



# **Thermal Management**

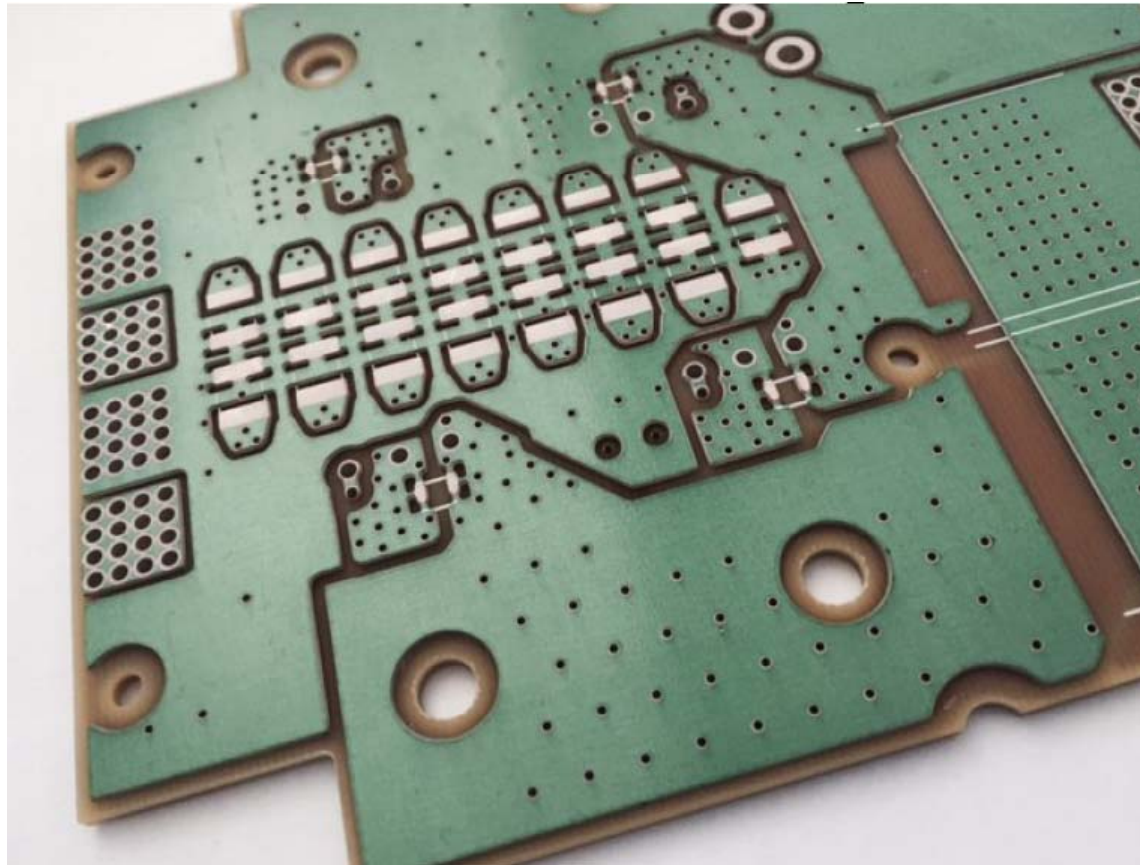
Wrekin Circuits Ltd



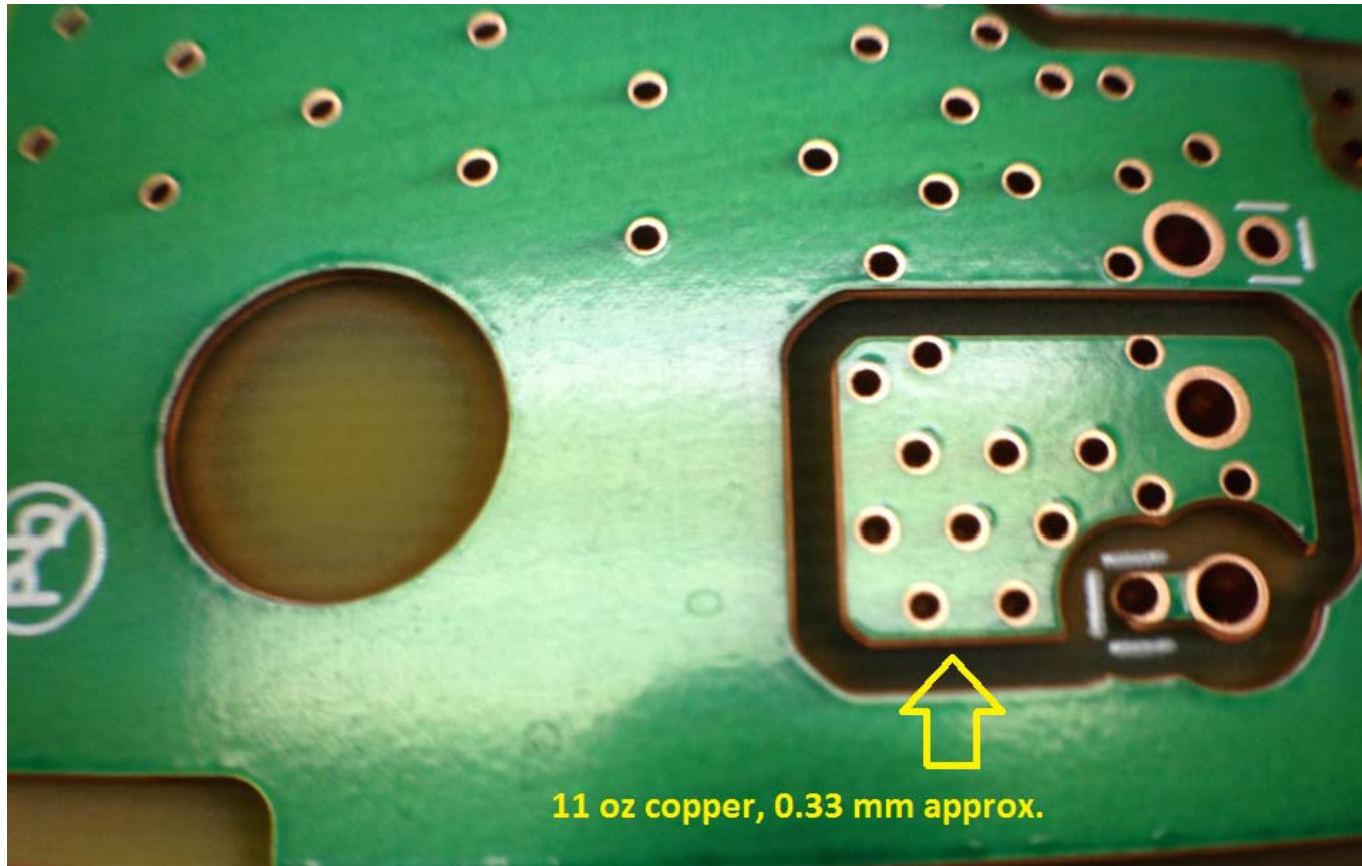
# Heavy Copper

- We stock 0.5, 1.0, 2.0, 3.0, 4.0, 6.0 and 10 oz copper.
- 1 oz copper 30 um after processing.
- We can manufacture pcbs with up to 16 oz copper on inner and outer layers.
- Applications include Planer transformer and High performance power supplies.

# 11 oz 4 Layer



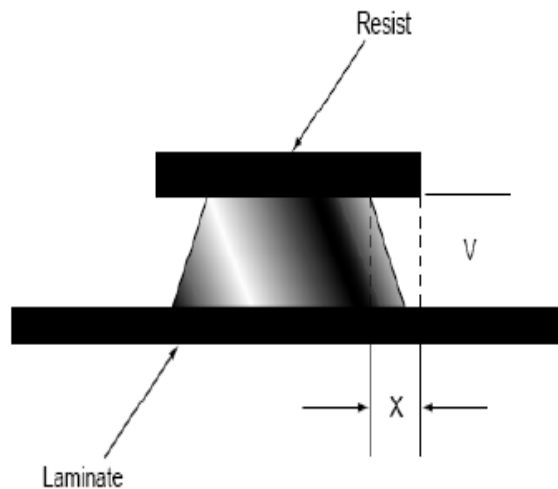
# 11 oz 4 Layer



# Heavy copper issues.

- The pcb cost and additional weight.
- Etch factor compensation.
- Insulation between layers.
- Solder mask coverage and ink thickness.
- Assembly problems associated with heat sink effects.

# Etch factor is critical in design



$$\text{Etch Factor} = \frac{v}{x}$$

"A" POINT OF NARROWEST CONDUCTOR WIDTH: This is not "Minimum Conductor Width" noted on master drawings or performance specifications.

"B" CONDUCTOR BASE WIDTH: The width that is measured when "Minimum Conductor Width" is noted on the master drawing or performance specification.

"C" PRODUCTION MASTER WIDTH: The width usually determines the width of the metal or organic resist on the etched conductor.

Design width of the conductor is specified on the master drawing and is most often measured at the conductor base "B" for compliance to "minimum conductor width" requirements.

# Etch compensation

## DESIGN GUIDELINES

COPPER	MINIMUM TRACKS	MINIMUM GAPS THOU/(mm)	
