



EZ-IO with *fastRise*[™]

Processing Guide

November 2015

Disclaimer:

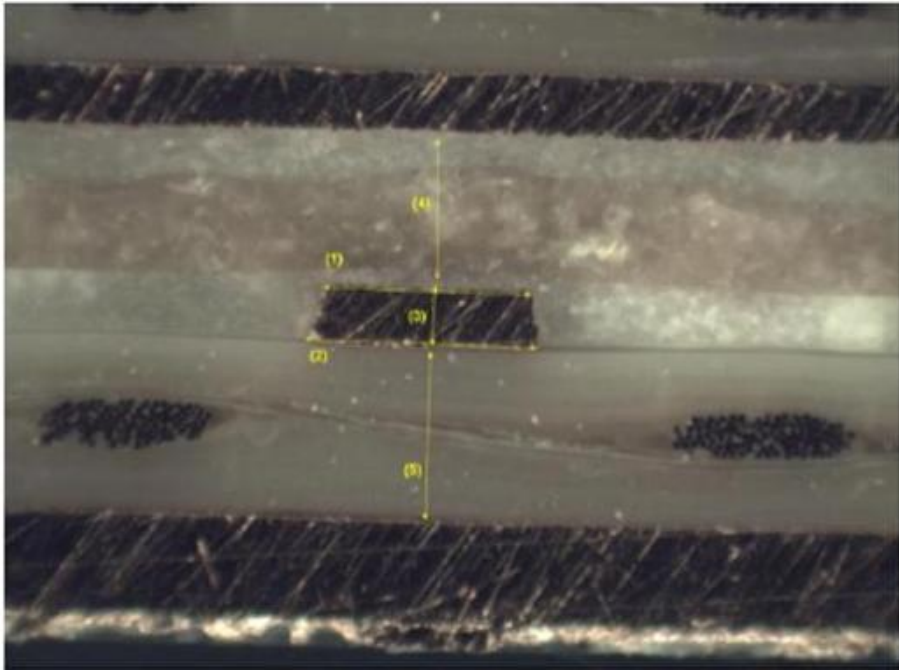
This process guide is provided to users of EZ-IO and *fastRise*[™] to assist in gaining an understanding of these materials and to quickly establish processes for PCB fabrication. It is assumed that the users will have a technical understanding and experience in the processes, equipment and standards related to PCB fabrication. The user will likely need to make adjustments to account for specific requirements and their production processes.

The following process recommendations are based on testing and production processes at several circuit board facilities. Each facility will have different product designs, equipment, or methods that will require modifications to these recommendations. For example, drilling parameters, routing parameters, and artwork compensation can vary dependent on circuit board thickness, design, processes, and equipment.

Adjustments should be based on the experience of each facility. Please contact your Taconic representative if assistance is required.

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fastRise™

EZ-IO

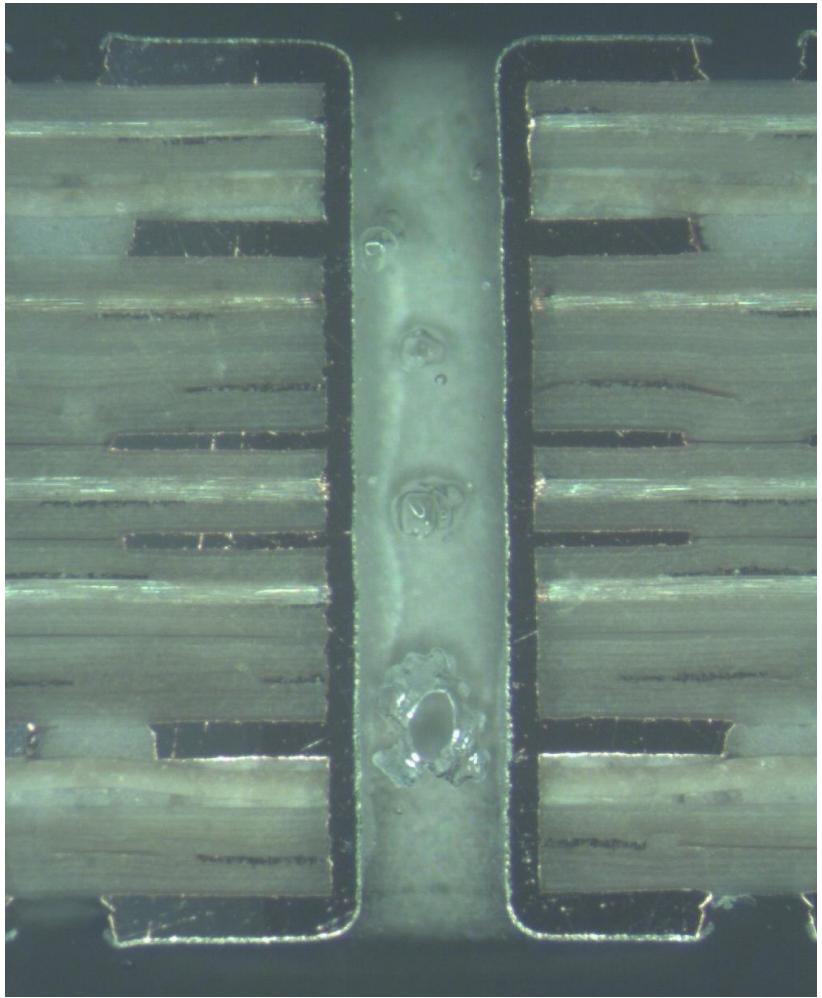
EZ-IO

fastRise™ S

Fusion bonded
EZ-IO
subassembly

fastRise™ S

EZ-IO



GENERAL INFORMATION

Overview

Taconic **EZ-IO** is a nanomaterial laminate clad in copper for use in fabricating printed circuitry. It is designed such that it obtains PTFE/ceramic performance while eliminating many of the difficulties traditionally associated with PTFE products. **EZ-IO** laminates maintain electrical properties which are optimal for high-speed digital, high density, or high frequency RF applications. **EZ-IO** laminates are dimensionally stable and registration on sequentially-laminated high-layer count PCBs is competitive with that of the highest performance epoxy laminates. Processing **EZ-IO** with *fastRise™ S* can be accomplished using standard epoxy circuit board processing methods coupled with either plasma or sodium treatment of the PTFE hole walls. Costs associated with processing **EZ-IO** laminates rival, or can even improve upon costs associated with processing epoxy laminates.

To compliment **EZ-IO** laminates, *fastRise™ S* prepregs have been engineered with similar nanomaterial technology. When used together, **EZ-IO** with *fastRise™ S* enables the use of stripline structures in sequentially-laminated high layer count boards (50+ layers) out to high data rates (43+ Gb/s) and mm-Wave frequencies.

For best results, **EZ-IO** cores should be bonded using *fastRise™ S* prepregs such as FR28-0040-50S and FR27-0050-40S

EZ-IO

EZ-IO laminate cores are highly loaded with submicron spherical silica with a minority component of PTFE and a minimal amount of woven fiberglass reinforcement. This formulation provides numerous benefits:

- Excellent dimensional stability and stiffness in the X, Y, and Z axes.
- Cleaner and straighter etched features
- Higher peel strengths with flatter coppers
- Dramatically less mechanical tool wear
- Simple laser processing with improved micro-via quality
- Low chemical uptake allowing for a finer pitch
- Very low dissipation factor
- Low dielectric constant

