

INSULATED ALUMINUM SUBSTRATES

Thermal Solutions for Hi Brightness LED Applications - Application Note



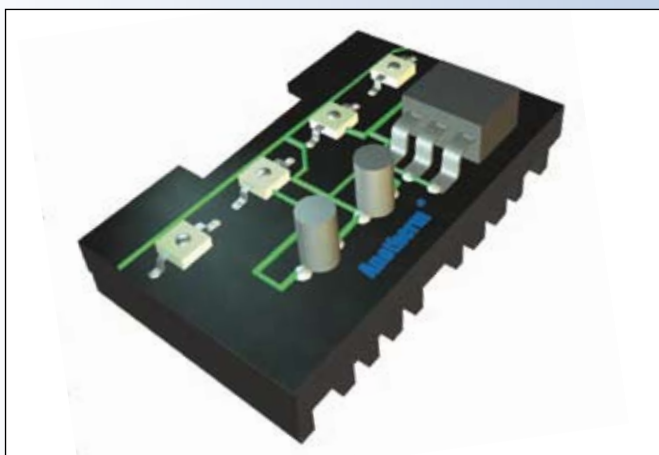
TT electronics is a leading designer and manufacturer of electronic components. As a result of our experience with power components, Anothertherm® substrates were developed as an innovative method of addressing thermal problems.

Anothertherm® substrates consist of a highly thermally conductive aluminum alloy substrate, with a high quality insulating dielectric layer and silver alloy conductor fired onto it.

The result is a low cost, rigid circuit board with unsurpassed thermal

efficiency. The completely inorganic construction results in substrate characteristics that maintain their properties even at high continuous operating temperatures. This process also allows the use of a wide range of substrate configurations including finned and multi-up arrays.

Hi brightness, high power LEDs and power semiconductors benefit from Anothertherm® substrates, allowing excellent heat transfer from the device package, resulting in better performance and improved reliability.



Anothertherm® substrates offer very high thermal conductivities with low thermal resistance from the die or chip to the substrate for power LED applications.

This results in:

- **Reduced operating temperature**
- **Higher operating power/density**
- **Improved reliability and reduced failures due to thermally induced problems.**

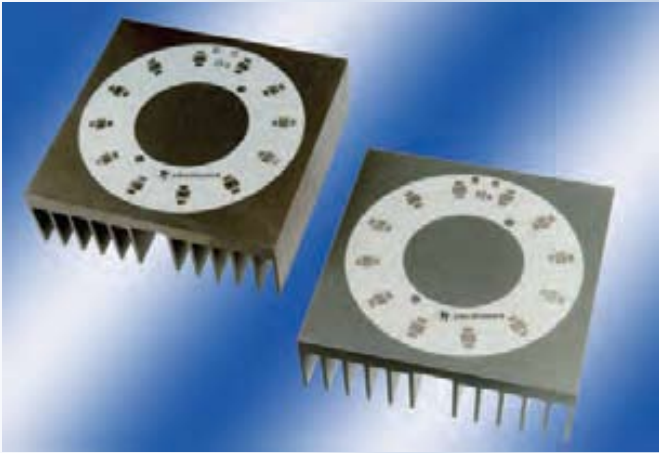
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Substrate Characteristics

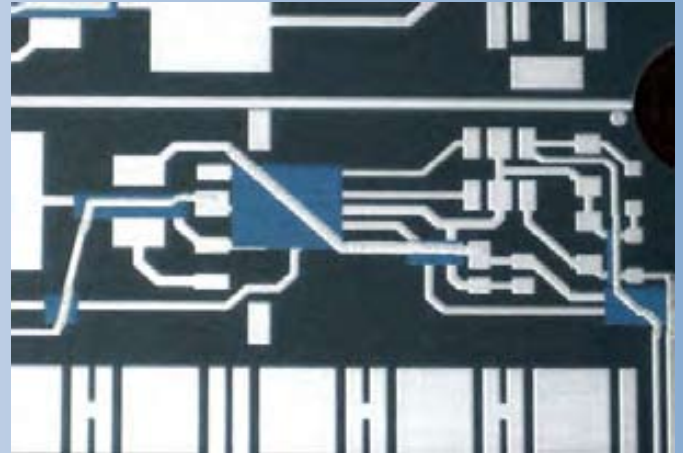
Base Material: The base material for the Anotherm® substrates is an aluminum alloy, either 3000 or 6000 series. These aluminum alloys have a high thermal conductivity and low cost. The common extrusion alloy, 6063 can be used for assemblies which are printed directly onto a heatsink. The thermal expansion coefficient of these alloys corresponds favorably with traditional P.C. board materials. Long term thermal shock testing confirms the ruggedness of the materials used in Anotherm® product without delamination or degradation.

