ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES®

IPC-4101B
with Amendments 1 & 2

Specification for Base Materials for Rigid and Multilayer Printed Boards

IPC-4101B with Amendments 1 & 2
April 2007

A standard developed by IPC

Supersedes IPC-4101B
with Amendment 1
February 2007

3000 Lakeside Drive, Suite 309S, Bannockburn, IL 60015-1249
Tel. 847.615.7100 Fax 847.615.7105
www.ipc.org

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 847/597-2872.

Thank you for your continued support.

IPC

ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES®

IPC-4101B with Amendments 1 & 2

Specification for Base Materials for Rigid and Multilayer Printed Boards

Developed by the Laminate/Prepreg Materials Subcommittee (3-11) of the Printed Board Base Materials Committee (3-10) of IPC

Supersedes:

IPC-4101B with
Amendment 1 - February 2007
IPC-4101B - June 2006
IPC-4101A with
Amendment 1 - June 2002
IPC-4101A - December 2001
IPC-4101 - December 1997
IPC-L-108
IPC-L-109
IPC-L-112
IPC-L-115
IPC-AM-361

Users of this standard 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

This Page Intentionally Left Blank

Acknowledgment

Any document involving a complex technology draws material from a vast number of sources. While the principal members of the Laminate/Prepreg Materials Subcommittee (3-11) of the Printed Board Base Materials Committee (3-10) 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 Board Base Materials Committee

Chair
Douglas J. Sober
Kaneka Texas Corporation

Vice Chair
Dewey Whittaker
Honeywell Inc.

Laminate/Prepreg Materials Subcommittee

Chair
Antonio R. Senese
Taconic-STL

Vice Chair
Douglas J. Sober
Kaneka Texas Corporation

Technical Liaisons of the IPC Board of Directors

Peter Bigelow
IMI Inc.

Sammy Yi
Flextronics International

Laminate/Prepreg Materials Subcommittee

Wolfgang Alberth, Isola GmbH

Masamitsu Aoki, Nokia Japan

Richard A. Barnett, Hewlett-Packard Company

Leonard Barrett, W. L. Gore & Associates Inc.

Don Belanger, Pacific Testing Laboratories, Inc.

Keith Bendyk, JPS Composite Materials

Erik J. Bergum, Polyclad Europe

Robert J. Black, Northrop Grumman Corporation

Scott A. Bowles, Hallmark Circuits Inc.

Jack R. Bramel, Jack Bramel & Associates

Thomas N. Bresnan, R&D Circuits

Mike Bryant, BGF Industries Inc

Victor J. Brzozowski, Northrop Grumman Corporation

Qiaoer Cai, Guangdong Shengyi Sci.Tech Co. Ltd.

John P. Cali, Gould Electronics Inc

H. Brandt Carter, JPS Composite Materials

Lonnie Cathel, LCY

Gerard Cave, Pacific Testing Laboratories, Inc.

Clifton W. Cavin, General Dynamics, C4 Systems

Phillip Chen, L-3 Communications Electronic Systems

Wennei Chen, Northrop Grumman Space Technology

Walter H. Christiansen, Hexion Specialty Chemicals

John Christmas, U.S. Air Force

Jennifer Chung, Hexion Specialty Chemicals

Christine R. Coapman, Delphi Electronics and Safety

Gordon Davy, Northrop Grumman Corporation

John D. Brita, Sanmina-SCI Corporation

Nitin B. Desai, Motorola Inc.

William C. Dieffenbacher, BAE Systems Platform Solutions

Raimund Doppelreiter, P-D Interglas Technologies AG

Paul G. DuFresne, Yates Foil USA Inc.

Patricia S. Dupuis, Raytheon Company

Theodore Edwards, Dynaco Corp.

Douglas Eng, PPG Industries Inc.

Werner Engelmaier, Engelmaier Associates, L.C.

Steven R. Ethridge, Dell Inc.

Thomas G. Farrell, Underwriters Laboratories Inc.

Herbert L. Fick, The Bergquist Company, Prescott

Terry M. Fischer, Hitachi Chemical Co. America, Ltd.

Lionel Fullwood, WKK Distribution Ltd.

Mahendra S. Gandhi, Northrop Grumman Space Technology

Patricia J. Goldman, Dielectric Solutions, LLC

William D. Hall, Oak-Mitsui, Inc.

