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IPC-4821

Amendment 1

Specification for Embedded Passive Device Capacitor Materials for Rigid and Multilayer Printed Boards

IPC-4821
Amendment 1
April 2010
A standard developed by IPC

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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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IPC-4821 - Amendment 1

Specification for Embedded Passive Device Capacitor Materials for Rigid and Multilayer Printed Boards

Developed by the Embedded Component Materials Subcommittee (D-52) of the Embedded Components Committee (D-50) of IPC

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

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Specification for Embedded Passive Device Capacitor Materials for Rigid and Multilayer Printed Boards Amendment 1

*Replace the **Foreword:** (appears prior to the Table of Contents) with the following:*

Foreword:

IPC-4821 was based on industry knowledge at the time of its original release in March 2006. Embedded passive devices may be made with a large variety of materials and cover a wide range of fabrication processes. In March of 2006, use of these materials was not widespread. As such, it was recognized that updates to this document would be needed and this Amendment 1 is the first such update. It is recommended that the customer and supplier continue to work together to set the criteria for acceptance of embedded passive material products.

*Replace the second paragraph of **1.2 Designation System** with the following:*

For example, a user wishing to order from specification sheet 1 would substitute the number "1" for the "S" in the designation examples (i.e., IPC-4821/1) shown in 1.2.1 through 1.2.3. To start the ordering process, one can use the specification sheets in this document in combination with relevant IPC documents for each material set (i.e., IPC-4563, IPC-4562, IPC-4101, or IPC-4104). Metal foils associated with an embedded passive material **shall** meet the requirements of IPC-4562 and the weight(s) of the foil(s) **shall** be specified on the purchase order.

*Replace the first three IPC standards in **2.1 IPC** with the following:*

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

IPC-CF-152 Composite Metallic Material Specification for Printed Wiring Boards

IPC-4563 Resin Coated Copper Foil for Printed Boards Guideline

*Add the following test method to the **IPC-TM-650** Test Methods Manual within **2.1 IPC**.*

2.5.7.2 Dielectric Withstanding Voltage (HiPot) Method - Thin Dielectric Layers for Printed Boards

*Replace **3.8.4.1 Copper Foil or Other Metal** with the following:*

Copper foil or other metal **shall** meet the requirements of IPC-4562, IPC-4563, IPC-CF-152, or as agreed upon between user and supplier. For alternate metals not covered by industry standards, requirements **shall** be as agreed upon between user and supplier. The treatment applied to the metal may be of interest to the circuit designer depending on the signal integrity and electrical performance desired.

*Replace **3.10.1 Visual Requirements of Laminate-Like Capacitor Materials** with the following:*

Laminate-like capacitor materials **shall** be tested in accordance with Table 3-1 and sections 3.10.1.1 through 3.10.1.6 using the test methods described therein and in the applicable specification sheets. Any defect within 7 mm [0.28 in] of the outside edges of the sheet or roll **shall** be disregarded. Unless otherwise specified, the working area of the specimen **shall** be a 300 mm x 300 mm [11.81 in x 11.81 in] area examined with normal or corrected 20/20 (also termed 6/6 or 1.0) vision. The worst 50 mm x 50 mm [1.97 in x 1.97 in] area **shall** be examined at 10X magnification unless otherwise specified. Visual inspection may be carried out under ambient temperature and humidity conditions.

*Replace row 17 in **Table 3-1 Testing Requirements for Laminate-Like Materials** with the following:*

17.	**HiPot**	**3.14.1.4**	**2.5.7.2**	✓	**A**	**1**

*Replace row 12 in **Table 3-2 Testing Requirements for Nonlaminate-Like Capacitor Materials** with the following:*

12.	**HiPot**	**3.14.2.4**	**2.5.7.2**	✓	**C**	**1**

*Replace the first paragraph in **3.10.1.1 Metal Indentations** with the following:*

When tested in accordance with section 3.10.1, metal indentations **shall** be located visually using normal or corrected 20/20 (also termed 6/6 or 1.0) vision. The longest dimension of each foil indentation in a specimen **shall** be measured with a suitable reticule on a minimum 4X magnifier, with referee inspections at 10X. The point value system shown in Table 3-3 **shall** be used to determine the point count for any 300 mm x 300 mm [11.81 in x 11.81 in] area:

*Replace the descriptive text for **Class D:** in **3.10.1.1 Metal Indentations** with the following:*

The total point count **shall** be 0 (zero) for any 300 mm x 300 mm [11.81 in x 11.81 in] area. A foil indentation greater than or equal to 0.13 mm [5.12 x 10^{-3} in] in its longest dimension **shall** not be acceptable. Resin spots **shall** be 0 (zero) as inspected with normal or corrected 20/20 (also termed 6/6 or 1.0) vision. If Class D is specified, other quality related features are also required of this quality class per IPC-4562.