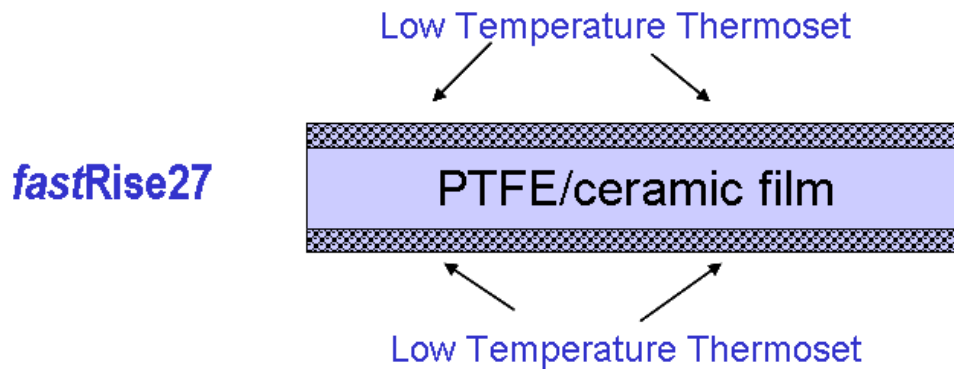
fastRise™ S Prepregs

fastRise™ prepreg is part of the Taconic product offering designed specifically for High Speed Digital /ATE (DUT) applications, and RF multilayer designs for mm-Wave frequencies. *fastRise™* utilizes a high loading of ceramic for low electrical loss and dimensional stability, a high performance thermoset resin as a bonding agent, and a small amount of PTFE. **For best results, **EZ-IO** should be combined with *fastRise™ S* prepregs.** *fastRise™ S* is a specific version of *fastRise™* which employs the same nanomaterial technology utilized in **EZ-IO**. *fastRise™ S* prepregs maintain the performance gains of **EZ-**

IO nanomaterials while retaining the simplified and reduced processing costs. Such prepregs include *fastRise™ S* part numbers FR28-0040-50S and FR27-0050-40S.

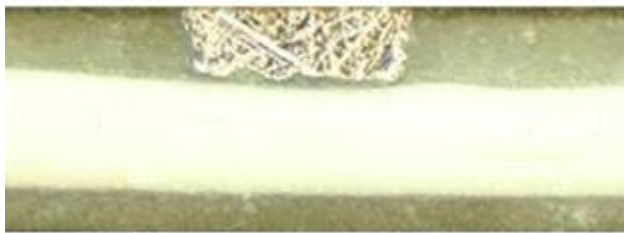
It is important to understand that the different *fastRise™* part numbers have been optimized for differing applications; using the nominal *fastRise™* part number for each design can greatly ease fabrication processing with improved quality. More detailed information regarding specific *fastRise™* part numbers can be found on the [data sheet](#).

Each ply of *fastRise™* is comprised of three layers; a pliable highly ceramic loaded PTFE film with a thermosetting adhesive resin on the top and bottom.

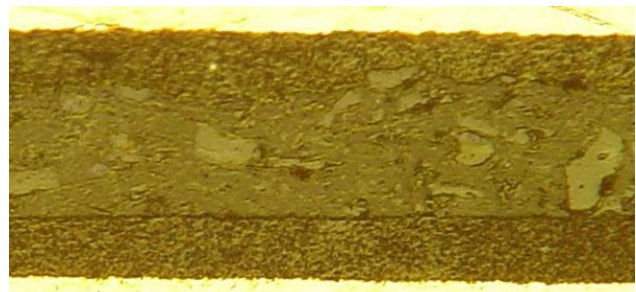


The thermoset properties of the *fastRise™* adhesive resin enable multiple sequential laminations and thermal excursions in standard PCB processing. The *fastRise™* thermoset resin system also acts to “lock” layer registration and further enhance dimensional stability and improving PCB rigidity.

fastRise S
(Nanomaterial)



fastRise
(Standard)



Notice the difference in the film particle sizes between the FR27-0050-40S and standard FR27-0050-40

STORAGE

EZ-IO

EZ-IO laminates should be stored flat in a clean dry area at room temperature. Cores will benefit from being stored between two stiffeners in order to prevent unnecessary bending of the layers or damaged corners. Soft slip sheets should be used to prevent dust and debris from being embossed into the material. EZ-IO has an indefinite shelf life.

fastRise™

Shelf Life

Taconic will not ship fastRise™ material with less than 90 days of remaining shelf life. In the event that prepreg expires, please contact with your Taconic technical sales person for assistance to coordinate retesting the expired prepreg.

Refrigeration

fastRise™ should be stored flat in a sealed bag below 42°F. Refrigeration temperatures of 14°F – 32°F are ideal for preventing unintended polymerization (cross-linking).

Upon removing fastRise™ prepreg from refrigeration, it should be allowed to acclimate to room temperature in a sealed bag. This will reduce the chance of moisture condensation on the prepreg and will also provide a more consistent start temperature for the lamination process. Bags should be resealed when not in use.

HANDLING

EZ-IO Laminate

The high ceramic content of EZ-IO combined with woven glass reinforcement greatly improves rigidity and dimensional stability as compared to traditional Ceramic/PTFE laminates. As with all laminate materials, especially thin materials, care should be taken to avoid distorting the material during handling.

Avoid bending or other mishandling which can lead to fracturing the fiberglass or micro-cracking the composite. These defects may cause various failures, some of which are believed to be a result of chemical infiltration of the fractures and/or micro-cracks.

Avoid mechanical scrubbing

Mechanical scrubbing may stretch and deform the material similar to thin core or flexible substrates. Pinch rollers used in many scrubbers may cause dents as particle or brush material are pressed into the surface of the laminate. Chemical cleaning is preferred.

Do not pick up a panel by one edge

Allowing the material to “flop” may stretch the copper and substrate. Lift the panel by two parallel edges; preferably the two closest dimensionally.

Do not stack panels directly on top of each other

The weight of the panels may emboss any particles or debris on the surface of the panel into adjacent panels. Vertical rack storage is recommended. If panels must be stacked, use clean soft slip sheet material between each panel and keep stack height to a minimum.

fastRise™ B-Stage

fastRise™ prepreg is supplied between two release sheets. The surface of fastRise™ may be tacky (especially for freshly manufactured material). Although it is recommended to allow refrigerated fastRise™ B-Stage prepregs to acclimate prior to opening a sealed bag, in some cases it may be advantageous to use the prepreg while it is cool* which will reduce the tackiness of the material and make handling easier.

**do not allow condensation to form on the prepreg*

INNER LAYER PREPARATION

Acclimation

If the laminate has seen extreme temperatures during shipment or storage, the material should be placed in ambient conditions for 8- 24 hours prior to processing.

Scaling

This data is for reference only and is dependent on numerous factors such as laminate thickness, copper thickness, copper type, circuit design, adjacent laminates / prepregs, lamination parameters, etc. Most PCB fabricators determine artwork compensation data by running a pilot lot or estimating based on previous experience.

	EZ-IO Scale Factors which should be applied to finish at nominal		
	X	Y	Comments
Innerlayer Etching	0.9991 – 0.9993	0.9991-0.9993	<i>Without a lamination cycle, the layers typically expand</i>
fastRise™ Lamination	1.0001-1.0009	1.0004 – 1.0009	<i>Layers usually contract, but the amount can be dependent upon the resin flow and conformance</i>

LAMINATION

Excessive resin flow should be avoided as it can cause flow channels or other undesirable conditions.

Quick Start

The following chart is provided as a general starting point for lamination recipe development. The later sections provide substantially more detail allowing recipes to be optimized for specific applications.

	Foil Lamination* / Low flow	Standard	High Flow / 30+ Layers
Vacuum	Full vacuum is recommended through entire cycle		
Vacuum Delay	Hold vacuum 10-20 minutes before applying heat or pressure		
Heating Rate	3 – 8 °F/min (1.7 – 4.4 °C/min)		
Critical Range	176°F – 302°F (80°C – 150°C)		
Pressure	100 – 200 psi	200 – 350 psi	350 – 550 psi
Cure Temp / Time (measured at bondline)	420 – 480 °F for 60 – 120 minutes (215.5 – 248.9 °C for 60 – 120 minutes)		
Cooling Rate	Less than 6°F/min (3.3°C/min)		
Breakdown	Breakdown or transfer to cold press when bondline is less than 200 °F (93.3°C)		

**Please see the section on Foil Lamination which covers additional process parameters*

Flow Patterns / Thieving

Solid copper boarders with small alternating “star burst” vent lines are ideal. Interlocking thieving patterns, offset diamonds, honeycombs, or other patterns which inhibit resin flow channels are also acceptable. Interlocking “star burst” flow patterns or other patterns which may promote resin flow channel formation should be avoided.

