TerraGreen® 400GE

Halogen-free, Ultra Low Loss Material

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. These recommendations contained herein cannot account for all possible board designs or processing environments and adjustments by the fabricator will be necessary. Fabricators should verify that PWBs made using these suggestions meet all applicable quality and performance requirements.

TerraGreen® 400GE has been specifically designed for extremely low loss applications where the best possible electrical performance is required. In order to achieve optimal thermal and electrical performance, an ultra low loss bond treatment and use of one of the recommended press cycles is 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. Material should be kept in original packaging until ready to use. All prepreg should be used as soon as possible. A First-In-First-Out (FIFO) inventory management system should be used. Do not stack heavy objects on top of the prepreg. High pressure can result damage and resin pull off.

If not handled properly, TerraGreen® 400G prepreg will absorb moisture, which will lead to depressed Tgs 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

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 the 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, do not vacuum seal TerraGreen® 400G prepreg. Storage should be in the absence of catalytic environments such as high radiation levels or intense ultraviolet light.

After Opening

Prepreg removed from original packaging should not be stacked. Tackiness may occur if too much pressure is applied directly to the prepreg.

© 2021, Isola Group, All rights reserved.

Part 2: Innerlayer Preparation

Isola Group's TerraGreen® 400GE 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 TerraGreen® 400G. 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.

Table 1

PCB Resin Content	Direction	Comp(in/in)
High RC%	Warp(Grain)	0.0016
"	Fill	0.0016
Low RC%	Warp(Grain)	0.0014
"	Fill	0.0012

(for reference) illustrates the suggested approach to characterizing laminate movement and provides approximate artwork compensation factors for TerraGreen® 400G 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 the specific lamination cycle used, border designs and grain orientation of laminate to prepreg. It is also suggested that specific laminate constructions are specified and adhered to so that dimensional variations due to changes in construction are avoided. Table 1 assumes that signal layers are either 1/2 or 1 ounce copper and ground layers are either 1 or 2 ounce copper. TerraGreen® 400G and Tachyon 100G scaling factors are very close and are considered interchangeable as a starting point.

Imaging and Etching

TerraGreen® 400G laminates are imaged using standard aqueous dry films and are compatible with both cupric chloride and ammoniacal etchants. Bond Enhancement TerraGreen® 400G uses < 1 micron Rz surface roughness copper (VLP1) to bond to the laminate surface. For optimal electrical performance, an equally high performance Ultra Low Loss (very low profile) bond enhancement is highly recommended.

Etch type bond enhancements are compatible for bonding and thermal properties with no limitation of use for PCB quality or reliability. However, electrical performance will be sacrificed and will result in significantly increased total signal loss, S21.

If immersion tin adhesion treatments are used, the fabricator should test the coating to verify adequate bond strength is developed with TerraGreen® 400GE prepregs.

Reduced black oxide systems are not recommended for TerraGreen® 400GE.

For conveyorized oxide replacements, an efficient dryer at the end of a conveyorized oxide replacement line must remove all moisture from the inner layer 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.

© 2021, Isola Group, All rights reserved.

Part 3: Lamination

The chemistry of TerraGreen® 400G2 is unique and can be laminated using typical FR4 type methods. The resin system requires more energy to cure than most materials. In order to achieve the optimal thermal properties for the resin system a longer press cycle for thick designs may be required.

Pressure requirements are dependent on product design and technology. Higher pressures can be used on difficult to fill designs such has heavy copper foil or partial plane features.

Isola Technical Service will provide support and lab testing to ensure the lamination cycle is performing properly.

After lamination, removal of TerraGreen® 400GE flash should be performed by routing rather than shearing to minimize crazing along the panel edges.

Table 2: TerraGreen® 400G General Lamination Parameters

Process	Recommendations
Vacuum Time	ecommended Minimum: On Risers: >10 min. Product temperature to not exceed 100°C
Curing Temperature	200°C (395°F) Do Not Exceed 222°C (437°F) Product Temperature
Curing Time	120 minutes at or above 200°C (395°F)
Resin Flow Window	100-150°C (210-300°F) 2-3°C/min heat rise Maintain heat ramp in this temperature range.
Heat Ramp	2-2.5°C/min (3.6-4.5°F/min) for best curing resultss
Pressure	375-425 PSI (26.5-30 Kg/cm2)
Pressure Application	Single Stage: Apply pressure after vacuum dwell time. Dual Stage: 100 PSI (7.0 Kg/cm²) after vacuum dwell time, switch to high pressure ≤ 90°C product temperature.
Pressure Drop (optional)	After 30 minutes at cure temperature, reduce pressure to 50 PSI (3.5 Kg/cm2) in hot press (optional)
Cool Down	Cool to 135-140°C (275-285°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.

Heat Ramp Rate is very important for TerraGreen® 400GE. Lower Heating rates have better performance. High Temperature Post Bake can be used on very high reliability designs to provide stress relief. Post Baking is not required but can improve some high-end designs. Post bake at 210°C (410°F) for 2 hrs.

