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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, FR408 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 <= 23 ºC 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 FR410 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 FR410. 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 IS410 laminate when using a hydraulic press.

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.

Imaging and Etching

IS410 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 IS410 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 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 IS410 prepregs.

Table 2: IS410 General Lamination Parameters

Process	Recommendation
Vacuum Time	20 minutes (no pressure, product on risers)
Curing Temperature	185°C (365°F)
Curing Time	75 minutes above 185°C (365°F) 90 minutes above 185°C (365°F) for thicker boards
Resin Flow Window	80-135°C (180-280°F) Maintain heat ramp in this temperature range.
Heat Ramp	2.2-4.5°C/min (4.0-8.0°F/min) The lower end of range is recommended only for low-mid layer count products. Higher layer count products or products requiring greater resin filling (≥ 2 oz copper) should run > 3.5°C/min. Platen temperature overshoot up to 215°C is acceptable to meet heat ramp requirements when using alternative oxides.
Pressure	200-250 PSI 14-17 kg/cm^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 ≤ 90°C (194°F) product temperature.
Pressure Drop	After 30 minutes at cure temperature, reduce pressure to 3.5 kg/cm^2) 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.

Table 2 outlines general suggestions for lamination temperature pressure based on press type used.

Part 3: Lamination

Standard Lamination

The amount of time at cure temperature, and to some extent the actual cure temperature of IS410, 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 an 60-75 minute cure for sub-assemblies depending on thickness and a 90 minute cure for the final assembly. This suggestion assumes a final assembly thickness ≥ 0.125″ (3.2 mm). Removal of IS410 flash should be performed by routing rather than shearing to minimize crazing along the panel edges.

Part 4: Drill

General

The IS410 materials exhibit greater modulus properties as a result of the increased thermal stability of the resin system. During drilling, the debris formation with IS410 is different from the standard FR406 materials. Due to the increased thermal decomposition properties of the resin system, the IS410 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

Maximum cutting speeds of 550 to 600 SFPM are suggested. Chiploads should not exceed 3.5 mils for bit diameters of .040″ and above. ***Table 3*** gives drill parameters by bit diameter for a maximum cutting speed of 550 SFPM and maximum chipload of 3.0 mils. Cutting speeds and chiploads in excess of those in ***Table 3*** have been successfully implemented on all of Isola's FR-4 products in 6 to 12 layer .060″ (1.6 mm) thick boards. The parameters in ***Table 3*** 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.

Stack Height and Hit Count

Stack heights and hit counts will vary according to construction and overall thickness of the boards being drilled. Standard .060″ thick boards have been successfully stacked 3 high for bit diameters down to 13.5 mils. As a general guideline, the sum of the board thickness in a multilayer drill stack should not exceed 200 mils. Maximum hit count for a small drill diameter is 1000. For drill diameters of 13.5 mils and greater, maximum hit count is 1500.

Table 3: Suggested Drilling Parameters For Initial IS410 Setup

Drill Size		Spindle Speed	Surface Speed Per Minute		Infeed		Chipload		Retract	
in	mm	RPM	SFPM	SMPM	in/min	m/min	mil/rev	mm/rev	in/min	m/min
0.0098	0.25	120,000	309	94	75	1.91	0.63	0.016	600	15
0.0118	0.30	105,000	325	99	85	2.16	0.81	0.021	800	20
0.013	0.35	102,000	368	112	78	1.98	0.76	0.019	800	20
0.0157	0.40	96,000	396	121	85	2.16	0.89	0.022	1000	25
0.0197	0.50	92,000	474	145	100	2.54	1.09	0.028	1000	25
0.0248	0.63	84,000	545	166	130	3.30	1.55	0.039	1000	25
0.0295	0.75	70,000	541	165	140	3.56	2.00	0.051	1000	25
0.0354	0.90	58,000	538	164	145	3.68	2.50	0.064	1000	25
0.0394	1.00	52,000	536	163	155	3.94	2.98	0.076	1000	25
0.0500	1.27	42,000	550	168	125	3.18	2.98	0.076	1000	25
0.0591	1.50	35,000	541	165	105	2.67	3.00	0.076	1000	25
0.0787	2.00	26,000	536	163	78	1.98	3.00	0.076	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.

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 IS410 than glycol ether based conditioners. Dwell times and temperatures typically used for most high performance, high-Tg materials should be satisfactory. Consult the chemical supplier for
suggested conditions.

Plasma Desmear

If available, plasma 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.

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 IS410 .

Plasma will readily etch back IS410 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 IS410. 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. Consult the chemical supplier for suggested conditions.

If plasma is not available, chemical etchback for 3-point connections must be done with extreme care on IS410 to minimize copper wicking.

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 IS410 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 4: Suggested Routing Parameters for Initial IS410 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

Chip breaker or diamond cut tool designs recommended.

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 IS410 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 6: Packaging and Storage

IS410 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.

IS410 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 IS410, 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 FR408 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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