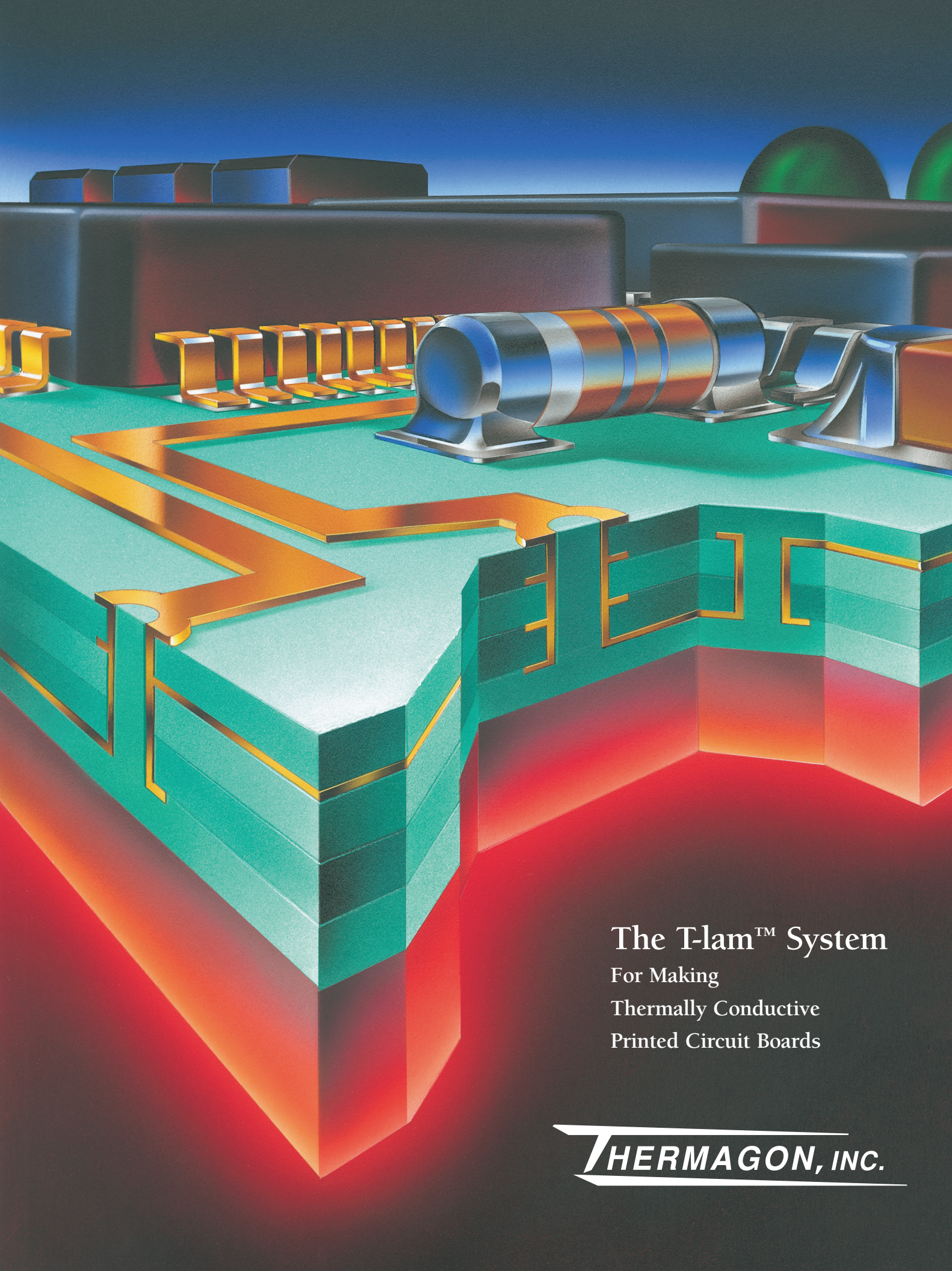
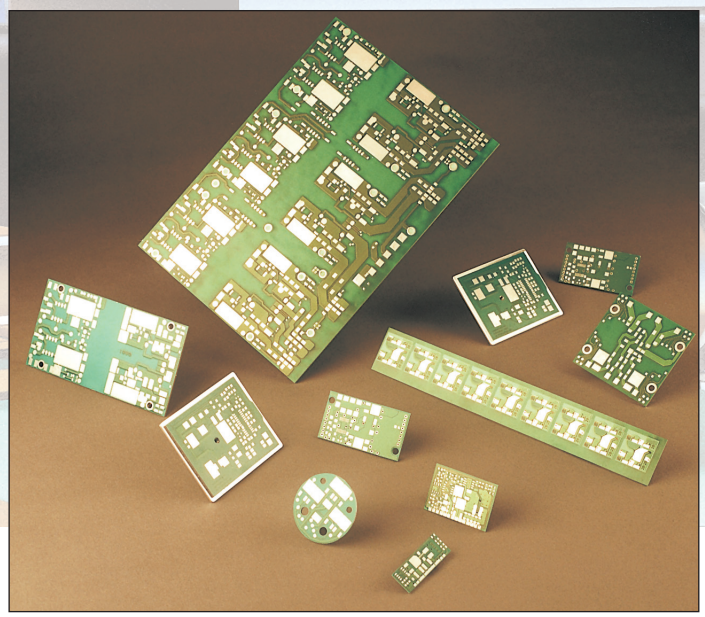


