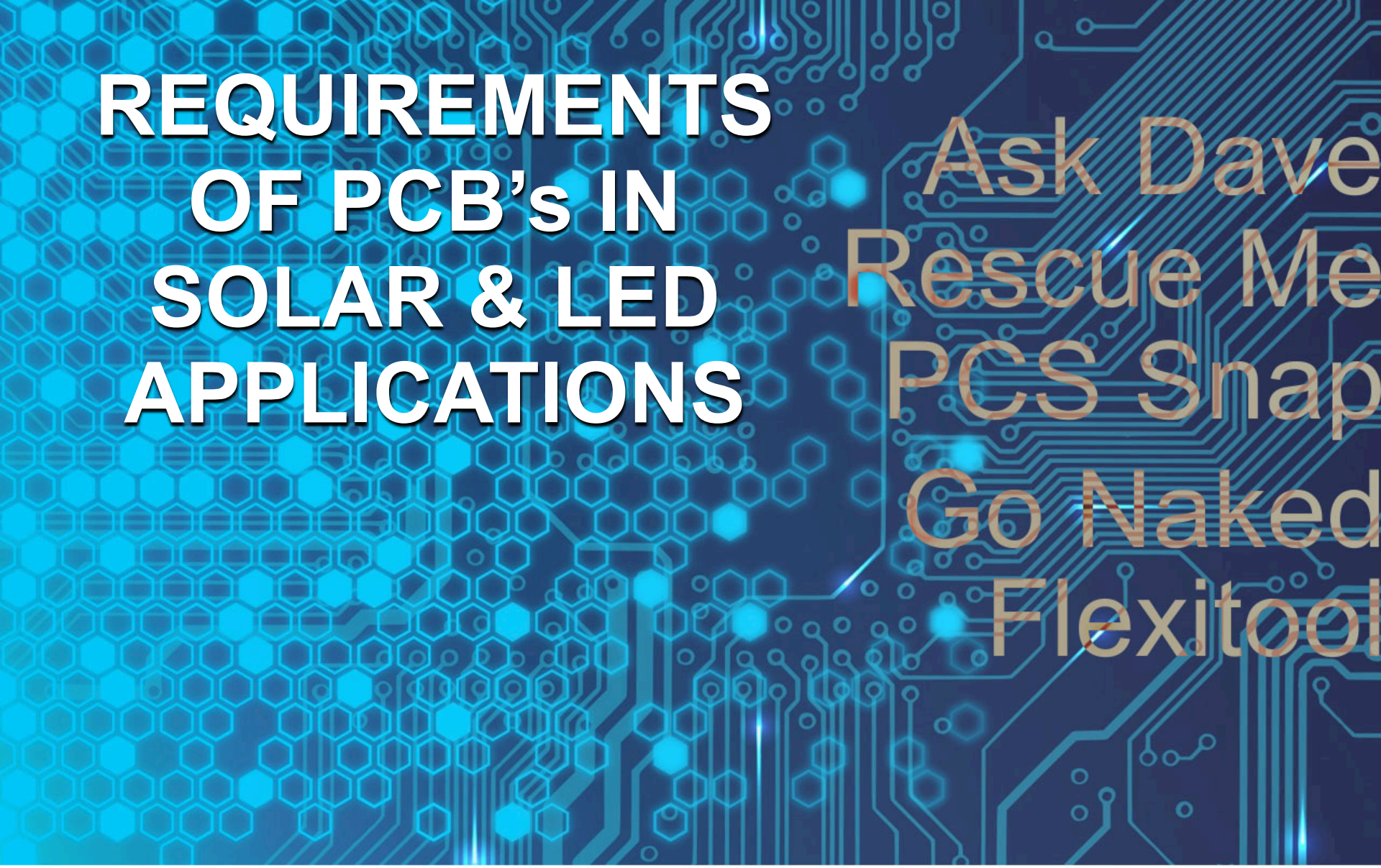
REQUIREMENTS OF PCB's IN SOLAR & LED APPLICATIONS