Padding and Conformance Materials

Press padding (outside separator plates) is recommended. Use of conformance materials such as Taconic TacPad, PTFE skive film, clutch lamination, or others are often helpful to balance pressure variations induced from circuits.

Pressure

Excessive pressure should be avoided; it can distort circuit patterns, induce resin/filler separation, or create flow channels.

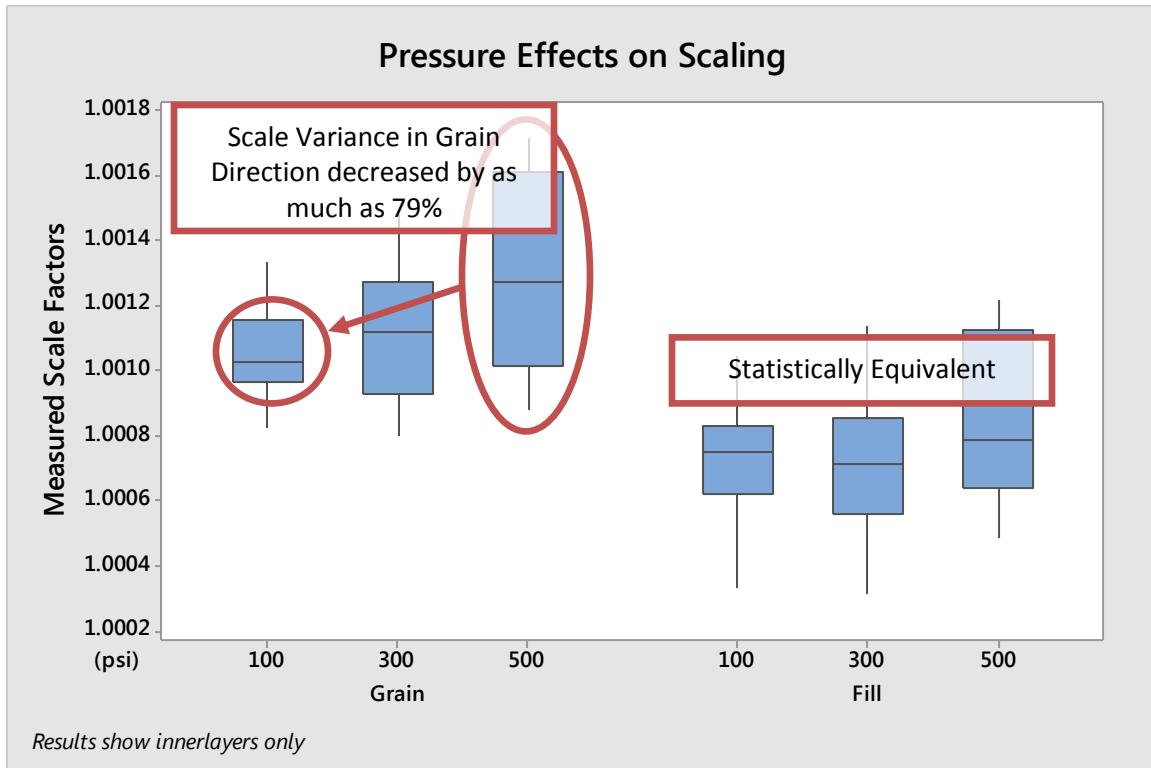
Full pressure should be achieved before the *fastRise™* reaches 248°F (120°C). *fastRise™* resin flow has been shown to be directly proportional to lamination pressure. Pressure can be used to control flow so that high-flowing *fastRise™* part numbers will act as no-flows or low-flowing part numbers achieve additional flow.

For example, FR27-0035-26 resin flow can be approximated with the following equation:

$$\text{Flow \%} = \text{Pressure} \times 0.0002 \quad [\text{psi}]$$

Lower pressures have been linked to decreased grain-direction scale variation between panels (see *Pressure Effects on Scaling* below). This effect was not observed in the fill-direction. Although low pressures can be used to reduce grain-direction scale variation, it is advised to modify heating rates before reducing the pressures; heating rates have a larger impact on scale variation and the risk of inadequate pressure is avoided.

Many fabricators find that a lamination pressure of 200-350 psi is effective for most products. In the event that high flow is required (e.g. heavy copper, via filling, etc.), some fabricators increase lamination pressure to 350-550 psi. Likewise, for low-flow applications (e.g. cavities, foil lamination, etc.) pressure ranges of 100-200 psi are often advantageous.



Low flow applications

Where limited or no resin flow is required, there are low resin flow formats of the *fastRise™* and the engineer should consider using these types along with exploring how to manage the flow level with pressure and time in the low viscosity window, with the specific design of pcb.

It is strongly recommended that suitable conformal press materials are used as well as employing methods for damming the resin flow in cut-outs or cavities.

Where cut-outs are made in the *fastRise™*, damming methods help with limited registration, restricted clearance to vias near the cavity, and gathering at the cut path when using mechanical processes. Although the minimum pressure should be used, pressure must be adequate to achieve adhesive contact surrounding the cutout area. Extending time in the low viscosity window may be helpful.

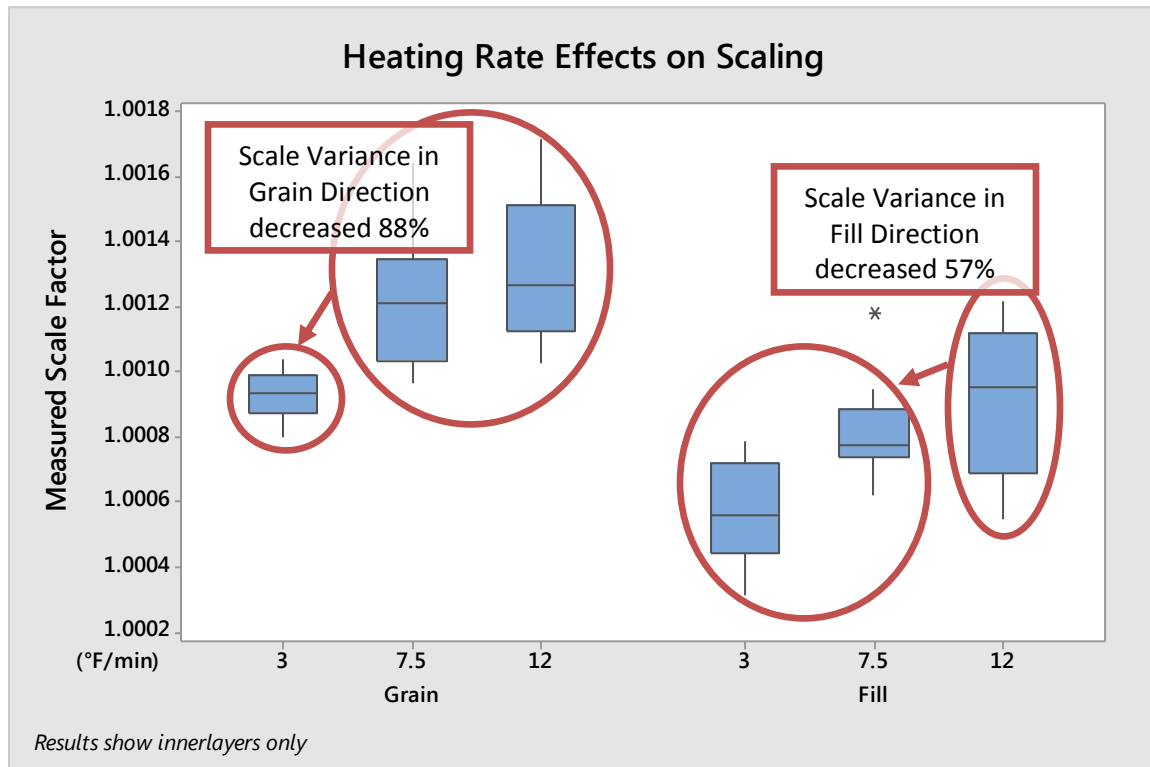
Temperature

Resin Flow Window / Critical Range

fastRise™ resin gels and melts between 176°F - 302°F (80°C – 150°C) and reaches its lowest viscosity between 215°F – 260°F (102°C – 127°C). Extending the time in which the resin is at its lowest viscosity can improve flow and is advantageous in hard to fill applications (e.g. heavy copper, embedded component cavities, via filling, etc.). Lengthening the time in this low viscosity window is accomplished by reducing the heating rate or by adding a dwell of up to 1 hour at 260°F (127°C).

