

Thermal Management Solutions for Printed Circuit Boards used in Digital and RF Power Electronics and LED assemblies

Sandy Kumar, Ph.D.
Director of Technology
American Standard Circuits, Inc
3615 Wolf Road
Franklin Park, IL 60131

Phone: (847) 455-1500 X 134; Fax: (847) 455-1518; Email: skumar@asc-i.com

American Standard Circuits, Inc. (ASC) has recently developed several new thermal interface materials and thermal management solutions for efficiently dissipating the heat generated during operation of various electronic power devices mounted on printed circuit boards (PCBs). We have several satisfied power electronics and LED customers using these thermally managed PCBs.

Various steps during the PCB fabrication, such as, bonding of aluminum / copper / brass heat sink by using thermal materials developed by ASC and precision machining are performed in-house in a cost efficient manner. Detailed information about our PCB capability is provided in our web site, www.asc-i.com

ASC provides thermal management solutions for a diverse range of customers requiring PCBs for power electronics, such as, LED, automotive, aerospace, and medium and high frequency telecommunication industries. Various types of thermal interface materials are manufactured in-house and the PCB fabricated as per customer's specifications.

The following is a list of thermal interface materials made and used by ASC in the fabrication of circuit boards for various customers.

1. **Thermasil[®]**: Flexible thermal bonding film to bond copper circuit layer with aluminum/brass/copper heat sink body
2. **Thermorig**: Rigid thermal bonding film to bond copper foil with copper foil to construct a *rigid* thermally conducting insulator board
3. **Conformal Thermasil**: Thermally conductive, electrically insulating conformal pad (putty type material) as interface between PCB and complex machined parts. The bonding can be permanent (room pressure curing below 200 F for 10 min) or temporary for assemble/disassemble by no curing
4. **Silver filled silicone (Silvosil)**: Thermally and electrically conducting bonding film for bonding PTFE based PCBs with heat sinks for RF applications

5. **Silver coated aluminum filled silicone (Metasil):** Thermally and electrically conducting bonding film for bonding PCBs with heat sinks for medium and low frequency applications
6. **Conformal gap pad for pressure sensitive applications (PSAs):** Thermally conductive, electrically insulating gap pad as interface between PCB and a flat heat sink. The assembly can be easily disassembled and reassembled.

For thermal management parts, the copper thickness of any layer can be varied from ¼ Oz to 8 Oz, each bonding film can be selected to any thickness from 3 mil upward and type and thickness of aluminum or other heat sink can be customized.

Available surface finishes on **aluminum** are:

- Electroless Nickel
- Electroless Nickel Immersion Gold (ENIG)
- Electrolytic Nickel with/without Gold
- Chromate
- Bare Al

Available surface finishes on **copper** are:

- Immersion Silver
- Immersion Tin
- HASL
- Electroless Nickel
- ENIG
- Electrolytic Nickel with/without Gold
- OSP (Organic Solder Preservative)

1. High Flexibility Thermally Conductive Thermasil[®]

The PCB layer is bonded to the heat sink (for example, aluminum, copper, brass, etc.) using our patented thermally conducting silicone based bonding film called Thermasil[®]. Thermasil[®] can be custom built to any thickness from 3 mil upward. Thermasil[®] is a thermally conducting silicone-based elastomer dielectric and offers excellent compensation of the CTE mismatch between the heat sink and the PCB layer. Thus, the bonded PCB assembly can go through multiple reflow or solder stress cycles without any risk of bond failure. These materials can function over a wide range of temperature, from -80 C to +350 C (110 F to 662 F).

The thermal conductivity of Thermasil[®] can be tailored to suit customer's specific thermal load and weight requirements. Thermal conductivity can be varied from 0.5 W/mK to 5.0 W/mK.

Usually, a 62-mil aluminum of 6061 alloy type is used as the heat sink. Aluminum of any other thickness or type can also be used.

