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Montréal- Toronto- Vancouver

Manufacturers Representative to Custom Products for the Electronics Industry
Représentants: Produits sur mesure pour l'industrie électronique

PCB Thermal Management for High Density Power Electronics

TTM Technologies

Inspiring Innovation

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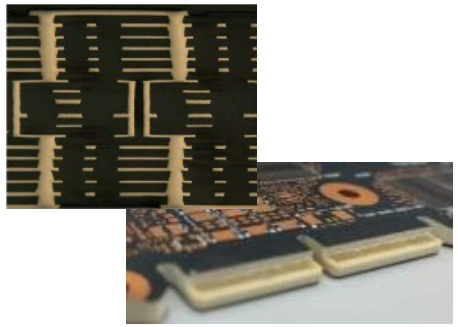
Diversified PCB Technologies and Integrated Electronics Solutions

Aerospace & Defense



- **Design-to-Spec & Build-to-Print product offerings**
  Full complement of software platforms - HFSS, Thermal, Solidworks, Allegro, Xpedition, Altium
  Custom build or Build-to-Print components and sub-assemblies to end-market mission-critical systems
- **Complex RF with mixed dielectrics**
- HDI & Ultra-HDI PCB's - 75um lines & spacing
- Substrates - 17um lines and spacing
- Flex & Rigid-Flex
- Microwave, Low loss and ultra low loss material offerings

Data Center Computing



- **Stacked Microvia / Advanced HDI Technology**
- **Stepped Finger Technology**
- **Asymmetrical N+M Technology**
- 56Gbps 400G / 112Gbps 800G
- Multiple Lamination PCB
- Ultra-low loss / Low-loss materials
- Advanced Signal Integrity Performance
- PCIe Gen 5 / 6 technology

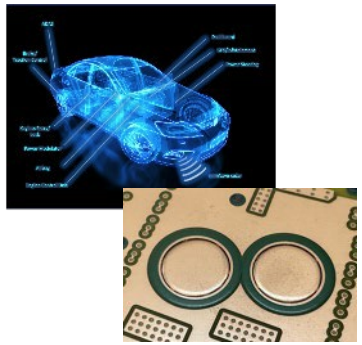


Networking



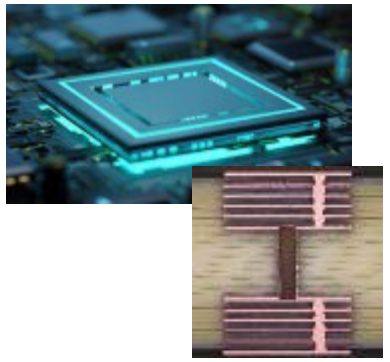
- **Asymmetrical N+M Technology**
  >30:1 High Aspect Ratio Plating
- **Insertion Loss Testing up to 67GHz**
  112Gbps 800G / 224Gbps 1.6T
- High Layer, 40+
- Extreme Low Loss + Materials
  Precision Backdrilling for reduced / stubless channels
- Advanced Signal Integrity Performance

Automotive



- **mmWave radar up to 110GHz**
- **Thermal solutions with coins, inlays and up to 12oz Cu**
- **High voltage solutions for 1,500V+ including long term reliability / CAF**
- Precision etch and registration technology
- Advanced HDI
- Low loss materials
- IATF16949

Medical & Industrial



- **Burn In Boards ("BIB")**
- **Symmetrical A+B with Microvias stack-ups**
- **RF / Digital mixed dielectrics**
- **Multilayer Deep Skip Vias**
- **Oversized Panels**
- **Complex Rigid-Flex**
- Device Under Test PCBs ("DUT")
- Buried Resistance ("BR") & Buried Capacitor ("BC")
- Advanced HDI

Global Footprint

(Effective on May, 2025)



North America Operations

1. Denver – DEN
2. North Jackson – NJ
3. Stafford – ST
4. Stafford Springs – SS
5. Sterling – STE
6. Syracuse – SYR
7. Salem – SAL
8. Forest Grove – FG
9. Santa Ana – SA
10. San Diego – SD
11. Chippewa Falls – CF
12. Logan – LG
13. San Jose – SJ
14. Toronto – TOR
15. Syracuse – SYR-W
16. Farmingdale – FRM
23. Eau Claire – ECL
24. Syracuse – SYD

Asia Pacific Operations

17. Zhongshan – ZS
18. Guangzhou – GZ
19. Huiyang – HY
20. Dongguan – DMC
21. Suzhou – SUZ
22. Penang – PNG
25. Penang – PNG II

Future Plants

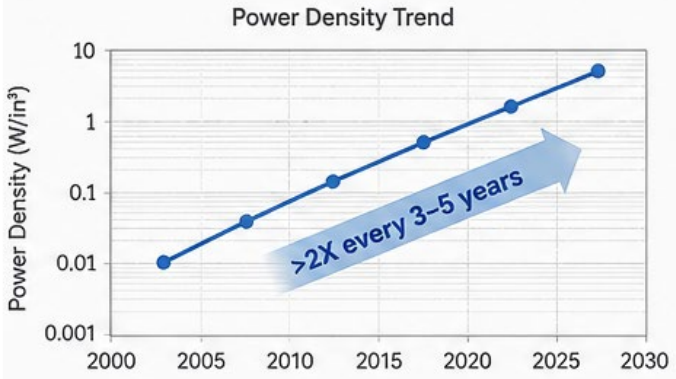
Introduction

The Thermal Challenge in Modern Power Electronics

Power density, Miniaturization and Thermal bottlenecks

1. INCREASING POWER DENSITY TRENDS

- Higher current & voltage ratings
- Faster switching frequencies
- More functionality in smaller space
- Power density increasing >2X every 3–5 years



AUTOMOTIVE
EV/HEV, OBC, Inverters

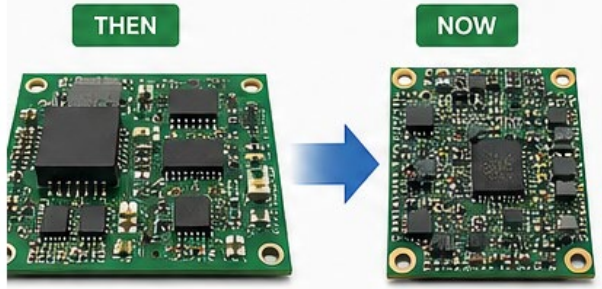
INDUSTRIAL
Drives, PSU, Welders

TELECOM
5G PSU, Rectifiers

POWER CONVERSION
DC-DC, UPS, Renewables

2. MINIATURIZATION EFFECTS

- Smaller footprints & thinner profiles
- Reduced airflow & heatsink size
- More components per unit area
- Less area available for heat spreading



Larger Size
Lower Power Density

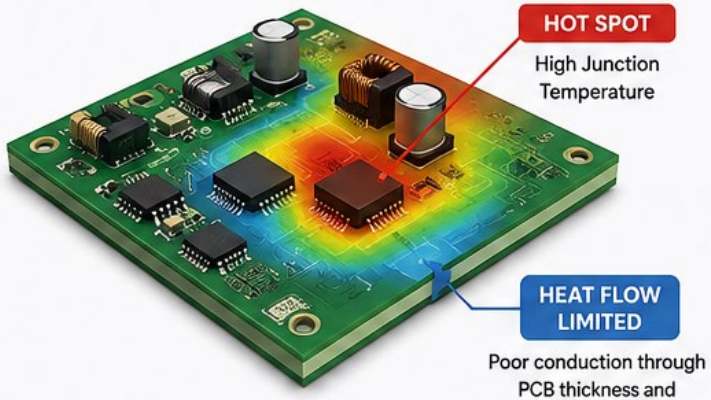
Smaller Size
Higher Power Density

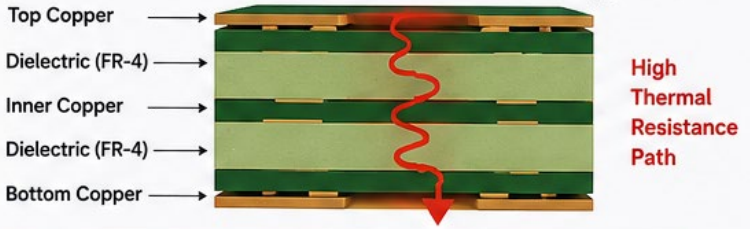
Result:

- Higher heat flux
- Localized hot spots
- Increased junction temperatures

3. THERMAL BOTTLENECKS IN PCB STRUCTURES

- Limited heat spreading in traditional PCBs
- Low thermal conductivity of FR-4
- Constrained heat flow paths
- Hot spots lead to performance loss, reliability issues, and reduced lifespan

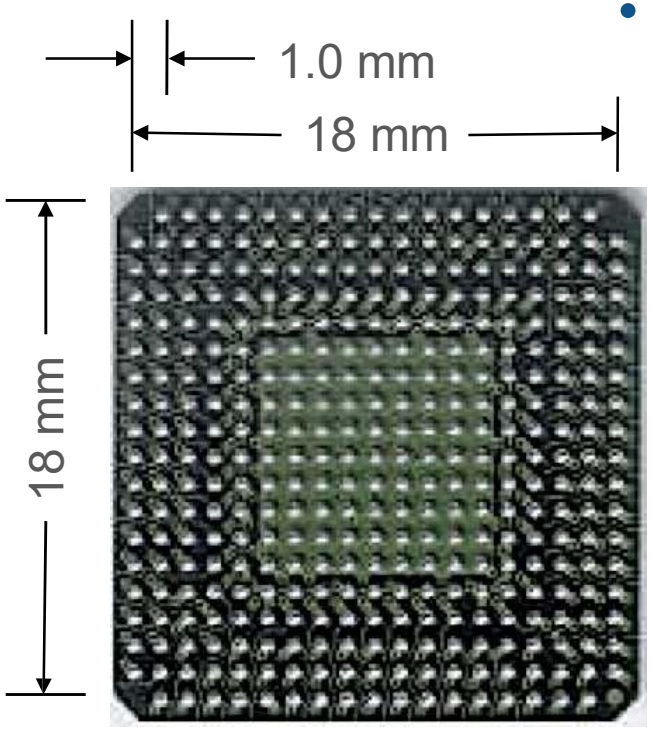




Thermal bottlenecks lead to higher temperatures and reduce system reliability.