	THOU/(mm)	INNER	OUTER
0.25 oz	3 (0.076)	3 (0.076)	3 (0.076)
0.50 oz	4 (0.102)	4 (0.102)	4 (0.102)
1.00 oz	5 (0.127)	5 (0.127)	5 (0.127)
2.00 oz	8 (0.203)	8 (0.203)	6 (0.152)
3.00 oz	<u>12 (0.304)</u>	<u>10 (0.254)</u>	8 (0.203)
4.00 oz	<u>12 (0.304)</u>	<u>12 (0.304)</u>	<u>10 (0.254)</u>
5.00 oz	<u>12 (0.304)</u>	<u>14 (0.355)</u>	<u>12 (0.304)</u>
6.00 oz	<u>12 (0.304)</u>	<u>16 (0.406)</u>	<u>14 (0.355)</u>
7.00 oz	<u>12 (0.304)</u>	<u>18 (0.457)</u>	<u>16 (0.406)</u>
8.00 oz	<u>12 (0.304)</u>	<u>20 (0.508)</u>	<u>18 (0.457)</u>
9.00 oz	<u>12 (0.304)</u>	<u>22 (0.559)</u>	<u>20 (0.508)</u>
10.00 oz	<u>12 (0.304)</u>	<u>24 (0.610)</u>	<u>22 (0.559)</u>
11.00 oz	<u>12 (0.304)</u>	<u>26 (0.660)</u>	<u>24 (0.610)</u>
12.00 oz	<u>12 (0.304)</u>	<u>28 (0.711)</u>	<u>26 (0.660)</u>

Please discuss high copper weight designs with our Technical Department

## **Insulation between copper layers.**

- On power and planner transformer pcbs insulation between critical layers can be very important. Primary and secondary windings.
- Most glass based FR4 materials are around 1000 volts per 25 um.
- By adding Kapton between layers the insulation values can be greatly increased.

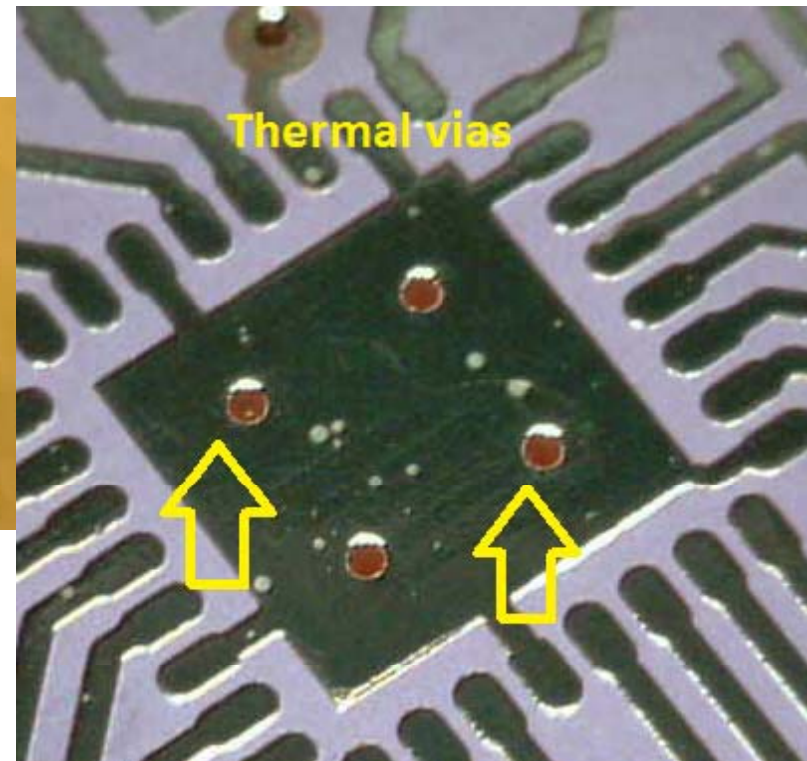
# Insulation resistance

- Isola PCL370HR (High TG FR4)
- Insulation 1350 V/MIL.
- Kapton
- Insulation 6000 to 7000 V/MIL.
- The next slide shows Kapton in a build to increase the insulation between layers.

