AGC
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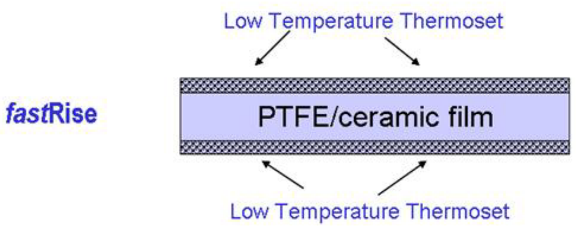
fastRise™

General Processing Guidelines

General Information

Overview

fastRise™ prepreg is designed for applications where low loss or high operating temperature is required. 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. 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:



It is important to understand that the different fastRise™ part numbers have been optimized for different applications; using the correct fastRise™ part number for each design can greatly ease fabrication and improve quality. fastRise™ can be roughly broken into four families (standard, specialty, S, and 7) in which variants of the center film and/or resin are used (details are discussed below). More detailed information regarding specific fastRise™ part number properties can be found on the data sheet(s).

fastRise™ Standard Prepregs

The standard fastRise™ family use a ceramic loaded PTFE film and are recommended for the majority of applications. This family provides a very versatile material with forgiving processing.

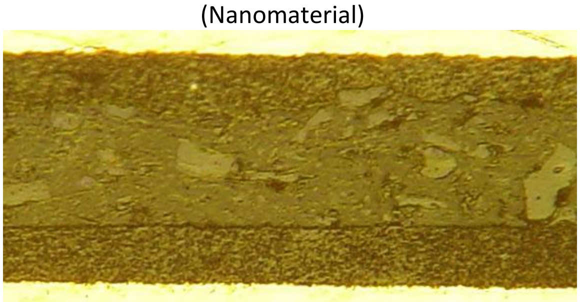
fastRise™ Specialty Prepregs

The specialty fastRise™ family uses a pure PTFE film which enables thinner dielectric thicknesses. Although this product is used daily in production applications with excellent results, it should be noted that it is less forgiving in processing and additional process development may be required. The primary difficulty is a result of drill smear from the pure PTFE film which can be resolved.

fastRise™ S Prepregs

The fastRise™ S family employs much of the same nanomaterial technology utilized in EZ-IO. fastRise™ S prepregs maintain the performance gains of EZ-IO nanomaterials while providing simplified and reduced processing costs. The fastRise™ S family will also grant improved hole quality for both mechanical and laser drilled vias. Such prepregs include fastRise™ S part numbers FR28-0040-50S and FR27-0050-40S, though others may also be made available.

fastRise S
(Nanomaterial)



fastRise
(Standard)

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

Storage

Store the material in a cool dry area away from direct sunlight and high humidity, avoiding material contamination. fastRise™ is certified to meet all requirements as agreed upon between the user and supplier for a given shelf life as defined by the storage conditions below.

Storage Conditions

Condition 1 (i.e. refrigeration) : <4.5°C (40°F)
Condition 2 (i.e. room temp) : <23°C (73°F), Relative Humidity <50%

When removing fastRise™ prepreg from refrigeration, it should be allowed to acclimate to room temperature in the 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.

Shelf Life
If material is stored under Condition 1 above, a shelf life of 180 days after receipt of shipment will apply. If material is stored under Condition 2 above, a shelf life of 90 days after receipt of shipment will apply. AGC will not ship fastRise™ material with less than 90 days of remaining shelf life. Packaging will default to indicate shelf life based on storage Condition 2 unless we are notified that Condition 1 applies. In the event that prepreg expires, please contact your AGC technical sales person for assistance to coordinate re-testing the expired prepreg.

Handling

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™ 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

Note: The fastRise™ resin exhibits a high degree of tackiness and should always be handled at cooler temperatures to prevent contamination or other handling damage.

Inner Layer Preparation

Laminate Preparation

fastRise™ will bond well to most other materials. Inner-layers should be clean and dry before bonding. Oxide treatments of copper surfaces are recommended.

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.

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.