Heating Rate

A cold start of the press is desirable. Typical *fastRise™* heating rates are 3°F/min – 8°F/min (1.7°C/min – 4.4°C/min) and rates of 3°F/min – 10°F/min (1.6°C/min – 5.5°C/min) have been successful. In difficult to fill applications such as heavy copper (>1oz.), via filling, etc. or in high layer count boards, a slow heating rate should be used. It is strongly recommended that low heating rates be used if the process is to accommodate tight registration requirements or high layer counts. Data has shown that lower heating rates (i.e. 3°F/min) can provide substantial improvements in registration repeatability



Curing

Curing begins at 395°F and *fastRise™* curing processes are usually designed to hold the bondline between 420°F – 450°F for a minimum of 1 hour. Curing temperatures of up to 480°F can be used and the elevated temperatures will achieve performance gains while lower temperatures have also been successful in hybrid lamination cycles.

Taconic has observed that higher lamination temperatures combined with a 2 hour dwell can lower Z-axis CTE values by more than 30%. High-reliability applications often use a 2 hour cure at the elevated temperatures. The reduction in Z axis CTE is related to the resin content of the *fastRise™* part number and will vary by *fastRise™* part number.

Elevated curing temperatures have also been shown to improve peel strengths. For this reason, it is strongly recommended that foil laminations use a cure temperature of at least 450°F.

Hybrid laminations have successfully been accomplished by curing at 395°F for 3 hours. Taconic advises caution as this is the minimum possible cure temperature and adhesion may be reduced.

Cooling

A slow cool is necessary to avoid any issues associated with delamination. The hot press should be cooled below 200°F before transferring to a cold press.

Foil Lamination

fastRise™ Selection

FR27-0040-43F and FR25-0021-45F were specifically designed for foil laminations and tend to provide superior surface quality and aesthetics. FR27-0040-43F is preferred due to the increased chances of drill smear with FR25-0021-45F. Other *fastRise™* part numbers will also work with foil lamination, but additional process development may be required. Lower flowing part numbers typically yield better results.

Recommended Foils

TWS or TW foils from Circuit Foils is ideal. Other copper foils with sufficient dendrite tooth structure may also be acceptable.

Pressure

Foil lamination requires minimal pressure. 100-200 PSI should be adequate and higher pressures may be used to fill copper that is plated to 1-2 oz. If the surface appearance shows signs of excessive flow or flow channels, the pressure should be reduced. Pressure has a little to no impact on peel strength. Cure temperature is much more effective at improving bond strengths.

Temperature

Slower heating rates are recommended for foil laminations and an added 60 minute dwell at 225°F (107°C) may also be advantageous to allow the resin to flow uniformly without flow channels. When heating from 225° (107°C) to 450°F (232°C), much lower heating rates of 3°F/min – 5°F/min should be used. A cure temperature of 450°F (232°C) for a minimum of 1 hour should be used for foil laminations. Peel strengths increase with elevated cure temperatures and extended cure times. Cooling rates should not exceed 6°F/min (3°C/min) until bondline is less than 200°F (93°C).

Foil Lamination Surface Quality

Excessive resin flow can cause flow channels which may be visible on the foil surface after lamination.



If the adhesion is good in some areas but delamination is found in other areas, it is likely the result of thermal shear stresses and there are several steps which can be taken. Cooling should never be done by transferring the laminates from a hot press to a cold press. Cooling rates of 2°F/min – 4°F/min or lower are ideal. An aluminum sheet and/or conformal padding (e.g. Taconic TacPad, skive PTFE, PacoPlus, etc.) placed between the panel and the steel plate will help reduce transferred shear stress. Press padding, such as PacoPad will also help.

Several fabricators have found clutch laminations helpful in which a layer of higher flowing prepreg (e.g. FR4, acrylic, polyimide) is placed between release sheets (e.g. PTFE film, foil release, PVDF film) that are then placed against the part during lamination. The higher flowing prepreg will flow providing hydrostatic pressure as well as offsetting thermal stresses.

Additional Notes

Poor Pressure Distribution

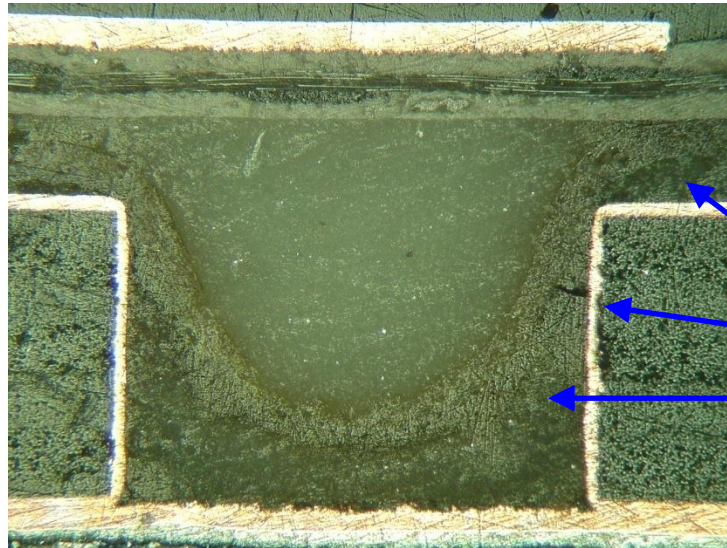
Constructions containing very low pressure areas with stacked regions of little or no copper between layers (e.g. coupons, ground clearances, fiducials, etc.) may require special considerations to achieve ideal bonding. Resin from the higher flowing *fastRise™* part numbers combined with higher pressures will fill the low pressure areas to balance the pressure. Although the low flow *fastRise™* may be capable, caution is advised to ensure that adequate resin flow and resin volume are present to avoid poor adhesion and resin starvation. Copper distribution should be as balanced as possible especially with thicker or plated circuits.

Multiple Ply Constructions

Resin flow can increase dramatically if multiple plies of *fastRise*[™] are used against each other. If high-flow is not desired, pressure should be reduced to approximately 25%-50% to prevent excess resin flow, resin separation, or formation of flow channels.

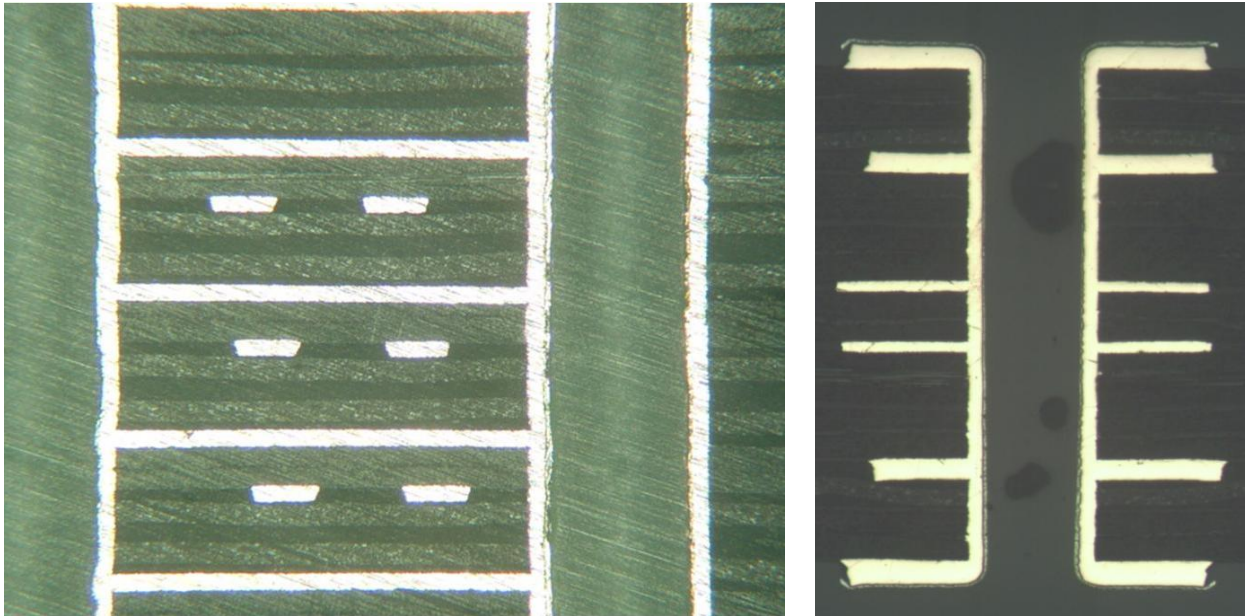
Encapsulating the conductor pattern

Although *fastRise*[™] film is not porous, it is flexible and will conform to circuit patterns. The film can have an elongation of 30-300% and will fill circuit patterns as long as there is sufficient resin to flow within the areas.