The T-lam™ System

For Making
Thermally Conductive
Printed Circuit Boards

THERMAGON, INC.

Thermal Management For High Power & Densely Packed Printed Circuit Boards



The T-lam System Helps You Meet Performance Demands

Today more than ever, electronics designers need to be able to pack higher powered components closer together, in smaller spaces. More power in less space means higher watt densities, which translates into increased heat. As temperatures rise, the reliability and functionality of an electronic system is impaired dramatically. Here is where the T-lam™ system for making thermally conductive printed circuit boards steps in to solve the problem with its IMPCB™ laminate, T-preg™ dielectric, and DSL™ materials.

The key to the effectiveness of IMPCB laminates for printed circuit boards is T-preg material, a thermally conductive yet electrically insulating prepreg. These dual properties make possible the practical use of metal heat spreaders as an integral part of circuit boards.

Select IMPCB Laminate for Your Metal-Based Printed Circuit Boards

IMPCB laminate with its metal base plate, its thermally conductive dielectric T-preg layer, and its copper circuitry layer, can be etched to make a single-sided, surface mount printed circuit board capable of dissipating many times more heat than its FR-4 counterpart. In many configurations the IMPCB single-sided printed circuit board can outperform alumina in heat dissipating capacity.

Multilayer and metal core printed circuit boards can be produced using T-preg dielectric and DSL material, our thermally conductive double-sided laminate.

IMPCB Laminate Benefits

- The thermal conductivity of approximately 5 W/m°C of the T-preg layer provides 10 times the heat dissipating capability of FR-4 for comparable thicknesses. Allows higher packing densities.
- Conventional processability and versatility, comparable to FR-4. You can process IMPCB laminate in virtually the same way as conventional boards: “many up” on a panel and easily routed, punched, sawed, or V-scored to separate.
- The typical thickness of 8-12 mils for the T-preg layer provides outstanding thermal performance with high dielectric strength and low capacitance.
- The pure copper traces provide better current carrying capability than alumina thick film circuits.
- IMPCB laminate with its integral metal base plate can eliminate the need for additional cooling hardware.

IMPCB™ Laminate–The Material for Single-Sided Metal-Based Printed Circuit Boards

What Is IMPCB Laminate?

Insulated Metal Printed Circuit Board (IMPCB) laminate features Thermagon's thermally conductive T-preg dielectric layer, which serves as the bonding agent for laminating the copper foil circuit layer to a heat dissipating metal base (usually aluminum). The T-preg dielectric layer serves three major functions:

1. Conducts heat.
2. Insulates electrically.
3. Serves as the adhesive.

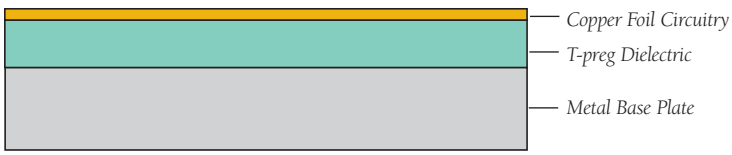
IMPCB laminate can be designed using copper circuitry weights of 1/4 oz. to 4 oz and metal base thicknesses from 0.040 to 0.250 inches. The thickness of the T-preg dielectric material can also be selected.