FACTORS INCREASING THERMAL DENSITY

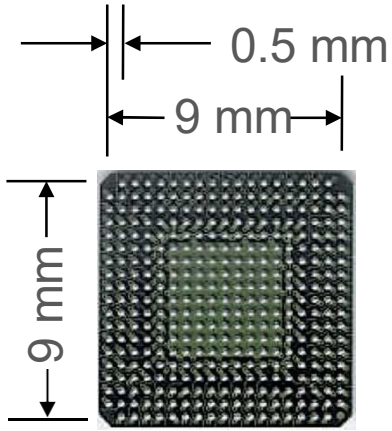
- Dramatic increase in semiconductor power
- Rapid reduction in component size



Power dissipation 3 watts

Power density **1.1** watts/cm

Density increase



Power dissipation 3 watts

Power density **3.7** watts/cm

Fundamentals of PCB Thermal Conductivity

HEAT FLOW MECHANISMS

Fundamentals of PCB Thermal Conductivity

Heat moves from high temperature to low temperature
Driven by temperature difference.

Conduction dominates inside the PCB
Through copper, dielectric, and vias.

Convection removes heat to ambient
From component and PCB surfaces.

Radiation has smaller contribution
Typically <5–10% in most PCB assemblies.

LATERAL vs THROUGH-THICKNESS HEAT FLOW

LATERAL (IN-PLANE)



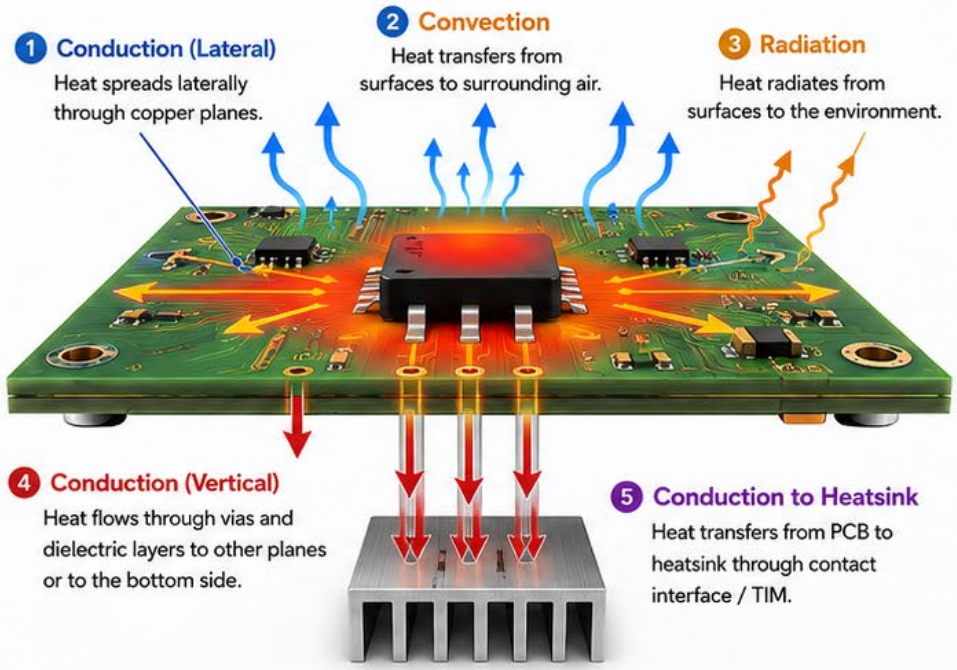
- Flows in copper planes
- Low thermal resistance
- Fast heat spreading
- Key to thermal uniformity

VS.

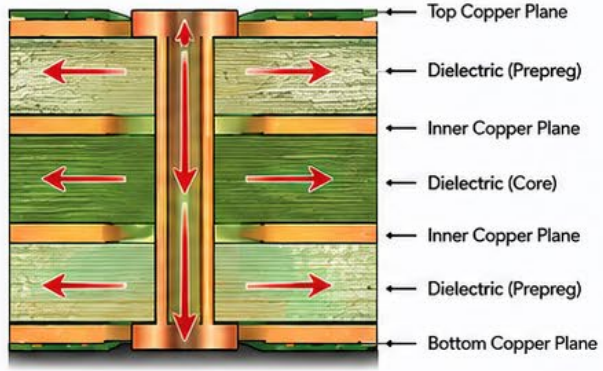
THROUGH-THICKNESS



- Flows through dielectrics and vias
- Higher thermal resistance
- Slower heat transfer
- Critical for heat removal to heatsinks or other layers



PCB STACK CROSS-SECTION



- Vertical heat flow (through-thickness)
- Lateral heat spreading (in-plane)
- Convective heat transfer (to air)
- Radiative heat transfer (to surroundings)

THREE MODES OF HEAT TRANSFER IN PCB ASSEMBLIES

CONDUCTION
- Dominant within PCB structure
- Through copper, dielectric, vias, and interfaces
- Enables heat spreading and transfer to heatsinks

CONVECTION
- Heat moves from surfaces to air
- Depends on airflow, orientation, and surface area
- Enhanced by fans, natural airflow, and enclosure design

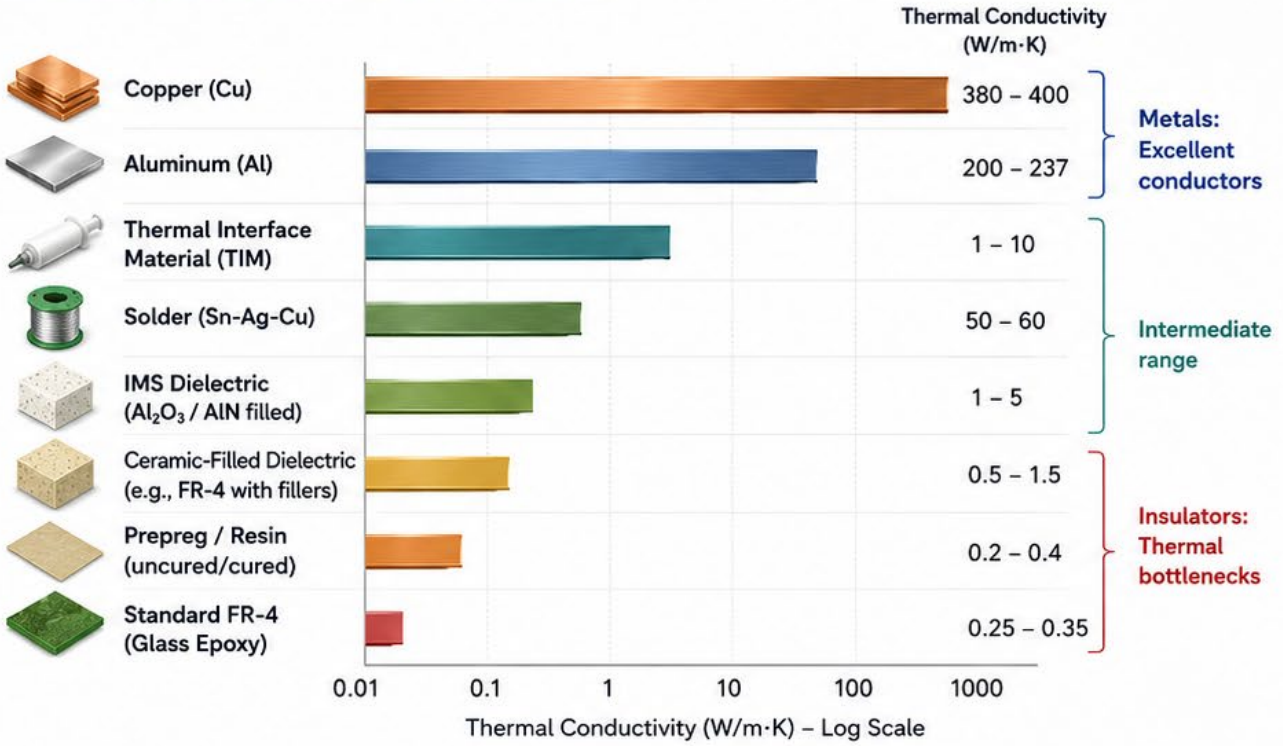
RADIATION
- Heat emitted as infrared radiation
- Depends on surface temperature and emissivity
- Minor contributor in most PCB assemblies

Effective PCB thermal design depends on understanding how heat leaves the component, moves through the board, and escapes to the environment.

THERMAL CONDUCTIVITY OF PCB MATERIALS

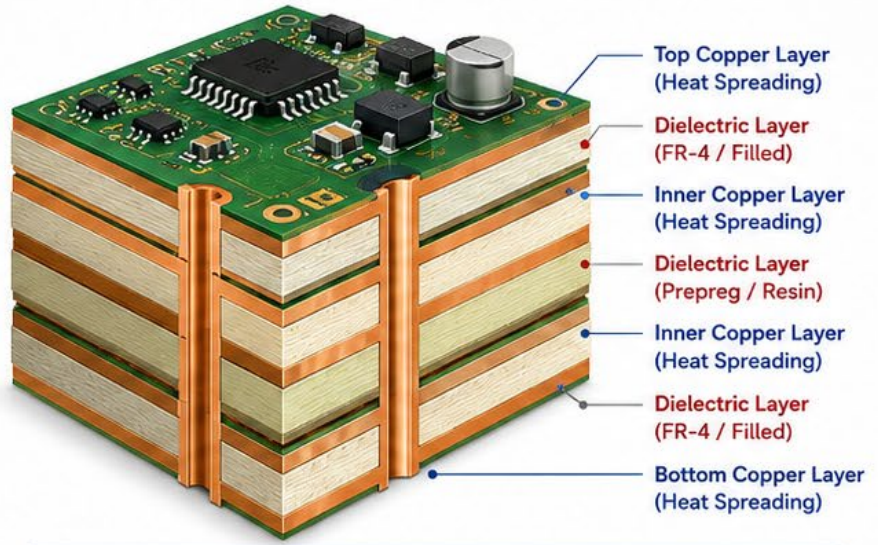
Fundamentals of PCB Thermal Conductivity

THERMAL CONDUCTIVITY COMPARISON (Approximate Values at 25 °C)



Copper is **~1,000 to >10,000×** more conductive than standard FR-4. This is why the PCB structure critically impacts heat flow.

WHERE THESE MATERIALS ARE USED IN A MULTILAYER PCB



- Copper is the primary heat spreader.
- FR-4 is a thermal bottleneck.
- Filled dielectrics can improve heat transfer.
- Material selection strongly affects junction temperature.

Note: Actual values vary by resin system, filler loading, temperature, and construction.

