PhaseBlue® Series Circuit Materials

Processing Guidelines

Product Description

PhaseBlue® Series Circuit Materials represent a disruptive new technology, delivering substantial dielectric and thermal performance advantages over traditional circuit materials. Built on a polyimide aerogel core, PhaseBlue leverages the long-standing reliability of polyimide — a material that has been deployed in billions of circuits since the 1960s — while remaining fully compatible with modern thin-core PCB fabrication processes. Retaining many of the hallmark characteristics of polyimide, PhaseBlue offers high temperature tolerance, formability, and environmental responsibility. As a fluorine-free, U.S.-designed and manufactured copper-clad laminate (CCL), PhaseBlue not only addresses growing concerns regarding PFAS and polyhalogenated materials, but also ensures compliance with IPC-4202C.

PhaseBlue's unique structure creates disruptive changes to the PCB industry. A processable laminate from a reticulated nanostructure (85% air and 15% polyimide) creates a dielectric constant (Dk) of <1.5 and a dissipation factor (Df) of < 0.001 (both at 1 GHz). These attributes provide great performance for antennas, RF, microwave, high-speed digital and other demanding applications. Incumbent materials at this performance level tend to be PTFE. PTFE is being phased out of many application types, because of its environmental impact and the new regulations being imposed on products made with the material. By coupling PhaseBlue's thickness (0.0065 - 0.030" / 165 - 750 µm) with its formability, three-dimensional and dense packaging solutions are easy to create. It has the lowest density of all common PCB materials and works wonderfully in space and aeronautical applications.

Assembly

Assembly is successfully accomplished through proper circuit design. Using FPCB techniques and consideration to heat flow in the material , most designs are easily assembled.

Processing

PhaseBlue's low density alters its physical characteristics, requiring minor modifications to standard PCB processing. It is a thin and light laminate. It needs to be framed to prevent damage. It processes much like a flexible circuit. Care in handling is important. The core polyimide aerogel is 85% air. While it is easy to bond to the polyimide portion of the material there is no bond to the air portion. This results in a relatively low peel strength of approximately 2 lb/in. Additionally, the mechanical Z-axis strength is provided by the polyimide content. Heat and pressure need to be tightly controlled to not crush the cell structure of the material in all but a few processes (including FR-4 processing, DES, etchback, excising, drill, etc.).

Storage

Recommended Storage Conditions:

- Temperature: 70 ± 5 °F (21 ± 3 °C)
- Relative Humidity: below 50%

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1. General Overview

PhaseBlue® is a disruptive, polyimide-based aerogel material designed for printed circuit applications. Its composition of 85% air and 15% polyimide combines proven reliability (used in billions of circuits since the 1960s) with a nanostructured foam-like morphology. Though it handles like a solid film, its porous structure significantly enhances electrical performance.

Key Properties	
Dielectric Constant	1.5 @ 1 GHz
Dissipation Factor	<0.001 @ 1 GHz
Thickness	0.0065 - 0.030" / 165 - 750 µm
Dielectric Density	Lowest among common PCB materials at 0.27 g/cm^3 – 0.45 g/cm^3
Composition	Laminate from reticulated nanostructure (85% air and 15% polyimide)
Formability	High; supports 3D, high-density packaging
Environmental Impact	Favorable compared to PTFE

Performance Advantages: PhaseBlue® is ideal for antennas, RF, microwave, and high-speed digital circuits. Unlike PTFE, which is being phased out due to environmental concerns, PhaseBlue® is both sustainable and high performing.

Applications: High-frequency antennas in electronic, space, and aeronautics applications.

Processing Notes: PhaseBlue's low density changes its physical characteristics, requiring minor changes in standard PCB processing.

Handling: Thin and lightweight, should be framed and handled like a flex circuit.

Adhesive bond: The core material is 85% air. While it is easy to bond to the polyimide portion of the material there is no bond to the air portion. This can provide a low peel strength, around 2 lb/in.

Lamination: Requires controlled heat and pressure to preserve the aerogel structure.

Compatibility with Standard FR-4 Processing: Supports standard FR-4 processes including DES, etchback, drilling, and excising.

Assembly Considerations: Successful assembly relies on thoughtful circuit design using FPCB methods. Managing heat flow during assembly is critical to maintaining structural integrity and reliability.

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2. Storage and Shelf-Life Conditions

Material Structure

PhaseBlue® is a composite laminate consisting of copper, polyimide aerogel, and adhesive layers.