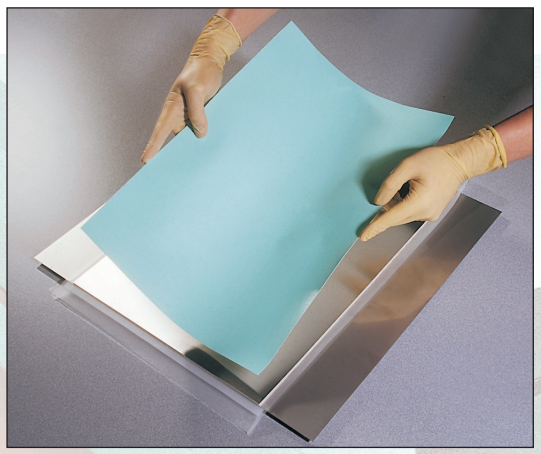
IMPCB laminate provides the raw material for single-sided surface mount printed circuit boards. Standard PCB processing is used for fabricating "print and etch" or "plate and etch" boards.

The copper foil circuitry layer is high ductility, electrodeposited copper. The copper weight or thickness selected depends on the application. Lower copper weight or thickness is used for fine lines and spaces in your circuitry, whereas heavier weight or thicker copper is used for high power and high current-carrying capability.

Choose the metal base for your IMPCB laminate from the following:

- Aluminum–most common because of its excellent thermal conductivity, light weight, and lower cost.
- Copper–used for its very high thermal conductivity and complete compatibility with existing printed circuit board chemistry.
- Copper-Molybdenum-Copper (Cu-Mo-Cu) or Copper Invar Copper (CIC)–used for lower CTE, matching alumina's coefficient of thermal expansion.





T-preg adhesive dielectric is room temperature stable for six months.

Metal Base-Plate Properties

Base Plate Material	Thermal Expansion Coefficient ppm/°C	Thermal Conductivity Z axis Watts/m°C	Thermal Resistance at 63 mils °C-in^2/Watt
Aluminum	24	173	0.0143
Copper	18	260	0.0095
Cu-Mo-Cu*	6	170	0.0146
CIC**	5	50	0.0500

**Copper-Molybdenum-Copper (13-74-13)*
***Copper-Invar-Copper (20-60-20)*

T-preg™ Dielectric & DSL™ Material: Keys to the T-lam™ System

T-preg Dielectric–The Essential Component of all T-lam System PCBs

T-preg dielectric with its outstanding electrical insulating capability makes possible the use of metal base materials as heat spreaders in printed circuit board laminate (IMPCB Laminate). This material's high thermal conductivity of approximately 5 W/m°C, high dielectric strength of 800V/mil, strong adhesion and room temperature stability make it ideal for use as a prepreg in thermally conductive printed circuit boards.

This T-preg material functions similarly to conventional prepreg used in the PCB industry, but with the following advantages:

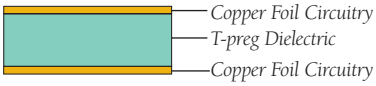
1. Thermally conductive.
2. Fiber glass cloth is not required.
3. Higher temperature stability.
4. Flow during curing enables in situ hole filling.

Thermagon's T-preg dielectric has several key advantages over other dielectric materials used to insulate metals in printed circuit board applications:

1. Higher thermal conductivity and correspondingly lower thermal resistance.
2. Used in thicker layers for improved dielectric strength and capacitance.
3. More easily drilled and machined.
4. Contains no abrasive fillers
5. Flows during cure for in situ hole filling.
6. Used as a free-standing prepreg for producing multilayer boards.
7. Available in any thickness of 8 mils or greater.

