	<p align="center">Material Specification</p>	<p align="center">CORP-SA-002</p>
<p align="center"><i>Corporate Document</i></p>	<p align="center">Specification for Base Materials</p>	<p align="center">PAGE 1 OF 8</p>


DATE	REVISION	DESCRIPTION OF CHANGES
7/21/2020	New	Initial Release

TITLE	APPROVAL SIGNATURE	DATE
Director of Supply Chain Management	<i>Marty Cormier</i>	7/21/2020
Corporate Quality	<i>Aileen Rehic</i>	7/21/2020

1.0 PURPOSE:

This specification defines product, packaging, shipping and general requirements for base materials, as follows:

- i. Copper-Clad Laminate
- ii. Unclad Laminate
- iii. Prepreg

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iv. Copper foil

2.0 SCOPE:

This Procedure applies to base materials purchased by TTM Technologies PCB Operations. Deviations to the requirements of this Procedure shall be detailed in writing by the Supplier and submitted to the applicable Purchasing Team for approval/waiver. Purchasing will communicate acceptance of such deviation in writing via a revised Purchase Order (change order).


Note: If a TTM site has a tighter requirement detailed in their internal Procedure or Work Instruction, it shall take priority over this document.

3.0 APPLICABLE SPECIFICATIONS:

- 3.1 IPC-4101 (current revision): Specification for Base Materials for Rigid and Multilayer Printed Boards
- 3.2 IPC-4103 (current revision): Specification for Base Materials for High Speed/High Frequency Applications
- 3.3 IPC-4202 (current revision): Flexible Base Dielectrics for Use in Flexible Printed Boards
- 3.4 IPC-4203 (current revision): Cover and Bonding Material for Flexible Printed Circuits
- 3.5 IPC-4562A-WAM1 (current revision): Metal Foil for Printed Board Applications
- 3.6 IPC-4563 (current revision): Resin Coated Copper Foil for Printed Board Guidelines
- 3.7 IPC-4811 (current revision): Specification for Embedded Passive Device Resistor Materials for Rigid and Multilayer Printed Boards
- 3.8 IPC-4821 (current revision): Specification for Embedded Passive Device Capacitor Materials for Rigid and Multilayer Printed Boards
- 3.9 IPC-1730 (current revision): Laminator Qualification Profile


4.0 PRODUCT REQUIREMENTS

- 4.1 All laminates shall be manufactured with Class C surface, RTF foil, stamped, unless specified otherwise on the Purchase Order. Stamp shall consist of the material type, lot number, core thickness, copper weight, and TTM Material Number, if so required by the specific TTM site.
- 4.2 All copper foils supplied to TTM shall fulfill IPC-4562 Grade III for high temperature elongation High Tensile & Elongation (HTE) copper foil, unless otherwise specified on the Purchase Order.
- 4.3 All copper foils used in the manufacture of laminate shall be electro-deposited copper with one side surface treated, unless otherwise specified by TTM.
- 4.4 Laminate shall be stamped. There shall be at least one space between each set of stamped characters. Laminate with unequal copper weight shall be stamped on the heavier side. All cores will be stamped on the grain direction side near a corner (3"- 5") and/or as defined by the

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specific TTM manufacturing site. The entire lot shall be stamped on the same corner and stacked accordingly. Stamp should be stylus type pin-printed, permanent ink or laser. Metal stamping (impression) is not a preferred method.


- 4.5 There shall be no copper wrinkles as seen under normal or corrected 20/20 vision. If detected, the Material shall be scrapped.
- 4.6 Scratches are permissible for sheets or panels when less than 5% of the nominal copper thickness in depth and less than 4 inches in length.
- 4.7 Pits and dents are permissible to a maximum of 5-count per 11.8" X 11.8" for Class C inspection criteria. Class C is the minimum class acceptable to TTM with the exception of double treated foil, which shall meet the requirements set forth in IPC-4101 (current revision), Class B, unless the pit or dent extends across a conductor, then it may be considered a defect.
- 4.8 Edge roughness or scalloping that result in raised copper burrs is not acceptable. Scalloped edges that extend more than .125" into the panel from the edge are not acceptable.
- 4.9 Prepreg and copper foil is to be tooled to TTM pin systems as defined by the specific TTM site. The hole-edge shall be clean and free of fibers and flaps. Haloing and fracturing shall not extend beyond .075" from tooled holes.
- 4.10 Resin content will be +-1.5% of the nominal specification for the average of measurements for that roll, with a maximum of +-1.8% for any single measurement.
- 4.11 All laminate with a thickness of .020" or thicker shall be beveled. Supplier to obtain approval in advance of shipment, if requesting to ship product with unbeveled edges.
- 4.12 All laminates with a thickness thinner than .0409" shall be supplied with a thickness tolerance meeting the requirements of IPC 4101 (current revision) Class C, unless overridden by a site-specific document.
- 4.13 All laminates with a thickness of .0409" or greater shall be supplied with a thickness tolerance meeting the requirements of IPC 4101 (current revision). The following are the thickness Classes:
 - 4.13.1 For Class A, Class B and Class C laminate materials, the thickness of the laminate base material without the metal cladding shall be measured with a micrometer.
 - 4.13.2 For Class K, Class L and Class M materials, the thickness of the laminate with the metal cladding shall be measured with a micrometer.
 - 4.13.3 For Class D materials, the thickness shall be determined by micro-section.
- 4.14 Buried Capacitance cores shall pass hi-pot testing prior to shipment unless preapproved in writing by TTM. Test Method shall be submitted to TTM and approved prior to hi-pot testing.