The flexible *fastRise* film has conformed so that the cavity is completely filled

DRILLING



Quick Start

The following chart is provided as a general starting point for drill process development. The later sections provide substantially more detail allowing the process to be optimized for differing applications.

	Imperial units	SI units
Entry Material	Phenolic (0.010" – 0.024")	Phenolic (0.25mm - 0.6mm)
Backer Material	Rigid Phenolic, Slickback, or comparable	
Cutting Speed (surface speed)	100 SFM	30.5 MPM
Chip Load	0.0010 in.	25.4 μm
Dwell	0-1000 ms (increase dwell time as speed and chip load deviate from above recommendations)	
Hit Count	700-1200	

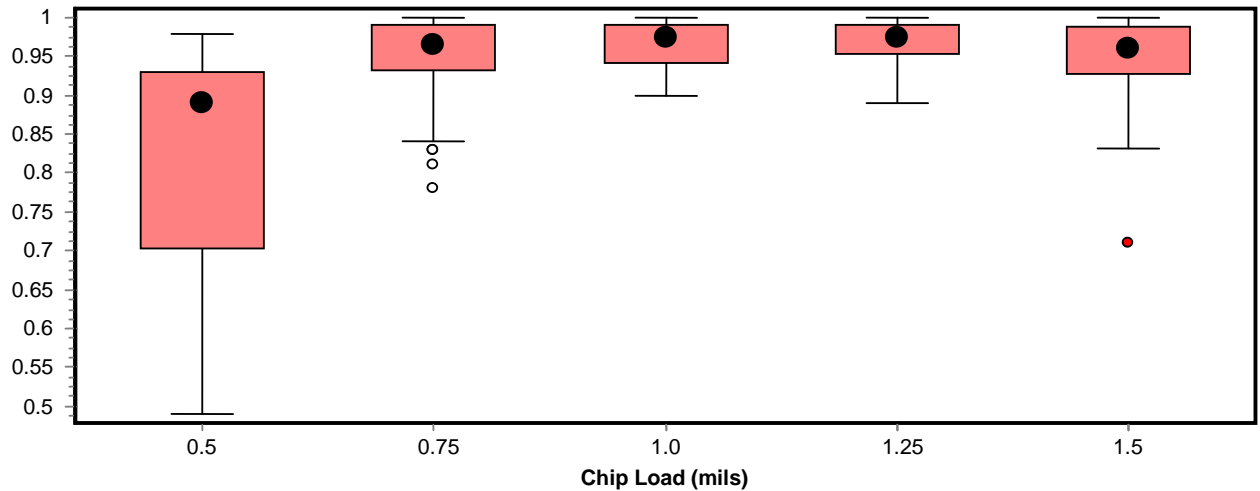
Drill Bits

Sharp drill bits are critical to any PTFE drilling; new drill bits should always be used. Undercut drill bits are recommended, but past studies have shown that some drill bit brands may obtain better results using their standard drill bits.

Chip Load

A nominal chip load of 1.0 mil (25.4 μm) should be used for all tool sizes. Increasing or decreasing the chip load from 1.0 mil (25.4 μm) has not been found to offer any quality improvements. Increasing the chip load to 1.25 mils (31.8 μm) may provide acceptable hole quality and improved productivity.

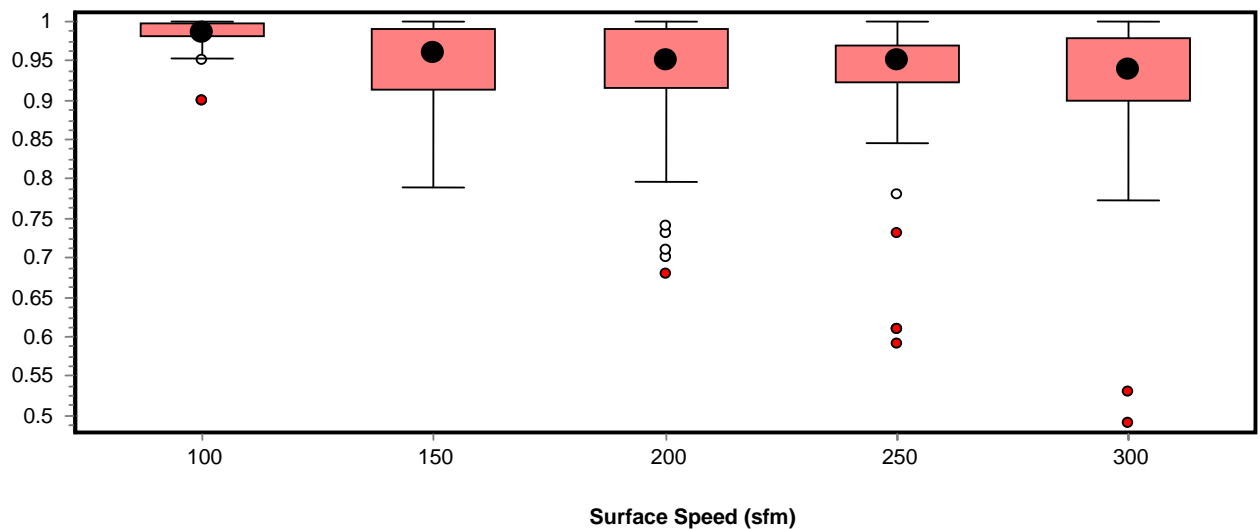
Hole Quality vs. Chip Load



Cutting Speed

Drill speeds of 100 SFM (30.5 m/min) or less is recommended. Slower speeds offer the greatest hole-quality improvements; they allow generated heat to dissipate before smearing PTFE. Drill speed can be increased due to equipment limitations, but added dwell times may become more important.

Hole Quality vs. Drill Speed



Dwell Time

Lower surface speeds will reduce or eliminate the need for dwell. If ideal cutting speeds cannot be obtained, a 250ms dwell is recommended for initial process setup in order to cool the drill bit between holes. Past Taconic studies have shown that hole-wall quality may improve as dwell times are increased to as much as 1000ms.

Peck Drilling

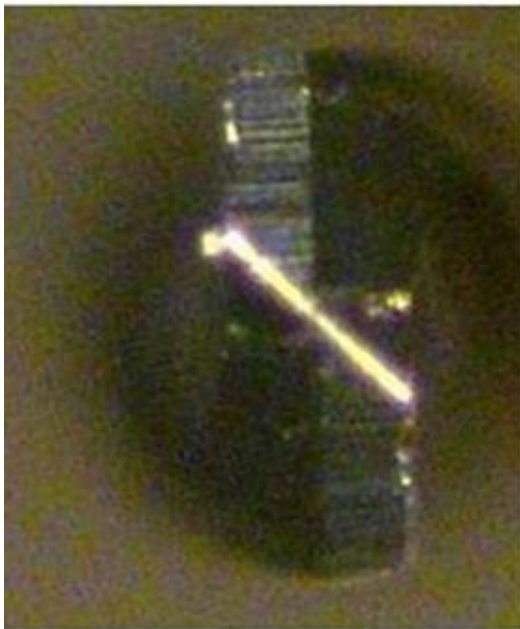
Peck drilling should be avoided where possible; it has been shown to increase drill bit wear as well as increase process time. Peck drilling may be required in some situations (e.g. bird nesting, hole plugging, chip extraction on thick panels, breaking thin drill bits, etc.).