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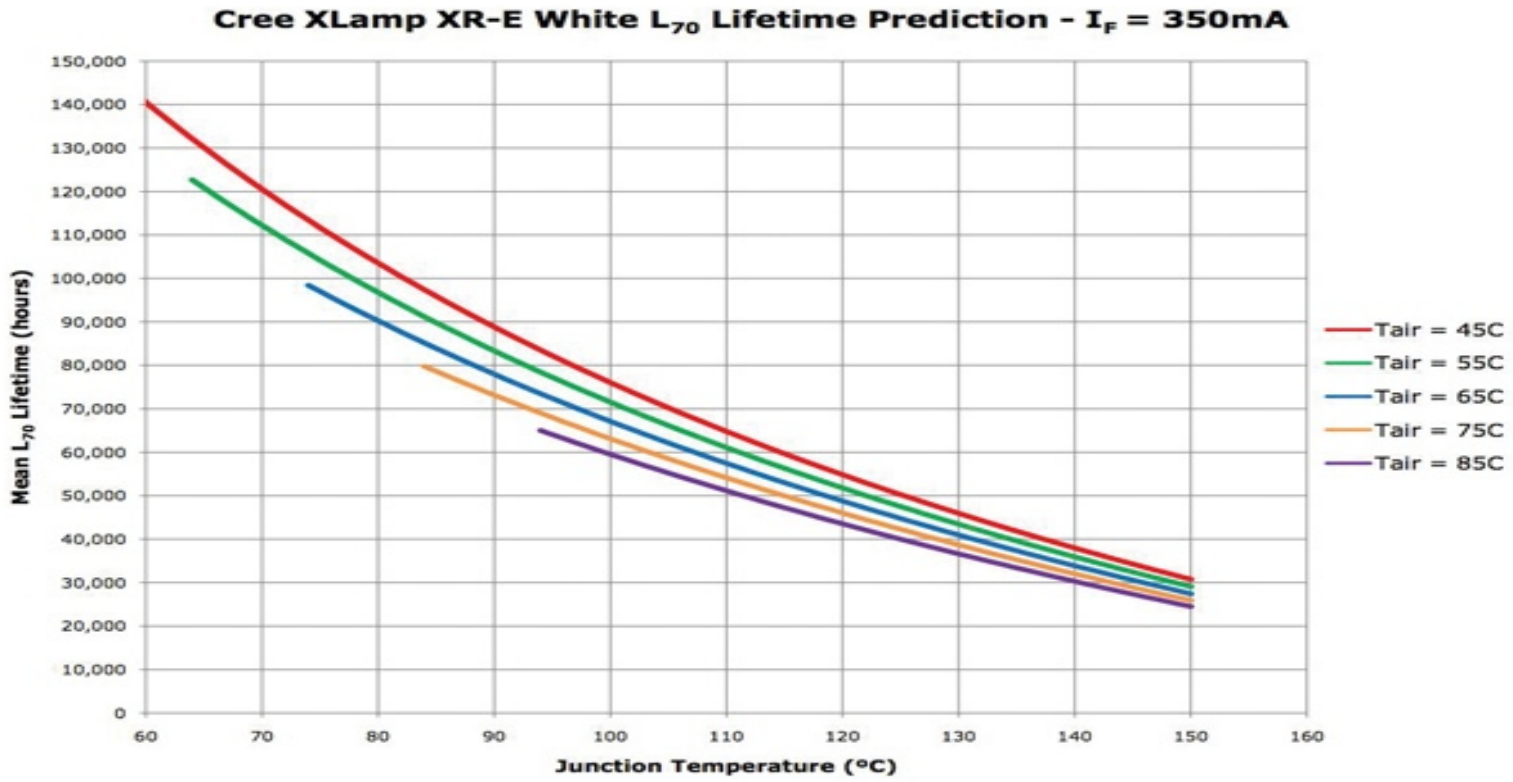
General PCB Requirements for LED's & Solar Cells