*Replace **3.14.1.4 HiPot Voltage** with the following:*

HiPot Voltage is a test that is used by printed wiring board manufacturers primarily to ensure that there are no shorts or near shorts in the finished printed wiring board. With the advent of thinner laminates, printed wiring board fabricators have begun testing patterned innerlayers of these thin laminates to ensure that the dielectric between conductor planes will withstand temporary overvoltage conditions in service as well as to ensure that there are no flaws in the dielectric that would cause breakdown at the specified voltage. Most laminate-like capacitor dielectrics are very thin and have high capacitance density. Because they are good capacitors, they appear as short circuits when initially charging. In addition, capacitor dielectric materials containing ceramic fillers such as barium titanate will exhibit increasing leakage current with increasing voltage since these type fillers are semi-conducting and not pure insulators. Voltage ramp rate and leakage current settings on commercial HiPot testers vary and these factors will also have an effect on the final result. Thus, when laminate-like capacitor materials are tested in accordance with IPC-TM-650, Method 2.5.7.2, the minimum HiPot voltage **shall** be as indicated in the applicable specification sheet or as agreed upon between user and supplier.

*Replace **3.14.2.4 HiPot Voltage** with the following:*

HiPot Voltage is a test that is used primarily to ensure the quality of the incoming dielectric material. HiPot testing may also be done in conjunction with printed wiring board manufacture to ensure that there are no shorts or near shorts in the semi-finished or finished board. With the advent of thinner laminates, printed wiring board fabricators have begun testing imaged innerlayers of these thin laminates to ensure that the dielectric between conductor planes will withstand temporary overvoltage conditions in service as well as to ensure that there are no flaws in the dielectric that would cause breakdown at the specified voltage. It is anticipated that similar testing will be done to non-laminate-like capacitor dielectrics even though they do not comprise the entire dielectric of an innerlayer. Most non-laminate-like capacitor materials are thin and have very high capacitance density. Because they are good capacitors, they appear as short circuits when initially charging. In addition, capacitor dielectric materials containing ceramic fillers such as barium titanate will exhibit increasing leakage current with increasing voltage since these type fillers are semi-conducting and not pure insulators. Voltage ramp rate and leakage current settings on commercial HiPot testers vary and these factors will also have an effect on the final result. Thus, when non-laminate-like capacitor materials are tested in accordance with IPC-TM-650, Method 2.5.7.2, the minimum HiPot voltage **shall** be as indicated in the applicable specification sheet or as agreed upon between user and supplier.

*Completely remove all of **6.3 HiPot Test Method** with no replacement.*

*Replace Specification Sheet **IPC-4821/1** with the following:*

Effective Date: April 2010

SPECIFICATION SHEET			
Specification Sheet #:	IPC-4821/1	**Passive Type:**	Capacitive
Form of Dielectric:	Sheet	**Reinforcement:**	None
Chemistry:	Polyimide	**Filler:**	None
Conductor Type:	Copper/Copper	**Encapsulant Chemistry:**	None
IPC-4821 Designation ID:	C1N2N1/1N		