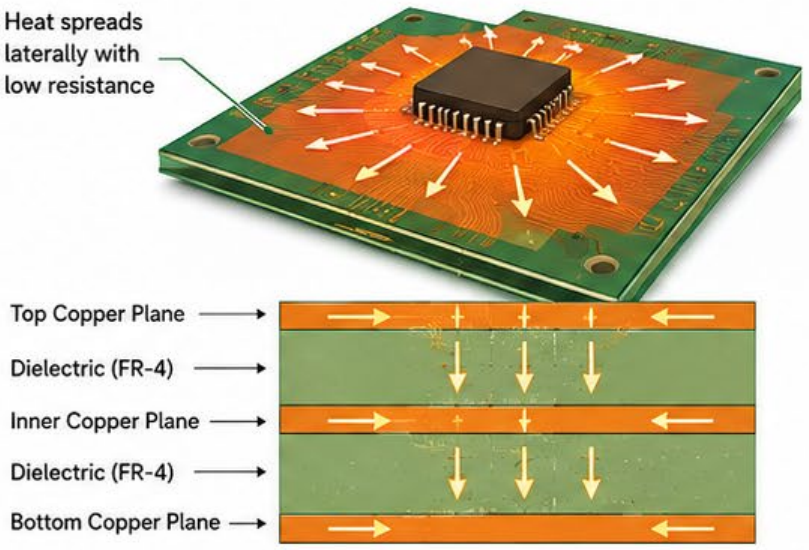
THE THERMAL PATH IS ONLY AS EFFECTIVE AS THE MATERIALS THAT MAKE UP THE PCB STRUCTURE.

COPPER VS DIELECTRIC THERMAL BEHAVIOR

Fundamentals of PCB Thermal Conductivity

COPPER: HIGHLY CONDUCTIVE HEAT SPREADER

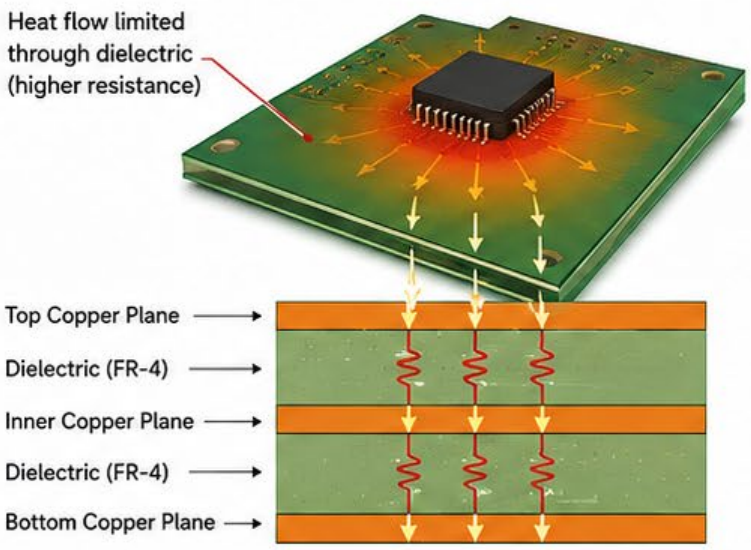
Copper planes rapidly spread heat laterally, lowering peak temperatures.



- High thermal conductivity enables efficient heat distribution
- Low thermal resistance in-plane and through copper thickness
- Copper coverage and thickness are key levers for thermal performance

DIELECTRIC: HEAT BARRIER / BOTTLENECK

Dielectric layers restrict heat flow, increasing temperature rise.



- Low thermal conductivity restricts heat flow
- Major contributor to overall thermal resistance
- Thicker or more dielectric layers increase temperature rise

PROPERTY	COPPER	FR-4 DIELECTRIC
Thermal Conductivity (W/m·K)	~385 – 400	~0.25 – 0.35
Heat Spreading Ability	Excellent (High)	Poor (Low)
Thermal Resistance Contribution	Very Low	Very High
Design Role	Heat Spreader & Conductor	Electrical Insulator & Heat Barrier

- Copper distributes heat efficiently.
- Dielectrics isolate electrically but resist heat flow.
- Thermal path design depends on copper content and thickness.
- Balancing electrical and thermal requirements is essential.

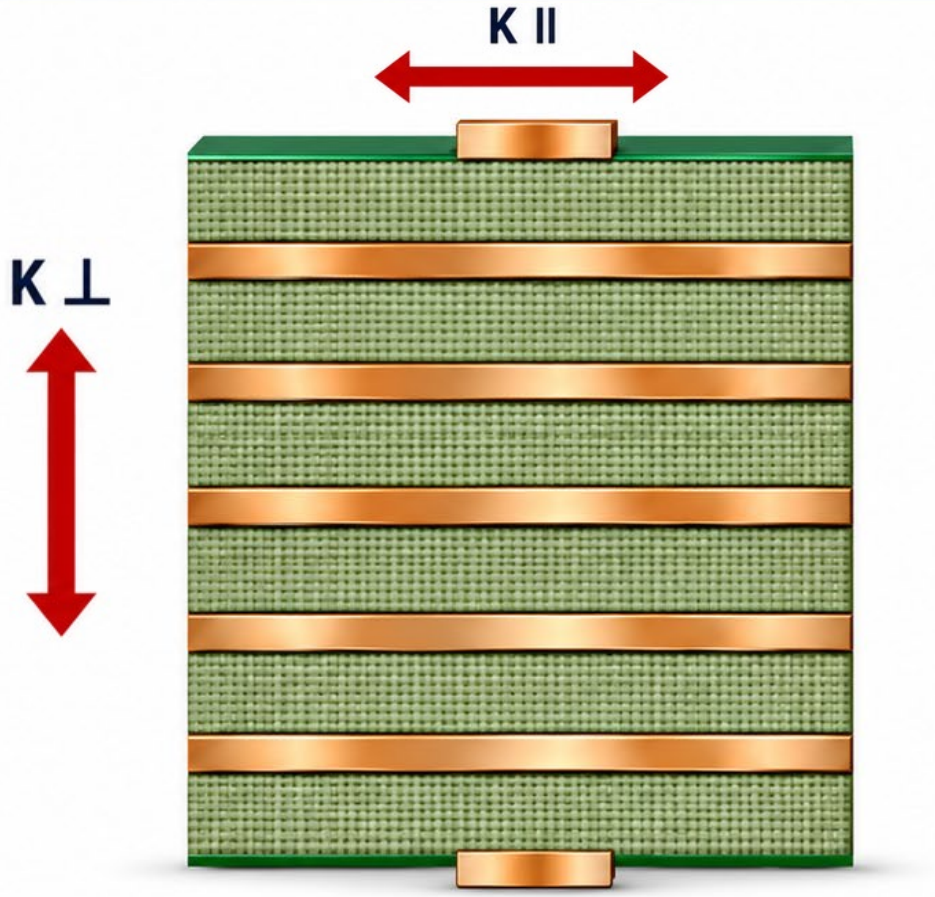
PCB THERMAL CONDUCTIVITY (ANISOTROPIC)

PCBs are composed of resin, glass, and copper distributod mainly parallel to the PCB surface. This non-uniform structure causes thermal conductivity to be anisotropic.

Approximate conductivity values differ in the parallel and perpendicular directions.

$K \parallel = 27.5$ W/m·K

$K \perp = 0.41$ W/m·K

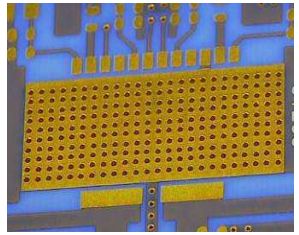


Approximate values are based on FR-4 laminate and vary with actual board construction and copper distribution.

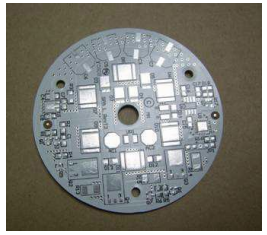
TTM Thermal Solutions Overview

TTM Technologies Thermal Solution Overview

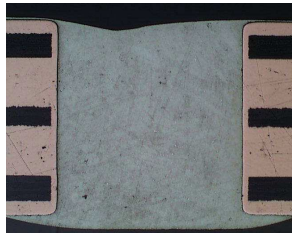
Via-Farm



IMS



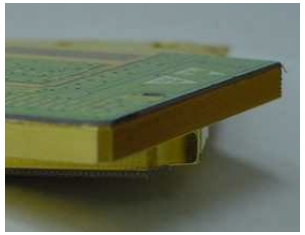
Heavy Copper



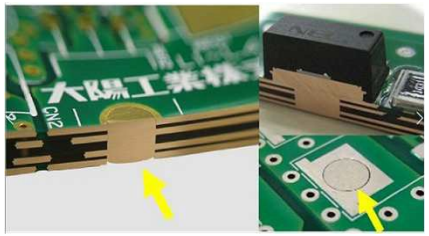
Heat Sink Paste



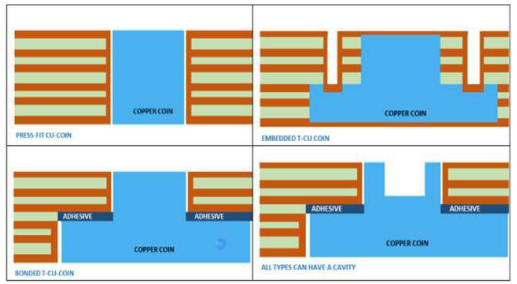
PSA Heatsink / Pallets

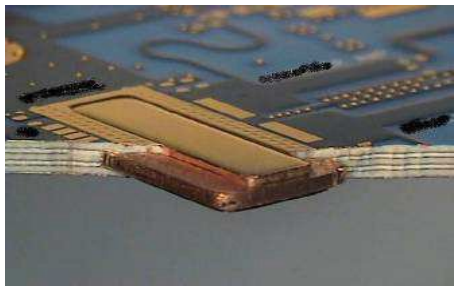


Press-fit Coin



Embedded Coin





Bus bar



THERMAL VIAS – VIA FARMS

Thermal via farms use arrays of plated vias to connect heat sources on the top side to internal and bottom copper planes, providing a low thermal resistance path for efficient heat spreading.