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- 4.15 Embedded Device Materials used in the manufacture of Printed Circuit Boards shall comply with IPC-4811 or IPC-4821 Standards.
- 4.16 If External Heat Sinks or Stiffeners are used, the bonding material shall confirm to the IPC-4101, IPC-4202 or IPC-4203 Standards.
- 4.17 In the event of a conflict between the requirements of this Document and the requirements of other procurement documents, the following order of precedence shall apply:
 - 4.17.1 TTM Purchase Order
 - 4.17.2 TTM Site-Specific Material Specification Addendum
 - 4.17.3 This Document
- 4.18 Supplier shall manufacture products in accordance with the IPC Specification noted on the TTM Purchase Order.
- 4.19 Supplier shall utilize the description on TTMs' Purchase Order and/or associated documentation (i.e. TTM Material Part Number) to determine product characteristics (thickness, size, product type, etc.).

5.0 PACKAGING REQUIREMENTS

- 5.1 There shall be a unique lot / batch number identified for each lot of material supplied. This will allow for traceability through the supplier's process and paperwork. If the Supplier does not have the capability to comply with this requirement, TTM shall stipulate stamping requirements in the Purchase Order and/or associated documentation.
- 5.2 The labeling for each box shall contain, at a minimum, the following information:
 - 5.2.1 Manufacturer Name
 - 5.2.2 Manufacturer Location
 - 5.2.3 Date of Manufacture (i.e. date of application of resin to glass stock)
 - 5.2.4 Distributor Fabrication Date (i.e. cut date) – specific to Prepreg
 - 5.2.5 Purchase Order #
 - 5.2.6 TTM Part Number
 - 5.2.7 Lot / Batch #
 - 5.2.8 Quantity
 - 5.2.9 Width X Grain (Grain stated with a "G" designation) – specific to Laminate and Prepreg
 - 5.2.10 Resin Type – specific to Laminate and Prepreg
 - 5.2.11 Thickness – specific to Laminate
 - 5.2.12 Construction/Glass Style – specific to Laminate and Prepreg
 - 5.2.13 Copper weight and type – specific to Laminate and Copper Foil


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5.2.14 Expiration Date – specific to Prepreg

- 5.3 Prepreg packages will not exceed 50 panels per package. 106 and 1080 glass styles may be packaged in quantities up to 100 panels, other than for resins systems considered to be more hydroscopic than the norm. These hydroscopic resins will be packaged in maximum stacks of 25. Packages will be vacuum-sealed and/or nitrogen purged then sealed within the packages to prevent exposure to the atmosphere. All packaging will be moisture resistant.
- 5.4 Prepregs with low resin, high resin or no flow type shall be color coded and clearly marked to distinguish these materials from the standard.
- 5.5 Unless approved prior to shipment, external laminate or copper foil packages shall not weigh more than 50 lbs. and internal laminate or copper foil packages shall not weigh more than 15 lbs. unless specific TTM manufacturing sites have tighter requirements (i.e. 25 lbs.).
- 5.6 Exceptions specific to a TTM site do exist and are detailed in their internal documentation and the Supplier shall be held accountable, if they fail to comply.
 - 5.6.1 Example: Specific to Forest Grove: Each container shipped to Forest Grove shall be placed on, or be part of a skid that has the following nominal dimensions – 42” L x 36” W x 4” H. Alternative pallet sizes shall be approved in writing prior to regular shipments.
 - 5.6.1.1 Each pallet must have fork lift openings on the 36” ends.
 - 5.6.1.2 Containers shall be strapped or banded with a minimum of 2 straps in each direction to the pallet to prevent lateral movement during transport & handling.
 - 5.6.1.3 No more than two bulk containers per pallet.