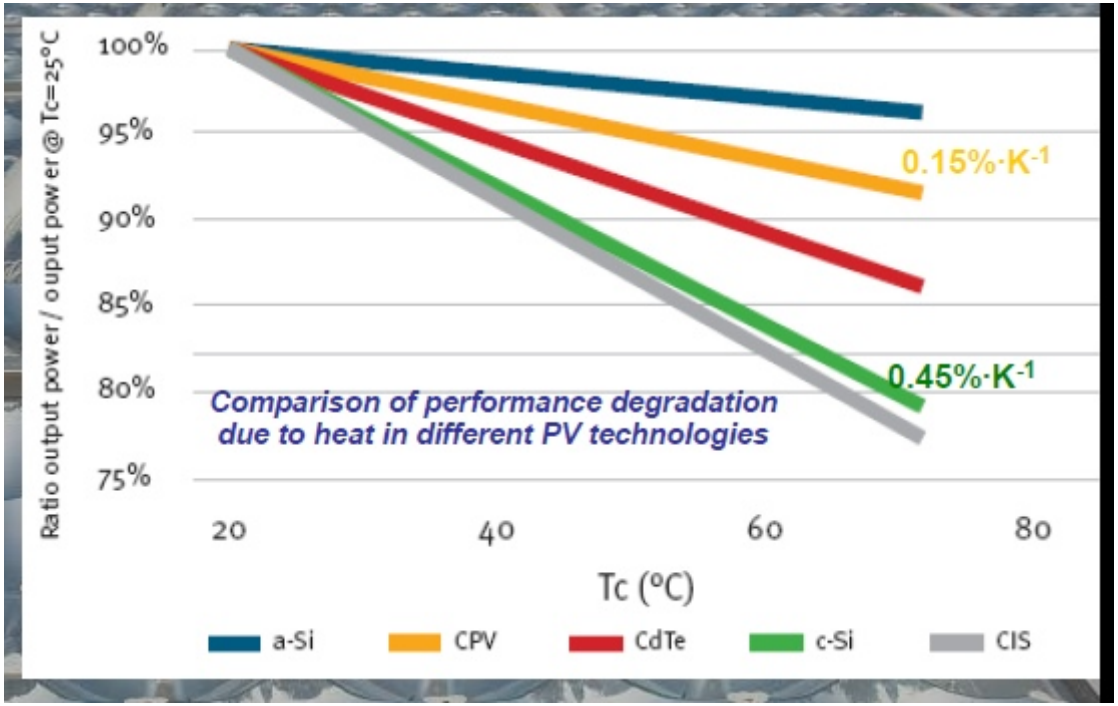
LED's & Photovoltaic (PV) Cells work more efficiently and have much greater longevity if they operate at their optimum temperature.

Thermal Management of these devices is therefore critical to ensure long-life, high reliability & efficiency; especially as these are relatively expensive products.

Example of LED Lifetime at various operating temperatures



Degradation of cell efficiency with increasing temperature



In a well constructed CPV module with passive cooling and good heat sinking then the cell may be at ~30C above the ambient temperature of the module.

Note the big difference between crystalline Si and CPV (III-V multi-junction cells)

PCB's for Thermal Management

- FR4 (CEM) – single-sided & PTH
- MPCB – a range of technology types

FR4 (CEM) PCB's

- Single-sided – use large copper areas to provide heat-sinking, suitable for low power/low density applications (up to 0.25W).
- PTH – using thermal vias to route heat generated by device through PCB to a plane on the other side (this plane can be connected to a secondary heat-sink or additional cooling device to improve efficiency). Suitable for LED's up to 1W but on low density applications.

