IS550H

Halogen Free, High Reliability 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 IS550H is a halogen-free product. The 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, IS550H 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 properties will be maintained for 6 months when stored at 5°C (41°F) or 3 months when stored at 23°C (73°F) and below 50% relative humidity.

Prepreg packages should be allowed to equilibrate to layup room conditions before opening to prevent moisture condensation on the prepreg.

Stabilization

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. 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.

Part 2: Innerlayer Preparation

Isola Group's IS550H 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 IS550H. 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 IS550H 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

IS550H 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 IS550H multilayer boards to date. Users should make sure the oxide or oxide replacement coating exhibits a consistent, 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. We suggest mild bake of oxide coated innerlayers (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 FR-4 due to the higher modulus properties of the resin system. The use of RTF foil will typically increase the bond strength by approximately 1 to 1.5 lbs as compared to non-RTF foil copper foil. If immersion tin adhesion treatments are used, the fabricator should test the coating to verify adequate bond strength is developed with IS550H prepregs.

Table 2: IS550H General Lamination Parameters

Process	Recommendation
Vacuum Time	20 minutes (no pressure, product on risers)
Curing Temperature	190-200°C (375-390°F)
Curing Time	200°C - 75 min 190°C - 100 min 190°C recommended for sequential lamination
Resin Flow Window	100-170°C (210-340°F) Maintain heat ramp in this temperature range.
Heat Ramp	2.5-5°C/min (4.5-9.0°F/min)
Pressure	350-450 PSI Select based on filling requirements
Pressure Application	Single Stage: Apply pressure after vacuum dwell time. Dual Stage: 7.0 Kg/cm^2 (100 PSI) after vacuum dwell time, switch to high pressure ≤ 85°C 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.

Part 3: Lamination

Standard Lamination

IS550H is a higher viscosity material than most Halogenated FR-4 materials. To get the best results during lamination, use higher pressures and higher heat rise rates than standard FR-4 materials. (See Table 2.) These operating parameters will ensure good fill and flow of the PWB. This material has very little flash, so edge tapering is minimal, and good thickness distribution is found. If you are producing higher layer counts (>20 layers) or use 2 oz or heavier copper, the need to follow the guidelines is more important. These processing parameters have performed well up on very difficult product designs.

Sequential Lamination

Sub-assemblies must be baked prior to performing the secondary lamination. Water will interfere with the curing of the IS550H resin system.

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

Removal of IS550H flash should be performed by routing rather than shearing to minimize crazing along the panel edges.

Part 4: Drill

General

IS550H 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 temperature of the resin system, the 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 recommended. 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

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 with the 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 IS550H Setup

Drill Size		Spindle Speed	Surface Speed Per Minute		Infeed		Chipload		Retract	
mm	Inch	RPM	SMPM	SFPM	Meter min.	Inch min	mm rev.	mil rev.	Meter min.	Inch 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	0.52	20	600
0.35	0.0138	94,000	103	339	1.98	78	0.021	0.52	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

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

Conventional permanganate desmear systems are effective for removal of IS550H resin from interconnect posts. Dwell times and temperatures typically used for most high performance FR-4 materials should be satisfactory. **NMP is not compatible with IS550H. DO NOT use NMP based swellers with IS550H.**

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. Care must be exercised to avoid excessive resin removal if both plasma and permanganate are employed together.

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 IS550H 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 IS550H. 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.

If plasma is not available, chemical etchback for 3-point connections can usually be accomplished using a double-pass through the permanganate line. Care must be taken when using a double-pass to minimize copper wicking. Consult the chemical supplier for suggested conditions.

NMP is not compatible with IS550H. DO NOT use NMP based swellers with IS550H.

Secondary Drilling

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

Modifications of the final PWB rout fabrication process may be necessary. Table 4 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 IS550H Setup

Tool Diameter		Spindle Speed	Spindle Travel Speed	
Inch	mm	RPM	Inch min.	Meter min.
0.0620	1.5748	45,000	20	0.508
0.0930	2.3622	35,000	40	1.016
0.1250	3.1750	25,000	50	1.270

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 fabricator should contact the scoring equipment and/or bit supplier for application specific suggestions for use with IS550H 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: Special Application - Embedded Heat Sink

IS550H is especially well suited for heat dissipation applications using embedded copper due to excellent high temperature resistance and thermal conductivity. IS550H has higher Tg and lower flow characteristics when compared with standard FR-4 product which results in a tight processing window for embedded heat sink applications.

PCB's with embedded heat sinks complicate PCB manufacturing and require a good understanding of process capability and product tolerance. There are two common issues with embedded heat sinks:

1. Low bond strength between prepreg and embedded heat sink due to poor oxide coating on the embedded heat sink.
2. Edge/corner delamination due to low fill resin or high localized lamination pressure. These lead to glass stop and oxide damage.

Isola recommends the following best practices for embedded heat sink designs:

1. To avoid the edges of heat sinks cutting into the glass fabric during lamination, the surrounding PCB thickness should be slightly thicker than the heat sink itself. This requires a stack-up adjustment of the PCB to account for the fabricated heat sink thickness plus its tolerance.
2. Chamfered edges of the heat sink will help reduce the stress distribution along the edges.
3. For the prepreg to form a good bond to the heat sinks, the heat sinks must be properly prepared for its surface to accept the oxide treatment with acceptable adhesion quality.

    a. The heat sink parts are commonly machined copper and are exposed to cutting fluids. Some heat sinks may be heat treated. Extra attention is required to ensure thorough cleaning of the surface to promote good oxide adhesion. Additional oxide processing time is often required to achieve equivalent bonding to standard PCB foil.
    b. Testing is suggested to evaluate the bond interface. Creating and building a test vehicle and exposing it to simulated reflow cycling is recommended.

4. Lamination pressure must be optimized to maximize resin flow and fill around the heat sink and at the same time preventing the heat sink from cutting into the glass fabric.
5. The edges and corners of the heat sinks are stress concentration points. A sufficient layer of resin between the embedded heat sink and the glass is required to prevent crack formation during thermal stress at those edge locations. Isola recommend to use the highest resin content 1080 prepreg directly against heat sinks.

Part 7: Packaging and Storage

IS550H 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.

IS550H 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 IS550H, 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 IS550H 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.

Part 9: Ordering Information

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

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