# Heavy copper builds with Kapton.

KAPTON		LAYER 1		.5 oz
				.002
PRE-PREG	=====			.0025 (1080x1)
PRE-PREG	=====			.0045 (106x3)
FOIL		LAYER 2		.0056 4 oz GP
PRE-PREG	=====			.006 (106x4)
		LAYER 3		.0007 .5 oz GP
CORE	=====			.004
		LAYER 4		.0007 .5 oz GP
PRE-PREG	=====			.006 (106x4)
		LAYER 5		.0007 .5 oz GP
CORE	=====			.004
		LAYER 6		.0007 .5 oz GP
PRE-PREG	=====			.006 (106x4)
FOIL		LAYER 7		.0056 4 oz GP
PRE-PREG	=====			.006 (106x4)
SPECIAL				.002 BARE KAPTON
PRE-PREG	=====			.006 (106x4)
FOIL		LAYER 8		.007 .5 oz GP

# Thermal Chimneys



# Thermal Chimneys

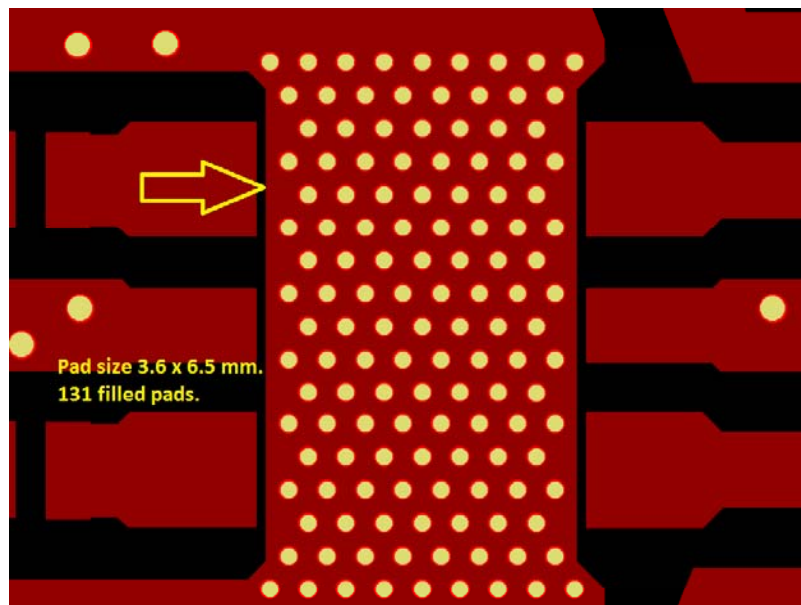
- These can be open, filled with solder or resin filled and plated over with copper.
- These can be connected to inner layers to improve the thermal conductivity of the surface pad.
- At the board edge they can transfer heat to the racking or enclosure.

# Thermal Chimneys



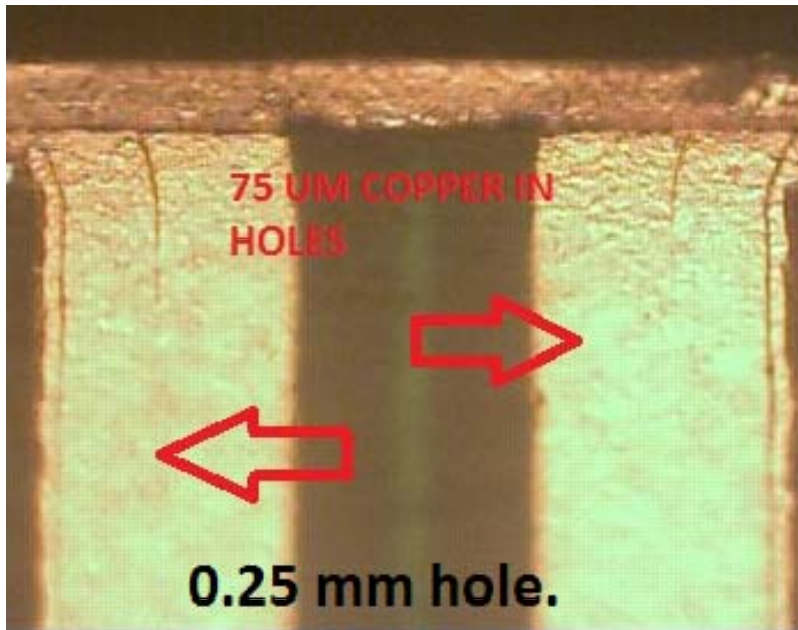
- This thermal pad is 6 x 6 mm.
- It has 16 off 0.3 mm holes.
- The copper in the holes is 25  $\mu\text{m}$ .
- The thermal conductivity of the pad can be calculated.

# High end Thermal Chimneys



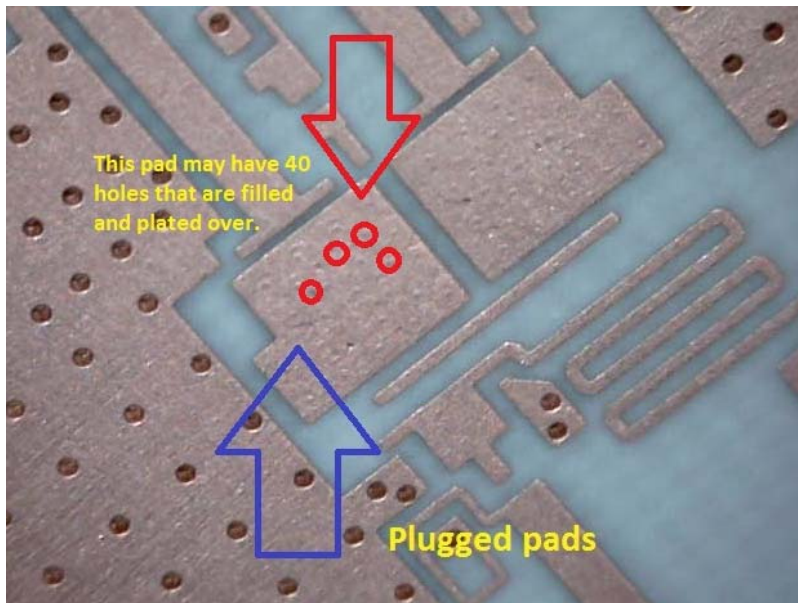
- By increasing the number of thermal vias on the pad the thermal conductivity is greatly increased.
- If the copper plating thickness in the hole is increased this increases thermal capacity.
- Flat thermal pads can be achieved by copper over plate.