EMBEDDED PASSIVE MATERIAL QUALIFICATON AND CONFORMANCE TYPICAL VALUES			
PROPERTY	**REFERENCE PARAGRAPH**	**TEST METHOD**	**TYPICAL VALUES**
Thickness (micron)	3.11.1.1	Section 3.11.1.1	12 - 25
Dimensional Stability (%) Stand alone: Method B Method C Single sided: Method B Method C	3.11.1.2	2.4.39 2.2.4	 -0.10 to -0.03 -0.10 to -0.03 N/A N/A
Peel Strength (N/mm)	3.12.1.1	2.4.8 2.4.9	1.4
Glass Transition Temperature, (°C)	3.12.1.3	2.4.24.5 2.4.25	195
CTE xy ($T<T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	25
CTE xy ($T>T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	40
CTE z ($T<T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	105
CTE z ($T>T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
Permittivity • at 1 MHz • at 1 GHz	3.14.1.1	 2.5.5.2 2.5.5.10	 3.5 AABUS
Loss Tangent • at 1 MHz • at 1 GHz	3.14.1.2	 2.5.5.2 2.5.5.10	 0.005 AABUS
Dielectric Strength (VDC/micron)	3.14.1.3	ASTM, Method D 149	236
HiPot (Volts DC)	3.14.1.4	2.5.7.2	≥500
Capacitance Density (nF/cm^2) • at 1 MHz • at 1 GHz	3.14.1.5	 2.5.5.2 2.5.5.10	 0.12 AABUS
Surface Resistivity (Ohm) A. 96 hours / 35°C / 90% RH B. At elevated temperature (at RTI value)	3.14.1.6	2.5.17.1	 $>10^{16}$ AABUS
Volume Resistivity (Ohm-cm)	3.14.1.6	2.5.17.1	$>10^{16}$
Temperature Coefficient of Capacitance (ppm/°C)	3.14.1.7	Section 3.14.1.7	-15
Flammability (UL 94)	3.13.1.1	UL 94 2.3.8.1 2.3.9 2.3.10	V-0
Moisture Resistance by Pressure Vessel Test (Optional)	3.15.1.1	2.6.16.1	AABUS
Moisture and Water Absorption (wt. %)	3.15.1.2	2.6.2.1	0.8
High Temperature / Humidity Accelerated Aging Minimum resistance (Ohms) Minimum capacitance (nF) Minimum loss tangent	3.15.1.3	Section 3.15.1.3	 AABUS AABUS AABUS

*Replace Specification Sheet **IPC-4821/2** with the following:*

Effective Date: April 2010

SPECIFICATION SHEET			
Specification Sheet #:	IPC-4821/2	**Passive Type:**	Capacitive
Form of Dielectric:	Paste	**Reinforcement:**	None
Chemistry:	Ceramic	**Filler:**	Barium Titanate
Conductor Type:	Copper/Copper Particle Paste	**Encapsulant Chemistry:**	None
IPC-4821 Designation ID:	C2N4A1/3N		

EMBEDDED PASSIVE MATERIAL QUALIFICATON AND CONFORMANCE TYPICAL VALUES			
PROPERTY	**REFERENCE PARAGRAPH**	**TEST METHOD**	**TYPICAL VALUES**
Viscosity	3.12.2.4	2.4.34 2.4.34.1 (reference only)	300 - 460 PaS
Permittivity • at 1 MHz • at 1 GHz	3.14.2.1	 2.5.5.2 2.5.5.10	 3000 (@10 KHz) AABUS
Loss Tangent • at 1 MHz • at 1 GHz	3.14.1.2	 2.5.5.2 2.5.5.10	 0.025 (@ 10 KHz) AABUS
Dielectric Strength (VDC/micron)	3.14.2.3	ASTM, Method D 149	11.8
HiPot (VoltDC)	3.14.2.4	2.5.7.2	100
Capacitance Density (nF/cm^2) • at 1 MHz • at 1 GHz	3.14.2.5	 2.5.5.2 2.5.5.10	 150 AABUS
Surface Resistivity (Ohm) A. 96 hours / 35°C / 90% RH B. At elevated temperature (at RTI value)	3.14.2.6	2.5.17.1	 AABUS AABUS
Volume Resistivity (Ohm-cm)	3.14.2.6	2.5.17.1	AABUS
Temperature Coefficient of Capacitance (ppm/°C)	3.14.2.7	Section 3.14.2.7	AABUS
Conductivity of Conductor Paste *(Siemens/m)*	3.14.2.8	Section 3.14.2.8	40 x 10^6
Moisture Resistance by Pressure Vessel Test (Optional)	3.15.2.1	2.6.16.1	AABUS

*Replace Specification Sheet **IPC-4821/3** with the following:*

Effective Date: April 2010

SPECIFICATION SHEET			
Specification Sheet #:	IPC-4821/3	**Passive Type:**	Capacitive
Form of Dielectric:	Sheet	**Reinforcement:**	None
Chemistry:	Epoxy	**Filler:**	Barium Titanate
Conductor Type:	Copper/Copper	**Encapsulant Chemistry:**	None
IPC-4821 Designation ID:	C1N1A1/1N		

