P95/P25 & P96/P26 Processing Guide

The processing guidelines contained in this document were developed through in-house testing and field experience. However, they *should be considered to be starting points that will require further adjustment.* Read the following review of processes for applicability to your particular Printed Wiring Board (PWB) fabrication environment. Remember that the suggestions contained herein can not account for all possible board designs or processing environments. Additional adjustments by the fabricator will be necessary. Isola can and will assist with this process, but the fabricator, not Isola, is ultimately responsible for their process and the end results. Fabricators should verify that PWBs made using these suggestions meet all applicable quality and performance requirements.

Part 1: Prepreg Storage and Handling

Isola Group's prepreg bonding sheets for use in multilayer printed circuit board applications are manufactured to specifications that include physical and electrical properties and processing characteristics relative to the laminating application. Handling and storage factors have an important influence on the desired performance of the prepreg. Some parameters are affected by the environment in which prepregs are stored. They can also deteriorate over extended periods of storage. The prepreg received by the customer is a glass fabric that has been impregnated with a stated quantity of low volatile, partially polymerized resin. The resin is tack-free but somewhat brittle. Many lamination problems arise from resin loss off the fabric due to improper handling. The fabric used is based on the order and supplies the required thickness. In most cases the amount of resin carried by the fabric increases as the fabric thickness decreases.

Isola Group offers a product line of polyimide-based prepregs and copper clad laminates for high temperature printed circuit applications. These products consist of an all polyimide resin system suitable for military (P95/P25), and flame resistant products (P96/P26) for commercial or industrial electronic applications requiring superior performance and the utmost in thermal properties. They utilize bismaleimide resin, fully cured without the use of MDA (Methylene Dianiline). The resulting polymer has a high Tg without the characteristic difficulties of brittleness and low initial bond strength associated with traditional thermoset polyimides.

Handling Suggestions

Handle all prepreg using clean gloves. Use sharp, precision equipment when cutting or paneling prepreg. Treat all prepreg as being very fragile. Use extreme care when handling very high resin content prepreg (glass fabrics 1080 and finer).

Storage Suggestions

Upon receipt, all prepreg should be immediately moved from the receiving area to a controlled environment. All prepreg should be used as soon as possible using a First-In-First-Out (FIFO) inventory management system. Prepreg properties will be maintained for 3 months when stored at 23°C (73°F) and below 50% relative humidity. If extended storage is required, separate facilities should be reserved with appropriate environmental control. **However, refrigeration at temperatures less than 41°F have limited effect on the useful life of polyimide prepregs. Long-term vacuum storage is *not* recommended.**

Polyimide prepreg flow characteristics are more responsive than typical epoxies to external factors such as moisture. Prepreg packages should be allowed to equilibrate to layup room conditions before opening to prevent moisture condensation on the prepreg.

Stabilization time will depend on storage temperature. In cases where storage temperature is significantly below room temperature, keep prepreg in package or plastic wrapping during stabilization period to prevent moisture condensation. Once the original packaging is opened, the prepreg should be used immediately. Remaining prepreg should be resealed in the original packaging with fresh desiccant. Storage should be in the absence of catalytic environments such as high radiation levels or intense ultraviolet light.

Prepregs are sold to IPC-4101C specifications, **except that storage at or below 5°C (41°F) does not extend the product's shelf life to 6 months.** After delivery to the customer, retesting services are available, but passing retest results do not constitute a re-certification. Prepregs will be tested at the original manufacturing site or at another appropriate site to be determined by Technical Service.

Prepreg Selection

Minimize the use of high resin content prepreg whenever possible to prevent excessive layer movement, Z-axis CTE and thickness variation. For best drilling and hole quality, selection of glass styles to match core constructions is recommended. For more information and assistance, consult with an Isola Group Technical Service Representative.

P25 prepreg is typically paired with P95 cores. Both materials are UL listed as "HB" material.

P26 prepreg is typically paired with P96 cores. Both materials are UL listed as "V-0" material.

Part 2: Innerlayer Preparation

Isola Group's P95/P96 laminates are fully cured and ready for processing. It has been the experience of most fabricators that stress relief bake cycles are not effective in reducing any movement of high performance laminates such as P95 and P96. Therefore, it is suggested that the movement of unbaked laminate be characterized and the appropriate artwork compensation factors are used.

Dimensional Stability

The net dimensional movement of laminate after the etch, oxide and lamination processes is typically shrinkage. This shrinkage is due to the relaxation of stresses that were induced when the laminate was pressed as well as shrinkage contribution from the resin system. Most of the movement will be observed in the grain direction of the laminate.