# 75 um copper in thermal vias.



- 75 um selective copper plate in 0.25 mm thermal via.
- Very large increase in thermal performance.
- Hole then 100 um resin filled and over plated.

# Thermal vias plated over with copper.

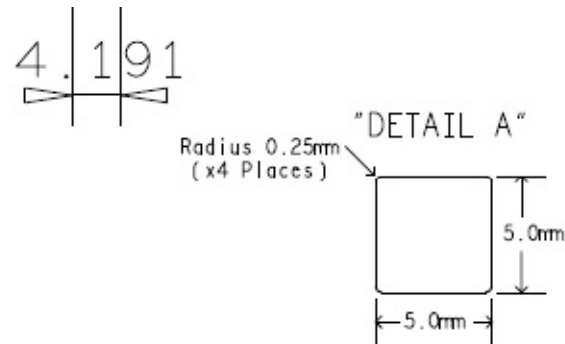


- Very high thermal conductivity.
- Flat pad for assembly.
- Internal connections can increase thermal capacity.
- Eliminate need for copper coin. Price advantage.
- Can be made in volume off shore.

# Copper coins

- Copper coins are normally used as a local heat sink. These can be added after assembly or during PCB fabrication.
- Tend to be used in high power RF applications and thermal hot spots.

# Copper coin insert

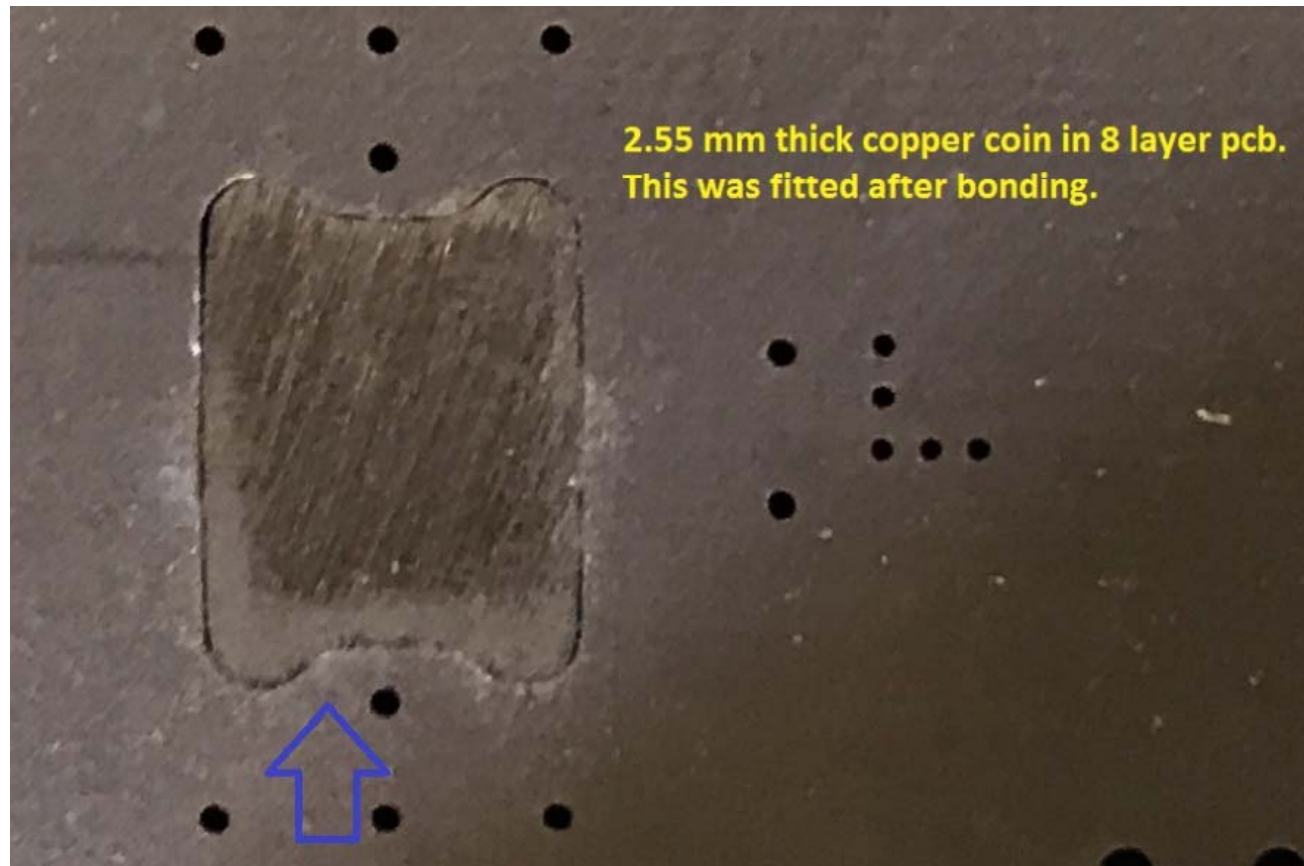


COPPER COIN INSERT  
MUST BE CONENCTED TO  
THE PLANES ON EXTERNAL  
LAYERS WITH PLATING

MUST ENSURE COPPER COIN  
IS FLUSH, FLAT, FREE OF BURRS ETC.  
AFTER PLATING, THE HEIGHT OF THE  
COPPER COIN MUST NOT EXCEED  
THE HEIGHT OF THE PLATED DUT PADS

