isola

IS420

Lead Free Epoxy Laminate and Prepreg

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.

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, IS420 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 IS420 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 IS420. 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.

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	0.0000-0.0002
"	Ground/Ground	Warp (grain)	0.0000-0.0002
"	"	Fill	0.0000-0.0002

Table 1 (for reference) illustrates the suggested approach to characterizing laminate movement and provides approximate artwork compensation factors for IS420 laminate when using a hydraulic press.

Table 1 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.
This table assumes that signal layers are either half or 1 ounce copper and ground layers are either 1 or 2 ounce copper.

Imaging and Etching

IS420 laminates are imaged using standard aqueous dry films and are compatible with both cupric chloride and ammoniacal etchants.

Bond Enhancement

Both reduced oxides and oxide alternative chemistries have been used successfully in fabricating IS420 multilayer boards to date. Users should make sure the oxide or oxide replacement coating exhibits a consistent and uniformly dark color.

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. Suggest mild bake of oxided innerlayers (15-30 minutes @ 80-100°C).

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 30 minutes minimum @ 100°C or higher is considered a "best practice", especially for boards to be subjected to "lead-free" processes. Drying in racks is preferred.***

Peel strengths may be slightly lower as compared to FR370 or 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. If immersion tin adhesion treatments are used, the fabricator should test the coating to verify adequate bond strength develops with IS420 prepregs.

Part 3: Lamination

Standard Lamination

The IS420 prepreg materials achieve maximum fluidity at approximately 20°F lower temperatures as compared to standard FR406 prepregs. Therefore, it is recommended that lamination press cycles with a delay, kick over to a high pressure (kiss cycle) be adjusted accordingly due to the lower melt and maximum fluidity temperatures. Additionally, vacuum assist lamination processes are suggested. Non-vacuum lamination
processes should be reviewed by Isola technical service engineers prior to production implementation. The amount of time at cure temperature, and to some extent the actual cure temperature of IS420, 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

Use a 90-120 minute cure for sub-assemblies depending on thickness and a ***120-150 minute cure for the final assembly.*** This suggestion assumes a final assembly thickness ≥ 0.125″ (3.2 mm). Removal of IS420 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 IS420 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.

Table 2: IS420 General Lamination Parameters

Process	Recommendation
Vacuum Time	20 minutes (no pressure, product on risers)
Curing Temperature	190°C (375°F)
Curing Time	120 minutes above 190°C (375°F)

Resin Flow Window	80-135°C (180-280°F) Maintain heat ramp in this temperature range.
Heat Ramp	2.5-6.5°C/min (5-12°F/min)
Pressure	See Table 2
Pressure Application	Single Stage: Apply pressure after vacuum dwell time. Dual Stage: 3.5 kg/cm^2 (50 PSI) after vacuum dwell time, switch to high pressure ≤ 80°C (176°F) product temperature.
Pressure Drop	After 30 minutes at cure temperature, reduce pressure to 3.5 kg/cm^2(50 PSI) in hot press (optional).
Cool Down	Cool to 135-140°C (275-285°F) at 2.8°C/min (5.0°F/ min) with 3.5 kg/cm^2 (50 PSI) pressure prior to removing or transferring the load.

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 3: IS420 Lamination Pressure

Lamination Method	Suggested Pressure Range
Hydraulic Pressing (without vacuum assist)	300-350 PSI 21-25 Kg/cm^2
Hydraulic Pressing (with vacuum assist via vacuum frames or bags)	250-300 PSI 18-21 Kg/cm^2
Hydraulic Pressing (vacuum enclosure)	200-250 PSI 14-18 Kg/cm^2

Table 3 outlines general suggestions for lamination pressure based on press type used. Note that these are guidelines only and the board design may require that these suggestions be modified. Consult Isola Technical Service for assistance.