There are situations that have been known to alter the proportion of shrinkage in grain versus fill direction in some board shops. These include autoclave pressing and cross-plying laminate grain direction to that of prepreg. While both of these practices have their advantages, material movement must be uniquely characterized.

The dimensional movement of high performance laminates is generally greater than that of epoxies.

Table 1 (for reference) illustrates the suggested approach to characterizing laminate movement and provides *approximate* artwork compensation factors for P95/P96 laminate when using a hydraulic press.

Table 1: Initial Artwork Compensation Factors

Base Thickness	Configuration	Direction	Comp (in/in)
≤ 0.005″	Signal/Signal	Warp (grain)	0.0008-0.0010
"	"	Fill	0.0001-0.0003
"	Signal/Ground	Warp (grain)	0.0006-0.0008
"	"	Fill	0.0001-0.0003
"	Ground/Ground	Warp (grain)	0.0002-0.0004
"	"	Fill	0.0000-0.0002
0.006-0.009″	Signal/Signal	Warp (grain)	0.0006-0.0008
"	"	Fill	0.0001-0.0003
"	Signal/Ground	Warp (grain)	0.0004-0.0006
"	"	Fill	0.0001-0.0003
"	Ground/Ground	Warp (grain)	0.0000-0.0002
"	"	Fill	0.0000-0.0002
0.010-0.014″	Signal/Signal	Warp (grain)	0.0002-0.0004
"	"	Fill	0.0000-0.0002
"	Signal/Ground	Warp (grain)	0.0001-0.0003
"	"	Fill	0.0000-0.0002
"	Ground/Ground	Warp (grain)	0.0000-0.0002
"	"	Fill	0.0000-0.0002

This table assumes that laminate and prepreg grain directions are oriented along the same dimension. Each shop must characterize material behavior given their particular lamination cycles, border designs and grain orientation of laminate to prepreg. It is also suggested that specific laminate constructions be specified and adhered to so that dimensional variations due to changes in construction are avoided.

Table 1 assumes that signal layers are either half or 1 ounce copper and ground layers are either 1 or 2 ounce copper. Thicker copper will generally contribute to greater dimensional movement in designs where the majority of the copper is removed.

Imaging and Etching

P95/P96 laminates are imaged using standard aqueous dry films and are compatible with both cupric chloride and ammoniacal etchants.

As with any polyimide laminate, prolonged or repeated exposure (such as image rework) to aqueous resist stripper baths with higher levels of alkalinity should be avoided. Strip and rinse should be thorough and finished with high quality water at neutral pH.

Bond Enhancement

Only oxide alternative chemistries are recommended for fabricating P95/P25 and P96/P26 multilayer boards. Users should make sure the oxide or oxide replacement coating exhibits a consistent, uniformly dark color.

Contact your Isola representative for use of P95/P96 materials with standard oxide processes.

Final rinses should be very thorough and include tempered high quality water at neutral pH. **Polyimide innerlayers should be thoroughly dried in an oven prior to lay-up. Bake cycles that fall between 200°F and 250°F for 60 minutes are generally acceptable.** It is generally suggested that post-oxide baking be performed vertically, in racks.

However, drying of layers for 30 minutes minimum @ 100°C (212°F) or higher is considered a requirement, regardless of whether or not the polyimide boards will be subjected to "lead-free" processes. Drying in racks is preferred.

The use of DSTFoil™ will typically increase the bond strength by approximately 1 to 1.5 lbs as compared to non-DSTFoil copper foil.

If immersion tin adhesion treatments are used, the fabricator should test the coating to verify adequate bond strength is developed with P25 and P26 prepregs.

Automatic Optical Inspection

P95/P96 etched polyimide laminates do not naturally fluoresce for enhancement of laser-based AOI systems. However, the dark tan-orange color provides contrast to copper for reflectance based AOI systems.

Part 3: Lamination

Package Lay-Up

If the prepreg has been stored such that moisture absorption may have occurred, it should be conditioned prior to lay-up. Subjecting the prepreg to vacuum desiccation for 8-24 hours prior to lay-up (24-hour duration using small stack height is suggested) will improve the flow consistency and produce higher Tg and superior product properties.

Standard Lamination

The use of Advanced Bond or Polytreat copper foil is strongly recommended. (Contact an Isola representative if additional help or process information is needed.)

The amount of time at cure temperature, and to some extent the actual cure temperature of P95/P25 and P96/P26 multilayer boards, will be determined by the thickness of the multilayer package being produced. Very thick boards will require a longer cure time to assure optimum material performance.