Dielectric Layer: The insulation system used on Anotherm® substrate is dense, reliable and able to withstand a large number of thermal shocks without degradation, and offer very good thermal conductivity. This inorganic dielectric layer gives a high quality insulation that is not affected by temperature or chemicals.

Conductors: Silver alloy conductors are screen printed and fixed onto the insulating dielectric layer. The standard conductor thickness is approximately 20 microns, although thicker conductors can be printed for higher current carrying capability.



Printed traces are available on finned heatsinks.



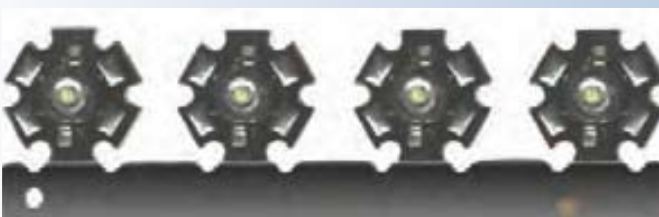
Crossovers/multiple layers are possible with the additive type Anotherm® technology.

Multiple Layers: Anotherm® substrates are ideal for applications requiring single layers on the front or backside of the board. When multiple layers or printed crossovers are required, polymer materials are used. As a result, the excellent thermal conductivity properties of Anotherm® substrates are lost in the additional layers. However, these traces can be used for carrying low power and control signals.

Wire Bonding: Wire bonding can be performed with gold conductors available on Anotherm®. Solder Masks Printed solder masking is available in a wide range of colors using a polymeric formulation. Common colors are white, royal blue, green, and black.

Heatsinks: One interesting characteristic of this technology is the capability of printing solderable conductors directly onto heatsinks, thereby simplifying the assembly of power systems.

Reliability: Anotherm® substrates have been proven through millions of unit-hours of successful operation as power resistors for automotive HVAC fan speed applications, many in very harsh applications. They have successfully passed requirements presently in use for automotive, and class 8 truck applications.



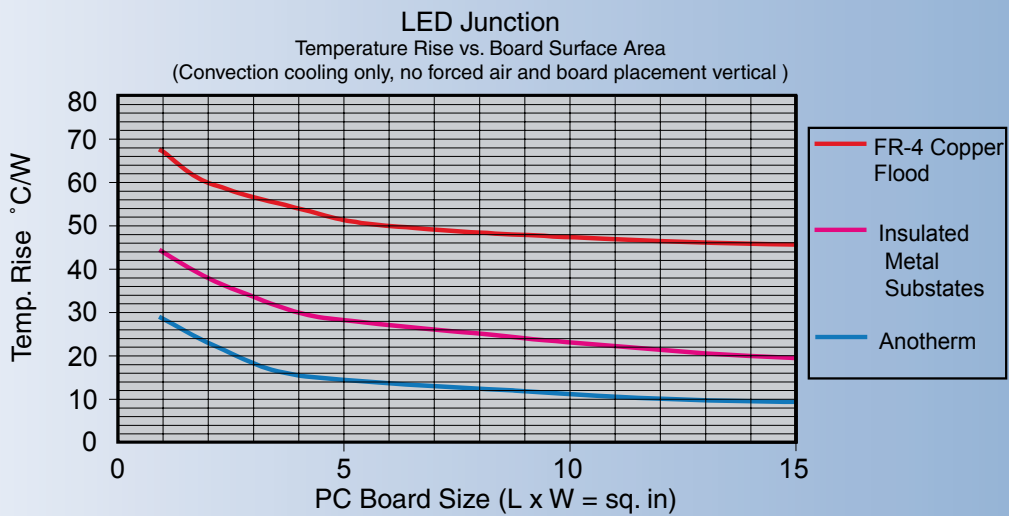
Anotherm® substrates can be scored and grooved for easy singulation.