MPCB's

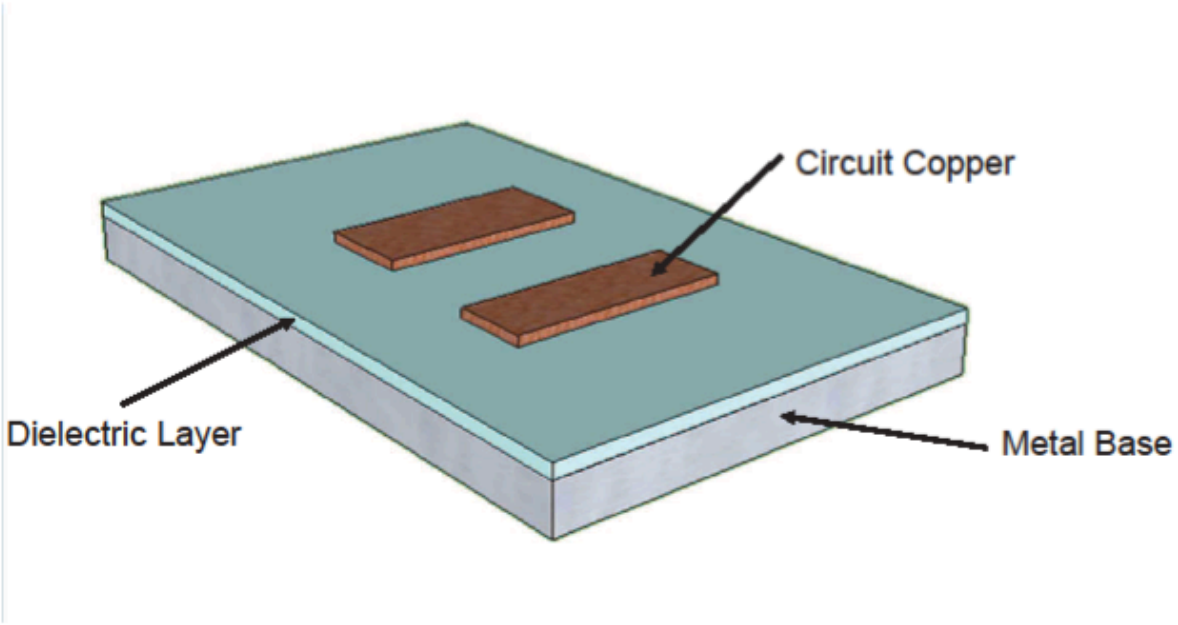
- MPCB's offer a convenient PCB solution for Thermal Management because they have an in-built heat-sink close to the heat source.
- Types of MPCB:
  - Standard IMS MPCB
  - New IMS MPCB
  - 'Chip On Board' MPCB
  - Hybrid (post-bonded) MPCB
  - Metal Core MPCB

Standard IMS MPCB

- IMS (Insulated Metal Substrate) – consists of copper foil bonded to a metal (heat-sink) base using a dielectric prepreg.

- Wide range of suppliers and materials available providing a variety of electrical and thermal performance characteristics.