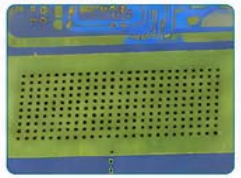
VIA FARMS – KEY BENEFITS

- Lowers junction-to-ambient thermal resistance
- Transfers heat vertically to internal planes/heatsink
- Distributes heat laterally within copper planes
- Enables compact, high-power designs

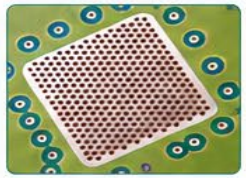
EXAMPLES OF VIA FARMS IN PCB DESIGNS



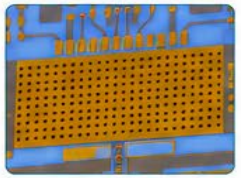
Component thermal pad



Large copper plane connection

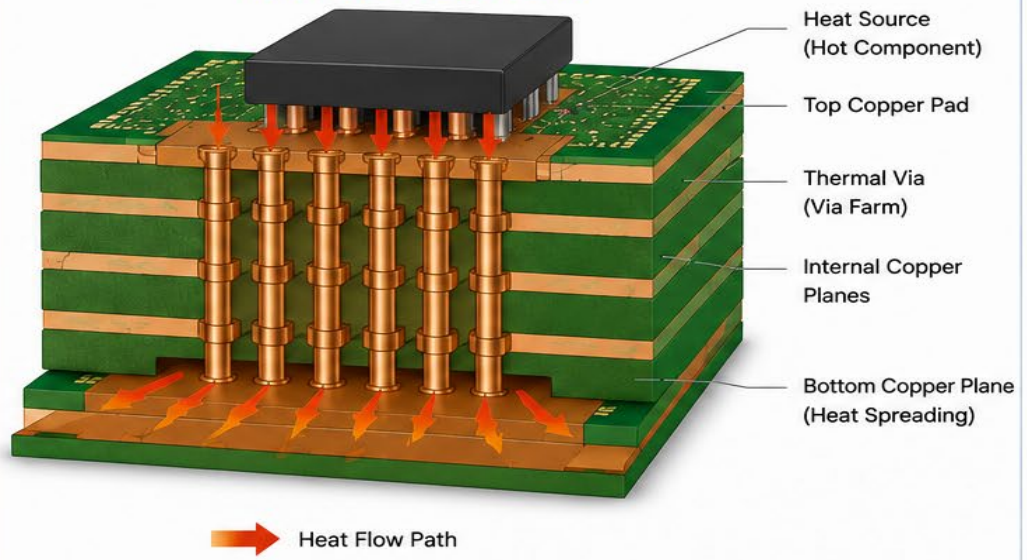


Power module thermal interface



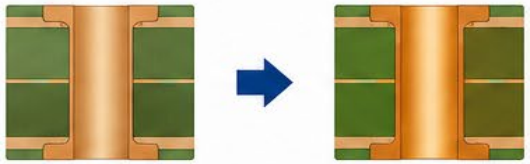
High-power area cooling

HOW VIA FARMS WORK



2 VIA PLATING ENHANCEMENT

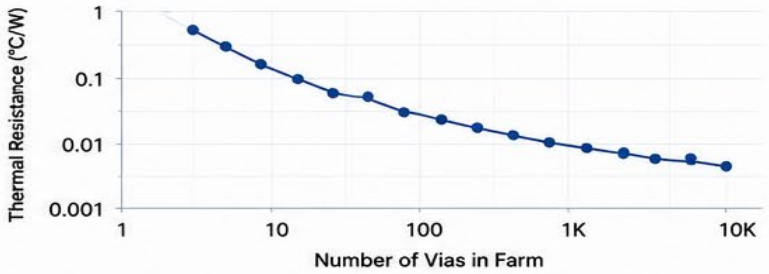
- Thicker copper plating reduces via thermal resistance.
- Optimized plating improves heat conduction and reliability.



Standard Plating (Lower Conductivity)

Enhanced Plating (Higher Conductivity)

3 THERMAL RESISTANCE BEHAVIOR



- More vias → Lower thermal resistance
- Larger via diameter → Lower resistance
- Shorter path to plane → Lower resistance

Increasing the number of thermal vias significantly reduces overall thermal resistance until diminishing returns are reached.

BONDED HEAT SINK WITH THERMAL VIA FARMS

Advanced PCB Thermal Management for High-Reliability Electronics

WHAT IS A BONDED HEAT SINK?

A bonded heat sink is a metal heat spreader thermally bonded to the PCB using thermal via farms beneath the component area, creating an efficient heat-flow path from the heat source through the PCB to the heat sink.

WHY IT MATTERS

INCREASED HEAT SPREADING

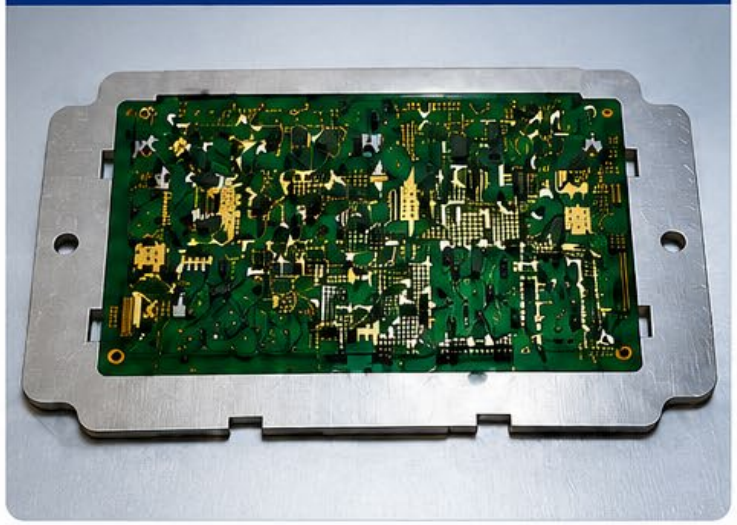
Pulls heat away from localized hot spots and distributes it across a larger area.

EFFICIENT VERTICAL HEAT FLOW

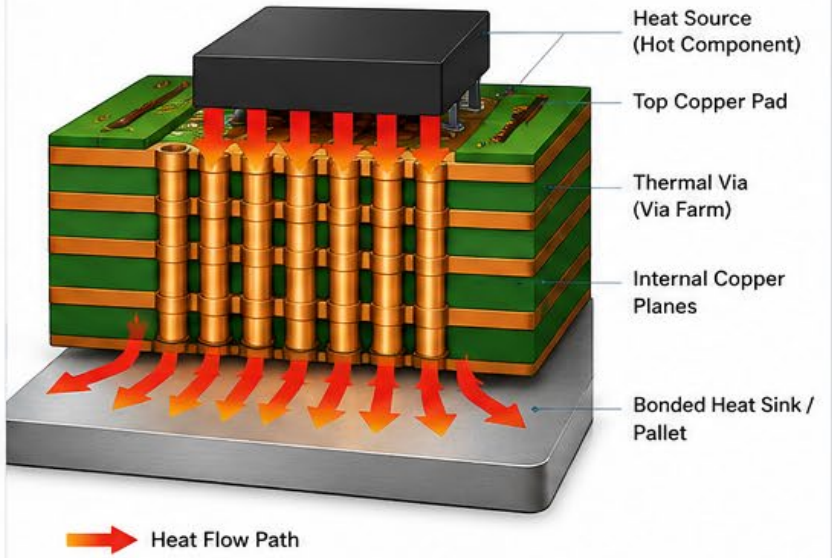
Thermal via farms create low-resistance paths for heat to flow from the component, through the PCB, to the bonded heat sink.

BONDED HEAT SINK / PALLET

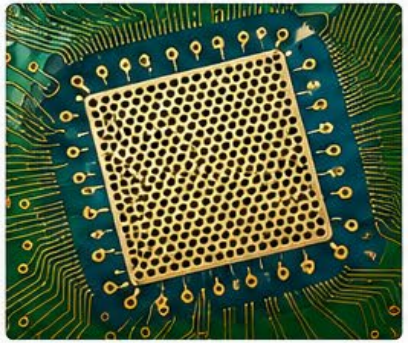
Attached to PCB



HOW IT WORKS



THERMAL VIA FARM UNDER PACKAGE AREA



- Dense array of thermal vias under the component area
- Connects top copper pad to internal and bottom planes
- Enables efficient transfer of heat to the bonded heat sink

DESIGN INSIGHTS

Cost-effective way to improve board-level thermal conductivity and create an enhanced thermal path through the PCB.

Multiple thermal vias placed beneath a thermal pad improve heat transfer, especially when the via array is sized to maximize coverage under the hot component.

Best performance is achieved when the via farm is paired with a bonded heat sink and an optimized thermal interface path.

KEY BENEFITS

- Lower operating temperature
- Improved reliability and longer product life
- Higher power density in compact designs
- Well suited for power, RF, automotive and industrial electronics

INTERNAL HEAVY COPPER LAYERS

Heavy Copper Architectures

WHAT ARE THEY?

- One or more internal copper layers with thickness significantly greater than standard copper.
- Acts as a low-resistance thermal plane and high-current conductor.
- Embedded within the PCB stack-up to maximize heat spreading.

