RT/duroid® 5870/5880 High Frequency Laminates Fabrication Guidelines

Notes on Packaging, Receiving, Storing, and Preparation for Processing

Packaging

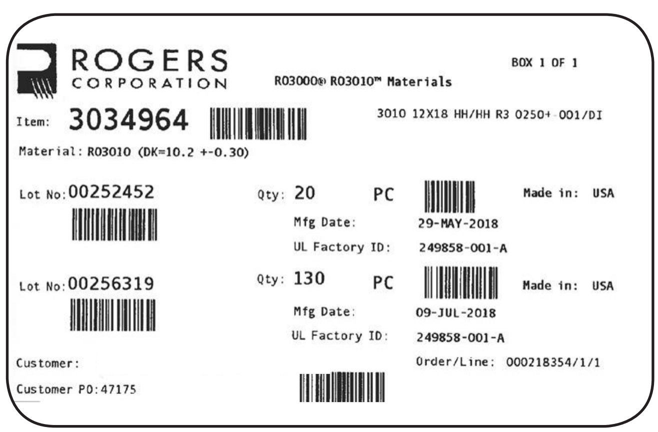
High frequency circuit laminates are shipped in reinforced corrugated cardboard containers. Filler cardboard sheets, self-adherent polyethylene sheets, and vacuum-sealed poly bubble pack protect the materials against damage during shipping.

Receiving

1) Open the shipping cartons and inspect material immediately upon receipt.
2) Advise the carrier of any shipping damage noted. It is helpful to photograph the containers and contents to support your claim.
3) All quality problems should be reported to Rogers' Customer Service as soon as possible, and not later than 30 days after receipt of the product.
4) Damaged or rejected material should not be returned without a proper return authorization obtained from the Customer Service Representative. Returns without proper authorization may be refused.
5) Every panel is packaged and labeled with the product identification and lot and sheet numbers. An example of a typical label is provided. Verify that this label is present on individual cores when the shipment is received.
6) Rogers Corporation maintains full traceability records for individual laminates based upon lot and sheet numbers. Maintaining traceability is often essential to understanding and correcting any problems that may arise. It is strongly urged that customers adopt an appropriate procedure for maintaining the identification of individual panels through storage, processing, and delivery of final product.

Storage

Rogers' laminates can be stored indefinitely at normal ambient room temperatures (65°F to 85°F, 18°C to 30°C) and humidity levels. At room temperature, the dielectric materials are inert to high humidity and atmospheric pollutants such as industrial gases and marine salts. However, metal claddings, such as copper foil or thick aluminum, brass, and copper backing can be oxidized or corroded during direct exposure to high humidity, sulfur oxides, and marine salts. The adherent polyethylene cover sheet (thick cores) or polythelene bag (thin laminates) provides a large measure of protection from corrosive atmospheres. Normal cleaning procedures, covered later in this publication, readily remove traces of corrosion from properly stored materials.



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Storage in Original Shipping Cartons

1) Stack cartons on a flat surface that is safely out of the way of mobile handling and moving equipment.
2) Cartons should be stacked to a maximum of five high to avoid excessive weight on the bottom packages.

Storage of Panels Removed from Cartons

1) Thin panels should remain sealed within the polyethylene bags and the adherent polyethylene sheets should remain on thicker cores. These packaging materials deter oxidation and corrosion of the metal layers and provide a measure of protection against mechanical damage (i.e. scratches, pits, dents, etc.).
2) Store panels on edge in slotted shelving units keeping the clad surfaces vertical. This provides easy access with low risk of damage to the metal surfaces.
3) If storage facilities do not permit vertical stacking:
   A) The shelf must be flat, smooth, and clean.
   B) The shelf must extend beyond the full area of the panels being stored.
   C) Surfaces of the laminates must be free of debris.
   D) Shelf loading should be kept below 50 pounds per square foot.
   E) Panels should be interleaved with soft, non-abrasive separator sheets.

Handling

PTFE-based materials are softer than most other rigid printed wiring board laminates and are more susceptible to handling damage. Cores clad only with copper foils are easily creased. Materials bonded to thick aluminum, brass, or copper plates are more prone to scratches, pits, and dents. Proper handling procedures should be followed.