Typical Metal-back Substrate

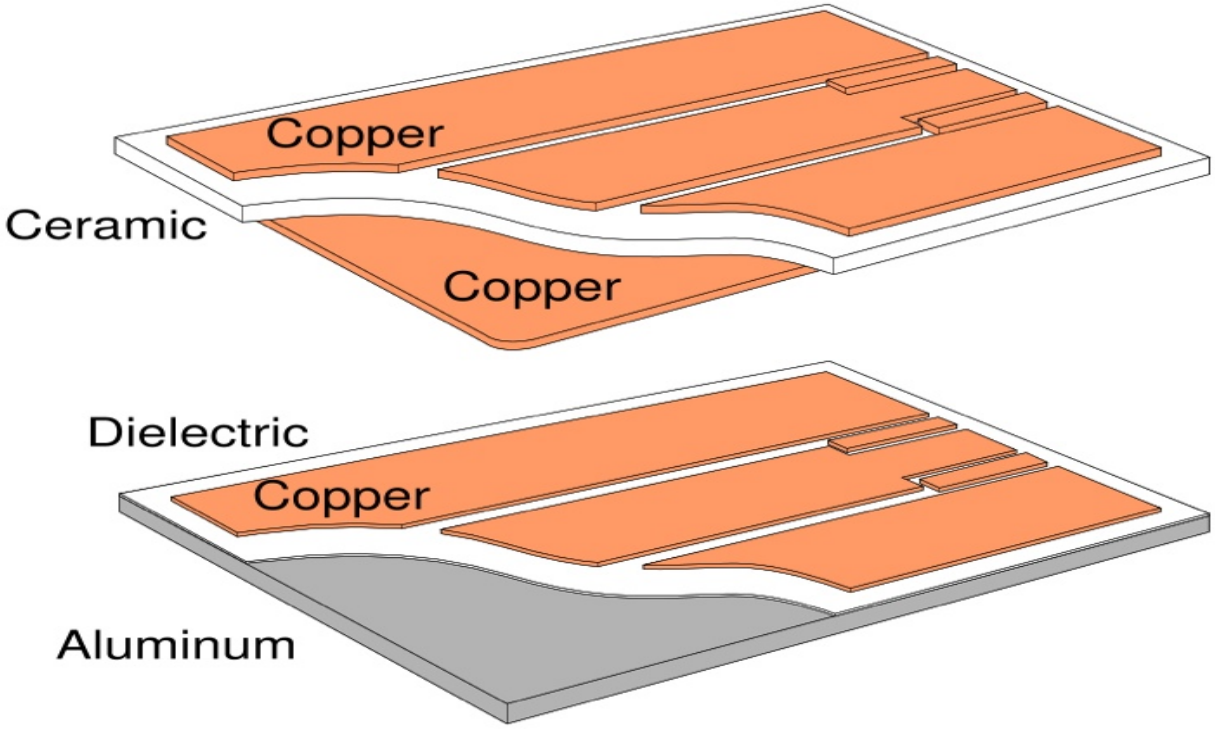


Standard IMS

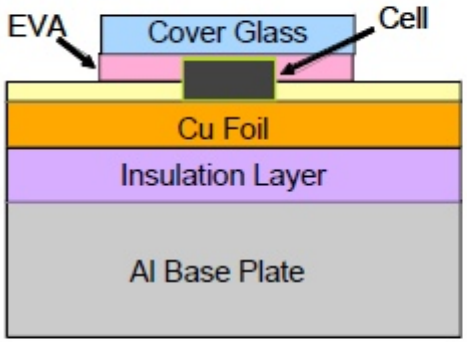
- Copper Foil: 1 – 10oz copper (380/400W/mK) – used to create the circuit image.
- Metal Base: 0.5 -3.2mm Aluminium (150/180W/mK) or Copper (380/400W/mK) – this acts as the primary heat-sink.
- Dielectric: 17-300micron; 0.25-3W/mK & Breakdown Resistance (500-1000V/25micron).

A single-sided circuit, where the heat generated by device is dissipated through the dielectric to the metal base (heat-sink). These can also be formable.

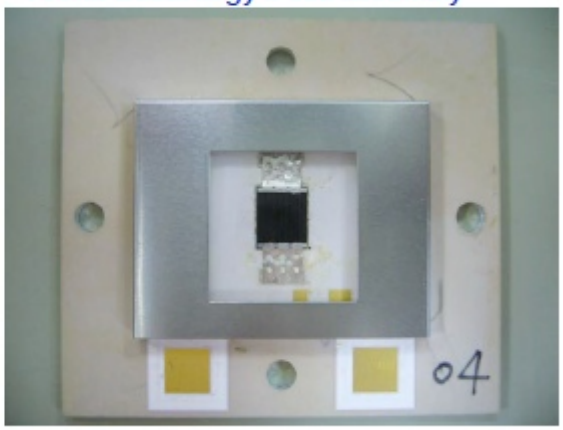
The 2 most popular heat-sinking solutions for CPV cell assemblies



