



IPC-4591A

Requirements for Printed Electronics Functional Conductive Materials

Developed by the D-63 Printed Electronics Functional Materials
Subcommittee of the D-60 Printed Electronics Committee of IPC

Supersedes:
IPC/JPCA-4591- November 2012

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

Acknowledgment

Any document involving a complex technology draws material from a vast number of sources. While the principal members of the D-63 Printed Electronics Functional Materials Subcommittee of IPC 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 the IPC extend their gratitude.

Printed Electronics Committee

Co-Chairs

Neil Bolding, MacDermid Enthone
Electronics Solutions

Daniel Gamota, Printovate
Technologies, Inc.

Printed Electronics Functional Materials Subcommittee

Chair

Josh Goldberg, Rogers Corporation

Technical Liaison of the IPC Board of Directors

Bob Neves

Microtek (Changzhou) Laboratoris

Printed Electronics Functional Materials Subcommittee

Leonard Allison, Engineered Materials
Systems

Sai Avuthu, Jabil Circuit, Inc.

Neil Bolding, MacDermid Enthone
Electronics Solutions

Alan Brown, Engineered Materials
Systems, Inc.

Alan Burk, ALMAX

John Crumpton, DuPont - RTP

Mahendra Gandhi, Northrop Grumman
Aerospace Systems

Ken Gann, Lab Tech

MaryAlice Gill, Jabil Circuit, Inc.

Josh Goldberg, Rogers Corporation

Scott Gordon, DuPont Teijin Films

Philip Henault, Raytheon Company

Mary Herndon, Raytheon Company

Daniel Hines, Laboratory for Physical
Sciences

Michael Jawitz, Orbital ATK

Rajesh Kumar, TTM Technologies

Mike Mastropietro, NextFlex

Roger Miedico, Raytheon Company

Dean Miner, 3M

Jeffrey Parker, Insulectro

HaridossSarma, GO 2 Scout 4 R&T

Jeff Shubrooks, Raytheon Company

Richard Snogren, Bristlecone LLC

David Sommervold, The Bergquist
Company/Henkel Electronic
Materials LLC

Brent Sweitzer, Multek Flexible
Circuits, Inc.

Brian Toleno, Microsoft Corporation

Hector Valladares, Honeywell
Aerospace

Steve Vetter, NSWC Crane

Diane Williams, Corning Incorporated

Table of Contents

1	SCOPE	3	3.2.10	Workmanship Requirements	9
1.1	Purpose	3	3.2.11	Shelf Life Determination	9
1.2	Classification System	3	3.2.12	Working Life (Pot Life) Determination	9
1.3	Manufacturing Processing Parameters	4	3.2.13	Additional Testing	9
1.3.1	Thermal Schedule	4	3.2.14	Special Requirements	9
1.3.2	Ultraviolet (UV) Schedule	4	4	QUALITY ASSURANCE PROVISIONS	10
1.3.3	Photoimageable Schedule	4	4.1	Responsibility for Inspection	10
1.3.4	Manufacturing Environment	4	4.2	Responsibility for Compliance	10
1.4	Qualification	4	4.3	Quality Assurance Program	10
1.5	Quality Conformance	4	4.4	Test Equipment and Inspection Facilities	10
1.6	Procurement Documentation	4	4.5	Preparation of Samples	10
1.7	Material Characteristics	4	4.6	Standard Laboratory Conditions	10
1.7.1	As Agreed Upon Between User and Supplier	5	4.7	Tolerances	10
1.8	Interpretation of Shall	5	4.9	Materials Inspection	10
1.9	Presentation	5	4.10	Qualification Inspection	10
1.10	Conflict	5	4.10.1	Sample Size	10
2	APPLICABLE DOCUMENTS	5	4.10.2	Frequency	10
2.1	IPC	5	4.11	Quality Conformance Inspection	10
2.2	ASTM International	5	4.11.1	Inspection of Product for Delivery	11
2.3	NCSL International	6	4.11.2	Sample Unit	11
2.4	ISO	6	4.11.3	Group A Inspection	11
3	REQUIREMENTS	6	4.11.4	Group B Inspection	12
3.1	Terms and Definitions	6	4.12	Statistical Process Control (SPC)	12
3.1.1	Solvent	6	4.12.1	Reduction of Quality Conformance Testing	12
3.1.2	Functional Conductive Material	7	5	PREPARATION FOR DELIVERY	12
3.1.3	Drying	7	5.1	Packaging	12
3.1.4	Volume Resistivity	7	5.2	Container Marking	13
3.1.5	Sheet Resistance	7	6	NOTES	13
3.1.6	Rheology	7	6.1	Ordering Data	13
3.1.7	Sintering	7	6.2	Chemical Resistance	13
3.1.8	Solution Processable	7			
3.1.9	Surface Tension	7			
3.1.10	Vehicle	7			
3.1.11	Viscosity	7			
3.1.12	Volatiles	7			
3.1.13	Preprocessed	7			
3.1.14	Postprocessed	7			
3.2	General Characterization Methodology	7			
3.2.1	Preprocessed Material Requirements	7			
3.2.2	Standardized Description for Preprocessed Functional Materials	7			
3.2.3	Rheology Requirements	8			
3.2.4	Density	8			
3.2.5	pH	8			
3.2.6	Visual	8			
3.2.7	Postprocessed Material Requirements	9			
3.2.8	Electrical Requirements	9			
3.2.9	Optical Requirements	9			