Typical PCBs fabricated using Thermasil[®] adhesive shown below:

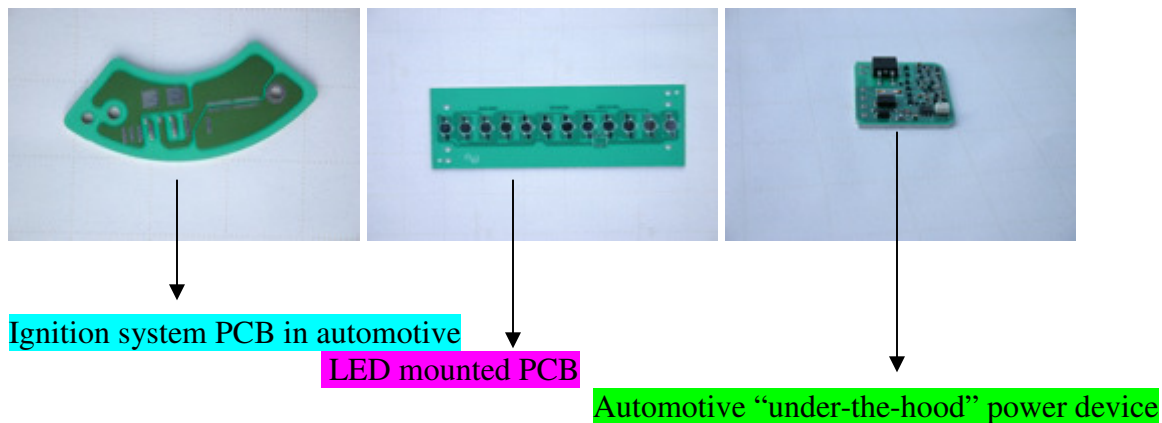
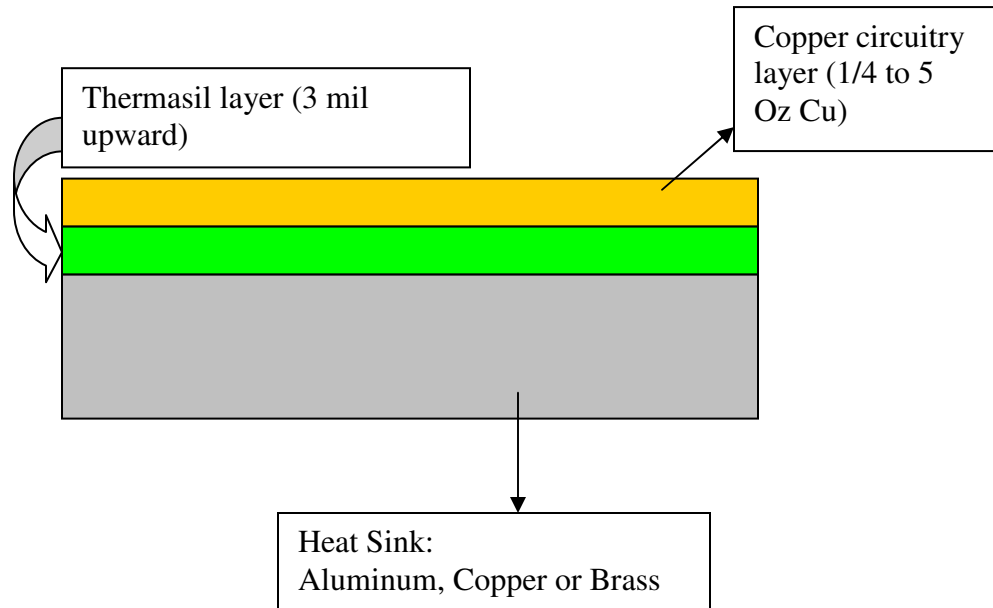


Table 1: Typical data for Thermasil[®] film

Property	Value	Test method used
Thickness	3 mil to 200 mil	ASTM D374
Tensile strength	500 psi	ASTM D412
Hardness (Shore A)	70 to 80	ASTM D2240
Elongation	250%	ASTM D412
Continuous use temperature	-40 to 450° F	
Thermal Conductivity	0.6 to 6.0 W/m-K	ASTM D5470
Electrical volume resistivity	10 ¹² to 10 ¹³	ASTM D257
Bond Strength	15 to 16 PPI	
Specific Gravity	1.43 to 1.45	