EMBEDDED PASSIVE MATERIAL QUALIFICATON AND CONFORMANCE TYPICAL VALUES			
PROPERTY	**REFERENCE PARAGRAPH**	**TEST METHOD**	**TYPICAL VALUES**
Thickness (micron)	3.11.1.1	Section 3.11.1.1	7 - 20
Dimensional Stability (%) Stand alone: Method B Method C Single sided: Method B Method C	3.11.1.2	2.4.39 2.2.4	 AABUS AABUS AABUS AABUS
Peel Strength (N/mm)	3.12.1.1	2.4.8 2.4.9	≥0.5
Glass Transition Temperature, (°C)	3.12.1.3	2.4.24.5 2.4.25	110 - 200
CTE xy ($T<T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	30 - 35
CTE xy ($T>T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
CTE z ($T<T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	30 - 35
CTE z ($T>T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
Permittivity • at 1 MHz • at 1 GHz	3.14.1.1	 2.5.5.2 2.5.5.10	 10 - 30 AABUS
Loss Tangent • at 1 MHz • at 1 GHz	3.14.1.2	 2.5.5.2 2.5.5.10	 0.01 - 0.03 AABUS
Dielectric Strength (VDC/micron)	3.14.1.3	ASTM, Method D 149	110 - 244
HiPot (Volts DC)	3.14.1.4	2.5.7.2	100 - 500
Capacitance Density (nF/cm^2) • at 1 MHz • at 1 GHz	3.14.1.5	 2.5.5.2 2.5.5.10	 0.7 - 1.8 AABUS
Surface Resistivity (Ohm) A. 96 hours / 35°C / 90% RH B. At elevated temperature (at RTI value)	3.14.1.6	2.5.17.1	 $>10^{11}$ AABUS
Volume Resistivity (Ohm-cm)	3.14.1.6	2.5.17.1	$>10^{12}$
Temperature Coefficient of Capacitance (ppm/°C)	3.14.1.7	Section 3.14.1.7	AABUS
Flammability (UL 94)	3.13.1.1	UL 94 2.3.8.1 2.3.9 2.3.10	V-0
Moisture Resistance by Pressure Vessel Test (Optional)	3.15.1.1	2.6.16.1	AABUS
Moisture and Water Absorption (wt. %)	3.15.1.2	2.6.2.1	0.4 - 1.2
High Temperature / Humidity Accelerated Aging Minimum resistance (Ohms) Minimum capacitance (nF) Minimum loss tangent	3.15.1.3	Section 3.15.1.3	 AABUS AABUS AABUS

*Replace Specification Sheet **IPC-4821/4** with the following:*

Effective Date: April 2010

SPECIFICATION SHEET			
Specification Sheet #:	IPC-4821/4	**Passive Type:**	Capacitive
Form of Dielectric:	Sheet	**Reinforcement:**	None
Chemistry:	Epoxy	**Filler:**	None
Conductor Type:	Copper/Copper	**Encapsulant Chemistry:**	None
IPC-4821 Designation ID:	C1N1N1/1N		