If traditional peck drilling is not used, hole-wall quality may be improved with the use of a “clean” peck where the peck depth is set to equal that of the phenolic entry. In this, the entry material will effectively clean the drill bit, retract to clear phenolic debris and cool, and then reenter to drill the hole.

Hit Count

EZ-IO yields exceptional tool life when ideal cutting speeds and chip loads are used. Hit counts of 700-1000 are recommended for initial process setup. Larger tools should use less hits while smaller tools are capable of much higher hit counts. Drill hit counts exceeding 2000 hits have been obtained on thick high layer count boards using small diameter tools. The nanomaterial technology used in **EZ-IO** and **fastRise™ S** causes very little, if any, wear on drill bits as can be seen in the following photographs of drill points and hole-wall quality.

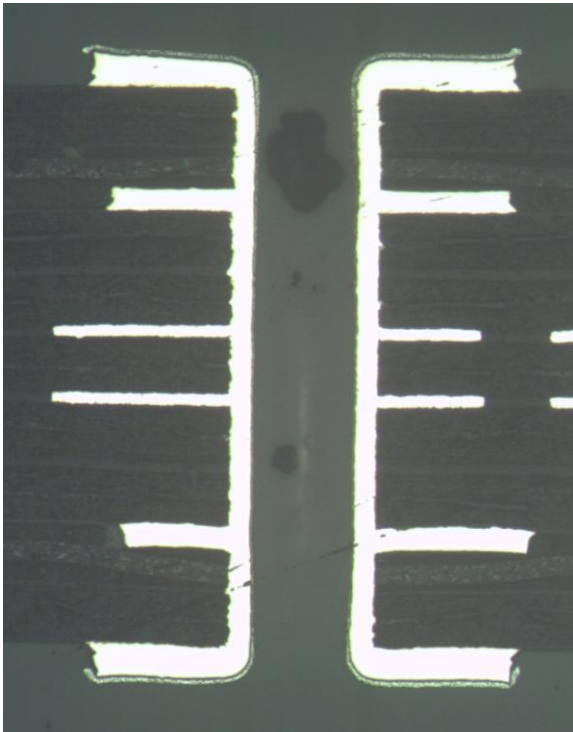
700 Hits - EZ-IO



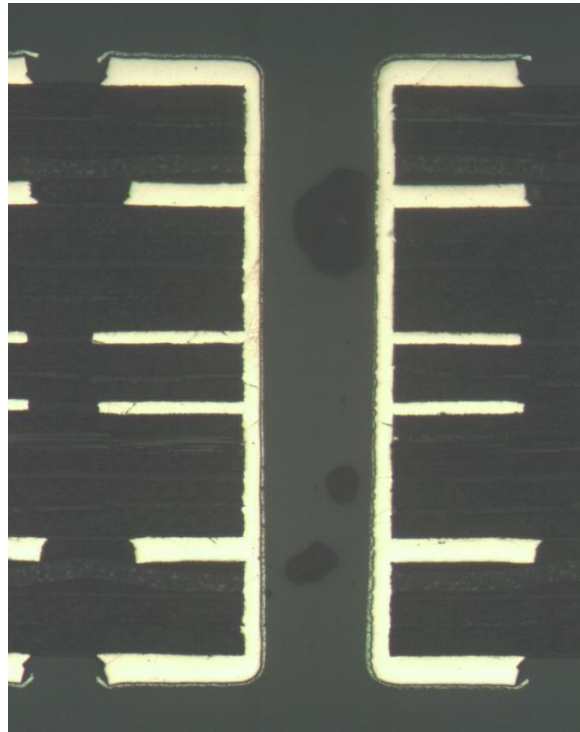
700 Hits – Traditional Ceramic/PTFE



100 Hits - EZ-IO

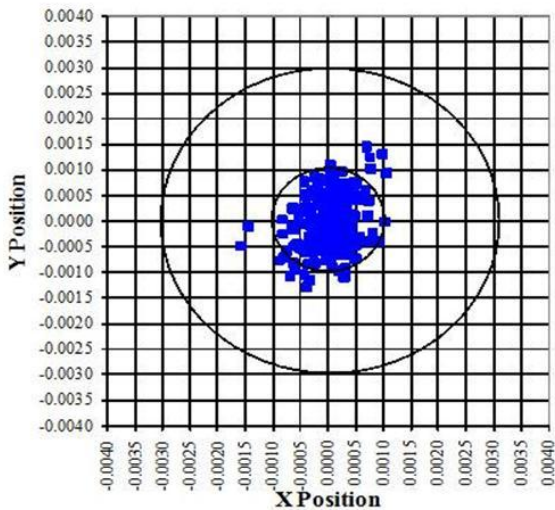


700 Hits - EZ-IO

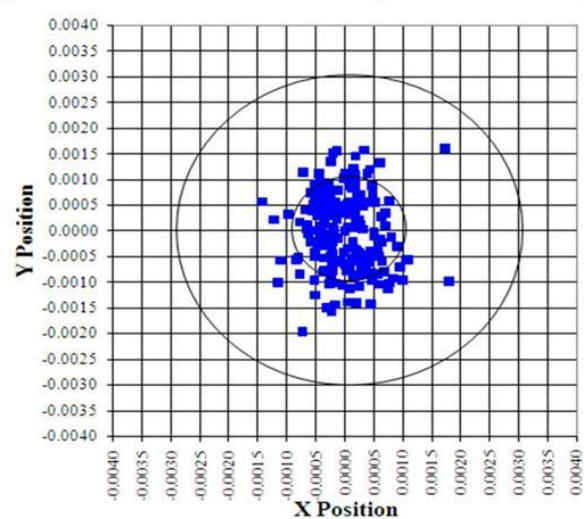


As the drill bit edges wear, the drill tool is more prone to wander and deflect. Measuring drill wander has been used to indicate tool life. The following charts show examples from one facility on the drill life obtained in their process.

Hole Positional Accuracy EZIO/FR28-0040-50S (20 mil holes)