Storage Instructions

Packaging	Keep sheets in their original shipping boxes until use. They are shipped between layers of sulfur-free paper to prevent copper oxidation.
Environment	Store in a temperature- and humidity-controlled environment at 70 ± 5 °F (21 ± 3 °C) and < 50% relative humidity.
Shelf Life	For best results, use the material within 12 months of manufacture, provided it is stored under the above recommended conditions.

PhaseBlue® Packaging

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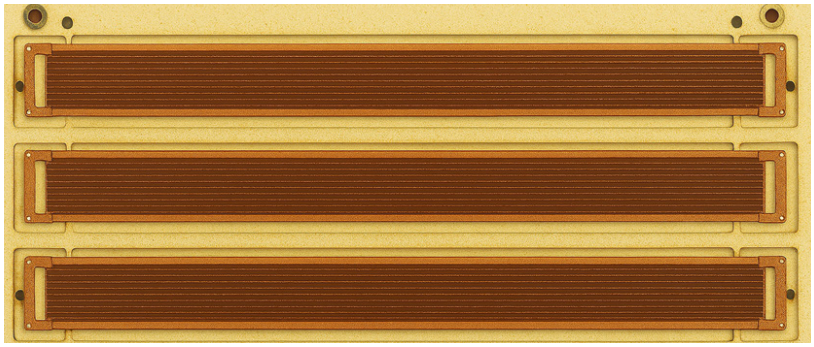
3. Precautions and Handling for Thin Material

PhaseBlue® is a thin, low-density composite laminate with unique handling requirements, particularly different from rigid or thicker circuit materials. PCB fabricators unfamiliar with flexible circuit processing or core innerlayer techniques may struggle with this material.

Support During Processing: PhaseBlue® must be supported throughout critical processes such as cleaning, DES, and plating. Panels should be securely taped to rigid frames to:

- Prevent wrapping around rollers
- Avoid being drawn into ventilation systems
- Minimize creasing and distortion
- This reduces mechanical stress and helps preserve material integrity
- Minimize oscillation and processing pressure wherever possible



PCB Design of PhaseBlue®

Substrate Damage: Inspect all sheets for tears prior to use.

- Edge tears may be taped, but be aware that polyimide-based materials have low tear propagation resistance
- Avoid using damaged sheets in critical applications

Manual Handling: Unframed sheets must be handled with care. The material can easily crease, wrinkle, or tear if treated like a rigid laminate. Always support the full surface area during transport and handling.

Mechanical Layer Preparation: Panels can be cut to size by means of shearing, diamond sawing or routing. Registration holes can be punched, drilled or lased into the panel. Other than the materials thin nature all of these processes should not need to change from other PCB materials.

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4. Surface Preparation

Standard wet cleaning procedures are effective for PhaseBlue®. During this step, the material should be framed to ensure stability and prevent deformation.

- Acceptable: Conventional cleaning chemistries and process pressures
- Not Recommended: Mechanical scrubbing, as it may stretch, distort, or damage the substrate

Lamination Presses

5. DES (Develop / Etch / Strip)

Framing Requirement: Panels must be framed prior to entering the DES line to maintain material flatness and process integrity throughout wet processing. This ensures stability and prevents issues such as material wrapping around rollers or panels being pulled into ventilation systems.

Etch Considerations: With a copper peel strength of approximately 2 lb/in, this can present delamination challenges if spray pressures are high, particularly around sharp circuit corners.

- Lowering spray pressures can be effective if etch completion is verified
- Radiused features are recommended to minimize stress concentrations during etch

Strip Considerations: Photoresist stripping should be closely monitored. Due to PhaseBlue's nanometric porosity, trace residues may occasionally remain on the surface. These residues have not demonstrated any measurable impact on performance. However, a more aggressive rinse or extended rinse time may improve surface cleanliness and eliminate potential cosmetic or inspection concerns.

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6. Lamination

The reticulated structure of PhaseBlue®, while very robust, can be compressed under high pressure or temperature excursions. Lamination pressures should be kept under 150 psi. As T_g is approached, the material softens. Temperatures under 100 °C are not an issue. Under 150 psi, higher temperatures to 150 °C can be used.

Additionally, standard platen press lamination using slip sheets, stainless steel plate separators and cowl plates provide a good copper surface for circuit processing.

Electrically Heated Platen Presses

7. Drilling Parameters

PhaseBlue® is compatible with both mechanical and laser drilling, supporting clean, low-defect PTH formation with minimal burring or delamination.