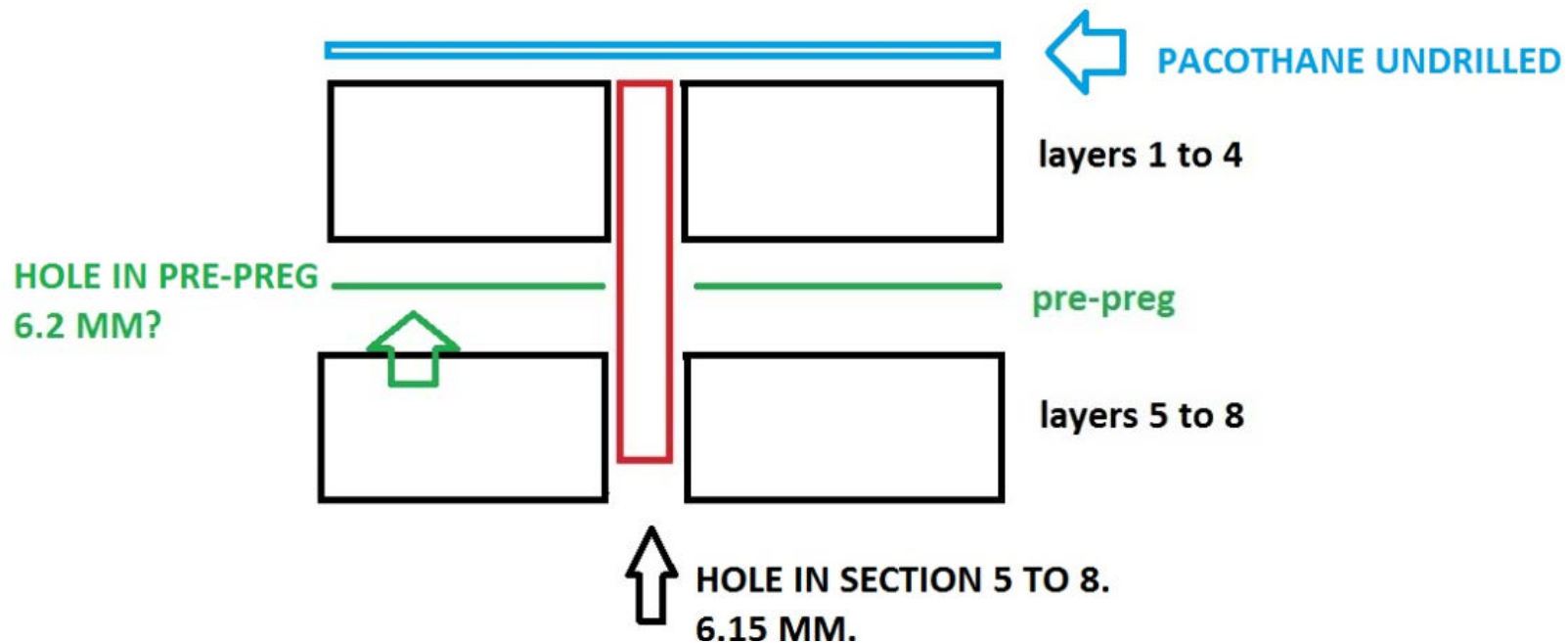
**The coin will not be above the plated dut pads but may have a slight dish down. it will be connected to the outer layers by plating.**

# Copper coins



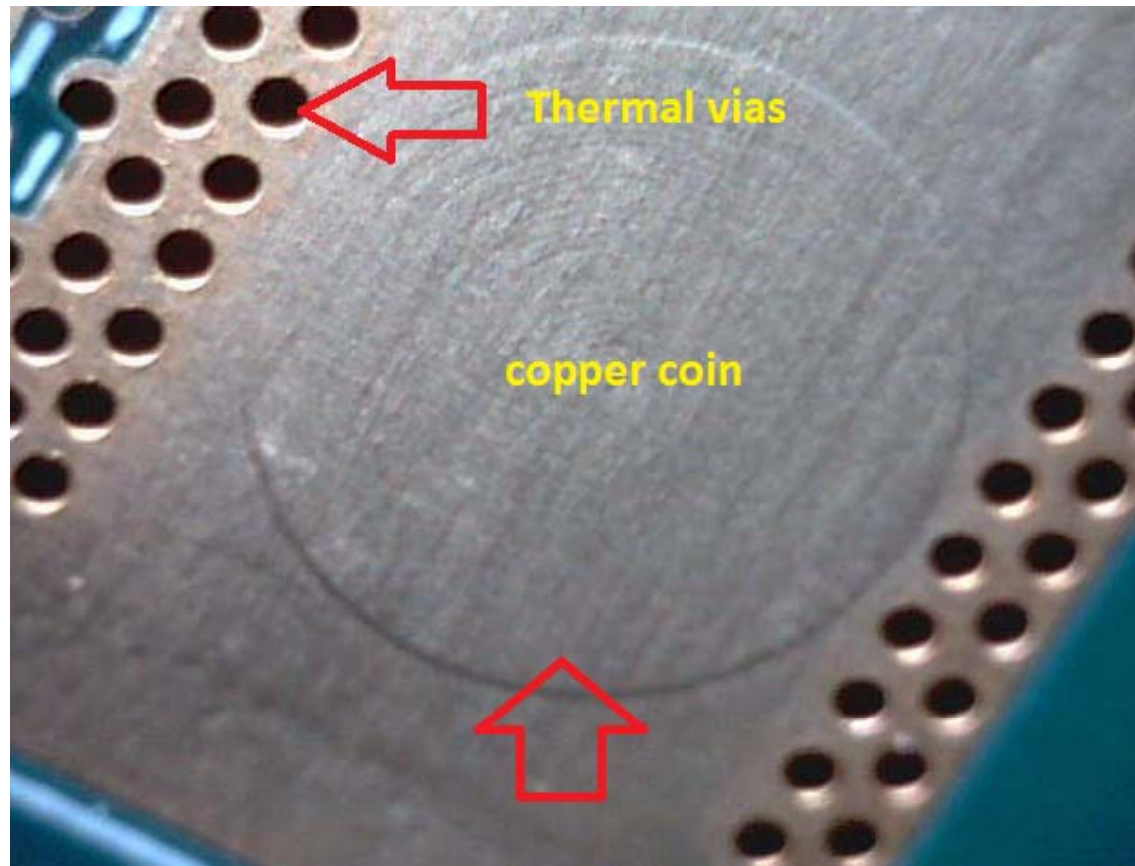
# Bonding copper coin in 8 layer pcb.