1) Wear gloves of knit nylon or other non-absorbent material when handling panels. Normal skin oils are slightly acidic and readily corrode copper surfaces. Fingerprints are difficult to remove as normal brighteners will dissolve the corrosion, but leave corrosive oils in the copper to cause the fingerprint to reappear hours or days later. The following procedure is recommended to remove fingerprints:
   A) Bright dip in dilute hydrochloric acid.
   B) Degrease in acetone, methyl ethyl ketone, or vapor degrease with chlorinated solvents.
   C) Water rinse and bake dry for 60 minutes @ 250°F (125°C).
   D) Repeat bright dip.
2) Keep work surfaces clean, dry, and completely free of debris.
3) Leave the polyethylene bag or sheet in place through initial processes such as shearing, sawing, blanking, and punching.
4) Only pick panels by two edges. Thin cores in particular lack the stiffness required to support themselves by one edge or corner, handling them in that manner may dimensionally distort the dielectric or impart a permanent crease.
5) During processing, cores should be transported between workstations on flat carrying trays, preferably interleaved with a soft, sulfur-free paper. Vertical racks should not be used unless they are slotted and provide adequate vertical support.

Single- and Double-Sided PCB Fabrication Guidelines

Surface Preparation

For panels protected by self-adhering polyethylene sheet, use the following steps to remove it and any adhesive residue. This should be done prior to drill (double-sided process) or just before the final copper cleaning step that immediately precedes the application of photoresist in a single-sided process. As mentioned before, gloves should be worn.

1) Lay the panel on a flat clean surface.
2) Peel back the film at one corner and extend the starting peel across the short edge.
3) Hold the exposed panel end against the flat surface and gently peel off the film in a horizontal direction away from the starting edge.
4) Turn the panel over and remove the film on the other side in a similar manner. Make sure that the work surface remains clean.
5) Remove adhesive residue by wiping with a lint-free cloth soaked in an alcohol solvent. Isopropanol, 70% to 100%, is recommended for low toxicity and flammability. Ketones, such as acetone or MEK, or halogenated hydrocarbon degreasing solvents are not particularly effective for removing adhesive spots.
6) The solvent clean should be followed with a clean water rinse.
7) Remove copper oxides using commercially available cleaners and microetchants.
8) Abrasive cleaning (e.g. pumice powder or conveyorized brush scrubbing) is not recommended. Mechanical surface preparation tends to cause microscopic scratches in copper. These scratches become stress risers that can lead to thermal stress cracks in some environmental conditions. While we strongly recommend against abrasive cleaning, we do understand in some circumstances that it can't be avoided. When abrasive cleaning is required, it should be performed with minimal pressure and an understanding of the risks involved. Brush scrubbing may cause material distortion.

Tooling Holes

Pinning or tooling holes can be punched, drilled, or routed using normal procedures.

Drilling

Avoiding Smear

Smear on drilled via walls is a well-known problem with epoxy-glass laminates. Overheated tools can thermally decompose the epoxy resin system causing it to soften. The softened resin system stretches slightly during drilling causing a connected "flap" of resin to form. Small pieces of debris may become lodged during drilling between the hole wall and the tool when they become shear-deformed and are loosely re-deposited. Resin flaps and re-deposited debris can be removed during plasma or permanganate desmear processes.

Similar types of smear occur when drilling PTFE composites. While re-deposited debris can be dislodged using vapor honing, there doesn't exist a proven way to remove the flap-style smear that is connected to a hole wall. As smear can't be readily removed, it must be avoided by employing tightly controlled drilling parameters and conservative tool life expectations.

Stack Construction

RT/duroid® 5870/5880 cores can be drilled individually or in stacks using pressed phenolic composite boards for entry and exit. The total thickness of the core material plus entry material and penetration into exit material should not exceed 75% of the drill's flute length. For most applications, the maximum stack height should be less than 0.240 inch (6.1 mm).

Drill Type

Carbide drills should be used to minimize wear of cutting edges. Standard style drills with an included lip angle of 130° are recommended. Undercut style drills where the flute diameter is reduced 0.025" (0.65 mm) from the cutting end may help to reduce re-deposited smear. The use of new drills is strongly urged. Re-pointed drills, if used, must be precision ground and visually inspected prior to use.

Drill Parameters

The optimum tool surface speed and infeed rates are 150 to 250 surface feet per minute (45 to 75 meters per minute) and 0.0015" (0.035 mm) to 0.0025" (0.065 mm) per revolution. The retract rate should be maintained between 400 and 500 inches per minute (IPM) (10 and 13 meters per minute). The drill bit should be changed once it has drilled 12" (30 cm) of dielectric.

