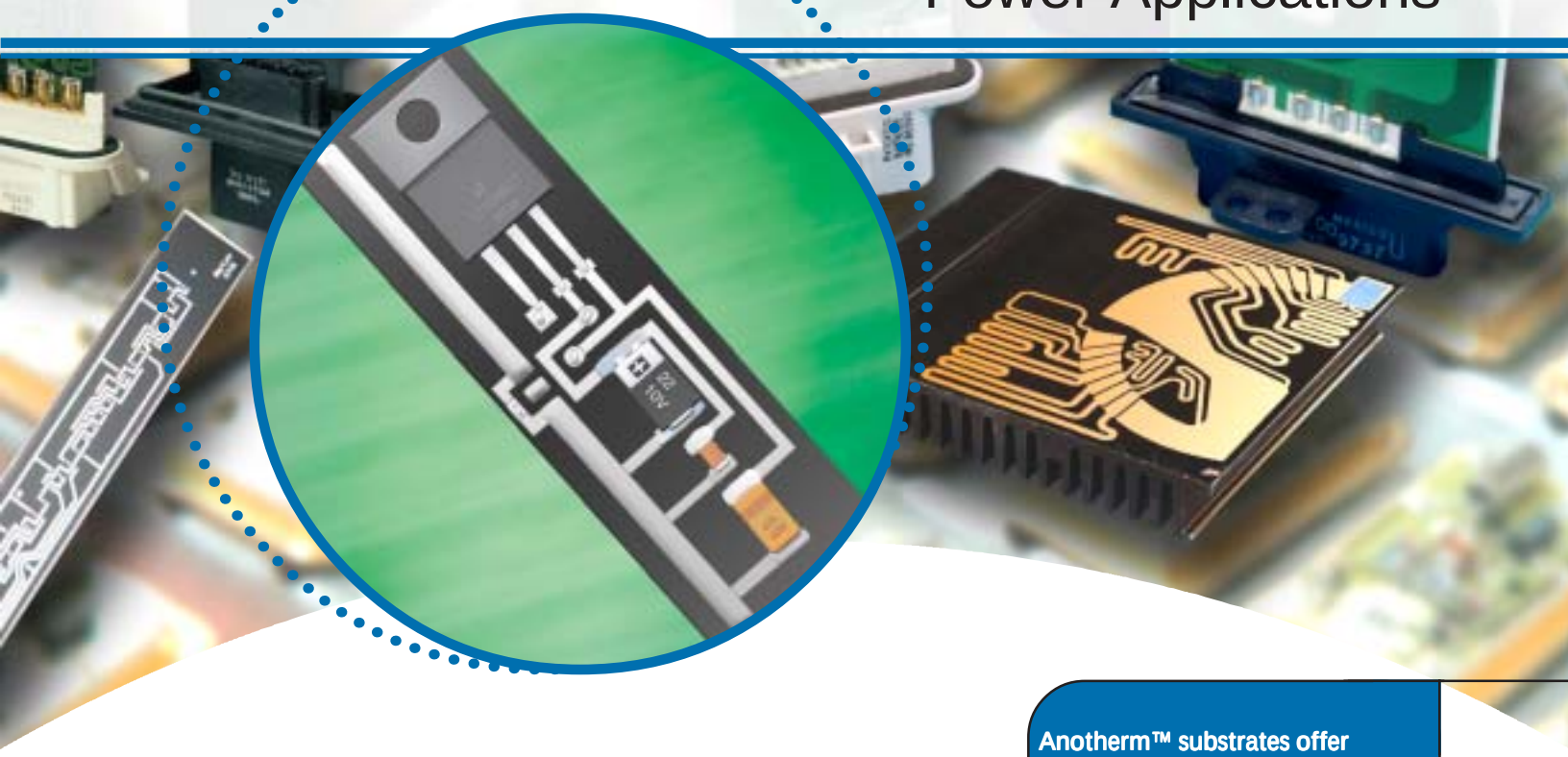
# Insulated Aluminum Substrates

## Thermal Solutions for Power Applications



T.T. Electronics is a leading designer and manufacturer of electronic components. As a result of our experience with power components, Anotherm™ substrates, an innovative method of addressing thermal problems was developed.

Anotherm™ substrates consist of a highly thermally conductive aluminum alloy substrate, with a special anodized aluminum oxide electrically insulating layer chemically grown on the aluminum core. This high temperature anodized layer offers good electrical isolation and excellent thermal transfer. Screen-printed, solderable conductors are then applied to the board and fired at 600°C.