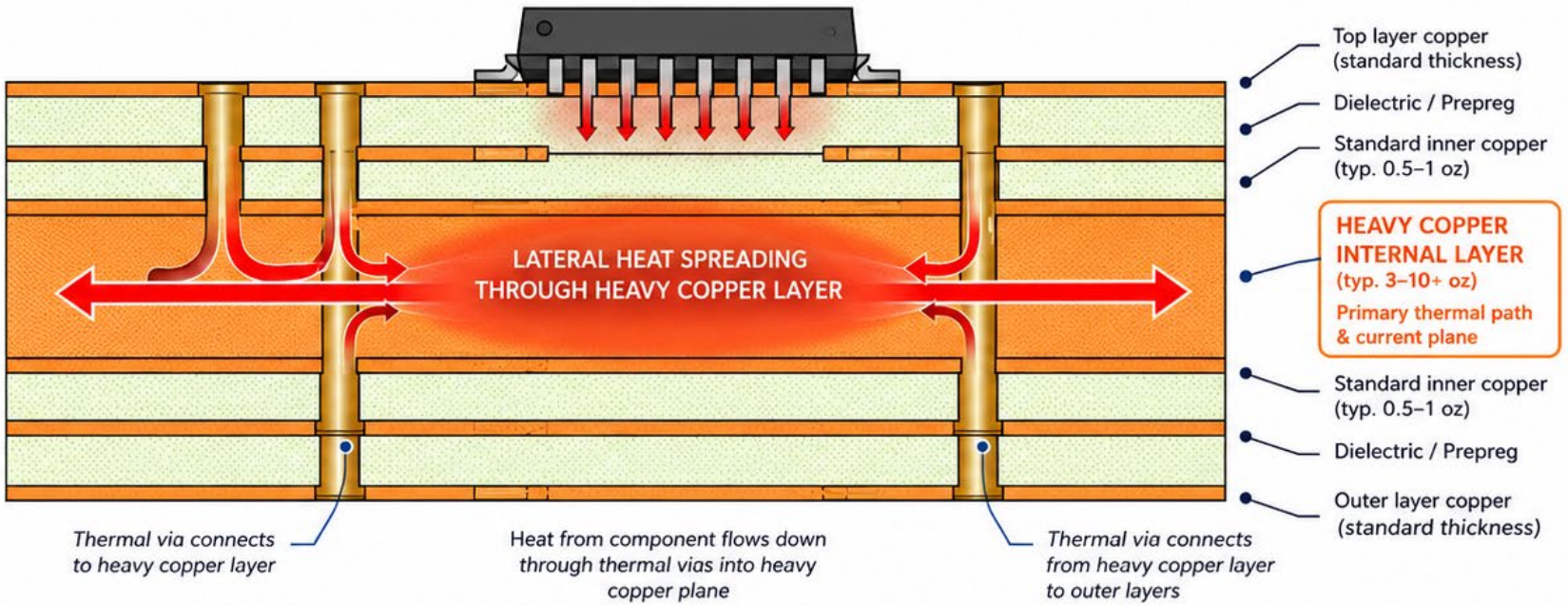
WHERE THEY ARE USED

- Power conversion & DC/DC regulators
- Automotive (EV/HEV, ADAS)
- Industrial drives & inverters
- High-current & high-power boards

DESIGN CONSIDERATIONS

- Larger trace/plane etch factors
- Lamination control & void management
- Stack-up symmetry & CTE matching
- Via count/placement for thermal coupling

HEAT FLOW & THERMAL SPREADING



STANDARD MULTILAYER STACK-UP (EXAMPLE)



- All copper layers same thickness (e.g., 1 oz)
- Heat must travel through dielectric to spread
- Higher thermal resistance
- Lower current carrying capacity

STACK-UP WITH INTERNAL HEAVY COPPER



- Embedded heavy copper layer (e.g., 3–10+ oz)
- Heat spreads laterally in low-resistance copper
- Lower thermal resistance
- Higher current carrying capacity

Heavy copper (3–10+ oz)

Standard copper (0.5–1 oz)

TAKEAWAY:
Embedded heavy copper layers act as low-resistance thermal spreaders and power planes, improving heat distribution, efficiency, and reliability in high-current, high-power PCB designs.

RELIABILITY CONSIDERATIONS

Heavy Copper Architectures

KEY RISKS

CTE MISMATCH
Different expansion rates can cause fatigue and delamination.

RESIN FLOW / LAMINATION QUALITY
Poor resin flow can lead to weak interfaces and delamination.

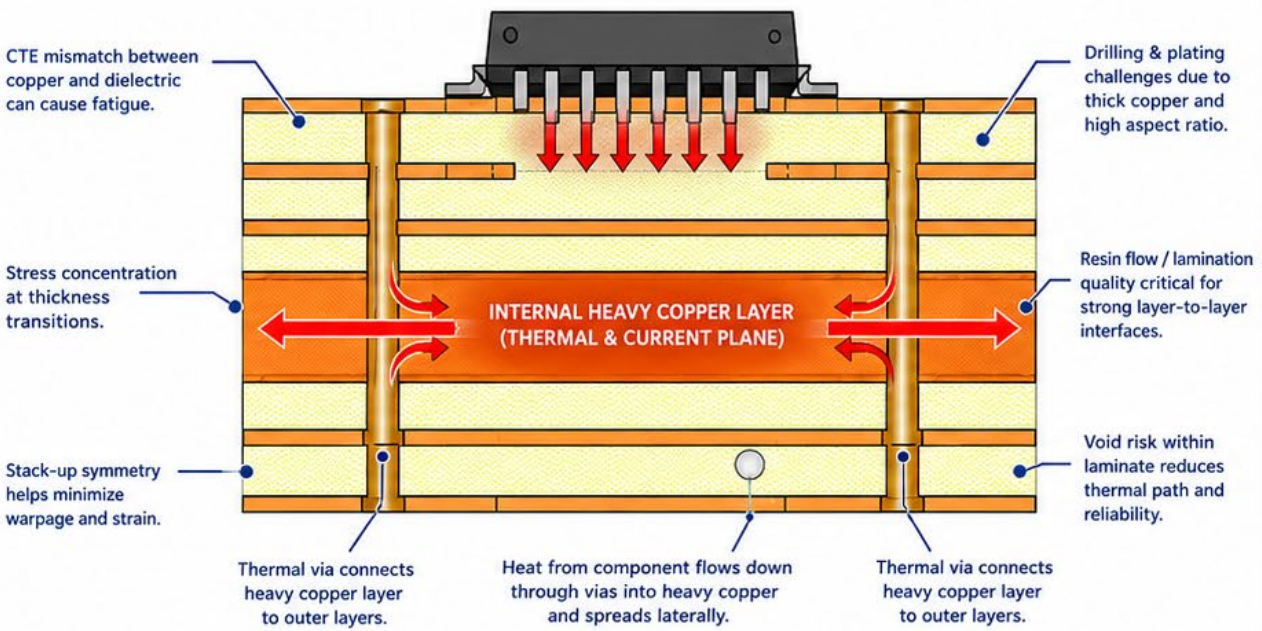
VOID RISK
Voids reduce thermal performance and can initiate failures.

DRILLING & PLATING CHALLENGES
Thick copper increases aspect ratio and plating uniformity issues.

STRESS CONCENTRATION
Abrupt thickness transitions create stress and crack initiation points.

STACK-UP ASYMMETRY
Imbalance can cause warpage, strain and reliability issues.

TYPICAL MULTILAYER PCB WITH INTERNAL HEAVY COPPER LAYER



BEST PRACTICES CHECKLIST

BALANCED STACK-UP
Distribute copper symmetrically around the heavy layer to minimize CTE mismatch.

CONTROLLED LAMINATION
Ensure adequate resin flow, pressure and temperature for strong bonding.

FILLET / TRANSITION DESIGN
Use gradual transitions and fillets to reduce stress concentrations.

VIA PLACEMENT & DENSITY
Place thermal vias strategically and maintain adequate density for heat and current paths.

VERIFY & QUALIFY
Validate through analysis, prototyping and reliability testing.

DESIGN GUIDELINES

- Balance copper above and below the heavy layer.
- Maintain symmetrical stack-up where practical.
- Minimize abrupt thickness transitions.
- Provide adequate edge support and stiffeners.

MANUFACTURING CONSIDERATIONS

DRILLING
- Use sharp, wear-resistant tools
- Optimize feed & speed
- Control entry/exit to
- minimize delamination

PLATING
- Ensure uniform copper thickness
- Control current density
- Monitor plating chemistry

LAMINATION
- Adequate resin flow and pressure
- Proper cycle & dwell time
- Use proven prepreg systems

INSPECTION
- X-ray for voids
- Cross-section analysis
- Thermal performance
- verification

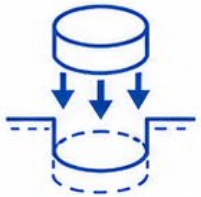
TAKEAWAY: Internal heavy copper layers significantly improve thermal and current performance, but introduce unique reliability risks. Successful designs require balanced stack-ups, controlled lamination, thoughtful transitions, and rigorous manufacturing and validation.

PRESS-FIT COINS

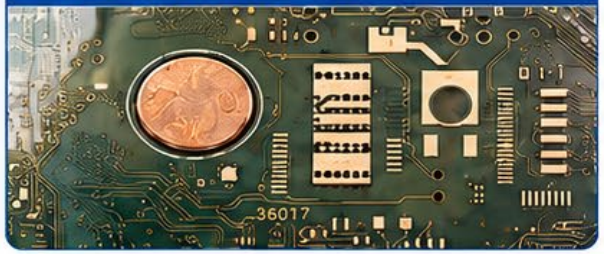
Copper Coins

WHAT IT IS

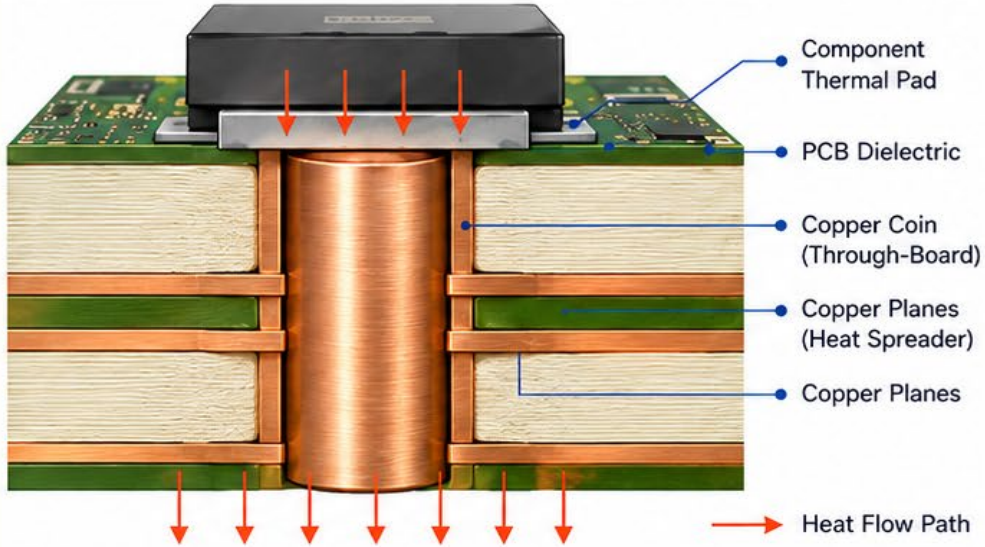
Press-fit copper coins are mechanically inserted into routed cavities in the PCB to create a direct, low-resistance thermal path from a hot component to a heat spreader region.



TOP VIEW (EXAMPLE)



HOW PRESS-FIT COINS WORK



KEY BENEFITS

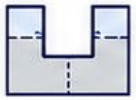
Lower Thermal Resistance
Provides a direct, low-resistance thermal path to spread heat efficiently.

Reduced Hot Spots
Draws heat away from localized sources for lower operating temperatures.