Part 4: Drill

General

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 and cutting speeds to drill TerraGreen® 400GE printed circuit boards. The parameters in Table 3 provide a moderate initial starting point for typical board designs. Boards with large amounts of copper in drilled holes or Non-Functional pads on most/all layer will need to lower tip speeds. Keep the infeed the same as standard.

Stack Height and Hit Count

Stack heights and hit counts will vary according to 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. Maximum hit count for drill diameters below 0.020″ is 1,000, while drills at or above 0.020″ diameter can be permitted up to 1,500 hits. These general guidelines are strongly influenced by board thickness, geometry, stack height, etc. Aluminum entry and lubricated backing help create good quality hole walls but are not essential in all applications. It is suggested that the fabricator's supplier of entry and backup be consulted.

© 2021, Isola Group, All rights reserved.

Table 3: Suggested Drilling Parameters For Initial TerraGreen 400G® Setup

Drill Size		Spindle Speed	Surface Speed		Infeed		Chipload		Retract	
Inch	mm	RPM	SFPM	SMPM	in/min.	m/min.	mil/rev.	mm/rev.	in/min	m/min
0.0098	0.25	100,000	258	79	40	1.02	0.40	0.010	600	15
0.0118	0.30	100,000	309	79	80	2.03	0.80	0.020	800	20
0.0138	0.35	95,500	345	94	120	3.05	1.26	0.032	800	20
0.0157	0.40	95,500	394	105	150	3.81	1.57	0.040	1000	25
0.0197	0.50	76,400	394	120	150	4.83	2.49	0.063	1000	25
0.0248	0.63	61,000	394	121	170	4.32	2.79	0.071	1000	25
0.0295	0.63	51,000	394	120	150	3.81	2.94	0.075	1000	25
0.0354	0.90	43,000	399	122	130	3.30	3.02	0.077	1000	25
0.0394	1.00	38,500	397	121	130	3.30	3.04	0.077	1000	25
0.0500	1.27	30,500	399	122	91	2.31	2.98	0.076	1000	25
0.0591	1.50	26,000	402	123	78	1.98	3.00	0.076	1000	25
0.0787	2.00	20,000	402	126	60	1.52	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 helps reduce smear and debris generation.

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

Trials show that TerraGreen® 400GE shows good response to chemical desmear. Processing parameters used for 170 Tg FR-4 should be used, excessive dwell time will cause etchback.

Two passes of chemical desmear is recommended for high reliability or thicker designs (>2.5 mm). A short plasma etch desmear can be used, comparable to standard FR-4, can be used instead of a second pass chemical desmear.

Plasma Desmear

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 process cycles designed for conventional FR-4 epoxy are suggested for use as initial starting parameters for TerraGreen® 400GE.

3-Point Etchback

True 3-point “etchback” exposes the inner layer “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”.

© 2021, Isola Group, All rights reserved.

Plasma will readily etch back TerraGreen® 400GE 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 TerraGreen® 400GE. 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 TerraGreen® 400GE to minimize copper wicking.

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 route fabrication process may be necessary. Table 4 lists initial starting parameters. **Note that parameters listed may require further adjustment.**

The customer should contact the scoring equipment and/or bit supplier for application specific suggestions for use with TerraGreen® 400GE 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

TerraGreen® 400GE 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.

TerraGreen® 400GE boards should be dry prior to packaging to ensure the most robust lead-free performance. Printed boards made from TerraGreen® 400GE that will use high temperature assembly and which require a long shelf life, recommended packaging is to use 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 TerraGreen® 400GE 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 polybromide biphenyls or polybromide biphenyl oxides as flame retardants in any product. Safety Data Sheets are available upon request.

© 2021, Isola Group, All rights reserved.

Part 8: Ordering Information

Contact your local sales representative or visit: **www.isola-group.com** for further information.

Isola Group Global Headquarters
6565 West Frye Road
Chandler, AZ 85226
Phone: 480-893-6527
Fax: 480-893-1409
info@isola-group.com

Isola Asia Pacific (Hong Kong) Ltd.
12/F, Kin Sang Commercial Centre,
49 King Yip Street, Kwun Tong,
Kowloon, Hong Kong
Phone:852-2418-1318
Fax: 852-2418-1533
info.hkg@isola-group.com

Isola GmbH
Isola Strasse 2
D-52348 Düren, Germany
Phone: 49-2421-8080
Fax: 49-2421-808164
info-dur@isola-group.com

The data contained in this document, while believed to be accurate and based on both field testing and analytical methods considered to be reliable, is for information purposes only. Any sales of these products will be governed by the terms and conditions of the agreement under which they are sold.

NOTES

The data contained in this document, while believed to be accurate and based on both field testing and analytical methods considered to be reliable, is for information purposes only. Any sales of these products will be governed by the terms and conditions of the agreement under which they are sold.

Isola, the Isola logo, Astra, Chronon, GETEK, I-Fill, IsoDesign, IsoStack, I-Speed, I-Tera, Polyclad, Stratus, TerraGreen, and The Base for Innovation are registered trademarks or trademarks of ISOLA USA Corp. in the United States and in other countries. Copyright © 2021 Isola Group. All rights reserved.