# TerraGreen® 400G2

**Halogen-free, Extremely Low Loss Material Subject to L2 Glass Availability**

# 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® 400G2 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 2: Innerlayer Preparation

Isola Group's TerraGreen® 400G2 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® 400G2. 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 Resin Content % | Warp(Grain) | 0.0016 |
| " | Fill | 0.0016 |
| Low Resin Content % | 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® 400G2 and Tachyon 100G scaling factors are very close and are considered interchangeable as a starting point.

### Imaging and Etching

TerraGreen® 400G2 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® 400G2 prepregs.

**Reduced black oxide systems are not recommended for TerraGreen® 400G2.**

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.

## 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® 400G2 flash should be performed by routing rather than shearing to minimize crazing along the panel edges.

**Table 2: TerraGreen® 400G2 General Lamination Parameters**

| Process | Recommendations |
|---|---|
| Vacuum Time | Recommended 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 results |
| Pressure | 375-425 PSI (26.5-30 Kg/cm²) |
| Pressure Application | Single Stage: Apply pressure after vacuum dwell time.<br>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® 400G2 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.

**Table 3: Suggested Drilling Parameters for Initial TerraGreen® 400G2 Setup**

| Drill Size | | Spindle Speed | Surface Speed | | Infeed | | Chip Load | | 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 | 245 | 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 | 0.75 | 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 |
| 0.500 | 1.27 | 30,500 | 399 | 122 | 91 | 2.31 | 2.31 | 0.076 | 1000 | 25 |
| 0.0591 | 1.50 | 26,000 | 402 | 123 | 78 | 1.98 | 1.98 | 0.076 | 1000 | 25 |
| 0.0787 | 2.00 | 20,000 | 402 | 126 | 60 | 1.52 | 1.52 | 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® 400G2 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® 400G.

**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”.

Plasma will readily etch back TerraGreen® 400G 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® 400G. 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® 400G 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® 400G 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® 400G2 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® 400G2 boards should be dry prior to packaging to ensure the most robust lead-free performance. Printed boards made from TerraGreen® 400G2 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® 400G 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.**

## Part 8: Ordering Information

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

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