Anatomy of a Thermasil^R bonded laminate

2. High Rigidity Thermally Conductive Silicone (Thermorig)

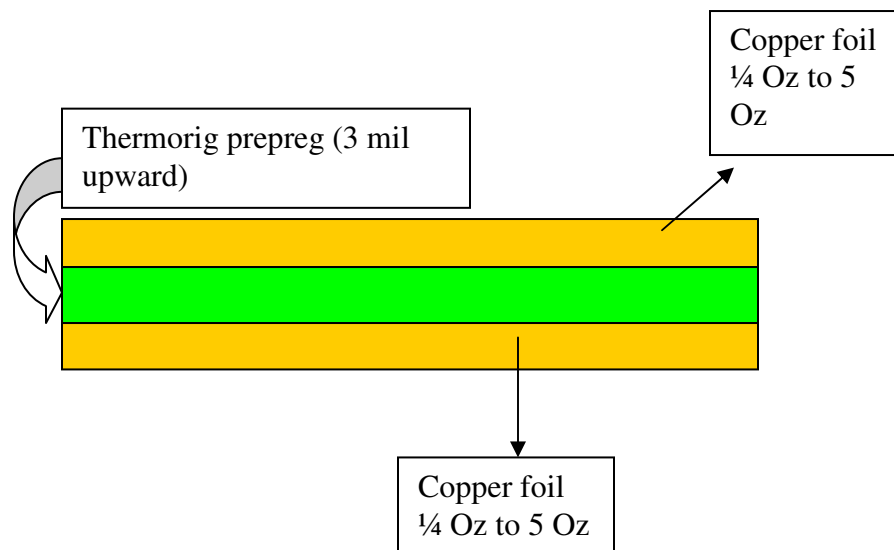
- Excellent bonding with most metallic substrates
- Excellent thermal conductivity
- Good dielectric strength

Applications:

- Rigid thermally conducting laminates for PCBs to replace FR4 and other poor thermally conducting dielectrics. The ground plane can then be bonded to heat sink like Al, Cu or brass using Thermasil^R.

Product data

- Specific gravity: 1.6 +/- 0.1 (ASTM D297)
- Thickness: Any thickness over 3 mil
- Durometer (Shore A): 90 +/- 5 (ASTM D2240)
- Tensile strength: 1020 PSI (ASTM D412)
- Elongation: 150% (ASTM D 412)
- Tear strength: 50 PPI (ASTM D624)
- Resistivity: 10^{12} ohm/cm (ASTM D991 (MOD))
- Thermal Conductivity: 4.5 BTU-Inch/Sq Ft/Deg F (ASTM F443)
- Flame Retardant: Pass (UL94V0)



Anatomy of copper bonded with copper using thermally conducting rigid prepreg, Thermorig

3. Conformal Thermally Conductive Silicone Pad

- Excellent bonding with most metallic substrates
- Excellent thermal conductivity
- Good dielectric strength

Applications:

- Conformal to modules on circuit boards with excellent thermal conductivity. Can be used to mount power devices in heat sink. Placement can be done either as a permanent bonding (cured by less than 200 F cure for 10 minutes without additional pressure) or for easy removing of parts from the sink (by gentle pressing of the device into the sink).