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Anothertherm® Design Guides

Substrate: Because of the improved thermal performance that Anothertherm® offers in comparison to traditional thermally conductive boards, a marked increase in performance can be realized in many applications. The graphs shown on this page show the differences in LED junction temperature when used with various board materials

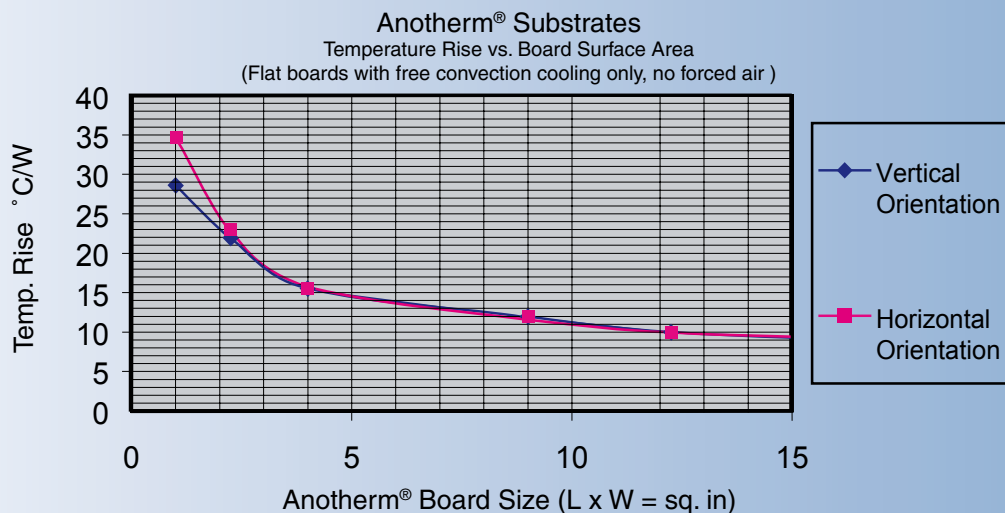
of different sizes. Although given for free air with convection cooling only, in all cases for a given size circuit board, Anothertherm® can lower the LED junction temperature (regardless of the LED manufacturer) on surface mounted LEDs.



*LED junction temperature versus board size. (Lumiled 1 Watt LED).

Board Size Calculation: The graph shown below can be used to assist in determining how large a board is needed for a particular application. For example, suppose we want to use a 3W LED in a horizontal position in an ambient temperature up to 60°C, without any forced air cooling, but with free convection present. Suppose also that we have as design criteria that the LED junction

temperature must not exceed 125°C. For these calculations, we determine that the maximum temperature rise allowed above ambient is: $125^{\circ}\text{C} - 60^{\circ}\text{C} = 65^{\circ}\text{C}$. Since we are dissipating 3W, we must limit the maximum board temperature rise to $65^{\circ}\text{C}/3\text{W} = 21.6^{\circ}\text{C}/\text{W}$. By consulting the graph, we see that the board size must be at least 2.25 sq. inches in area.



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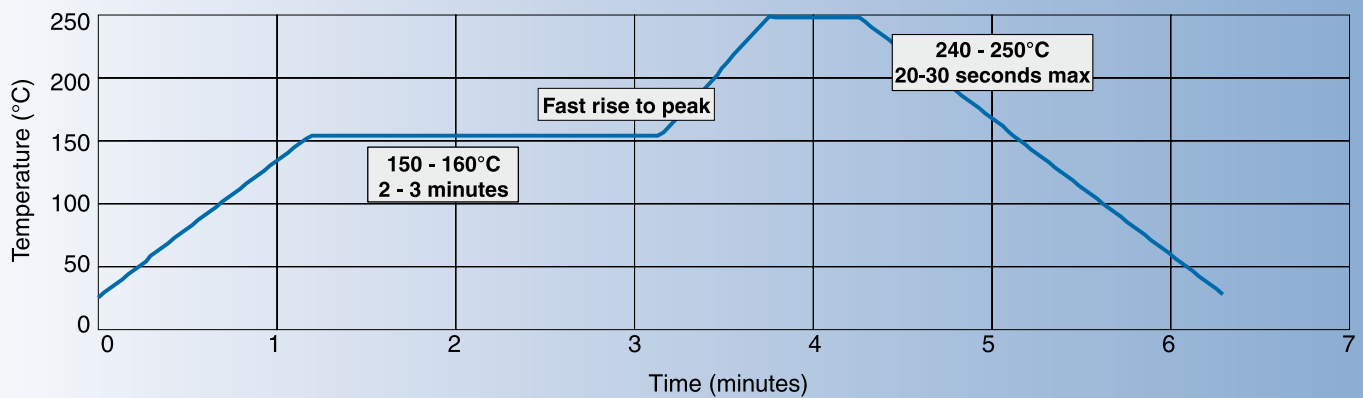
Soldering