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Equations for using surface speed, infeed rate, and tool diameter to calculate spindle and infeed speeds are provided below along with a quick reference table:

Entry: Phenolic Composite		0.010"-0.030" (0.25-0.75 mm)
Exit: Phenolic Composite		>0.060" (1.5mm)
Chip Load:		0.0015-0.0025" (0.032-0.065mm)
Surface Speed:		150-250 ft/min (45-75m/min)
Retract Rate:		400-500 inch/min (10-13 m/min)
Tool Life Estimates:	**Stack Height**	**Maximum Hit Count**
	0.060" (1.5mm)	300
	0.120" (3.0mm)	250
	0.180" (4.5mm)	100

Equations for calculating spindle speed and infeed rate:

Spindle Speed (RPM)=765/Tool Dia. (inch)
Infeed (IPM) = Spindle Speed X Chip Load

Quick Reference Table for Various Tool Diameters Calculated Using 200 SFM and 0.002"/":

Tool Size		Spindle Speed	Infeed	
(in)	**(mm)**	**(RPM)**	**(IPM)**	**(m/min)**
0.0197	0.50	38800	77.6	2.0
0.0256	0.65	29800	60.0	1.5
0.0295	0.75	25900	51.9	1.3
0.0394	1.00	20000	40.0	1.0
0.0492	1.25	20000	40.0	1.0
0.0625	1.59	20000	40.0	1.0
0.1250	3.18	20000	50.0	1.0

Deburring

The use of flat, rigid entry/exit materials, conservative drilling parameters, and limited hit counts with new drills should minimize the risk of copper burring. When drilled properly, the cores should be ready for subsequent processing. Chemical preparation is preferred, but if mechanical or hand pumice scrubbing processes are used to deburr boards, the force applied must be minimized to prevent gouging and dimensional distortion.

Hole Preparation

Loosely re-deposited debris in the holes can be removed using vapor- or hydro-honing processes. These processes involve directing abrasive particles carried in water or air streams through the drilled holes. The soft laminates must be adequately supported through these processes. A glass etch in hydrofluoric acid may be required after drill.

Drilled holes in PTFE-based laminates must be treated prior to the deposition of a conductive seed layer (e.g. electroless copper or direct metallization). Not performing a surface activation treatment will most likely result in poor metal adhesion or plating voids. Two common pre-treatments for PTFE materials are sodium treatment and plasma treatment. Sodium treatment is very much the preferred option for treating RT/duroid 5870/5880 materials. Plasma treatment should be considered only if a direct metallization process will be used instead of electroless copper.

Sodium treatments consist of a highly reactive sodium napthalene complex in glycol ether solution. They are very effective at making PTFE surfaces wettable prior to metal deposition.

Sources for sodium treatment chemicals:

FluoroEtch® Etchant
Acton Technologies, Inc
100 Thompson St
Pittston, PA 18640
570-654-0612

W.L. Gore Tetra-Etch® etchant 500 ML available from
R.S. Hughes Company, Inc
1162 Sonora Court
Sunnyvale, CA 94086
408 739 3211

Sources for sodium treatment services:

FluoroEtch Etchant
Acton Technologies, Inc
100 Thompson St
Pittston, PA 18640
570-654-0612

G & S Associates
1865 Sampson Ave.
Corona, CA 92879
http://www.gsassociates.com
951 739 7513

A recommended plasma treatment prior to direct metallization would use a 70/30 H2/N2 blend, NH3, or N2 gases. Plasma conditions would be:

Gases:	70/30 or 80/20 H2/N2, NH3, N2 or He
Pressure:	100 mTORR pumpdown
Power:	4000 Watts
Frequency:	40 KHz
Voltage:	500-600 V
Cycle Time:	10-30 minutes

Courtesy of March Plasma

Gases	H2/N2	He	N2
Power	1800W	1800W	1800w
Frequency	13.56 MHz	13.56 MHz	13.56 MHz
Pressure	150 mTor	173 mTor	181 mTor
Gas Mixture (%)	70/30	100	100
Temperature	200°F	200 °F	200°F
Time (minutes)	10 to 20	5 to 10	5 to 10

Courtesy of Plasma Etch Systems

Metallization

Low to regular deposition rate electroless copper processes or electroless copper alternatives such as Crimson, Shadow, and Black Hole may be used to deposit a conductive seed layer once the PTFE surface has been properly treated. As the PTFE resin system is soft and somewhat compressible, a flash plate build-up of copper 0.0001"–0.0003" (0.0025-0.0076mm) thick should be applied prior to preparing metal surfaces for photoresist.

External Circuitization

The following guidelines are based upon a conventional pattern plate process.

Photoresist Application/Imaging/Developing

Copper surfaces should be chemically prepared rather than mechanically scrubbed prior to photoresist application. A standard chemical preparation process would include cleaners to remove oily deposits and fingerprints and a microetch to remove copper passivation layers and oxides. Standard photoresist application, imaging, and developing procedures can be used.

Electroplating Cu & Sn/Pb or Sn

Conventional electroplating processes can be used. Panels should be handled carefully during racking and unracking to avoid damage or distortion.

