved or dispersed in a vehicle, etc.

3.11 functional thermally active material A material or material composite comprised of a reactive component or components that have intrinsic material properties that enable the control of shape, structure, or color. These materials can change their structural properties that result in a thermal property change or can assemble into highly organized structures of interacting parts that can adaptively change in response to their thermal environment. Example functional thermally active materials have the ability to modulate radiant and convective heat transfer.

3.12 hybrid structure A structure that integrates at least one printed element with at least one nonprinted element. The nonprinted element may include components such as integrated circuits (ICs), passive components such as resistors, capacitors, and inductors, or other devices. This term does not refer to high temperature printed ceramic hybrid structures which are referred to as hybrids.

3.13 in-body The term used to describe the physical placement of a device, component, or product internal to the human body.

3.14 nonfunctional material A material or material composite that displays no apparent intrinsic material properties (e.g., electrical, optical, or thermal attributes) as a final (post-processed) printed structure (thin or thick film).

3.15 nonprinted conductor An electrically conductive structure that can be fabricated by different processes other than printing, such as copper plating of additive trace formation, Ni/Au electroless plating of surface finish, copper clad subtractive, etc.

3.16 on-body Term used to describe the physical placement of a device, component, or product on the external surface of the body e.g., outside the human body.

3.17 printed electronics based devices A single layer or multi-layered structure fabricated using printed electronics based materials and processes. The structure can be an active device (field effect transistors, MEMS, etc.) or a passive device (capacitors, inductors, resistors, etc.).

3.18 printed electronics based material A material that is solution processable or has a rheology that enables it to be processed by printed electronics based processes. Example printed electronics based materials are: functional conductive materials, functional biologically active materials, functional chemically active materials, etc.

3.19 printed electronics based process A printing process used to fabricate patterned structures of defined dimensions in ambient conditions (i.e., without the use of high temperatures or the use of high vacuum) that are considered lower in conversion cost. Example printing processes are: screen printing, flexographic printing, gravure printing, slot-die coating, atomized spray coating, micro-dispensing, inkjet printing, etc.

3.20 printed electronics based final products A single layer or multi-layered structure fabricated using printed electronics based materials and processes which does not require connection to additional components to provide functionality. Example final products are: point-of-purchase retail signage, RFID tags.

3.21 printed electronics based modules and units A single layer or multilayer structure fabricated using printed electronics based materials and processes which may have packaging (e.g., barrier films, encapsulation) to enable performance in ambient environments. In addition to packaging, the structure **shall** have an I/O for connection to other modules and units. Example modules and units are: displays (e.g., emissive, reflective), lighting units (e.g., OLED, EL), power (e.g., primary batteries, secondary batteries, PV modules).

3.22 printed electronics through-hole A hole that makes an electrical connection between conductive patterns on internal layers, external layers, or both, of a printed circuit.

3.23 printed electronics via A printed electronics through hole that is used as an interlayer connection, but in which there is no intention to insert a component lead or other reinforcing material.

3.24 surface finish A material that is applied to the surface of a different material that forms an interface and bulk structure that provides mechanical, electrical, or chemical performance enhancement. The material may also perform as a temporary passivation interface which is decomposed or removed at a future processing step. Example surface finishes preserve the interface for metallurgical joining as in solder interconnects or adhesion as in a polymer thick film.