Sequential Lamination

Due to the variation in designs for sequential lamination, we recommend contacting your Isola representative to get recommendations for your application.

Removal of the polyimide flash should be performed by routing rather than shearing to minimize crazing along the panel edges.

Single-Stage and Dual-Stage Press Cycle Lamination

The suggested lamination parameters for the single-stage and dual-stage lamination cycles are shown in **Table 2** and **Table 3.** The lamination cycle selected will be a function of board stackup, complexity and thickness as well as the lamination presses capability. **Thicker boards may require additional dwell time at curing temperature to achieve full cure.** See "Standard Lamination" previously discussed.

Choosing a dual stage or "kiss" cycle for P95/P25 and P96/P26 multilayer boards may improve results in some applications. Use these cycles to enhance the wetting of the glass along the extreme edges and corners of the panel or to minimize circuit image transfer ("telegraphing") on foil constructions.

All cycles include a pressure reduction step in the lamination cycle, which facilitates stress relief of the package during the cure step. Further, all cycles assume vacuum is maintained throughout the heating cycle and all cycles presume that the book is cooled to a temperature well below the Tg of the material before the press is opened. All three conditions are considered to represent "best practice" conditions during lamination by Isola.

While use of both the pressure drop cycle and cooling well below Tg in the "hot" press are strongly suggested, these steps are considered to be "optional" and the PCB fabricator may have equipment or capacity limitations which prevent following these suggestions.

Table 2: P95/P25 and P96/P26 General Lamination Parameters

Vacuum Time	30 minutes (no pressure, product on risers)
Curing Temperature	220°C (425°F)
Curing Time	150 minutes (above 220°C (425°F) Thicker boards (>3 mm) should be cured 180 min.
Resin Flow Window	80 to 140°C (180 to 280°F) Maintain heat ramp in this temperature range.
Heat Ramp	5.0 to 7.0°C/min (9 to 13°F/min)
Pressure	See Table 2.
Pressure Application	Single Stage – Apply pressure after vacuum dwell time. Dual Stage – 50 PSI (3.5 Kg/cm²) after vacuum dwell time, switch to high pressure ≤ 90°C product temperature.
Pressure Drop	After 30 minutes at cure temperature, reduce pressure to 50 PSI (3.5 Kg/cm²) in hot press (optional).
Cool Down	Cool to 135 to 140°C (275 to 285°F) at 2.8°C/min (5.0°F/min) with 50 PSI (3.5 Kg/ cm²) pressure prior to removing or transferring the load.

Table 3 outlines general suggestions for lamination pressure based on press type used. However, the fabricator should take board design characteristics and panel size into account when setting pressure.

Table 3: P95/P25 and P96/P26 Lamination Pressure

Lamination Method	Suggested Pressure Range
Hydraulic Pressing (without vacuum assist)	300-350 PSI 21-25 Kg/cm²
Hydraulic Pressing (with vacuum assist via vacuum frames or bags)	250-300 PSI 18-21 Kg/cm²
Hydraulic Pressing (vacuum enclosure)	200-250 PSI 14-18 Kg/cm²
Autoclave Pressing	150-175 PSI 11-12.5 Kg/cm²

Oven Cure Option

For those situations where either press capacity or press temperature capability is a restricting factor, boards can be cooled after 60 minutes at 182°C (360°F) and removed from the press. A post-lamination bake in a convection oven will be necessary to complete the cure, using the following process:

1. Carefully remove packages from tooling and remove all flash from panels. The flash should be removed by routing processes instead of shearing processes in order to avoid crazing. **NOTE: Polyimide in an undercured state will be very brittle. Handle panels very carefully.**
2. Vacuum all debris and dust from panels.
3. Stack panels on flat shelves or a flat support apparatus so that the panels remain flat. Keep stack height to less than 1″.
4. Place the panels in an air circulating convection oven and raise the oven temperature to a temperature that permits all panels in the stack to reach 218°C (425°F) for a minimum of 3 hours. It is strongly recommended that the fabricator place a thermocouple in the center of the stack when setting up the process conditions (oven temperature set point and total dwell time) to ensure that the panels are exposed to the suggested curing conditions.
5. Allow panels to cool slowly by shutting the oven heaters off and opening the oven door. Allow the panels to cool until they are cool enough to handle before removing them from the oven. Note that handling hot panels can induce warpage.