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.

Traditional methods of removing excess heat from components have centered on the use of heat sinks with thermal grease or polymer pads to thermally connect the device to the heatsink. With Anotherm™ substrates, the entire board becomes the heat sink with no extra hardware (clips, screws, etc) required. In addition, the characteristics of the printed thick film conductors allow direct wirebonding from dies to the printed conductors.

**Anotherm™ substrates offer very high thermal conductivities with low thermal resistance from the die or chip to the substrate.**

**This results in:**

- **Reduced Operating Temperature**
- **Higher operating power density**
- **Reduce or eliminate heat sinks**
- **Improved reliability and reduced failures due to thermally induced problems.**
- **Lower assembly cost by eliminating attached heatsinks and mounting hardware**

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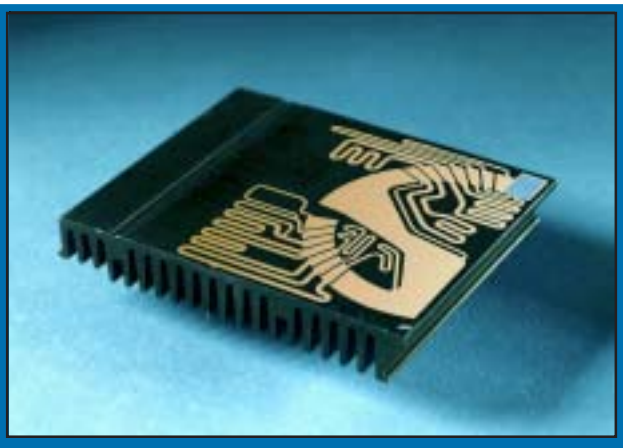
# Substrate Characteristics

The base material for the Anotherm® substrates is an aluminum alloy, either 3003 or 6061. This aluminum alloy has a high thermal conductivity and low cost. The thermal expansion coefficient of this material corresponds favorably with traditional P.C. board materials as shown in the table below. Long term thermal shock testing confirms the ruggedness of the dielectric medium.

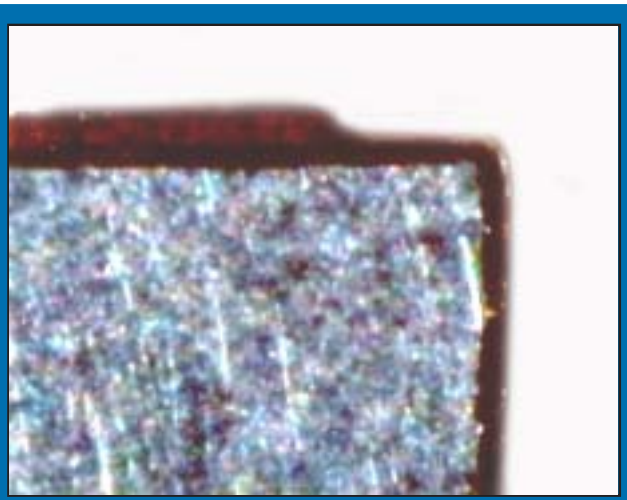
| Material | Thermal Expansion Coefficient (ppm/K) | Thermal Conductivity (W/m-K) |
|---|---|---|
| **FR-4 P.C. Board** | 16-20 | 0.8 |
| **Anotherm® 3003/6061 Aluminum** | 23.4 | 173 |
| **304 Stainless Steel** | 16.4 | 17.3 |
| **96% Alumina Ceramic** | 6.5 | 21 |
| **Copper** | 16.5 | 386 |

**Dielectric Layer:** The Insulation system used on the Anotherm® substrate system is an anodically grown coating (similar to hard coat anodizing), that deposits a dense, thin film of aluminum oxide approximately 0.0014" thick (0.035mm) onto the aluminum surface. This inorganic dielectric layer gives a high quality insulation that is not affected by temperature or chemicals.

**Multiple Layers:** Anotherm™ substrates are ideal for applications requiring single layer or front and backside traces. 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.



Printed traces on finned heatsink available.