COPPER COIN 6.0 MM. HOLE LAYERS 1 TO 4 NEEDS TO BE DRILLED  
TIGHT. 6.05 MM. WHEN BUILDING STACK TAP IN COINS

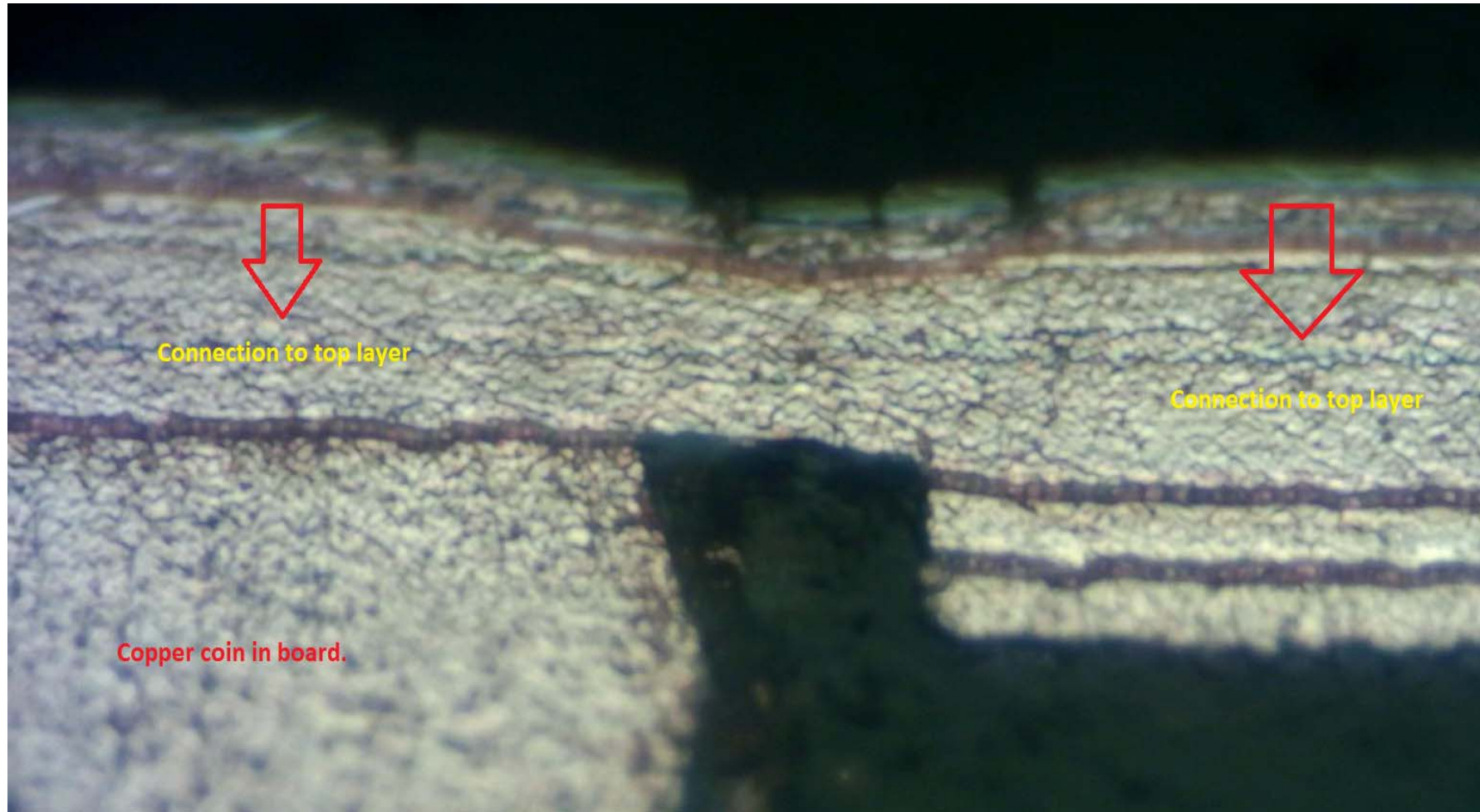


The pre-preg flows around the coin and  
bonds the coin in to the board.