6.0 SHIPPING REQUIREMENTS

- 6.1 Shipping tolerance - +/- 10%. TTM may accept over shipments. Supplier to contact TTM and advise of over shipment, TTM will advise if extra quantities can be accepted. Quantity detailed on the Package must be accurate.
- 6.2 Certificates of Conformance (C of C) are required for each lot of material shipped to TTM. The certificate shall contain the same information as that required under Section 5.2 detailed above.
 - 6.2.1 Supplier exceptions to the C of C requirements shall be maintained by Purchasing on the SCM Sharepoint Portal.
 - 6.2.2 If the material is from an Authorized/Licensed/Franchised Distributor, the Certificate of Conformance shall contain the original information from the Manufacturer, as required


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under Section 5.2, with the exception that the quantity and Purchase Order Number will refer to the quantity shipped by the Distributor.


- 6.3 Test Reports are required for each lot of Prepreg shipped to TTM.
- 6.4 The supplier shall specify in a timely manner, but always prior to shipment, if the shelf life of prepreg materials is less than 90 days from its' expiration date. All deliveries for these products shall be pre-approved by TTM.
- 6.5 The supplier shall ensure that all Prepreg shipped/delivered from consignment or VMI stock will be in order of the date of manufacture (i.e. FIFO).
- 6.6 Supplier shall follow the delivery method specified on the Purchase Order. Supplier may ship early, if approved by TTM.
- 6.7 Individual packages may be palletized. If so, they must be banded securely.
- 6.8 Packaging must prevent any damages to material shipped. The containers must be sufficient to withstand normal air and surface handling. TTM may reject any materials improperly packaged or secured.

7.0 GENERAL REQUIREMENTS

- 7.1 Supplier may utilize ink stamping or laser stamping. Ink must remain on the laminate core through standard inner layer resist stripping. If laser stamping is utilized, it shall penetrate deep enough into the copper so that it is legible during TTM's processes.
- 7.2 Supplier shall complete a current revision of the IPC-1730: Laminator Qualification Profile, and shall provide it, if requested by TTM.
- 7.3 Supplier shall disclose RoHS or REACH restricted substances.
- 7.4 In the event supplier suspects, or is made aware of a potential non-conformance in product already shipped to TTM, the supplier shall issue a quality alert to the TTM Director Supply Chain and the Corporate Quality Director for dissemination to all TTM sites. Supplier will work with TTM to immediately remove and replace, as warranted, such material.
- 7.5 Surface quality, thickness, length and width, material, etc. shall comply with the Purchase Order, and will be monitored upon receipt. TTM reserves the right to reject the entire Lot / Batch due to any nonconformance detected during the inspection/test process.

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- 7.5.1 Any construction change, process change or material change from other than what is specified on the Purchase Order "or purchase contract" must be approved in writing.
- 7.6 TTM reserves the right to reject the entire package if there is any evidence of packaging damage upon receipt.
- 7.7 Supplier shall notify TTM, in writing at least 90 days in advance, of any changes to suppliers product, raw materials and/or process that may have a potential impact on the quality of supplier's and/or TTMs' finished product. This includes but is not limited to, changes in facilities, equipment and critical material suppliers.
- 7.8 When requested by TTM, TTMs' customer or a regulatory agency, and when provided with reasonable written notice from TTM, the supplier shall grant right of access to all facilities and applicable records pertaining to TTMs' orders.
- 7.9 Supplier shall ensure TTM requirements as outlined on the Purchase Order, this document and applicable documents, as well as, additional key characteristics are provided to sub-tier suppliers, as applicable, to ensure conformance to TTMs' requirements.
- 7.10 TTM may, from time to time, request a summary document demonstrating (via collected data) the supplier's process capabilities to include:
- 7.10.1 Laminate thickness
- 7.10.1.1 Each line item should list the applicable construction; mean, upper and lower control limits, the standard deviation, Cpk and Cp. Histograms or profile charts accompanied by the descriptive statistics, to provide evidence of consistency of the supplier's process for each laminate thickness.
- 7.10.2 Prepreg resin content
- 7.10.2.1 Each line item should list the applicable construction; mean, upper and lower control limits, the standard deviation, Cpk and Cp. Histograms or profile charts accompanied by the descriptive statistics, to provide evidence of consistency of the supplier's process for each construction.
- 7.10.3 Control Limit violations
- 7.10.3.1 All instances of control limit violations will require a formal response from the supplier.
- 7.11 TTM orders may be rated as "DX" or "DO" under the Defense Priorities and Allocations System regulation (15 CFR 700). When deemed necessary, TTM will clearly mark "DX" on applicable

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Purchase Orders. Supplier is required to follow all the provisions of that regulation in filling the order and in obtaining items needed to fill the order. If the supplier rejects such an order, the supplier shall notify TTM in writing within 2 business days.

- 7.12 Supplier shall maintain records on file for a minimum of 7 years from date of shipment. Records include but are not limited to test report data, inspection results, certificate of compliances (C of C's), etc. Records shall be available within 24 hours of request.
- 7.13 A formal corrective action plan will be required from the supplier if materials received do not conform to this specification and/or the purchase order.