Robert Hearn, Dow Chemical USA

Adam E. Hen, Celestica International Inc.

Philip M. Henault, Raytheon Company

Happy T. Holden, Asian Pacific Materials

Russell Hornung, Arlon MED

Shelly Hsu, Compeq Manufacturing Co. Ltd.

David K. Iguchi, Nelco North America

Neeta Jayaraman, Amphenol TCS

John Jephson, Circuit Foil Trading, Inc.

Laurence G. Johnson, LGJ Technologies

Ted J. Jones, NSWC - Crane

Yvonne Julian-Hargrove, Dow Chemical USA

Akimasa Kajita, Nitto Boseki Co., Ltd.

Joan F. Karner, Holaday Circuits Inc.

Hideo Kato, Nitto Boseki Co., Ltd.

Roy M. Keen, Rockwell Collins

Stephen N. Keller, Trace Laboratories - East

Thomas E. Kemp, Rockwell Collins

Tom Knipp, Park/Nelco

Robert J. Konsowitz, Flextronics

Karin LaBerge, Microtek Laboratories

Bruce Lee, MacDermid, Inc.

Fen-Yi Lee, Nan Ya Plastics Corporation

Edward E. Lewis, Jr., Isola Laminate Systems Corporation

Doug Leys, Nelco North America

Peter Liang, Nan Ya Plastics Corporation

Louis Lin, Nan Ya Plastics Corporation

David D. Lowery, Summit Products & Services

P. Douglas Lyle, AGY

Alfred F. Macha, Sanmina-SCI Phoenix Inc.

Kenneth J. Manning, Raytheon Company

Rene R. Martinez, Northrop Grumman Space Technology

Brian C. McCrory, Delsen Testing Laboratories

David R. McGowan, Electropac Co. Inc.

David R. McGregor, E. I. du Pont de Nemours and Co.

Bill Mercer, Dow Chemical USA

Nicholas C. Mescia, Nanolytics Inc.

Renee J. Michalkiewicz, Trace Laboratories - East

Roger Miedico, Raytheon Company

Noe P. Navarro, UL APEX Co., Ltd.

David R. Nelson, Raytheon Company

Bob Neves, Microtek Laboratories

Steven M. Nolan, C.I.D.+, Lockheed Martin Maritime Systems

Thomas J. Nowak, Saint-Gobain Performance Plastics

Robert Nurmi, Taconic Advanced Dielectric Division

Debora L. Obitz, Trace Laboratories - East

Gerard A. O'Brien, Photocircuits Corporation

Scott S. Opperhauser, Trace Laboratories - East

Deepak K. Pai, C.I.D.+, General Dynamics-Advanced Information

Bihari Patel, MacDermid, Inc.

John P. Penc, Taconic Advanced Dielectric Division

Scott Peterson, Tapco Circuit Supply

Thierry Philibert, Hexcel Fabrics S.A.

George Piotrowski, Isola Laminate Systems

Miguel A. Rincon, Jr., Electroply Inc.

Paul B. Rose, Lockheed Martin Missile & Fire Control

Roberta Rose, Taconic Advanced Dielectric Division

Wayne Rothschild, IBM Corporation

Visa Ruuhonen, Nokia Oyj

Jerome S. Sallo, Ph.D., Sallo Consulting Services

Karl A. Sauter, Sun Microsystems Inc.

Rolland D. Savage, Gould Electronics Inc.

Chuck Schenetzke, Microtek Laboratories

Steve M. Sekanina, Isola Laminate Systems

Kenneth C. Selk, Northrop Grumman Space Technology

Lowell Sherman, Defense Supply Center Columbus

Hans L. Shin, Pacific Testing Laboratories, Inc.

Michael C. Shin, Pacific Testing Laboratories, Inc.

Joseph T. Slanina, Honeywell Inc.

Robert Smail, ILNorplex-Micanita

Clark A. Smedstad, PGE Industries

David Sommervold, The Bergquist Company, Prescott

Bruce W. Sorensen, Asian Pacific Materials

George L. Stefanelongo, The Boeing Company

George T. Stoddart, CSA International

Michael Sullivan, Arlon Materials for Electronics

Kurt Summa, FTG Circuits, Inc.

Takayuki Suzuki, Hitachi Chemical Co. America, Ltd.