Magnified sectioned view of Anotherm™ substrate and trace. The anodized insulation layer gives excellent continuos coverage, even around sharp corners

**Solder Masks:** Printed solder masking is available using a polymeric formulation.

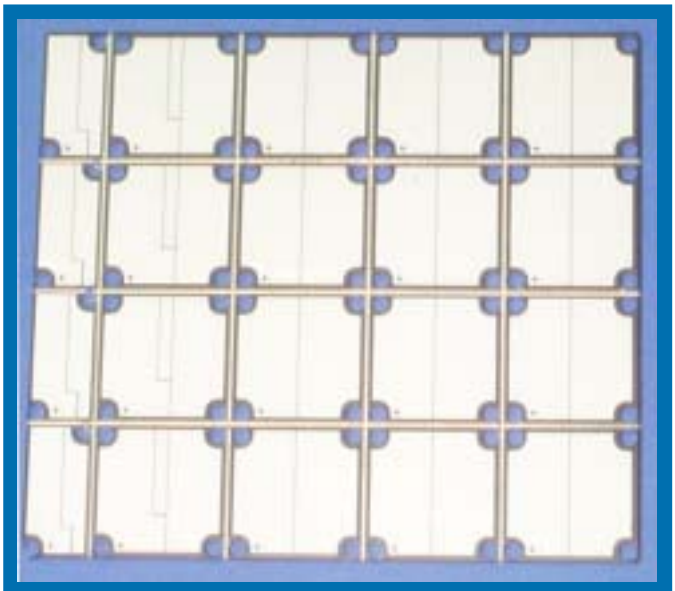
**Heatsinks:** One interesting characteristic of this technology is the capability of printing solderable conductors directly onto heatsinks, thereby simplifying the assembly of power systems.

**Reliability:** Anotherm™ substrates have been proven through use in millions of unit-hours of successful operation in use 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.

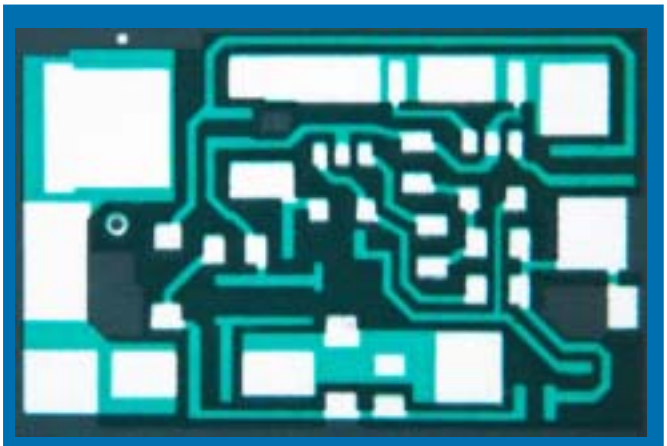
**Soldering:** Components can be soldered to traces printed on Anotherm™ substrates. The use of solder alloys containing silver is strongly recommended, such as 62Sn36Pb2Ag or Sn96Ag4.

# Specifications

| | |
|---|---|
| **Maximum Operating Voltage** | 250 VAC |
| **Maximum Continuous Operating Temperature** | 400°C (w/o Solder Maskant)<br>175°C (w/ Solder Maskant) |
| **Thermal Impedance** | 0.2°C/Watt** |
| **Minimum Line Width/Spacing** | 0.006"/0.006"<br>(0.15mm/0.15mm) |
| **Conductor Trace Thickness** | 12±2 microns standard (470 microinches), up to 150 microns (0.006") for high current applications |
| **Conductor Trace Resistivity** | 0.0017 ohms/sq./mil thickness |
| **Dielectric Thickness** | 0.0014" (35 microns) Nominal |
| **Maximum Substrate Size** | 8"x10"<br>(203mm x 254mm) |
| **Maximum Substrate Thickness** | 0.75"<br>(19mm) |
| **Thermal Impedance from printed pad to aluminum core, pad size = 0.1 sq. in. | |



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



Anotherm™ substrates are compatible with chip & wire assembly.

**Applications**:

- Solid State Relays
- Automotive Power Electronics
- L.E.D. Displays
- 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

Custom circuits and traces are also available on arrayed Anotherm™ substrates.

# Performance Data

| Characteristic | Test Method | Test Summary | Performance |
|---|---|---|---|
| **Thermal Shock** | Mil-Std-202 Method 107B | -65°C to +150°C 1000 cycles | <2% ΔR/R |
| **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 |
| **High Temperature Exposure** | Mil-R-55342 | 1000 Hrs @ 150°C | 0.35% ΔR/R |
| **Resistivity** | IRC Test | Calculate resistivity on printed trace of known thickness on aluminum | 1.7 mΩ/sq/mil |
| **Solder Wetting (Sn62/Pb36/Ag2)** | Mil-Std-202 Method 208 | 245°C for 5 seconds solder dip | >95% minimum coverage |

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