DSL, Double-Sided Laminate Material: The Means For Multilayer Construction

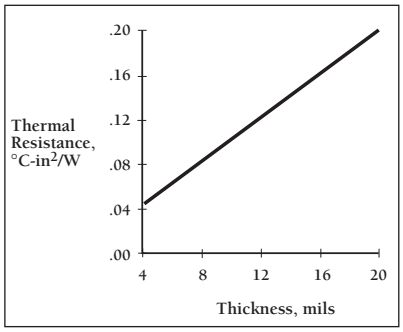
Thermagon's DSL material is constructed of T-preg dielectric with copper foil on both sides, forming a laminate which can be incorporated into a metal-based board or used by itself. DSL material is a thermally conductive laminate which can be printed and etched with plated thru holes like conventional FR-4 double-sided laminate.

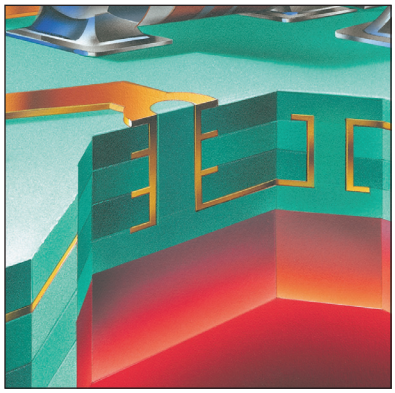


The major advantage of DSL over conventional FR-4 double-sided laminate is its ability to transfer about 10 times more heat for a given thickness.

Compared to FR-4 or to other thermally conductive materials used in printed circuit board construction, DSL material has a low dielectric constant of 3.5. This results in lower capacitance.

T-preg Thermal Resistance





T-preg dielectric flows during the processing of the board to enable in situ hole filling. This provides a simple method for making insulated plated thru-holes (PTHs) and thermal vias.

T-preg Performance Properties

Typical Cured Properties (No Fiber Glass)	T-preg™*
Thermal Conductivity, W/m°C	5
Dielectric Strength, Volts/mil	800
Dielectric Constant, @1 KHz	3.5
Lap Shear, Al/Al, psi	1400
Peel Strength, Cu foil, pli, min	6
Hardness, Shore D	76
Flexural Strength, MPa	50
Elongation, %	0.51
Volume Resistivity, ohms-cm	7.4×10^{14}
Surface Resistivity, ohms	1.1×10^{10}
Comparative Tracking Index	600
Water Absorption, Δ weight %	0.10**
Cure Schedule, °C/hours	170/0.75
Continuous Use Temp., °C	130
Intermittent Use Temp., °C	250
Shelf Life, °C/Months	20/6
Color	Green

**T-preg™ (1KA) is UL recognized 94V-0 file E165095*
***After 168 hours*

PCB Construction Using IMPCB™ Laminate, T-preg™ Dielectric & DSL Material

Flexibility for Customizing Your Design

Thermagon works with OEMs and selected PCB fabricators to help design circuit boards using the T-lam System. Prototypes and small volume production are available through Thermagon. Large volume production is produced directly through a PCB fabricator, using Thermagon's IMPCB laminate, T-preg dielectric, and DSL material.

Specifying Guidelines

Thermagon will work with you to help choose the many options for obtaining: 1) IMPCB laminate, 2) T-preg dielectric, and 3) DSL materials. All three materials are available in the following sizes:

12" x 18" • 16" x 18" • 18" x 24"

For IMPCB Laminate Specify:

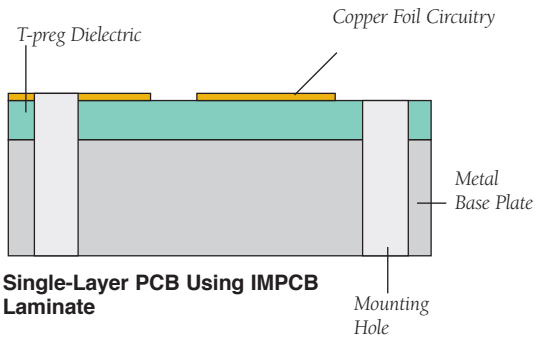
- Copper Circuitry Weight: 1/4 to 4 oz.
- Metal Base Material: Standard: Aluminum. Other: Copper; Cu-Mo-Cu; CIC.
- Metal-base Thickness: .040" to .250".
- T-preg Dielectric Thickness: ≥ 8 mils.