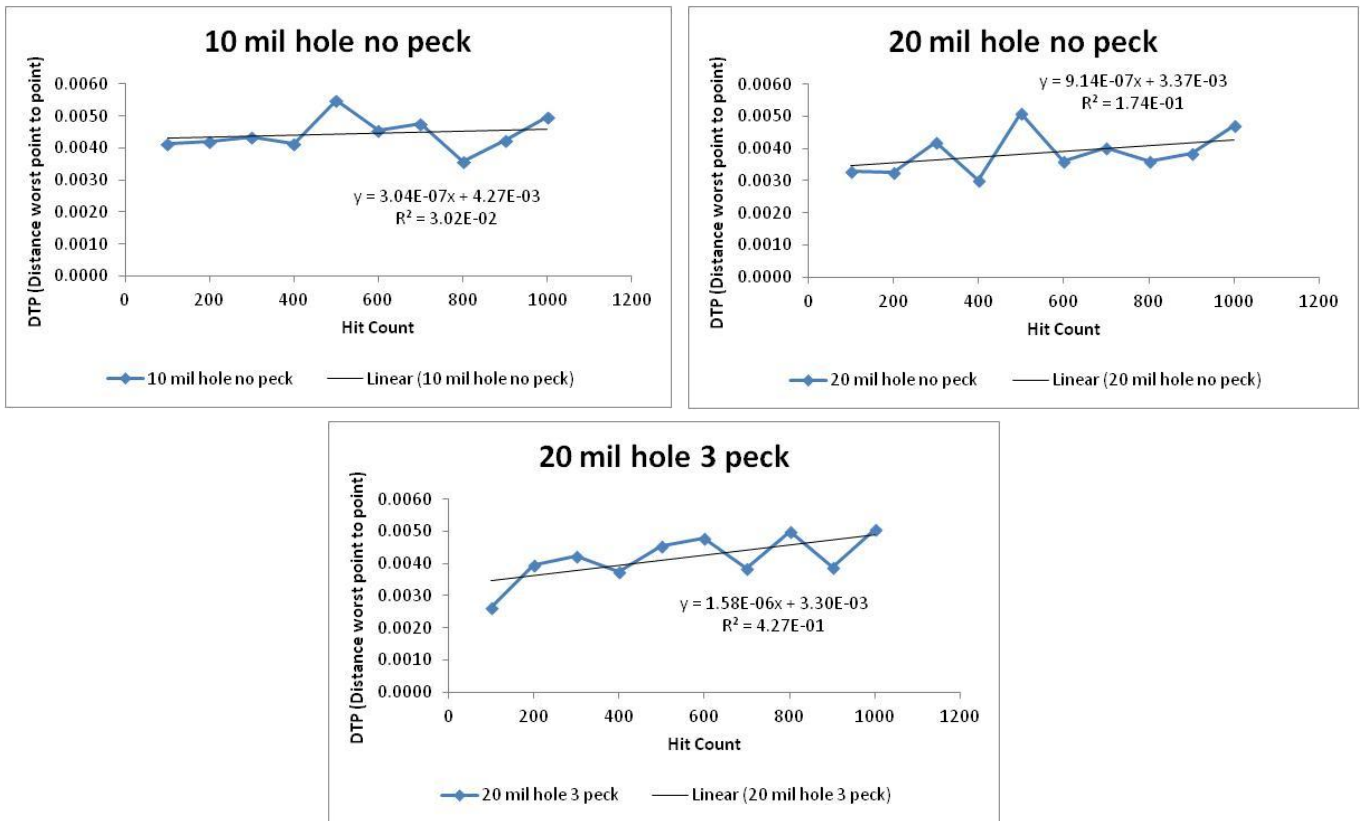
100 Hits



1000 Hits

The following chart shows the positional accuracy of a drill tool drilling through a 100 mil thick multilayer comprised of EZ-IO and *fastRise™ S* (FR28-0040-50S). The data suggests that peck drilling is worse than using a no peck approach. The problem with peck drilling is that every time the drill retracts

and reenters the hole there is some damage to the drill or the tool. Peck drilling is sometimes the only choice when you have to remove debris from thick panels. Under ideal circumstances, it is best not to peck drill.



Entry / Backer Materials

Entry

Rigid entry and exit material is critical in order to remove any debris or deposits from the drill bit. 10-25 mil phenolic entry is acceptable for most applications and 30-50 mil phenolic entry can be used if pressure foot clearance is substantial.

Backer

Like the entry, rigid backer is necessary to prevent burring and aid in obtaining hole-wall quality. Thick phenolic is typical and lubricated rigid backers such as SlickBack® from L.C.O.A.® have also been found to be very successful.

Laser Drilling / MicroVias

EZ-IO

Testing has shown that EZ-IO laminates respond well to either UV/YAG lasers or CO₂ lasers. Microvia quality and consistency can be superior to that of flat-glass epoxies, laser-drillable glasses, or ceramic loaded materials.

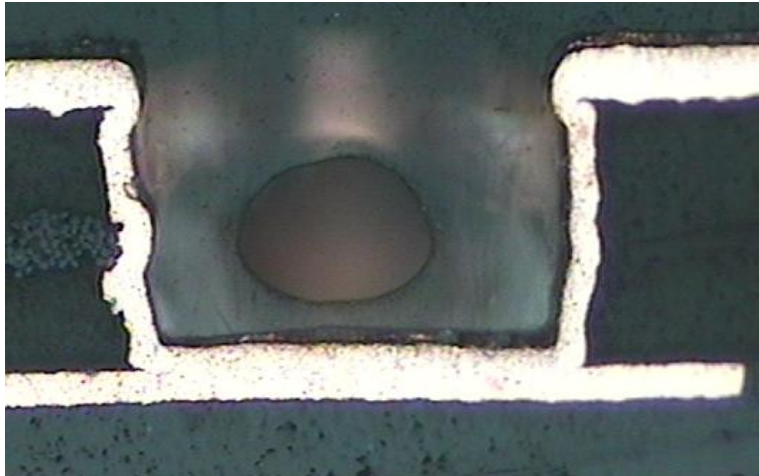


Photo by Boardtek

fastRise[™]

The lasing of the *fastRise*[™] part numbers will vary between the different part numbers; please consult the *fastRise*[™] datasheet for details regarding the ideal part numbers. Standard *fastRise*[™] part numbers or *fastRise*[™] S part numbers typically yield improved hole-wall quality.

FR28-0050-40

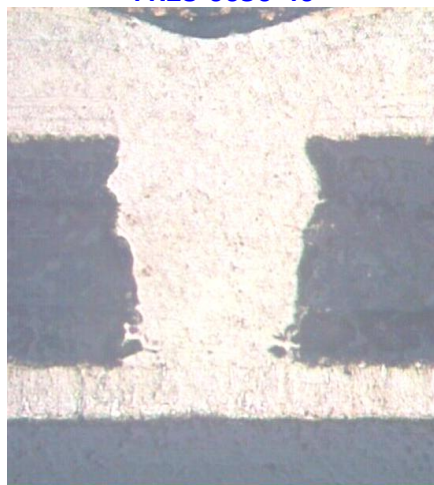


Photo by Hughes Circuits

HOLE WALL PREPARATION

fastRise™ and *EZ-IO* require a PTFE activation cycle. *fastRise™* will benefit from a desmear/etchback process performed prior to the PTFE activation.

Desmear

Plasma

If panels have been exposed to moisture, bake the boards at 220°F - 250°F (104°C - 121°C) for 1 hour. Standard FR4/epoxy desmear processes should then be used. The desmear plasma time is typically half that of standard FR4/epoxy times because *fastRise™* resin system tends to etch back very quickly.

Permanganate

Permanganate desmear IS NOT RECOMMENDED and has been shown to be very aggressive on *fastRise™* resulting in excessive etchback. This is due to the high silica filler content and thermoset content in the resin system.

PTFE Activation

Plasma

If panels have been exposed to moisture, pre-bake the boards at 220°F - 250°F (104°C - 121°C) for 1 hour. Plasma treat the PTFE resin using 70%/30% Hydrogen/Nitrogen gas mixture. 100% Helium may also suffice. Power settings for the RF-signal generator are typically 60-75% of full rated power for 30-60 minutes. Thick panels or high-aspect ratio holes may require extended plasma cycle times. Thick panels may also benefit from an additional 30 minute O₂ plasma process prior to the PTFE activation plasma.

Sodium Etch

Sodium Etches (e.g. Fluoroetch) work well with both *fastRise™* and *EZ-IO*. Follow the manufacturer's recommended treatment process. Subsequently, bake for 1 hour at 250° F [121°C] prior to plating to remove moisture that may have been absorbed during the sodium treatment process.

Chlorine can have adverse effects on the sodium treatment. Do not subject exposed sodium etch treated holes to heavily concentrated chlorine-based chemical processes.

Process Example

The following table is offered by March Plasma as a basic starting point recipe:

Power (kW)	Pressure (mT)	Gases	Gas Ratios	Flow (slm)	Pl Temp (°C)	Time (minutes)	Function
4.5	250	O ₂ / N ₂	90 / 10	2.5	90	A/R	Heating
4	250	CF ₄ / O ₂	10 / 90	2.5	99	10	Thermoset etch-back
4	250	O ₂	100	2.5	99	5	Removes fluorine and cleans the glass
4.2	250	N ₂	100	2.5	99	30	Activates PTFE. H ₂ /N ₂ Cycle is typically more effective and reliable

PLATING

EZ-IO has been engineered to be highly resistant to chemical infiltration and a robust hole wall preparation process is necessary for a successful deposition plating process. Following hole wall preparation, *fastRise™* / EZ-IO will accept standard electroless copper or direct metallization plating.