Tables

Table 1-1	Postprocessed Functional Conductive Material – Structure Classification	3
Table 1-2	Postprocessed Functional Conductive Material – Bulk Composition Classification	3
Table 1-3	Preprocessed Functional Conductive Material – Conductive Classification	4
Table 4-1	Test Method Frequency	11
Table 4-2	Sampling Plan for Group A Inspection	11

Requirements for Printed Electronics Functional Conductive Materials

1 SCOPE

This standard establishes the classification system and the qualification and quality conformance requirements for functional conductive materials used in printed electronics applications.

1.1 Purpose The purpose of this standard is to provide practitioners of printed electronics with the necessary technical structure to design and manufacture product meeting conformance to industry-determined metrics.

1.2 Classification System The user has the responsibility to specify on the procurement documentation materials capable of meeting the requirements of this specification and end-item use.

Note: When possible, material callout information should be reviewed with the supplier to obtain concurrence that the part will meet customer requirements and, if necessary, to update the procurement documentation accordingly.

The classification system defined in 1.2.1 through 1.2.1.3 identifies functional conductive materials for printed electronics applications.

1.2.1 Functional Conductive Material Designation The functional conductive material designation is intended for use on material purchase orders (see 6.1). Designers **shall** specify on master drawings their material selection only. This is because the specific designation is lengthy and requires fabricator-level knowledge for making the detailed selections.

The functional conductive material designation should be in the form shown of the example below:

IPC-4591/2 – A1

Where:

2 = Postprocessed structure classification (see 1.2.1.1), specifying sintering

A = Postprocessed bulk classification (see 1.2.1.2), specifying metal

1 = Preprocessed conductive classification (see 1.2.1.3), specifying spheres

1.2.1.1 Postprocessed Functional Conductive Material – Structure Classification The postprocessed functional conductive material structure classification **shall** be designated per Table 1-1.

Table 1-1 Postprocessed Functional Conductive Material – Structure Classification

Designation	Type
1	Percolation
2	Sintering
3	Metal organic decomposition
4	Intrinsically conductive polymer
5	Other

1.2.1.2 Postprocessed Functional Conductive Material – Bulk Composition Classification The postprocessed functional conductive material bulk composition **shall** be designated per Table 1-2.

Table 1-2 Postprocessed Functional Conductive Material – Bulk Composition Classification

Designation	Type
A	Metal
B	Metal oxide
C	Organic
D	Allotropes of carbon
E	Other

Table note: For combinations, use multiple letters separated by a slash(es).