For T-preg Dielectric Specify:

- Thickness: Standard: 8, 10, 12 mil. Other: 8 to 100 mil.
- Optional: Fiber glass cloth, 1 or 2 layers.

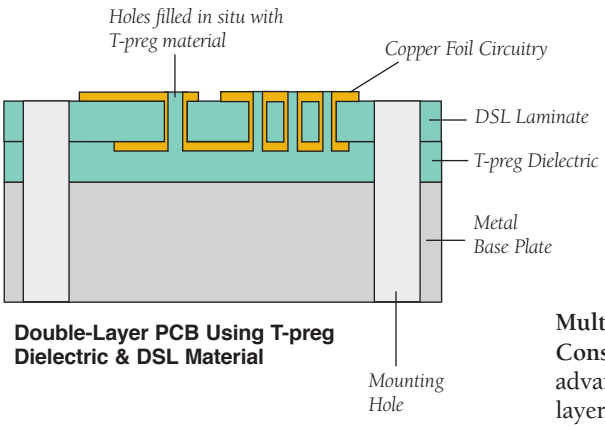
For DSL material specify:

- Copper Circuitry Weight: 1/4 to 4 oz.
- Number of Layers of T-preg dielectric.
- T-preg Dielectric Thickness: 8 to 100 mils.
- Optional: Fiber glass cloth, 1 or 2 layers.



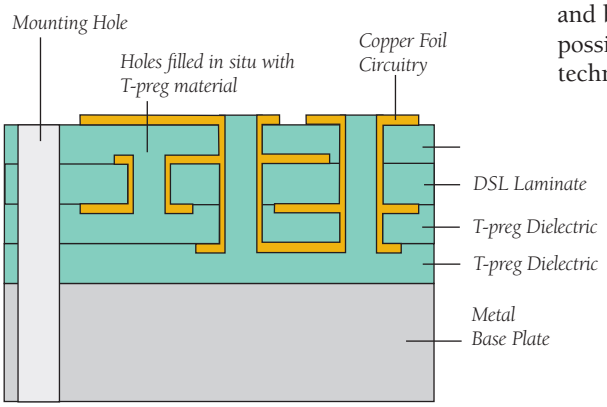
Single-Layer PCB Using IMPCB Laminate

Single-Layer Construction Using IMPCB Laminate–Can be processed like standard single-sided "print and etch" or "plate and etch" PCBs. Protect metal base materials from the etchant by applying polyester masking tape. The heat-dissipating metal base can eliminate the need for cooling hardware and also serve as one side of the chassis.



Double-Layer PCB Using T-preg Dielectric & DSL Material

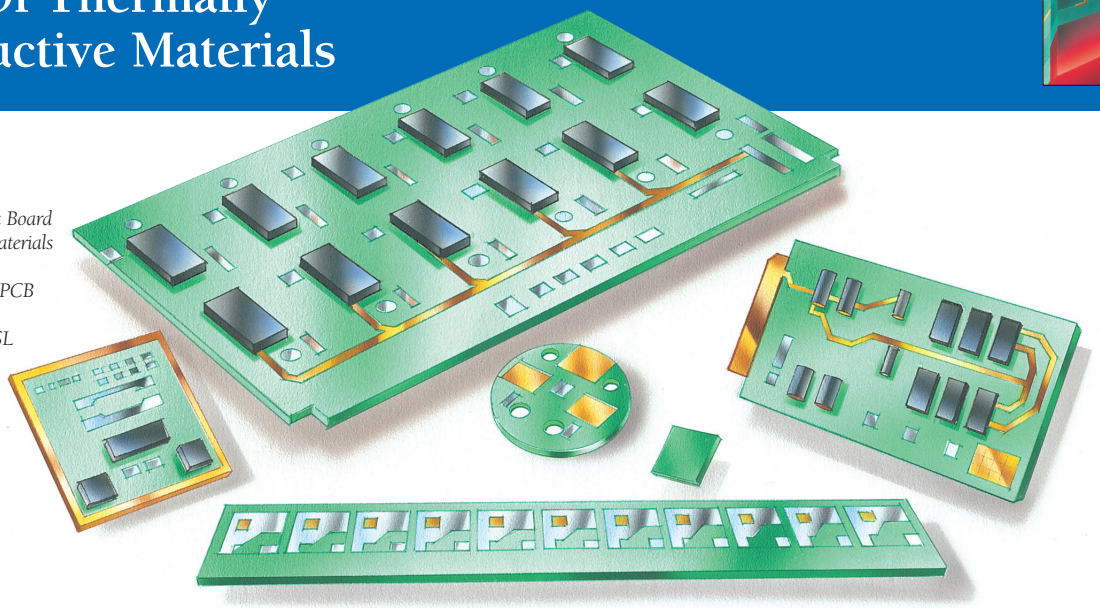
Multilayer Construction– All the advantages of single-layer IMPCB construction, but allowing for increased circuit density in the inner layers. Plated Thru- Holes and blind and buried vias are all possible with T-lam technology.