For high-aspect ratios or other difficult to plate applications, a second pass through the electroless process may be required to ensure proper hole-wall coverage. It may also be beneficial to run a short duration of electrolyzed copper, rinse etc., then restart the electrolyzed copper from the beginning to expose the hole wall to fresh chemistry.

IMAGE, DEVELOP, ETCH, STRIP OF EZ-IO

When copper surface preparation is required, chemical cleaning processes are preferred (e.g. microetch); mechanical scrubbing (e.g. pumice scrub) should be avoided due to possible mechanical damage. Otherwise, standard processing should be used.

SOLDER MASK

No special treatment is required if the surface has not been mechanically scrubbed. In rare cases where adhesion is poor, a plasma treatment may be used to activate the exposed PTFE.

SOLDER REFLOW

A pre-bake cycle of 2 – 3 hours at 300° F [150°C] is recommended prior to thermal stressing. Longer pre-heat times and minimal cycle times may be advantageous depending on design and processes.

ROUTING / MILLING

fastRise™ / *EZ-IO* can be successfully machined using standard router bits or end mills. Rigid phenolic entry and a rigid backer should be used. In some cases, adding paper (white paper or craft paper) between the phenolic and the part allows better conformance to surface topography (e.g. circuits, soldermask, etc.) and may reduce burring. For tight tolerances or superior edge quality, a “rough cut” placed 0.005 in. -0.010 in. off the part edge may be run prior to the “finish” cut at the nominal part edge.

Router Diameter		Spindle Speed (kRPM)	Feed Rate	
(mils)	(mm)		(in/min)	(m/min)
33	0.8	50	10.8	0.27
39	1.0	40	12.2	0.31
47	1.2	34	12.6	0.32
63	1.6	25	18.7	0.48
78	2.0	20	27.2	0.69
94	2.4	20	35.0	0.89
118	3.0	20	42.5	1.08
125	3.2	20	43.3	1.10

APPENDIX

Drill Charts

Size		Spindle Speed	Infeed	
(inches)	(mm)		(in/min)	(m/min)
.0040	0.10	95.5	96	2.44
.0050	0.13	76.4	76	1.93
.0059	0.15	64.7	65	1.65
.0063	0.16	60.6	61	1.55
.0067	0.17	57.0	57	1.45
.0071	0.18	53.8	54	1.37
.0075	0.19	50.9	51	1.30
.0079	0.20	48.4	48	1.22
.0083	0.21	46.0	46	1.17
.0087	0.22	43.9	44	1.12
.0091	0.23	42.0	42	1.07
.0095	0.24	40.2	40	1.02
.0098	0.25	39.0	39	0.99
.0100	0.25	38.2	38	0.97
.0105	0.27	36.4	36	0.91
.0110	0.28	34.7	35	0.89
.0115	0.29	33.2	33	0.84
.0118	0.30	32.4	32	0.81
.0120	0.30	31.8	32	0.81
.0125	0.32	30.6	31	0.79
.0130	0.33	29.4	29	0.74
.0135	0.34	28.3	28	0.71
.0138	0.35	27.7	28	0.71
.0145	0.37	26.3	26	0.66
.0156	0.40	24.5	25	0.64
.0158	0.40	24.2	24	0.61
.0160	0.41	23.9	24	0.61
.0177	0.45	21.6	22	0.56
.0180	0.46	21.2	21	0.53

Size		Spindle Speed	Infeed	
(inches)	(mm)		(in/min)	(m/min)
.0197	0.50	19.4	19	0.48
.0200	0.51	19.1	19	0.48
.0210	0.53	18.2	18	0.46
.0217	0.55	17.6	18	0.46
.0225	0.57	17.0	17	0.43
.0236	0.60	16.2	16	0.41
.0240	0.61	15.9	16	0.41
.0250	0.64	15.3	15	0.38
.0256	0.65	14.9	15	0.38
.0260	0.66	14.7	15	0.38
.0276	0.70	13.8	14	0.36
.0280	0.71	13.6	14	0.36
.0292	0.74	13.1	13	0.33
.0295	0.75	12.9	13	0.33
.0310	0.79	12.3	12	0.30
.0312	0.79	12.2	12	0.30
.0315	0.80	12.1	12	0.30
.0320	0.81	11.9	12	0.30
.0330	0.84	11.6	12	0.30
.0335	0.85	11.4	11	0.28
.0350	0.89	10.9	11	0.28
.0354	0.90	10.8	11	0.28
.0360	0.91	10.6	11	0.28
.0370	0.94	10.3	10	0.25
.0374	0.95	10.2	10	0.25
.0380	0.97	10.1	10	0.25
.0390	0.99	9.8	10	0.25
.0394	1.00	9.7	10	0.25
.0400	1.02	9.5	10	0.25

Size		Spindle Speed	Infeed	
(inches)	(mm)		(in/min)	(m/min)
.0410	1.04	9.3	9	0.23
.0413	1.05	9.2	9	0.23
.0420	1.07	9.1	9	0.23
.0430	1.09	8.9	9	0.23
.0433	1.10	8.8	9	0.23
.0453	1.15	8.4	8	0.20
.0465	1.18	8.2	8	0.20
.0469	1.19	8.1	8	0.20
.0472	1.20	8.1	8	0.20
.0492	1.25	7.8	8	0.20
.0512	1.30	7.5	8	0.20
.0520	1.32	7.3	7	0.18
.0531	1.35	7.2	7	0.18
.0550	1.40	6.9	7	0.18
.0551	1.40	6.9	7	0.18
.0571	1.45	6.7	7	0.18
.0591	1.50	6.5	7	0.18
.0595	1.51	6.4	6	0.15
.0610	1.55	6.3	6	0.15
.0625	1.59	6.1	6	0.15
.0630	1.60	6.1	6	0.15
.0635	1.61	6.0	6	0.15
.0650	1.65	5.9	6	0.15
.0669	1.70	5.7	6	0.15
.0670	1.70	5.7	6	0.15
.0689	1.75	5.5	6	0.15
.0700	1.78	5.5	6	0.15
.0709	1.80	5.4	5	0.13
.0728	1.85	5.2	5	0.13
.0730	1.85	5.2	5	0.13
.0748	1.90	5.1	5	0.13
.0760	1.93	5.0	5	0.13
.0768	1.95	5.0	5	0.13
.0781	1.98	4.9	5	0.13
.0785	1.99	4.9	5	0.13

Size		Spindle Speed	Infeed	
(inches)	(mm)		(in/min)	(m/min)
.0787	2.00	4.9	5	0.13
.0807	2.05	4.7	5	0.13
.0810	2.06	4.7	5	0.13
.0820	2.08	4.7	5	0.13
.0827	2.10	4.6	5	0.13
.0846	2.15	4.5	5	0.13
.0860	2.18	4.4	4	0.10
.0866	2.20	4.4	4	0.10
.0886	2.25	4.3	4	0.10
.0890	2.26	4.3	4	0.10
.0906	2.30	4.2	4	0.10
.0925	2.35	4.1	4	0.10
.0935	2.37	4.1	4	0.10
.0938	2.38	4.1	4	0.10
.0945	2.40	4.0	4	0.10
.0960	2.44	4.0	4	0.10
.0965	2.45	4.0	4	0.10
.0980	2.49	3.9	4	0.10
.0984	2.50	3.9	4	0.10
.0995	2.53	3.8	4	0.10
.1004	2.55	3.8	4	0.10
.1015	2.58	3.8	4	0.10
.1024	2.60	3.7	4	0.10
.1040	2.64	3.7	4	0.10
.1043	2.65	3.7	4	0.10
.1063	2.70	3.6	4	0.10
.1065	2.71	3.6	4	0.10
.1083	2.75	3.5	4	0.10
.1094	2.78	3.5	4	0.10
.1100	2.79	3.5	4	0.10
.1102	2.80	3.5	4	0.10
.1110	2.82	3.4	3	0.08
.1122	2.85	3.4	3	0.08
.1130	2.87	3.4	3	0.08
.1142	2.90	3.3	3	0.08