	Low Flow / Foil Lamination	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 (2 – 4°C/min)		
Critical Range	176°F – 302°F (80°C – 150°C)		
Pressure	100 – 200 psi	200 – 350 psi	350 – 500 psi
Cure Temp / Time (measured at bondline)	420°F -480°F for 60 – 120 minutes (215 – 250°C for 60 - 120 minutes)		
Cooling Rate	Less than 6°F/min (3°C/min)		
Breakdown	Breakdown or transfer to cold press when bondline is less than 200°F (95°C)		

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

Padding and Conformance Materials

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

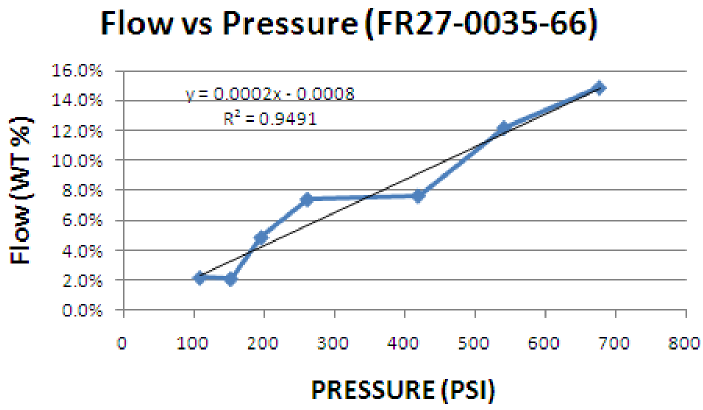
Pressure

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

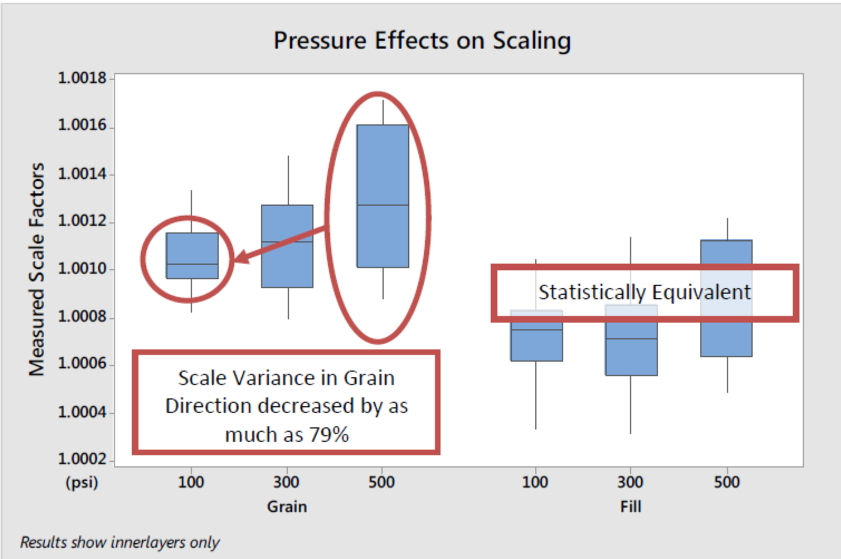
Full pressure should be achieved before the fastRise™ reaches 250°F (120°C). fastRise™ resin flow has been shown to be directly proportional to lamination pressure. Pressure can be used to control flow so that high-flowing fastRise™ part numbers can potentially act as no-flows. Conversely, low-flowing part numbers can achieve additional flow with increased pressure.

For example, FR27-0035-66 resin flow can be approximated with the following equation:

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



Data has shown that lower lamination pressures are 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 because 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 the majority of 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.

Note: The fastRise™ resin is a lower flowing resin and should be laminated using the highest possible pressure (500+ psi). Care should also be taken during the design phase to minimize low pressure areas in the board and coupons to prevent lamination voids.