Jorgen Svensson, Sony Ericsson Mobile Communications AB

Valentin Tereshkin, Elma Ltd.

Chris Totten, Saint-Gobain BTI Inc.

Crystal E. Vanderpan, Underwriters Laboratories Inc.

William D. Varnell, Ph.D., Polyclad laminates Inc.

Daniel Welch, Arlon MED

James R. White, Hallmark Circuits Inc.

Wally Younger, Isola Laminate Systems

Table of Contents

Figures

Tables

This Page Intentionally Left Blank

Specification for Base Materials for Rigid and Multilayer Printed Boards

1 SCOPE

This specification covers the requirements for base materials, herein referred to as laminate or prepreg, to be used primarily for rigid or multilayer printed boards for electrical and electronic circuits.

1.1 Classification The system shown below identifies clad and unclad laminate or prepreg base materials. The specification sheets serve as a cross-reference connecting the outlined callout system in this document to previously used systems.

Example for laminate base materials where this specification is referenced:

L	Material Designator (see 1.1.1)
25	Specification Sheet Number (see 1.1.1)
1500	Nominal Laminate Thickness (see 1.1.2)
C1/C1	Metal Cladding Type and Nominal Weight/ Thickness (see 1.1.3)
A	Thickness Tolerance Class (see 1.1.4)
A	Surface Quality Class (see 1.1.5)

Example for prepreg base materials where this specification is referenced:

P	Material Designator (see 1.1.1)
25	Specification Sheet Number (see 1.1.1)
E7628	Reinforcement Style (see 1.1.6)
TW	Resin Content Method (see 1.1.7)
RE	Flow Parameter Method (see 1.1.7)
VC	Optional Prepreg Method (see 1.1.7)

1.1.1 Specification Sheet Description At the end of this document is a series of specification sheets. Each specification sheet outlines requirements for both laminate and prepreg for each product grade. The specification sheets are organized by a specific reinforcement type, resin system, and/or construction and are provided with a specification sheet number for ordering purposes. For convenience, the laminate and prepreg requirements for materials of the like composition are on the same specification sheet. Material Designator ''L'' indicates laminate material and Material Designator ''P'' indicates prepreg material as shown in designation examples in 1.1. When certifying to multiple specification sheets, the strongest performance requirements **shall** apply.

The headings for each specification sheet include reference definitions for the material, which cover the reinforcements, resin systems, flame retardants, and fillers used, as well as its other known identifications and glass transition temperature, T_g. The specific line items within the specification sheets are the requirements that material **shall** meet in order to be certified to this specification.

1.1.2 Nominal Laminate Thickness The nominal thickness is identified by four digits. For all substrates covered by this document, thicknesses may be specified or measured either over the cladding or over the dielectric (see 1.1.4 and 3.8.4.2). For metric specification, the first digit represents whole millimeters, the second represents tenths of millimeters, etc. For orders requiring English units, the four digits indicate the thickness in ten-thousandths of an inch (tenths of mils). In the example shown in 1.1, 1500 is designated for the English unit usage of 0600 for a laminate with thickness of 1.5 mm [59.1 mil].

1.1.3 Metal Cladding Type and Nominal Weight/ Thickness The type and nominal weight or thickness of the metallic cladding for laminate base material is identified by five designators. The first and fourth designators indicate the type of cladding; the third designator is a slash mark that differentiates sides of the base material; the second and fifth designators indicate the nominal weight or thickness of the metallic cladding.

1.1.3.1 Metal Cladding Type The types of metallic cladding and the designators representing them are shown in Table 1-1. Table 1-1 is provided as a reference only. The referee document is the latest version of IPC-CF-148, IPC-4562, or IPC-CF-152 as appropriate. Cladding types C and R, and cladding types H and S, may be used interchangeably as agreed upon between user and supplier. Cladding type H can be used for type C and type S can be used for type R. Cladding type R may be substituted for type C, and cladding type S may be substituted for type H.

1.1.3.2 Nominal Weight/Thickness The weight or thickness of metallic cladding and the designators representing them are listed in Table 1-2. Table 1-2 is provided as a reference only. The referee document is the latest version of IPC-CF-148, IPC-4562, or IPC-CF-152 as appropriate.

1.1.4 Thickness Tolerance (Laminate) The class of thickness tolerance for laminate base material is identified by either A, B, C, D, K, L, M, or X (as agreed upon