The use of solders containing silver (such as common alloys SN62Pb36Ag2 or Sn96Ag4) and most lead free RoHS compliant solder (such as the common SAC305 and SAC405 alloys) is required when soldering to Anotherm®. The reflow profile shown should be utilized as a guide to obtain best results. The key to a proper

profile is to keep the temperature and time above the solder liquidus temperature to a minimum; otherwise excessive leaching of the conductor can adversely affect the adhesion of soldered components

Suggested Anotherm® Solder Reflow Profile

Lead (Pb) Free SAC 305/405 and SN96 Solder Alloys



Performance Data

Characteristics	Test Method	Test Summary	Performance
Thermal Shock	MIL-STD-202 Method 107B	-65°C to +150°C 1000 cycles	No delamination or degradation
Adhesion (initial)	IRC Test	2mm x 2mm pad, 0.8 mm soldered wire, vertical pull	>3.6kgf
Adhesion (aged)	IRC Test	2mm x 2mm pad, 0.8 mm soldered wire, vertical pull, aged 100 hrs at 150°C	>1.8kgf
Solder Wetting (Sn62/Pb36/Ag2)	MIL-STD-202 Method 208	245°C for 5 seconds solder dip	>95% minimum coverage

Specifications

Maximum Operating Voltage	2KV ¹
Maximum Continuous Operating Temperature	300°C (without solder maskant) 175°C (with solder maskant)
Thermal Impedance	0.02°C/W ²
Minimum Line Width/Spacing	0.006"/0.006" (0.15mm/0.15mm)
Nominal Conductor Trace Thickness	20 microns standard (800 microinches) up to 150 microns (0.006" for high current applications)
Nominal Conductor Trace Resistivity	0.0017 Ω/sq/mil thickness
Dielectric Thickness	0.0014" (35 microns) nominal
Maximum Substrate Size	10" x 18" (254mm x 457mm)

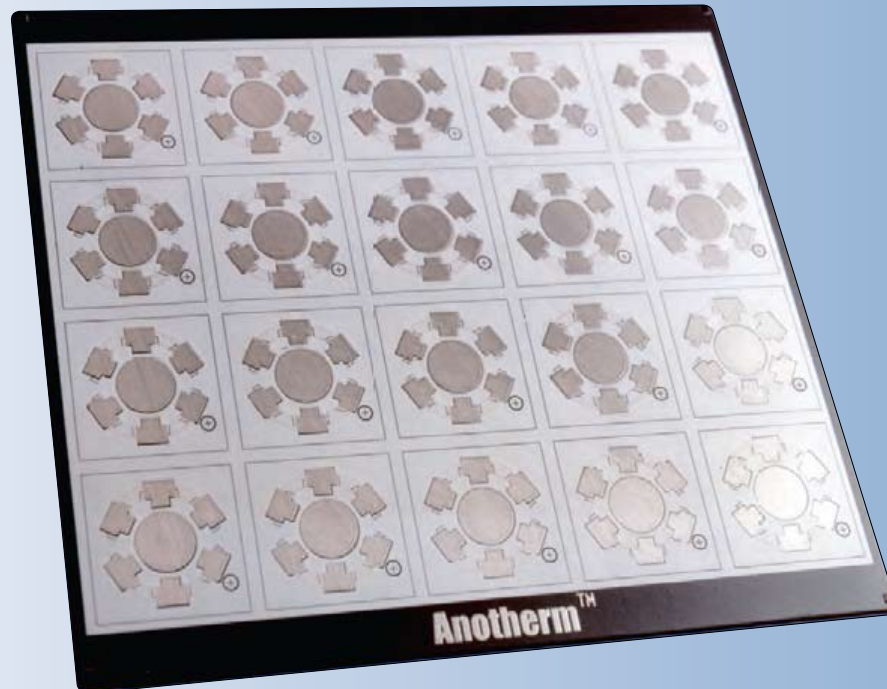
Notes: 1. Maximum voltage will depend on dielectric thickness. 2. Thermal impedance from printed pad to aluminum core, pad size = 0.1 sq.in. The metal core of the substrate should be kept electrically isolated.