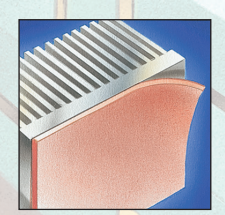
Multilayer Circuit Board Using T-preg Dielectric, & DSL Material

Thermagon's Complete Line Of Thermally Conductive Materials

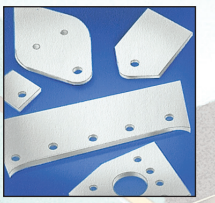
Make Your Circuit Board of Choice With Materials from the T-lam System: IMPCB Laminate, T-preg Dielectric, and DSL Material.



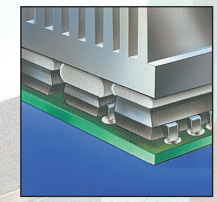
- *Metal-Based PCB: Single-Layer & Multilayer. Featuring a thermally-conductive, dielectric, polymer bonding the copper foil circuit layer to heat-dissipating metal base (copper, aluminum, etc.).*
- *Metal Core PCB.*
- *T-preg Dielectric PCB: No Metal Base or Core.*
- *Hybrid PCB: T-preg Dielectric/Prepreg DSL Material. Selectively replacing sections of FR-4 prepreg with T-preg dielectric to create economical, thermally-conductive insets for circuitry and mounting pads of heat-generating components.*
- *Hybrid PCB: FR-4 PCB/T-preg Metal-Based Boards. Double-sided FR-4 circuit board bonded to a metal base using T-preg dielectric for economical heat transfer.*



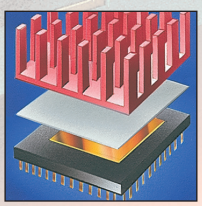
T-pli™ 200 Series: Thermally Conductive Elastomers.



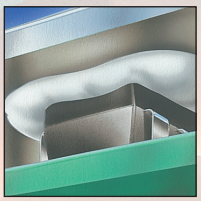
T-gon™ 200 Series: Thermally Conductive, Electrically Insulating, Interface Materials.



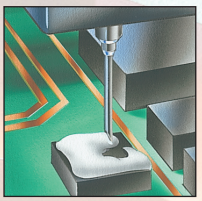
T-flex™ 200 Series: Thermally Conductive Conformable Gap Fillers.



T-dux™ Interface: Thermally Conductive Silicone Interface. A 4-mil fiber glass reinforced silicone interface material for conducting heat away from components in applications not needing electrical insulation. Excellent cost versus performance.



T-putty™ 500 Series: Thermally Conductive Putty. Ultra-soft, conformable, paste-type putty for transferring heat from very delicate parts able to tolerate minimal pressures and stresses.



T-grease™: Thermally Conductive Interface Compound. Ultra-high thermally conductive compound for heat transfer between semiconductor case and its heat sink.

THERMAGON, INC.

"Specialists in Thermally-Conductive Polymeric Materials"

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