Resist Strip,Cu Etch, Sn or Sn/Pb Strip

Standard etchants and strip solutions may be used. Complete rinsing should follow the strip/etch/strip processing. Thin cores may require the support of leader boards or frames through conveyorized processes.

The post-etched surface of the cores will retain the imprint of the copper cladding's dendritic tooth profile. This surface, if left undisturbed, provides adequate surface area for mechanical bonding of most soldermasks and adhesive systems used for multi-layer bonding. Not wiping or scrubbing the etched surfaces will allow the cores to proceed through soldermask application or multi-layer bonding without requiring special pre-treatments. Sodium treatment would become required if the etched surfaces are disturbed in any manner.

Soldermask Application

Epoxy-based solder masks such as Hysol® SR1000 are preferred if the soldermask will be selectively silver screened. Most photoimageable solder masks have been found to provide adequate adhesion.

Final Metal Surface

All final metal surface options (i.e. HASL, Sn, Sn/Pb, Ni/Au, Ag, OSP, etc.) can be applied using normal procedures.

Final Circuitization

Individual circuits in RT/duroid 5870/5880 materials can be routed, scored, or punched depending upon edge quality requirements. General recommendations for routing are provided below:

Tool type: The preferred tools for routing soft PTFE materials are carbide double-fluted, spiral–up endmills. Tool styles which provide numerous cutting edges (e.g. diamond-cut and multi-fluted chipbreakers) quickly become clogged with resin. Drill point, as opposed to fishtail end, router bit designs are preferred.

Entry/Exit/Interleaving Materials

Rigid pressed phenolic composite board materials are required to provide adequate support to the soft dielectric materials. Three to four sheets of kraft paper should be interleaved between cores when routing multi-panel stacks. Kraft paper may be required against circuit surfaces when routing through etched metal features.

Rout Parameters and Tool Life

Surface speeds of 150 SFM (45 m/Min) and lateral feed rates of 0.002" (.05 mm) per revolution are recommended. The equations used to calculate drill conditions based upon tool diameters are also used to calculate routing speeds. Tool life expectancy is between 30 and 50 feet of linear travel.

Special Considerations For Improved Edge Quality

- Pre-rout vacuum channels in backer boards to improve the efficiency of debris removal.
- Make rough cuts by moving the router bit along outside edges in a counterclockwise direction and along internal edges in a clockwise direction. Make a second fine cut in a similar direction.
- Whenever possible, rout through copper layers, as doing so minimizes burr formation.

Multilayer Considerations

Inner-Layer Preparation

Standard photoresist and etch procedures are used. Care should be taken to preserve the as-etched dielectric surface or a sodium treatment of the surface would become necessary. Selection of an appropriate copper surface treatment is dependent upon the adhesive system selected.

Adhesive Systems

Two categories of adhesive systems, thermoplastic and thermoset, have been used when bonding RT/duroid 5870/5880 multilayers. Thermoplastics, such as DuPont's FEP film or Rogers' 3001 film, are typically selected when electrical properties of the adhesive layers are critical. The dielectric constant and dissipation factor of FEP is 2.1 and 0.0003. The dielectric constant and dissipation factor of 3001 film is 2.28 and 0.003. Thermosets, such as FR-4 prepreg can be chosen when electrical properties are less critical.

Thermoplastics

Melting point is an important consideration when selecting a thermoplastic adhesive. FEP melts at 500°F (260°C) and is therefore stable through most PCB and assembly processes. The 390°F (200°C) melting point of 3001 film can result in the film re-melting if subsequent PCB or assembly processes are higher in temperature and longer in duration than a few minutes. Copper surfaces should be prepared using a microetch, brown oxide, red oxide, or one of the subtractive process oxide alternatives. 3001 film should not be used against a continuous metal plane.

The thermoplastic adhesives should be bonded with applied pressure between 50 and 250 PSI. The ramp to temperature (525-550°F, 275-290°C for FEP, 425-450°F, 220-230°C for 3001) can be 6-8°F/Min (3.5-4.5°C/Min) and the dwell at temperature should be 20-30 minutes. Cooling to 250°F (120°C) at a rate of 2-4°F/Min (1.5-2.5°C/Min) should be completed under pressure. Transfer cooling can result in delamination.

Thermosets

Refer to vendor recommendations for appropriate oxide types and bond conditions when using thermoset adhesive systems.

Post-Bond PCB Processing

Guidelines for double-sided circuit processing would apply to multilayer through hole and outer-layer processing.

The information in this fabrication guideline is intended to assist you in fabricating Rogers' circuit materials. It is not intended to and does not create any warranties express or implied, including any warranty of merchantability or fitness for a particular purpose or that the results shown on this fabrication guideline will be achieved by a user for a particular purpose. The user should determine the suitability of Rogers' circuit materials for each application.

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