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

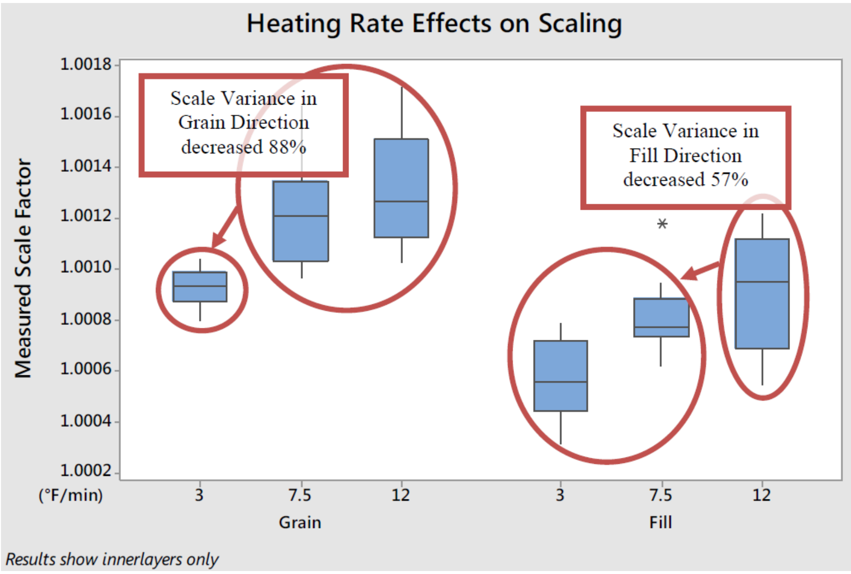
Resin Flow Window / Critical Range

fastRise™ resin gels and flows between 176°F - 302°F (80°C – 150°C) and reaches its lowest viscosity between 215°F – 260°F (100°C – 125°C). Extending the time in which the resin is at its lowest viscosity can improve flow and may be 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 250°F (120°C).

Note: Due to its lower flow rate, fastRise™ laminations should always include a 30-60 minute dwell at 250°F (120°C) against anything other than ½ oz copper (or where low pressure areas may exist).

Heating Rate

A cold start of the press is desirable. Typical fastRise™ heating rates are 3-8°F/min (2-4°C/min) and rates of 3-10°F/min (2-5°C /min have been successful. In difficult to fill applications such as heavy copper (>1oz.), via filling, using fastRise™, 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 can provide substantial improvements in registration repeatability (see Heating Rate Effects on Scaling below)



Curing

Curing begins at 395°F (200°C) and fastRise™ curing processes are usually designed to hold the bondline between 420°F – 450°F (215°C – 230°C) for a minimum of 1 hour. Curing temperatures of up to 480°F (250°C) can be used and the elevated temperatures will achieve performance gains while lower temperatures have also been successful in hybrid lamination cycles. AGC 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 (230°C). Hybrid laminations have successfully been accomplished by curing at 395°F (200°C) for 3 hours. AGC 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 (95°C) before transferring to a cold press. In situations where mismatched CTE's may induce delamination or where warping may be an issue, slower cooling rates may provide better results.

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 (110°C) may also be advantageous to allow the resin to flow uniformly without flow channels. When heating from 225° (110°C) to 450°F (230°C), much lower heating rates of 3-5°F/min (2-3°C/min) should be used.

A cure temperature of 450°F (230°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 (95°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 2-4°F/min (1-2°C/min) or lower are ideal.

An aluminum sheet and/or conformal padding (e.g. AGC 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 provide hydrostatic pressure as well as offset thermal stresses.

Additional Notes

Cavity Applications

All fastRise™ part numbers can be successfully used in cavity applications. Prepreg cutbacks are often 0.005”-0.020” (0.1 – 0.5 mm), but results can vary widely based on the board design, processing, and between fastRise™ part numbers. Low flowing part numbers, such as FR27-0040-43F and FR25-0021-12-45F, are often ideal for processing without a plug or dam to restrain resin flow.

Other part numbers will benefit from the use of a plug or dam to contain resin flow from depositing within the cavity area. Since resin flow is proportional to lamination pressure, pressures as low as 75-150 psi are sometimes used to prevent resin flow into the cavity area.

Again, results can be greatly impacted by design, process, or differences between part numbers. AGC Technical Service is available for assistance.

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.