Part 4: Drill

General

Polyimide materials are more difficult to drill than conventional FR-4 epoxy materials. The material is very abrasive and drill wear will occur more quickly than with conventional epoxy laminates. Drilling parameters and other processing conditions are very dependent on circuit boards features, including thickness, number of conductor layers, etc. The following information should be considered for initial set-up and modified as appropriate for the individual situation.

Panel Stack Height

Panel stacks should not exceed 0.200″ in total height of board material. If the individual panel thickness exceeds 0.100″, then better results will be attained by drilling the boards one-high.

Hit Count (Number of Hits)

The number of hits on a single drill bit should be limited to 750 to 1,200. This is dependent on the board design and build, board/stack thickness, number of copper layers, etc. The bit size will also dictate the number of hits. Note that an excessive hit count will produce excessive drill bit wear and will impact hole wall roughness and quality.

Drilling Support Materials

Drill bit suppliers and drill entry/backup material suppliers should be consulted when choosing entry and backup materials for polyimide drilling. Proper choice of entry material can help to reduce drill bit entry burrs, can reduce drill wander and in some cases can assist in heat dissipation.

Backup materials provide stack support and can facilitate both chip removal and heat dissipation, depending on the material chosen. Lubricated materials and materials designed specifically to reduce bit temperature can be advantageous when drilling polyimide materials due to the higher heat levels generated during drilling of polyimides vs. epoxy materials.

Table 4: Suggested Drilling Parameters For Initial P95/P96 Setup

Drill Size		Spindle Speed	Surface Speed Per Minute		Infeed		Chipload		Retract	
Inch	mm	RPM	SFPM	SMPM	Inch min.	Meter min.	Mil Rev.	mm Rev.	Inch min.	Meter min.
0.0098	0.25	75,000	193	59	60	1.52	0.80	0.020	600	15
0.0118	0.30	72,000	223	68	63	1.60	0.88	0.022	800	20
0.0138	0.35	72,000	260	79	67	1.70	0.93	0.024	800	20
0.0157	0.40	69,000	284	87	69	1.75	1.00	0.025	1000	25
0.0197	0.50	57,000	294	90	57	1.45	1.00	0.025	1000	25
Contact your Isola Technical Support representative for large hole drilling parameters.										

Drill Bits

Use only new bits. Conventional geometry bits are acceptable for larger holes, (> 1.25 mm in diameter). Undercut bits are recommended for holes less than 1.25 mm diameter. Justification depends on board configuration (thickness, aspect ratio, total copper, etc.) and drill limitations.

Cutting Speed and Chipload

Maximum cutting speeds of 300 to 500 SFPM are recommended. Chiploads should not exceed 2.5 mils for bit diameters of .040″ and above. **Table 4** provides a set of suggested parameters for initial set-up of the drill operation for Isola polyimide laminates. It provides drill parameters by bit diameter for a maximum cutting speed of 500 SFPM and maximum chipload of 2.5 mils. Modifications may be necessary given the individual drill application. Thick boards with heavy copper or special cladding such as invar will require more conservative drill parameters.

It is suggested that drill bit suppliers also be contacted for drilling parameter suggestions that are specific to their drill bit geometries.

Part 5: Hole Wall Preparation

General

Good desmear and electroless copper deposition performance are more easily achieved when the drilled hole quality is good. The generation of smooth, debris free hole walls is influenced by the degree of resin cure, drilling conditions and board design considerations. The elimination of 7628 or similar heavy glasses (whenever possible), coupled with properly adjusted drill parameters on fully cured boards has been shown to improve overall drilled hole quality. This helps reduce smear generation, which improves desmear performance and can ultimately help to reduce copper wicking.

Factors which influence chemical desmear rates, and therefore the suggestions in this document, include: resin type, chemistry type, bath dwell times, bath temperatures, chemical concentrations in each bath and the *amount of solution transfer through the holes.*

Factors which influence the *amount of solution transfer through the holes* include: hole size, panel thickness, work bar stroke length, panel separation in the rack and the use of solution agitation, rack vibration and rack “bumping” to remove air bubbles from the holes.

Chemical Desmear

Although the term “desmear” is usually a misnomer when dealing with polyimides, standard permanganates have provided a satisfactory hole wall cleaning of Isola Group polyimides prior to plating. Consult your chemical supplier in setting up a permanganate process, as there are specific solvent baths available for polyimides.

Plasma Desmear

Plasma processing can be used to remove drill smear and debris. During plasma processing, polyimide hole walls tend to become very smooth, which can result in low electroless copper adhesion. Further, some ash may also be present after plasma etching is complete.