- Hole wall quality, blind via formation, and excising have shown consistently defect-free results

Both laser and mechanical methods can be used depending on design requirements and fabrication capabilities.

Drilling Recommendations:

- Start with standard polyimide feed and speed settings
- Inspect hole quality after initial runs
- Adjust parameters as needed based on observed performance

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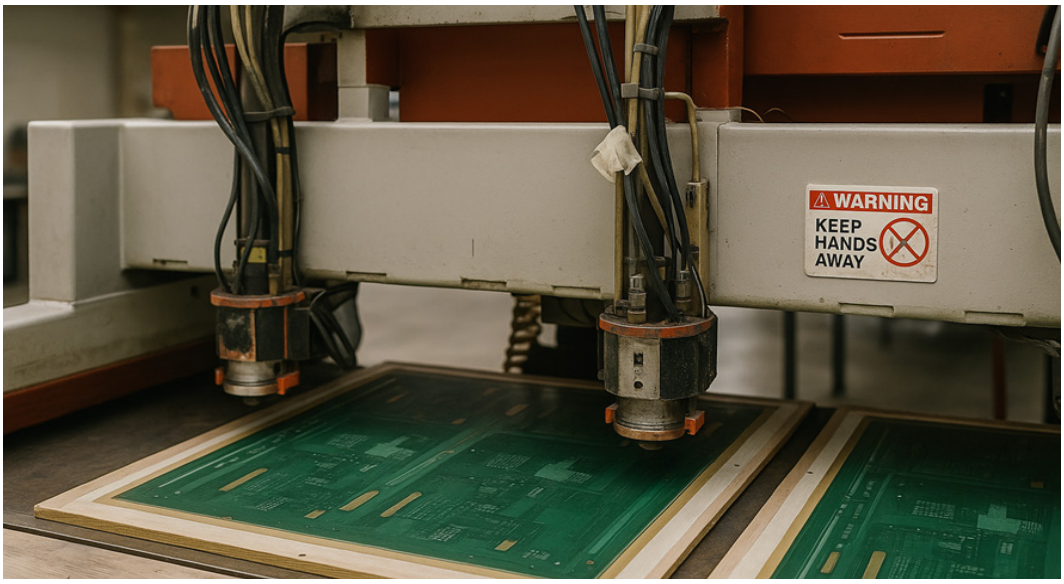

Multi-Spindle NC Drill

8. Etchback / Desmear / Hole Preparation

PhaseBlue® does not contain PTFE or other smear- prone materials, so aggressive plasma exposure or sodium etch processes are unnecessary and should be avoided, however low energy plasma processing is effective. As a high-performance thermal insulator, PhaseBlue® does not dissipate concentrated heat well, and plasma exposure can lead to embrittlement of the substrate.

Recommended Approach

- Use standard chemical etchback methods, such as permanganate based processes
- These are widely available in conventional plating baths and are effective for PhaseBlue®
- Consistent hole wall etchback and high-quality plating results have been achieved using these methods

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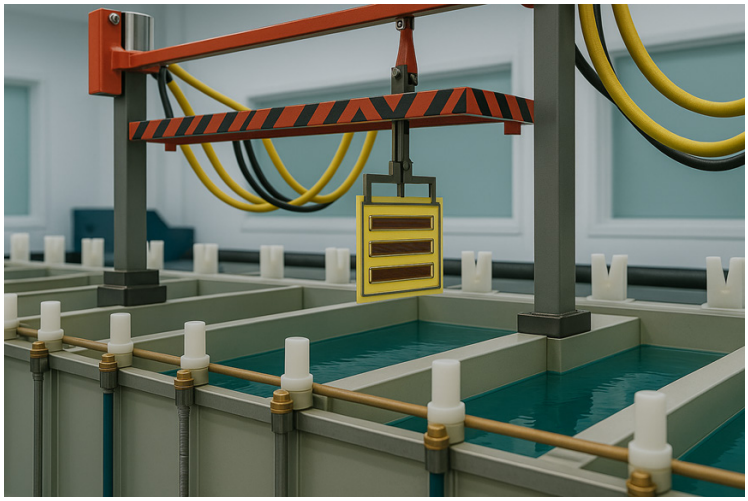
9. Plating

PhaseBlue® is compatible with a wide range of plating chemistries, such as electroplated copper, electroless copper, ENIG, gold, nickel, and tin/lead. Like polyimide, it plates reliably and consistently, and supports standard plating processes without modification, delivering high-quality finishes across various metal systems. Sulfuric acid based electroless plating is not compatible with PhaseBlue®.