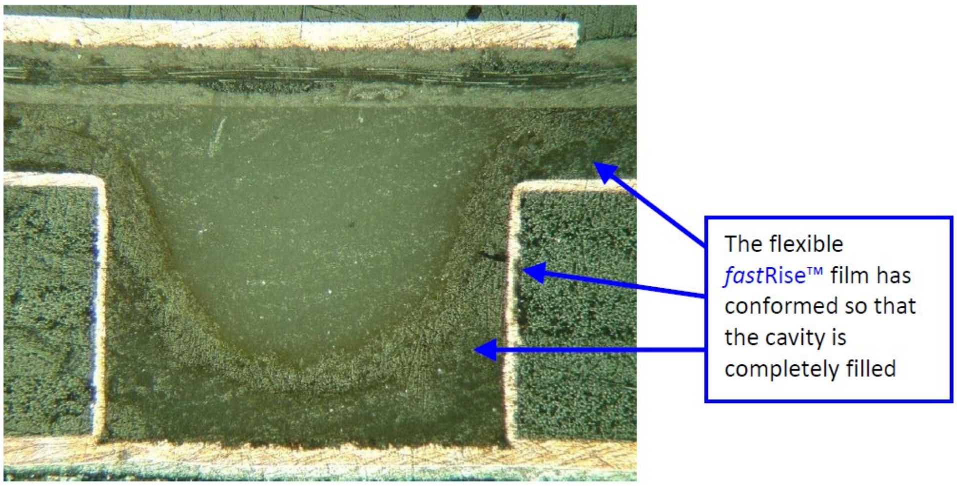
Although the low flow fastRise™ may be capable, caution is advised to ensure that adequate resin flow and resin volume are present to avoid poor adhesion and resin starvation. Copper distribution should be as balanced as possible especially with thicker or plated circuits.

Multiple Ply Constructions

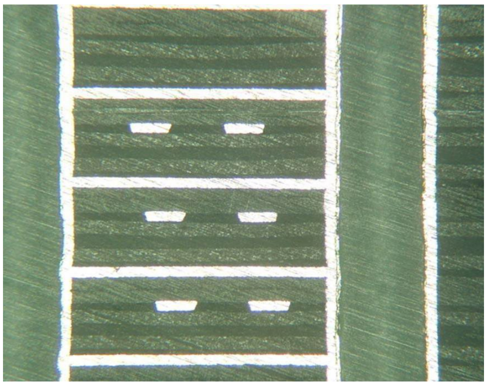
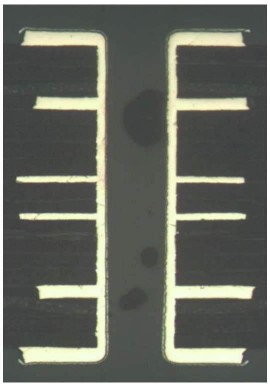
Resin flow can increase dramatically if multiple plies of fastRise™ are used against each other. If high-flow is not desired, pressure should be reduced to approximately 25%-50% to prevent excess resin flow, resin separation, or formation of flow channels.

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.



Drilling

In most cases, the laminate cores will dictate drilling parameters. The following information is provided as a general suggested starting point where fastRise is the primary material. Contact AGC technical service for AGC laminate processing guides.

Quick Start

	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 µm
Dwell	0-1000 ms (increase dwell time as speed and chip load deviate from above recommendations)	

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 chip load of 1.0 mil (25 µm) is common when fastRise™ is paired with ceramic/PTFE laminates. Increasing the chip load to 1.25 mils (30 µm) may provide acceptable hole quality and improved productivity.

Cutting Speed

Drill speeds of 100 SFM (30.5 m/min) or less will usually eliminate drill smear if it is present. The slower speeds 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.

Dwell Time

If smear is present and 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 AGC studies have shown that hole-wall quality in PTFE materials may improve as dwell times are increased to as much as 1000ms.

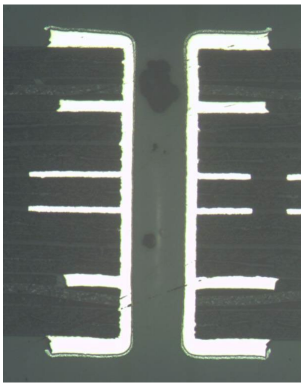
Peck Drilling

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 in PTFE laminates 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.