Boards should be subjected to a single pass through the permanganate desmear line to provide suitable roughness in the hole wall and remove the residual ash. Although not mandatory, this “best practice” increases process latitude in subsequent metallization steps and is strongly suggested.

3-Point Etchback

True 3-point "etchback" exposes the innerlayer “post” on *all three sides* for subsequent plating processes. This will require a more robust approach compared to simple desmear, which is designed only to remove resin smear from the vertical surface of the innerlayer interconnect “posts”.

When using wet chemistry to achieve 3-point etchback, a 2-hour bake at 218°C (425°F) prior to hole wall preparation has been determined to enhance the performance of the various permanganate baths in achieving a full military etchback of Isola Group polyimides. Depending on the permanganate desmear chemistry used, a double pass process may be necessary in getting the amount of etchback required.

If plasma is used for 3-point etchback, boards should be subjected to a single pass through the permanganate desmear line to provide suitable roughness in the hole wall and remove the residual ash. Although not mandatory, this “best practice” increases process latitude in subsequent metallization steps and is strongly suggested.

Glass and Drill Debris Removal

Conventional hydrofluoric acid or fluoboric type etchants are acceptable for glass bundle removal.

Secondary Drilling

Avoiding secondary drilling, whenever possible, is a good practice for P95/P96 materials. 130 degree point angle geometries are necessary to avoid crazing around secondary drilled hole perimeters. As common with most high Tg epoxy materials with increased modulus properties, the use of entry and backer material may be necessary during the secondary drilling of larger hole sizes on polyimide materials to avoid crazing/fracturing at the hole perimeter.

Special attention should be paid to the curing process if secondary drilling operations are to be utilized. Excessive curing can render the laminate matrix brittle, which can lead to crazing issues during secondary drilling operations, even when proper entry and backup materials are used.

Solder Leveling

All board types and configurations should be baked to remove moisture prior to any solder leveling and fusing procedures, which includes HASL and reflow by IR or hot oil. Suggested bake cycle is 121-135°C (250-275°F) for a minimum of 4 hours to as long as 12 hours or as required to remove all moisture.

Routing and Scoring

Due to the greater modulus properties and hardness of the P95/P96 materials, modifications of the final PWB rout fabrication process will be necessary.

It is strongly suggested that the scoring equipment and/or router bit manufacturer be contacted for application specific suggestions for use with polyimide laminate materials.

For PWB designs requiring scored geometries, the testing of various Tgs and resin content materials has determined that adjustments to the process will be necessary. As the modulus strength of materials increases, the maximum resultant web thickness (dependent on the scored edge depth) must be decreased to avoid excessive fracturing upon breaking away the scored materials.

Individual board designs/stack-ups may require adjustment of score depth geometries. **Thinner web thicknesses are typically required.** This is influenced by layer count, glass types and retained copper in the design.

Your Isola Technical Account Manager may also be able to provide some initial suggestions, but these should be reviewed with the scoring equipment supplier and validated through testing by the individual PWB fabricator.

Part 6: Packaging and Storage

Isola recommends using best practices in storage and packaging, as noted below, to reduce risk during lead-free assembly.

P95/P96 boards should be dry prior to packaging to ensure the most robust lead-free performance. For some complex, high reliability designs, baking prior to solder mask application can be implemented to ensure maximum floor life in assembly processing. Printed boards made for high temperature assembly from P95/P96, which require a long shelf life, the best protection is provided using a Moisture Barrier Bag (MBB) with a Humidity Indicator Card (HIC) and adequate drying desiccant inside the MBB to prevent moisture absorption during shipment and long-term storage.

Upon opening the MBB, the boards should be processed within 168 hours when maximum shop floor conditions are at < 30°C (85°F)/60% RH. MBB bags that are opened for inspection should be resealed immediately to protect the boards from moisture uptake.

Part 7: Health and Safety

Always handle laminate with care. Laminate edges are typically sharp and can cause cuts and scratches if not handled properly. Handling and machining of prepreg and laminate can create dust (see P95/P96 Material Safety Data Sheet).

Appropriate ventilation is necessary in machining/punching areas. The use of protective masks is suggested to avoid inhaling dust. Gloves, aprons and/or safety glasses are suggested if individuals have frequent or prolonged skin or eye contact with dust.

Isola Group does not use polybromidebiphenyls or polybromide-biphenyloxides as flame retardants in any product. Material Safety Data Sheets are available upon request.

Part 8: Ordering Information

Contact your local sales representative or contactt: **info@isola-group.com** for further information.

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