# Copper coin after bonding.



# Micro section of copper coin in board.





# **STEP PLATING PROCESS**

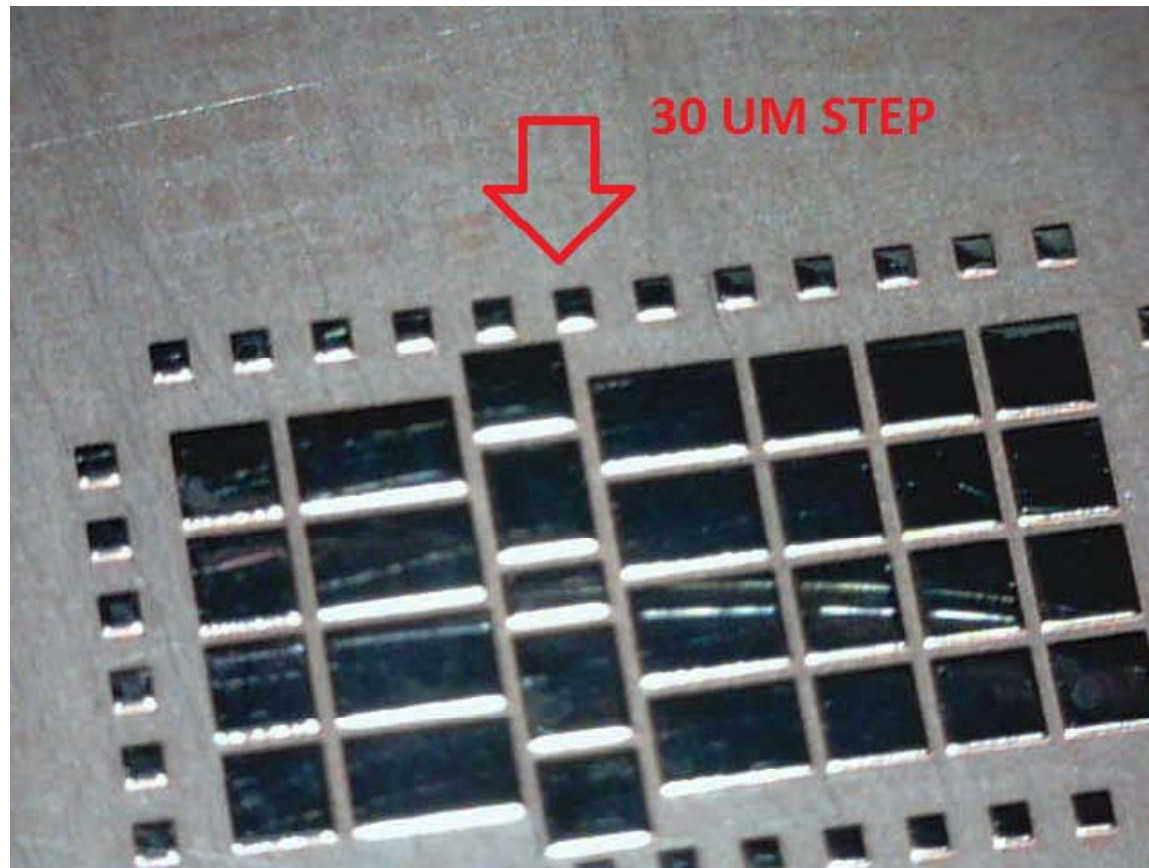
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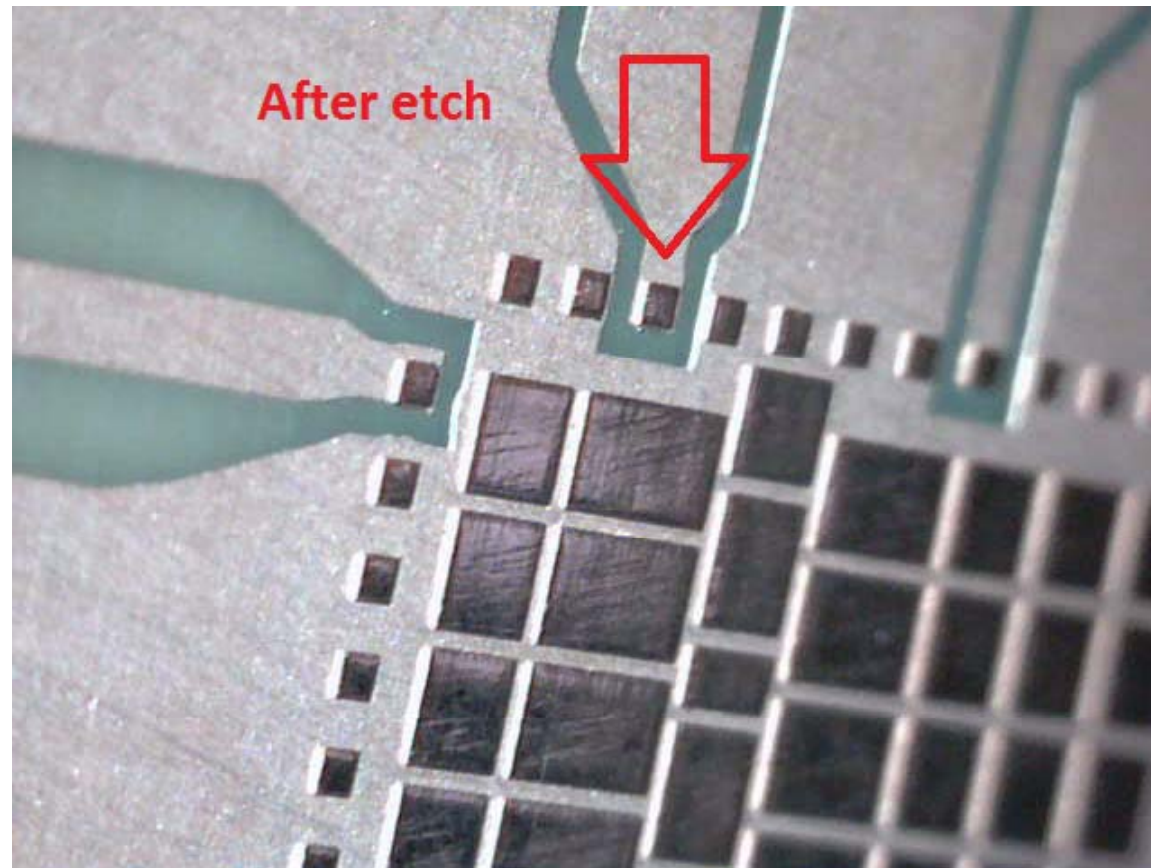
# STEP PLATING

- The step plating process give the option to have thick copper in isolated position on the outer layers of a pcb.
- This can give additional thermal performance in the areas.
- This process can also give additional height to ensure the stepped areas are above the solder mask.