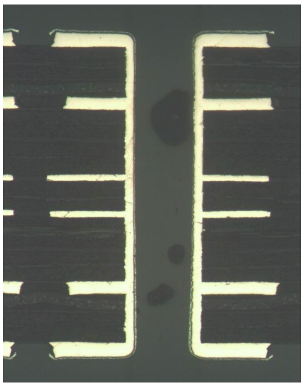
Hit Count

Hit counts can vary widely and are usually determined by the laminates used. Hit counts of 100-300 hits per bit are typical for ceramic/PTFE constructions. However, in cases where fastRise™ S or Specialty fastRise™ are used with nanomaterials (i.e. EZ-IO) or non-ceramic laminates, hit counts of 700-1000 are not uncommon. Hit counts exceeding 2000 hits have been obtained on thick high layer count boards using EZ-IO and fastRise™ S (see the following photos).

Note: fastRise™ contains fiberglass reinforcement and drill life will be affected accordingly.



100 Hits - EZ-IO / fastRise™ S



700 Hits - EZ-IO / fastRise™ S

Entry / Backer Materials

Rigid entry and exit material is critical in order to remove any debris or deposits from the drill bit. 0.010 – 0.025" (0.25 – 0.60 mm) phenolic entry is acceptable for most applications and 0.030 – 0.050" (0.75 – 1.25 mm) phenolic entry can be used if pressure foot clearance is substantial. 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 successful.

Laser Drilling / MicroVias

The lasing of the fastRise™ part numbers will vary between the different part numbers; please consult the fastRise™ data sheet or selector guide for details regarding the ideal part numbers. The lack of fiberglass reinforcement produces smoother hole wall plating. Standard fastRise™ part numbers or fastRise™ S part numbers typically yield improved hole-wall quality.

Laser microvia in FR27-0050-40 as performed by Hughes Circuits

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Hole Wall Preparation

fastRise™ requires 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 (105°C - 120°C) for one or more hours to drive out moisture. 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. If permanganate baths must be used for desmear or activation of other materials used in conjunction with fastRise™, consult with your AGC technical service representative for specific process recommendations.

PTFE Activation

Plasma

If panels have been exposed to moisture, pre-bake the boards at 220°F - 250°F (105°C - 120°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, but results may vary. 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 fastRise™ as well as other AGC materials. Follow the manufacturer's recommended treatment process. Subsequently, bake for 1 hour at 250°F (120°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)	Pnl Temp (°C)	Time (minutes)	Function
4.5	250	O2 / N2	90 / 10	2.5	90	A/R	Heating
4	250	CF4 / O2	10 / 90	2.5	99	10	Thermoset etch-back
4	250	O2	100	2.5	99	5	Removes fluorine and cleans the glass
4.2	250	N2	100	2.5	99	30	Activates PTFE. 70/30 H2/N2 Cycle is typically more effective and reliable

Note: Regardless of which method of hole wall treatment is used, desmearing of the thermoset resin should be done prior to treatment of the PTFE resin.

Plating

A robust hole wall preparation process is necessary for a successful deposition plating process due to the PTFE content in the fastRise™. Following hole wall preparation, fastRise™ 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 is sometime used 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, Srtip

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. Although fastRise™ should be resistant to this damage, typical materials used in conjunction with fastRise™ may not be. Otherwise, standard processing should be used.

Solder Mask

Panels should be clean and dry. No other special treatment is required if the surface has not been mechanically scrubbed.

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™ can be successfully machined using standard router bits or end mills. Machine parameters will be driven by the laminates used. In general, 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 – 0.010" (0.1 – 0.2 mm) off the part edge may be run prior to the finish cut at the nominal part edge.

These guidelines can provide only basic and reference information for PCB fabricators. Because of different environment, equipment, tooling and so on, in all instances, the user shall determine suitability in any given conditions or applications. For more detailed processing information, please contact with the AGC engineer or sales representative.

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