Product data

- Specific gravity: 1.3 +/- 0.1 (ASTM D297)
- Durometer (Shore A): 55 +/- 5 (ASTM D2240)
- Tensile strength: 625 PSI (ASTM D412)
- Elongation: 315% (ASTM D 412)
- Tear strength: 62 PPI (ASTM D624)
- Resistivity: 10^{12} ohm/cm (ASTM D991 (MOD))
- Thermal Conductivity: 3.7 BTU-Inch/Sq Ft/Deg F (ASTM F443)
- Flame Retardant: Pass (UL94V0)

4. Electrically Conductive Silver-Silicone

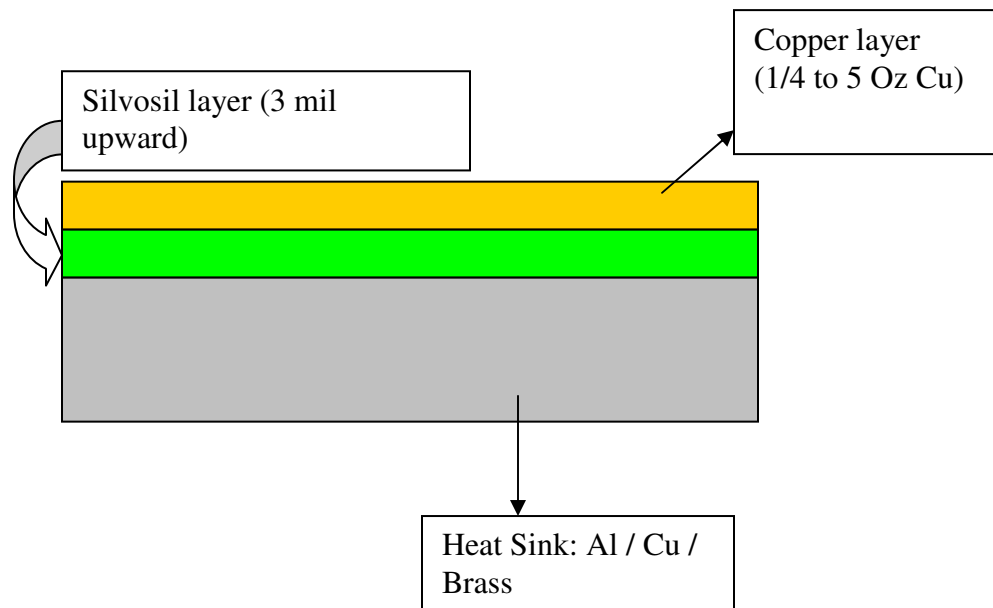
- Excellent bonding with most metallic substrates
- 75 Durometer electrically conductive adhesive
- Excellent thermal conductivity and crush strength

Applications:

- Bonding of ground plane with heat sinks for RF circuits
- Excellent RFI/EMI/EMP shielding

Product data

- Specific gravity: 2.1 +/- 0.1 (ASTM D297)
- Durometer (Shore A): 75 +/- 7 (ASTM D2240)
- Tensile strength: 200 PSI (ASTM D412)
- Elongation: 200% (ASTM D 412)
- Tear strength: 50 PPI (ASTM D624)
- Resistivity: 0.0007 ohm/cm (ASTM D991 (MOD))
- Thermal Conductivity: 13.5 BTU-Inch/Sq Ft/Deg F (ASTM F443)
- Flame Retardant: Pass (UL94V0)



Anatomy of a thermally and electrically conducting Silvosil bonded laminate for RF applications