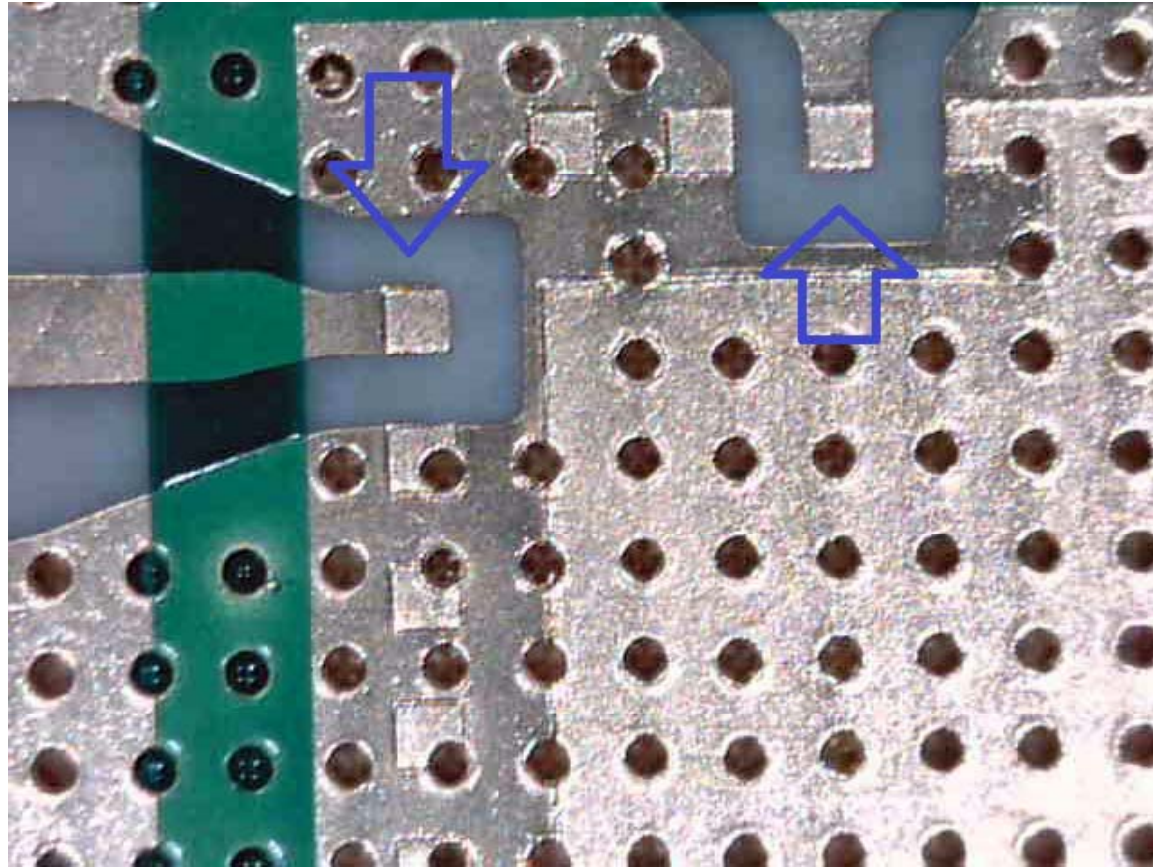
# STEP PLATING IMAGES



# STEP PLATING IMAGE



# STEP PLATING IMAGE



# Summary

- THIS NEW PROCESS OFFERS THE END USER A NUMBER OF KEY ADVANTAGES. THESE INCLUDE IMPROVED THERMAL PERFORMANCE.
- THE ABILITY TO HAVE THICK COPPER IN ISOLATED SECTION ON A FINE LINE DESIGN.

# Aluminium backing

- Insulated metal substrate (IMS)
- Aluminium core can be bonded to the outside of a board as a heat sink.
- This can be bonded using standard and thermally conductive adhesives.
- Aluminium core cannot be inside a multilayer pcb.

# IMS

Build-up 1 layer



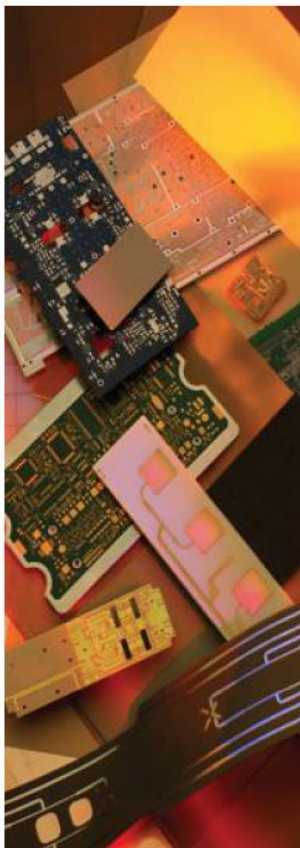
□ Aluminum   □ Thermal Prepreg   □ Copper 1-10 Oz   □ Soldermask

# Thermal conductive substrates

- Many laminate manufacturers are now producing thermally conductive materials. Listed below is some that we have used to make thermally conductive pcbs.
- Arlon 91 and 92ML.
- Ventec VT-4A.

# Performance of Arlon 92ML

## THERMALLY CONDUCTIVE MULTILAYERABLE EPOXY LAMINATE AND PREPREG



Arlon 92ML ceramic filled thermally conductive multifunctional epoxy laminate and prepreg products provide best-in-class thermal performance with increased thermal conductivity of 2 W/mK for multilayer PWB's for applications requiring thermal management throughout the entire board volume.

### Features:

- Thermal Conductivity 2.0 W/m-K, 6-8x that of FR-4, reduces hot-spots and dependence on thermal vias and heat-sinks to dissipate heat
- Glass Transition Temperature 170°C provides excellent plated through hole reliability, lead-free solder application
- Decomposition temperature >350°C is ideally suited for lead-free solder processing and offers significant improvement over other thermally conductive laminate materials
- Coefficient of Thermal Expansion close to that of Copper and Aluminum for planar stability during process
- Best-in-class thermal performance with T260>60 minutes, T280>15 minutes and T300 > 5 minutes.
- Electrical Strength >1000 Volts/mil for use in high power handling Applications
- Engineered for use with metal backing for producing Metal-Clad PCBs

# Performance of Ventec VT-4A

## General Information

Ventec offers 4 types of Aluminum base laminate and prepreg, which have below features,

- VT-44A / VT-44A PP: Thermal conductivity – 1.0W/mK, Ceramic Filled
- VT-4A1 / VT-4A1 PP: Thermal conductivity – 1.6W/mK, Ceramic Filled
- VT-4A2 / VT-4A2 PP: Thermal conductivity – 2.2W/mK, Ceramic Filled
- VT-4A3 : Thermal conductivity – 3.0W/mK, Ceramic Filled
- Excellent Electrical and Mechanical Characteristics
- Flame Retardant(UL94 V0)

## Application

- Power Conversion
- PDP, LED, Regulator for TV
- Monitor Drives
- Rectifier, Power supply

# Thermally conductive substrates

- These allow Wrekin to make very thin thermally conductive pcbs that can be bonded to Aluminium or copper backing plates. This allows for high thermal transfer from the board to the heat plane.
- These pcbs can be double sided or multilayer. This is a big difference from IMS (1 layer).
- Application include LED and engine products.

# Multilayer pcbs using conductive pre-preg and Aluminium heat sink.

FOIL		LAYER 1		.5 oz
PRE-PREG	=====			.005 (1080x2)
		LAYER 2		.0007 1 oz
CORE	=====			.004
		LAYER 3		.0007 1 oz
PRE-PREG	=====			.0025 (1080x1)
SPECIAL		LAYER 4		.062 ALUMINIUM

# Summary

- Wrekin Circuits make Pcb's for a wide diverse range of applications & clients .
- We specialise in working with our suppliers and customers to develop new processes & techniques to solve thermal challenges.
- ***Excelling in Collaborative engineering***