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 properties, 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 or damage to the woven glass 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.

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. If not handled properly, IS415 prepreg will absorb moisture, which will lead to depressed Tg's and cure and affect flow in the press. If extended storage is required, separate facilities should be reserved with appropriate environmental control. Prepreg should be stored at ≤ 23ºC and below 50% humidity.

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.

Part 2: Innerlayer Preparation

Isola Group's IS415 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 IS415. 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.

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.

Table 1: Initial Artwork Compensation Factors

Base Thickness	Configuration	Direction	Comp (in/in)
≤ 0.005″	Signal/Signal	Warp (grain)	0.0007-0.0009
"	"	Fill	0.0001-0.0003
"	Signal/Ground	Warp (grain)	0.0005-0.0007
"		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)	0.0005-0.0007
"	"	Fill	0.0001-0.0003
"	Signal/Ground	Warp (grain)	0.0003-0.0005
"	"	Fill	0.0000-0.0002
"	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	0.0000-0.0003
"	Ground/Ground	Warp (grain)	0.0000-0.0003
"	"	Fill	0.0000-0.0002

Table 1 (for reference) illustrates the suggested approach to characterizing laminate movement and provides approximate artwork compensation factors *for IS415 laminate when using a hydraulic press.*

Imaging and Etching

IS415 laminates are imaged using standard aqueous dry films and are compatible with both cupric chloride and ammoniacal etchants.

Bond Enhancement

Oxide alternative chemistries have been used successfully in fabricating IS415 multilayer boards to date and are the only bond enhancement recommended for lead-free applications. Reduced black oxide has been used successfully, but is more design and process sensitive, as well as being less thermally stable. Users should make sure the oxide or oxide replacement coating exhibits a consistent and uniformly dark color.

For conveyorized oxide replacements, an efficient dryer at the end of a conveyorized oxide replacement line should remove all moisture from the innerlayer surface. ***However, drying of layers for 120 minutes minimum @ 110°C (230°F) or higher is required for boards to be subjected to "lead-free" processes. Drying in racks is preferred.***

Wet cores interfere with the curing of prepreg, leading to low Tg values and degraded performance. Users need to verify the effectiveness of their process to achieve dry cores.

If reduced oxides are used, consult the chemical supplier for post oxide baking considerations as excessive baking may lead to lower pink ring resistance. It is generally suggested that post-oxide baking be performed vertically, in racks.

Peel strengths may be slightly lower as compared to FR406 due to the higher modulus properties of the resin system. The use of DSTFoil™ will typically increase the bond strength by approximately 1 to 1.5 lbs as compared to non-DSTFoil copper foil. The use of standard, non-drum side outer layer foil is recommended for all lead-free applications.

If immersion tin adhesion treatments are used, the fabricator should test the coating to verify adequate bond strength develops with IS415 prepregs.

Part 3: Lamination

Standard Lamination

The amount of time at cure temperature and the required pressure will be a function of board thickness and retained copper circuitry thickness and distribution. In general, thinner boards will operate at the lower end of the time and temperature range, and thicker boards should be run at the higher range.

Faster heat ramps lower the minimum achieved viscosity and improve resin fill and flow, but cause the material to spend less time in the flow window. This creates a tighter process window and is more likely to result in glass stop/glass lock conditions. A cycle with an isotherm hold is not recommended for faster heat ramps. Slower heat ramps do not achieve the same relative viscosity but enable the product to spend more time in the flow window, creating a wider process window. Slow heat ramps work well with isotherm lamination cycles.

Sequential Lamination

Sub-assemblies must be baked prior to performing the secondary lamination. Water will interfere with the curing of the IS415 resin system.

Sub-assemblies require much longer baking, particularly when stored in open environment. Baking times range from 3 to 24 hours at 110-180°C (230-356°F). Consult with an Isola Technical Expert for recommendations.

Removal of IS415 flash should be performed by routing rather than shearing to minimize crazing along the panel edges.

Table 2: IS415 General Lamination Parameters

Process	Recommendation

Vacuum Time	30 minutes (no pressure, product on risers)
Curing Temperature	188-202°C (370-395°F)
Curing Time	130-160 minutes (time at cure temperature or above 190°C (375°F).
Heat Ramp	3.5-5.0°C/min (6.2-9.0°F/min) from 100°C to 150°C (210°F to 300°F) Target > 4°C/min Product temperature overshoot to 205°C (400°F) acceptable to meet heat ramp requirements with alternative oxides.
Pressure	200-350 PSI 14-24 kg/cm^2
Pressure Application	3.5 kg/cm^2 (50 PSI) after vacuum dwell time, switch to high pressure ≤ 100°C (210°F) product temperature.
Pressure Drop	After 30 minutes at cure temperature or above 190°C reduce pressure to 3.5 kg/cm^2 (50 PSI).
Cool Down	Cool to 135-140°C (275-285°F) at 2.5°C/min (4.5°F/min) at 3.5 kg/cm^2 (50 PSI) pressure prior to removing or transferring the load.

Table 2 outlines general suggestions for lamination temperature pressure.

Part 4: Drill

General

The IS415 materials exhibit increased thermal stability of the resin system and generate little or no smear. To assure effective removal of the resin debris during drilling, undercut drill geometries and high helix tools are strongly recommended on drills up to 1.0 mm in diameter. On high layer count technologies and thicker overall board thicknesses, peck drilling parameters may be necessary. Suggested parameters are outlined below for typical multilayer designs.

Cutting Speed and Chipload

Relative to standard FR-4 parameters, use lower chiploads to drill IS415 printed circuit boards. The parameters in Table 4 provide a moderate initial starting point for typical board designs. Thick boards with heavy copper or special cladding such as invar will require more conservative drill parameters. Boards with numerous 2 oz. copper innerlayers or boards with coarse glass weave may require more conservative parameters.