Processing Notes

- Framing is recommended during plating, especially in oscillating baths to maintain panel stability
- Pads-only plating has been successfully used in some applications to minimize copper trace thickness while preserving rolled annealed copper performance



Panel Plating Tank

10. Coverfilms / Soldermasks

PhaseBlue® is compatible with both liquid and dry film soldermasks.

- Curtain coating for liquid soldermask and nip lamination for dry film have both been successfully implemented.
- During lamination, nip roll pressure should not exceed 100 psi, and temperature should remain below 150 °C to preserve the aerogel structure.

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11. Surface Finishes

PhaseBlue® is compatible with various standard surface finishes used to preserve solderability and ensure reliable electrical connections. Treatments such as Entek, Immersion Silver, ENIG, and similar processes have been successfully applied without issue.

12. Stiffener Attachment

Stiffeners are often required to reinforce thin sections of the circuit or to support components in mechanically stressed areas. Common stiffener materials include FR-4, polyimide, PET, stainless steel, and ceramic.

Adhesive Recommendations:

- Preferred Adhesive: Pressure-sensitive adhesives (PSA) are preferred, as they require minimal pressure and heat during application.
- High Temperature Applications:
  - Acrylic- or epoxy-based adhesives may be used, though they typically require lamination.
  - In such cases, ensure lamination temperatures remain below 150 °C and pressures below 100 psi to avoid compressing or altering the PhaseBlue® structure.

13. Excising

PhaseBlue® can be successfully excised using various methods, including die cutting, laser cutting, NC knife, and steel rule dies. In practice, all of these techniques have produced acceptable edge quality.

14. Component Attachment

PhaseBlue® passes the IPC solder float test, but due to its sensitivity to cumulative heat exposure, soldering should use only the necessary temperature and dwell time to form reliable joints.

- Low-temperature solders are suitable and may help mitigate thermal stress
- Eutectic solder has been successfully used in military and aerospace applications

Adhesive-Based Attachment

- When using adhesives for component mounting, air-cure systems are preferred—even with slightly longer dwell times—to minimize thermal load
- Due to low bond strength and CTE mismatch, rapid thermal ramps or long unsupported traces can result in trace lift or delamination

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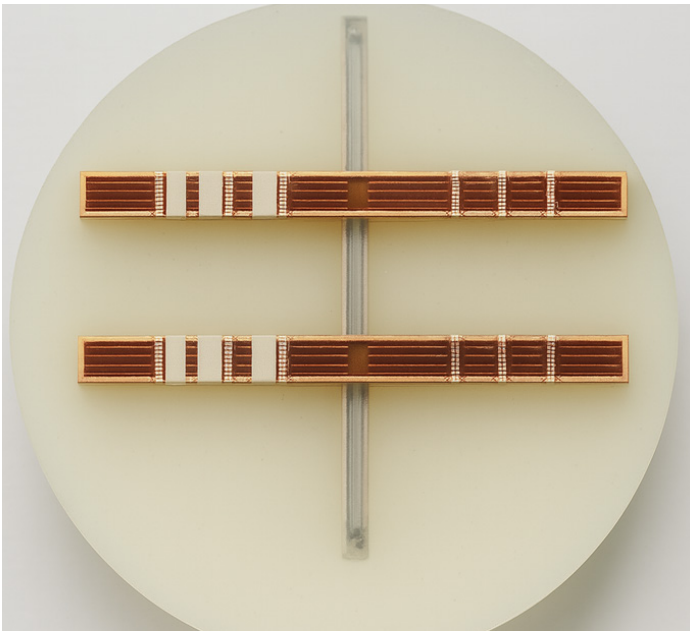
Careful thermal management during assembly is critical for long-term reliability.

15. Quality Control Recommendations

To ensure reliability and consistency in PhaseBlue-based assemblies, the following quality control steps are recommended:

Visual Inspection	Check for lifted traces, physical damage, surface defects, and proper component placement
Microsection Analysis	Evaluate plated through-hole (PTH) quality using cross-sectional analysis of a test coupon
Impedance Testing	Use a microstrip control coupon to verify impedance stability, especially after lamination
Electrical Test	Perform full circuit continuity and isolation testing on the finished pattern
Dimensional Stability Check	Measure a dedicated coupon to assess elongation or dimensional shift during processing



PRINTED CIRCUIT BOARD AUTOMATED OPTICAL INSPECTION

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Please reach out to the Blueshift team with any questions!

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