Improved Power Density
Enables higher performance in compact designs.

High-Volume Friendly
Mechanical insertion process is robust and well suited for mass production.

MANUFACTURING NOTES



1. ROUTED CAVITY PREPARATION
Precisely route cavity to controlled depth and size for proper coin fit and planarity.



2. MECHANICAL INSERTION
Press-fit coin into cavity using controlled force for a tight, reliable fit.



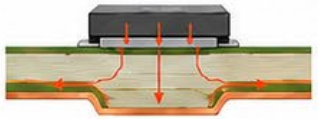
3. PLANARITY CONTROL
Ensure coin is flush or slightly recessed to maintain a flat surface for assembly.



4. INTERFACE QUALITY
Tight mechanical fit ensures excellent thermal contact and reliability.

THERMAL PATH COMPARISON

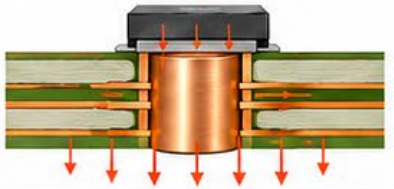
STANDARD PCB (COPPER ONLY PATH)



Higher thermal resistance
Localized heat spread

VS.

PRESS-FIT COIN (ENHANCED PATH)



Lower thermal resistance
Efficient, uniform heat spread

THERMAL TRANSFER IMPROVEMENTS

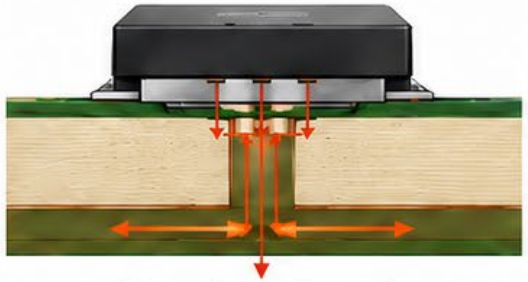
Copper Coins

WHY COINS HELP

- Provide a direct copper heat path between the heat source and large copper structures.
- Reduce localized thermal bottlenecks and hot spots under power components.
- Spread heat laterally into larger copper planes or external heatsinks for better dissipation.
- Lower junction temperatures for improved reliability and longer life.

HEAT FLOW & THERMAL SPREADING

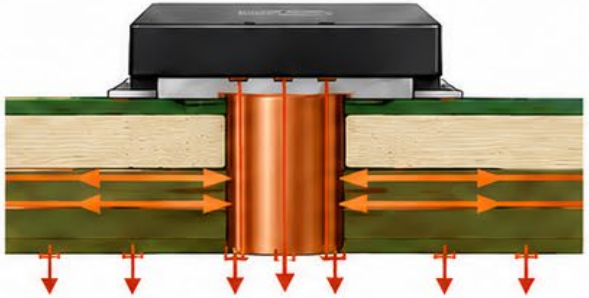
STANDARD PCB HEAT PATH
(Higher Thermal Resistance)



Narrow, localized heat path
limited lateral spreading

⚠ Higher thermal resistance
Localized hot spots

COIN-ENHANCED HEAT PATH
(Lower Thermal Resistance)



Direct copper coin heat path
with wide lateral spreading

✓ Lower thermal resistance
Reduced hot spots

PERFORMANCE IMPACT

Lower Operating Temperature
Reduces junction temperature for cooler, more reliable operation.

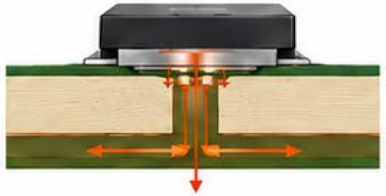
Reduced Hot Spots
Minimizes localized hotspots that can accelerate component aging and failure.

More Uniform Temperature Distribution
Heat is distributed more evenly across the copper structure.

Higher Allowable Power Density
Enables more power in the same footprint with confidence.

STANDARD VS COIN-ENHANCED THERMAL PATH

STANDARD PCB
(COPPER ONLY PATH)

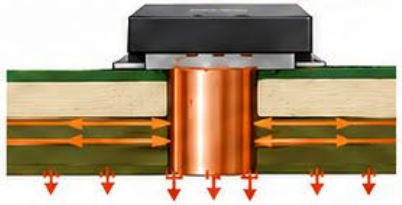


- Heat flows through small copper area.
- Limited lateral spreading in planes.
- Higher thermal resistance and hot spots.

⚠ Higher Temperature • Lower Reliability • Limited Power Capability

VS.

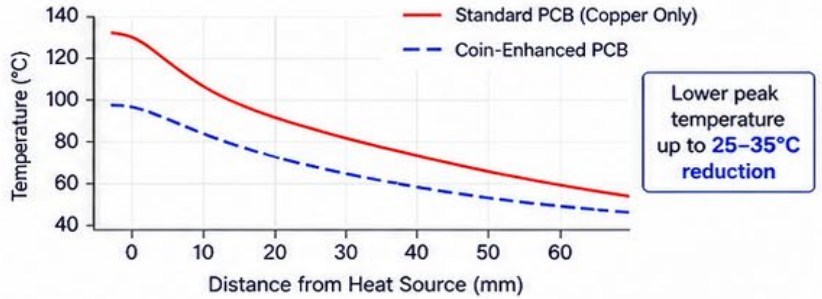
COIN-ENHANCED PCB
(ENHANCED PATH)



- Heat transfers through copper coin.
- Wide lateral and downward spreading.
- Lower thermal resistance and reduced hot spots.

✓ Lower Temperature • Higher Reliability • Higher Power Capability

TEMPERATURE TREND

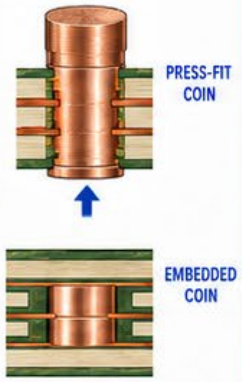


MANUFACTURING APPROACHES

Copper Coins

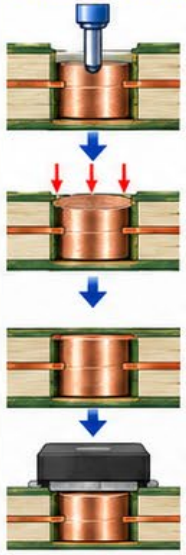
APPROACH OVERVIEW

Copper coins can be added to the PCB either by mechanical press-fit insertion into routed cavities or by embedding and integration during PCB lamination and build-up to create efficient, low-resistance thermal paths.



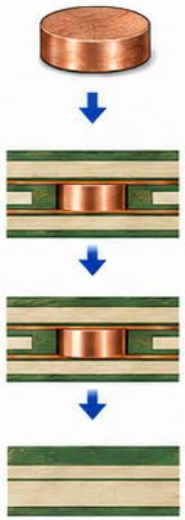
PRESS-FIT VS EMBEDDED PROCESS

PRESS-FIT COIN (MECHANICAL INSERTION)



1. **ROUTED CAVITY**
   Route cavity in inner layers or core to the required depth and dimensions.
2. **MECHANICAL INSERTION**
   Press-fit copper coin into the cavity using controlled force.
3. **PLANARITY CONTROL**
   Ensure coin is flush or slightly recessed to maintain a flat surface for assembly.
4. **FINAL ASSEMBLY**
   Continue PCB build and assembly process.

EMBEDDED COIN (INTEGRATION)



1. **COIN PREPARATION**
   Prepare copper coin (Thickness, finish, cleaning as required).
2. **STACK-UP PLACEMENT**
   Place coin at the designed location within the PCB stack-up.
3. **LAMINATION / BONDING**
   Laminatte prepregs and resin flows secure coin within the stack.
4. **PLANARIZATION / FINAL BUILD**
   Surface planarization and continue PCB build to final product.

PROCESS COMPARISON

CRITERIA	PRESS-FIT COIN	EMBEDDED COIN
THERMAL PERFORMANCE	High	Very High
PROCESS COMPLEXITY	Lower	Higher
VOLUME SUITABILITY	High (Mid–High Volume)	High (Mid–High Volume)
FLATNESS / ASSEMBLY COMPATIBILITY	Good (Flush or Slightly Recessed)	Excellent (Integrated & Planar)
COST (IMPACT)	Lower	Moderate to Higher

KEY FABRICATION CONTROLS

CAVITY TOLERANCE
Tight control of diameter and depth for secure fit and contact

COIN THICKNESS TOLERANCE
Consistent thickness for proper fit and platedvia access to planes

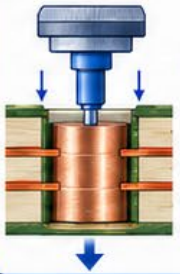
PLANARITY CONTROL
Maintain flush or recessed target to ensure flat surface for assembly.

RESIN FLOW / BOND QUALITY
Ensure resin flow to coin surfaces for strong bond and void control

DRILLING / PLATING INTERACTION
Protect coin edges and ensure plating continuity and reliability.

INSPECTION / CROSS-SECTION VERIFICATION
Verify coin position, bond quality, and planarity through AOI/CS inspection

WHEN TO USE EACH



PRESS-FIT COIN

- Ideal for retrofit, high-volume solutions.
- Best for direct insert applications.
- Lower process complexity and cost impact.
- Suitable for when slight recess is acceptable.