5. Electrically Conductive Silver Plated Metal-Silicone

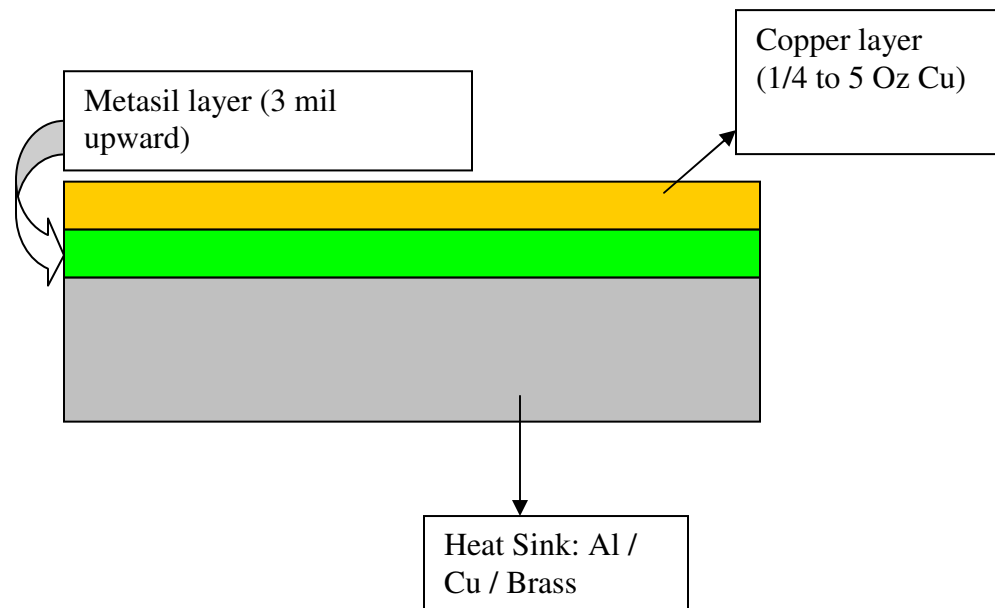
- Excellent bonding with most metallic substrates
- 75 Durometer electrically conductive adhesive
- Excellent thermal conductivity and crush strength

Applications:

- Bonding of ground plane with heat sinks for moderate frequency circuits
- Good RFI/EMI/EMP shielding

Product data

- Specific gravity: 2.1 +/- 0.1 (ASTM D297)
- Durometer (Shore A): 75 +/- 7 (ASTM D2240)
- Tensile strength: 200 PSI (ASTM D412)
- Elongation: 200% (ASTM D 412)
- Tear strength: 50 PPI (ASTM D624)
- Resistivity: 0.002 ohm/cm (ASTM D991 (MOD))
- Thermal Conductivity: 13.5 BTU-Inch/Sq Ft/Deg F (ASTM F443)
- Flame Retardant: Pass (UL94V0)



Anatomy of a thermally and electrically conducting Metasil bonded laminate for moderate frequency circuits

6. Thermally Conductive PSA Silicone Film

- Excellent bonding with most metallic substrates
- Excellent thermal conductivity
- Good dielectric strength
- Can be supplied either for permanent bonding or temporary (removable) bonding film of customer specified thickness

Applications:

- Attachment of electronic device to the heat sink can be done either as a permanent bonding (cured by low pressure and low temperature) or in easy removable form from the sink (by gentle pressing of the device to the sink).

Product data

- Specific gravity: 1.3 +/- 0.1 (ASTM D297)
- Durometer (Shore A): 55 +/- 5 (ASTM D2240)
- Tensile strength: 625 PSI (ASTM D412)
- Elongation: 280% (ASTM D 412)
- Tear strength: 60 PPI (ASTM D624)
- Resistivity: 10^{12} ohm/cm (ASTM D991 (MOD))
- Thermal Conductivity: 3.7 BTU-Inch/Sq Ft/Deg F (ASTM F443)
- Flame Retardant: Pass (UL94V0)

Typical Configurations:

1. Copper circuit layer / thermally conducting dielectric using Thermorig prepreg / Copper ground plane / Thermasil / Aluminum heat sink: Heat sink is electrically isolated from ground plane Cu
2. Copper circuit layer / Thermorig prepreg / Copper ground plane / Silvosil / Aluminum heat sink: Heat sink is electrically connected to ground plane Cu for other power devices such as automotive parts
3. Copper circuit layer / Thermorig prepreg / Copper ground plane / Metasil / Aluminum heat sink: Heat sink is electrically connected to ground plane Cu for other power devices such as automotive parts
4. Copper circuit layer / Thermorig prepreg / Copper ground plane / Silvosil / Aluminum heat sink: Heat sink is electrically connected to ground plane Cu for RF applications
5. Copper circuit layer / Thermorig prepreg / Copper ground plane / Metasil / Aluminum heat sink: Heat sink is electrically connected to ground plane Cu for medium frequency applications
6. Copper circuit layer / Thermasil / Aluminum heat sink