CPV Cell assembly on Std IMS MPCB



Arima EcoEnergy's cell assembly



New IMS MPCB

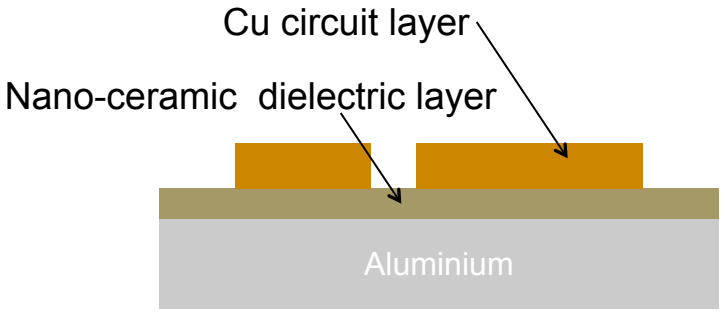
Nanotherm

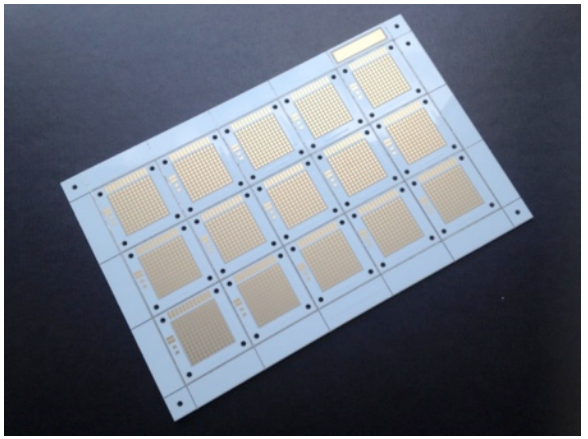
A new generation of high performance IMS; the ceramic (Aluminium Oxide) is grown directly onto the Aluminium base material and then the copper layer is plated directly to the ceramic – this results in an IMS with very low Thermal Resistance.

What is a Nanotherm™ Substrate?

NANOTHERM™

- Nanotherm's technology allows the conversion of Aluminium into Alumina (Aluminium oxide).
- Alumina is a dielectric material and therefore can be used to separate a heat spreader from a Cu circuit layer.
- Thermal performance is much better than filled-epoxy/PI dielectrics used in metal-backed PCBs
  - Nanotherm k = 7 W/mK
  - Rth = 0.02 for 10 micron of nano-ceramic
- Resulting PCB has a thermal resistance improvement over leading metal-backed PCB material of between;
  - 20% for a bonded Cu circuit layer, and
  - 75% for direct metallisation of nano-ceramic





144 die array on Nanotherm material (replacing Aluminium Nitride ceramic tile)

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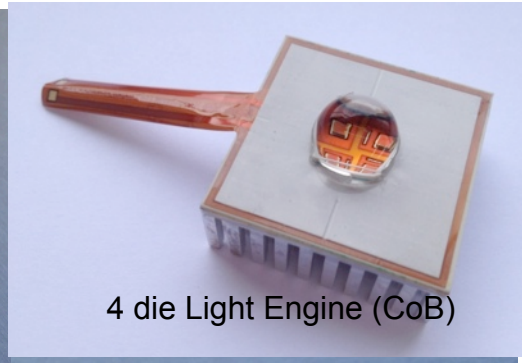
What is Circuit-on-Heatsink?

NANOTHERM™

- The conversion of Aluminium to Alumina can be performed on any 3d Aluminium form.
- This allows the circuit to be formed ***directly*** onto the heatsink – no PCB.
- SMT or Chip-on-Board (CoB) assembly is then used to populate the circuit.



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Why Nanotherm?