EMBEDDED PASSIVE MATERIAL QUALIFICATON AND CONFORMANCE TYPICAL VALUES

PROPERTY	REFERENCE PARAGRAPH	TEST METHOD	TYPICAL VALUES
Thickness (micron)	3.11.1.1	Section 3.11.1.1	8 - 24
Dimensional Stability (%) Stand alone: Method B Method C Single sided: Method B Method C	3.11.1.2	2.4.39 2.2.4	 AABUS AABUS N/A N/A
Peel Strength (N/mm)	3.12.1.1	2.4.8 2.4.9	1.4
Glass Transition Temperature, (°C)	3.12.1.3	2.4.24.5 2.4.25	200
CTE xy (T_g) (ppm/°C)	3.12.1.4	2.4.24.5	18 - 22
CTE xy (TT_g) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
CTE z (T_g) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
CTE z (TT_g) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
Permittivity • at 1 MHz • at 1 GHz	3.14.1.1	 2.5.5.2 2.5.5.10	 4.4 AABUS
Loss Tangent • at 1 MHz • at 1 GHz	3.14.1.2	 2.5.5.2 2.5.5.10	 0.015 AABUS
Dielectric Strength (VDC/micron)	3.14.1.3	ASTM, Method D 149	197 - 287
HiPot (Volt PDC)	3.14.1.4	2.5.7.2	500
Capacitance Density (nF/cm^2) • at 1 MHz • at 1 GHz	3.14.1.5	 2.5.5.2 2.5.5.10	 0.155 - 0.480 AABUS
Surface Resistivity (Ohm) A. 96 hours / 35°C / 90% RH B. At elevated temperature (at RTI value)	3.14.1.6	2.5.17.1	 $>10^{12}$ AABUS
Volume Resistivity (Ohm-cm)	3.14.1.6	2.5.17.1	$>10^{14}$
Temperature Coefficient of Capacitance (ppm/°C)	3.14.1.7	Section 3.14.1.7	AABUS
Flammability (UL 94)	3.13.1.1	UL 94 2.3.8.1 2.3.9 2.3.10	V-0
Moisture Resistance by Pressure Vessel Test (Optional)	3.15.1.1	2.6.16.1	AABUS
Moisture and Water Absorption (wt. %)	3.15.1.2	2.6.2.1	1.3
High Temperature / Humidity Accelerated Aging Minimum resistance (Ohms) Minimum capacitance (nF) Minimum loss tangent	3.15.1.3	Section 3.15.1.3	 AABUS AABUS AABUS

*Replace Specification Sheet **IPC-4821/5** with the following:*

Effective Date: April 2010

SPECIFICATION SHEET			
Specification Sheet #:	IPC-4821/5	**Passive Type:**	Capacitive
Form of Dielectric:	Sheet	**Reinforcement:**	Woven Glass
Chemistry:	Epoxy	**Filler:**	None
Conductor Type:	Copper/Copper	**Encapsulant Chemistry:**	None
IPC-4821 Designation ID:	C1A1N1/1N		

EMBEDDED PASSIVE MATERIAL QUALIFICATON AND CONFORMANCE TYPICAL VALUES			
PROPERTY	**REFERENCE PARAGRAPH**	**TEST METHOD**	**TYPICAL VALUES**
Thickness (micron)	3.11.1.1	Section 3.11.1.1	25 - 50
Dimensional Stability (%) Stand alone: Method B Method C Single sided: Method B Method C	3.11.1.2	2.4.39 2.2.4	 AABUS AABUS N/A N/A
Peel Strength (N/mm)	3.12.1.1	2.4.8 2.4.9	1.0
Glass Transition Temperature, (°C)	3.12.1.3	2.4.24.5 2.4.25	140
CTE xy ($T<T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
CTE xy ($T>T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
CTE z ($T<T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
CTE z ($T>T_g$) (ppm/°C)	3.12.1.4	2.4.24.5	AABUS
Permittivity • at 1 MHz • at 1 GHz	3.14.1.1	 2.5.5.2 2.5.5.10	 4.5 AABUS
Loss Tangent • at 1 MHz • at 1 GHz	3.14.1.2	 2.5.5.2 2.5.5.10	 0.02 AABUS
Dielectric Strength (VDC/micron)	3.14.1.3	ASTM, Method D 149	AABUS
HiPot (Volt DC)	3.14.1.4	2.5.7.2	500
Capacitance Density (nF/cm^2) • at 1 MHz • at 1 GHz	3.14.1.5	 2.5.5.2 2.5.5.10	 0.08 - 0.16 AABUS
Surface Resistivity (Ohm) A. 96 hours / 35°C / 90% RH B. At elevated temperature (at RTI value)	3.14.1.6	2.5.17.1	 $>10^{12}$ AABUS
Volume Resistivity (Ohm-cm)	3.14.1.6	2.5.17.1	$>10^{13}$
Temperature Coefficient of Capacitance (ppm/°C)	3.14.1.7	Section 3.14.1.7	AABUS
Flammability (UL 94)	3.13.1.1	UL 94 2.3.8.1 2.3.9 2.3.10	V-0
Moisture Resistance by Pressure Vessel Test (Optional)	3.15.1.1	2.6.16.1	AABUS
Moisture and Water Absorption (wt. %)	3.15.1.2	2.6.2.1	AABUS
High Temperature / Humidity Accelerated Aging Minimum resistance (Ohms) Minimum capacitance (nF) Minimum loss tangent	3.15.1.3	Section 3.15.1.3	 AABUS AABUS AABUS