High cutting speeds and high chiploads are associated with rough holes and fracturing around the glass yarn.

Stack Height and Hit Count

Stack heights and hit counts will vary with the construction and overall thickness of the boards being drilled. For thicker boards, above 2.5 mm (100 mils) overall, with high layer counts, drill one high. Use undercut bits for particularly demanding designs. Aluminum entry and lubricated backing help create good quality hole walls but are not essential in all applications.

Table 4: Suggested Drilling Parameters For Initial IS415 Setup

Drill Size		Spindle Speed	Surface Speed Per Minute		Infeed		Chipload		Retract	
mm	in	RPM	SMPM	SFPM	m/min	in/min	m/rev	in/rev	m/min	in/min
0.25	0.0098	120,000	94	309	1.57	62	0.013	0.52	15	600
0.30	0.0118	105,000	99	325	1.78	70	0.017	0.67	20	800
0.35	0.0138	94,000	103	339	1.98	78	0.021	0.83	20	800
0.40	0.0157	85,000	107	350	2.16	85	0.025	1.00	25	1000
0.50	0.0197	75,000	118	387	2.54	100	0.034	1.33	25	1000
0.63	0.0248	60,000	119	390	2.29	90	0.038	1.50	25	1000
0.75	0.0295	50,000	118	387	2.16	85	0.043	1.70	25	1000
0.90	0.0354	43,000	122	399	1.91	75	0.044	1.74	25	1000
1.00	0.0394	38,000	119	392	1.73	68	0.045	1.79	25	1000
1.27	0.0500	32,000	128	419	1.57	62	0.049	1.94	25	1000
1.50	0.0591	28,000	132	433	1.42	56	0.051	2.00	25	1000
2.00	0.0787	22,000	138	454	1.27	50	0.058	2.27	25	1000

Part 5: Hole Wall Preparation

General

When IS415 is properly cured and drilled, it will generate very little smear. The main purpose of desmear processing on this material is to remove debris and provide an acceptable texture to the hole walls.

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, vertical or horizontal process equipment and equipment agitation parameters.

Chemical Desmear

Trials performed by chemical suppliers show that IS415 is more chemically resistant than typical FR-4 resin systems. Absorption of solvent swellers has been associated with fracturing or crazing of glass between holes. Chemical desmear should be run without solvent swellers. If not feasible, alkaline butyl carbitol swellers have less impact. NMP chemistries are more aggressive and can cause reliability issues, in addition to the fracturing noted above, after lead-free thermal stress. ***Use of* NMP swellers is strongly discouraged.**

Plasma Desmear

Plasma desmearing is the preferred method of desmear for IS415 materials. It can consistently etch a chemically resistant resin system, and when properly run provides good hole wall texturing. It can be used with or without a single permanganate pass (to be determined by each fabricator). Plasma processing tends to improve overall hole quality, particularly in thick and/or high aspect ratio boards. Standard plasma gas mixtures and cycles are satisfactory.

Hole Wall Condition Verification

It is recommended that users take test samples for hole wall inspection after drill and deburring and after desmearing. The post drill condition indicates hole cleanliness and hole wall damage. Post desmear indicates desmear effectiveness and resin texturing. SEM pictures of holes cut vertically in half have been effective for executing this verification.

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”.

Permanganate chemistry alone should not be used to attain a full 3-point etchback for IS415.

A combination of plasma and chemical processing is suggested. Testing indicates that the plasma provides nearly all of the resin removal. Chemical desmear should be used primarily for hole cleaning and conditioning. If plasma is not available, chemical etchback for 3-point
connections must be done with extreme care on IS415 to minimize copper wicking. This is not recommended. If chemical processing alone is used, it will be necessary to either extend the dwell times in chemical baths or subject the boards to a double pass through the chemical desmear system. Consult the chemical supplier for suggested conditions. ***The slow dissolution rate of IS415 resin into chemical etching alone may not result in true 3-point etchback.***

Secondary Drilling

As common with most high Tg materials with increased modulus properties, the use of entry and backer material may be necessary during the secondary drilling of larger hole sizes to avoid crazing/fracturing at the hole perimeter. Additionally, sharper plunge point angle geometries may be necessary to avoid crazing around secondary drilled hole perimeters.

Routing and Scoring

Due to the greater modulus properties of the IS415 materials, modifications of the final PWB rout fabrication process may be necessary. Table 5 lists initial starting parameters using chip breaker or diamond cut tool designs. **Note that parameters listed may require further adjustment.**

Table 5: Suggested Routing Parameters for Initial IS415 Setup

Tool Diameter		Spindle Speed	Spindle Travel Speed	
in	mm	RPM	in/min	m/min
0.062	1.57	45,000	20	0.51
0.093	2.36	35,000	40	1.02
0.125	3.18	25,000	50	1.27

For PWB designs requiring scored geometries, the testing of various Tg's 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.

The customer should contact the scoring equipment and/or **bit supplier for application specific suggestions for use with IS415 materials.** Your Isola Technical Account Manager may also be able to provide some initial suggestions, but these should be validated through testing by the individual PWB fabricator.

Part 6: Packaging and Storage

IS415 finished boards have low moisture sensitivity and good shelf life. However, Isola recommends using best practices in storage and packaging, as noted below, to reduce risk during lead-free assembly.

IS415 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 IS415, 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 IS415 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 polybromidebiphenyloxides as flame retardants in any product. Material Safety Data Sheets are available upon request.

Part 8: Ordering Information

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

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NOTES

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