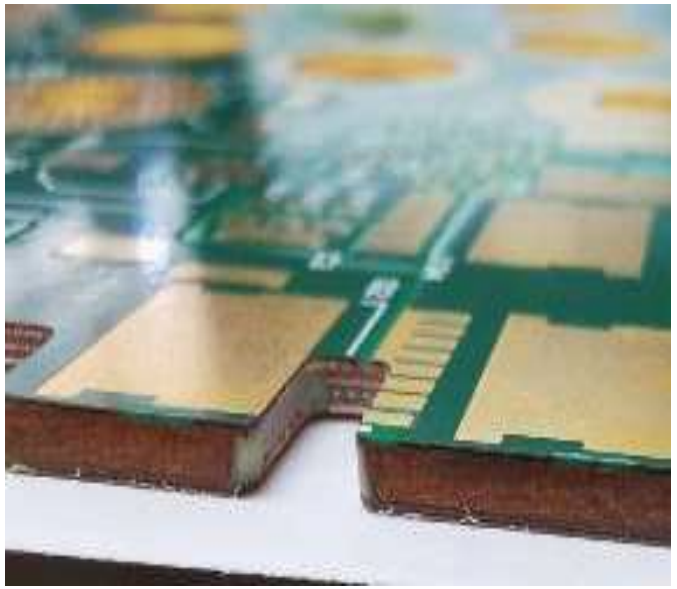


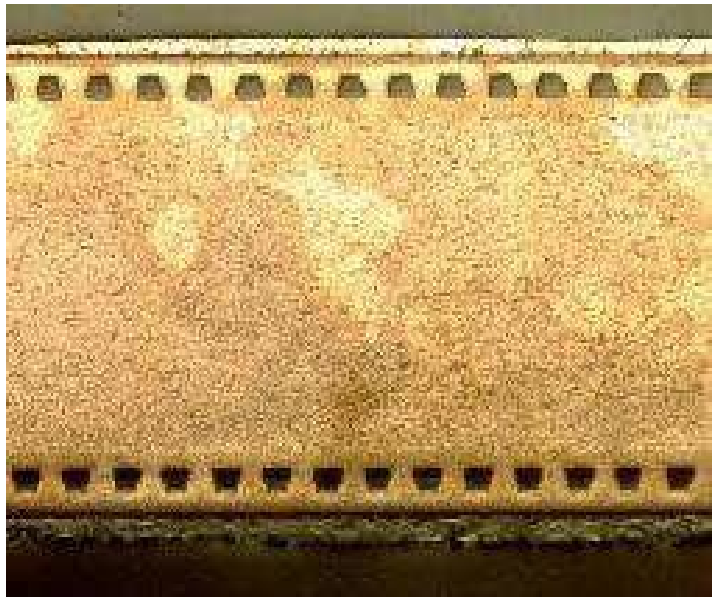
EMBEDDED COIN

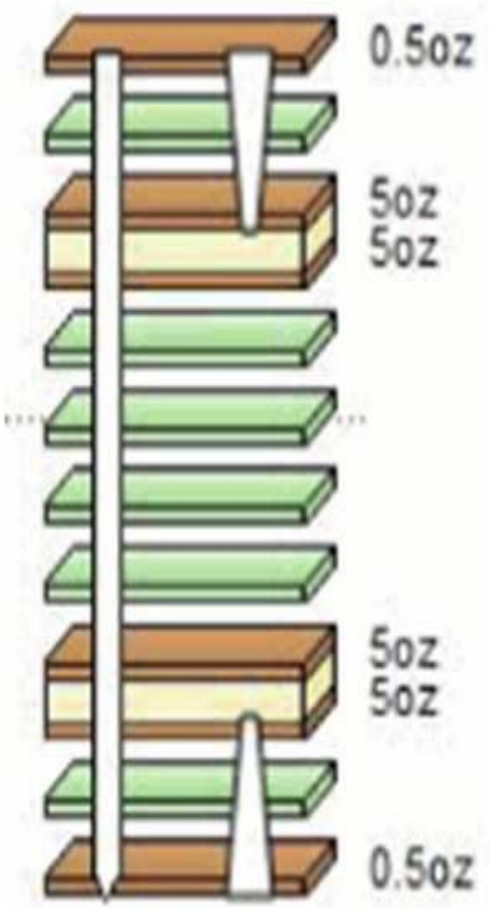
- Best for compact, high-performance designs.
- Provides integrated thermal paths and superior flatness.
- Ideal for power-dense and space-constrained products.
- Enables advanced thermal management architectures.

EMBEDDED COIN EXAMPLE

Layer Count	Coin Thickness	Coin Shape	Board Thickness	Min drill size on coin	Surface Finish
6 Layer	1.525mm coin	Rectangular	2.0mm	0.125mm	ENIG







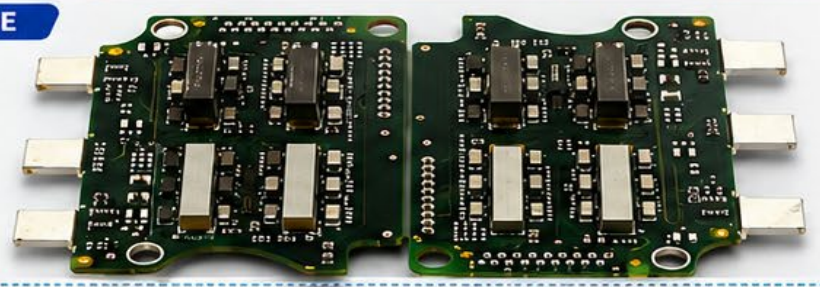
EMBEDDED BUSBARS

Integrated Current + Thermal Management for High-Current Applications

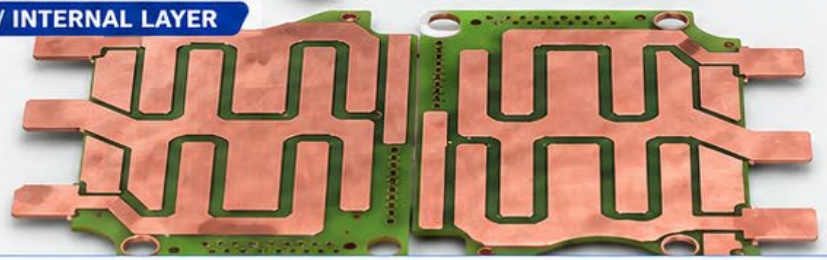
EMBEDDED BUS-BAR PCB

Top side and bottom side current-path design

TOP SIDE

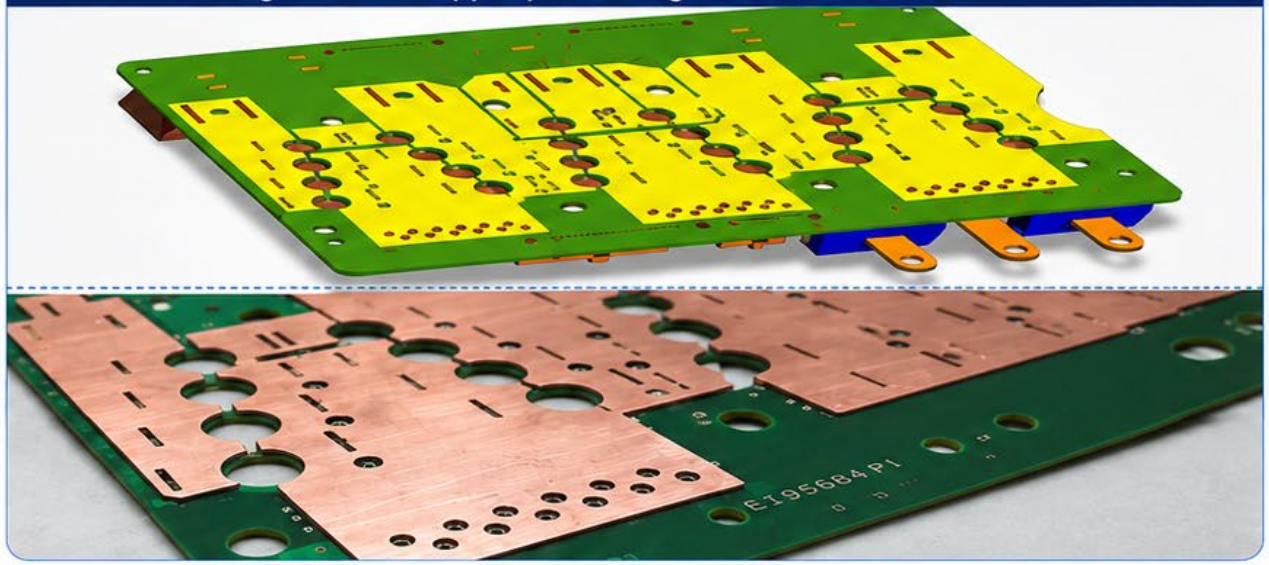


BOTTOM / INTERNAL LAYER



BUS-BAR INTEGRATION

High-current copper paths integrated into the PCB



WHAT IT DOES

Embedded bus-bars integrate thick copper conductors into the PCB structure.

Create robust low-resistance current paths for high-power applications.

Help route high current separately from fine signal circuitry while supporting heat spreading.

DESIGN INSIGHTS

- Embedded bus-bars are used when standard copper foil alone may not provide enough current-carrying capability or cross-sectional area.
- The integrated copper structure can support higher current density, lower voltage drop, and more efficient power distribution in compact assemblies.
- This approach is well suited for power conversion, battery systems, automotive electronics, and industrial equipment requiring durable high-current interconnects.

BENEFITS

- Higher current-carrying capability
- Lower resistive loss and voltage drop
- Compact integration with strong mechanical support
- Improved thermal spreading / heat management
- Well suited for power, automotive, battery, and industrial applications

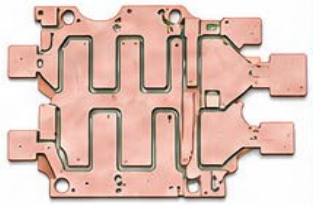
Embedded Busbars

WHAT THE MANUFACTURING SHOWS

- Bus-bars are fabricated as thick copper features within the PCB.
- Precise alignment with the board stack-up ensures optimal current paths.
- Integrated within the PCB for superior current carrying and thermal performance.
- Used in applications where standard copper alone may not be sufficient.

MANUFACTURING APPROACH

1 Copper bus-bar pattern preparation



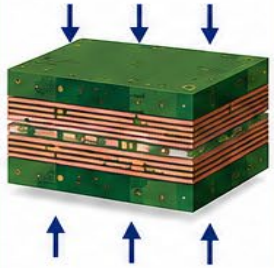
Thick copper features are etched / machined to form bus-bar patterns.

2 Alignment / lay-up into PCB structure



Copper patterns are positioned and aligned within the PCB stack-up.

3 Lamination / integration



Heat and pressure bond the copper features into the PCB lamination.

4 Final machining / drilling / assembly



Machining, drilling, and plating define features and enable assembly.

DESIGN INSIGHTS

- Embedded bus-bars provide mechanical integration and structural support.
- Large copper cross-section enables better current sharing and lower stress.
- Reduced resistive loss and voltage drop improve power efficiency.
- Enhanced thermal spreading helps maintain lower operating temperatures.