Part 4: Drill

General

The IS420 material has high thermal performance and stability. Due to this high thermal performance, the material tends to form free standing chips during drilling, and is not likely to create drill smear. Due to the increased thermal decomposition properties of the resin system, the IS420 drill debris remains as free particles and will not impact the drill flute relief volumes. To assure effective removal of the resin debris during drilling, undercut drill geometries and high helix tools are suggested. 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 IS420 printed circuit boards. The parameters in **Table 4** provide a moderate initial starting range 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.

Stack Height and Hit Count

Stack heights and hit counts will vary with construction and overall thickness of the boards being drilled. For thicker boards (above 75 mils or 1.91 mm overall) with high layer counts, drill one high. Aluminum entry and lubricated backing help create good quality hole walls but are not essential in all applications. Do not exceed 1,000 hits for bits below 0.020″ diameter and 1,500 hits for bits above 0.020″.

Table 4: Suggested Drilling Parameters For Initial IS420 Setup

Drill Size		Spindle Speed	Surface Speed Per Minute		Infeed		Chipload		Retract	
inch	mm	rpm	SFPM	SMPM	in/min	m/min	mil/rev	mm/rev	in/min	m/min
0.0098	0.25	120,000	309	94	80	2.2	0.71	0.018	600	15
0.0118	0.30	115,000	356	108	100	2.5	0.87	0.022	800	20
0.0138	0.35	110,000	397	121	110	2.8	1.00	0.025	1000	25
0.0157	0.40	105,000	433	132	130	3.3	1.24	0.031	1000	25
0.0197	0.50	97,000	500	152	145	3.7	1.49	0.038	1000	25
0.0256	0.65	75,000	502	153	135	3.4	1.80	0.046	1000	25
0.0295	0.75	65,000	502	153	135	3.4	2.08	0.053	1000	25
0.0394	1.00	49,000	505	154	100	2.5	2.04	0.052	1000	25
0.0492	1.25	39,000	502	153	82	2.1	2.10	0.053	1000	25
0.0591	1.50	33,000	510	156	70	2.8	2.12	0.054	1000	25
0.0787	2.00	24,000	495	151	53	1.3	2.21	0.056	1000	25

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.
Make sure boards are fully cured and that drilling conditions are properly adjusted!

Chemical Desmear

As with many other high performance resin systems, permanganate desmear processes which utilize cyclic amine (NMP) type conditioners have demonstrated more robust hole cleaning and surface topography performance on IS420 than glycol ether based conditioners. Dwell times and temperatures typically used for most high performance materials should be satisfactory, although some benefit is sometimes seen with extended dwells. Consult the chemical supplier for suggested conditions.

Plasma Desmear

IS420 generally does not require plasma etching. If available, plasma can be used with or without a single permanganate pass (to be determined by each fabricator). ***Care must be exercised to avoid excessive resin removal if both plasma and permanganate are employed together.***

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.

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". Plasma will readily etch back IS420 resin. Standard plasma gas mixtures and process cycles designed for conventional FR-4 epoxy are satisfactory and are suggested for use as initial starting parameters for etchback of 370HR. The practice of following the plasma process with a chemical process is suggested rather than plasma alone to increase hole wall texture and remove plasma ash residues. ***Chemical etchback alone is not recommended for achieving 3-point etchback on IS420.***

Part 6: Secondary Drilling, Routing and Scoring

Secondary Drilling

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 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 IS420 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 IS420 Setup

Tool Diameter		Spindle Speed	Spindle Travel Speed	
inch	mm	rpm	in/min	m/min
0.0620	1.60	45,000	20	0.50
0.0930	2.50	35,000	40	1.00
0.1250	3.20	25,000	50	1.30

Chip breaker or diamond cut tool designs recommended.

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.

The customer should contact the scoring equipment and/ or bit supplier for application specific suggestions for use with IS420 materials.

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 7: Packaging and Storage

IS420 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.

IS420 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 IS420, 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 8: 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 IS420 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 9: Ordering Information

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

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