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Another™ Design Criteria / Recommendations

Design Category	Design Parameter	Standard Design Recommendation and Specification	
Circuit Design	Minimum circuit trace width	Printed Conductor Thickness	Minimum Track Width
		10mm	0.006" (150mm)
		20mm	0.006" (150mm)
		35mm	0.010" (250mm)
	Minimum spaces between traces	70mm	0.010" (250mm)
		Printed Conductor Thickness	Minimum Track Width
		10mm	0.004" (100mm)
Minimum circuit to edge blanking	20mm	0.006" (150mm)	
	35mm	0.010" (250mm)	
Minimum circuit to edge (V-scored/milled/routed)	70mm	0.015" (380mm)	
	One Material Thickness +0.020" (500mm)		
Minimum conductor to hole edge	Substrate Material Thickness	Circuit to Edge Distance	
	0.080" (1.0mm)	0.026" (0.66mm)	
Minimum Annular Ring	0.050" (1.3mm)	0.028" (0.71mm)	
	0.063" (1.5mm)	0.029" (0.74mm)	
Maximum Substrate Size	One Material Thickness.		
Substrate Dimensions	Minimum Annular Ring	Punched hole 0.030" (0.76mm) Drilled hole 0.010" (0.25mm) minimum.	
	Keep Out Areas Around the Edge of the Panels	18" x 10" — 457.2mm x 254mm Consult factory for larger sizes.	
	Substrate Thickness	0.200" (5mm)	
	Printed Heatsinks	1.25mm and 1.6mm standard. Other thicknesses are available upon request.	
Solder Mask Design	Solder Mask Apertures	Contact factory to discuss requirements (1.75" maximum thickness).	
	Minimum Aperture Size	It is recommended that the customer design the solder mask to overlap the conductor by a minimum of 0.010" (0.25mm).	
Mechanical Design	Hole to Board Edge	0.010" x 0.010" (0.25mm x 0.25mm)	
	Punched Hole Size	Minimum distance from edge of the hole to the edge of the board is one material thickness.	
	Minimum Drilled Hole Diameter	Minimum punched hole size is 1.5 x material thickness.	
	Minimum Edge Radius	Substrate Material Thickness	Circuit to Edge Distance
Minimum Circuit to Edge for Blanking	0.040" (1.0mm)	0.030" (0.76mm)	
	0.050" (1.3mm)	One Material Thickness	No radius on V-scored panels.
	0.060" (1.5mm)	One Material Thickness +0.020" (500mm)	

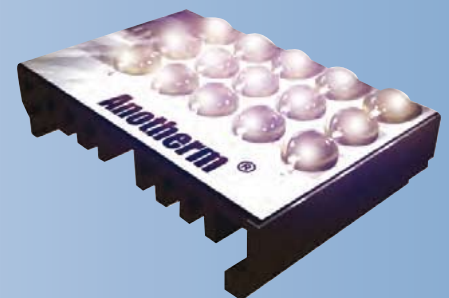
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Custom circuits and traces are available on arrayed Anotherm® substrates.

Other applications:

- Solid state relays
- Automotive power electronics
- DC-DC switching power supplies
- Power amplifiers
- Low voltage motor controls
- High temperature electronics such as “down-hole” oilfield telemetry and automotive engine compartment applications



TT electronics: leading in fixed resistor technology.

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