BENEFITS

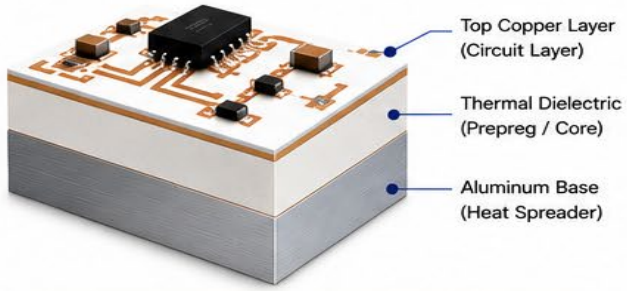
- Higher current-carrying capability
- Lower resistive loss and voltage drop
- Compact integration with strong mechanical support
- Well suited for power, automotive, battery, and industrial applications

INSULATED METAL SUBSTRATES (IMS) FOR POWER APPLICATIONS

High Thermal Performance for Power Electronics, LED Lighting and Automotive Systems

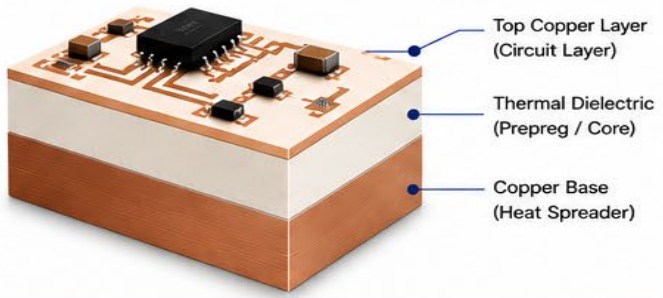
ALUMINUM AND COPPER IMS STRUCTURES

ALUMINUM IMS STRUCTURE



Lightweight, excellent thermal performance and cost effective.

COPPER IMS STRUCTURE



Higher thermal conductivity, superior heat spreading and ideal for high power density designs.

LED AND AUTOMOTIVE APPLICATIONS

LED LIGHTING APPLICATIONS

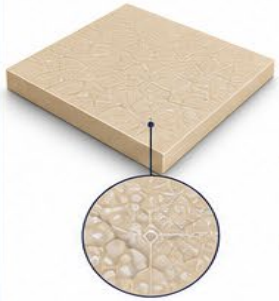


AUTOMOTIVE APPLICATIONS



Enable high reliability, long life and excellent thermal management in demanding environments.

THERMAL PREPREGS (DIELECTRIC LAYER)



- Ceramic / inorganic-filled dielectric systems improve heat transfer from the circuit layer to the metal base.
- Material selection balances thermal conductivity, dielectric strength, Dk / Df, thickness, and bonding performance.
- Higher dielectric strength supports electrical isolation in power and automotive applications.
- Available in multiple dielectric thicknesses to balance thermal resistance, voltage isolation, and manufacturability.

MANUFACTURING CHALLENGES

Machining of metal base
Requires specialized tools and parameters to avoid burrs and delamination.

Adhesion control
Ensuring strong bond between copper, dielectric layer and metal base.

Flatness and warpage
Metal base can cause board distortion during lamination and processing.

Thermal expansion mismatch
Managing CTE differences between metal, dielectric and copper to prevent stress.

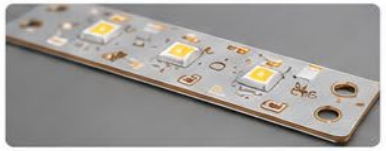


Controlled drilling and routing are critical for quality and reliability.

APPLICATION SPOTLIGHT

LED MODULE ON IMS

- Efficient heat transfer from LED junction to metal base
- Supports compact, high brightness and longer life



AUTOMOTIVE POWER MODULE ON IMS

- High current carrying capability with excellent thermal dissipation
- Improves reliability and reduces system size and weight



KEY BENEFITS

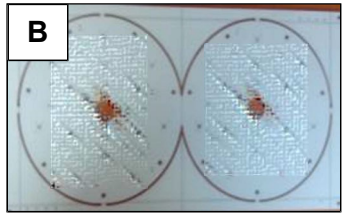
- Superior thermal performance
- High reliability and long life
- Supports high power density designs
- Lightweight solutions for automotive and LED applications

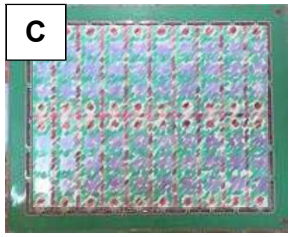
INSULATED METAL SUBSTRATES

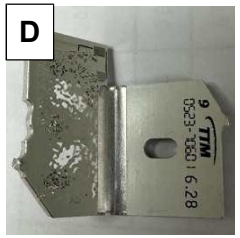
Single-Layer Insulated Metal Substrates (IMS)

Metal Type	Layers	IMS thickness	Surface treatment	Special process	Marking
5052 Al	1 Layer	74.8 mil	LF-HASL	/	A
5052 Al	1 Layer	39.4 mil	LF-HASL	/	B
5052 Al	1 Layer	39.4 mil	LF-HASL	/	C
5052 Al	1 Layer	63 mil	LF-HASL	Control depth routing	D







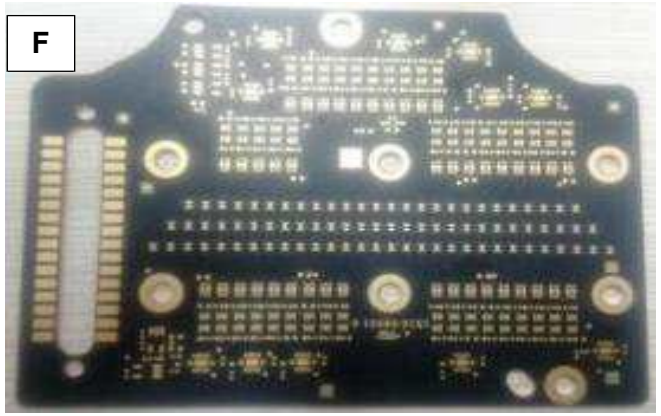


INSULATED METAL SUBSTRATES

Insulated Metal Substrates (IMS) - Cu

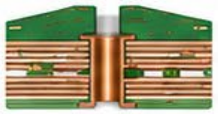
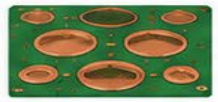
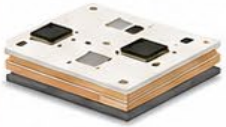
Metal Type	Layers	IMS thickness	Surface treatment	Special process	Marking
C1100	2 Layer	59 mil	Imm. Gold	Cu based IMS Full panel Immersion gold	E
C1100	2 Layer	42.4 mil	Imm. Gold	/	F





COMPARATIVE TECHNOLOGY MATRIX

Compare key thermal management technologies to select the best fit for your application

TECHNOLOGY	THERMAL PERFORMANCE	COST	MANUFACTURABILITY	RELIABILITY	BEST APPLICATIONS
 **Thermal Vias** Plated vias for heat transfer to inner layers or planes.	Moderate	Low	Easy	Good	Moderate power applications
 **Heavy Copper** Thick copper layers to carry higher current and spread heat.	High	Medium	Moderate	Good	High current applications
 **Copper Coins** Copper features embedded in inner layers for hotspot cooling.	Very High	Higher	Complex	Excellent	Hotspot cooling and thermal management
 **IMS (Aluminum / Copper)** Insulated Metal Substrate for efficient heat dissipation.	High	Medium	Moderate	Good	LED lighting and automotive applications
 **Busbars** Embedded copper bus-bars for high current distribution.	Very High	High	Complex	Excellent	High current power systems

KEY TAKEAWAY

- Match thermal performance to power density and hotspot requirements.
- Balance performance benefits with total system cost.
- Consider manufacturability to ensure reliable and scalable production.
- Choose technologies that deliver long-term reliability in your application.

DESIGN RECOMMENDATIONS & SELECTION GUIDELINES

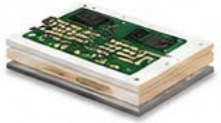
Make informed choices to achieve optimal thermal performance, cost, and manufacturability

1 CHOOSING THE RIGHT THERMAL TECHNOLOGY

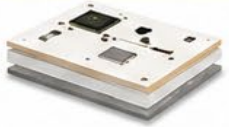
Match the thermal solution to your application requirements.



Conventional FR-4
Low power density, cost-sensitive designs



Metal Core PCBs
Better heat dissipation for moderate power applications



IMS (Aluminum / Copper)
High thermal performance for LED and automotive applications

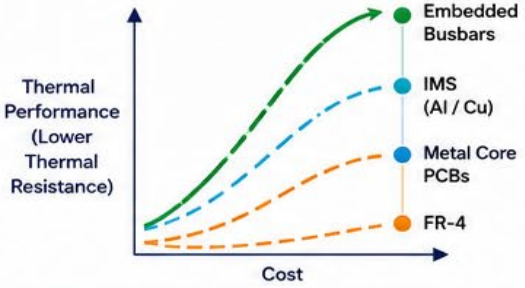


Embedded Busbars
Ultra-high current capacity and integrated thermal managenment

✓ Consider power level, thermal resistance targets, space constraints, and reliability requirements.

2 THERMAL-PERFORMANCE VS COST OPTIMIZATION

Balance performance needs with cost targets.



- Define thermal targets early (e.g., junction temperature, ΔT, thermal resistance).
- Evaluate total system cost, not just PCB cost (heat sinks, airflow, reliability).
- Use the right technology—avoid over-design that increases cost without real thermal benefit.

✓ Optimize for the best value, not just the lowest initial cost.

3 MANUFACTURABILITY CONSIDERATIONS

Design for reliable production and repeatable quality.

- Follow fabrication guidelines for layer stack-up, minimum copper thickness, and clearances.
- Consider drilling aspect ratios, via filling, and plated copper reliability.
- Ensure proper thermal path continuity (pads, vias, copper thickness).
- Specify appropriate materials and finishes for electrical, thermal, and environmental reliability.
- Run DFM checks and prototype early to validate manufacturability and performance.

✓ Good design for manufacturing reduces risk, cost, and time to market.

4 EARLY COLLABORATION WITH PCB FABRICATORS

Engage with your PCB partner early in the design phase.

- Discuss application needs, thermal targets, and performance expectations.
- Review material options, stack-up feasibility, and process capabilities.
- Get input on design trade-offs, alternatives, and cost impacts.
- Align on test methods, quality standards, and delivery requirements.

✓ Early collaboration enables better design decisions and smoother production.

KEY TAKEAWAY

- Choose the right thermal technology for your application.
- Optimize performance and cost for the best total value.
- Design with manufacturability in mind.
- Collaborate early for faster, more reliable success.

Questions?



TTM Technologies

Inspiring Innovation

Thank You!

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