NANOTHERM™

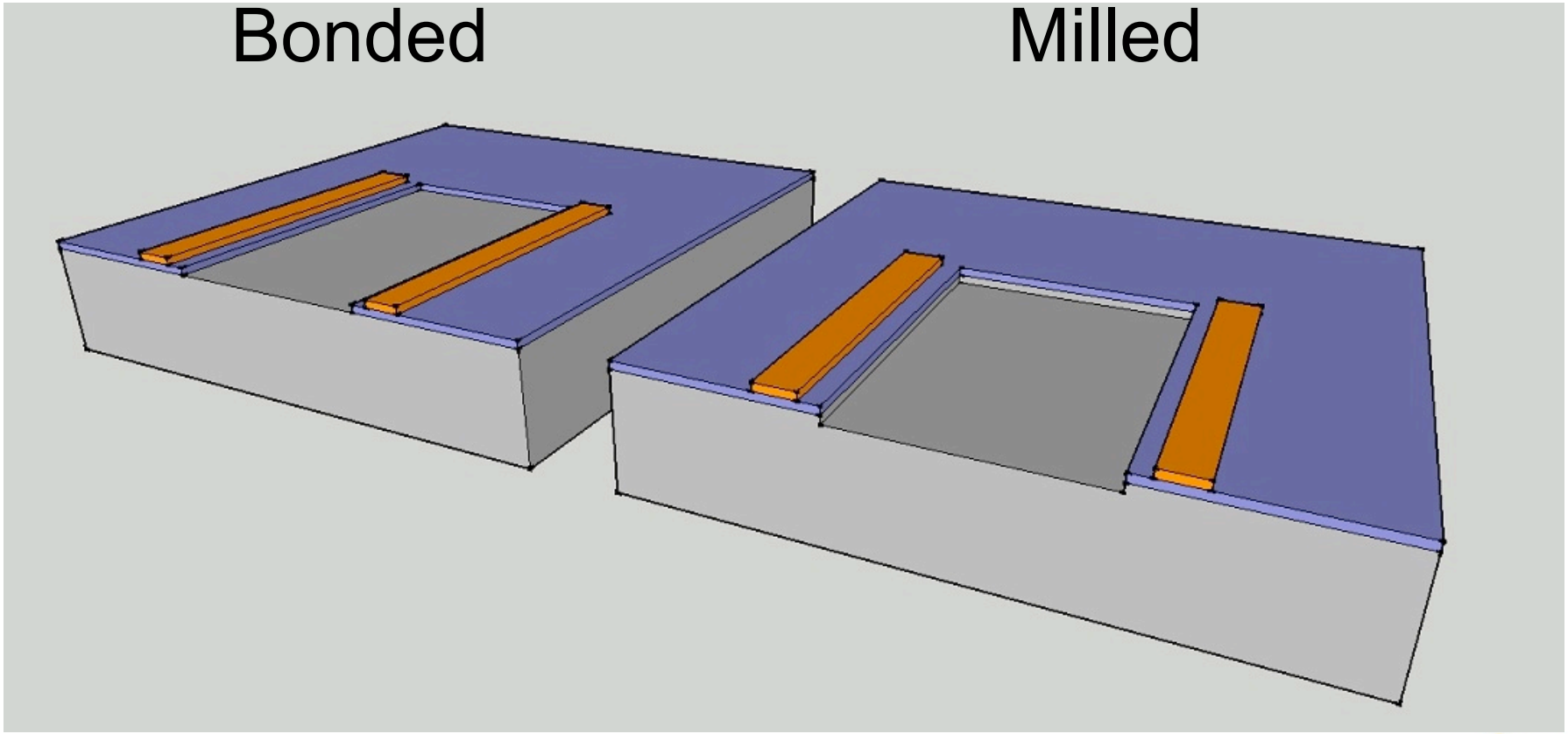
- **Metal-backed PCB**
  - A way of reducing die temperature without having to move to Cu-backed PCBs, or, in more extreme cases Metallised Ceramic (AlN) tiles.
    - Cost saving
    - Yield improvement (ceramic tile is very brittle!)
    - Weight reduction (Al is approx. 3x lighter than Cu)
- **Circuit-on-Heatsink**
  - Allows circuitry to be formed directly onto heat sinks.
  - Reduces overall system cost by removing PCB and Thermal Interface Material (TIM).
  - Removes 3 thermal interfaces in the stack.
  - Enables Chip-on-Heat sink assemblies– die are directly soldered and wire bonded to the heat sink.

Chip On Board MPCB

Chip On Board MPCB: the dielectric is selectively removed from the locations of the heat source (i.e. LED or PV cell body) so that when assembled the heat source is in direct contact with the heat-sink.

These apertures in the dielectric are created by milling or by using a bespoke bonding process.

Chip On Board MPCB



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Metal Core MPCB

Metal Core MPCB: these have a metal heat-sink layer bonded inside the PCB typically using ceramic-loaded prepregs.

Components can be mounted on both sides of the PCB and the heat is dissipated to the heat-sink (metal core) through the dielectric or by thermal vias.

Hybrid MPCB

These are PCB's (PTH or multilayer) made using standard dielectrics (FR4 etc) or from ceramic-loaded materials which are then bonded to a metal base (heat-sink) using ceramic-loaded prepreg.

The circuit utilises thermal vias and copper planes to heat-spread and dissipate heat from the PCB to the metal base.

Summary

At the PCB level, there are range of Thermal Management solutions available and so fabricators should provide the best option based on performance versus cost.

IMS materials are relatively expensive and panel sizes are limited so fabricators need to work closely with the designers to ensure best material utilisation from standard panels.

Thank you

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